Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)
Available online at www.inia.es/sjar
http://dx.doi.org/10.5424/sjar/2014121-3803

Spanish Journal of Agricultural Research 2014 12(1): 133-150
ISSN: 1695-971-X
eISSN: 2171-9292

Factors affecting somatic cell count in dairy goats: a review

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Abstract

Somatic cell count (SCC) in monitoring udder health has been described in numerous studies as a useful method for the diagnosis of intramammary infection (IMI), and it is considered in standards of quality and hygiene of cow's milk in many countries. However, several authors have questioned the validity of SCC as a reliable IMI diagnosis tool in dairy goats. This review attempts to reflect the importance of different infectious and non-infectious factors that can modify SCC values in goat milk, and must, therefore, be taken into account when using the SCC as a tool in the improvement of udder health and the quality of milk in this species. In dairy goats, some investigations have shown that mammary bacterial infections are a major cause of increased SCC and loss of production. In goats however, the relationship between bacterial infections and SCC values is not as simple as in dairy cattle, since non-infectious factors also have a big impact on SCC. Intrinsic factors are those that depend directly on the animal: time and number of lactation (higher SCC late in lactation and in aged goats), prolificity (higher SCC in multiple births), milking time (higher SCC in evening compared to morning milking) and number of milkings per day, among others. Extrinsic factors include: milking routine (lower SCC in machine than in manual milking), seasonality and food. In addition, milk secretion in goats is mostly apocrine and therefore characterized by the presence of epithelial debris or cytoplasmic particles, which makes the use of DNA specific counters mandatory. All this information is of interest in order to correctly interpret the SCC in goat milk and to establish differential SCC standards.

Additional key words: infectious and non-infectious factors; milk quality; mastitis; benchmarking.

Introduction

Mastitis is an inflammation of the mammary gland and is the most serious and costly disease in dairy goats, representing the most frequent cause of culling for sanitary reasons (Bergonier *et al*., 2003; Leitner *et al*., 2008; Marogna *et al*., 2010). Goat milk production is a dynamic and growing industry that is fundamental to the wellbeing of hundreds of millions of people worldwide and is an important part of the economy in many countries (Silanikove *et al*., 2010).

Some of the goat breeds raised in developed countries have become highly specialized dairy animals (Coop, 1982; Capote *et al*., 2008). In these countries, the number of goats is declining, while milk production is increasing due to the high yield of dairy herds (Haenlein, 2004). In the EU context, the dairy goat sector has the greatest economic importance in Mediterranean countries such as France, Spain, Italy and Greece, which currently have high *per capita* income, thus breaking the topic of goat production as a synonym of underdevelopment and poverty (Boyazoglu & Morand-Fehr, 2001).

In recent decades, dairy goat production systems have evolved towards an intensification level that is not always accompanied by improved facilities or better handling and milking routine. This has led to an increase in intramammary infections (IMI) and a worsening of milk quality (Castel *et al*., 2010). The somatic cell count (SCC) is an indicator used to mo-

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Received: 29-11-12. Accepted: 03-02-14.

Abbreviations used: 1X/2X (once/twice milking day); CAEV (Caprine arthritis encephalitis virus); CFM (control fraction of milk); CMT (California mastitis test); CNS (coagulase negative staphylococci); CP (cytoplasmic particles); IMI (intramammary infection); mP (minor pathogens); MP (major pathogens); PMN (polymorphonuclear neutrophils); SC (somatic cells); SCC (somatic cell count); TMC (total microbial count).

nitor those problems, but its performance should be assessed in depth in order to be used with the same efficiency and objective parameters in the overall management of the herd as in dairy cattle (Burriel, 2000).

In dairy goats, Leitner *et al*. (2004) indicated that the direct income loss from decreased milk yield and the strong immune response to bacterial udder contamination, which results in elevated SCC, appear to be of much greater magnitude than noted in dairy cows. Currently, there are dairy industries that determine milk quality on SCC figures with the aim of obtaining products with hygienic, sanitary, dietetic, nutritional, gustative and gastronomic quality (Boyazoglu & Morand-Fehr, 2001). However, high quality dairy products can only be produced from good quality milk. Quality milk should be able to tolerate technological treatment and be transformed into products that satisfy the expectations of consumers, in terms of nutritional, hygienic and sensory attributes (Ribeiro & Ribeiro, 2010). To this end, it is very important to understand which are the infectious and non-infectious factors contributing to SCC values variation. The final goal is to establish discriminatory thresholds affecting milk quality and legal limits for goat milk.

This review deals with the current knowledge about somatic cells (SC) and SCC in dairy goats and with the factors that, affecting SCC figures, have to be taken into account in the correct management of udder health and milk quality in goat herds.

Somatic cells

The milk of all mammals contains different types of cells whose origin is the body itself. In the decade of the 1960s, Paape first coined the concept of "somatic cells" to refer to these cells (Contreras & Sánchez, 2000), which can be divided into two groups according to their origin: blood-borne SC and epithelial SC.

Somatic cells are present in healthy mammary glands, but regarding mammary inflammation driven by any cause there is an increased influx of blood leukocytes (Gonzalo *et al*., 1998) by chemo-taxis and diapedesis. Blood-borne SC include macrophages, lymphocytes and particularly, polymorph nuclear (PMN) and neutrophils (Sordillo & Streicher, 2002). The presence of leukocytes in milk results in increased SCC values, which can be considered as an indicator of inflammation of the udder (Bergonier *et al*., 1996), although this interpretation should take into account the noninfectious factors that can influence the SCC.

In dairy goats, PMN neutrophils are the predominant cell type in uninfected glands (45-75%), although the cell types present in the milk from ewes free from IMI are similar to those observed in milk from cows. In both species, macrophages are the predominant cell type (45-88%) in healthy udders. PMN leukocytes comprise about 2-40% of the milk cell population, lymphocytes 6-20%, and eosinophilis and epithelial cells are also present to a lesser extent (Bergonier *et al*., 2003; Blagitz *et al*., 2008). The presence in the milk of these cell types is of mainly inflammatory and immune origin, while cytoplasmic particles (CP) and epithelial cells are not (Bergonier *et al*., 1996).

Epithelial cells in milk result from desquamation of the epithelium of alveoli and ducts of the mammary gland. The significance of the presence of such cells in milk is mainly physiological, by regeneration of normal epithelia (Paape & Capuco, 1997). Recent studies have shown that a vast majority of epithelial cells present in milk are viable and exhibit characteristics of fully differentiated alveolar cells; *in vitro* culture of these cells has been used as a model in studies related to lacto-genesis, cancer, immunology and viral infections (Boutinaud & Jammes, 2002).

Besides the presence of SC, there are also extracellular membranous material, nuclear debris and cell fragments in the milk that correspond to large portions of cytoplasm originated from the distal alveolar mammary secretory cells. These formations are often referred to as CP and are very abundant when milk secretion is apocrine, as in the case of goats, and very few or virtually absent, when the discharge is merocrine, as in cattle (Gonzalo *et al*., 1998).

Somatic cells in goats and other species

In summary, and according to different authors (Paape *et al*., 2001; Boutinand & Jammes, 2002; Paape *et al*., 2007), there are three characteristics that distinguish goat milk from sheep or cow: higher values of SCC, CP and PMN.

Threshold value of SCC

The cell concentration in goat milk is higher than in cow and sheep milk (Contreras *et al*., 1997; Paape *et*

al., 2007). Thus, in the absence of mastitis, the SCC in goat milk can vary between $270 \cdot 10^3$ and $2{,}000 \cdot 10^3$ SC mL^{-1}, whereas in cow and sheep milk it would be between $10 \cdot 10^3$ and $200 \cdot 10^3$ SC mL^{-1} (Paape *et al*., 2001). Sometimes, cut-off values show large differences because these thresholds depend on counting methods. To obtain accurate milk SCC for goats, only cell counting procedures specific for DNA should be used. Moreover, histopathological studies carried out on udders of goats with high SCC, but no intra-mammary infection, have not found any kind of disorder in the gland, suggesting that high SCC can be of physiological and not pathological nature (Zeng & Escobar, 1995).

Using a composite SCC to detect mastitis by *Streptococcus aureus* in goats, Koop *et al*. (2011) proposed a cut-off value of $1{,}500 \cdot 10^3$ SC mL^{-1}, with 0.9 and 0.95 sensitivity and specificity values, respectively. In this study, foremilk samples were collected from both udder halves for bacteriological culture. Min *et al*. (2007), discarding foremilk fractions, reported average SCC values ranging from 2,000 to $4{,}000 \cdot 10^3$ SC mL^{-1} in infected dairy goats and concluded that SCC in goat milk is not highly correlated to IMI. Both studies used the Fossomatic cell counter. However, Persson & Olofsson (2011) used deLaval cell counter and found a mean SCC of $711 \cdot 10^3$ SC mL^{-1} for infected glands and $481 \cdot 10^3$ SC mL^{-1} for non-infected ones, with sensitivity and specificity values of 0.67 and 0.63 respectively. In this study milk samples were aseptically collected from each udder half.

Cytoplasmic particles

In terms of CP, the counts in goat milk are very high compared with other species, because of milk secretion being apocrine (Dulin *et al*., 1983; Paape & Capuco, 1997; Souza *et al*., 2012). CP, similar in size to milk SC, are normal constituents of their milk, although concentrations of CP are much higher in milk from goats than from ewes (Souza *et al*., 2012). This type of secretion is characterized by the detachment of the apical part of the epithelial cells from their base at the end of the secretory phase and their release into the alveolar lumen (Perrin & Baudry, 1993). By contrast, the secretion of milk in the cow is of merocrine type without loss of epithelial cytoplasm (Neveu *et al*., 2002). Although the sheep milk secretion also has an important apocrine component, the concentration of CP is usually very low, in the order of 1/10 of that found in goat milk (Paape *et al*., 2001). These particles have spherical morphology with a size between 5 and 30 μm, and most (~99%) lack nucleus (Dulin *et al*., 1983; Paape & Capuco, 1997), and are countered as SC when specific DNA methods are not used (Marco *et al*., 2012).

Polymorphonuclear neutrophils

In goat milk secretion PMN are the main cellular component in both healthy and in infected glands (Dulin *et al*., 1983; Rota *et al*., 1993a; Sierra *et al*., 1999), representing ~70% of the SC. An interesting aspect to note is that the chemotactic factors that attract PMN to healthy milk glands are different to those operating in glands with mastitis (Manlongat *et al*., 1998). Moreover, Bagnicka *et al*. (2011) showed that not only the neutrophils and macrophages but also eosinophils play a crucial defensive role against the pathogenic bacteria.

Factors associated with somatic cell count

The main factors influencing SCC in goat milk, divided into inflammatory and non-inflammatory, are described below and summarized in Table 1.

Inflammatory origin factors

In general, the scientific literature classifies mastitis into clinical, subclinical, and chronic (Bergonier *et al*., 2003). Clinical mastitis appears with evident pathological signs affecting the udder, with both quantitative and qualitative milk alterations. Subclinical mastitis is characterized by the presence of an IMI without clinical symptoms and is often accompanied by a rise in milk SCC. Several authors (*i.e*., Zeng & Escobar, 1995) suggested that high SCC can be associated with lower milk yield. Moreover, a decrease in milk yield was also observed by Leitner *et al*. (2004) for goats after inoculation with CNS in udders. Reductions in milk yield are largely due to physical damage of the mammary gland alveolar cells, and to the consequent reduction in the synthetic and secretory functions of mammary gland. Moreover, chronic mastitis can be clinical or subclinical (Contreras *et al*., 2003, 2007; Marogna *et al*., 2012).

Table 1. Main factors influencing somatic cell count in goat milk

Inflammatory	Infectious etiology	Bacteria Caprine arthritis encephalitis virus
	Noninfectious etiology	Physical agents Chemical agents
Non inflammatory	Intrinsic	Fraction of milking Time between milking Milking frequency Daily variations Stage of lactation Number of lactation Prolificacy Breed Poduction level Heat
	Extrinsic	Type of milking Feed Stress Seasonality Farming system Facilities
Other factors	Counting methods Conservation and storage of samples	

Infectious factors

Intra-mammary infection caused by bacteria is the main cause of increased SCC in goat milk (Raynal-Ljutovac *et al*., 2007), as occurs in sheep milk (*i.e*., Gonzalo *et al*., 2002) and cow milk (*i.e*., Harmon, 1994) due to inflammation of the mammary gland resulting in a greater influx of leukocytes in milk and, consequently, an increase in SC. Even though the intramammary infection increases the SCC, the intensity of the inflammatory reaction also depends on the microorganisms involved (Contreras *et al*., 1997). Therefore, the SCC can be used as a method for indirect diagnosis of IMI. It can also be considered as a sensitive tool for analyzing the effects of IMI on milk yield, milk composition and efficiency of curd and cheese production and other factors negatively influenced by IMI (Raynal-Ljutovac *et al*., 2007; Koop *et al*., 2009). SCC is highly recommended because it may help in defining milk quality, preventing food toxicity and searching for strategies to improve milk yield and quality (Silanikove *et al*., 2010).

The most common mastitis pathogens have been classified as minor (mP) and major pathogens (MP), according to the degree of inflammation they produce in the mammary gland (Bagnicka *et al*., 2011). Furthermore, it is widely accepted that the increase of SCC is related to the pathogenicity of the etiological agents of the IMI.

Intramammary bacterial infections: etiology and prevalence

Subclinical mastitis is common in goats and is mainly caused by contagious pathogens [*Staphylococcus aureus*, coagulase-negative *Staphylococci* (CNS), *Streptococci agalactiae*, *Streptococci* Group C and *Mycoplasma* spp. (Bagnicka *et al*., 2011; Persson & Olofsson, 2011)]. Staphylococcal infections are characterized by dynamic fluctuations and cyclic bacterial shedding in milk, which leads to fluctuations in SCC and cause false negative bacteriological results (Bergonier *et al*., 2003).

Several reviews (Bergonier *et al*., 2003; Moroni *et al*., 2005; Contreras *et al*., 2007) indicate that the annual incidence of clinical mastitis in goats is very low (< 5%), while subclinical mastitis ranges from 9 to 50% (Moroni *et al*., 2005; Leitner *et al*., 2007; Min *et al*., 2007) and is mainly caused by contagious pathogens. Moreover, the prevalence of subclinical mastitis is usually between 5% and 30% and the germs responsible are usually CNS (about 80% of infections), *S. aureus* (6%), gram-negative bacteria (8%) and *Streptococci* (6%) (Contreras *et al*., 2007; Leitner *et al*., 2008; Bagnicka *et al*., 2011; Marco *et al*., 2012).

SCC normally fluctuates depending on the organism number and viability (Bergonier *et al*., 2003). Some authors have isolated mastitis pathogens from milk samples with very low SCC, whereas others have found high proportions of bacteriologically negative milk samples with high SCC (Leitner *et al*., 2007; Nunes *et al*., 2008). In this case, the value of SCC as an indirect method for mastitis diagnosis is questionable.

Staphylococci is the most frequently isolated bacterial genus during IMI in goats, and it can account for over 90% of all bacterial species identified in these infections (Leitner *et al*., 2007; Min *et al*., 2007; Marogna *et al*., 2012). Among *Staphylococci, S. aureus* is considered the most important pathogenic agent of mastitis in dairy goats; it has been found with frequencies ranging from 4% to 40% of all isolated microorganisms (Leitner *et al*., 2007; Min *et al*., 2007; Marogna *et al*., 2010). It is responsible for clinical, subclinical, and chronic mastitis, often characterized by a marked increase in SCC. Its elevated pathogenic

potential leads to a relatively severe gangrenous mastitis, with very high morbidity and mortality rates (Moroni *et al*., 2005).

CNS can also cause subclinical and clinical mastitis, accompanied by a significant increase in milk SCC (Moroni *et al*., 2005; Contreras *et al*., 2007; Koop *et al*., 2010).

Streptococci is the second most frequently isolated genus in goat milk after *Staphylococci*, with a prevalence ranging from 1% to 9% (Moroni *et al*., 2005; Marogna *et al*., 2012). However, *Mycoplasma agalactiae, M. mycoides subsp. capri, M. capricolum subsp. Capricolum* and *M. putrefaciens* are the MP responsible for clinical contagious agalactia, which is also associated with high bulk tank milk SCC for goat herds with a geometric mean SCC exceeding $2{,}900 \cdot 10^3$ SC mL^{-1} (Corrales *et al*., 2004; Contreras *et al*., 2007). In contrast, when mycoplasmas are isolated from subclinical mastitis the SCC cause a moderate elevation, since the value obtained from glands infected by these pathogens is about double that found in uninfected glands (Martinez *et al*., 1999; Sánchez *et al*., 1999). In this case, on farms with no clinical symptoms of mycoplasma, the SCC in bulk milk fails to differ depending on whether or not this organism is isolated (Corrales *et al*., 2004).

Effect of caprine arthritis encephalitis virus

The interaction between IMI and the virus of the arthritis encephalitis virus (CAEV) accounts for the fact that, while in seronegative animals the IMI significantly increases the SCC (Martínez, 2000), in CAEV seropositive animals this increase is more moderate (Sánchez *et al*., 1998a,b). Despite the above, Luengo *et al*. (2004) confirmed that there is no significant interaction between the CAEV virus and the infection status of the mammary gland with respect to the SCC. This would explain *a priori* the worsening of the production records of seropositive goats, even more evident in elder goats (Martinez, 2000).

Non-infectious factors

Physical origin factors affecting the mammary gland, such as injuries of different nature, which can be at pinpointed times (during grazing or while confined in pen) or repeated (during milking or breastfeeding), could lead to increases in the SCC in the absence of intra-mammary infection (Perrin & Baudry, 1993). Also, some chemicals, such as active ingredients and excipients of intra-mammary therapeutic preparations, can increase the SCC (Long *et al*., 1984).

Non-inflammatory origin factors

Factors depending directly on the animal (intrinsic factors) or not (extrinsic factors) contribute significantly to changes of SCC in milk of dairy goats. For instance, Gonzalo (2002, 2005) mentioned that aspects such as parity, breed, stage of lactation, type of birth, monthly, seasonal variations, etc. may explain 48% of SCC variance (Gonzalo , 2002, 2005). Reviewing 12 references, Martínez (2000) found a range of SCC means from $272 \cdot 10^3$ (Poutrel *et al*., 1997) to $2{,}000 \cdot 10^3$ SC mL^{-1} from pathogens free udders (Contreras *et al*., 1997); hence, it is key to consider all non-inflammatory factors to understand SCC.

Intrinsic factors

Intrinsic factors are those that depend directly on the animal and are difficult to be modified. These affect both the production and the composition of the milk. The following are their specific effects on the SCC.

Fraction of milking

In goat milk there are various fractions obtained during milking. The first one is obtained with the pump machine and corresponds to the cistern and alveolar milk. Then, before removal of the teat cups, milking can be finished off with the machine, with a vigorous massage of the udder. After removal of the teat cups, some milk remains in the udder; one part may be extracted manually, although it is not usually done to goats; and the rest corresponds to the residual milk, which can only be removed after application of oxytocin. Normally, the first squirts taken before the beginning of milking are the fraction used for bacteriological diagnosis and SCC. Several studies have found that the first milk squirts have a similar SCC, although these are always slightly lower compared to the control fraction of milk (CFM, the milk recordings collected from milk official control) (De Cremoux *et*

al., 1996). For example, Contreras *et al*. (1997) found an average SCC of 687,000 and 763,000 SC mL^{-1} in the first squirt fractions and CFM, respectively. Similarly, Martínez (2000), analyzing about 600 samples from nearly 100 goats, found a mean SCC of 998,000 and 1,139,000 SC mL^{-1} in the first controlled squirts and CFM, respectively.

Time between milking

In goats, it has been found that the SCC of milk obtained from the evening milking is between 17-78% higher than that obtained from the morning (Sinapis & Vlachos, 1999; Cedeen *et al*., 2008). Some authors explained that this is due to a dilution effect, because the amount of milk obtained in the morning milking is between 35-69% higher than in the afternoon one (Aleandri *et al*., 1996; Contreras *et al*., 1997). Bergonier *et al*. (1996) argued that this could be due to the effect of changes in intra-alveolar pressure on leukocyte diapedesis into the lumen of the acini. When milking in the morning, there is a greater amount of milk in the udder and, therefore, intra-mammary pressure results in a lower transfer of leukocytes from the blood into the milk, thereby reducing the concentration of SCC in milk. Another aspect that may explain this phenomenon is the existence of a "drag effect" from the morning milking to the evening one. The milk obtained in the afternoon (shorter time interval) will have a greater concentration of SC with respect to the morning milking for two reasons: a) because in the udder there is initially (after the morning milking) more residual milk with high concentration of SC, and b) because there is a shorter time elapse from the previous milking (morning) and less milk is synthesized and therefore diluted, hence there is less residual milk in the udder (Gonzalo *et al*., 1994).

Milking frequency

Some breeds are milked twice a day (Saanen, Alpina), others are milked once a day (Majorera, Tinerfeña) while others depend on the production system (Castel *et al*., 2010). Murciano-Granadina, Malagueña y Florida breeds results being uneven (Capote *et al*., 2008).

By reducing or increasing the number of milkings per day, daily milk production decreases or increases, respectively (Zeng *et al*., 1997). Mainly, a dilution effect would be expected, so the SCC would vary contrary to the production of milk; however, the results of literature do not coincide. For example, in the Murciano-Granadine breed, Salama *et al*. (2003) found no differences in the SCC of tank milk by comparing one milking per day (1X) and two milkings a day (2X), although the SCN level was increased. On the other hand, Komara *et al*. (2009), in two experiments realized with Alpine breed goats, found that only one of them, considering only multiparous goats, had an increase in counts going from 2X to 1X (179,800 and 400,300 cells mL^{-1}, respectively). These results could suggest that high yielding goats or specific breeds cannot be adapted to 1X (Komara *et al*., 2009). Other authors agreed in finding an increase in counts 1X over 2X performed in cattle (Rémond *et al*., 2004) and sheep (Nudda *et al*., 2002).

Daily variations

In goats, several authors have noted a significant variability in daily (Zeng *et al*., 1997), weekly (Pettersen, 1981) as well as monthly SCC (Martínez, 2000).

Thus, in first parity goats the SCC can range from day to day values of less than $200 \cdot 10^3$ to $1{,}000 \cdot 10^3$ SC mL^{-1} (or even over $2{,}000 \cdot 10^3$ SC mL^{-1}) and the next day back again to the normal mean value (Zeng *et al*., 1997). Besides, that these sudden elevations may occur several times during lactation (Zeng *et al*., 1997).

Stage of lactation

Physiologically, dairy goats have SCC with an upward trend corresponding to the progression of the productive period (Poutrel *et al*., 1997). This trend shows an inverse relationship with milk production (Rota *et al*., 1993b).

Thus, the cellular concentration of goat milk is so high that, according to Corrales *et al*. (1996), at the end of lactation it is impossible to distinguish between uninfected and healthy glands through SCC. Several authors have explained that the increase in SCC during the lactation due to a dilution effect (Wilson *et al*., 1995; Bergonier *et al*., 1996; Zeng *et al*., 1996) and because the advancement of the lactation implies a decrease in production and there is a significant negative correlation between SCC and milk production (Rota *et al*., 1993b; Zeng & Escobar, 1995), the SCC

being higher at the end of lactation (Baudry *et al*., 1993; Gomes *et al*., 2006).

In other similar studies, Paape *et al*. (2007) counts were lowest at first parity, averaging ~200 · 10^3 SC mL^{-1} at 15 days of lactation and these reached maximums of around 500 · 10^3 SC mL^{-1} at 285 days. By the fifth parity, counts averaged ~250 · 10^3 SC mL^{-1} at 15 days and increased to a maximum of ~1,150 · 10^3 SC mL^{-1} at 285 days of lactation.

Number of lactation

The influence of the number of lactation on the SCC seems to depend on the health status of the udder and the agent involved if there is an intra-mammary infection. Thus, De Cremoux *et al*. (1996) found that age has a significant influence on SCC in goats infected with MP; while in the case of goats infected with CNS, the effect of age is significant only after 100 days of lactation. This can be attributed to a longer exposure of the older animals to pathogens compared to younger animals, and to chronic infections established during the previous lactation and not completely eliminated during the dry period, rather than to a higher infection rate in older animals (Sánchez-Rodríguez *et al*., 2008; Marogna *et al*., 2012). However, Luengo *et al*. (2004) showed that, considering only the glands with IMI, SCC is not higher in older animals. Test properties of composite SCC for detecting both MP and mP have been found to be strongly dependent on parity, with increasing parity yielding higher sensitivity and markedly lower specificity (Koop *et al*., 2011).

Prolificacy

Most studies find that the type of birth influences the SCC (Luengo *et al*., 2004; Jiménez-Granado *et al*., 2012a). Highest counts are obtained in animals with multiple birth (1,666.9 · 10^3 ± 137.1 · 10^3 SC mL^{-1}, $p < 0.05$) and breeding than in those with simple birth (Jiménez-Granado *et al*., 2012a), although the former produce more milk than the latter (Sinapis & Vlachos, 1999). This result could be attributed to a worse health status of the udder in mothers who breastfeed two kids compared to those who only nurse one. However, this explanation seems insufficient, since Luengo *et al*. (2004) also found that when raising kids with artificial feeding, the goats with multiple births also have higher counts than those of single birth. Despite the above, it should be pointed out that some studies found that the prolificacy does not influence the SCC (Sánchez-Rodríguez *et al*., 2000).

Breed

The authoritative information contrasted on the SCC in different dairy goat breeds (Zeng *et al*., 1996) cannot categorically confirm the genetic implications of that factor. However, according to Sánchez *et al*. (1998a), possible racial differences may attributed to the different health status, level of production and characteristics of management between them. From the studies by Sánchez-Rodríguez *et al*. (2005), it is concluded that both the number of bacteria and the SCC are lower in herds of Murciano-Granadine pure bred when compared to crossed herds. This mayan indirect indication of other factors; because purebred herds tend to be more organized and have more technology.

Milk yield and contents

Milk production is lower for primiparous than for multiparous dairy goats; while the highest production is for parity 3 or 4 (Goetsch *et al*., 2011). The information about goats indicates that in the absence of infection, less productive animals result in higher SCC (Wilson *et al*., 1995; Martínez, 2000; Sánchez-Rodríguez *et al*., 2000). Likewise, Jiménez-Granado *et al*. (2012b) found that Florida breed goats producing > 3 kg of milk day^{-1} showed the lowest SCC (≤ 954 · 10^3 SC mL^{-1}) in milk controls.

Moreover, Chen *et al*. (2010) found that milk composition (fat, protein, lactose, casein, and total solids), did not change when milk SCC varied from 214,000 to 1,450 · 10^3 SC mL^{-1}. However, total sensory scores and body and texture scores for cheeses made from high SCC milk were lower than those for cheeses made from low and medium SCC milks. Finally, Chen *et al*. (2010) concluded that SCC in goat milk did not affect the yield of semisoft cheese but resulted in inferior sensory quality of aged cheeses. In this sense, Jiménez-Granado *et al*. (2012c) analyzed the relation between the mean percentage of fat and protein in Florida goats (5.04% and 3.35% respectively) and SCC, and established < 1,300 · 10^3 SC mL^{-1} as a target to maintain milk bromatological quality.

Heat

Some authors have found that when goats are on heat, either natural or induced (Moroni *et al*., 2007); both at the station of estrus (Aleandri *et al*., 1996) and of anoestro (McDougall & Voermans, 2002), there is a significant increase in SCC. This increase is unexplained by the slight decrease in milk production, suggesting that it is the heat directly responsible for the cell growth, probably due to still unknown physiological mechanisms (McDougall & Voermans, 2002). Mehdid *et al*. (2010) made a study with 32 goats (20 healthy and 12 with unilateral IMI), where nearly 60% of goats showed a case of transient elevation of SCC, appearing in both, in healthy goats as in infected ones, as well as in primiparous and multiparous goats. Thus, these authors conclude that estrus is probably the main factor causing SCC transient elevations for non-infectious origin, in farm conditions. On the other hand, it seems that common situations and events affecting stress levels on farms apparently did not affect the SCC (Mehdid *et al*., 2010).

There is a controversy about whether the effect of heat on the SCC is dependent on the infection status of the udder in the case of infected glands. In this sense, Bergonier *et al*. (2003) indicate that estrus can cause a greater increase in SCC in infected glands than in healthy glands.

Extrinsic factors

Type of milking

The effect of the type of milking (manual or mechanical) on the SCC in goats has been studied by several authors, although the results do not always coincide. Randy *et al*. (1991) obtained lower counts in the animals milked by machine, while Kosev *et al*. (1996) found lower counts in those milked by hand. However, Zeng *et al*. (1996) observed similar counts in both types of milking. Possibly the differences found in these studies are due to different prevalence of IMI, different productive periods, age of animals, etc. (Sánchez *et al*., 1998a). In Murciano-Granadine breed goats, Díaz *et al*. (2004) did not find any influence on SCC by two combinations of parameters (vacuum, pulsation rate and ratio of 40/90/60 *vs.* 36/120/60). Manzur (2007) failed to show that the SCC varies with the type of driving of the milk (mid line *vs.* low line); but noted that the use of teat cups with automatic valves, in which the vacuum is not cut manually before detaching the teat cups, increases the risk of mastitis and the SCC at the beginning of lactation. In recent experiments, Manzur *et al*. (2012) have demonstrated that there are no significant differences between mid-line and low-line milking groups; besides this factor does not affect any other relevant milking features, such as the total milk yield, SCC, total milking time for each animal or teat-end condition.

In fact, mechanical milking has been associated with a 1.3 higher risk of general microbiological positivity, and to a 1.53 higher risk of positivity to *Streptococcus uberis*, while manual milking has been associated with a 3.4 higher risk of positivity to *Staphylococci caprae* (Marogna *et al*., 2012).

Feed

An unbalanced ration (nitrogen, energy or minerals) can be the cause of the increase in the SCC of milk from the bulk tank (Sánchez *et al*., 2007). Generally, when feeding causes metabolic disorders (acidosis, alkalosis, etc.) it causes elevation of SCC (Lerondelle *et al*., 1992; Fedele *et al*., 1996). This increase is probably due, at least in part, to a reduced milk production in animals suffering from such disorders, which translates into a higher cell concentration.

Fedele *et al*. (1996) studied the effect of different types of rations on the SCC, noting that when the goat diets are only based on grazing, the SCC values are slightly lower than when these are supplemented with a concentrated energy (barley); whereas higher counts are obtained when supplemented with a protein concentrate.

A similar study was carried out by Sánchez-Rodríguez *et al*. (2005), comparing different types of diets: complete diet or ration, semi-complete diet, mixture of grains or compound feed. The herds that were fed with complete balanced diets showed a significantly lower SCC than in other diets.

Stress

There are various handlings of the herd that presumably produce some kind of stress, causing spontaneous elevations of SCC in bulk tank milk. For example, at the time of goats mating, when introducing the males into the herd, there is usually an increase of SCC in the

milk bulk tank (Aleandri *et al*., 1996; Calderini *et al*., 1996; Borges *et al*., 2004). However, it is unclear whether this increase is due to the effect of heat or stress by the introduction of males or both factors. On the other hand, various management practices such as blood draws and tuberculin skin testing can temporally increase the level of SCC in bulk tank milk (Corrales *et al*., 1997). There has also been detected an increase of SCC after vaccination against enterotoxaemia (Lerondelle *et al*., 1992). Pérez-Baena *et al*. (2012) proved that the stress level of goats in response to parasitic diseases (*i.e*. mange) produces a reduction in milk production and an increase in SCC, reaching levels of $950{,}000 \cdot 10^3$ SCC mL^{-1}.

Regarding to transportation, McDougall *et al*. (2002) found that the transportation in trucks for 45 min does not affect the SCC, in the short-term (one hour after transportation).

Seasonality

The binomial photoperiod-temperature influences on milk production and, indirectly, the SCC (Peris *et al*., 2002b). García-Hernández *et al*. (2007) associated effects of long day photoperiod on increased per cent milk fat and decreased SCC ($< 1{,}705 \cdot 10^3$ SC mL^{-1}). Thus, in the spring season (increasing photoperiod, mild temperatures, and sometimes better feed) the production tends to increase and therefore the SCC is reduced (Peris *et al*., 2002a). In contrast, in the autumn months the situation tends to be opposite. Moreover, in the summer it is expected that the SCC will tend to increase as temperatures decrease the production (Delgado-Pertíñez *et al*., 2003).

Farming system

When comparing indoors farms with semi-intensive ones, levels of SCC are lower in the former (Sánchez-Rodríguez *et al*., 2005). This could be due to better milking facilities and routines, as well as better hygiene in the intensive and indoors farms. Furthermore, when systems based on grazing and indoor systems are compared, the milk components (fat, protein, lactose) appear to be rather less influenced by the type of farming system than by the level of milk production. Natural pasture based farming systems produce milk rich in fat, micro-components and volatile components. In this sense, the farmer should look for a management balance by choosing a level of intensification without damaging the quality of milk used in cheese-making. In the future, farmers could select farming and feeding systems in accordance with trade conditions, consumers demands and socio-economic conditions. (Morand-Fehr *et al*., 2007).

Facilities

As would be expected, good facilities are crucial to obtain milk with significantly fewer bacteria and less SCC. Often, these parameters do not get any better when the emphasis is only on the facilities and milking routine, forgetting the role that the facilities play as a whole. Thus, the differences in milking installations had no significant result in the experiments by Sánchez-Rodríguez *et al*. (2005).

Rearing system

Delgado-Pertíñez *et al*. (2009) found that there is a significant effect of the rearing system on the contents in fat ($p < 0.01$), protein ($p < 0.05$), and non-fat dry extract ($p < 0.05$); the goats with artificial rearing showthe highest values. However, no effect of the rearing system on the somatic cell count was observed.

Mastitis control strategies

The evidence of high milk SCC associated with serious economic losses and food safety risk linked to subclinical mastitis emphasize the need to implement mastitis control programs in order to improve milk hygiene and mammary health, as well as to increase the economic return to producers. Thus, several authors (*i.e*. Poutrel *et al*., 1997; Sánchez *et al*., 2007) conclude that systematic antibiotic treatment of goats at drying-off is an efficient method for the reduction of subclinical mastitis. Poutrel *et al*. (1997) recommend systematic treatment when SCC in bulk milk is high ($> 1{,}000 \cdot 10^3$ cells mL^{-1}), and when CNS are involved in IMI.

Other factors

Counting methods

As already mentioned, goat milk has the peculiarity of containing a large number of CP. Therefore, in order

to make the SCC without taking these particles into account, only specific DNA methods should be used (Dulin *et al*., 1983; Sierra *et al*., 1998; Marco *et al*., 2012). Standardization of SCC counters for small ruminant milk is also essential in SCC laboratories and equipment in order to guarantee accuracy and reproducibility of results (Raynal-Ljutovac *et al*., 2007).

Count by direct microscopic method is the standard method for conducting the SCC (ISO/IDF, 2008). The specific DNA stains most frequently used are the red-green pyronin methyl (reference staining in the USA), May-Grünwald-Giens and Gallego's trichrome (Gonzalo *et al*., 1998; Berry & Broughan, 2007). Methylene blue staining should not be used with goat milk because it is not DNA specific and therefore does not differentiate between leukocytes and CP, implying that the counts give higher values than the real ones (Raynal-Ljutovac *et al*., 2007). In fact, the new rules on SCC (ISO/IDF, 2008) recommend methyl-green red pyronin staining for goat milk.

Although flow cytometric methods have been described for quick cell differentiation in cow milk, there has been little investigation of such methods for goat milk SCC (Boulaaba *et al*., 2011). The fluoro-opto-electronic method is a specific DNA method based on the count of nucleated elements specified after staining the DNA nucleus with a fluorescent dye (ethidium bromide). According to Gonzalo *et al*. (2006), this method has adequate accuracy and repeatability values compared to the microscopic reference method, with a correlation coefficient of 0.96. Droke *et al*. (1993) confirmed the validity of this method, since they did not find significant differences between this method and the direct counting by methyl-green pyronin red staining. Similar studies showed how to use flow cytometric dot plots to elaborate quick differential cell count for goats in a similar way to that for bovine milk; however, it was necessary to use DNA-specific fluorescent dyes in order to avoid overlapping of SC and CP; but in this method it is possible to conduct differential cell count more quickly (< 45 min) and objectively than with the traditional microscopic differentiation techniques (Boulaaba *et al*., 2011).

Moreover, in recent years, portable equipment is being marketed to perform counts in the field: PortaSCC® (PortaScience Inc., Moorestown, NJ, USA), based on an enzymatic reaction, and two machines that electronically count cells labeled with a fluorescent dye (ethidium bromide or propidium iodide), C-system Reader® (Digital Bio Tech, Ansan, Korea) and DeLaval cell counter (DeLaval International AB, Tumba, Sweden). The latter has been evaluated in cow milk (Malinowski *et al*., 2008), goat milk (Berry & Broughan, 2007) and sheep milk (Gonzalo *et al*., 2006), showing very good accuracy and repeating results; although it is necessary to make adaptations in the sample preparation when high fat and protein content milk are used (Gonzalo *et al*., 2008). These direct methods show as an advantage, that they are objective and accurate; and as disadvantages, that they can be time-consuming if samples are sent to a laboratory or costly when used at the farm because expensive equipment is required (Persson & Olofsson, 2011).

The SCC is performed routinely in laboratories approved for official milk control, using the fluoro-opto-electronic method equipment to count disk cytometry or, currently more commonly, by flow cytometry (Bintsis *et al*., 2008).

Conservation and storage of samples

Several authors (*i.e*. Gonzalo *et al*., 2004; Sánchez *et al*., 2005) have shown the importance of standardizing the methodology of samples preservation and their analysis in order to guarantee the reproducibility of SCC results; since there are certain factors that may affect the accuracy of the results: the conservation of the sample (temperature and time), the type of preservative and the temperature of the analysis.

Regarding the conservation of samples, these must not be kept at room temperature. In this case there is a rapid deterioration in the integrity of SC and therefore counts decrease as the days pass, as was found in cow milk (Kennedy *et al*., 1982) and sheep milk (Gonzalo *et al*., 2003). Sánchez *et al*. (2005) found that the conservation of goat milk samples in the refrigerator (4°C) without any preservative, allows stable counts for 10 days. However, other authors, after having studied sheep milk, advise against making the counts in refrigerated samples without preservatives, as these tend to lessen or worsen the correlation with the reference method (Gonzalo *et al*., 1998).

Moreover, in sheep milk samples preserved by freezing, Martinez *et al*. (2003) found that the analysis at 60°C caused a decrease in the SCC, in relation to the analysis at 40°C. However, a similar experiment conducted in goat milk (Sierra *et al*., 2006) showed that the SCC did not differ between the two analysis temperatures. In other work done with ovine milk samples, Gonzalo *et al*. (2004) found that analytical

temperature did not affect SCC accuracy, although it did affect repeatability.

Among the preservatives used in refrigerated samples, in general bronopol has showed the best results, because the SCC decreases to a small extent; < 5% in goat milk (Sánchez *et al*., 2005) and < 2.8% in sheep milk (Gonzalo *et al*., 2003), during the first 10 days of refrigeration.

In goat milk, Sánchez *et al*. (2005) also found that bronopol allowed for greater stabilization of the SCC after freezing (compared to azidiol or non-use of preservative), although they fell by 4-7% According to these authors, it is possible that the bronopol fluorescent dye helps penetrate further into the SC, thus giving a strong fluorescent signal in the equipments which analyze with the fluoro-opto-electronic method.

In summary, based on the works mentioned, Gonzalo (2005) and Raynal-Ljutovac *et al*. (2007) indicate that in sheep and goat milk, the best results of precision and repeatability of SCC are obtained using bronopol preserved milk samples stored at refrigeration temperature and analyzed at 40°C within 5 days after collection. Furthermore, most studies also found that in unpreserved samples kept in refrigeration, counts at 24-48 h after collection only differ with respect to the conditions outlined above (Gonzalo *et al*., 2003; Martínez *et al.,* 2003; Sánchez *et al*., 2005). Bronopol is bactericidal and therefore it is incompatible with the bacterial counts by instrumental analysis. Azidiol is the preservative most commonly used in all milk testing laboratories in Spain (Elizondo *et al*., 2007).

Table 2 shows numerical data SCC with the variation factors mentioned above.

Quality payment schemes based on bulk tank milk SCC

The main use for sheep and goat milk in the world is for cheese making that is usually conducted at farm

Table 2. Somatic cell count values with variations for the same factor. The table shows arithmetic means, except ◇ = geometric means

Factors	Somatic cell count (10^3 cells mL^{-1})	Reference
Major pathogens *e.g.: Staphylococcus aureus,*	2,100-4,100	Martínez, 2000 (◇)
Streptococcus spp, *Pseudomonas* spp, etc.	1,500	Koop *et al*., 2011 (◇)
	2,000-4,000	Min *et al*., 2007 (◇)
Mycoplasma agalactiae	2,900	Contreras *et al*., 2007
Coagulase negative sthaphylococci: *Staph. caprae,*	600-800	Martínez, 2000 (◇)
Staph. xylosus and *Staph. hominis*	1,010	Persson & Olofsson, 2011
S. epidermidis and *S. simulans*	1,000	Martínez, 2000 (◇)
Non mastitis	450	Leitner, 2007 (◇)
	345	Persson & Olofsson, 2011
	500	Goetsch *et al*., 2011
Factors of milking: The first streams	687	Contreras *et al*., 1997
	998	Martínez, 2000 (◇)
Control of milk	763	Contreras *et al*., 1997
	11,390	Martínez, 2000 (◇)
Number of milkings day^{-1} (once)	400[a]	Komara *et al*., 2009
(twice)	180[b]	Komara *et al*., 2009
Daily variation: (Primiparous goats)	< 200-2,000	Zeng *et al*., 1997
	1,705	García-Hernández *et al*., 2007 (◇)
	1,666.9	Jiménez-Granado *et al*., 2012
Stage of lactation: Beginning	200-500	Corrales *et al*., 1996; Moroni *et al*., 2005; Paape *et al*., 2007
Rest of lactation	1,000-3,100	Corrales *et al*., 1996; Moroni *et al*., 2005;
	1,500	Paape *et al*., 2007
Number of lactation: 1st	380	Paape *et al*., 2007
3rd	700	Paape *et al*., 2007
5th	850	Paape *et al*., 2007

Table 2 (cont.). Somatic cell count values with variations for the same factor. The table shows arithmetic means, except ◊ = geometric means

Factors	Somatic cell count (10^3 cells mL^{-1})	Reference
Breed: Saanen	< 575[a]	Calderini *et al*., 1996
Alpina	716[b]	Calderini *et al*., 1996
Murciano-Granadina	1,307[a]	Sánchez *et al*., 2005
Crossbred	2005[b]	Sánchez *et al*., 2005
Milking: Level of low vacuum (38 kPa)	< 392[a]	Sinapis *et al*., 1999
Level of high vacuum (45 kPa)	563[b]	Sinapis *et al*., 1999
Level of high vacuum (52 kPa)	704[c]	Sinapis *et al*., 1999
Pulsations 60:40	704[a]	Sinapis *et al*., 1999
Pulsations 70:30	854[b]	Sinapis *et al*., 1999
Pulsations 50:50	1,259[c]	Sinapis *et al*., 1999
Pulsation rate 120 p min^{-1}	602[a]	Sinapis *et al*., 1999
Pulsation rate 90 p min^{-1}	705[b]	Sinapis *et al*., 1999
Pulsation rate 60 p min^{-1}	1,687[c]	Sinapis *et al*., 1999
Final unit	1,607	Sánchez *et al*., 2005
Pitcher	1,623	Sánchez *et al*., 2005
Farming systems: Confined systems	1,427[a]	Sánchez-Rodríguez *et al*., 2005
Semi-intensive	2,453[b]	Sánchez-Rodríguez *et al*., 2005
Feeding: Complete	1,385[a]	Sánchez-Rodríguez *et al*., 2005
Semicomplete	2,005[b]	Sánchez-Rodríguez *et al*., 2005
Mixed grains	2,003[ab]	Sánchez-Rodríguez *et al*., 2005
Compound feed	1,720[ab]	Sánchez-Rodríguez *et al*., 2005
Facilities: Good	1,410[a]	Sánchez-Rodríguez *et al*., 2005
Regular	1940[b]	Sánchez-Rodríguez *et al*., 2005
Antibiotic: Yes	1,874	Sánchez-Rodríguez *et al*., 2005
	1,204	Poutrel *et al*., 1997
(Dry teraphy) No	1,709	Sánchez-Rodríguez *et al*., 2005
	925	Poutrel *et al*., 1997
Selective	1,326	Sánchez-Rodríguez *et al*., 2005
Rearing: Natural	1,715	Sánchez-Rodríguez *et al*., 2005
Artificial	1447	Sánchez-Rodríguez *et al*., 2005
Seal: Yes	1,630	Sánchez-Rodríguez *et al*., 2005
No	1,603	Sánchez-Rodríguez *et al*., 2005

[a,b,c] Different letters into an author show significant differences between means, according to different tests.

level or in small local dairies in Mediterranean and South-East European countries; although some big cheese factories can also be found, mainly in Western Europe. The quality of the milk for cheese making depends essentially on its physical and chemical composition and on hygienic (bacterial count, SCC, etc.) and sanitary factors (Pirisi *et al*., 2007).

In the European Union, Regulation 853/2004 (EOJ, 2004) states that raw cow milk at 30°C must have a total microbial count (TMC) ≤ 10^5 bacteria mL^{-1} and a SCC ≤ $400 \cdot 10^3$ SC mL^{-1}. For raw milk from other species, these criteria are specified only for TMC, ≤ $1,500 \cdot 10^3$ bacteria mL^{-1} and ≤ $500 \cdot 10^3$ bacteria mL^{-1} when the manufacture process involves both heat and non-heat treatment. The absence of specific criteria regarding SCC for goats derives from the high variability of their SCC, even in healthy animals, and because the relationship between TMC and SCC has yet to be clarified (Raynal-Ljutovac *et al*., 2007). In the USA, where criteria for milk production are issued by the pasteurized milk ordinance (US PMO, 2009), SCC in goat milk should not exceed $1,000 \cdot 10^3$ SC mL^{-1} for individual goats, although farmers are struggling to keep it below these levels in bulk tank milk (Paape *et al*., 2001).

Moreover, the inter-professionals of dairy goats in France have established that the SCC must be taken into account for the payment of milk, with a penalty in excess established at $1,500 \cdot 10^3$ SC mL^{-1} for the year 2000 and at $1,000 \cdot 10^3$ SC mL^{-1} for the year 2005 (De Cremoux, 2000). Similar figures were set in the conclusions of the International Congress of Milk Somatic Cell and Small Ruminants held in Bella (Italy) in 1994, which suggested that this value should not exceed to $1,500 \cdot 10^3$ SC mL^{-1}.

As optimal levels, some authors, like Boutinand & Jammes (2002) and Paape *et al*. (2001) provide lower levels to $1,100 \cdot 10^3$ SC mL^{-1}. As compared to this level, the meta-analysis of the distribution of herds of goats according to the SCC by the Inter-Professional Dairy Laboratory of Castilla-Leon from 1997 to 2010 (Table 3) indicates that 89.9% of farms have a SCC > $1,100 \cdot 10^3$ SC mL^{-1}; although the number of farms with >$1,700 \cdot 10^3$ SC mL^{-1} has decreased in recent years. Lower levels were found in different states and regions of the USA during 2000-2004, with SCC from 450,000 to 700,000 SC mL^{-1} (Paape *et al*., 2007).

Conclusions

Adequate sanitary control of herds is the best guarantee to prevent the occurrence of pathogens (mastitis) and to ensure the imperative requirement of food safety of dairy products from small ruminants. Subclinical mastitis is not detected visually, so it requires an indirect method, such as the SCC, to detect udder health. Different testing equipment and procedures are of variable reliability and applicability to goat milk, unless appropriate correction factors and calibration are used for this species. Once perfected for goats, as in the case of cattle and even sheep, fixed limits or thresholds should be established based on them for a hygienic and sanitary classification of milk, and even used as a form of payment to farmers based on the quality of the milk. It could be useful, to make a reference to half udder or goat SCC threshold.

Nowadays there is not enough information or general agreement to use SCC as a clear and precise tool of dairy goat mammary health as it is for dairy cows. Nevertheless there is enough evidences to expect its utility and researchers to carry on studying SCC in order to perfect this potential tool.

Taking all the above into consideration, it is necessary to study deeply and examine non-infectious and infectious factors contributing to elevations in SCC and to consider these when establishing legal limits for goat milk, with special attention to infectious factors (mastitis). The parameters which should be considered as well as their economic weight, have to be esta-

Table 3. Descriptive statistic of meta-analysis of somatic cell count distribution (%) of milk sold by the goat stockbreeding controlled by the *Laboratorio Interprofesional Lechero de Castilla-León* (Interprofessional Milk Laboratory of Castilla-León) from 1997 to 2010 (Tierras Ganadería, 2011). N = 200 herds

Year	1-500 (10^3 cells mL^{-1})	500-750 (10^3 cells mL^{-1})	750-1,100 (10^3 cells mL^{-1})	1,100-1,700 (10^3 cells mL^{-1})	1,700-5,000 (10^3 cells mL^{-1})
1997	1.2	1.8	2.99	12.57	81.44
1998	2.87	4.73	8.61	21.62	62.16
1999	2.06	2.57	7.34	29.86	58.17
2000	1.29	1.87	6.25	21.55	69.04
2001	1.32	2.46	5.49	24.61	66.12
2002	1.23	1.94	6.07	24.63	66.43
2003	0.57	1.71	6.03	23.21	68.49
2004	0.67	1.51	8.56	28.36	60.91
2005	0.95	3	11.22	38.39	46.45
2006	0.38	3.05	4.96	22.14	69.47
2007	0.93	3.26	10.23	25.58	60
2008	3.26	1.63	4.89	22.83	67.39
2009	1.68	1.68	4.47	25.7	66.48
2010	0.66	1.32	2.65	31.79	63.58
Mean	1.4 ± 0.23	2.3 ± 0.25	6.4 ± 0.68	25.2 ± 1.58	64.7 ± 2.06
Maximum	3.26	4.73	11.22	38.39	81.44
Minimum	0.38	1.32	2.65	12.57	46.45

blished. At the same time, it appears to be necessary to develop and improve the technical assistance given to breeders; so that they may adopt the most suitable measures in order to obtain high quality milk within the economic limits and potentials at farm level. Furthermore, the knowledge of factors associated with the SCC and its correlation with production and milk quality in goats is of great interest to veterinarians, technicians and producers. Some tools such as CMT can be very interesting too. Goat farmers would therefore benefit from using CMT in their daily work at the farm. CMT is an easy and cheap method, which can be performed as a "goat-side" test. For this purpose, a first approach should take into account at least: lactations number, stage of lactation and farming system in order to establish different levels of SCC.

As a result of increased knowledge of SCC factors, this could be considered for the future to be used as a benchmarking tool for the management and diagnosis of the different situations on goat farms. The different handling, production system, feeding, breeding programs, reproduction, milking routines, ...will determine the different measures to be taken.

References

Aleandri MA, Fagiolo P, Calderini R, Colafrancesco G, Giangolini R, Rosati, De Michelis F, 1996. Studies conducted on somatic cells counts of goats milk. In: Somatic cells and milk of small ruminants (Rubino R, ed). Wageningen Pers. EAAP 77: 65-70.

Bagnicka E, Winnicka A, Jóźwik A, Rzewuska M, Strzałkowska N, Kościuczuk E, Prusak B, Kaba J, Horbańczuk J, Krzyżewski J, 2011. Relationship between somatic cell count and bacterial pathogens in goat milk. Small Rumin Res 100(1): 72-77.

Baudry G, Jaubert G, Perrin G, 1993. Typologie des élevages des chévres en fonction de numération cellulaire du lait de troupeau. Rev Med Vet 4: 335-341.

Bergonier D, Lagriffoul G, Berthelot X, Barillet F, 1996. Facteurs de variation non infectieux des comptages de cellules somatiques chez les ovins et caprins laitiers. Wageningen Pers EAAP 77: 112-135.

Bergonier D, De Crémoux R, Rupp R, Lagriffoul G, Berthelot X, 2003. Mastitis of dairy small ruminants. Vet Res 34(5): 689-716.

Berry E, Broughan J, 2007. Use of the DeLaval cell counter (DCC) on goats' milk. J Dairy Res 74(3): 345-348.

Bintsis T, Angelidis AS, Psoni L, 2008. Modern laboratory practices – Analysis of dairy products. In: Advanced dairy science and technology (Britz TJ & Robinson RK, eds). Wiley Online Library. pp: 183-261.

Blagitz MG, Batista CF, Souza FN, Benites NR, Melville PA, Stricagnolo CR, Ricciardi M, Gomes V, Azedo MR, Sanches BGS, Della Libera AMMP, 2008. Perfil celular e microbiológico do leite de ovelhas Santa Inês no período lactante e pós-desmame. Pesq Vet Bras 28: 417-422.

Borges-Pizarro CH, Cordeiro PRC, Bresslau S, 2004. Seasonal variation of goat' milk composition and somatic cell count in Southeastern Brazil. Int Symp Fut Sheep and Goat Dairy Sect. Zaragoza, Spain.

Boulaaba A, Grabowski N, Klein G, 2011. Differential cell count of caprine milk by flow cytometry and microscopy. Small Rumin Res 97(1-3): 117-123.

Boutinaud M, Jammes H, 2002. Potential uses of milk epithelial cells: a review. Reprod Nutr Dev 42(2): 133-147.

Boyazoglu J, Morand-Fehr P, 2001. Mediterranean dairy sheep and goat products and their quality, a critical review. Small Rumin Res 40(1): 1-11.

Burriel AR, 2000. Somatic cell counts determined by the Coulter or Fossomatic Counter and their relationship to administration of oxytocin. Small Rumin Res 35(1): 81-84.

Calderini P, Colafrancesco R, Fagiolo A, Reitano ME, De Michelis F, 1996. Somatic cells count in milk from mastitis-free goats intensively reared and controlled until the sixth lactation. Wageningen Pers EAAP 77: 177-181.

Capote J, Castro N, Caja G, Fernández G, Briggs H, Argüello A, 2008. Effects of the frequency of milking and lactation stage on milk fractions and milk composition in Tinerfeña dairy goats. Small Rumin Res 75(2-3): 252-255.

Castel JM, Ruiz FA, Mena Y, Sánchez-Rodríguez M, 2010. Present situation and future perspectives for goat production systems in Spain. Small Rumin Res 89(2-3): 207-210.

Cedeen F, Kaya SO, Daskiran I, 2008. Somatic cell, udder and milk yield in goat. Rev Med Vet 159(4): 237-242.

Chen SX, Wang JZ, Van-Kessel JS, Ren FZ, Zeng SS, 2010. Effect of somatic cell count in goat milk on yield, sensory quality, and fatty acid profile of semisoft cheese. J Dairy Sci 93(4): 1345-1354.

Contreras A, Sánchez A, 2000. Recuento de células somáticas en pequeños rumiantes II Caprino. Ovis 67: 25-36.

Contreras A, Sánchez A, Corrales JC, Marco JC, 1997. Concepto e importancia de las mamitis caprinas. Ovis 58: 11-31.

Contreras A, Luengo C, Sánchez A, Corrales JC, 2003. The role of intramammary pathogens in dairy goats. Lives Prod Sci 79(2-3): 273-283.

Contreras A, Sierra D, Sánchez A, Corrales JC, Marco JC, Paape MJ, Gonzalo C, 2007. Mastitis in small ruminants. Small Rumin Res 68(1-2): 145-153.

Coop IE, 1982. Sheep and goat production. Lives Prod Sci 10(1): 93-94.

Corrales JC, Sánchez A, Sierra D, Marco JC, Contreras A, 1996. Relationship between somatic cell counts and intramammary pathogens in goats. Wageningen Pers EAAP 77: 89-92.

Corrales JC, Contreras A, Sánchez A, Marco J, Rabal F, 1997. Adaptación de las condiciones de la aplicación de la

directiva comunitaria 92/46 para el recuento de células somáticas, a nivel de tanque, en leche de ganado caprino. XXI Jornadas Científicas de la Sociedad Española de Ovinotecnia y Caprinotecnia. Logroño, Spain. pp: 221-227.

Corrales JC, Sánchez A, Luengo C, Poveda JB, Contreras A, 2004. Effect of clinical contagious agalactia on the bulk tank milk somatic cell count in Murciano-Granadina Goat Herds. J Dairy Sci 87(10): 3165-3171.

De Cremoux R, 2000. Células somáticas en leche de cabra y estrategias de control. Situación en Francia. Ovis 261: 35-40.

De Cremoux R, Pillet R, Ducelliez M, Heuchel V, Puotrel B, 1996. Influence du nombre et du stade de lactacion sur les numerations cellulaires du lait de chèvre. Wageningen Pers. EAAP 77: 161-165.

Delgado-Pertíñez M, Alcalde MJ, Guzmán-Guerrero JL, Castel JM, Mena Y, Caravaca F, 2003. Effect of hygiene-sanitary management on goat milk quality in semi-extensive systems in Spain. Small Rumin Res 47(1): 51-61.

Delgado-Pertíñez M, Guzmán-Guerrero Jl, Mena Y, Castel JM, González-Redondo P, Caravaca FP, 2009. Influence of kid rearing systems on milk yield, kid growth and cost of Florida dairy goats. Small Rumin Res 81(2-3): 105-111.

Díaz JR, Romero G, Peris C, Fernández N, 2004. Efecto de diferentes condiciones del ordeño mecánico en el estado del pezón. Bovis 118: 49-60.

Droke EA, Paape MJ, Di Carlo AL, 1993. Prevalence of high somatic cell counts in bulk tank goat milk. J Dairy Sci 76(4): 1035-1039.

Dulin AM, Paape MJ, Schultze WD, Weinland BT, 1983. Effect of Parity, stage of lactation, and intramammary infection on concentration of somatic cells and cytoplasmic particles in goat milk. J Dairy Sci 66(11): 2426-2433.

Elizondo J, Aldunate A, Ezcurra P, Gallego I, Saigos E, Ulayare, Izco JM, 2007. Efficiency of the proportion of azidiol on preservation in ewe's milk samples for analysis. Food Control 18: 185-190.

EOJ, 2004. 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 European Journal Union L139/55 30/04/2004.

Fedele V, Claps S, Rubino R, 1996. Effect of feding systems on somatic cells count in goats. Wageningen Pers EAAP 77: 167-172.

García-Hernández R, Newton G, Horner S, Nuti LC, 2007. Effect of photoperiod on milk yield and quality, and reproduction in dairy goats. Livest Sci 110 (3): 214-220.

Goetsch AL, Zeng SS, Gipson TA, 2011. Factors affecting goat milk production and quality. Small Rumin Res 101(1-3): 55-63.

Gomes V, Melville-Paiva-Della Libera AM, Paiva M, Madureira KM, Araújo WP, 2006. Effect of the stage of lactation on somatic cell counts in healthy goats (*Caprae hircus*) breed in Brazil. Small Rumin Res 64(1-2): 30-34.

Gonzalo C, 2005. Somatic cell of sheep and goat milks, analytical, sanitary, productive and technological aspects. In: International dairy federation (Future of sheep and goats dairy sector) 0501/part 3 (Special Issue): 128-133.

Gonzalo C, Carriedo JA, Baro JA, San Primitivo F, 1994. Factors influencing variation of test day milk yield, somatic cell count, fat, and protein in dairy sheep. J Dairy Sci 77(6): 1537-1542.

Gonzalo C, Martínez JR, San Primitivo F, 1998. Significación y métodos de valoración del recuento celular en la leche de oveja. Ovis 56: 13-25.

Gonzalo C, Ariznabarreta A, Carriedo JA, San Primitivo F, 2002. Mammary pathogens and their relationship to somatic cell count and milk yield losses in dairy ewes. J Dairy Sci 85(6): 1460-1467.

Gonzalo C, Martínez JR, Carriedo JA, San Primitivo F, 2003. Fossomatic cell-counting on ewe milk, comparison with direct microscopy and study of variation factors. J Dairy Sci 86(1): 138-145.

Gonzalo C, Boixo JC, Carriedo JA, San Primitivo F, 2004. Evaluation of rapid somatic cell counters under different analytical conditions in ovine milk. J Dairy Sci 87: 3623-3628.

Gonzalo C, Linage B, Carriedo JA, De la Fuente F, Primitivo FS, 2006. Evaluation of the overall accuracy of the DeLaval cell counter for somatic cell counts in ovine milk. J Dairy Sci 89(12): 4613-4619.

Gonzalo C, Linage B, Carriedo JA, De la Fuente LF, 2008. Short communication: evaluation of the overall accuracy of the DeLaval cell counter for somatic cell count in ovine milk, effect of soak time in diluted and undiluted milk samples. J Dairy Sci 91(8): 3114-3118.

Haenlein GFW, 2004. Goat milk in human nutrition. Small Rumin Res 51(2): 155-163.

Harmon RJ, 1994. Physiology of mastitis and factors affecting somatic cell counts. J Dairy Sci 77(7): 2103-2112.

ISO/IDF, 2008. Milk enumeration of somatic cells. Part 1, Microscopic method reference method). ISO 13366-1. IDF 148-1 (ISO and IDF).

Jiménez-Granado R, Rodríguez-Estévez V, Morantes M, Arce C, Sánchez-Rodríguez M, 2012a. Relationship between reproductive parameters and somatic cell count in dairy goats. Reprod Domest Anim 47(3): 90-123.

Jiménez-Granado R, Rodríguez-Estévez V, Arce C, Morantes M, López-Fariña MD, Rodríguez-Zarco M, Sánchez-Rodríguez M, 2012b. El rendimiento productivo en el caprino lechero de raza Florida y su relación con las células somáticas. Proc XXXVII Cong Nac Sociedad Española de Ovinotecnia y Caprinotecnia, Ciudad Real, Sept 19-21. pp: 363-366.

Jiménez-Granado R, Rodríguez-Estévez V, Arce C, Morantes M, López-Fariña MD, Pérez-Salas R, Sánchez-Rodríguez M, 2012c. Relación del recuento de células somáticas con la calidad bromatológica de la leche de cabra Florida: grasa y proteína. Proc XXXVII Cong Nac Sociedad Española de Ovinotecnia y Caprinotecnia, Ciudad Real, Sept 19-21. pp: 159-163.

Kennedy BW, Sethar MS, Tong AKW, Moxley JE, Downey BR, 1982. Environmental factors influencing test-day somatic cell counts in Holsteins. J Dairy Sci 65(2): 275-280.

Komara M, Boutinaud M, Ben-Chedly H, Guinard-Flament J, Marnet PG, 2009. Once-daily milking effects in high-yielding Alpine dairy goats. J Dairy Sci 92(11): 5447-5455.

Koop G, Nielen M, Van-Werven T, 2009. Bulk milk somatic cell counts are related to bulk milk total bacterial counts and several herd-level risk factors in dairy goats. J Dairy Sci 92(9): 4355-4364.

Koop G, Van-Werven T, Schuiling HJ, Nielen M, 2010. The effect of subclinical mastitis on milk yield in dairy goats. J Dairy Sci 93(12): 5809-5817.

Koop G, Van-Werven T, Toft N, Nielen M, 2011. Estimating test characteristics of somatic cell count to detect *Staphylococcus aureus*-infected dairy goats using latent class analysis. J Dairy Sci 94(6): 2902-2911.

Kosev K, Tzolov S, Denev S, Michailova G, Koleva M, 1996. Influence of lactation and type of milking on the somatic cell count in goat's milk. Wageningen Pers EAAP 77: 227-229.

Leitner G, Merin U, Glickman A, Weisblit L, Krifucks O, Shwimmer A, Saran A, 2004. Factors influencing milk and quality in assaf sheep and goats crossbreds. South Afr J Anim Sci 31(1): 162-164.

Leitner G, Merin U, Lavi Y, Egber A, Silanikove N, 2007. Aetiology of intramammary infection and its effect on milk composition in goat flocks. J Dairy Res 74(2): 186-193.

Leitner G, Silanikove N, Merin U, 2008. Estimate of milk and curd yield loss of sheep and goats with intrammamary infection and its relation to somatic cell count. Small Rumin Res 74(1-3): 221-225.

Lerondelle C, Richard Y, Issartial J, 1992. Factors affecting somatic cell counts in goat milk. Small Rumin Res 8 (1-2): 129-139.

Long PE, Heavner JE, Ziv G, Geleta JN, Nepote K, 1984. Depletion of antibiotics from the mammary gland of goats. J Dairy Sci 67(3): 707-712.

Luengo C, Sánchez A, Corrales JC, Fernández C, Contreras A, 2004. Influence of intramammary infection and non-infection factors on somatic cell counts in dairy goats. J Dairy Res 71(2): 169-74.

Malinowski E, Smulski S, Gehrke M, Klossowska A, Arczyńska A, Kaczmarowski M, 2008. Effect of storage conditions and preservation with Bronopol on somatic cell count with the DeLaval cell counter in cow milk. Med Weter 64(11): 1299-1303.

Manlongat N, Yang TJ, Hinckley LS, Bendel RB, Krider M, 1998. Physiologic chemoattractant induced migration of polymorphonuclear leukocytes in milk. Clin Diagn Lab Immunol 5: 375-381.

Manzur A, 2007. Estudios de ordeño mecánico en ganado caprino. Doctoral thesis. Universidad Politécnica de Valencia, Spain. 138 pp.

Manzur A, Díaz JR, Mehdid A, Fernández M, Peris C, 2012. Effect of mik-line milking systems on milking characteristics in goats. J Dairy Res 79(3): 375-382.

Marco JC, Jacquin C, Esnal A, Jiménez R, Sánchez M, Gonzalo C, 2012. Los programas de mejora de la calidad de la leche: Su impacto en la rentabilidad de las explotaciones de caprino lechero. Tierras Caprino 2: 8-19.

Marogna G, Rolesu S, Lollai S, Tola S, Leori G, 2010. Clinical findings in sheep farms affected by recurrent bacterial mastitis. Small Rumin Res 88(2-3): 119-125.

Marogna G, Pilo C, Vidili A, Tola S, Schianchi G, Leori SG, 2012. Comparison of clinical findings, microbiological results, and farming parameters in goat herds affected by recurrent infectious mastitis. Small Rumin Res 102(1): 74-83.

Martínez B, 2000. El recuento de células somáticas en la leche de cabra, factores de variación y efecto sobre la producción y composición de la leche. Tesis doctoral. Universidad Politécnica de Valencia, Spain. 307 pp.

Martínez B, Peris C, Vega S, 1999. Relación entre el recuento de células somáticas y los patógenos intramamarios aislados en el ganado caprino lechero de la Comunidad Valenciana. XXIV Jornadas Científicas, Sociedad Española de Ovinotecnia y Caprinotecnia, Soria, Spain. pp: 325-329.

Martínez JR, Gonzalo C, Carriedo JA, San Primitivo F, 2003. Effect of freezing on fossomatic cell counting in ewe milk. J Dairy Sci 86(8): 2583-2587.

McDougall S, Voermans M, 2002. Influence of estrus on somatic cell count in dairy goats. J Dairy Sci 85(2): 378-383.

McDougall S, Anniss FM, Cullum AA, 2002. Effect of transport stress on somatic cell counts in dairy goats. Proc N Z Soc Anim Prod 62: 16-18.

Mehdid MA, Díaz JR, Manzur A, Peris C, 2010. Non-infectious transient elevations of somatic cells count in goat's milk. Proc XXXV Cong Nac Sociedad Española de Ovinotecnia y Caprinotecnia, Valladolid, Sept 22-24. pp: 121-125.

Min BR, Tomita G, Hart SP, 2007. Effect of subclinical intramammary infection on somatic cell counts and chemical composition of goats' milk. J Dairy Res 74(2): 204-210.

Morand-Fehr P, Fedele V, Decandia M, Le Frileux Y, 2007. Influence of farming and feeding systems on composition and quality of goat and sheep milk. Small Rumin Res 68(2-3): 20-34.

Moroni P, Pisoni G, Ruffo G, Boettcher PJ, 2005. Risk factors for intramammary infections and relationship with somatic-cell counts in Italian dairy goats. Prev Vet Med 69(3-4): 163-173.

Moroni P, Pisoni G, Savoini G, Van-Lier E, Acuña S, Damián JP, Meikle A, 2007. Influence of estrus of dairy goats on somatic cell count, milk traits, and sex steroid receptors in the mammary gland. J Dairy Sci 90(2): 790-797.

Neveu C, Riaublanc A, Miranda G, Chich JF, Martín P, 2002. Is the apocrine milk secretion process observed in the goat species rooted in the perturbation of the intracellular transport mechanism induced by defective alleles at the alpha(s1)-Cn locus? Reprod Nutr Dev 42(2): 163-172.

Nudda A, Bencini R, Mijatovic S, Pulina G, 2002. The yield and composition of milk in Sarda, Awassi, and Merino sheep milked unilaterally at different frequencies. J Dairy Sci 85(11): 2879-2884.

Nunes GR, Blagitz MG, Freitas CB, Souza FN, Ricciardi M, Stricagnolo CR, Sanches BGS, Azedo MR, Sucupira MCA, Della Libera AMMP, 2008. Evaluation of the indicators of inflammation in the diagnosis of ovine matitis. Arqu Ins Biol 75(3): 271-278.

Paape MJ, Capuco AV, 1997. Cellular defense mechanisms in the udder and lactation of goats. J Anim Sci 75: 556-565.

Paape MJ, Poutrel B, Contreras A, Marco JC, Capuco AV, 2001. Milk somatic cells and lactation in small ruminants. J Dairy Sci 84: 237-244.

Paape MJ, Wiggans GR, Bannerman DD, Thomas DL, Sanders AH, Contreras A, Moroni P, Miller RH, 2007. Monitoring goat and sheep milk somatic cell counts. Small Rumin Res 68(1-2): 114-125.

Pérez-Baena I, Blasco E, Sánchez-Quinche A, Romero T, Mazón J, Peris C, 2012. Efecto de la sarna sobre la producción y la composición de la leche en cabras. Revista Albéitar 158: 10-11.

Peris C, Díaz JR, Fernández N, Rodríguez M, Molina P, Orres A, 2002a. Influencia del ordeño mecánico sobre la mamitis I. IV Jornadas Científicas Internacionales de Ovinotecnia y Caprinotecnia, SEOC, Valencia. Spain. pp: 360-366.

Peris C, Segura C, Palomares JL, Rodríguez M, Díaz JR, Fernández N, 2002b. La calidad de la leche de cabra producida en las comunidades autónomas de Valencia y Murcia. IV Jornadas Científicas Internacionales de Ovinotecnia y Caprinotecnia, (SEOC). Valencia. Spain. pp: 360-366.

Perrin GG, Baudry C, 1993. Numérations cellulaires du lait de chèvre. Le Lait 73: 489-497.

Persson Y, Olofsson I, 2011. Direct and indirect measurement of somatic cell count as indicator of intramammary infection in dairy goats. Acta Vet Scand 53: 15.

Pettersen KE, 1981. Cell content in goat's milk. Acta Vet Scand 22: 226-237.

Pirisi A, Lauret A, Dubeuf JP, 2007. Basic and incentive payments for goat and sheep milk in relation to quality. Small Rumin Res 68(1-2): 167-178.

Poutrel B, De Crémoux R, Ducelliez M, Verneau D, 1997. Control of intramammary infections in goats, impact on somatic cell counts. J Anim Sci 75(2): 566-570.

Randy HA, Caler WA, Miner WA, Miner WH, Atwood AC, Howarg DB, 1991. Effect of lactation number, year, and milking management practices on milk yield and SCC of french Alpine dairy goats. J Dairy Sci 74(1): 311.

Raynal-Ljutovac K, Pirisi A, De Crémoux R, Gonzalo C, 2007. Somatic cells of goat and sheep milk: Analytical, sanitary, productive and technological aspects. Small Rumin Res 68(1-2): 126-144.

Rémond B, Pomiès D, Dupont D, Hilliard Y, 2004. Once-a-day milking of multiparous Holstein cows throughout the entire lactation, milk yield and composition, and nutritional status. Anim Res 53(3): 201-212.

Ribeiro AC, Ribeiro SDA, 2010. Specialty products made from goat milk. Small Rumin Res 89: 225-233.

Rota AM, Gonzalo C, Rodríguez PL, Rojas AI, Martin L, Tovar JJ, 1993a. Somatic cell types in goats milk in relation to total cell count, stage and number of lactation. Small Rumin Res 12 (1): 89-98.

Rota AM, Gonzalo C, Rodríguez PL, Rojas AI, Martín L, Tovar JJ, 1993b. Effects of stage of lactation and parity on somatic cell counts in milk of Verata goats and algebraic models of their lactation curves. Small Rumin Res 12(2): 211-219.

Salama AAK, Such X, Caja G, Rovai M, Casals R, Albanell E, Marín MP, Martí A, 2003. Effects of once versus twice daily milking throughout lactation on milk yield and milk composition in dairy goats. J Dairy Sci 86(5): 1673-1680.

Sánchez A, Corrales JC, Marco J, Contreras A, 1998a. Aplicación del recuento de células somáticas para el control de las mamitis caprinas. Ovis 54: 37-51.

Sánchez A, Luengo C, Corrales JC, Contreras A, 1998b. Modificación del recuento celular en la leche de cabras según la serología frente al virus de la artritis-encefalitis caprina y la infección intramamaria de etiología bacteriana. XV Reunión de Técnicos Especialistas en Mamitis y Calidad de Leche, Lugo, Spain.

Sánchez A, Corrales JC, Luengo C, Contreras A, 1999. Intramammary pathogens and somatic cell counts in dairy goats. Wageningen Pers EAAP 95: 124-129.

Sánchez A, Sierra D, Luengo C, Corrales JC, Morales CT, Contreras A, Gonzalo C, 2005. Influence of storage and preservation on fossomatic cell count and composition of goat milk. J Dairy Sci 88(9): 3095-3100.

Sánchez J, Montes P, Jiménez A, Andres S, 2007. Prevention of clinical mastitis with barium selenate in dairy goats from a selenium-deficient area. J Dairy Sci 90(5): 2350-2354.

Sánchez-Rodríguez M, Gómez Castro AG, Mata Moreno C, Doménech García V, López Baldán D, Romero AM, Cabello A, 2000. Resultados productivos del rebaño experimental de raza Florida. FEAGAS 1(18): 105-107.

Sánchez-Rodríguez M, Gil-Rubio JM, Beltrán-Hermoso M, Muñoz-Cobos I, Santos-Alcudia R, Martos-Peinado J, 2005. Calidad de la leche en el grupo caprino de Covap y su relación con parámetros técnicos y de manejo. IX Jornadas Científicas de la Sociedad Española de Ovinotecnia y Caprinotecnia, Granada, Spain. pp: 89-92.

Sánchez-Rodríguez M, Martos J, Aparicio D, Martín D, García A, García-Schiafino S, Muñoz EM, 2008. Evolución del recuento de células somáticas en cabras lecheras tras la prueba de campo con tratamiento de secado. XII Jornadas Científicas de la Sociedad Española de Ovinotecnia y Caprinotecnia, Granada, Spain. pp: 498-502.

Sierra D, Sánchez A, Corrales JC, Contreras A, 1998. Recuentos celulares diferenciales en leche de ganado caprino. XV Reunión de Técnicos Especialistas en Mamitis y Calidad de la Leche. Lugo, 24 noviembre.

Sierra D, Sánchez A, Corrales JC,Contreras A, 1999. Differential cell counts in goat's milk. Milking and milk production of dairy sheep and goats. Wageningen Pers EAAP 95: 178-180.

Sierra D, Sánchez A, Luengo C, Corrales JC, Morales CT, Contreras A, Gonzalo C, 2006. Temperature effects

on fossomatic cell counts in goats milk. Int Dairy J 16: 385-387.

Silanikove N, Leitner G, Merin U, Prosser CG, 2010. Recent advances in exploiting goat's milk: quality, safety and production aspects. Small Rumin Res 89(2-3): 110-124.

Sinapis E, Vlachos L, 1999. Influence du niveau de vide de la machine á traire et des facteurs zootechniques sur les comptages de cellules somatiques chez les chévres locales greques [Milking and milk production of dairy sheep and goats]. Wageningen Pers. EAAP 95: 513-518.

Sordillo LM, Streicher KL, 2002. Mammary gland immunity and mastitis susceptibility. J Mam Gland Biol Neopl 7: 135-146.

Souza FN, Blagitz MG, Penna CFAM, Della Libera AMMP, Heinemann MB, Cerqueira MMOP, 2012. Somatic cell count in small ruminants, friend or foe? Small Rumin Res 107(2): 65-75.

Tierras Ganadería, 2011. Preocupación por las células somáticas. Tierras Ganadería 177: 10-12.

US PMO, 2009. Pasteurized milk ordinance (2009 revision) of the United States Food and Drug Administration. Available in http://www.fda.gov/downloads/Food/GuidanceRegulation/UCM209789.pdf. [November 26, 2012].

Wilson DJ, Stewart KN, Sears PM, 1995. Effects of stage of lactation, production, parity and season on somatic cell counts in infected and uninfected dairy goats. Small Rumin Res 16(2): 165-169.

Zeng SS, Escobar EN, 1995. Effect of parity and milk production on somatic cell count, standard plate count and composition of goat milk. Small Rumin Res 17(3): 269-274.

Zeng SS, Escobar EN, Brown-Crowder I, 1996. Evaluation of screening tests for detection of antibiotic residues in goat milk. Small Rumin Res 21(2): 155-160.

Zeng SS, Escobar EN, Popham T, 1997. Daily variations in somatic cell count, composition, and production of Alpine goat milk. Small Rumin Res 26(3): 253-260.