

# CAN SOMATIC CELL COUNTS GET TOO LOW ?

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## Introduction

Somatic cell counts are used as quality parameter for raw milk. The assumption is that high cell counts are associated with poor quality raw milk, and lower cell counts indicate better quality. The somatic cell count penalty limits for saleable milk differ between countries, with the European Union and Australia and New Zealand at 400,000, Canada at 500,000 and the United States at 750,000 (Paape et al. 1997). Within these countries, separate incentive programs exist to motivate dairy producers to produce milk with cell counts lower than 200,000, 150,000 or even 100,000 cells per ml of milk. These incentive programs are specifically attractive to producers when milk price is low and meeting the requirements for incentives is one feasible way to somewhat improve of the dairy. Usually, reduction of cell counts leads to an expected economic benefit with an estimated 4 to 1 benefit to cost ratio (Harmon 1994). However, it is unclear whether it is economically attractive to reduce cell counts to very low levels. Also, there is continuous concern as to whether very low cell counts are biologically optimal or whether a certain base level of somatic cells is required to protect the cow from intramammary infections with major pathogens. The argument is not new: to improve this base level of somatic cells a series of experimental studies on abraded intramammary devices was conducted about 20 years ago (Paape et al. 1991). These devices were not developed further since they showed too many side effects such as very high cell counts, chronic staphylococcus infections and even symptoms of clinical mastitis.

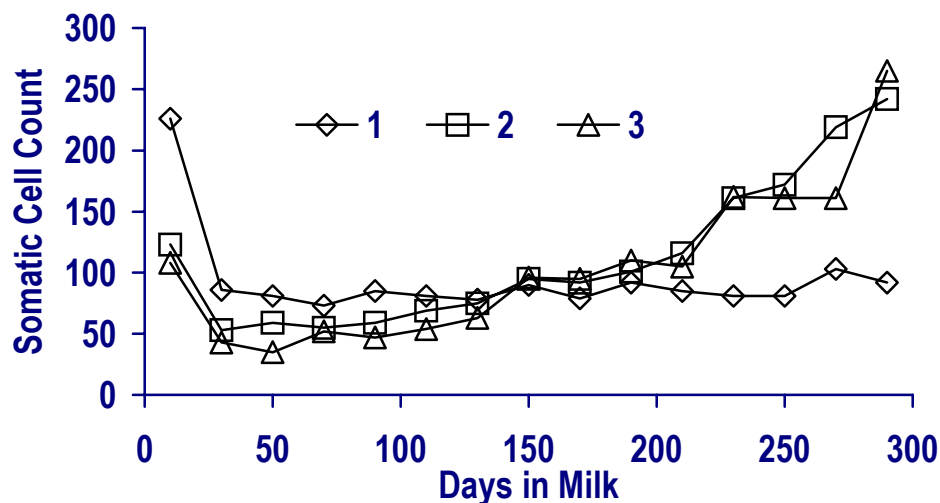
Several experimental challenge studies have shown the benefit of somewhat higher somatic cell counts (Shuster et al. 1996, Schukken et al. 1999). It is as of yet not clear whether this advantage of slightly higher cell counts also exists under more natural exposure circumstances. In this presentation we attempt to summarise the recent findings in this area and attempt to answer the question that is in the title of this presentation.

## Somatic Cells in Milk: Morphology and Function

In a normal non infected and non inflamed quarter, the somatic cell population consists of polymorphnuclear cells, macrophages, lymphocytes and epithelial cells (Concha 1986). The majority of cells are macrophages (approximately 60% of cells), lymphocytes are approximately 30% of cells, and polymorphnuclear cells form approximately 10% of the population, the epithelial cells are about 2% (Burvenich et al. 1995, Paape and Contreras 1997, Paape et al. 1991). Somatic cell counts are relatively low, usually at or below 50,000 cells per ml. In Figure 1, the upper 95% confidence limit is shown, indicating that 95% of

uninfected cows is below approximately 100,000 cells per ml., except in the last month of lactation. In long term uninfected cows the number of cells in milk follow an approximate inverse lactation curve (Laevens et al. 1997, Schepers et al. 1997, Harmon 1994, Brolund 1985).

Figure 1. The upper 95% confidence limit of somatic cell counts in uninfected cows, the numbers in the legend indicate three parity groups: first parity, second parity and third and higher parities (Adapted from Schepers et al. 1997).



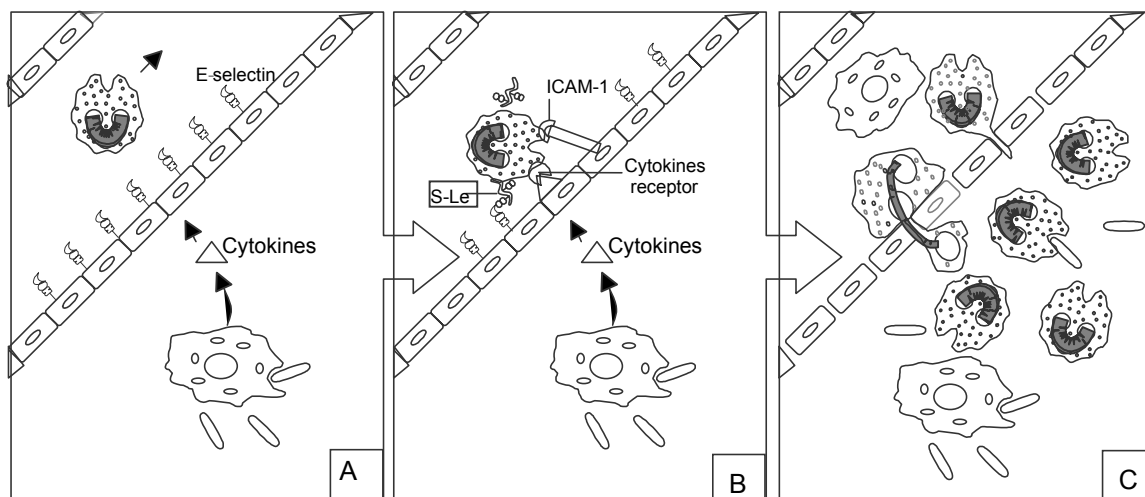
Macrophages play a crucial role in the innate defence mechanisms of the mammary gland. The macrophages have an important function in ingestion of foreign materials such as micro organisms and cellular debris, but also have a key function in antigen processing and presentation in association with the major histo-compatibility complex (Sordillo et al. 1997). Finally, macrophages produce cytokines, small inflammatory modulators which are important in initiating the inflammatory response to incoming microorganisms (Zecconi et al. 2000).

Lymphocytes maintain a steady state of induction versus suppression of the immune response (Burvenich et al. 1995, Sordillo et al. 1997). In milk from normal cows, the lymphocyte population is comprised predominantly of T-cells (approximately 60% of lymphocytes) with relatively few B-cells (approximately 20% of lymphocytes). The majority of T-cells are CD8+ (cytotoxic T-cells) with a lower proportion of CD4+ cells (T-helper cells) (Taylor et al. 1997, Soltys and Quinn 1999). These lymphocytes produce a host of cytokines that are important to maintain a steady state and a balanced immune response to invading micro organisms. The

cytokines form a chemical gradient towards which the polymorphnuclear show a chemotactic movement. This process is depicted in figure 2. Lymphocytes also function as scavengers, removing old or damaged cells. The T-cell distribution in the mammary gland is similar to populations found on other mucosal surfaces (Roitt et al. 1998, Asai et al. 2000).

Polymorph-nuclear cells are the primary warriors in the mammary gland. Their function is specifically in phagocytosis and killing of invading bacteria (Sordillo et al. 1997).

Figure 2. The process of PMN chemo-attraction into the mammary gland (From Suriyasathaporn et al. 2000b).



During the inflammatory response, all these resident cells act in an organized manner to eliminate the inflammatory noxe. During the early inflammatory response the resident cells attempt to phagocytose and kill the incoming bacteria, and they produce cytokines to attract immune cells toward the site of inflammation. Consequently, there is a massive influx of polymorphnuclear cells, and a somewhat pathogen dependent preferential influx of CD4+ T-cells (Taylor et al. 1997, Sordillo et al. 1997, van Werven et al. 1997).

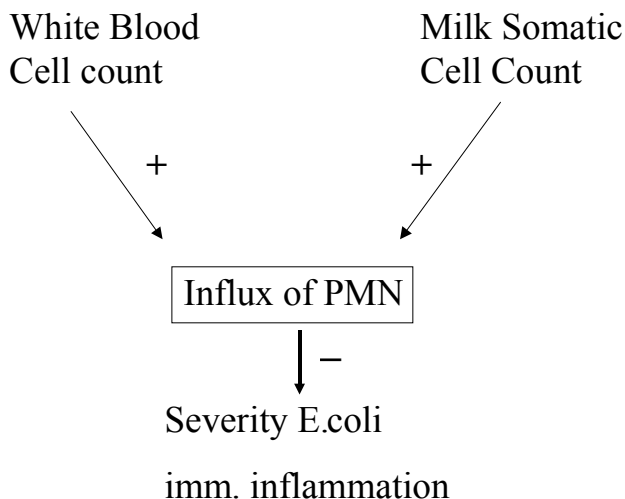
Clearly the resident somatic cells have an important function in the immune response to invading micro organisms. The extreme situation of no milk somatic cells at all, if it were to exist, would be an unfavourable situation for the host.

### Very Low Cell Counts and the Response to Experimental Infections

Several experimental challenge studies have shown a decreased immune responsiveness in cows with low somatic cell counts before challenge. Usually cows selected for such studies have cell counts below 200,000 cells per ml, and within these cows the lower cell count cows

appear to be at higher risk of infection or more severe outcome of infection. Shuster et al. (1996) performed an *E.coli* challenge experiment. They observed a negative correlation between pre-infection somatic cell counts and severity of inflammation. Pre-challenge cell counts were correlated to CD18 expression and inversely correlated to bacterial growth after challenge. Also, cytokine production was lower in cows with lower pre-challenge cell counts leading to a significantly lower leukocyte recruitment in the early phase of the inflammation. Schukken et al. challenged 135 cows with *S.aureus*. Cows with higher somatic cells before challenge were at lower risk of becoming chronically infected with *S.aureus*. Cows that became infected had a mean cell count of 36,000 cells, whereas cows that were able to eliminate the challenge infection had a pre-challenge cell count of 122,000 cells per ml (Schukken et al. 1999). Clearly these are very low cell counts. In a meta analysis of several *E.coli* challenge experiments van Werven et al. (1997) observed that cows with low blood leukocyte counts and low milk somatic cell counts pre challenge had a significantly slower influx of polymorphnuclear cells into the mammary gland after challenge. This was also associated with more severe clinical disease. Disease was quantified by evaluating bacterial growth and quarter milk production loss. These relationships are summarised in Figure 3.

Figure 3. Summary of relationships between peripheral white blood cell counts, milk somatic cell counts, post challenge influx of polymorphnuclear cells into the mammary gland, and severity of *E.coli* inflammation. Adapted from van Werven et al. 1997.

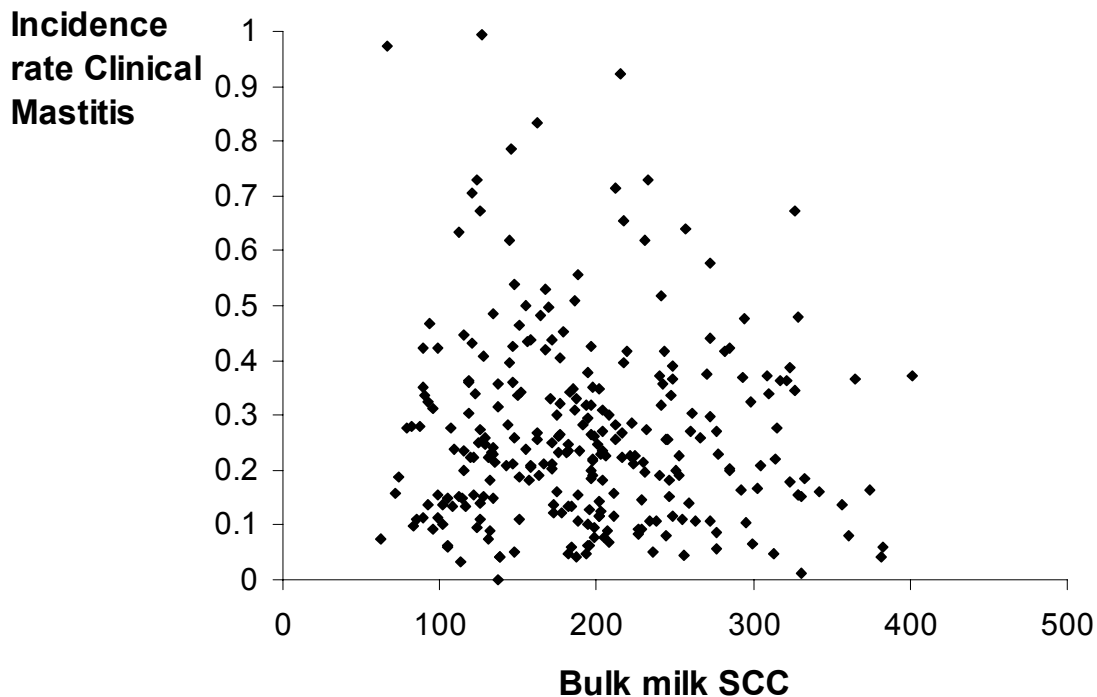


These and other studies suggest that in tightly controlled challenge studies in a previously uninfected quarter, a very low somatic cell count puts a cow at greater risk of become infected or showing a more severe response to intramammary challenge.

## Very Low Cell Counts and the Response to Natural Infections

There are relatively few studies that have studied somatic cell counts in cows under normal circumstances and evaluated their relationship to natural infections. There are a number of studies looking at clinical mastitis incidence in herds with low bulk milk somatic cell counts. Erskine et al. (1988) observed a higher incidence of *E.coli* mastitis in low cell count herds, and an absence of *S.agalactia* mastitis. Barkema et al. (1998) observed something very similar in a study of 300 Dutch dairy herds. This latter study was specifically designed to evaluate whether low bulk milk somatic cell counts were associated with higher incidences of clinical mastitis. The results of this study are depicted in figure 4. There was no correlation between bulk milk somatic cell count and total clinical mastitis incidence, although the incidence of clinical mastitis with severe systemic symptoms was significantly higher in low cell count herds (Barkema et al. 1998). The latter was also observed in a number of UK studies on toxic mastitis (Green et al. 1996, Tadich et al. 1998).

Figure 4. Relationship between incidence rate of clinical mastitis and mean annual bulk milk somatic cell count in 300 Dutch dairy herds (Barkema et al. 1998).

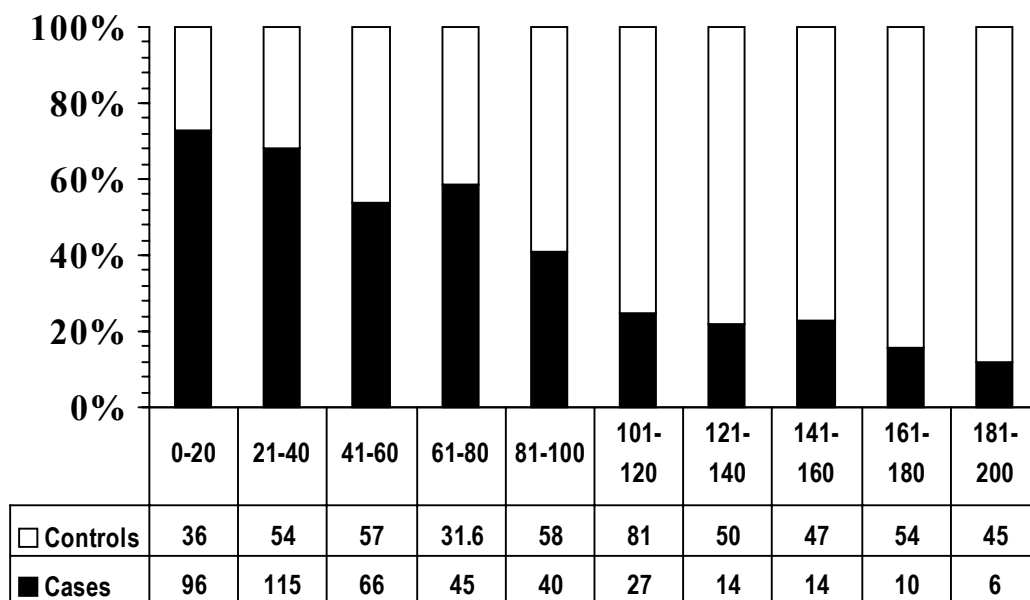


In a recent UK study of clinical mastitis in 1838 low bulk milk somatic cell count herds (annual mean below 100,000 cells) a similar picture was observed. The mean incidence was 23 cases of clinical mastitis per 100 cows per year (Peeler et al. 2000). The range was from 0.6 to 147.1 cases per 100 cows per year, indicating that both high and low incidences of clinical mastitis were present among herds with a low bulk milk somatic cell count. These studies indicate that there does not appear to be a linear relationship between bulk milk somatic cell

count and the incidence rate of clinical mastitis, although there might be a greater proportion of severe (toxic) cases in low bulk milk somatic cell count herds (Green et al. 1996, Tadich et al. 1998).

At cow level, most studies have either shown no association between somatic cell count level and a subsequent risk of clinical mastitis, or an increased risk of mastitis when somatic cell counts were higher (Rupp et al. 2000, Beaudeau et al. 1998, Coffey et al. 1986, Deluyker et al. 1993). Most of these studies classify cows with a cell count below 100,000 cells as low cell count cows. In a recent study on a single low cell count herd, an increased risk for clinical mastitis was observed in cows with very low somatic cell counts. A linear relationship between somatic cell counts before clinical mastitis and the risk of showing clinical signs was observed, especially in cows with cell counts less than 100,000 cells per ml. (Suriyasathaporn et al. 2000a). The results of this study are shown in figure 5.

Figure 5. Risk of showing clinical signs of mastitis (cases) classified by somatic cell count levels before the occurrence of mastitis. The numbers in the data table relate to the number of cases and controls in each of the SCC categories (from Suriyasathaporn et al. 2000).



### SCC before case/control

Seegers et al. (2000) also reported some initial evidence that cows with either very low somatic cell counts, or high somatic cell counts were at increased risk of showing clinical signs of mastitis. Resulting in a U-shaped relationship between somatic cell counts and clinical mastitis risk.

## Discussion and Conclusions

The papers regarding low somatic cell counts and the subsequent risk of clinical mastitis are currently not consistent in showing a clear increased risk for disease. However, evidence is accumulating that at the very low end of the distribution of somatic cells, cows may be at higher risk of clinical cases of mastitis, or show more severe signs when becoming infected. Clearly, somatic cells play an important role in the innate immunity of the uninfected and not inflamed mammary gland. A complete absence of cells would put cows at risk for disease, and the current reports suggest that a very low concentration of somatic cells increases the risk of clinical mastitis. At the very low end of the somatic cell counts scale, cows may be at higher risk of severe clinical disease. It is currently unclear how low bulk milk somatic cell count levels relate to cow cell count levels. Do all low bulk milk somatic cell count herds also have a high proportion of cows with very low cell counts, or are cow cell counts in some herds more evenly distributed. More knowledge is necessary with regard to distribution of cell counts in low cell count herds, and the risks associated with these very low cell counts.

The possibility for increased mastitis risk at very low cell counts levels needs to be communicated in a very careful manner. Especially because somatic cell count levels in large numbers of dairy herds throughout the world are decreasing. Hence, cell count levels between countries and between farms within countries are greatly different. What is defined in one country or region as a low cell count, is considered relatively high in another country or region. Still, the majority of farms would benefit from further reducing bulk milk somatic cell counts. Even in herds with low bulk milk somatic cell counts there is sufficient variation in clinical mastitis incidence to define management procedures that are associated with both a low bulk milk somatic cell counts and a low incidence of clinical mastitis (Peeler et al. 2000, Barkema et al. 1998). Hence, a situation where both bulk milk cell counts and clinical mastitis incidence are low appears feasible.

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