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Udder Morphology Traits and Milk Production of Najdi and Naeimi Ewes under Intensive Condition

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ABSTRACT

A total of fifty multiparous ewes were selected immediately after lambing to study the relationship between udder morphology traits and milk production of Najdi and Naeimi ewes (n=25/ breed) under intensive Saudi Arabia condition. Immediately after lambing, lambs were allowed to suckle freely for 8 weeks; there after lambs were weaned. During suckling period, udder typology, udder depth and suspensory ligament in the udder wear visually evaluated 3 weeks after lambing. One week before weaning (Week 7), udder measurements and daily milk yield potential were determined. After weaning (Week 9), milk yield and composition wear determined, as well as cisternal and alveolar milk was measured 8h after the morning milking. Udders of Type II were the most frequent (45.6%) in both breeds. However, Naeimi breed showed a higher incidence (19.3%) of Type III, whereas Najdi sheep presented a larger percentage (29.8%) of Type I udders. The incidence of Type IV wear high (17.6%) in the two breeds. The presence of the suspensors ligaments wear observed in 75% and 46% of Najdi and Naeimi ewes, respectively. The proportion of Najdi and Naeimi ewes with udder depth over the level of the hook was 51% and 56%, respectively. Litter size and gender of lambs did not affect ($p > 0.05$) milk yield and udder measurements, but gender of lambs significantly ($p < 0.05$) affected teats length and width. In addition, lamb's birth weight significantly affected milk yield ($p < 0.05$) and teat length and angle ($p < 0.01$) in Najdi and Naeimi ewes. Birth weight and gender of lambs did not produce any significant effect on milk composition, but litter of size significantly affected milk fat and total solids content. Najdi ewes produced greater (+33.3%; $p < 0.01$) milk yield and presented greater ($P<0.01$) udder depth, teat length and distance between teat than Naeimi ewes. Milk composition did not differ between Najdi and Naeimi ewes one week before weaning. The SCC varied significantly ($P<0.05$) between breeds and had a mean value of 9.7×105 cells/mL (log SCC = 6.16) and 6.6×105 cells/mL (log SCC = 5.5) in Najdi and Naeimi ewes, respectively. On average, cisternal milk accounted for 64% and 53% of the total udder milk in Najdi and Naeimi ewes, respectively. Fat percentages in alveolar milk were 41% and 37% greater ($p < 0.05$) than cisternal milk one week after weaning in Najdi and Naeimi ewes, respectively. In conclusion the indigenous Najdi and Naeimi ewes had acceptable udder morphology traits for machine milking. Udder morphology measurements and milk fractions had positive correlations with milk yield and can be adopted in breeding programs.

Introduction

The interest in studying the udder morphology of dairy sheep has been increased in the last few years (Ayadi *et al.*, 2014a). Therefore, exploring the external (udder typology and morphology) and internal (alveolar and cisternal milk) structure of the udder is useful for evaluating milk yield potential and milking ability in dairy ewes. Cisternal size and udder morphology traits are correlated with milk secretion rate and milk emission kinetics during machine milking in dairy sheep (Rovai, 2000; Ayadi *et al.,* 2014b).

Sheep play an important role in the agribusiness economy of Saudi Arabia, where the sheep population is close to 11.5 million head (General Authority for Statistics, KSA, 2015). The Black Najdi and Naeimi are the most popular and predominant breeds in the central region of Saudi Arabia. Nevertheless, scientific reports on the potentiality of local Najdi and Naeimi sheep are scarce (Ayadi *et al.,* 2014a).

Thus, evaluation of udder typology as well as external and internal udder morphology and the study of their relationship with milk yield can be a useful tool in selection programs for improving milk production and milking ability.

Materials and Methods

Animals and management

To carry out this experiment, multiparous Najdi (n=25; BW= 64.0 ± 3.2 kg) and Naeimi (n=25; BW= 53.0 ± 2.8 kg) ewes in their second or third parities were selected immediately after lambing to the Experimental Farm at Ammariah, Animal Production Department, College of Food and Agriculture Sciences, King Saud University. All ewes fed 1.5 kg/head of commercial pellets (DM basis; 14.50% crude protein, 1.20% ether extract, 42.90% neutral detergent fiber, 14.20% acid detergent fiber, 7.50% ashes and 2.87 Mcal metabolizable energy kg-1 DM) in addition to ad libitum alfalfa hay to cover their nutrient requirements according to the physiological status (NRC, 1985). Fresh drinking water was freely available. At lambing time, birth weights (<5 or >5 kg), litter size and sex of lambs were recorded. Immediately after lambing, lambs were allowed to suckle freely for 8 weeks; thereafter lambs were weaned. During suckling period, udder typology after 3 weeks of lambing, udder measurements and daily milk yield potential one week before weaning were determined, as well, daily milk yield production one week after weaning was determined.

External udder morphometry and typology

Udder typology was visually evaluated on all ewes and according to teat angle was classified into 4 types (Gallego *et al.*, 1983) as following: Type I = horizontal teats; Type II = teats at 45 degrees; Type III = vertical teats – most desirable ("udder machine"); Type IV = mis-shaped udder. In addition, the udder was evaluated according to presence of the median suspensory ligament as 1 (present) or 0 (absent). Moreover, the udder depth was evaluated as shallow (over the level of hook), average (at the hook level) and deep (below the level of hook).

External udder morphology was performed 4h after milking one week before weaning (Week 7). Udder morphometry include udder depth (UD: distance between the rear udder attachment and the base of teat; cm) and udder width (UW: the longest horizontal line between the left and right sides of the udder from a rear view; cm). Teat length (TL: distance between the teat attachment and the teat orifice; mm), teat diameter (TD: diameter at the middle of the teat; mm), teat angle (TAº: inclination with regard to the vertical position), and distance between teats (DT: a horizontal distance between the two bases of the teats; mm).

Milk yield potential and milk analysis

One week before weaning (Week 7), milk yield potential was determined in a 4h-period by complete udder emptying. To ensure complete and total milk let-down, two i.m. injections of oxytocin (4 IU/ewe) were given at 4-h interval between milking (Doney *et al.,* 1979). Milk yield potential in a 24h period was calculated from milk yield every 4h-period times 6. After weaning, the milk yield production in a 24h-period was obtained by hand milking ewes twice a day (0800 and 1600).

The milking routine included hand milking without the aid of oxytocin, udder and teats cleaning, hand striping and teats dipping in 7% iodine solution immediately after milking.

Milk samples (60 mL) were collected from the total milk yield of ewes before (Week 7) and after weaning (Week 9). Samples were stored in plastic vials and immediately cooled to 4ºC, transported to the laboratory, and kept frozen at -20ºC pending analysis. Approximate chemical analysis, including fat, protein, lactose, solid-non-fat and total solid percentages, were analyzed in the collected milk samples using a MilkoScan (Minor Type 78100, FOSS Electric, Denmark). To evaluate the udder health, the California mastitis test (CMT) and the somatic cell counts (SCC) were performed during the experimental periods. The CMT was performed using Bovivet CMT test kit, Kruuse, Germany and the SCC by using Fossomatic Minor somatic cell counter (Fossomatic 90, FOSS Electric, Denmark).

Milk fractions in the udder compartments

A subset of 8 Najdi and 8 Naimi ewes were selected randomly to study the milk partitioning between cisternal and alveolar udder compartments. One week after weaning, cisternal and alveolar milks were measured 8h after the morning milking.

To prevent undesired milk letdown and overestimating cisternal milk, ewes were i.v. injected with 10µg/kg BW of Atosiban (Tractocile, Ferring Middele East, Jordan) as an oxytocin receptor-blocking agent in order to determine the cisternal milk. Approximately 20 min after the Atosiban injection, ewes were received i.v. injection of oxytocin (2 IU/ewe) to induce milk letdown in order to determine alveolar milk. Milk samples of each fraction were collected and processed immediately after milking.

Statistical Analysis

Data were analyzed using General Linear Model (SAS, 2012) according the following model: $Y_{ijk} = \mu + B_i + W_j + BW_{ij} + \varepsilon_{ijk}$, whereas,

Y_{ijk} is the individual observation, µ is the overall mean, B_i is the ith breed of ewes, W_j is the jth week of lactation, BW_{ij} is the interaction between breed and week of lactation, and ε_{ij} or ε_{ijk} is the experimental errors. Pearson's correlation coefficients between measurements were determined. Significance was declared as $P < 0.05$ unless indicated using DUNCAN test (SAS, 2012) .

Results and Discussion

No subclinical mastitis was detected in any of the udders during the experimental period as indicated by the CMT. Preliminary statistical analysis revealed no significant differences ($p > 0.05$) between the values of right and left udder morphology traits, therefore, values for each trait were averaged.

Udders of Type II were the most frequent (45.6%) in both breeds (Table 1). However, Naeimi breed showed a higher incidence (19.3%) of Type III, whereas Najdi sheep presented a larger percentage (29.8%) of Type I udders. The incidence of Type IV was very high (17.6%) in the two breeds

The presence of the suspensors ligaments was observed in 75% and 46% of Najdi and Naeimi ewes, respectively. The proportion of Najdi and Naeimi ewes with udder depth over the level of the hook was 51% and 56%, respectively. The obtained results were in the same range with those previously reported in Awassi and Assaf breeds (Jatsch and Sagi, 1978) as well as, in Manchega and Lacaune breeds (Rovai, 2001).

Litter size and gender of lambs (Table 2) did not produce any effects ($p > 0.05$) on milk yield and udder measurements, but gender of lambs it significantly ($p < 0.05$) affected teats length and width. In addition, lamb's birth weight significantly affected milk yield ($p < 0.05$) and teat length and angle ($p < 0.01$) in Najdi and Naeimi ewes (Table 2). Ewes, which gave birth to heavier lambs, produced more milk than those of lighter weight lambs that probably because bigger lambs require larger amounts of milk and therefore exert a greater suckling stimulus. This finding is supported by Nudda *et al.,* (2002) in Awassi ewes. Najdi and Naeimi ewes had shorter teat length and smaller teat width and angle than Manchega, Lacaune, Istrian dairy crossbred and Bergamasca ewes (Rovai *et al.,* 1999; Such *et al.,* 1999; Dzidic *et al.,* 2004; Emediato *et al.,* 2008). Nevertheless, in contrary, had longer teat length than Sicilo-Sarde dairy ewes (Ayadi *et al.,* 2011), and greater teat angle than French Rouge de l'Ouest ewes (Malher and Vrayla-Anesti, 1994). The udder depth and width measurements in this study of the two breed were greater than the values reported for Sicilo-Sarde dairy ewes (Ayadi *et al.,* 2011), but similar to those reported for Manchega and Lacaune dairy ewes (Such *et al.,* 1999; Rovai *et al.,* 2008). Birth weight and gender of lambs did not produce any significant effect on milk composition, but litter of size significantly affected milk fat and total solids content. This observation supported previous results reported in dairy ewes, in which ewes rearing twins produced more milk, with higher concentrations of fat and protein than those reared single lambs (Abd Allah *et al.,* 2011; Ayadi *et al.,* 2014a).

Najdi ewes produced greater (+33.3%; $p < 0.01$) milk yield and presented greater ($P<0.01$) udder depth, teat length and distance between teat than Naeimi ewes (Table 2). Milk composition did not differ between Najdi and Naeimi ewes one week before weaning, and the percentage of fat, protein, lactose and total solids were 4.48, 3.96, 4.75 and 14.7%, respectively. Litter size affect significantly fat content in which single have high fat content compared to the twin (4.43 % *vs* 2.89%). Milk of Najdi and Naeimi ewes has lower percentage of total solids compared to other reported values for a number of European and Asian dairy sheep breeds (Ayadi *et al.,* 2014a). The SCC varied significantly ($P<0.05$) between breeds and had a mean value of 9.7×10^5 cells/mL (log SCC = 6.16) and 6.6×10^5 cells/mL (log SCC = 5.5) in Najdi and Naeimi ewes, respectively. The mean SCC value observed in both Saudi indigenous breed was higher than those values reported in other dairy sheep breeds, where the average SCC did not exceed 500,000 cells/mL (Pengov, 2001; Paape *et al.,* 2007). The discrepancies in SCC values between our result and previous studies in dairy sheep are probably due to the differences in milking management; hand milking elicited greater SCC in the milk than machine milking (Gonzalo *et al.,* 2005). Correlation coefficients of udder morphology traits and milk yield in Najdi and Naeimi ewes one week before weaning are shown in Table (3).

Positive correlations were observed ($p < 0.05$) in two breeds between udder depth and width, between teat length and teat width, between udder depth, width and distance between teats. These results in accordance with those previously reported in dairy ewes (Rovai *et al.,* 1999; Ayadi *et al.,* 2011; 2014b). Estimated daily milk yield was positively correlated ($r= 0.27$ to 0.50; $p < 0.05$) with udder depth, width, and distance between teats in Najdi and Naeimi ewes. Nevertheless, no correlations between teat morphology traits and estimated daily milk yield were observed in two breeds. These results is in agreement with previous reports by Labussiere (1988); Arranz *et al.,* (1989) ; Fernández *et al.,* (1995) ; Rovai *et al.,* (2008) and Ayadi *et al.,* (2011; 2014b) in dairy ewes.

The least squares means for milk production in Najdi and Naeimi ewes before and after weaning are shown in (Table 4). Estimated daily milk yield one week before weaning showed a decrease of 41% and 25% at the time of weaning in Najdi and Naeimi ewes, respectively.

Table.1 Udder typology, suspensory ligaments and udder depth of Najdi and Naeimi ewes 3 weeks after lambing.

	Najdi	Naeimi	DF	Value	Prob.
Udder typology (%)[1]					
1	25.00	27.00	3	1.33	0.721
2	33.00	31.00			
3	29.00	19.00			
4	13.00	23.00			
Suspensory ligaments (SL, %)[2]					
0	25.00^{b}	54.00	1	4.34	0.037
1	75.00^{a}	46.00			
Udder depth (UD, %)[3]					
1	51.00	56.00	2	1.26	0.530
2	26.00	28.00			
3	23.00	16.00			

[1] Udder typology Type I = horizontal teats; Type II = teats at 45 degrees; Type III = vertical teats; Type IV = mis-shaped udder: [2] suspensory ligament 1 (presence) or 0 (not present): [3] Udder depth as 1 (over the level of hook); 2 (at the hook level); 3 (below the level of hook). 4 Degrees of freedom.

Table.2 Effect of lamb's birth weight, gender, litter size and breed on estimated milk yield and udder morphology traits before weaning.

Factor	No	MY (L/d)	Teat measures			Udder measures (cm)		
			TL(cm)	TW(cm)	TA°	DT	UD	UW
Breed								
Najdi	12	1.26^{a}	3.13	1.81^{a}	29.17	12.67^{a}	16.03^{a}	12.51
Naeimi	13	0.84^{b}	2.18	1.52^{b}	27.74	10.13^{b}	13.16^{b}	11.49
***p* value**		0.004	0.188	0.018	0.16	0.014	0.001	0.28
Litter size								
Single	18	1.02	3.20	1.60	30.48	11.70	14.82	12.39
Twin	7	1.40	2.86	1.53	28.42	11.10	14.37	11.60
***p* value**		0.11	0.18	1.69	0.21	0.57	0.58	0.45
Gender								
Female	12	1.07	2.76^{b}	1.49^{b}	29.20	10.89	14.47	11.93
Male	13	0.99	3.40^{a}	1.76^{a}	30.60	11.11	14.37	11.70
***p* value**		0.35	0.02	0.04	0.21	0.42	0.59	0.71
Birth weight								
> 5	14	1.40^{a}	3.57^{a}	1.65	33.93^{a}	11.50	14.37	11.02
< 5	11	0.69^{b}	2.74^{b}	1.58	28.97^{b}	11.30	14.81	11.98
***p* value**		0.01	0.02	0.51	0.04	0.85	0.62	0.96
SEM		0.20	0.28	0.15	2.04	0.68	0.54	0.67

a,b Means in same column within a factor carrying different superscripts differ ($p < 0.05$); 1Milk yield potential in a 24 h-period was calculated from milk yield in 4h-period times 6: SEM standard error of mean: 2 TL: teat length, TW: teat width, TA: teat angle; :3 DT: distance between teats, UD: udder depth, UW: udder width.

Table.3 Correlation coefficients1 between udder morphology traits (cm) and estimated daily milk yield (EDMY) in Najdi and Naeimi ewes before weaning.

Traits	EDMY	TL	Tw	TA	DT	UD	UW
EDMY		0.10	-0.19	0.15	0.35*	0.27	0.19
TL	0.06		0.50**	0.26	0.26	- 0.17	0.36
Tw	-0.23	0.90***		0.17	0.26	-0.16	0.34
TA	0.31	0.12	0.03		0.33	-0.13	0.24
DT	0.26*	0.21	0.20	0.30		0.84**	0.77**
UD	0.46*	-0.26	-0.25*	-0.04	0.65*		0.85**
UW	0.29*	0.16	0.15	0.39	0.71**	0.56*	

1 lower and upper diagonal values within a trait indicate the coefficients of Najdi and Naemai ewes; 2 TL: teat length, TW: teat width, TA: teat angle .3 DT: distance between teats, UD: udder depth, UW: udder width.. * p < 0.05 ,** p<0.01, ,*** p<0

Table.4 Least squares means for milk yield, milk composition and Somatic Cell Counts (SCC) in Najdi, Naeimi ewes before and after weaning.

	Najdi		**Naemai**	
	Before	After	Before	After
Milk production, L/d^{-1}				
Milk yield	1.26±0.23^{a}	0.75±0.22^{b}	0.84±0.18^{a}	0.63±0.15^{b}
ECM[3]	1.19±0.18^{a}	0.79±0.22^{b}	0.67±0.14^{a}	0.54±0.15^{b}
Milk compositions (%)				
Fat	4.18±0.62	4.48±0.62	3.81±0.92	3.88±0.62
Protein	3.96±0.24	4.09±0.24	4.42±0.42	4.68±0.18
Lactose	4.75±0.38	4.85±0.48	4.64±0.42	4.54±0.27
Total solid	13.11±0.67	14.71±0.82	13.05±0.45	12.41±0.54
Udder health				
SCC, ×10^{5} cells/mL	3.66±4.02	10.67±3.28	4.06±2.16	6.59±2.74
Log SCC	4.50±0.54^{a}	8.46±0.58^{b}	4.58±0.36	5.53±0.38

a,b Means in same column within a factor carrying different superscripts differ (p<0.05); SEM: standard error of mean. [1]Milk yield potential in a 24 h-period was calculated from milk yield in 4h-period times 6; :[2]Milk yield production in a 24h-period was obtained by hand milking twice a day; : [3]Energy Corrected Milk; ECM = Milk yield, L.d-1 (0.071 + 0.15 × Fat (%) +0.043×Protein (%)+0.2224).

Table.5 Least squares means of cisternal and alveolar milk volumes and compositions at 8 h milking interval after weaning in Najdi and Naeimi ewes.

Item	**Najdi**			**Naemai**		
	Cisternal	**Alveolar**	**SEM**	**Cisternal**	**Alveolar**	**SEM**
Milk volume-8h, L	0.42^{a}	0.16^{b}	0.08	0.49	0.47	0.09
Milk volume-8h, %	63.85	36.14	7.39	52.98	47.02	8.48
Milk compositions (%)						
Fat	2.67^{b}	4.51^{a}	0.75	3.77^{b}	5.91^{a}	0.81
Protein	3.99	4.06	0.15	4.25	4.40	0.16
Lactose	5.05	4.95	0.45	4.61	4.60	0.31
Total solid	12.53	14.17	0.58	13.63	15.52	0.62

a,b Means in the same row within each period carrying different superscripts differ (p < 0.05).

This milk yield drop was also observed in differences breeds of dairy ewes and can be explained by the partial disappearance of the stimulus produced by the lamb when suckling (Labussiere, 1988; Gargouri *et al.,* 1993; Ayadi *et al.,* 2011; 2014a). On the others hand, the discrepancies in milk yield dropping rates between Najdi and Naeimi ewes are probably due to breed differences in milk yield and the capacity to storage milk between milking (cisternal size). In the present study, milk composition did not differ before and after weaning; this result is in general disagreement with the findings for differences sheep breeds, who found a high protein content and lower lactose content in milking period than the value in suckling period (Gargouri *et al.,* 1993; Ayadi *et al.,* 2014a). The SCC increased significantly (+38%; $P<0.05$) after weaning in Najdi ewes and did not change in Naeimi ewes. This results agreed in part with those reported finding in literatures (Paape *et al.,* 2007; Ayadi *et al.,* 2014a).

Studying the patterns of milk accumulation and storage in the udder and their relationship with milk yield can help to improve techniques and routines for machine milking in dairy ewes.

On average, cisternal milk accounted for 64% and 53% of the total udder milk in Najdi and Naeimi ewes, respectively (Table 5). The percentages of Najdi and Naeimi cisternal milk were similar to the percentages reported in Manchega ewes (Rovai *et al.,* 2002; Castillo *et al.,* 2009), East Friesian crossbred dairy ewes (McKusick *et al.,* 2002b) and Sicilo-Sarde dairy ewes (Ayadi *et al.,* 2011). On the other hand, the percentages of cisternal milk in the current study were lower than those percentages in Lacuane (Rovai *et al.,* 2002; Castillo *et al.,* 2009) and Sarda ewes (Nudda *et al.,* 2000). Generally, animals that store a large amount of milk in the gland cistern generally produce more milk, milked faster and tolerate extended milking intervals (Ayadi *et al.,* 2003; Castillo *et al.,* 2008). In this work, cisternal milk was positively correlated with total milk yield in Najdi ($r= 0.82$ $p < 0.05$) and Naeimi ($r= 0.94$; $p < 0.05$) ewes, indicating that cisternal size could be used for predicting milk yield.

Fat percentages in alveolar milk were 41% and 37% greater ($p < 0.05$) than cisternal milk one week after weaning in Najdi and Naeimi ewes, respectively. This result agreed with those previously reported in sheep (McKusick *et al.,* 2002b; Castillo *et al.,* 2008). Ayadi *et al.,* (2014b), goats (Salama *et al.,* 2004), cows (Caja *et al.,* 2004) and dromedary camels (Ayadi *et al.,* 2013). The difference between milk fractions can be explained by the viscosity and large size of fat globules, which are accumulated in the alveolar compartment (Ayadi *et al.,* 2004). Concurrently, protein, lactose and total solids percentages did not differ ($p > 0.05$) between cisternal and alveolar milk fractions in both breeds. These results agree with those previously reported in dairy ewes (Rovai *et al.,* 2008; Ayadi *et al.,* 2014b).

The Indigenous Najdi and Naeimi ewes have acceptable udder morphology traits for machine milking. Udder morphology measurements and milk fractions had positive correlations with milk yield and can be adopted in breeding programs. Further research with larger numbers of ewes is required to confirm these results.

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