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Research Article

Factors Affecting Milk Yield, Composition and Udder Health of Najdi Ewes

[1,2]M. Ayadi, [1]A.M. Matar, [1]R.S. Aljumaah, [1]M.A. Alshaikh and [1]M. Abouheif
[1]Department of Animal Production, College of Food and Agriculture Sciences, King Saud University, P.O. Box 2460, Riyadh 11451, Riyadh, Saudi Arabia
[2]Département de Biotechnologie Animale, Institut Supérieur de Biotechnologie de Beja, Université de Jendouba, B.P. 382, Av. Habib Bourguiba, 9000 Beja, Tunisia

Abstract: Although Najdi milk has been historically utilized by bedouins to process traditional dairy products, no published studies have been focused on their milk productivity and quality traits. This study was planned to investigate the effects of litter size, sex of lamb and lamb's birth weight on milk yield, compositions and udder health during suckling and milking periods. A total of 30 multiparous ewes were utilized in this study. Litter size and sex of lambs did not produce any effects ($p>0.05$) on milk yield, fat, protein, lactose, total solids and Somatic Cell Counts (SCC); whereas, lamb's birth weight significantly ($p<0.05$) affected the milk yield, but not the compositions. Daily milk yield reached the maximum 2.13±0.24 L in the 3rd week and gradually decreased ($p>0.05$) to attain 1.88±0.18 L in the 9th week of lactation. Average milk yield were 2.17 and 1.71 $L.d^{-1}$, for ewes that gave birth to lambs weighing >5 and <5 kg, respectively; the corresponding yields during milking period were 0.52 and 0.34 $L.d^{-1}$, respectively. Milk compositions remained constant throughout the suckling period, but percentages of fat, protein and total milk solids increased ($p<0.05$) and lactose decreased ($p<0.05$) in the 10th week of lactation compared to other weeks in milking period. The SCC during suckling and milking periods did not change ($p>0.05$) and had a mean value of 9.95×10^5 cells/mL. It is concluded that the indigenous Najdi ewes have a noticeable potential for milk production, but milk compositions were lower in comparison to other international dairy sheep.

Keywords: Milk composition, milk yield, Najdi ewes, somatic cell counts

INTRODUCTION

Sheep is an important part of the agribusiness economy of the kingdom of Saudi Arabia. The Najdi is the most popular and predominant sheep breed of the central region of the kingdom. Najdi belongs to the fat-tailed, non-seasonal group of sheep, well adapted to the extreme hot environment and feed and water scarcity. Najdi ewes have been used for milk production under traditional Bedouin rearing conditions; milk is processed into a cheese-like product directly on the farms. Although use of sheep milk is generally a tradition especially in the Middle East countries, it is getting more important in dairy sector because of its high dry matter contents and their exceptional nutritive value (Abdel-Rahman and Mehaia, 1996).

Composition of sheep milk and its yield are influenced by several factors including ewe breed, age, stage of lactation, lambing season, milking system and feeding (Bocquier and Caja, 1993; Abd Allah *et al*., 2011). With the exception of lactose, milk composition and milk yield are negatively correlated in sheep (Caja and Bocquier, 2000), indicating the necessity to find an equilibrium between practices that will increase milk yield and reduce its content.

The Somatic Cell Counts (SCC) in milk is representative of the health of the udder and can be an indicator of the potential presence of mastitis (Paape *et al*., 2007). As the SCC increases in the milk, the composition of milk changes, with a reduction in fat, casein and total solids (Pirisi *et al*., 2000). As far as we searched the scientific database, sparse information is available about the factors affecting milk production in Najdi sheep. Therefore, the aim of the present study was to evaluate the effects of litter size, sex of lamb and lamb's birth weight on milk yield, composition and quality during suckling and milking periods in Najdi sheep under the intensive production system of Saudi Arabia.

MATERIALS AND METHODS

Animals and management conditions: Thirty Najdi ewes weighing an average of 60-65 kg and approximately three years of age were utilized for this study. All ewes lambed during December to March 2012 (26°C and 10 RH) in a semi-open sheds at the

Corresponding Author: M. Ayadi, Department of Animal Production, College of Food and Agriculture Sciences, King Saud University, P.O. Box 2460, Riyadh 11451, Riyadh, Saudi Arabia

Experimental Animal Farm, King Saud University, Riyadh. Ewes were allotted into homogenous groups according to their weight, managed similarly throughout the study and fed commercial pellets in addition to *ad libitum* alfalfa hay to meet their daily energy and protein requirements (NRC, 1985). Fresh water and mineralized salt blocks were freely available.

Experimental procedures: At lambing time, birth weights (<5 or >5 kg), litter size and sex of lambs were recorded. All lambs were suckled their dams freely throughout the first 9 weeks of lactation (suckling period); thereafter, lambs were weaned and the ewes were hand milked once daily (08:00) up to the 12th week of lactation (milking period).

During the suckling period, milk yield potential in 24 h-period was estimated in the 3rd, 6th and 9th week of lactation; the estimation started after complete udder emptying by hand milking with the aid of an i.m. injection of oxytocin (4 IU/ewe). To ensure complete and total milk letdown, two i.m. injections of oxytocin were given at 4-h interval according to the methodology of Doney *et al*. (1979). Milk yield potential in a 24 h-period was calculated from milk yield in 4-h-period times 6. After weaning, milk yield was recorded in the 10th, 11th and 12th weeks of lactation (milking period). The milking routine included, hand milking once daily with udder preparation and teats cleaning, hand striping and teats dipping in iodine solution immediately after milking.

Sampling and milk analyses: Milk samples (100 mL) were collected from the total milk yield of each ewe during suckling and milking periods. Signs of mastitis, physical udder injuries and grossly visible abnormalities were recorded. California Mastitis Test (CMT) and Somatic Cell Counts (SCC) were measured as an indirect sign of the udder health status. Samples were stored in plastic vials and immediately cooled to 4°C, transported to the laboratory and kept frozen at -20°C pending analyses.

Approximate chemical analyses including fat, protein, lactose, solids-not-fat and total solids percentages were analyzed for all collected milk samples using a Milko Scan (Minor Type 78100, FOSS Electric, Denmark). The CMT was performed using Bovivet CMT kit (Bovi Vet, Kruuse, Germany). The SCC was determined as count/mL using Fossomatic Minor somatic cell counter (Fossomatic 90, FOSS Electric, Denmark).

Statistical analyses: Data were statistically analyzed using the LSM procedures of SAS statistical package (SAS, 2009). It was assumed that there were no significant interactions among factors affecting milk yield and composition. Effects of factors such as litter size, sex of lambs and lamb's weight at birth on milk yield and chemical composition of milk during each of suckling and milking periods were examined using the following model:

$$Y_{ijkl} = \mu + L_i + S_j + W_k + e_{ijkl},$$

where,
Y_{ijkl} = Individual value
μ = Expected mean
L_i = Effect of litter size
S_j = Effect of sex of lamb
W_k = Lamb's birth weight
e_{ijkl} = Error term

Analyses of correlations among all the variables were performed and the differences between means were determined by Fischer's least significant difference. The level for statistical significance was set at $p<0.05$.

RESULTS

The Californian Mastitis Test revealed that two lactating ewes developed a clinical mastitis in the 10th week of lactation. Intramammary infection was confirmed by milk bacteriology and data were deleted, but data from the suckling period were utilized. Data from Fig. 1 and 2 showed that milk yield and composition remained statistically unchanged ($p>0.05$) throughout the suckling period; the estimated daily milk yield reached the maximum (2.13±0.24 L.d^{-1}) in the 3rd week of lactation and gradually decreased non-significantly ($p>0.05$) to attain 1.88±0.18 L in the 9th week of lactation. After weaning the lambs, milk yield did not significantly ($p>0.05$) differ and remained constant throughout the 10th, 11th and 12th weeks of milking period with an average daily yield of 0.43±0.10 L. The observed drop in milk yield (-75%, $p<0.05$) was due to the transition from suckling to milking. Therefore, for ease of presentation, data within each of suckling and milking periods were pooled. During suckling and milking periods, litter size and sex of lambs did not produce any effects ($p>0.05$) on milk yield, fat, protein, lactose, total solids contents and SCC; whereas, birth weight significantly ($p<0.05$) affected the milk yield, but not the milk composition and SCC (Table 1).

The least-squares means for milk fat and total solids percentages did not differ ($p>0.05$) between suckling and milking periods, whereas the average percentages of protein and lactose in suckling period were lower and higher ($p<0.05$), respectively, than those values in milking period (Table 2). The percentages of fat, protein and total milk solids increased ($p<0.05$) and lactose decreased ($p<0.05$) in the 10th week of lactation compared to other studied weeks in milking period (Fig. 2). The SCC during suckling and milking periods did not change significantly ($p>0.05$) and had a mean value of 9.95×10^5 cells/mL (log SCC = 6.36).

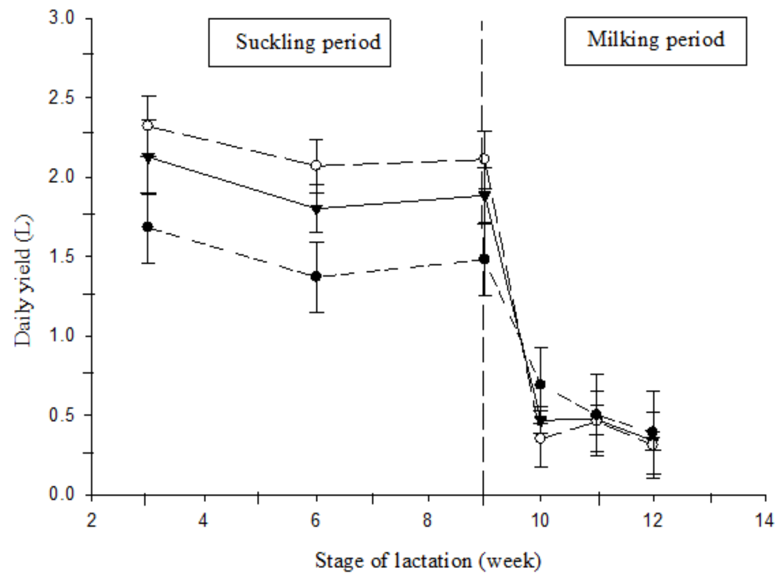

Fig. 1: Changes in milk yield during lactation period in Najdi ewes as affected by their lambs' birth weights. —▼— average daily milk yield; — o — ewes suckled lambs weighting >5 kg at birth; —●— ewes suckled lambs weighting <5 kg at birth

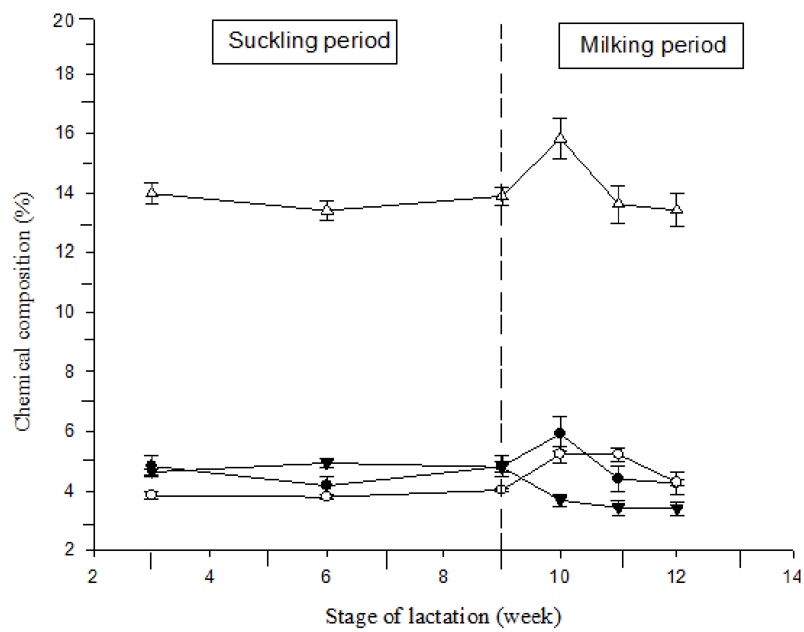

Fig. 2: Changes in milk compositions during lactation period in Najdi ewes. —●— Fat %; —o— Protein %; —▼— lactose %; —Δ— Total solids %.

Estimated average milk yield were 2.17±0.26 and 1.71±0.26 $L.d^{-1}$, for the ewes that had suckled lambs weighing >5 and <5 kg at birth, respectively; the corresponding yields during the milking period were 0.52±0.19 and 0.34±0.19 $L.d^{-1}$, respectively (Fig. 1). The sharp drop in milk production after weaning, was more pronounced in ewes which gave birth to heavier lambs (-83%, $p<0.05$) compared to those of lighter weight lambs (-53%, $p<0.05$). Generally, the analysis of original data revealed that average daily milk yield during suckling period increased by 86.4 mL for each extra kg of lamb's weight at birth ($p<0.01$).

Coefficients of phenotypic correlations between milk yield and milk components during suckling and milking periods are given in Table 3. The positive correlation coefficients between daily milk yield and lactose, as well as total solids percentages during milking period were higher than those respective values

Table 1: Least squares means[1] of some factors affecting milk yield, composition and somatic cell counts in Najdi ewes during suckling and milking periods

Factor	No.	Milk yield $L.d^{-1}$	Fat %	Protein %	Lactose %	T. solids %	SCC×10^5 cells/mL
	------- Sucking period[1] -------						
Litter size:							
Single	19	1.84	4.82	3.79	4.92	13.45	10.80
Twin	11	2.04	4.40	3.97	4.65	14.05	8.38
Sex of lamb:							
Male	18	1.98	4.79	3.97	4.78	13.75	8.95
Female	12	1.90	4.43	3.81	4.80	13.74	10.23
Birth weight							
>5	18	2.17^{a}	4.52	3.82	4.90	13.85	10.12
<5	12	1.71^{b}	4.70	3.95	4.71	13.66	9.06
±SEM		0.26	0.33	0.09	0.13	0.63	0.85
	------- Milking period[2] -------						
Litter size:							
Single	18	0.46	4.94	5.04	3.53	14.68	9.64
Twin	10	0.39	4.93	5.24	3.51	14.08	11.00
Sex of lamb:							
Male	16	0.43	4.50	5.09	3.47	14.40	11.12
Female	12	0.44	5.37	5.19	3.55	14.36	9.52
Birth weight							
>5	17	0.52^{a}	5.37	5.16	3.51	14.43	10.42
<5	11	0.34^{b}	4.51	5.12	3.53	14.33	10.22
±SEM		0.11	0.56	0.25	0.18	0.61	0.79

[a,b] Means in same column within a factor carrying different superscripts differ ($p<0.05$); [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 once a day

Table 2: Least squares Means (± SE) for milk yield, milk composition and Somatic Cell Counts (SCC) during suckling and milking periods in Najdi ewes

Items	Suckling period[1] (0-9 weeks)	Milking period[2] (10-12 weeks)
Ewe numbers	30	28
Milk production, $L.d^{-1}$		
Milk yield	$1.9±0.09^{a}$	$0.43±0.09^{b}$
ECM[3]	$2.8±0.12^{a}$	$0.56±0.13^{b}$
Milk composition, %		
Fat	4.61±0.23	4.94±0.25
Protein	$3.89±0.09^{b}$	$5.14±0.10^{a}$
Lactose	$4.79±0.10^{a}$	$3.52±0.11^{b}$
Total solids	13.75±0.28	14.38±0.30
SCC, ×10^5 cells/mL	9.59±81	10.32±90

[a,b] Means on the same row bearing different superscripts differ ($p<0.05$); [1]: Milk yield potential in a 24 h-period was calculated from milk yield in 4 h-period times 6; [2]: Milk yield production in a 24 h-period was obtained by hand milking once a day; [3]: Energy Corrected Milk; ECM = Milk yield, $L.d^{-1}$ (0.071 + 0.15 × Fat (%) +0.043×Protein (%)+0.2224)

Table 3: Correlation coefficients[1] among daily milk yield and milk compositions (%)

Parameters	Milk	Fat	Protein	Lactose
Fat	-0.02			
	-0.24*			
Protein	-0.25*	0.29*		
	-0.33**	0.25*		
Lactose	0.17*	-0.07	-0.26	
	0.55**	-0.11	-0.49**	
Total solid	0.18	0.90**	0.27*	0.03
	0.25*	0.92**	0.42**	0.23*

[1]Upper and lower lines denote the coefficients during suckling and milking periods, respectively; *$p<0.05$; **$p<0.01$

reported in suckling period. Similarly, negative coefficients were found between daily milk yield and milk fat and protein percentages.

DISCUSSION

Because of the lamb-ewe suckling bond, lactation curve for milk yield in sheep consists only of a decreasing phase and thus, do not shows the typical pattern seen in dairy cows, which is characterized by an initial phase that increases to a maximum, followed by a decreasing phase. In the present study, estimated daily milk yield during the suckling period showed a sharp decrease (-75%) at the time of weaning. This milk yield drop was also observed in Manchega ewes (-40%; Gargouri *et al*. (1993)), in Lacaune and Awassi breeds (-30% to -40%; Labussière (1988)) and in Sicilo-Srade dairy ewes (-49%; Ayadi *et al*. (2011)). This drop can be explained by the partial disappearance of the stimulus produced by the lamb when suckling. According to Marnet (1997), the decline in milk production at weaning (23-35%) might be explained mainly by a reduced emptying frequency (20-25%) and to a lesser degree by mother-kid separation (3-7%). When extended emptying intervals were practiced, intramammary pressure increased and alveolar drainage decreased, all of which negatively affect milk secretion and consequently daily milk yield (Castillo *et al*., 2009). In addition, Castillo *et al*. (2008) have shown differences in the ability of dairy ewes to tolerate extended emptying intervals according to the size of the cisternal udder compartment. The discrepancies in milk yield dropping rates between our results and previous studies are probably due to breed differences in milk yield and milking management. According to Labussière (1988), milk yield variations between breeds (i.e., potential of production, mammary morphology and cisternal capacity) could be one of the main factors responsible for the variable and contradictory results reported in literatures.

Litter size and sex of lambs did not produce any significant effect on milk yield and compositions. This observation is supported by Yilmaz *et al.* (2011), but disagrees with 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). Najdi ewes, which gave birth to heavier lambs, produced more milk than those of lighter weight lambs and that probably because bigger lambs require larger amounts of milk and therefore exert a greater suckling stimulus. Nudda *et al*. (2002) also reported similar result in Awassi ewes and stated that greater suckling stimulus by bigger lambs accelerated the synthesis of milk.

Milk in Najdi sheep has lower percent of total solids compared to other reported values (14.4 vs. 16-19%) for a number of European and Asian dairy sheep breeds (Alichanidis and Polychroniadou, 1996). Lipids are the most important components of milk in terms of cost, nutrition, physical and sensory characteristics that it impart to dairy products. The obtained milk fat content in the present study during milking period (4.94%) was lower than the values reported for Lacuane (7.0%) and Manchega (6.2%) ewes by Castillo *et al*. (2009), Awassi ewes (7.4%) by Nudda *et al*. (2002), Rahmani ewes (5.62%) by Abd Allah *et al*. (2011) and similar to those reported for Chios ewes (4.7%) by Abd Allah *et al*. (2011). Breed differences and nutrition programs can explain the discrepancies between our results and previous studies.

In the present study, milk protein content ($p<0.05$) differ between suckling and milking periods; this result is in general agreement with the findings for Manchega ewes by Gargouri *et al*. (1993), who found that protein content in milking period was higher than the value in suckling period. The average percentage of lactose during suckling period was higher ($p<0.05$) than the reported value during milking period. However, similar trend was observed in the literatures (Yilmaz *et al*., 2011), in which lactose content at the beginning of lactation was higher than the mid and late stage of lactation. Milk composition percentages remained constant ($p>0.05$) throughout the suckling period, but the percentages of fat, protein and total milk solids increased ($p<0.05$) and lactose decreased ($p<0.05$) in the 10th week of lactation compared to other studied weeks in milking period. Castillo *et al*. (2009) found that, sudden decreased in milking frequency in dairy ewes increased milk fat and protein contents in the milk collected on days after this milking transition, but returned to its normal values thereafter.

Negative correlations between daily milk yield and fat and protein percentages were observed in this study. These findings are in agreements with those results in literatures (Caja and Bocquier, 2000; Yilmaz *et al*., 2011) who confirmed the existence of a negative relationship between quantity and quality of the milk, which has implications for programs of genetic improvement of milk production in sheep.

Measurement of Somatic Cell Counts (SCC) in sheep milk is a good indicator of mastitis and, is an accepted parameter for the evaluation of milk quality (Gonzalo *et al*., 2005). The mean SCC value (9.95×10^5 cells/mL) observed in our study 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). However, the obtained SCC of 9.95×10^5 cells/mL value is within the accepted range established by the Food and Drug Administration, USA, in which it sets the legal upper limit for sheep milk to 1.0×10^6 cells/mL (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). The SCC did not change ($p>0.05$) between suckling and milking period, which agreed with those reported findings in literatures (Paape *et al*., 2007), but disagreed with those of Fahr *et al*. (2001).

CONCLUSION

The results of the present study revealed that the indigenous Najdi ewes have a noticeable potential for milk production. Ewes suckling lambs weighing >5 kg at birth produced more milk yield compared to those of lighter weight lambs. However, improving the nutritional management of the lactating ewes in order to ameliorate milk compositions is recommended.

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