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Research Article

Effect of Vacuum Level on Udder Aspect and Milking in the Sicilo-Sarde Ewes

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Abstract

The study aimed to investigate the effect of vacuum level on udder traits, milking time, milk yield, and components in Tunisian Sicilo-Sarde ewes. The trial was carried out at the UCPA farm of Gnadil-Béja (Tunisia) among three periods of late lactation where 3 vacuum levels (40, 50, and 60 kPa) were applied for each one. Udder traits were measured before each milking, and milking time and milk amount were recorded. Milk total solids (TS), fat, solids not fat (SNF), protein, lactose, milk urea nitrogen (MUN), and somatic cell counts (SCC) were determined. Results showed significant effects of lactation day on udder traits with the exception of teats length. Machine milking time (32.75 sec) and milk yield (0.78 L/ewe/d) were the highest at the beginning of the experiment. Excepting somatic cell counts and milk urea nitrogen, the highest values of milk components were observed at the intermediate period of the experiment. Significant effects of vacuum level on machine milking time and milk yield were observed ($P<0.05$), where values are the highest with the low (40 kPa) and the intermediate (50 kPa) vacuum levels, respectively. Similarly, milk solids not fat content was higher in the groups of 40 and 50 kPa than that of 60 kPa. Contrarily to protein content, milk fat obtained with 50 kPa was higher than those of 40 and 60 kPa.

INTRODUCTION

In dairy farming, knowledge of the udder morphology permits the identification of the mammary traits indispensable in selection programs [1]. Milking frequency, vacuum level, pulsation rate, and pulsator ratio represent the most suitable operative parameters that regulate machine milking [2]. The vacuum level is regulated according to the milking system (high or low) and the country customs contrarily to pulsation parameters which are specific for each species. A vacuum level of 40 kPa was recommended for goats and ewes [3]. Similarly, it has been reported that the appropriate teat-end average vacuum level is between 28 and 38 kPa [4] during the maximum flow phase (ISO 5707:2007). In contrast, an extremely low vacuum level causes an increase in both liner slips and machine-on time and consequently a decrease in milk flow rate [5]. A high vacuum level (>42 kPa) is suitable to assist the teat canal opening but can cause severe teat tissue damage and seems higher compared with the value recommended for Sarda sheep (26 kPa), Lacaune sheep (25 to 35.9 kPa) [2], mountain Greek breed Boutsiko (16.59 kPa) [6], and Saanen goats (34.6 kPa) (Le Du and Benmederbel, 1984). Milking operation greatly affects productivity requirements in dairy goat farms, where milking time could represent up to 55% of labor, according to the frequency of milking and performance of milkers [7]. An increase in milk amount (1.24 vs. 1.05 kg) was founded in sheep and goats when the vacuum level decreases from 44 to 35 kPa [8]; in contrast, any difference has been reported for Alpine goats [9]. The use of alternate pulsations with a high vacuum level limits the time of milking [9]. Similarly, negative relationships were reported between vacuum level and milking time [8]. Vacuum level is among the most parameters of the milking machine which can considerably affect udder health. SCC was considered as a way to assess milk quality and animal health [10]. Dairy production is an essential means to satisfy social and economic needs in the Maghreb countries such as poverty and malnutrition [11]. However, despite their potential contribution, limited attention has been reserved for dairy ewes and goats in the Maghreb regions [12]. Under the harsh environments prevailing in these regions, ewe and goat are mainly reared

for meat and most breeds have not been selected for milk, except the Tunisian Sicilo-Sarde sheep [13], Dairy sheep represents a micro-sector dominated by the Sicilo-Sarde breed as the only specialized dairy sheep in North Africa, since its milk is processed in "SOTULAIFROM" factory and represents a cheese type "Roquefort" [14]. Sicilo-Sarde ewes showed appropriate aptitudes for machine milking [15], and their milk yield is mainly affected by feed, age, number, and sex of lambs [16]. Until now, Sicilo-Sarde farming is missing references on milking settings, even after the maximum flow phase where ewes are usually milked with a high vacuum level (>40 kPa), and at this stage, drying period represents the critical moment for making herd management decisions. In order to define optimum milking practice satisfying the physiological needs of ewe, the present study aimed to evaluate the effects of lactation day, vacuum level (38, 44, and 50 kPa), and the milking session on udder traits, milking time, milk yield and components during late lactation in Sicilo-Sarde ewes.

MATERIALS AND METHODS

This study was carried out at the UCPA farm of Gnadil in Béja (Tunisia), this region is characterized by a sub-humid climate stage with an annual rainfall of 600–800 mm [17]. A total of 30 multiparous ewes (5 ± 2 years of age; 1st– 5th of lactation) from a 608-head herd was observed from 21st February to 21st April 2019. In these conditions, the herd was moved for grazing once a day (11:30 a.m to 16:00 p.m.) and then kept on the farm during the night from September to Marsh, while grazing becomes twice a day (8:30 to 12:00 a.m. and 15:30 to 18:30 p.m.) from April to 2 weeks before the expected lambing date. Animals are daily fed in winter with oats hay (1.5– 2 kg/head) and graze thatch pasture in the summer. During the year, ewes were fed concentrate each morning (400 to 600 g/head), excepting Jun and July, and they had access to water twice a day. The trial was carried out among 3 periods of 12 d each (141±7; 169±7 and 200±7 d of lactation). For each period, 3 vacuum levels (40, 50, and 60 kPa) were applied every 4 d with the same parameters (120 pulsations/min and 50:50 pulsator ratio) where a pre-experimental phase of 5 d was applied before each one for familiarizing ewes to each tested vacuum level. The 1st d of each period (4 d), milking time (s) of the morning (08:00 a.m.) and afternoon (16:00 p.m.) milking (SEZER-Turkey, mechanic milking) were recorded. The milk amount was recorded at the 2nd d, and at the 3rd d, teat length, teat width, udder length, the distance between teats, the height of the right cistern, and the height of the left cistern were measured twice daily (08:00 a.m. and 16:00 p.m.). Each last day (4th d) of each period, a milk sample (100 mL/ewe) was collected (at 08:00 a.m. and at 16:00 p.m.) to be analyzed (Milkoscan FTS-FCM) for total solids (TS), fat, solids not fat (SNF), protein, lactose, milk urea nitrogen (MUN) and somatic cell counts (SCC). All analyses were performed with SAS 9.0 (SAS Institute Inc., Cary, NC, USA). The Proc GLM was used to evaluate the effects of lactation day, vacuum level, and the milking session on udder traits, milking time, milk yield, and components as follow. The linear model used was as follow: $Yijk = \mu + Vli + Ldj + Msk + VlLdMsijk + eijk$ Where: Yijk the observation of the studied variable; μ the general mean; Vli the fixed effect of the vacuum level (Low VL1= 40, Medium VL2 = 50, High VL3 = 60kPa); Ldj: the fixed effect of the lactation day (Ld1 = Early, Ld2 = Intermediate, Ld3 = Late experiment); MsK: the fixed effect of milking session (M1 = Mornig milking, M2 = Afternoon milking); VlLdMsijk: vacuum level × lactation day × Milking session interaction, and eijk: the residual effect. Differences among the lactation days, vacuum levels, and milking sessions were evaluated using the test of Student–Newman–Keuls. Noting that data of milk urea nitrogen (MUN), total solids (TS), solids not fat (SNF), and lactose contained missing recordings according to lactation day.

RESULTS AND DISCUSSION

The effects of lactation day, vacuum level, and milking session on udder traits are presented in Table 1. An average teat length of 26.4±0.2 mm and teat width of 11.1±0.1 mm, an udder length of 78.6±0.8 mm, a distance between teats of 77.9±0.7 mm, a height of the right cistern of 49.3±0.7 mm and a height of the left cistern of 50.6±0.7 mm were observed. There were significant effects of lactation day on the udder traits, except for teats length. Udder shows lower ($P<0.001$) teat width at 141±7 and 169±7 d of lactation than that at 200±7 d. The Teat length of Sicilo-Sarde ewes did not vary significantly during the trial, while the distance between teats and cistern height increased ($P<0.05$) from 141±7 to 200 ±7 d. However, this was not the case for udder length, which diminishes at 200±7 d. None of the measurements of teat length, teat width, udder length, the distance between teats, and height of the cistern is affected by the vacuum level. Similarly, the milking session and the interaction between factors did not influence any of the udder traits ($P>0.05$). The present study provides, for the first time, a detailed account of the influence of lactation day, vacuum level, and milking session on udder morphology, milking time, milk yield, and components in the Sicilo-Sarde sheep. Compared to our result (26.4 mm), a lower average teat length was previously founded by Ayadi et al. [15], in the same breed (18.5 mm), and by Martínez et al. [18], in Chilota and Suffolk Down breed (22.6 and 22.8 mm, respectively), however, higher teat length (31–34 mm), was reported in Barbarine

Table 1: Effects of lactation day, vacuum level, and the milking session on udder traits in Sicilo-Sarde dairy ewes

Traits (mm)	Overall M. ± S.D	(Mean ± S.D) day of lactation				Vacuum level (kPa)				Milking session		
		141±7	169±7	200±7	*P-value*	40	50	60	*P-value*	Morning	Afternoon	*P-value*
Teat length	26.37 ± 3.84	26.23	26.33	26.53	0.7482	26.49	26.27	26.34	0.8625	26.43	26.30	0.6996
Teat width	11.08 ± 2.07	10.36^{b}	10.65^{b}	12.21^{a}	<.0001	11.15	11.07	11.00	0.7745	11.11	11.04	0.6489
Udder length	78.62 ± 12.85	79.54^{A}	80.97^{a}	75.36^{b}	<.0001	78.74	78.53	78.60	0.9879	78.68	78.56	0.9152
Distance teats	77.93 ± 12.68	75.39^{b}	77.11^{b}	81.27^{a}	<.0001	77.22	78.61	77.95	0.5735	77.95	77.90	0.9537
Height of right cistern	49.26 ± 11.77	51.86^{a}	45.00^{b}	49.93^{a}	<.0001	49.72	49.58	48.48	0.5409	49.42	49.10	0.7539
Height of left cistern	50.58 ± 12.29	50.96^{b}	46.86^{c}	53.92^{a}	<.0001	50.96	50.65	50.12	0.7975	50.72	50.44	0.7914

Abbreviations: Data are reported as means and associated standard deviations. Means with different lowercase letters on the same row differ significantly (P < 0.05).

Table 2: Effects of lactation day, vacuum level, and milking session on milking time, milk composition, and SCC in Sicilo-Sarde dairy ewes

Parameters	Overall M. ± S.D	(Mean ± S.D) day of lactation				Vacuum level (kPa)				Milking session		
		141±7	169±7	200±7	*P-value*	40	50	60	*P-value*	Morning	Afternoon	*P-value*
Milking time (sec)	29.69 ± 10.80	32.75^{a}	28.62^{b}	27.72^{b}	<.0001	33.00^{a}	29.84^{b}	26.25^{c}	<.0001	30.86^{a}	28.52^{b}	0.0069
Milk yield (L/ewe/d)	0,65 ± 0,18	0.78^{a}	0.60^{b}	0.58^{b}	<.0001	0.64	0.67	0.65	0. 2	0.78^{a}	0.52^{b}	0.003
Fat (%)	6.73 ± 1.76	6.88^{b}	7.21^{a}	6.06^{c}	<.0001	6.33^{b}	7.36^{a}	6.46^{b}	<.0001	6.68	6.77	0.4950
Protein (%)	6.29 ± 1.04	5.94^{c}	6.84^{a}	6.54^{b}	<.0001	6.12^{b}	6.46^{a}	6.72^{a}	0.<.0001	6.31	6.26	0.5778
SCC (×103 c/ml)	1711.43 ± 4046.67	2034.3	1654.9	1452.3	0.4103	1606.3	1628.5	1897.3	0.7495	1786.6	1635.7	0.6590
MUN (mg/dL)	41.38 ± 9.52	.	41.93	40.84	0.2299	43.45^{a}	43.65^{a}	37.03^{b}	<.0001	42.61^{a}	40.14^{b}	0.0060
TS (%)	18.26 ± 1.39	.	.	.	.	18.35	18.33	18.09	0.4976	18.76^{a}	17.75^{b}	<.0001
SNF (%)	11.64 ± 0.52	.	.	.	.	11.72^{a}	11.70^{a}	11.50^{b}	0.0281	11.61	11.67	0.4163
Lactose (%)	4.52 ± 0.47	.	.	.	.	4.75^{a}	4.43^{b}	4.37^{b}	<.0001	4.50	4.53	0.7501

Abbreviations: [Data are reported as means and associated standard deviations. Means with different lowercase letters on the same row differ significantly (P < 0.05).]

ewes [19]. Small teats can reduce the milking ability of the ewe, although an increase in teat size can be expected as a result of milk yield selection [18]. The udder length in our work (78.62 mm) was close to that reported for Suffolk Down ewe (76.9 mm), but smaller than those reported in Chilota (86.3 mm) and Churra (93.0 mm) [20]. The distance between teats of Sicilo-Sarde ewes (7.7 cm) was similar to that reported (7.5 cm) for the same breed [15], but lower than those reported for Najdi ewe (10.4 to 15.1 cm). Similarly, the cisterns of Sicilo-Sarde showed lower height (49.3– 50.6 mm) than those reported by Martínez et al. [18], for Chilota (86 to 87 mm) or Suffolk sheep (77 – 90 mm). The significant effect of lactation day on udder measurements and milking time observed for Sicilo-Sarde ewes, except the teat length, are similar to the results reported in Barbarine ewes by Ayadi et al. [19]. It has been reported that udder size change is compatible with the decrease of milk yield [18]. Similarly, milking time was the lowest at 200±7 and 169±7 d compared to that at 141±7 d of lactation, such variation was compatible with the reduction of milk yield potential throughout lactation [19]. The teat length of Sicilo-Sarde ewes did not vary during the trial. This result is similar to those of Najdi sheep [19]. The increase in the distance between teats and the height of the cistern as lactation progresses may be due to an increase in the size of the udder as per the synthesis of mammary tissues, with the advancement of the lactation stage. However, this was not the case for some traits defining udder size, in particular udder length which diminished at 200 ± 7 d, coinciding with the involution of the mammary gland at the end of lactation. The effects of lactation day, vacuum level, and the milking session on machine milking time, milk yield, and components are presented in Table 2. Significant differences (P<0.05) among the lactation days were observed for all parameters, except SCC and NUM. Machine milking time and milk yield have the highest values at the beginning of the experiment (141±7 d). The highest fat contents were observed at the intermediate period, as compared to those at the beginning and at the end of the experiment. However, total protein content shows the lowest value at 141 d and then increases at 169 d before its decreasing. The value of milk SCC was high at 141 d and decreased slightly (P>0.05) to 169 and 200 d. There were significant effects of vacuum level on machine milking time (P<0.001), where time was the highest with the lowest vacuum level, hence the time decreased (P≤0.05) by 0.1 min/ewe as the vacuum level increases from 40 to 60 kPa. However, milk yield did not differ significantly according to vacuum level. Significant differences (P<0.05) were observed between the vacuum levels for fat, protein, MUN, SNF, and lactose. The fat content obtained at 50 kPa was higher (4.75%) than those at 40 and 60 kPa. The lactose content was higher when using 40 kPa than those at 50 and 60 kPa (4.43 and 4.37%, respectively), contrary to the protein content. Milk MUN and SNF were significantly higher at 40 and 50 kPa than that at 60 kPa (P<0.01). The TS and SCC did not differ according to the vacuum level. Regardless of the milking session, significant effects were observed on milking time, milk yield, NUM, and TS where values are highest in the morning compared to those in the

afternoon milking. The interaction between factors did not influence any of the machine milking time, milk yield, and components (P>0.05). The milking time was influenced by vacuum level, with a reduced value following the use of the highest level (60 kPa) as it has been reported in goats [21].The morning milking time and milk yield were higher than those of evening milking. Similar differences in the amount of partial morning and evening milk yields with the same milking interval were observed in cows [22]. The increase of fat and total protein in milk until 169 d and their decrease at 200 d of lactation were comparable to those reported in Lacaune ewes [23], and in Dalmatian Pramenka ewes [24]. Noting that, the major change in milk components occurred during the first 30 d of lactation, which coincide with the highest milk yield in dairy ewes. Excepting the SCC at the 141 d of lactation, our results are in line with the legal limit of SCC designed for bulk tank milk for goats and sheep (should not be lower than 1.5×106c/mL) as suggested by the EU authorities (International Symposium of Somatic Cells and Milk of Small Ruminants, 1994). A medium vacuum level increases the milking time and improves the extraction of alveolar milk richest in fat, and this can explain partially the significant difference in milk fat content [21]. Following one-only machine milking, the fat content raises with time in cow milk as a part of fat granules is retained and the amount of milk corresponds to the alveolar fraction the rich in fat compared to the cisternal fraction [25]. Milk somatic cell count did not vary significantly according to vacuum level in Sicilo-Sarde ewe similar to previous results found in dairy ewes and goats [21]. In contrast, a high somatic cell count has already been reported in a study maintaining a high vacuum level for a longer period in sheep and this increases the risk of the udder infection [26].

CONCLUSION

It was concluded that vacuum level does not affect udder measurements in dairy Sicilo-Sarde sheep but has several effects on machine milking time, milk yield, and components; the use of a medium vacuum level of 50 kPa seems to be the suitable choice, since milk MUN, SNF and Fat contents were the highest. This level was less stressful for teat tissue, did not cause any detrimental effects on udder health, and appears more appropriate than the extreme vacuum levels (40–60 kPa) regarding milking performances.

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REFERENCES

1. Makovicky P, Nagy M. Makovický P. The comparison of ewe udder morphology traits of improved Valachian, Tsigai, Lacaune breeds and their crosses. Mljekarstvo. 2014; 64: 86-93.
2. Marnet PG, Combaud JF, Le Du J. Dano Y. Effect of pulsation rate and vacuum level on oxytocin release, milk parameters and teat and reaction. Proceedings Symposium on Milk Synthesis, Secretion and Removal in Ruminants, Berne, Switzerland. 1996; 114: 26-27
3. Marnet PG, McKusick BC. Regulation of milk ejection and milking efficiency in small ruminants. Livest Prod Sci. 2001; 70: 125-133.
4. Hubert SM, Williams TJ, Athrey G. Insights into the molecular basis of wooden breast based on comparative analysis of fast and slow growth broilers. bioRxiv. 2018; 356683
5. Rasmussen MD, Madsen NP. Effects of milkline vacuum, pulsator airline vacuum, and cluster weight on milk yield, teat condition, and udder health. J Dairy Sci. 2000; 83: 77-84.
6. Sinapis E, Marnet PG, Skapetas B, Hatziminaoglou I. Vacuum level for opening the teat sphincter and the change of the teat end wall thickness during the machine milking of mountainous Greek breed (Boutsiko) ewes. Small Rumin Res. 2007; 69: 136-143.
7. Blasco E, Gomez EA, Vicente C, Vidal G, Peris C. Factors affecting milking speed in Murciano-Granadina breed goats. J Dairy Sci. 2016; 99: 10102-10108.
8. Caria M, Boselli C, Murgia L, Rosati R, Pazzona A. Influence of low vacuum levels on milking characteristics of sheep, goat, and buffalo. J Agric Eng. 2013; 44.
9. Bueso-Ródenas J, Tangorra FM, Romero G, Guidobono-Cavalchini A, Díaz JR. Effects of pulsation type (alternate and simultaneous) on mechanical milking of dairy goats (I): a study in Alpine goats varying the system vacuum level. Small Rumin Res. 2016; 144: 300-304.
10. Raynal-Ljutovac K, Pirisi A, de Crémoux R, Gonzalo, C. Somatic cells of goat and sheep milk: analytical, sanitary, productive and technological aspects. Small Rumin Res. 2007; 68: 126-144.
11. McDermott JJ, Staal SJ, Freeman HA, Herrero M, Van De Steeg JA. Sustaining intensification of smallholder livestock systems in the tropics. Livest Prod Sci. 2010; 130: 95-109.
12. Chniter M, Darej C, Belhadj-Slimen, I, Chouchene W. Lactation Performance of Small Ruminants in the Maghreb Region. In: Lactation in Farm Animals-Biology, Physiological Basis, Nutritional Requirements, and Modelization (Ed. M'Hamdi N.). IntechOpen. London, United Kingdom. 2019; 39-51.
13. Atti N, Rouissi H, Othmane MH. Milk production, milk fatty acid composition, and conjugated linoleic acid (CLA) content in dairy ewes raised on a feedlot or grazing pasture. Livest Sci. 2006; 104: 121-127.
14. Djemali M, Hamrouni A. Ingredients and Pathways for Sustainable Sheep Breeding Strategies under Low Input Production Systems: The example of two distinct sheep breeds. JVSAH. 2019; 7.
15. Ayadi M, Suchc X, Ezzehizi N, Zouari M, Najar T, Ben M'Radd M, et al. Relationship between mammary morphology traits and milk yield of Sicilo-Sarde dairy sheep in Tunisia. Small Rumin Res. 2011; 96: 41-45.
16. Moujahed N, Ben Henda N, Darej C, Rekik B, Damergi C, Kayouli, C. Analyse des principaux facteurs de variation de la production laitière et de la composition du lait chez la brebis Sicilo-Sarde dans la région de Béja (Tunisie). Livest Res Rural Dev. 2009; 21.
17. El-Hentati H, Aloulou R, Derouich W, Gaddeh O. Molecular Comparison

between the Sicilian-Sardinian Sheep Populations in Tunisia using ISSR Markers. Indian J Anim Res. 2020; B-1217: 1-3.

18. Martínez ME, Calderón C, De la Barra R, De la Fuente F, Gonzalo C. Udder morphological traits and milk yield of Chilota and Suffolk sheep breeds. Chil J Agric Res. 2011; 71: 90-95.
19. Ayadi M, Matar AM, Aljumaah RS, Alshaikh MA, Abouheif MA. Evolution of udder morphology, alveolar, and cisternal milk compartment during lactation and their relationship with milk yield in Najdi sheep. Span J Agric Res. 2014; 12: 1061-1070.
20. Fernández G, Álvarez P, San Primitivo F, de la Fuente LF. Factors affecting variation of udder traits of dairy ewes. J Dairy Sci. 1995; 78: 842-849.
21. Zucali M, Tamburini A, Sandrucci A, Gislon G, Bava L. Effect of vacuum level on milk flow and vacuum stability in Alpine goat. Small Rumin Res. 2019; 171: 1-7.
22. Lee C, Pollak EJ, Everett RW, Mcculloch CE. Multiplicative factors for estimation of daily milk component yields from single morning or afternoon tests. J Dairy Sci. 1995; 78: 221-235.
23. Kuchtík J, Konečná L, Sýkora V, Šustov K, Fajman M, Kos I. Changes of physico-chemical characteristics, somatic cell count and curd quality during lactation and their relationships in Lacaune ewes. Mljekarstvo. 2017; 67: 138-145.
24. Matutinovic S, Kalit S, Salajpal K, Vrdoljak J. Effects of flock, year and season on the quality of milk from an indigenous breed in the sub-Mediterranean area. Small Rumin Res. 2011; 100: 159-163.
25. Lollivier V, Guinard-Flament J, Ollivier-Bousquet M, Marnet PG. Oxytocin and milk removal: Two important sources of variation in milk production and milk quality during and between milkings. Reprod Nutr Dev. 2002; 42: 173-186.
26. Lu CD, Potchoiba MJ, Loetz ER. Influence of vacuum level, pulsation ratio and rate on milking performance and udder health in dairy goats. Small Rumin Res. 1991; 5: 1-8.
27. International Symposium of Somatic Cells and Milk of Small Ruminants. In: EAAP Publication 77. Bella (Italy). 1994; 25-27.
28. Le Du J, Benmederbel B. Aptitude des chèvres de race Saanen a la traite mécanique: Relation avec les caractéristiques physiques du trayon. Ann Zootech. 1984; 33: 375-384.