Journal of Animal and Feed Sciences, 18, 2009, 420–428

Milk yield and composition in line 05 dairy ewes as related to somatic cell counts

J. Olechnowicz[1], J.M. Jaśkowski, P. Antosik and D. Bukowska

Poznań University of Life Sciences,
Department of Agricultural Veterinary
Wojska Polskiego 52, 61-625 Poznań, Poland

(Received 21 April 2008; revised version 29 January 2009; accepted 24 June 2009)

ABSTRACT

A total of 1512 milk samples from udder halves was collected at monthly intervals from 189 line 05 dairy ewes throughout milking periods. Each ewe was tested 4 times. Milk composition was examined in terms of somatic cell contents (SCC) in ewe milk in three groups: group 0 consisted of ewes that on each test day had $\leq 250 \times 10^3$ cells/ml in left and right udder halves, group 1 comprised ewes with $\leq 250 \times 10^3$ in one half of the udder and $>250 \times 10^3$ cells/ml in the other half, whereas group 2 contained ewes that had $>250 \times 10^3$ cells/ml in the left and right udder halves (also on each test day). SCC in milk from one or both halves of udders exceeding 250×10^3 cells/ml resulted in a statistically significant ($P<0.01$), 20.7%, decrease in daily milk production.

Correlation coefficients between SCC and fat and protein percentages in milk were positive and equaled 0.24 and 0.18, respectively. A negative value of the correlation coefficient was recorded between log SCC and lactose percentage (-0.49).

KEY WORDS: dairy ewes, SCC, milk components, milk yield

INTRODUCTION

Variation in somatic cell count (SCC) in ewe milk is significantly affected by the breed, flock, successive lambing, stage of lactation, type of birth, and oestrus of ewes (Fuertes et al., 1998; Gonzalo et al., 2002). Numerous authors have shown that a high level of somatic cells in ewe milk is connected with a higher protein

[1] Corresponding author: e-mail: olejanko@up.poznan.pl

percentage compared with the protein content in low SCC milk (Nudda et al., 2003; Albenzio et al., 2004; Bianchi et al., 2004). However, other authors reported low protein contents in milk with a high SCC (Jaeggi et al., 2003). Other investigations have shown no differences in protein content in ewe milk with high and low somatic cell levels (Pirisi et al., 1996, 2000). Fat content in ewe milk increased significantly in infected udder halves in the research presented by Bianchi et al. (2004).

In ewes of milk breeds, the physiological and pathological levels of somatic cells in milk range from 0.25 to 1.0 × 10^6 cells/ml (El-Saied et al., 1998; Pengov, 2001). Some authors state that the threshold between health and disease of an udder half in ewes is an SCC of 250-300 × 10^3/ml (Pengov, 2001).

The milk of line 05 dairy ewes (milk yield is approx. 124 kg in lactation) is characterized by a low SCC (log 5.168, i.e. 145 × 10^3 cells/ml); its fat, protein and lactose contents amount to 5.51, 6.10 and 4.90%, respectively (Olechnowicz and Sobek, 2007).

Since ewe milk is frequently used to produce cheeses and liquid milk products, it is of considerable scientific importance to determine correlations between milk yield and composition and factors modifying them, as is the case with SCC. The aim of this study was to determine the effect of different SCCs from udder halves on the production and composition of milk in dairy ewes of line 05.

MATERIAL AND METHODS

Experimental design

The investigations were conducted in the years 2000-2002 at the Złotniki Agricultural Experimental Station, belonging to the Poznań University of Life Sciences. The experimental material consisted of line 05 dairy ewes milked for 16 weeks in two calendar seasons: spring-summer (from March to June) and summer-autumn (from July to October). In both seasons different ewes were milked and the milking period was 4 months. After two months of maternal nursing (60±22 days) ewes with clinically healthy udders were designated for mechanical milking. Sheep were milked mechanically in a Westfalia 14-unit milking parlour. Maintenance tests of the milking machine were performed annually by measuring pulsation rate and pulsator rates using a MilkoTest 2000 electronic pulsograph (Bilgery). The milking vacuum was 41 kPa, the pulsation rate of individual clusters ranged from 121.7 to 126.7 pulses/min and the pulsator rate was 50±5%.

Winter feeding of ewes was based on haylage, maize silage, mangolds, meadow hay, and all-mash, while the basis for summer feeding of sheep was green fodder

from lucerne and cereal grain. The estimated nutritive value of the ration for milked ewes was 11 MJ energy and 320 g crude protein in 2.3 kg DM.

Chemical analyses

Milk testing was conducted 4 times in the milking period at monthly intervals by determining milk yield from the morning and evening milkings (ml). Before the morning milking and after forestripping, washing and wiping of teats, approx. 50 ml milk (preserved with CC preparation) were collected from udder halves in order to record percentages of fat, protein and lactose as well as SCC. The CC preparation ensures the maintenance of chemical parameters of milk samples for 30 days at room temperature (0.25 g/50 ml milk).

Milk samples were analysed at a Milk Testing Laboratory, determining the basic milk composition with a MilkoScan device (Foss Electric, Italy), while SCCs were determined using a Fossomatic 90 apparatus (Foss Electric, Denmark). The number of somatic cells in milk was transformed into a common logarithm (Ali and Shook, 1980). In the period of the experiment a total of 1512 milk samples were collected from udder halves from 189 ewes. Each ewe was tested 4 times.

Statistical analysis

In this study ewes were divided into 3 groups, taking into consideration the threshold value of SCC in milk (250×10^3 /ml). Group 0 consisted of ewes that on each test day had $\leq 250 \times 10^3$ cells/ml in left and right udder halves, group 1 comprised ewes with $\leq 250 \times 10^3$ in one half of the udder and $>250 \times 10^3$ cells/ml in the other half, whereas group 2 contained ewes that had $>250 \times 10^3$ cells/ml in the left and right udder halves.

Collected numerical data were analysed using two-way analysis of variance with the use of the SAS package (SAS, 2000). In the calculations the following linear model was applied:

$$y_{ij} = \mu + A_i + B_j + e_{ij}$$

where: y_{ij} - contents of fat, protein and lactose (%) in milk in terms of udder halves, daily milk yield (ml) from the udder, μ - grand mean, A_i - the effect of somatic cell count (log SCC) in milk in groups of ewes ($_i = 0, 1, 2$), B_j - the effect of the stage of lactation ($_j = 1, 2, 3, 4$ month of milking), e_{ij} - the effect of random error.

The Scheffe test was used to determine significant differences in milk yield and milk composition for three groups of ewes.

In the study, phenotypic correlation coefficients were estimated between

basic milk components (log SCC, contents of fat, protein and lactose) based on procedures of Pearson's linear correlations (SAS, 2000). A reduction of milk production in ewes in relation to the exceeded threshold value, adopted in the study for the number of somatic cells in terms of udder halves, was estimated according to the method proposed by Leitner et al. (2008).

RESULTS

Means and standard deviations of the analysed traits are presented in Table 1. The mean daily milk yield was 976.51 ml. The mean log SCC was 5.19 and the mean content of fat, protein and lactose in milk was 5.45, 6.12 and 4.92%, respectively. Standard deviations and ranges for milk components and milk production in line 05 dairy ewes are relatively high, which is consistent with the selection requirement in these ewes towards improved milk components and production.

Table 1. Phenotypic means, standard deviation, minimum and maximum for milk components and production dairy ewes of line 05

Trait	n	Mean	Standard deviation	Minimum	Maximum
Somatic cell count, log SCC	1512	5.19	0.785	3.00	7.23
Fat content, %	1512	5.45	2.191	1.46	16.34
Protein content, %	1512	6.12	1.079	3.10	12.56
Lactose content, %	1512	4.92	0.708	0.42	6.85
Milk production, ml/d	756	976.51	436.98	100.00	2650.00

Data for daily production and milk composition, depending on the counts of somatic cells in milk from udder halves, are presented in Table 2. Ewes characterized during lactation by the number of somatic cells in milk from both udder halves up to 250 × 10^3/ml (group 0) produced more milk (1092.44 ml)

Table 2. Means of milk yield and milk composition depending on SCC from the udder half

Factor	No. of animals	Milk production d, ml	No. of half udders	Fat %	Protein %	Lactose %
Group of ewes[1]	756	**	1512	**	**	**
0	399	1092.44^{A}	798	5.04^{aA}	5.94^{A}	5.14^{A}
1	193	918.83^{B}	386	5.40^{bA}	6.14^{B}	4.91^{B}
2	164	762.34^{C}	328	6.52^{B}	6.53^{C}	4.39^{C}
Stage of lactation	756	**	1512	**	**	**

[1] 0 - SCC in milk from left and right halves of the udder below 250×10^3 cells/ml; 1 - SCC in milk from one half of the udder below 250 × 10^3 cells/ml and from the other half of the udder above 250×10^3 cells/ml; 2 - SCC in milk from left and right halves of the udder above 250×10^3 cells/ml

$^{A, B, C (a, b)}$ means in the same column followed by different letters are different at P<0.01 (P<0.05)

**P<0.01

than ewes from groups 1 and 2, respectively: 918.83 and 762.34 ml (P<0.01), in which SCC in milk from one (ewes from group 1) or both udder halves (ewes from group 2) exceeded 250 × 10^3/ml. Milk yield for ewes from group 2 was significantly lower than that for ewes from group 1 (P<0.01). Data on milk composition indicate that the level of somatic cells in milk from udder halves has a significant effect on percentages of fat, protein and lactose. An increase in SCC in ewe milk over 250 × 10^3/ml resulted in increased concentrations of fat and protein and reduced concentration of lactose in milk (P<0.01).

The stage of lactation did not have an effect on milk yield or composition in any group of ewes. For all lactation periods (throughout the entire 4 months) ewes of groups 0, 1 and 2 had consistent SCC levels in milk samples from udder halves, thus the trends were identical within the 3 defined groups. However, the stage of lactation had a significant effect on the observed parameters in the analysis in which the factor of ewe groups was omitted.

Table 3 shows the evaluation of milk yield losses. Reduced milk production in ewes, connected with the exceeded threshold value for SCC (over 250 000/ml) in milk from udder halves, was estimated to be 20.7%.

Table 3. The evaluation of milk losses of ewes

No. of animals	Milk production, ml/d in groups of ewes[1]			Milk loss, %		The evaluation of milk loss, %[2]
	0	1	2	1	2	
756	1092.44	918.83	762.34	15.89	30.22	20.7

[1] see Table 2; [2] result obtained according to Leitner et al., 2008

Table 4 presents values of phenotypic correlation coefficients between the analysed characteristics of ewe milk. The values of the correlation coefficients between log SCC and percentages of fat and protein in milk were positive, amounting to 0.24 and 0.18. Negative correlation coefficients were obtained between log SCC and lactose percentage (-0.49). The correlation coefficients between percentages of fat and protein and lactose content were negative, -0.53 and -0.42, respectively.

Table 4. Correlation coefficients between analysed characteristics of the milk

Analysed characteristics	Fat, %	Protein, %	Lactose, %
Log SCC	0.24**	0.18**	-0.49**
Fat, %		0.58**	-0.53**
Protein, %			-0.42**

** P<0.01

DISCUSSION

The means for milk yield, log SCC, fat, protein and lactose contents were comparable to those in other dairy sheep breeds (El-Saied et al., 1998; Fuertes et al., 1998; Riggio et al., 2007). Low standard deviations and narrower ranges for fat, protein and lactose contents, and milk production have been reported for sheep by other authors (Fuertes et al., 1998; Ploumi et al., 1998; Nudda et al., 2003).

Reduction in milk production was associated with an increase in SCC. For 2379 ewes belonging to 10 flocks of the Spanish breed, Churra, El-Saied et al. (1999) found that a high SCC was associated with a lower milk yield. The results agreed with those found by Gonzalo et al. (2002). Nudda et al. (2003) reported a significant decrease of milk yield in Sarda ewes with SCCs>1 000 000 cells/ml.

Pirisi et al. (1996) obtained milk samples from two groups of Sarda ewes with low (<500 000/ml) and high (>1 000 000/ml) SCCs. They found that the lactose content was higher (5.02%) in milk samples with low somatic cell levels than in ones with higher somatic cell counts (4.63%). Results of milk sample analyses for ewes of the same breed with low (<500 000/ml), moderate (500 000-1000 000/ml) and high (1 000 000-2 000 000/ml) SCCs showed significantly more lactose (4.74 g/100 g milk) in milk with a low somatic cell count than in milk from the other two groups, 4.54 and 4.38 g/100 g milk, respectively ($P<0.01$) (Pirisi et al., 2000).

In Sarda ewes, a higher milk yield was found in milk with an SCC<1 000000/ml than in milk with an SCC >1 000 000/ml, 1104 and 1015 g/d, respectively (Nudda et al., 2003). No significant differences were recorded in fat content in milk (g/l) in classes of somatic cells: <500 000; 500 000-1 000 000 and >1 000 000/ml. However, total protein content was significantly higher in milk in the class of somatic cell level >1 000 000/ml (53.57 and 53.17 vs 55.05 g/l). A reduction of lactose content with increasing numbers of somatic cells amounting to 45.33 and 44.42 vs 42.35 g/l, respectively, was also observed ($P<0.01$).

Albenzio et al. (2004) investigated the percentages of protein, fat and lactose in two groups of Comisana ewes with different levels of somatic cells in milk. Groups were LSCC (low SCC) when the SCC content was below 500 000/ml and HSCC (high SCC) when it exceeded 1 000 000/ml. In ewes from group HSCC, a higher percentage of total protein was recorded in early and late lactation (5.86 and 6.27%) than in ewes from group LSCC (5.40 and 5.99%). In milk from group HSCC in early, middle and late lactation, the lactose content was a significantly lower (4.47, 4.08 and 3.70%, respectively) than in milk of ewes from group LSCC (4.81, 4.59 and 4.36%) ($P<0.05$). According to those authors, the stage of lactation had an effect on the protein and lactose contents in ewe milk ($P<0.001$), while SCC × stage of lactation interactions were statistically non-

significant. The results of the investigations reported by Albenzio et al. (2004) did not show any effect of the somatic cell level on the fat percentage in milk. The fat concentration depended significantly on the stage of lactation. According to those authors, the effects of SCC on milk fat are controversial. Milk yield declined with lactation stage, whereas fat and protein contents increased and lactose content decreased (Ploumi et al., 1998). According to Sevi et al. (2004) milk composition in Comisana ewes was affected by the stage of lactation and lambing season. El-Saied et al. (1998) found that log SCC (≤250 000) was not affected by the stage of lactation and type of birth of ewes.

Bianchi et al. (2004) reported for Sardinian ewes that an udder was assumed to be healthy when the SCC of each milk sample collected 3 times from each ewe at regular intervals during May to July was <500 000 cells/ml, infected when for at least 2 samples SCC values were >1 million cells/ml, and doubtful in the other cases. In milk from healthy mammary glands, higher contents of lactose and fat were recorded, equaling 4.65 and 7.06%, respectively, than in milk from infected glands, with 4.51 and 6.16%, respectively ($P<0.05$). Total protein content was higher in milk from infected mammary glands (5.95%) than in milk from healthy udders (5.47%).

In Assaf × Churra and Castelana crossbred ewes, Vivar-Quintana et al. (2006) observed a significant decrease in the lactose concentration ($P<0.05$) with SCC, but SCC did not significantly affect fat or protein contents of milk.

The difference in milk yield between Lacune ewes with low (SCC<1×10^5 cells/ml) and high (SCC> 5×10^5 cells/ml) SCCs was about 14% of the average milk yield (Pellegrini et al., 1997). Milk yield losses in Churra ewes ranged from 3 to 10%, depending on the organism group (a minor vs major pathogen) and the uni- or bilateral character of infection (Gonzalo et al., 2002).

Lower levels of phenotypic correlation coefficients between log SCC and fat percentage in milk of Churra ewes have been reported, i.e. 0.01 (Fuertes et al., 1998) and 0.04 (Othmane et al., 2002). Riggio et al. (2007) estimated the value of the phenotypic correlation coefficient between SCS (Somatic Cell Score) and fat content in milk (%) at 0.14 in Valle del Belice ewes.

Similar values to those recorded in this study were reported for correlation coefficients between log SCC and protein content in milk of Churra ewes, equaling 0.16 (El-Saied et al., 1998) and 0.13 (Othmane et al., 2002) based on ln SCC and protein content in g/l. A lower correlation coefficient of 0.09 between these traits was given by Fuertes et al. (1998). Riggio et al. (2007) reported a correlation coefficient between SCS and protein content in milk of Valle del Belice ewes of 0.25.

Lower correlation coefficients than those calculated in this study between log SCC and lactose percentage in milk were reported by Fuertes et al. (1998),

who estimated the value of this coefficient in Churra ewes to be -0.29, while Othmane et al. (2002) reported -0.12 (ln SCC and lactose content in milk in g/l).

Correlation coefficients similar to those given in this study for the correlation between contents of fat and protein in milk were reported by Fuertes et al. (1998), Othmane et al. (2002) and Riggio et al. (2007), being 0.76, 0.62 and 0.53, respectively. Correlation coefficients between contents of protein and lactose in the milk of Churra ewes given by other authors were on the same level (-0.41) as those recorded in this study (Othmane et al., 2002) or higher (-0.61) (Fuertes et al., 1998). Correlation coefficients between log SCC and milk production for Churra ewes have been reported to be negative -0.10 (Fuertes et al., 1998) and -0.15 (El-Saied et al., 1998).

CONCLUSIONS

In the present study, in milk of line 05 dairy ewes the fat and protein contents increased and lactose concentration decreased when somatic cell counts (SCC) increased to above 250×10^3 cells/ml. Milk yield, SCC in milk samples from udder halves and milk composition depended on the level of SCC recorded in milk from udder halves. SCC in milk from one or both udder halves exceeding 250×10^3 cells/ml resulted in a statistically significant ($P<0.01$), about 20.7%, decrease in daily milk production of ewes.

Correlation coefficients between log SCC and percentages of fat and protein in milk were positive and amounted to 0.24 and 0.18, respectively. The correlation coefficient between log SCC and lactose percentage was negative (-0.49).

REFERENCES

Albenzio M., Caroprese M., Santillo A., Marino R., Taibi L., Sevi A., 2004. Effects of somatic cell count and stage of lactation on the plasmin activity and cheese-making properties of ewe milk. J. Dairy Sci. 87, 533-542

Ali A.K.A., Shook G.E., 1980. An optimum transformation for somatic cell concentration in milk. J. Dairy Sci. 63, 487-490

Bianchi L., Bolla A., Budelli E., Caroli A., Casoli C., Pauselli M., Duranti E., 2004. Effect of udder health status and lactation phase on the characteristics of Sardinian ewe milk. J. Dairy Sci. 87, 2401-2408

El-Saied U.M., Carriedo J.A., De La Fuente L.F., San Primitivo F., 1999. Genetic parameters of lactation cell counts and milk and protein yields in dairy ewes. J. Dairy Sci. 82, 639-644

El-Saied U.M., Carriedo J.A., San Primitivo F., 1998. Heritability of test day somatic cell counts and its relationship with milk yield and protein percentage in dairy ewes. J. Dairy Sci. 81, 2956-2961

Fuertes J.A., Gonzalo C., Carriedo J.A., San Primitivo F., 1998. Parameters of test day milk yield and milk components for dairy ewes. J. Dairy Sci. 81, 1300-1307

Gonzalo C., Ariznabarreta A., Carriedo J.A., San Primitivo F., 2002. Mammary pathogens and their relationship to somatic cell count and milk yield losses in dairy ewes. J. Dairy Sci. 85, 1460-1467

Jaeggi J.J., Govindasamy-Lucey S., Berger Y.M., Johnson M.E., Mc Kusik B.C., Thomas D.L., Wendorff W.L., 2003. Hard ewe's milk cheese manufactured from milk of three different groups of somatic cell counts. J. Dairy Sci. 86, 3082-3089

Leitner G., Silanikove N., Merin U., 2008. Estimate of milk and curd yield loss of sheep and goats with intramammary infection and its relation to somatic cell count. Small Ruminant Res. 74, 221-225

Nudda A., Feligini M., Battacone G., Macciotta N.P.P., Pulina G., 2003. Effects of lactation stage, parity, β-lactoglobulin genotype and milk SCC on whey protein composition in Sarda dairy ewes. Ital. J. Anim. Sci. 2, 29-39

Olechnowicz J., Sobek Z., 2007. Level of production and basic composition of milk in dairy sheep line 05 (in Polish). Med. wet. 63, 1595-1599

Othmane M.H., Carriedo J.A., De La Fuente L.F., San Primitivo F., 2002. Factors affecting test-day milk composition in dairy ewes, and relationships amongst various milk components. J. Dairy Sci. 69, 53-62

Pellegrini O., Remeuf F., Rivemale M., Barillet F., 1997. Renneting properties of milk from individual ewes: influence of genetic and non-genetic variables, and relationship with physicochemical characteristics. J. Dairy Res. 64, 355-366

Pengov A., 2001. The role of coagulase-negative *Staphylococcus* spp. and associated somatic cell counts in the ovine mammary gland. J. Dairy Sci. 84, 572-574

Pirisi A., Piredda G., Corna M., Pes M., Pintus S., Ledda A., 2000. Influence of somatic cell count on ewe's milk composition, cheese yield and cheese quality. In: Proceedings of 6th Great Lakes Dairy Sheep Symposium. Guelph (Canada), pp. 47-59

Pirisi A., Piredda G., Podda F., Pintus S., 1996. Effect of somatic cell count on sheep milk composition and cheese-making properties. In: Somatic Cells and Milk of Small Ruminants. Symposium on Somatic Cells and Milk of Small Ruminants. EAAP Publication 77. Bella (Italy), pp. 245-251

Ploumi K., Belibasaki S., Triantaphyllidis G., 1998. Some factors affecting daily milk yield and composition in a flock of Chios ewes. Small Ruminant Res. 28, 89-92

Riggio V., Finocchiaro R., van Kaam J.B., Portolano B., Bovenhuis H., 2007. Parameters for milk somatic cell score and relationships with production traits in primiparous dairy sheep. J. Dairy Sci. 90, 1998-2003

SAS, 2000. SAS OnlineDoc, Version 8. SAS Institute Inc. Cary, NC

Sevi A., Albenzio M., Marino R., Santillo A., Muscio A., 2004. Effects of lambing season and stage of lactation on eve milk quality. Small Ruminant Res. 51, 251-259

Vivar-Quintana A.M., Beneitez De La Mano E., Revilla I., 2006. Relationship between somatic cell counts and the properties of yoghurt made from ewes' milk. Int. Dairy J. 16, 262-267