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Short communication

Determination of milk production losses and variations of fat and protein percentages according to different levels of somatic cell count in Valle del Belice dairy sheep

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ABSTRACT

The somatic cell count (SCC) of milk is widely used to monitor udder health and the milk quality and because of its positive genetic correlation with mastitis this trait was included in breeding schemes of dairy sheep. The aim of this study was to estimate the loss in milk yield (MY) and related composition resulting from different levels of somatic cell count in Valle del Belice dairy sheep. Data were collected between 2006 and 2016 in 15 flocks following an A4 recording scheme. Somatic cell count (SCC), fat and protein percentage (F% and P%) were determined using mid-infrared spectroscopy. To evaluate loss in test day MY, F% and P%, five different classes of SCC were arbitrarily defined: $SCC1 \leq 500 \times 10^3$, $500 \times 10^3 < SCC2 \leq 1000 \times 10^3$, $1000 \times 10^3 < SCC3 \leq 1500 \times 10^3$, $1500 \times 10^3 < SCC4 \leq 2000 \times 10^3$ and $SCC5 > 2000 \times 10^3$. To estimate the loss of milk production and quality a linear model, with test day milk production traits as dependent variable, was used. Furthermore, the effect of order of parity and season of lambing were investigated to study the effects on milk production traits. Least squares means were computed for milk production traits and the differences between means were determined by Fischer's least significant difference. The estimated losses in MY according to the level of used SCC were approximately 16% whereas there was an increase of 0.06% and 0.29% for fat and protein percentage, respectively. Apart from environmental factors and management, this study confirms that high levels of somatic cell count in sheep milk are associated with milk yield losses and changes in milk composition. Results suggest that it is necessary to implement a program aimed to reduce the milk somatic cell count in ewes' milk, with the aim of improving the quality of ewes' milk and dairy products.

1. Introduction

The major income from dairy animals is derived from milk therefore factors that reduce milk quantity and quality can cause high economic losses to the farmers. Sheep milk production accounts for 4.6% of the total milk production in Italy (ISTAT, 2016) and the Mediterranean basin with 60% of total world production is the most important area . Mastitis is an inflammation of the udder, generally caused by bacteria and it is the most prevalent disease present in dairy livestock species that, in addition to altering the state of well-being and health of the animals, it leads to economic loss mainly due to loss of milk during lactation, veterinary treatments, lower longevity and involuntary culling (Tolone et al., 2013a). Udder infection in dairy sheep has negative effects both on the yield and quality of milk (Gonzalo et al., 2006) with economic losses greater than those reported for dairy cattle (Halasa et al., 2009). Mammary infections also cause high somatic cell count (SCC) (Ariznabarreta et al., 2002; Pengov, 2001), and result in important losses of curd and cheese yields (Leitner et al., 2008; Raynal-Ljutovac et al., 2007). Therefore, mastitis, in addition to being a problem in animal welfare, is a food quality and safety problem. Selecting for increased genetic resistance to mastitis can be done directly or indirectly. Direct bacteriological assay is considered to be the most reliable method of diagnosis of mastitis in sheep, because it provides information on both the infected quarters and the involved pathogens. However, it is difficult to implement on a large scale because it is expensive, slow and requires significant laboratory support (McDougall et al., 2001). Among the indirect methods, the most frequently used to detect mastitis are the California Mastitis Test (CMT) and electrical impedance. These methods are indicators of the SCC of milk. The SCC of milk is widely used to monitor udder health and milk quality and it was included in the breeding schemes of dairy sheep such as for the Lacaune breed in France (Barillet, 2007). The measure of SCC has the following

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properties: it can be routinely recorded in most milk recording systems and it is an indicator of both clinical and subclinical infections. Research documenting distinct physiological differences in the process of milk secretion between cows, sheep and goats establishes a lack of justification for applying cow milk regulatory standards to small ruminant milk, specifically using SCC. Whereas in cattle SCC values between 250×10^3 and 300×10^3 cells/mL are recommended as most satisfactory discrimination thresholds between healthy and infected udders (Leitner et al., 2008), in sheep there is no universally accepted threshold. To determine a SCC threshold value in order to discriminate between healthy and infected animals would be of crucial importance both for consumer's safety and for small ruminants breeding system. Mastitis-control costs are *a priori* known or easy to estimate, whereas losses due to different levels of SCC are more difficult to evaluate accurately. Therefore, an appropriate evaluation of SCC effect on MY is needed because the decrease in milk production is considered the main component of the economic losses. The aim of this study was to estimate losses in MY, and variation of F% and P% according to different levels of SCC in Valle del Belice dairy sheep. These results could be used as basic input in estimation of SCC economic value to implement a selection index that includes SCC as trait.

2. Materials and methods

Phenotypic data were collected by the University of Palermo between 2006 and 2016 in 15 Valle del Belice flocks. The procedures involving animal sample collection followed the recommendation of directive 2010/63/EU. Milk samples were collected at approximately monthly intervals following an A4 recording scheme (ICAR, 2014). All ewes were milked manually twice a day and milk from both milking was collected, stored at 4 °C and transferred to the laboratory, to determine daily MY, F%, P% and SCC. Within 48 h from samples collection, milk composition was determined by the method of infrared spectrophotometry using Combifoss 6200 (Foss Electric Hillerød, Denmark) equipment. The original data set used for this study included 92,261 records of 6763 ewes. Data editing was performed using S.A.S. version 9.2 (SAS, Institute Inc., 2010) to guarantee the quality of the data to be analyzed. All test-day records used in the analysis were required to have information regarding MY, F%, P% and SCC. Animals with less than 3 test-day measurements within lactation were discarded. After editing, the data set consisted of 17,060 observations of 2418 ewes. Five stages of lactation were determined according to days in milk (DIM) as follows: 1: DIM ≤ 60; 2: 60 < DIM ≤ 120; 3: 120 < DIM ≤ 180; 4: 180 < DIM ≤ 270 and 5: DIM > 270. Season of lambing (SOL) was classified in three classes: 1 if the lambing was from August to November; 2 from December to March; 3 from April to July. To evaluate loss in test day MY, F% and P%, five different classes of SCC were arbitrarily defined: $SCC1 \leq 500 \times 10^3$; $500 \times 10^3 < SCC2 \leq 1000 \times 10^3$; $1000 \times 10^3 < SCC3 \leq 1500 \times 10^3$; $1500 \times 10^3 < SCC4 \leq 2000 \times 10^3$ and $SCC5 > 2000 \times 10^3$ cells/ml. To estimate the loss of MY, P% and F% according to different levels of SCC, a linear model was used with the GLM procedure of the S.A.S. version 9.2 (SAS, Institute Inc., 2010). In particular, the following model was used for MY and P%:

$$y_{ijklm} = \mu + FYS_i + OP_j + \beta(\mathrm{AOP})_{ijkl} + SCC_k + DIM_l + e_{ijklm}$$

$$y_{ijklm} = \mu + FYS_i + OP_j + \beta(\mathrm{AOP})_{ijkl} + SCC_k + MY_l(\mathrm{FLOCK^*DIM}) + e_{ijklm}$$

where y_{ijklm} is the ijklmth observations vector for MY, P% or F% test day as weighted mean of morning and evening milk production; μ is the population mean; FYS_i is the random effect of flock by year of parity and season; OP_j is the fixed effect of parity class j (4 levels); $(AOP)_{ijklm}$ is the age of lambing as covariate; SCC_k is the fixed effect of SCC levels l (5 levels); DIM_l is the fixed effect of days in milk m (5 levels) and e_{ijklm} is the random error. In the second model MY_l(FLOCK*DIM) interaction was used to adjust F% for milk production within flock and stage of lactation. Furthermore, the effect of OP and SOL were investigated to study the relation between parity and season of lambing with milk production traits including all the observations. Least squares means (LSM) were computed for MY, F% and P% and the differences between means were determined by Fischer's least significant difference.

Table 1
Descriptive statistics of test-day milk yield (MY, g), somatic cell count (SCC × 10^3), fat (F %) and protein (P%) percentages in Valle del Belice sheep breed.

Daily measurements	N	Mean ± SD	Min	Max
MY (g)	17,060	1135 ± 603	56	4300
SCC × 10^3	17,060	1544 ± 3547	5	29,368
F%	17,060	7.25 ± 1.23	2.33	14.56
P%	17,060	5.80 ± 0.72	3.46	13.90

SD: standard deviation.

3. Results

The descriptive statistics for milk production traits were reported in Table 1. All fixed effects, for MY and P% included in the first model were highly significant ($P < 0.001$). Table 2 showed the losses for MY, F% and P% due to different levels of SOL and OP fixed effects. The effect of losses in MY, and variation of F% and P% according to different levels of SCC were reported in Table 3. The estimated losses in MY were approximately 16% and ranged from 1052 g for SCC1 to 883 g for SCC5 (Table 3). The Fig. 1a reported that milk production for SCC1 was statistically different for milk production of each SCC class. It should be noted that according to the different levels used for SCC, an inverse effect on milk yield was observed (Table 3). Table 3 showed the least square means for F% depending on SCC class. The F% increased from 7.39% to 7.47% corresponding to an increase of around 0.06%. The F% for the SCC1 class was statistically different only from F% of SCC5 class (Fig. 1b). The least-squares means for P% depending on SCC class were reported in Table 3. Protein percentage increased from 5.69% to 5.98% corresponding to an increase of 0.29% of protein concentration in milk. The Fig. 1c showed that P% for SCC1 was statistically different for P% of each SCC class. It should be noted that according to the different classes used for SCC, a continuous increase on P% was observed (Table 3).

4. Discussion

In the present study the milk production losses and variation of F% and P% according to different levels of SCC in Valle del Belice dairy sheep were investigated.

The means for MY, F% and P% were similar to those reported by Tolone et al. (2013a, 2013b) while the mean SCC was higher than the value obtained by the same authors for the Valle del Belice sheep breed (Tolone et al., 2013b). Ewes lambed from August to November (SOL 1) produced more milk than those lambed from December to March (SOL

Table 2
Effects of parity (OP) and season of lambing (SOL) on milk yield (MY, g), fat (F%) and protein (P%) percentages in Valle del Belice sheep breed.

	Levels	MY (g)	F%	P%
SOL	1	0.000	0.000	0.000
	2	−180.4	−0.030	−0.06
	3	−166.7	0.12	−0.13
OP	1	−52.78	0.11	0.02
	2	0.000	0.000	0.000
	3	−80.09	0.11	0.06
	4	−6.16	0.21	0.13