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Research Article

The relationship between udder conformation and milk quantity and quality in Iraqi Awassi ewes*

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Abstract

The study aimed to determine the udder measurements and type, test-day (TD) milk yield, milk composition, somatic cell count (SCC) and total bacterial count, and to evaluate the relationships between these characteristics in Iraqi Awassi ewes. Animal material consisted of 50 Awassi ewes, aged 1 to 4 years, in lactation period. TD milk yield was recorded fortnightly from the second week after parturition for three times. Milk samples were analyzed for fat, solid non-fat, protein, and lactose content. Udder morphological traits recorded in the study were udder circumference, udder depth, teat diameter, teat length, distance between teats, udder height and teat height. Total bacterial count and SCC in milk samples were determined. Udder type had no significant effect on TD milk yield, SCC, and milk composition traits. Weak correlations were found between udder measurements and milk composition traits. Udder depth was statistically significant correlated with SCC ($p<0.05$). It was found that Iraqi Awassi ewes had a healthy mammary gland and consumable milk due to their low SCC (39.20 x103 cells/ml) and bacterial content. Since there is an increased risk of infection due to contact with the ground, ewes which have the cylindrical udder with upward and lateral teats can be selected instead of ewes which have the pear-shaped udder with downwards and inclined teats. Also, ewes which have medium-sized, well-shaped udders with upward and lateral teats may be more suitable for machine milking.

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Keywords
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Somatic cell count
Udder type

IRAK İVESİ KOYUNLARINDA MEME ÖZELLİKLERİ VE SÜT KALİTESİ ARASINDAKİ İLİŞKİLER

Özet

Çalışmada, Irak İvesi koyunlarında meme ölçümleri ve tipi, test günü (TG) süt verimi, süt bileşimi, somatik hücre sayısı (SHS) ve toplam bakteri sayısını belirlemek ve bu özellikler arasındaki ilişkileri değerlendirmek amaçlandı. Çalışma materyali, laktasyon dönemindeki 1-4 yaş arasında 50 baş İvesi koyunundan oluştu. Test günü süt verimi, doğumdan sonraki ikinci haftadan itibaren üç denetim olmak üzere iki haftada bir kaydedildi. Süt örneklerinde yağ, yağsız kuru madde, protein ve laktoz içeriği analiz edildi. Çalışmada ele alınan morfolojik meme özelliklerini, meme çevresi, meme derinliği, meme başı çapı, meme başı uzunluğu, meme başları arasındaki mesafe, memenin yerden yüksekliği ve meme başlarının yerden yüksekliği oluşturdu. Süt örneklerindeki toplam bakteri sayısı ve SHS belirlendi. Meme tipinin, TG süt verimi, SHS ve süt bileşimi özellikleri üzerinde önemli bir etkisi yoktu. Meme ölçümleri ile süt bileşimi özellikleri arasında zayıf korelasyonlar bulundu. Meme derinliği, SHS ile istatistiki olarak önemli korelasyon gösterdi (p<0.05).
Irak İvesi koyunlarının, sütlerindeki düşük SHS (39.20 x10 3 hücre/ml) ve bakteri içeriği nedeniyle sağlıklı bir meme bezi ve tüketilebilir süte sahip olduğu tespit edildi. Meme başlarının zemine temasından dolayı enfeksiyon riski arttığı için, meme başları yukarı ve

Anahtar Kelimeler
İvesi
Süt
Somatik hücre sayısı
Meme tipi

yana doğru olan silindirik meme yapısına sahip koyunlar, meme başları aşağıya doğru ve eğimli olan armut biçimli meme yapısına sahip koyunlar yerine tercih edilebilir. Ayrıca meme başı yukarı ve yanlara doğru orta büyüklükte, iyi şekilli memelere sahip koyunlar makineli sağım için daha uygun olabilir.

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INTRODUCTION

The interest in the anatomy and morphology of sheep udder has increased in recent years due to its relationship with milk production and milking ability [1]. The relationship of udder conformation with milk yield in sheep has been investigated in many studies [2, 3, 4]. The udder morphology traits that showed positive and significant correlations with milk yield were udder circumference (r= 0.37 to 0.75), udder width (r= 0.22 to 0.62), udder depth (r= 0.47 to 0.74) and udder length (r= 0.57 to 0.58) [5, 6, 7, 8, 9]. Additionally, milk yield has been shown to be correlated positively and significantly with distance between teats, teat diameter and length [10].

The first practical use of udder morphology in dairy sheep was made by using the udder typology tables which based on four basic udder types in Awassi, Assaf, Sarda and Manchega sheep. Udder typology in sheep is recommended as a useful tool for the classification of machine milking groups in addition for selecting and culling of breeding animals [2]. Dag and Zülkadir [11] determined that udder type had a significant effect on mastitis frequencies in Awassi sheep (p<0.01). In a study conducted on 10 different sheep breeds, it was reported that the udder types had a small effect on milk yield, but could be crucial in terms of machine milking ability [12]. Milk yield and composition are the main traits used for selective breeding in dairy sheep [13]. The quantity and quality of milk is determined by genetic and environmental factors, flock management and animal health status [14]. Somatic cell count (SCC) consists a major indicator of udder health given their defensive role against the infections of mammary gland [15]. The normal range of SCC in bacteria free udders of goats (□300.000 cells/ml) and sheep (□200.000 cells/ml) is higher than in dairy cows (□70.000 cells/ml) [16]. Milk yield and milk composition parameters in dairy sheep show an impairment starting from 300.000 cells/ml. Therefore, increased SCC from 300.000 cells/ml to 1.000.000 cells/ml indicates that such a milk secretion is in the transition period from normal to mastitic milk [17]. Raw milk microbiota has a direct impact on the quality of milk and dairy products. Microorganisms not only affect milk quality and shelf life, but also produce extracellular lipases and proteases that can cause spoilage [18]. Total bacterial count is an indicator of udder hygiene status in dairy sheep and can also determine milk quality and its price [19]. Sheep milk has been reported to be an important source of infection for human beings due to gastroenteritis-related pathogenic bacteria, such as Salmonella spp, Staphylococci, Enterococci and E. coli. [20].

Awassi sheep, considered the most common breed in Iraq, is also an important breed for milk production [21]. Al-Samarai et al. [22] reported that the average total milk yield of Iraqi Awassi sheep ranged between 73 to 132 kg. Merkhan [10] who investigated the characteristics of the udder, milk yield and their relationship in Iraq Awassi sheep noted positive and significant correlations between udder traits and milk yield. In another study carried out on unimproved Iraqi Awassi ewes, milk yield was found to be significantly

($p \leq 0.05$) affected by udder shape [23]. However, no research on the relationships between udder characteristics and milk quality in Iraqi Awassi ewes has been conducted thus far. The main objectives of this study were to describe udder conformation, to estimate TD milk yield, fat, protein, lactose, and solid non-fat content as well as total bacterial count and somatic cell count, and the relationships between these characteristics in Iraqi Awassi ewes.

MATERIAL AND METHOD

Animals and management

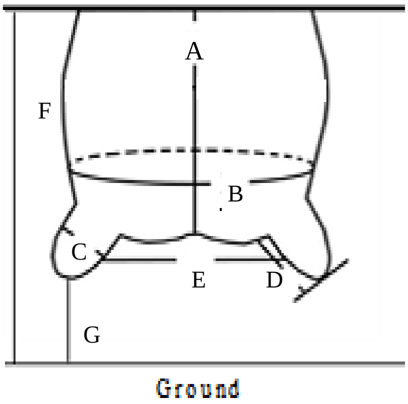
This study was conducted at a commercial farm located in Summel/Dohuk/Iraq from May to July in 2018. Fifty ewes, aged 1-4 years, in the lambing season were randomly selected from a herd of 200 sheep. The sheep kept under semi-intensive conditions were protected from high temperature, cold and adverse weather conditions. The farm also had good ventilation and all standard farm requirements. Sheep were grazed in natural pastures during the day and fed with 0.2 kg/concentrate of mixed grain based on barley and wheat bran indoors.

Methods

The experimental procedures were approved by Van Yuzuncu Yil University Ethical Committee on Animal Experimentation (reference no 2018/07). Milk yield was recorded fortnightly from second week after parturition for three times (TD1, TD2, TD3). On the test-day, the lambs were separated from their dams at 8:00 p.m., and on the next day at 8.00 a.m., ewes were milked by hand [24]. Milk quantity was recorded using Silberbrand Eterna measuring cylinder (Duran, Germany). Daily milk yield was estimated by doubling the morning milk yield [25]. Composition (fat, solid non-fat, protein, lactose) of milk samples taken from ewes was determined by Ekomilk machine (Eon Trading Inc). Milk samples were collected on the same TD and SCC were measured by the direct microscopic method as described by Coles [26]. Milk quality characteristics were analyzed separately for each test day.

A sample of about 50 ml of milk was taken for microbiological test (bacterial identification and counting) under sterilized conditions. Total viable count (TVC) was recorded according to Yousef and Carlstrom [27]. For TVC, nutrient agar plates were used by spread platting under sterilized conditions. The inoculated plates were incubated for 24 hours at 35-37 ˚C. The TVC was recorded by using colony counter. For Streptococcus spp. and Staphylococcus aureus, blood agar (Condalab) and mannitol salt agar (Condalab) were used under sterilized conditions. The plates were incubated for 24 hours at 35-37 ℃ and then the colonies were counted.

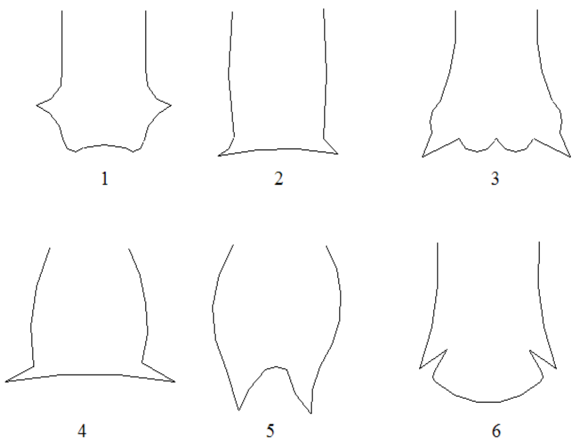
Udder measurements included the following traits: udder circumference above teats (UC, cm), right and left teat diameter in the middle of the teat (TD, mm), right and left teat length (TL, mm), udder depth as rear distance between the abdominal wall and the udder cleft (UD, cm), distance between the two teats (DBT, cm), udder height from the ground (UHG, cm), teat height from the ground (THG, cm) (Figure 1). Measurements of TD and TL were taken by using a caliper, the other udder measurements were measured by using a tape. All measurements were taken before the milking of the ewes [8].



A. Udder depth (UD)
B. Udder circumference (UC)
C. Teat diameter (TD)
D. Teat length (TL)
E. Distance between teats (DBT)
F. Udder height from the ground (UHG)
G. Teat height from the ground (THG)

Figure 1. Udder measurements scheme [28].

Udder type traits were evaluated according to Epstein [29], who described six different types of udder in Awassi sheep (Figure 2). However, only 1st and 3rd udder types were found in the study. The first udder type was a cylindrical udder with high and horizontal teats, while the third udder type was pear-shaped with low and oblique teats.



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

Figure 2. Sketch of udder types in sheep [28, 29].

Statistical analysis

In the study, the effects of ewe age and udder type on TD milk yield, milk composition, SSC, udder measurements, and total bacteria count were investigated. The data were analyzed by least squares means using the general linear models in SAS [30]. Test-days were taken as repeated measurements. Duncan's multiple-range test was used to compare differences between the means of the sub-groups. Pearson correlation coefficient analysis was used to measure of linear association among the traits. The statistical analysis was based on the general linear model:

$$Y_{ijkl} = \mu + a_i + b_j + c_k + e_{ijkl}$$

Where: Y_{ijk} = Test-day milk yield, milk composition, SSC, udder measurements, total bacteria count of any sheep

μ = The overall mean
a_i = The effect of age of ewes (i = 4 levels; 1= 1-1.5 years, 2= 2-2.5 years, 3= 3-3.5 years, 4= 4 years)
b_j = The effect of udder type (j = 2 levels; 1= 1st type, 2= 3rd type)
c_k= The effect of test-day (k= 3 levels; 1= TD1; 2= TD2; 3= TD3)
e_{ijk} = The random error term

RESULT AND DISCUSSION

Test-day milk yield, somatic cell count and milk composition traits

The average test-day milk yield was found to be 489.50±22.07 ml (Table 1). Jawasreh et al. [31] reported higher value (0.882 kg) of test-day milk yield in Jordan Awassi ewes than the present study. In the present study, test-day milk yields ranged from 355.40 ml (TD1) to 568.70 ml (TD3) in the study (p<0.01). These values were similar to the values ranging between 396.56 to 546.52 gram reported by Alkass and Gardi [32] for test-day milk yields in Iraqi Awassi ewes (p<0.01).

The overall mean SCC in milk was determined to be 39.20 x103 cells/ml in the study. Berthelot et al. [33] reported that a mammary gland with <0.5x106 cells/ml values indicate a healthy situation, and a mammary gland with >1.0x106 cells/ml values indicate clinical or subclinical mastitis. The low SCC levels in this study might be a result of the good udder health of experimental ewes. The SCC values observed in this study were found to be higher than the values reported by Arias et al. [34] and lower than those reported by Bonelli et al. [35]. Contrary to the study findings, Arias et al. [34] found highly significant effect of ewe age on SCS, increasing with the age.

Table 1. Means (±S.E.) for TD milk yield, SCC and milk composition traits according to the age, udder type and test-days in Iraq Awassi ewes

Factors	N	TD milk yield (ml)	SCC 10^3 cells/ml (logSCC)	Fat (%)	Solid non-fat (%)	Protein (%)	Lactose (%)
		$\bar{x} \pm S_{\bar{x}}$	$\bar{x} \pm S_{\bar{x}}$	$\bar{x} \pm S_{\bar{x}}$	$\bar{x} \pm S_{\bar{x}}$	$\bar{x} \pm S_{\bar{x}}$	$\bar{x} \pm S_{\bar{x}}$
Overall mean	150	489.50±22.07	39.20±2.44 (4.55±0.01)	6.72±0.19	9.50±0.06	4.53±0.06	4.33±0.02
Age						*	
1-1.5	27	499.63±37.74	44.19±4.64 (4.59±0.04)	6.78±0.26	9.73±0.25	4.80±0.18^a	4.37±0.03
2-2.5	45	477.00±31.42	38.73±3.24 (4.56±0.03)	7.02±0.32	9.38±0.11	4.41±0.09^b	4.26±0.04
≥3	78	488.05±21.32	36.83±1.57 (4.54±0.02)	6.51±0.23	9.49±0.07	4.49±0.06^b	4.37±0.04
Udder type							
1	72	472.08±20.36	37.07±1.73 (4.54±0.02)	6.46±0.20	9.52±0.10	4.60±0.08	4.36±0.05
3	78	505.58±24.36	40.30±2.47 (4.57±0.02)	6.95±0.24	9.48±0.09	4.46±0.06	4.31±0.02
Test-days		**		**		*	
TD1	50	355.40±18.48^b	40.20±3.03 (4.56±0.03)	7.82±0.27^a	9.47±0.15	4.35±0.12^b	4.35±0.06
TD2	50	537.35±28.23^a	38.04±2.57 (4.55±0.03)	5.73±0.23^c	9.60±0.10	4.67±0.08^a	4.35±0.03
TD3	50	568.70±25.47^a	37.96±2.31 (4.55±0.02)	6.58±0.25^b	9.43±0.08	4.55±0.06^{ab}	4.30±0.03

*: p<0.05; **: p<0.01; a, b, c: Means values with different letters in the same column are significantly different

Age of ewes and udder type had no statistically significant effect on TD milk yield and SCC. Contrary to the study findings, Jawasreh and Khasawneh [36] reported to have statistically significant effect of ewe's age on test-day milk yield in Jordan Awassi sheep.
In this study, the cylindrical udder with upward and lateral teats (1st udder type) was observed in 24 ewes, and 26 ewes had pear-shaped udder with downwards and inclined teats (3rd udder type). Type 2, 4, 5, and 6 from the udder types described by Epstein [29] was not observed in Iraqi Awassi ewes. Similarly, Türkyılmaz et al. [28] observed only ewes with 1st udder type (33.3%) and 3rd udder type (66.6%) in Turkish Awassi sheep. In the study, udder type had non-significant effect on test-day milk yield. As to this finding, Dag and Zülkadir [11] reported that milk production was not influenced by udder types. Contrary to the study findings, Dogan et al. [38] and Kaygısız and Dag [39] determined significant effect of udder types on lactation milk yield. Average SCC values obtained in ewes with 1st and 3rd udder type were lower than values reported by Dogan [37] for Anatolian Merino ewes.
On the other hand, test-day milk yield was statistically significant affected by test-days ($p<0.01$). Milk yield in TD1 was lower than that of TD2 and TD3 ($p<0.01$).
The average content of fat, solid non-fat, protein and lactose in milk was determined as 6.72±0.19, 9.50±0.06, 4.53±0.06 and 4.33.33±0.02 %, respectively. Ewe age had only statistically significant effect on milk protein content in the study ($p<0.05$). Milk samples taken from ewes aged 1-1.5 years had a higher protein content (4.80±0.18 %) than those ewes aged 2-2.5 (4.41±0.09 %) and ≥3 years (4.49±0.06 %) ($p<0.05$). Contrary to the study findings, Abd Allah et al. [40] reported the significant effect of ewe age on fat content ($p<0.05$), but no significant effect on protein content.
Udder types did not have a significant effect on the milk composition in this study. This result was consistent with the findings of Dogan et al. [38]. Compared with the contents of milk composition according to udder types, Iraqi Awassi ewes with 1st and 3rd udder type had lower milk composition content than those Anatolian Merino ewes [38].
The fat content of milk was determined as 7.82±0.27%, 5.73±0.23% and 6.58±0.25% in TD1, TD2 and TD3 and the differences between the test-days were found statistically significant ($p<0.01$). Protein content of milk in TD2 was significantly higher than that of milk in TD1 ($p<0.05$). Iraqi Awassi ewes had higher milk fat content and lower solid non-fat, protein, and lactose content compared to the values reported by Abd Allah et al. [40], Alexopoulos et al. [41] and Carrillo-Pineda et al. [42] for different sheep breeds.

Total bacterial count

Total bacterial count was 56.94±7.72 cfu/mL in the milk samples taken during the study (Table 2). During the study, Streptococcus spp., the main cause of mastitis, was determined in only 2 milk samples (4%), while Staphylococcus aureus was found in 15 milk samples (30%). The number of Streptococcus spp. isolated from milk samples in this study was found to be lower than that of reported by Hariharan et al. [43], but the number of Staphylococcus aureus was found higher. In agreement with this study, Staphylococcus aureus was detected in 30% (15 positive samples) of examined ewe's milk samples by Abo El-Makarem [44].

Table 2. Total bacteria (cfu/mL) and the isolated bacteria count in Iraq Awassi ewes

Traits	$\bar{x} \pm S_{\bar{x}}$
Total bacteria count	56.94±7.72
The isolated bacteria	**n (%)**
Streptococcus spp.	2 (4%)
Staphylococcus aureus	15 (30%)

Udder measurements

Means and standard errors for udder measurements in Iraqi Awassi ewes are shown in Table 3. The effect of udder type on UC was statistically significant ($p<0.01$). Ewes with 3rd udder type had higher UC value (42.06±0.56 cm) than those ewes with 1st udder type (39.13±0.52 cm).
Udder depth (UD) was greater in older ewes. A statistically significant difference was found between ewe ages in UD measurements ($p<0.01$). The highest DBT value was determined in 2-2.5 years old ewes (16.30±0.81 cm), while ≥3 years old ewes had the lowest DBT value (14.08±0.40 cm) ($p<0.05$). The value of DBT measurement in ewes with 3rd udder type (15.88±0.57 cm) was higher than ewes with 1st udder type (13.65±0.35 cm) ($p<0.05$).

Table 3. Means (±S.E.) for udder measurements in Iraq Awassi ewes

Factors	n	UC (cm) $\bar{x} \pm S_{\bar{x}}$	UD (cm) $\bar{x} \pm S_{\bar{x}}$	DBT (cm) $\bar{x} \pm S_{\bar{x}}$	TL (mm) $\bar{x} \pm S_{\bar{x}}$	TD (mm) $\bar{x} \pm S_{\bar{x}}$	UHG (cm) $\bar{x} \pm S_{\bar{x}}$	THG (cm) $\bar{x} \pm S_{\bar{x}}$
Overall mean	50	40.65±0.43	19.81±0.26	14.81±0.37	2.85±0.09	16.92±0.35	42.93±0.40	20.27±0.40
Age			**	*			**	*
1-1.5	9	39.78±0.72	18.61±0.41^{b}	14.44±0.84^{b}	2.79±0.18	16.03±0.83	39.77±0.61^{c}	18.37±0.87^{b}
2-2.5	15	41.93±0.64	19.13±0.33^{b}	16.30±0.81^{a}	2.63±0.14	16.67±0.73	42.18±0.82^{b}	20.42±0.83^{ab}
≥3	26	40.21±0.68	20.62±0.38^{a}	14.08±0.40^{b}	2.99±0.12	17.37±0.45	44.46±0.32^{a}	20.85±0.49^{a}
Udder type		**		*				
1	24	39.13±0.52^{b}	19.98±0.39	13.65±0.35^{b}	2.91±0.11	16.64±0.51	43.14±0.54	20.25±0.67
3	26	42.06±0.56^{a}	19.65±0.35	15.88±0.57^{a}	2.78±0.13	17.17±0.49	42.74±0.60	20.30±0.48

UC: Udder Circumference; UD: Udder Depth; DBT: Distance between Teats; TL: Teat Length; TD: Teat Diameter; UHG: Udder Height from the Ground; THG: Teat Height from the Ground
*: $p<0.05$; **: $p<0.01$; a, b, c: Means values with different letters in the same column are significantly different

The age of ewes had also statistically significant effect on UHG ($p<0.01$). Udder height from the ground (UHG) increased steadily from 39.77±0.61 cm in ewes aged 1-1.5 years to 42.18±0.82 cm in ewes aged 2-2.5 years and 44.46±0.32 cm in ewes aged ≥3 years ($p<0.01$). As for the height of teat from the ground (THG), the difference between 1-1.5 and ≥3 aged ewes was found statistically significant ($p<0.05$). On the other hand, the effect of udder type on UD, TL, TD, UHG and THG was not significant.
Iraqi Awassi ewes had higher UC, DBT, TL, TD and lower THG values compared to the values reported by Ozyürek [9] for Turkish Awassi sheep. In this study, the measurements of UC, TL, and TD were not affected by ewe's age, whereas the effect of ewe age on UD ($p<0.01$), DBT ($p<0.05$), UHG ($p<0.01$) and THG ($p<0.05$) was statistically significant. Dag and Zülkadir [11] determined no significant effect of ewe age on studied all udder measurements in unimproved Awassi sheep. However, Merkhan [10] found statistically significant effect of ewe's age only on left teat diameter ($p<0.05$) and right teat length ($p<0.05$) measurements in Awassi sheep.
The effect of udder type on UC ($p<0.01$) and DBT ($p<0.05$) from udder measurements was statistically significant. However, measurements of UD, TL, TD, UHG, and THG were not affected by udder type in the study. Similarly, Dogan et al. [38] and Ozyürek [9] indicated that there were statistically significant effects of udder type on various udder measurements.

Correlations among test-day milk yield, somatic cell count, udder measurements, milk composition traits

Correlation coefficients among milk composition traits, test-day milk yield and somatic cell count are shown in Table 4. Solid non-fat had positive (r= 0.637) and highly important (p<0.001) correlation with protein. The correlation coefficient between solid non-fat and lactose was found to be r= 0.277 (p<0.05).

Table 4. Pearson's correlation coefficients among milk composition traits, test-day milk yield and somatic cell count

	Solid non-fat	Protein	Lactose	TDMY	SCC
Fat	-0.067	0.119	0.0612	0.266	-0.265
Solid non-fat		0.637***	0.277*	-0.159	0.060
Protein			0.351**	0.072	-0.118
Lactose				0.216	-0.290*
TDMY					-0.344**

TDMY: Test Day Milk Yield; SCC: Somatic Cell Count
*: p<0.05; **: p<0.01; ***: p<0.001

The content of protein was positively and significantly correlated with lactose (r= 0.351, p<0.01). Protein content of milk had weak correlations with TDMY and SCC. On the other hand, lactose content of milk had a negative and significant correlation with SCC (r= -0.290, p<0.05). The correlation coefficient was determined as r= -0.344 between average test-day milk yield and SCC in the study (p<0.01).

There were statistically significant and moderate relations among solid non-fat, protein and lactose content (p<0.05, p<0.01, p<0.001). These findings were agreement with Carrillo-Pineda et al. [42]. The correlations of milk composition traits with TDMY and SCC, except for correlation between lactose content and SCC (r= -0.290, p<0.05), in this study were not significant. It was found that the test-day milk yield was negatively and significantly correlated with SCC in Iraqi Awassi ewes (r= -0.344, p<0.01). Oravcova et al. [45] reported very weak but statistically significant correlations between SCC and milk yield (r= -0.07, p<0.01), fat content (r= 0.05, p<0.05), protein content (r= 0.13, p<0.01), and lactose content (r= -0.24, p<0.01). Similarly, a trend toward lower milk production with higher SCC was stated by Vrskova et al. [46] and Tancin et al. [47]. Because high SCC values in milk are associated with udder infection, infected udder tissue results in reduced milk production.

In this study, positive and statistically significant correlations were found between UC and DBT (p<0.01), between UD and UHG (p<0.01), and between UHG and THG (p<0.001) (Table 5). In addition, UD was correlated negatively and significantly with THG (p<0.05). Ozis Altıncekic and Koyuncu [48] determined that udder circumference had positive and statistically significant correlations with udder width, udder length, teat angle and udder volume in different sheep breeds. The authors also reported that these traits might be suitable selection markers to improve the milking ability of ewes.

Table 5. Pearson's correlation coefficients between udder measurements

	UD	DBT	TL	TD	UHG	THG
UC	0.117	0.431**	-0.101	0.156	-0.098	-0.151
UD		-0.119	0.041	0.192	0.359**	-0.294*
DBT			-0.233	0.029	-0.092	0.034
TL				0.091	-0.004	-0.243
TD					0.242	0.098
UHG						0.765***

UC: Udder Circumference; UD: Udder Depth; DBT: Distance between Teats; TL: Teat Length; TD: Teat Diameter; UHG: Udder Height from the Ground; THG: Teat Height from the Ground
*: p<0.05; **: p<0.01; ***: p<0.001

As shown in Table 6, it was found positive and negative but rather weak correlations between udder measurements and milk composition traits. The highest correlation was found between teat length (TL) measurement and solid non-fat (SNF) content of milk (r= 0.278) (p<0.05). In addition, measurements of length and height of udder showed negative but extremely weak correlations with test-day milk yield (TDMY). The correlation coefficient between UD measurement and SCC was found to be negative and significant (r= -0.329, p<0.05).

Table 6. Pearson's correlation coefficients among udder measurements, milk composition traits, test-day milk yield and somatic cell count

	Fat	SNF	Protein	Lactose	TDMY	SCC
UC	-0.073	-0.020	-0.053	-0.019	0.251	-0.140
UD	-0.081	-0.077	0.040	-0.133	-0.070	-0.329*
DBT	0.010	0.012	-0.132	0.005	0.100	0.010
TL	-0.100	0.278*	0.152	0.171	-0.101	0.216
TD	0.069	0.175	0.058	-0.023	0.226	-0.118
UHG	-0.034	0.120	0.028	0.170	-0.080	-0.159
THG	0.039	0.110	-0.030	0.218	-0.013	0.007

UC: Udder Circumference; UD: Udder Depth; DBT: Distance between Teats; TL: Teat Length; TD: Teat Diameter; UHG: Udder Height from the Ground; THG: Teat Height from the Ground; SNF: Solid Non-Fat; TDMY: Test-Day Milk Yield; SCC: Somatic Cell Count
*: p<0.05

Similarly, Kominakis et al. [3] revealed that none of the udder measurements and teat dimensions was correlated with milk contents and somatic cell count in Frizarta dairy sheep. Contrary to the findings of the present study, the positive correlations between udder circumference and milk components were found by Iniguez et al. [49]. Various studies investigating the relationships between udder measurements and milk yield revealed that among these measurements, udder circumference, udder depth, udder width, udder size, distance between teats was the most positively and statistically significant correlated with milk yield [7, 10, 23].

CONCLUSION

As a result, the udder type had no significant effect on test-day milk yield, somatic cell count, and milk composition traits in Iraqi Awassi ewes. As expected, the morphological characteristics of the udder changed by udder type. There were rather weak positive and negative correlations between udder measurements and milk composition traits. Only udder depth measurement from udder traits was correlated significantly but negative with somatic cell count (p<0.05). It was found that the studied Iraqi Awassi ewes had a healthy mammary gland and consumable milk due to their low SCC (39.20 x10^3 cells/ml) and bacterial content. Since there is an increased risk of infection due to contact with the ground, ewes which have the cylindrical udder with upward and lateral teats (1^{st} udder type) can be selected instead of ewes which have the pear-shaped udder with downwards and inclined teats (3^{rd} udder type). Ewes which have medium-sized, well-shaped udders with upward and lateral teats may be more suitable for machine milking. Moreover, further researches with larger numbers on Iraqi Awassi ewes are required to confirm these results.

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