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-
monitor 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 that can influence the SCC.

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 lactogenesis, 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**

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 eosinophils 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).

**Threshold value of SCC**

The cell concentration in goat milk is higher than in cow and sheep milk (Contreras et al., 1997; Paape et
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 Staphylococcus 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).
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 intra-mammary 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.

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<th>Table 1. Main factors influencing somatic cell count in goat milk</th>
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**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 \( \times 10^3 \) 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; Sanchez 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 (Martinez, 2000), in CAEV seropositive animals this increase is more moderate (Sanchez 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, Martinez (2000) found a range of SCC means from 272 \( \times 10^3 \) SC mL\(^{-1}\) from pathogens free udders (Contreras et al., 1997) to 2,000 \( \times 10^3 \) SC mL\(^{-1}\) from pathogen 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 elapsed 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 · 10³ to 1,000 · 10³ SC mL⁻¹ (or even over 2,000 · 10³ 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 \(200 \cdot 10^3\) SC mL\(^{-1}\) at 15 days of lactation and these reached maximums of around \(500 \cdot 10^3\) SC mL\(^{-1}\) at 285 days. By the fifth parity, counts averaged \(250 \cdot 10^3\) SC mL\(^{-1}\) at 15 days and increased to a maximum of \(1,150 \cdot 10^3\) 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 \((1,666.9 \cdot 10^3 \pm 137.1 \cdot 10^3\) 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 may an 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 \((\leq 954 \cdot 10^3\) 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 \(1,450 \cdot 10^3\) 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 \(< 1,300 \cdot 10^3\) 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-Rodriguez 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 temporarily 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 · 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 · 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 show the 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 · 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 (Boulaba et al., 2011). The fluoropto-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 (Boulaba 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 fluoropto-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>
<thead>
<tr>
<th>Factors</th>
<th>Somatic cell count (10³ cells mL⁻¹)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major pathogens e.g.: <em>Staphylococcus aureus</em>, <em>Streptococcus spp</em>, <em>Pseudomonas spp</em>, etc.</td>
<td>2,100-4,100</td>
<td>Martínez, 2000 (◊)</td>
</tr>
<tr>
<td></td>
<td>1,500</td>
<td>Koop et al., 2011 (◊)</td>
</tr>
<tr>
<td></td>
<td>2,000-4,000</td>
<td>Min et al., 2007 (◊)</td>
</tr>
<tr>
<td><em>Mycoplasma agalactiae</em></td>
<td>2,900</td>
<td>Contreras et al., 2007</td>
</tr>
<tr>
<td>Coagulase negative staphylococci: <em>Staph. caprae</em>, <em>Staph. xylosus</em> and <em>Staph. hominis</em></td>
<td>600-800</td>
<td>Martínez, 2000 (◊)</td>
</tr>
<tr>
<td></td>
<td>1,010</td>
<td>Persson &amp; Olofsson, 2011</td>
</tr>
<tr>
<td></td>
<td>1,000</td>
<td>Martínez, 2000 (◊)</td>
</tr>
<tr>
<td></td>
<td>450</td>
<td>Leitner, 2007 (◊)</td>
</tr>
<tr>
<td></td>
<td>345</td>
<td>Persson &amp; Olofsson, 2011</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>Goetsch et al., 2011</td>
</tr>
<tr>
<td>Non mastitis</td>
<td>450</td>
<td>Martínez, 2000 (◊)</td>
</tr>
<tr>
<td>Factors of milking: The first streams</td>
<td>687</td>
<td>Contreras et al., 1997</td>
</tr>
<tr>
<td></td>
<td>998</td>
<td>Martínez, 2000 (◊)</td>
</tr>
<tr>
<td>Control of milk</td>
<td>763</td>
<td>Contreras et al., 1997</td>
</tr>
<tr>
<td></td>
<td>11,390</td>
<td>Martínez, 2000 (◊)</td>
</tr>
<tr>
<td>Number of milkings day⁻¹ (once)</td>
<td>400a</td>
<td>Komara et al., 2009</td>
</tr>
<tr>
<td>(twice)</td>
<td>180b</td>
<td>Komara et al., 2009</td>
</tr>
<tr>
<td>Daily variation: (Primiparous goats)</td>
<td>&lt;200-2,000</td>
<td>Zeng et al., 1997</td>
</tr>
<tr>
<td></td>
<td>1,705</td>
<td>García-Hernández et al., 2007 (◊)</td>
</tr>
<tr>
<td></td>
<td>1,666.9</td>
<td>Jiménez-Granado et al., 2012</td>
</tr>
<tr>
<td>Stage of lactation: Beginning</td>
<td>200-500</td>
<td>Corrales et al., 1996; Moroni et al., 2005; Paape et al., 2007</td>
</tr>
<tr>
<td>Rest of lactation</td>
<td>1,000-3,100</td>
<td>Corrales et al., 1996; Moroni et al., 2005; Paape et al., 2007</td>
</tr>
<tr>
<td></td>
<td>1,500</td>
<td>Paape et al., 2007</td>
</tr>
<tr>
<td>Number of lactation: 1st</td>
<td>380</td>
<td>Paape et al., 2007</td>
</tr>
<tr>
<td>3rd</td>
<td>700</td>
<td>Paape et al., 2007</td>
</tr>
<tr>
<td>5th</td>
<td>850</td>
<td>Paape et al., 2007</td>
</tr>
</tbody>
</table>
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) \( \leq 10^5 \) bacteria mL\(^{-1}\) and a SCC \( \leq 400 \cdot 10^3 \) SC mL\(^{-1}\). For raw milk from other species, these criteria are specified only for TMC, \( \leq 1,500 \cdot 10^3 \) bacteria mL\(^{-1}\) and \( \leq 500 \cdot 10^3 \) 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).

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

<table>
<thead>
<tr>
<th>Factors</th>
<th>Somatic cell count (10^3 cells mL(^{-1}))</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breed: Saanen</td>
<td>&lt;575(^a)</td>
<td>Calderini et al., 1996</td>
</tr>
<tr>
<td>Alpina</td>
<td>716(^b)</td>
<td>Calderini et al., 1996</td>
</tr>
<tr>
<td>Murciano-Granadina</td>
<td>1,307(^a)</td>
<td>Sánchez et al., 2005</td>
</tr>
<tr>
<td>Crossbred</td>
<td>2005(^b)</td>
<td>Sánchez et al., 2005</td>
</tr>
<tr>
<td>Milking: Level of low vacuum (38 kPa)</td>
<td>&lt;392(^a)</td>
<td>Sinapis et al., 1999</td>
</tr>
<tr>
<td>Level of high vacuum (45 kPa)</td>
<td>563(^b)</td>
<td>Sinapis et al., 1999</td>
</tr>
<tr>
<td>Level of high vacuum (52 kPa)</td>
<td>704(^c)</td>
<td>Sinapis et al., 1999</td>
</tr>
<tr>
<td>Pulsations 60:40</td>
<td>704(^a)</td>
<td>Sinapis et al., 1999</td>
</tr>
<tr>
<td>Pulsations 70:30</td>
<td>854(^b)</td>
<td>Sinapis et al., 1999</td>
</tr>
<tr>
<td>Pulsations 50:50</td>
<td>1,259(^c)</td>
<td>Sinapis et al., 1999</td>
</tr>
<tr>
<td>Pulsation rate 120 p min(^{-1})</td>
<td>602(^a)</td>
<td>Sinapis et al., 1999</td>
</tr>
<tr>
<td>Pulsation rate 90 p min(^{-1})</td>
<td>705(^b)</td>
<td>Sinapis et al., 1999</td>
</tr>
<tr>
<td>Pulsation rate 60 p min(^{-1})</td>
<td>1,687(^c)</td>
<td>Sinapis et al., 1999</td>
</tr>
<tr>
<td>Final unit</td>
<td>1,607</td>
<td>Sánchez et al., 2005</td>
</tr>
<tr>
<td>Pitcher</td>
<td>1,623</td>
<td>Sánchez et al., 2005</td>
</tr>
<tr>
<td>Farming systems: Confined systems</td>
<td></td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>Semi-intensive</td>
<td>1,427(^a)</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>Feeding: Complete</td>
<td>1,385(^a)</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>Semicomplete</td>
<td>2,005(^b)</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>Mixed grains</td>
<td>2,003(^ab)</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>Compound feed</td>
<td>1,720(^ab)</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>Facilities: Good</td>
<td>1,410(^a)</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>Regular</td>
<td>1940(^b)</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>Antibiotic: Yes</td>
<td>1,874</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>(Dry teraphy) No</td>
<td>1,709</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>Selective</td>
<td>1,326</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>Rearing: Natural</td>
<td>1,715</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>Artificial</td>
<td>1,447</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>Seal: Yes</td>
<td>1,630</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
<tr>
<td>No</td>
<td>1,603</td>
<td>Sánchez-Rodríguez et al., 2005</td>
</tr>
</tbody>
</table>

\(^a,b,c\) Different letters into an author show significant differences between means, according to different tests.
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 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

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

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