Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)
Available online at www.inia.es/sjar

Spanish Journal of Agricultural Research 2010 8(2), 334-341
ISSN: 1695-971-X

# Management and sanitary practices in ewe dairy farms and bulk milk somatic cell count

A. Molina[1,2]*, M. Yamaki[1,2], M. I. Berruga[1,2], R. L. Althaus[3] and M. P. Molina[4]

[1] *Departamento de Ciencia y Tecnología Agroforestal. ETSIA. Universidad de Castilla-La Mancha. 02071 Albacete. Spain*
[2] *Sección de Calidad Alimentaria. Instituto de Desarrollo Regional. Universidad de Castilla-La Mancha. 02071 Albacete. Spain*
[3] *Cátedra de Biofísica. Facultad de Ciencias Veterinarias. Universidad Nacional del Litoral. 3080 Esperanza. Argentina*
[4] *Departamento de Ciencia Animal. Universidad Politécnica. 46071 Valencia. Spain*

## Abstract

This study was done to establish relationships between management and sanitary practices on ewe dairy farms and the quality of milk produced. For this purpose, a survey was carried out on 118 farms and a total of 121,117 animals in the Castilla-La Mancha region (Southeast Spain) in which the veterinarians of the Association of Sanitary Defence participated. Flocks varied considerably in size, ranging from 120-7,200 sheep, with an average milking period lasting 3-5 months and milk yields of between 50 and 150 litres per lactation by mechanical systems on 75.0% of farms. Sanitary practices during milking are still not commonplace; 53.3% performed post milking teat disinfection, 37.0% did the California mastitis test, 31.1% had a dry therapy programme and only 18.6% of farms kept records of animals with clinical mastitis. Nonetheless, the results revealed that 42.7% of the farms surveyed showed good quality hygienic milk (bulk milk somatic cell count, BMSCC $< 600 \times 10^3$ cells mL$^{-1}$). On most farms, the rate of animals with clinical mastitis was less than 5.0%, while that of subclinical mastitis cases was less than 5.0% on 25.6% of farms. Certain factors like mechanical milking, post milking teat disinfection, recording animals with clinical mastitis and controlling the frequency of animals with subclinical mastitis did not exceed 5.0%. Those risk factors for increased BMSCC levels were significant. Therefore, farmers are recommended to bear these factors in mind, and to instil the importance of carrying out these practices when implementing a good dairy farm practices system.

**Additional key words**: ewe milk, good dairy farming practices, milk quality.

## Resumen

### Prácticas de manejo e higiénico-sanitarias en las explotaciones lecheras y recuento de células somáticas en leche de tanque

El trabajo se llevó a cabo para conocer las condiciones higiénico-sanitarias de las explotaciones de ovino manchego, y su posible relación con la sanidad de la ubre y la calidad de la leche obtenida. Para ello se elaboró una encuesta que se dirigió a los veterinarios responsables de Agrupaciones de Defensa Sanitaria de Castilla-La Mancha. Se analizaron las encuestas de 118 explotaciones, que incluyen un total de 121.117 animales de ordeño. Los resultados obtenidos mostraron que, a pesar de la enorme variabilidad en el tamaño de las explotaciones (desde 120 hasta 7.200 ovejas), la mayoría de ellas poseen sala de ordeño (75%), siendo la duración media del ordeño entre 3-5 meses y la producción de leche por oveja y lactación entre 50-150 L. Las prácticas sanitarias durante el ordeño no están muy extendidas, ya que el 53,3% realiza sellado postordeño, el 37,0% lleva a cabo el test de California, el 31,1% sigue la terapia de secado y el 18,6% de las explotaciones registra a los animales con mastitis. Del total de explotaciones encuestadas, 42,7% producen leche con un recuento de células somáticas $< 600 \times 10^3$ células mL$^{-1}$. La mayoría de ellas posee valores por

* Corresponding author: ana.molina@uclm.es
Received: 06-07-09; Accepted: 23-03-10.

Abbreviations used: ASD (Association of Sanitary Defence), BMSCC (bulk milk somatic cell count), CMT (California mastitis test), GDFP (good dairy farm practices), HACCP (hazard analysis and critical control point), PDO (protected designation of origin), SCC (somatic cell count).

debajo del 5% de animales con mastitis clínicas, y entre las subclínicas, más de la cuarta parte de las granjas (25,6%) tienen una incidencia < 5%. Prácticas como el ordeño mecánico, el sellado postordeño, el registro de animales con mastitis clínicas y controlar que la frecuencia de animales con mastitis subclínica no supere el 5% fueron significativos factores de riesgo del incremento del recuento de células somáticas en tanque. En conclusión, cuando se pretenda implantar un programa de buenas prácticas ganaderas en un grupo de explotaciones de ovino de leche, es recomendable incorporarlas para mejorar el recuento celular y por lo tanto la calidad higiénico-sanitaria de la leche producida.

**Palabras claves adicionales**: buenas prácticas ganaderas, calidad de leche, oveja.

# Introduction

In recent years, ewe dairy farming has become more important thanks to genetic selection and to better feeding conditions (Haenlein, 2007) which have led to higher milk yields and improved milk quality. Sheep milk is mainly destined for dairy products, basically pure sheep cheeses, but also mixed types (Pirisi *et al.,* 2007). Many of these products have a distinction of quality (Protected Denomination of Origin (PDO) etc.), which involves basic food products having certain quality standards. The quality of PDO products must be guaranteed, which is a practice that starts on the farm. Currently, the production guidelines and marketing standards for hygienic quality milk within the food safety framework are set by Council Directives 92/46/EC and 94/71/EC (OJ, 1992, 1994).

European guideline compliance has greatly improved the quality of milk on sheep dairy farms (Gallego, 2002; Gonzalo *et al.,* 2005; Pirisi *et al.,* 2007) thanks to the cooperation of dairy farmers, veterinarians and laboratory technicians. Quality control systems for milk payments have been defined and applied. The hazard analysis and critical control point (HACCP) is the official quality management method for dairy industry milk (Cullor, 1997). On dairy farms, good dairy farming practices (GDFP) guarantee the hygienic quality of the milk, and include (EC) 852/2004 and (EC) 853/2004 (OJ, 2004a,b) regulations. These food safety guidelines encourage the GDFP in which different aspects, such as animal health, milk hygiene, animal feed and water, animal welfare and the environment, are integrally controlled. It is necessary to develop milk quality and safety improvement programmes for ewe dairy farms which adapt to their particular production conditions (Bencini and Pulina, 1997; Bergonier and Berthelot, 2003; Serrano *et al.,* 2003; Gonzalo *et al.,* 2005).

Many authors consider that somatic cell count (SCC) values are not only valuable indicators of udder health, but also indirectly reveal parameters for sanitary control and management practices (Paape *et al.,* 2001). In cows, the factors associated with a low bulk milk somatic cell count (BMSCC) are those related to improved environmental and hygiene applications before and during milking (Tadich *et al.,* 2003; Jayarao *et al*., 2004). Currently, there is a regulatory limit set for this species by Council Directives 92/46/EC and 94/71/EC. However, despite there being no set maximum BMSCC or individual SCC values for the milk of small ruminants, there appears to be good agreement (De la Cruz *et al.,* 1994; González-Rodríguez *et al.,* 1995; Gonzalo *et al.,* 2005) as to considering that BMSCC values over 500-600 $\times 10^3$ cell mL$^{-1}$ would be associated with an increased prevalence of mammary infections and with significant losses in the milk production of small ruminants. Therefore it is necessary to conduct studies which could help improve the hygiene-sanitary quality of ewe's milk by firstly improving the BMSCC.

With this in mind, the aim of our work was to study the characteristics of ewe dairy farms in terms of management and sanitary practices during milking and their relationship with milk quality and udder health. This work is considered necessary before implementing a GDFP system to guarantee the sanitary quality of milk destined for cheese making.

# Material and methods

A questionnaire was drawn up (Table 1) to obtain information about general farm management characteristics and sanitary practices during milking as regards milk hygiene. A total of 490 ewe dairy farms located in Castilla-La Mancha (Southeast Spain) participated in the survey which was conducted over one complete year. These dairy farms supplied milk for PDO Manchego Cheese production and participated in a study into the presence of antibiotic residues and the methods to detect inhibitors in ewe's milk (Yamaki *et al.,* 2004, 2006).

**Table 1.** List of questions in the survey

| | | |
|---|---|---|
| General farm management characteristics | Flock size (animals) | < 500 / 500-1000 / > 1,000 |
| | Milking period (months) | < 3 / 3-5 / >5 |
| | Milk yield (L) | < 50 / 50-100 / 100-150 / 150-200 / > 200 |
| | Dry-off period (months) | 1 / 2 / > 2 |
| | Doing partial suckling | Yes / No |
| | Doing artificial suckling | Yes / No |
| | Milking procedures | Mechanical / Manual |
| Sanitary practices in milking | Bulk milk cell counts mL$^{-1}$ ($\times 10^3$) | <600 / >600 |
| | Checking milking machine (times yr$^{-1}$) | Sometimes / Once / Twice / More than twice |
| | Teat disinfection in post-milking | Yes: Only mastitis cases<br>Only first two weeks<br>After every milking<br>No |
| | Keeping records of animals with clinical mastitis | Yes / No |
| | Dry therapy | Yes / No |
| | Using the California mastitis test | Yes: < 25% in the flock<br>>25% in the flock<br>No |
| | Ratio of animals with clinical mastitis in the flock (%) | <5 / 5-10 / 10-15 / >15 |
| | Ratio of animals with sub-clinical mastitis in the flock (%) | <5 / 5-10 / 10-15 / >15 |

The questionnaire was completed with the help of the veterinarians in charge of the sanitary control on ewe dairy farms in Castilla-La Mancha. A total of 118 questionnaires were answered, whose results are provided in this work and which include information obtained from a total of 121,117 ewes.

## Statistical analysis

A multiple logistic regression model (Hosmer and Lemeshow, 1989) was conducted to test the effects of two groups of factors: general farm management characteristics and sanitary practices during milking and their effect on BMSCC levels. The data collected from the questionnaires were entered as binary factors as follows: BMSCC levels were coded as high (0: BMSCC $< 600 \times 10^3$ cells mL$^{-1}$) and low (1: BMSCC $> 600 \times 10^3$ cells mL$^{-1}$).

Each factor group was tested separately according to models [1] and [2]. After firstly analysing the logistic regression models, all the significant factors of each group were reassessed together. A forward stepwise procedure was used to test the final model [3] and was based on the significance tests done on the change in deviance (indicated D) when including, or not, factors in the model. This statistic is approximately distributed as a chi-square with the appropriate degree of freedom. Wald's statistic tested whether the coefficients (and the constant) of the model were significant. All the analyses were done with SPSS (SPSS, vers 15).

$$\begin{gathered} \mathrm{L}ijklmno = \beta 0 + \beta 1[\mathrm{FS}]i + \beta 2\ [\mathrm{MP}]j + \\ + \beta 3\ [\mathrm{MY}]k + \beta 4\ [\mathrm{DP}]l + \beta 5\ [\mathrm{PS}]m + \\ + \beta 6\ [\mathrm{AS}]n + \beta 7\ [\mathrm{Mp}]o + \varepsilon ijklmno \end{gathered} \tag{1}$$

$$\begin{gathered} \mathrm{L}ijklmno = \beta 0 + \beta 1\ [\mathrm{ChM}]i + \\ + \beta 2\ [\mathrm{TD}]j + \beta 3\ [\mathrm{KR}]k + \beta 4\ [\mathrm{DT}]l + \\ + \beta 5\ [\mathrm{CMT}]m + \beta 6\ [\mathrm{RCM}]n + \\ + \beta 7\ [\mathrm{RSM}]o + \varepsilon ijklmno \end{gathered} \tag{2}$$

$$\begin{gathered} \mathrm{L}ijkl = \beta 0 + \beta 1\ [\mathrm{Mp}]i + \beta 2\ [\mathrm{TD}]j + \\ + \beta 3\ [\mathrm{KR}]k + \beta 4\ [\mathrm{RSM}]l + \varepsilon ijkl \end{gathered} \tag{3}$$

where FS: flock size, MP: milking period, MY: milk yield, DP: dry-off period, PS: doing partial suckling, AS: doing artificial suckling, Mp: milking procedures, ChM: checking milking machine, TD: teat disinfection in post-milking, KR: keeping records of animals with clinical mastitis, DT: dry therapy, CMT: California mastitis test, RCM: ratio of animals with clinical mastitis in the flock, and RSM: ratio of animals with sub-clinical mastitis in the flock.

## Results

The general farm management characteristics group revealed that flock sizes varied considerably, ranging from 120 to 7,200 animals with a mean size of 1,035 ewes. Group distribution was well balanced as 35.9% (42/117) of the farms had less than 500 animals; 35.9% of the farms had 500-1,000 animals, and 28.2% had more than 1,000 animals.

As regards milking periods (Fig. 1), a large percentage of farms (72.4%: 84/116) milked for periods of 3-5 months, while 19.8% of the surveyed farms milked less than 3 months. A close relationship was found between the milking period and the milk yield as 79.7% (75/94) of both the intermediate yield levels (50-100 and 100-150 L) were obtained for milking periods of over 3-5-months. The groups which presented the highest yield of 150-200 L (6.8%) and over 200 L (4.2%) could be linked to those farms highly specialized in dairy production. Other data related to the handling practices during milking indicated that the dry off period lasted 2 months on roughly half the farms (51.9%; 54/104), while a similar percentage of farms (57/107) undertook partial suckling. Nonetheless, 95.7% (110/115) of the farms did not carry out artificial suckling.

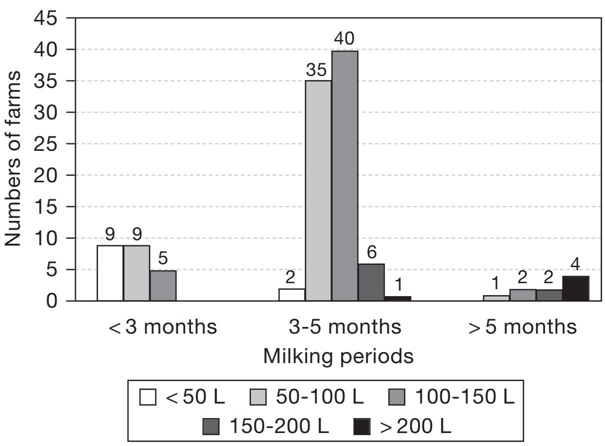


**Figure 1.** Farm distribution related to milking period and milk yield (n = 116).

A forward stepwise logistic regression model was carried out according to [1]. The effect of the farm management factors on the BMSCC level was statistically significant ($D_{1,104} = 5.643$, $P < 0.05$), and showed that only one factor, mechanical milking, was affected by BMSCC $> 600 \times 10^3$ cells $mL^{-1}$ (the coefficient for mechanical milking, –1.224, Wald's test = 5.158, $df = 1$, $P = 0.023$). Moreover, the negative significance noted with the BMSCC could indicate that the less frequent mechanical milking, the greater the risk of increasing BMSCC values (data not shown).

Regarding the sanitary milking practices associated with milk hygiene, the information obtained from the survey showed that 42.7% (47/110) of the farms obtained a high BMSCC ($< 600 \times 10^3$ cells $mL^{-1}$), whereas over half of them (57.3%) obtained a low BMSCC ($> 600 \times 10^3$ cells $mL^{-1}$).

In terms of milking procedures, 74.6% (88/118) of farms did mechanical milking, whereas only 25.4% manually milked. All the farms with mechanical milk systems had records of checking the milking machine. However, such maintenance was recorded once or twice a year for 70.4% (62/88) of farms, while 15.9% of farms recorded such checks more than twice a year.

The survey into post milking teat disinfection revealed that this practice has been slowly incorporated onto ewe dairy farms given that 53.3% (63/118) of farms actually performed this. The frequency distribution of post milking tip dipping demonstrated that 31.4% of farms conducted this practice after each milking, 16.9% (20/118) did so with only mastitis cases, and 5.1% did so in the first two weeks of milking.

In this study, only 18.6% (22/118) of farms kept records of animals with clinical mastitis. Furthermore, 31.4% (37/118) of farms answered the questions about dry therapy; moreover, 43 of the 118 farms carried out the CMT, indicating that this practice was less wide in small dairy ruminants than in dairy cattle, and that it should be extended because it improves the hygienic quality of milk and helps detect those animals infected by subclinical mastitis.

Concerning clinical and subclinical mastitis, the results of the questionnaire indicated that 82.7% (81/98) of the farms claimed they had less than 5.0% of clinical mastitis cases in their flocks. However, 25.6% (22/86) of farms had less than 5.0% of cases of subclinical mastitis among their flocks. The highest rate was 5-10% (40.7%), while 22.1% of farms presented a rate of 10-15%. A low rate (11.6%) was observed for more than 15.0% of subclinical mastitis cases in flocks.

The effect of the sanitary practices associated with milk hygiene on the BMSCC level was statistically significant ($D_{7,86} = 65.428$, $P < 0.001$). Indeed, the significant factors with a BMSCC value of $> 600 \times 10^3$ cells $mL^{-1}$ were associated with post milking teat disinfection ($P = 0.005$), keeping records of animals with clinical mastitis ($P = 0.024$), and the rate of animals with subclinical mastitis in flocks ($P = 0.004$) (data not shown).

A final logistic regression model [3] was carried out to assess the four above-mentioned statistically significant factors together with BMSCC $> 600 \times 10^3$ cells $mL^{-1}$ (Table 2; $D_{7,86} = 68{,}433$, $P < 0.001$). The associated factors were post milking teat disinfection ($P = 0.007$), keeping records of animals with clinical mastitis ($P = 0.015$), and the rate of animals with subclinical mastitis in flocks ($P = 0.002$), while mechanical milking was not significant ($P = 0.997$).

When the post milking teat disinfection factor was compared with the remaining factors by using the «after every milking» option, the results revealed that the options «did not do this» or «only for mastitis cases» were significant practices in both positive and statistical terms ($P = 0.003$ and $P = 0.029$, respectively). However, conducting this practice in the first two weeks was not significant ($P = 0.361$).

As regards keeping records of animals with subclinical mastitis, a negative significance was observed for a high BMSCC (coefficient, –2.282, Wald's test = 5.903, $df = 1$, $P = 0.015$; Table 2) in relation to not keeping records. When comparing the change in the BMSCC levels to the rate of animals with subclinical mastitis above 15.0% in flocks, only the < 5% group was seen to be negatively associated with a high BMSCC ($P = 0.017$), while the remaining rates ranged from 5-10% ($P = 0.231$) to 10-15% ($P = 0.861$), were not significant.

## Discussion

The SCC in milk is a reliable parameter to indirectly diagnose the health status of mammary glands (De la Cruz *et al.,* 1994; Bencini and Pulina, 1997; Paape *et al.,* 2001; Gonzalo *et al.,* 2002; Contreras *et al.,* 2007) and is, therefore, an effective tool to control mammary illnesses like mastitis. Factors such as breed, flock, animal's age, lactation stage, udder health and hygiene, and handling during milking, all influence SCC values (Bergonier and Berthelot, 2003; Gonzalo *et al.,* 2005). Consequently, these values are not only necessary indicators of milk quality in sanitary terms, but also indirectly reveal parameters for sanitary control and management practices on small ruminant dairy farms (González-Rodríguez *et al.,* 1995; Gonzalo *et al.,* 2005). On 42.7% of the farms surveyed, the BMSCC was $< 600 \times 10^3$ cells $mL^{-1}$, and these results coincide with other studies done previously on the Manchegan breed (Serrano *et al.,* 2003).

In the survey, flock size distributed almost equally in each category, and this distribution could be explained by the different production systems in the study

**Table 2.** Results of the final logistic regression model with the factors associated with BMSCC $> 600 \times 10^3$ cells $mL^{-1}$

| Factor | Estimated regression model | | | |
|---|---|---|---|---|
| | Estimate | Likelihood ratio test (chi-square) | *df* | *P* |
| | Constant = 2.161 | 0.983 | 1 | 0.322 |
| Using post-milking teat disinfection[a] | | 12.144 | 3 | 0.007 |
| No | 3.049 | 9.010 | 1 | 0.003 |
| Only mastitis cases | 2.166 | 4.786 | 1 | 0.029 |
| First two weeks | –1.621 | 0.834 | 1 | 0.361 |
| Keeping records of animal with clinical mastitis[b] (yes) | –2.282 | 5.903 | 1 | 0.015 |
| % of animals with sub-clinical mastitis in the flock[c] | | 14.967 | 3 | 0.002 |
| < 5% | –5.628 | 5.658 | 1 | 0.017 |
| 5-10% | –2.608 | 1.437 | 1 | 0.231 |
| 10-15% | 0.402 | 0.030 | 1 | 0.861 |

The estimation change of the BMSCC levels in relation to the reference level of: [a] using teat disinfection after every milking; [b] not keeping a record of animal with sub-clinical mastitis; [c] more than 15% animals in the flock with sub-clinical mastitis.

area which ranged from semi-extensive to intensive (Gallego, 2002). The majority of farms reported milking their animals for 3 to 5 months (72.4%) and performing dry off for 2 months or for more than 2 months (84.6%). These results coincide with those of other studies carried out in the La Mancha area and are associated with a reproduction cycle of 3 parturitions in two years (Gallego, 2002). Of all the farms surveyed, 19.8% stated they milked less than 3 months on account of their mixed production (meat and milk). The rest of the farms mentioned long milking periods (over 5 months), which could be due to them having animals with a high potential milk production, a reproduction rate of 1 parturition per year in many cases, or being in the breed selection scheme. With regard to the average milk yield, the majority of the farms (94/118) responded between 50 to 100 L and 100 to 150 L. These yields came close to the estimated average yield in the region of the local breed, that is, the Manchega breed (Gallego, 2002; Serrano *et al.,* 2003).

The partial suckling method involved milking ewes and nursing lambs during the lactation period, which was done simultaneously. In this study, half the farms carried out this method since its offers a series of advantages such as increased marketable milk and the progressive weaning of lambs without affecting their subsequent growth. However, artificial suckling, as the most commonly used method on dairy goat farms, was not as extended on dairy sheep farms.

Mechanical milking was seen to be a highly extended practice among the farms surveyed, and was slightly higher than that which other authors have observed (Gallego, 2002). This could possibly be due to the expansion of new milking parlours thanks to the favourable perspectives on the price of ewe's milk in the study area in recent years. Indeed, it was one of the reasons that has contributed to improving milk quality. According to the analysis done in the stepwise logistic regression model for farm management characteristics, only mechanical milking was seen to be statistically and negatively significance with a BMSCC of $> 600 \times 10^3$ cells $mL^{-1}$. In other words, it is somewhat difficult to keep good BMSCC levels with manual milking because of the complexity involved in sustaining sanitary conditions (Bencini and Pulina, 1997; Gonzalo *et al.,* 2006, 2009). After the analysis of the stepwise logistic regression model however, we did an assessment with the significant variables of the group of hygiene practices associated with milk hygiene. This factor was seen to be non-significant ($P = 0.997$) in terms of high BMSCC levels (see Table 2), suggesting that performing hygiene practices was a more important factor to maintain good quality milk with desirable BMSCC levels.

With regard to checking milking machines, this factor was not associated with the BMSCC ($P = 0.163$). However, various authors have mentioned the importance of maintaining milking machines because if they did not work properly, they could markedly influence the sanitary condition of ewes' udders. The value obtained was low (70.4%) if we bear in mind that optimising milk machine standards and periodically checking milking equipment should be carried out if these measures are to improve the health of flocks (Gonzalo *et al.,* 2005; Contreras *et al.,* 2007).

One of the effective prevention methods to avoid mammary infections is post milking teat disinfection, which has mainly been applied in highly infected flocks of small ruminants (Paape *et al.,* 2001; Begonier and Berthelot, 2003). This is a very important finding given the effectiveness of the prevention method to avoid mammary infections as this practice prevents mastitis pathogens from penetrating the teat canal which remains open for some time after milking, thus preventing exposure to possible contamination (Contreras *et al.,* 2007). This factor was associated with a high BMSCC when assessed with only the hygiene practice variables (Model [2]) and when tested with all the significant variables (Model [3]). The risk of new bacterial infections occurring during lactation could increase during the weaning period in sheep (Gonzalo *et al.,* 2006). This study indicated that many farms perform partial suckling, and that this period coincided with the final weaning and the beginning of the milking period when ewes were more exposed to high-risk infection. Therefore, the result of the estimation change of the BMSCC levels could be accounted for by applying this practice after each milking in order to maintain appropriate BMSCC levels. However, applying this practice only in mastitis cases affected the BMSCC levels just as not performing this practice did (Paape *et al.,* 2001; Jayarao *et al.,* 2004).

To improve milk quality, it is useful to administer an intramammary antibiotic during the dry off period since this treatment is able to reduce old infections, or even new ones which might appear during the dry off period (Paape *et al.,* 2001; Gonzalo *et al.,* 2005, 2006, 2009). The affirmative response rate to antibiotic treatment during dry off periods was lower than in cattle dairy farms where this treatment is employed routinely

(Jayarao *et al.,* 2004). However, applying antibiotic treatment during the dry off period in this study was not significant in the BMSCC in model [2] ($P = 0.463$).

Another tool to indirectly diagnose subclinical mastitis is the CMT. Even though it was not significant with a high BMSCC ($P = 0.103$) in this study, this test could estimate the cellular count semi-quantitatively, and it proves most useful on farms because it is swift, simple to use and low-cost (Hueston *et al.,* 1986; Paape *et al.,* 2001). Furthermore, all the cited authors have mentioned its convenient use for selective antibiotic therapy during dry off periods to avoid excessive administration in healthy udders and residue contamination in milk (Paape *et al.,* 2001). Consequently, it could be necessary to apply this practice in a higher percentage of animals in flocks to obtain more benefits.

In relation to keeping records of animals with subclinical and clinical mastitis, all the frequencies obtained were within the intervals described for small ruminants (Begonier and Berthelot, 2003; Contreras *et al.,* 2007). In this study, the keeping of records of animals with clinical mastitis factor associated negatively with a high BMSCC by the first ($P = 0.024$: data not shown) and the final ($P = 0.015$) stepwise logistic regression models. Various authors (Schultz, 1997; Tadich *et al.,* 2003) have reported how the effect of a few animals with an extremely high individual SCC was particularly noticeable in relation to the BMSCC levels in the flock. Therefore, it is important that farmers keep records of the animals with clinical mastitis to avoid mixing bad quality milk with good quality milk. Regarding the change in the BMSCC levels of the rate of animals with sub-clinical mastitis being over 15%, only less than 5% associated negatively with a high BMSCC ($P = 0.017$). According to Gonzalo *et al.* (2002), the BMSCC levels related to the severity of subclinical mastitis in ewes. Therefore, farmers and veterinarians should pay more attention to treating infected animals in a flock with a subclinical mastitis rate over 5% in order to improve milk quality.

In conclusion, the importance of factors like mechanical milking, post milking teat disinfection, recording animals with clinical mastitis and controlling the frequency of animals with subclinical mastitis not exceeding 5.0%, are related with increased BMSCC levels and should, therefore, be considered on ewe dairy farms. It is also necessary for ewe dairy farmers to instil the importance of carrying out these practices when implementing a good dairy farm practices system.

## Acknowledgements

This work has been funded by the 191/IA-40 project from the Regional Ministry of Agriculture and the Environment (Junta de Comunidades de Castilla-La Mancha, Spain). The authors would like to thank the farmers and veterinarians in charge of the sanitary control of ewe dairy farms in Castilla-La Mancha for their invaluable help in the experiment. Special thanks go to Professors T. Landete-Castillejos and R. Bernabéu for their assistance with the methodology and statistical analyses.

## References

BENCINI R., PULINA G., 1997. The quality of sheep milk: a review. Aust J Exp Ag 37, 485-504.

BERGONIER D., BERTHELOT X., 2003. New advances in epizootiology and control of ewe mastitis. Liv Prod Sci 79, 1-16.

CONTRERAS A., SIERRA D., SÁNCHEZ A., CORRALES J.C., MARCO J.C., PAAPE M.J., GONZALO C., 2007. Mastitis in small ruminants. Small Rumin Res 68, 145-153.

CULLOR J.S., 1997. HACCP (hazard analysis critical control points): is it coming to the dairy? J Dairy Sci 80, 3449-3452.

DE LA CRUZ M., SERRANO E., MONTORO V., MARCO J., ROMEO M., BALSEGA R., ALBIZU I., AMORENA B., 1994. Etiology and prevalence of subclinical mastitis in the Manchega sheep at mid-late lactation. Small Rumin Res 14, 175-180.

GALLEGO R., 2002. Análisis de estructuras y sistemas de producción en el sector del ganado ovino manchego. Available at http://www.libroblancoagricultura.com/libroblanco/jautonomica/c_mancha/comunicaciones/gallego.pdf. [15.05.2008]. [In Spanish].

GONZÁLEZ-RODRÍGUEZ M.C., GONZALO C., SAN PRIMITIVO F., CÁRMENES P., 1995. Relationship between somatic cell count and intramammary infection of the half udder in dairy ewes. J Dairy Sci 78, 2759-2759.

GONZALO C., ARIZNABARRETA A., CARRIEDO J.A., SAN PRIMITIVO F., 2002. Mammary pathogens and their relationship with somatic cell count and milk yield loss in dairy ewes. J Dairy Sci 85, 1460-1467.

GONZALO C., CARRIEDO J.A., BLANCO M.A., BENEITEZ E., JUÁREZ M.T., DE LA FUENTE L.F., SAN PRIMITIVO F., 2005. Factors of variation influencing bulk tank somatic cell count in dairy sheep. J Dairy Sci 88, 969-974.

GONZALO C., CARRIEDO J.A., BENEITEZ E., JUÁREZ M.T., DE LA FUENTE L.F., SAN PRIMITIVO F., 2006. Short communication: bulk tank total bacterial count in dairy sheep: Factors of variation and relationship with somatic cell count. J Dairy Sci 89, 549-9552.

GONZALO C., LINAGE B., CARRIEDO J.A., JUÁREZ M.T., BENEITEZ E., MARTÍNEZ A., DE LA FUENTE L.F., 2009. Effect of dry therapy using an intramammary infusion on bulk tank somatic cell count in sheep. J Dairy Sci 92, 156-159.

HAENLEIN G.F.W., 2007. About the evolution of goat and sheep milk production. Small Rumin Res 68, 3-6.

HOSMER D.W., LEMESHOW S., 1989. Applied logistic regression. John Wiley & Sons, NY, USA.

HUESTON W.D., HARTWING N.R., JUD J., 1986. Detection of ovine intramammary infection with the California mastitis test. J Am Vet Med Assoc 188, 522-524.

JAYARAO B.M., PILLAI S.R., SAWANT A.A., WOLFGANG D.R., HEGDE N.V., 2004. Guidelines for monitoring bulk milk tank somatic cell and bacterial counts. J Dairy Sci 87, 3561-3573.

OJ, 1992. Council Directive 92/46/EEC of 16 June 1992 laying down the health rules for the production and placing on the market of raw milk, heat-treated milk and milk-based products. Official Journal of the European Communities, L 268 17/12/1992. p. 1.

OJ, 1994. Council Directive 94/71/EEC of 13 December amending Directive 92/46/EEC laying down the health rules for the production and placing on the market of raw milk, heat-treated milk and milk-based products. Official Journal of the European Communities, L 368 13/12/1994. p. 33.

OJ, 2004a. Corrigendum to Regulation (EC) No 852 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs. Official Journal of the European Communities, L 139 30/04/2004. p. 3.

OJ, 2004b. Corrigendum to Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin. Official Journal of the European Communities, L 139 30/04/2004. p. 22.

PAAPE M.J., POUTREL B., CONTRERAS A., MARCO J.C., CAPUCO A.V., 2001. Milk somatic cells and lactation in small ruminants. J Dairy Sci 84, 237-244.

PIRISI A., LAURET A., DUBEUF J.P., 2007. Basis and incentive payments for goat and sheep in relation to quality. Small Rumin Res 68, 167-178.

SERRANO M., PÉREZ-GUZMÁN M.D., MONTORO V., JURADO J.J., 2003. Genetic analysis of somatic cell count and milk traits in Manchega ewes. Livestock Prod Sci 84, 1-10.

SCHULTZ L.H., 1997. Somatic cell counting of milk in production testing programs as a mastitis control technique. J Am Vet Med Assoc 170, 1244-1246.

TADICH N., KRUZE J., LOCHER G., GREEN L.E., 2003. Risk factors associated with BMSCC greater than 200,000 cells/mL in dairy herd in southern Chile. Prevent Vet Med 58, 15-24.

YAMAKI M., BERRUGA M.I., ALTHAUS R.L., MOLINA M.P., MOLINA A., 2004. Occurrence of antibiotic residues in milk from Manchega ewe dairy farms. J Dairy Sci 87, 3132–3137.

YAMAKI M., BERRUGA M.I., ALTHAUS R.L., MOLINA M.P., MOLINA A., 2006. Screening of antibiotic residues in ewe milk destined to Manchego cheese by Eclipse 100ov. Food Addit Contam 23, 660-667.