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Guidelines for the use and interpretation of bovine milk somatic cell counts (SCC) in the dairy industry

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Guidelines for the use and interpretation of bovine milk somatic cell counts (SCC) in the dairy industry

FOREWORD

Mastitis is an important animal health issue for the global dairy sector. It can result in milk quality issues and has a major economic influence on farm profitability. The determination of bovine milk somatic cell count (SCC) enables detection of intramammary infections. This informs management decisions regarding mastitis control, including treatments both during and at the end of lactation, surveillance of intramammary infection status and preventive strategies. IDF undertook this work to provide guidance on the interpretation and use of SCC, with the aim of improving animal health and milk quality worldwide.

This document gives an overview of the various ways that bovine milk SCC can be both measured and interpreted and provides guidance on its use at various levels. There is a section on factors that can affect SCC and areas to take into account when reviewing SCC data.

Interpretation of SCC data will depend on whether they originate from a quarter, cow or bulk tank sample and involves consideration of several other aspects, the most important of which is how the data will be used. Different thresholds are required in different circumstances, depending on the level of risk.

Various countries and stakeholders of the dairy sector were consulted throughout the development process of this guide to ensure its robustness and wide applicability.

This paper will be valuable for dairy producers and their advisers, dairy processors and regulators.

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Nico van Belzen, PhD
Director General
International Dairy Federation
Brussels, August 2013

Guidelines for the use and interpretation of bovine milk somatic cell counts (SCC) in the dairy industry

SUMMARY

- Milk from most uninfected mammary glands have a normal concentration of somatic cells
- The concentration of somatic cells or somatic cell count (SCC) can be used to indicate the inflammatory status of the mammary gland
- A single SCC threshold is not suitable in all circumstances – bulk milk, cow, quarter
- At the cow level, a cut-off of around 200,000 cells/ml can be used – above this value the cow is likely to be infected. A quarter level may be used for research purposes and then a cut-off of around 100,000 cells/ml can be used – below this level the quarter is unlikely to be infected
- A single SCC should not be used to determine infection status
- The SCC can either be measured directly or other parameters used to give an indication of the infection status
- SCC can be used to monitor mastitis or cell count programs and to calculate herd dynamics
- SCC can be used at the cow level to determine possible infection status and thus further actions – bacteriology, treatment options in lactation or at drying off, e.g. milking order, breeding or culling decisions

1. WHAT IS MILK SOMATIC CELL COUNT AND WHY IS IT IMPORTANT?

Milk from the uninfected mammary gland has a certain normal, species-variable concentration of somatic cells or somatic cell count (SCC). Normally, in uninfected glands the cell count is less than 100,000 cells per ml, comprised of epithelial cells and leucocytes (Leitner et al., 2012). Upon entry of bacteria into the mammary gland there is an influx of cells (mainly leucocytes) into the gland. The speed of this response depends on the invading bacteria species and the immune response of the cow and not on the number of cells already in the gland. The concentration of cells can increase from below 50,000 cells per ml to several millions within hours (Persson and Sandgren, 1992). Depending on the outcome of the insult, the SCC can return to normal levels within 24 hours or remain high for a long time if the gland becomes chronically infected.

Therefore, SCC and their differentiation can be used as indicators of a possibility of mammary gland infection and its infection status (Rivas et al., 2013).

Caution is required when extrapolating scientific SCC data and applying it to real life situations for *all* IDF countries. The objective of this paper is to consider both the scientific and practical aspects of determining cell counts in milk and how the interpretation of the counts can vary.

The SCC is used primarily as an indicator of udder health but it is increasingly being used as a measure of milk quality, and as a parameter to determine milk value. The SCC is rarely used to measure the safety of milk. Many countries have established cell count limits as a component of their milk payment system.

The SCC, or cell concentration, may be determined at the individual gland or quarter for cows or

half for goats and sheep (and as appropriately for other species). This is typical for research purposes. More commonly, the cell count is measured for the individual animal or the bulk milk supply from the herd (flock) or collection vessel.

When interpreting SCC data, it is essential to consider the level of measurement (bulk milk, cow or quarter). The SCC can vary according to the accuracy of the method used and other factors (physiological, inflammatory and sample and processing factors). It is important, particularly at the cow or quarter level, not to rely on one value to determine the udder health status of the cow, as this status can vary within a day depending on the outcome from an inflammatory insult.

The increase in SCC of milk is usually a response to infection of the mammary gland and is most commonly caused by bacteria. Other factors outlined later can result in minor variations in cell count. The ranges of SCC observed in infected and uninfected cows overlap, so it is impossible to select a single threshold that clearly separates uninfected from infected cows. Regardless of what threshold is chosen, there will be some uninfected cows with a SCC above the threshold (false positive) and some infected cows with SCC below the threshold (false negative) (Rivas et al., 2013).

The standard method of expressing the characteristics of a diagnostic test is to compute the sensitivity and specificity of the test. Any threshold used as a management tool to distinguish uninfected from infected must in practice minimize diagnostic errors. Lower values may be used depending on the interpretation need. A single threshold might not be suitable in all circumstances. Selection of the threshold can depend on whether the aim is to maximize sensitivity, thus using a lower threshold (e.g. selection of cows for different dry cow strategies) or to maximize specificity, thus using a higher threshold (e.g. selection of cows to be culled).

Research has shown that uninfected quarters of dairy cows in commercial production have a mean SCC of 10,000–70,000 cells/ml (Heeschen, 1974 Brolund 1985, Whist and Østerås 2006). Thus, at the quarter level, when the SCC from an individual quarter is less than 100,000 cells/ml it is unlikely that an infection exists, but when the cell count exceeds 200,000 cells/ml the probability of infection is high (Smith et al., 2001).

The optimal cut-off point with minimum error in distinguishing between uninfected and infected at the level of the cow for major pathogens for composite samples is 200,000 cells/ml (Dohoo and Leslie, 1991; Schepers et al., 1997; Dohoo et al., 2011a, 2011b; NMC 2001). Although this cut-off level for a cow is higher than for a quarter, it is usually done for different purposes because the cow level is used for management whereas the quarter level is used for research purposes.

2. HOW IS MILK CELL COUNT DETERMINED?

Reference method

Direct microscopic somatic cell counting (DMSCC)

DMSCC is the reference method, using methylene blue or ethidium bromide stains (Forest and Small 1959; ISO 13366-1/IDF 148-1: 2008). Possible errors arise from unequal distribution of cells in the smears, subjective counting and misidentification of stained structures. The microscopic method is infrequently used because it is time-consuming, requires skilled technicians and the potential for significant errors always exists.

Routine methods

Coulter Milk Counter

This was the first automated instrument that was used in practice and has been superseded by the fluoro-opto-electronic method. This method is infrequently used now and there is no current International Standards Organization (ISO) standard for this method.

Fluoro-opto-electronic instruments

The DNA of the cell nucleus is stained with a fluorescent dye. Cells that fluoresce are counted using flow cytometry or disk cytometry as they move through a stimulating light beam. In practice, this method is more commonly used than other methods and it is estimated that 85% of the world's milk supply is tested using this principle. A variety of instruments are available that use this methodology, which is optimized to count somatic cells or smaller DNA-containing particles, e.g. bacteria, fungal cells and some algae. The method

is suitable for the rapid and inexpensive cell counting of a large number of samples. This is the only standardized automated method for counting somatic cells in milk (ISO 13366-2:2006/IDF 148-2: 2006).

Charge coupled device (CCD) camera

This method measures cell counts using a CCD camera. The DNA of the cells is stained with propidium iodide and the fluorescence generated is detected from a digital image that is converted by software to give a cell count value. Single-use cassettes are used in dedicated instruments and a cell count value is generated in less than one minute. The instrument is calibrated at the time of manufacture. This method is useful for laboratories with low throughput of samples or at the farm level. Based on the same principle, on-farm instruments with liquid reagents and a glass cuvette instead of cassettes can be used on-line for determination of SCC at each milking.

Research methods in addition to those used above

Differential inflammatory cell counting

Cells are stained with specific antibodies and then counted using flow cytometry. This is more precise than the direct microscope method and can be used to determine the stage of the inflammation, even of quarters with a low SCC (Koess and Hamann, 2008; Leitner et al., 2012). This is currently not a reference method.

Direct epifluorescence filter technique (DEFT)

This technique can be used to determine the differential inflammatory cell count microscopically using different dye solutions. This method may be used to differentiate lymphocyte/monocyte and polymorphonucleocyte populations.

Indirect methods

California Mastitis Test (CMT)

CMT is the most common cow-side test used by farmers and veterinarians for the indirect measurement of SCC in milk. A detergent or alkali precipitates cellular DNA, creating a gel that can be stained using a pH indicator. The change in viscosity on gel formation is measured to give an indication of the cell count. This test is relatively inexpensive and rapid, and is in general an easy-to-use indicator of cell count in real time. It has a low sensitivity and specificity so cannot be used for accurate and reliable estimation of the cell count (Schalm and Noorlander, 1957; Schalm et al., 1971; Sargeant et al., 2001). Potential errors with this test are due to subjective readings and categorization of the formed gel. This is a cow-side test to be performed on recently taken samples and is not recommended for use in laboratories or on older samples. Generally, a grade system of 1–5 is used, where 5 indicates a cell count greater than 5,000,000 cells/ml. Variations of this method may be used.

Wisconsin Mastitis Test (WMT)

WMT works on the same principle as the CMT. Instead of a subjective rating, the amount of gel that forms is measured in millimetres (mm) using a calibrated tube or on a plate surface. Although the WMT test is conducted under more precise procedures and standard temperature conditions than the CMT, it is still not a reliable measure of SCC (Rodrigues et al., 2009).

Other parameters measuring indicators of inflammation

Although SCC is used as the most accurate indicator of mastitis (subclinical or clinical), various other parameters of milk composition can be analysed to indirectly indicate possible infection of the mammary gland and thus, possibly, an abnormal cell count.

These methods *do not* measure the SCC in milk but are used because of several compositional changes in the milk as a result of the bacterial invasion, i.e. the inflammatory response and interactions along with an increase in SCC. Measurements include concentrations of acute phase proteins (haptoglobin, C reactive protein and serum amyloid A), antitrypsin, lactose, bovine serum albumin, casein, enzymes (*N*-acetyl-β-D-glucosaminidase, alkaline phosphatase, catalase, esterases and lactate dehydrogenase) and ions (chloride, sodium and potassium). Various tests are available to measure these compositional changes in milk.

Chemical changes

Various test kits are available to measure changes in individual milk samples and some in-line systems are commercially available.

Electrical conductivity

Measurement of the electrical conductivity of milk, due to changes in the concentration of ions in the milk, was first described as a useful test by Davies (1938). Various hand-held and in-line systems are now commonly available. Mathematical algorithms can be used to increase the sensitivity and specificity of this method by taking into account previous readings, herd data, etc. (IDF Bulletin 321, 1994). The electrical conductivity is used within in-line milking machine systems to allow early detection of a possible increase in the SCC (Hogeveen et al., 2010).

Quality assurance of tests

Methods and instruments used to indicate abnormal milk and cell count must be calibrated and verified to promote accuracy and precision (repeatability, reproducibility) and equivalence of counting. Although it is routine laboratory practice to run standard samples (pilot and blank samples) at the prescribed intervals in an (ISO/IEC 17025:2005) accredited laboratory quality system, it is also important for individual laboratories to participate in a proficiency testing programme, either national or international. This is essential and not only as good practice for those countries where maximum limits are placed on bulk milk SCC in the frame of payment systems, but also if SCC is executed for monitoring the udder health status of individual animals (Hillerton et al., 2004). Suitable reference materials and ability to participate in proficiency testing in a laboratory network structure are fundamental for this to work. A joint project group of IDF and ICAR (International Committee on Animal Recording) is presently developing an international reference system for SCC to promote better equivalence on an international scale (IDF Bulletin 427, 2008).

3. WHY DOES MILK CELL COUNT VARY?

The SCC is primarily used to distinguish between an inflamed (or infected) and uninfected cow or quarter. Generally, the most important cause of an elevated SCC is a bacterial infection of one or more quarters. Systemic disease can result in an elevated milk SCC. Other factors that can affect SCC are listed below.

Stage of lactation

SCC in uninfected cows is highest at calving, lowest during peak to mid lactation and can increase towards the end of lactation as milk yield decreases. This is mainly due to a dilution effect related to the volume of milk produced (Brolund, 1985; Dohoo and Morris, 1993; Laevens et al., 1997; De Vliegher et al., 2004).

Breed

Differences exist between cattle breeds in cell count levels (Heeschen, 1975; Elbers et al., 1998; Persson Waller et al., 2009). However, the breed effect may be more linked to differences in infectious status than in the baseline level of physiologically normal cell count in uninfected quarters.

Genetics

Although heritability estimates of SCC are moderate (10–30%), significant genetic variation exists to enable improvements in SCC through genetic selection. Due to a strong and positive correlation with mastitis (around 65%), indirect improvements in mastitis prevalence can also be expected. Most countries with genetic evaluations have had SCC genetic selection components in bull proofs since the mid- to late-1990s. In some cases, selection of bulls based on SCC components has facilitated improvements in individual herd and national SCC levels.

Parity

Parity has no significant influence on SCC as long as the mammary gland is uninfected (Harmon 1994; Sheldrake 1983). However, older cows can have a higher average cell count than younger cows and this is related to the greater likelihood of exposure to pathogens and thus intramammary infection. Cows with a history of infection also tend to show greater cellular response to subsequent infections than uninfected cows (Jaartsveld et al., 1983; Sheldrake et al., 1983).

Day-to-day variation

This is considered normal, but SCC varies more in infected than in uninfected cows. A single cell count test result is relatively inconclusive and infection status should be determined on the basis of a series of counts (Whist and Østerås, 2006).

Diurnal variation and milking/sampling interval

The SCC can vary with the milking interval and this is largely due to a dilution effect. In the normal udder, the majority of leukocytes migrate into the mammary tissues soon after completion of the

milking process (Griffin et al., 1977). The SCC then decreases with time as the milk volume increases (van der Iest and Hillerton, 1989; Lakic et al., 2011). This has been suggested to be the result of proportional dilution relative to milking interval, and is thought to be greater in high-producing cows than in low-producing cows (Harmon, 1994). This has been highlighted as a potential problem in collection from automatic milking systems with irregular milking intervals and small milking herds (Fernando and Spahr, 1983; Syrstad and Ron, 1979). Algorithms are available from milk testing services to correct variations due to uneven milking intervals. On-line milking systems equipped with an automatic milk sampling device have the benefit of sampling all quarters at any given time during milking, and thus should be more accurate and repeatable.

Time of sampling

True foremilk samples and strippings after the end of milking can have a higher cell count than composite samples. Sample type must be taken into account when interpreting cell counts (Ostensson et al., 1988; Woolford et al., 1998; Sarikaya and Bruckmaier, 2006; Wellnitz et al., 2009). This means that sample type must be taken into account when interpreting cell count.

Sampling procedures

The technique for bulk tank sampling is crucial, and sufficient agitation of milk is required to ensure that the sample taken is representative of a true count. (ISO 707:2008/IDF 50: 2008). The milk-collecting truck can be equipped with an automatic milk sampler, which will collect a representative sample when the bulk tank is being emptied.

Stress and trauma

A variety of stress-induced effects have been reported to influence SCC. Isolation, weather change, agitation, heat stress, earthquake, co-mingling of cattle, oestrus and overmilking can all potentially affect cell counts, even though few published papers have revealed any significant change in the cell counts in uninfected cows (Elvinger et al., 1991). Similarly, any physical trauma to the udder will temporarily result in an increased cell count. As a guideline, it is accepted that any stress on a cow or the udder can possibly precipitate an increase in the SCC.

Management factors

Type of housing, bedding, milking system operation and maintenance, and manure handling can have an impact on individual mammary gland infection status, usually through infection levels, and thus indirectly influence SCC (Hogan et al., 1989; Green et al., 2008; Nyman et al., 2009).

Seasonal

Seasonal trends in SCC have been reported. These vary depending on the country and calving patterns, and no consistent seasonal trends have been reported. The seasonal trend effect may be physiological or due to increased bacterial contamination of teats from environmental situations providing conditions for enhanced bacterial growth and increase in udder infections (Østerås et al., 2006Reksen et al., 2008)

Storage procedures

Both freezing samples and storing preserved samples, even at 4°C, result in a decrease in the SCC of the sample (ISO 13366-2:2006/IDF 148-2: 2006; IDF Bulletin 427, 2008) .

4. HOW CAN THE DATA BE HANDLED?

An individual quarter or cow cell count can vary in time, and a single value should not be used to determine the udder health status of the cow (IDF Bulletin 321, 1994). Repeated sampling with an interval of 10 days between samples will give a better indication of mammary health (IDF Bulletin 448, 2011).

Various schemes are in place internationally to determine individual cow SCC and to analyse data for individual farms or herds. These schemes are run by organizations that are usually members of the International Committee for Animal Recording (ICAR). Different methods are used to present these data.

The geometric mean

The geometric mean (G_m) gives the best indicator on the central tendency for SCC. It is recommended for presenting bulk milk data and gives a lower value than other methods. One way of determining the geometric mean is to calculate the logarithm in base 10 of each observation and then the mean is the antilog of the simple average. An example is shown below:

n_1 = 150,000, log(150,000) = 5.18
n_2 = 230,000, log(230,000) = 5.36
n_3 = 300,000, log(300,000) = 5.48
Mean of log(n_1,n_2,n_3) = 5.34
G_m = 218,000 cells/ml

An alternative method of calculation is to multiply the observations and then take the n^{th} root of the number of observations; this is the G_m. Using the three examples given in the example above:

n_1 = 150,000, n_2 = 230,000, n_3 = 300,000
Gm = 3√150,000 × 230,000 × 300,000 = 218,000 cells/ml

The arithmetic mean

Although this is the most commonly used type of average, it is generally not recommended as a method for presenting SCC data. To determine the arithmetic mean of a set of *n* numbers, add the numbers in the set and divide the sum by *n*.

Somatic cell score (SCS) or linear score (LS)

In some countries (e.g. USA) the SCS or LS is used, where SCS = ln(SCC/100,000)/ln2 + 3. An example calculation is given below:

SCC = 200,000 cells/ml
Divide the SCC by 100,000
(200,000/100,000 = 2)
Divide the ln of this value by ln2 (ln2/ln2 = 1)
Add 3 to the result (1 + 3 = 4)
The somatic cell score is 4

Conversion of an average somatic cell score back to SCC produces a geometric mean:

SCC = 100,000 × e(SCS–3) × ln2

Weighted mean

Besides direct measurement of the bulk milk somatic cell count (BMSCC), the BMSCC can also be calculated by taking the weighted mean of the individual cow SCC. This is done by using the individual cow SCC and yield and takes into account the individual cow contribution by volume (weight) of milk produced. Because cows with higher SCC generally produce less milk, calculating the weighted mean of the cow SCC can reduce the effect of individual cows with a very high SCC on bulk milk values.

5. HOW CAN THE DATA BE USED?

SCC and milk quality

Milk with a higher cell count is of poorer quality (Barbano and Santos, 2006). Milk yield is reduced and constituents of milk altered (e.g. lipase, protein types, enzymes, ions and pH changes) (Ott and Novak, 2001; Reichmuth, 1975; Eberhart et al 1982). Thus, an elevated SCC can affect the value of the milk supply.

The compositional changes in milk that occur with increasing cell count can have a major influence on milk quality and its use in processing (Schultz, 1977; Leitner et al., 2011). Protein changes occurring with increasing cell count include a reduction in casein and increase in lower quality serum-derived whey proteins. The increase in enzymes from damaged tissue can also affect milk quality. Plasmin can reduce casein content, and lipases can result in off-flavours. These changes in milk composition reduce the volume of cheese made from milk with a high cell count.

Bulk milk with a high cell count is more likely to have detectable antimicrobial residues, which can cause problems in processing milk and result in rejection of the milk (Ruegg and Tabone, 2000).

6. INTERPRETATION OF SCC

SCC is the most frequently used indicator of udder health in dairy cows. Interpretation of a SCC value will depend on whether it is from a quarter, cow or bulk tank (herd) sample.

Interpretation will depend also on whether the value is being used for:

- Regulatory milk quality level
- Suitability purposes
- Determination of infection status and future management options

The aim of any threshold or intervention level depends on the purpose of this definition and will also depend on the individual situation or country.

Within many countries there are maximum limits on the BMSCC, either from a regulatory limit or from a milk buyer, which can depend on the end use of the milk.

As there can be multiple factors that influence cell count both at the quarter, cow or bulk milk level, it is recommended that more than one value is obtained before making a decision.

Quarter level

The quarter is the secreting unit. Any research on the physiological variation in the SCC and baseline

level should preferably use quarter level data.

Cow level

SCC is commonly measured as a composite cow sample. When interpreting cell counts from composite samples, from all four quarters into one sample, it is important to consider the dilution effect that milk from normal quarters has on elevated counts from infected quarters. See Appendix 1 for the effect of one high SCC quarter on the cow level SCC. Cows can be classified on the basis of their mean SCC level, and the probability of intramammary infection can be calculated.

Herd level

The BMSCC in a milk vat or tank is the average of all cows in the herd. Acceptable levels may have to meet a threshold that is a regulatory level or general suitability level, depending on the end use of the milk.

Monitoring SCC at the herd level requires longitudinal data, given the variability of inflammatory responses between the cows that make up a herd.

When interpreting BMSCC, it is important to remember that elevation of the count may result from a few cows having an exceptionally high cell count or from a general elevation of count in many of the cows in the herd. Also, the BMSCC does not provide any information about which cows are affected. A BMSCC gives an average indication of the udder health condition of the herd as a whole and an indicator for further action, but will not be able to indicate particular cows requiring attention.

The BMSCC can be used to monitor the progress of mastitis control programs in a herd and to aid in selecting management options.

7. USE OF SCC DATA AT COW LEVEL

SCC at the cow level can be used as a management guide for decisions on:

- Determining possible infection status
- Whether to undertake bacteriology testing or not
- Treatment decisions for clinical and subclinical infections
- Strategies at the end of lactation (dry cow therapy strategies) to prevent or treat existing infections at both the quarter and cow level
- Determining milk order or group
- Decisions related to breeding or culling
- Calculating the herd mastitis dynamics

Antimicrobial treatment

Usually all acute clinical cases of mastitis are treated on detection but subclinical infections, depending on the infection type, may be treated at the end of lactation. Knowing the SCC and the pathogen isolated from a quarter can be useful in determining if and which treatment is appropriate and when it should be applied. Selection of a cow for milk bacteriology has been suggested when a cow somatic cell score (linear score) is 5 (equivalent to 283,000–565,000 cells/ml) (NMC, 2010). Some infections are treated at the end of lactation rather than during lactation, e.g. those caused by *Streptococcus dysgalactiae* and *Staphylococcus aureus*. However, treatment of subclinical infections based solely upon high SCC has limited success in reducing SCC (Barkema et al., 2006).

Dry cow strategies

Dry cow strategies vary between countries. In some instances, all cows are treated with an antibiotic, an internal teat sealant or a combination of both an antibiotic and a teat sealant. In other countries, selective dry cow strategies are followed by, e.g. antimicrobial treatment, which would be used only for a cow with a geometric mean SCC greater than 100,000 cells/ml and isolation of *Staphylococcus aureus*, *Streptococcus agalactiae, Streptococcus dysgalactiae* or *Streptococcus uberis*. Cows with a consistently high SCC should be dried-off early, with appropriate antimicrobial treatment, or culled.

Milking order

In most systems, a defined milking order or separation of high SCC cows is good practice for minimizing spread of contagious pathogens. Cows with a higher SCC should be grouped separately and milked after the main herd. It is easier to instigate this in smaller herds or where cows are in management groups.

Withholding of milk

This can be used where there are ethical, legal and financial maxima on the cell count. Some cell count reports provide cell count contribution values to the bulk milk cell count. This allows milk

from a select number of cows to be removed from the bulk tank while management options can be decided on.

Culling decisions

Selection of cows to cull is usually a complicated decision that is influenced by a variety of factors; however, persistently high SCC at the cow level can be one factor.

Breeding decisions

Most countries with breeding indices for bulls now include a factor for both cell count and mastitis. Positive selection for low SCC is advantageous and breeding indices are calculated using robust SCC data.

Count reports provide individual cow cell count contributions to the bulk milk cell count. This allows milk from a selected number of cows to be removed from the bulk supply while management actions are implemented.

Use of SCC data to describe infection dynamics

SCC data are used to describe udder health dynamics at the herd level. It is possible to calculate new infection rates, prevalence of high SCC, duration of high SCC and changes in SCC according to stage of lactation. A limit of 200,000 cells/ml is used to indicate infection at the cow level (Smith et al., 2001; Dohoo et al., 2011a; Dohoo et al., 2011b), but other limits can also be appropriate.

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9. APPENDIX 1

Table 1 shows the likely cell count of one infected quarter of a cow (in 1000 cells/ml) (with the infected quarter contributing 10, 20 or 30% of the whole udder milk yield) when each of three uninfected quarters has a cell count of 100,000, 150,000 or 200,000 cells/ml, for a whole cow cell count up to 1,000,000 cells/ml. The example when the cow cell count is 400,000 cells/ml is shown in bold (from Hillerton, 1999).

Table 1. Predicted cell counts in a infected quarter at different whole cow cell counts

Uninfected quarter cell count	Infected quarter yield*	Cow cell count ('000 cells/mL)									
		200	250	300	**400**	500	600	700	800	900	1000
100	30%	430	600	730	**1100**	1430	1760	2100	2360	2760	3100
	20%	600	850	1100	**1600**	2100	2600	3100	3600	4100	4600
	10%	1100	1600	2100	**3100**	4100	5100	6100	7100	8100	9100
150	30%	320	480	650	**980**	1320	1650	1980	2320	2650	2980
	20%	400	650	900	**1400**	1900	2400	2900	3400	3900	4400
	10%	650	1150	1650	**2650**	3650	4650	5650	6650	7650	8650
200	30%	200	370	530	**860**	1200	1530	1870	2200	2530	2860
	20%	200	450	700	**1200**	1700	2200	2700	3200	3700	4200
	10%	200	750	1200	**2200**	3200	4200	5200	6200	7200	8200

*Infected quarter yield as a percentage of total udder yield

Table 2 shows the likely cell count in composite milk (1000 cells/ml) when each of the three uninfected quarters has a cell count of 10,000, 25,000, 50,000 or 100,000 cells/ml, and the infected quarter has a reduction of 10, 20 or 30% of the milk yield of a healthy quarter, as the infected quarter SCC ranges from 100,000 to 9,000,000 cells/ml. Highlighted in dark blue is the composite SCC close to 200,000 cells/ml and highlighted in light blue is the composite SCC close to 100,000 cells/ml.

Table 2: Effect of one infected quarter on the cow level SCC

Uninfected quarter	Reduced production in infected quarter	Composite milk somatic cell count (in 1000 cells/ml)												
		Infected quarter SCC												
		100	200	250	300	400	800	1000	2000	3000	4000	5000	7500	9000
10	30%	27	46	55	65	**84**	159	**197**	186	576	765	954	1427	1711
	20%	29	50	61	71	**92**	176	**218**	429	639	850	1061	1587	1903
	10%	31	54	65	77	**100**	**192**	238	469	700	931	1162	1738	2082
25	30%	39	58	68	77	**96**	172	**209**	399	588	777	966	1439	1723
	20%	41	62	72	83	**104**	188	**230**	441	651	862	1072	1599	1914
	10%	42	65	77	88	**112**	**204**	250	481	712	942	1173	1750	2096
50	30%	59	78	88	**97**	116	**192**	230	419	608	797	986	1459	1743
	20%	61	82	92	**103**	124	**208**	250	461	671	882	1092	1618	1934
	10%	62	85	96	**108**	131	**223**	269	500	731	962	1192	1769	2115
100	30%	**100**	119	128	138	157	**232**	270	459	649	838	1027	1500	1784
	20%	**100**	121	132	142	163	**247**	289	500	711	921	1132	1658	1974
	10%	**100**	123	135	146	169	**262**	308	538	769	1000	1231	1808	2154

GUIDELINES FOR THE USE AND INTERPRETATION OF BOVINE MILK SOMATIC CELL COUNTS (SCC) IN THE DAIRY INDUSTRY

ABSTRACT

Somatic cell count (SCC) is the most frequently used indicator of udder health in dairy cows. This article looks at the scientific and practical aspects of determining the SCC in milk and how the counts can vary. Presentation of the data is discussed and guidelines given for its interpretation on the quarter, cow and bulk milk levels. Also outlined is how SCC data at the cow level can be used as a management guide.

Keywords: Dairy, mastitis, milk, milk quality, SCC, somatic cell count, udder health

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ANNEX 1

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In the case of native English speakers the author's national conventions (British, American etc.) are respected for spelling, grammar etc. but errors will be corrected and explanation given where confusion might arise, for example, in the case of units with differing values (gallon) or words with significantly different meanings (billion).

"	Usually double quotes and not single quotes
? !	Half-space before and after question marks, and exclamation marks
±	Half-space before and after
microorganisms	Without a hyphen
Infra-red	With a hyphen
et al.	Not underlined nor italic
e.g., i.e.,...	Spelled out in English - for example, that is
litre	Not liter unless the author is American
ml, mg,...	Space between number and ml, mg,...
skimmilk	One word if adjective, two words if substantive
sulfuric, sulfite, sulfate	Not sulphuric, sulphite, sulphate (as agreed by IUPAC)
AOAC INTERNATIONAL	Not AOACI
programme	Not program unless a) author is American or b) computer program
milk and milk product	rather than "milk and dairy product" - Normally some latitude can be allowed in non scientific texts
-ize, -ization	Not -ise, -isation with a few exceptions
Decimal comma	in Standards (only) in both languages (as agreed by ISO)

No space between figure and % - i.e. 6%, etc.

Milkfat	One word
USA, UK, GB	No stops
Figure	To be written out in full
1000-9000	No comma
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hours	Ø h
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