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Udder Health Status of First Parity Dairy Cows in Early-Lactation Based on Somatic Cell Count Categories

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Abstract

The main aim of this study was to investigate the prevalence of intramammary infection (IMI) in early-lactation of primiparous cows using milk recording cow composite somatic cell count (CSCC) categories (combining the first 2 milk recording results after calving). Another aim was to evaluate the milk urea (MU) content as a potential supplementary indicator to SCC or CSCC for the identification of IMI in primiparous cows after calving. This retrospective observational study was conducted on records of test-day of primiparous cows over a period of 6 years (January 2016 to December 2021. The SCC data for 158 Holstein Friesian primiparous cows, with their first milk recording 5 to 35 days after calving and their second milk recording 28 to 56 days in milk (DIM), were identified. Each primiparous cow was assigned a CSCC category (low-low, low-high, high-low or high-high) based on the CSCC at the first 2 milking recordings using the following cut-offs: ≤150,000 cells/ml (low), >150,000 cells/ml (high). The association between CSCC categories and MV content was analyzed using correlation models. At the first milk recording, a proportion of 63.29% was in the low SCC category, and the rest (36.71%) was in the high SCC category. At the second milk recording, a proportion of primiparous cows in CSCC categories was 59.49%, 3.80%, 27.85% and 8.86% in low-low, low-high, high-low and high-high, respectively. At the second milk recording, a proportion of 12.66% of primiparous cows was in the high CSCC category and a proportion of 87.34% of primiparous cows was in the low CSCC category, indicating a poor and a good udder health, respectively. The association of SCC with MU content in low and in high SCC categories at the first milk recording was positive and moderate (+0.49) and negative and strong (−0.97), respectively. The association of CSCC categories with MU contents at the second milk recording was inconclusive. We concluded that CSCC categories may be a useful tool for identifying success and problems regarding the udder health of primiparous cows in early lactation.

Keywords

Intramammary Infection, Somatic Cell Count, Composite Somatic Cell Count, Milk Urea Content

1. Introduction

Somatic cell count (SCC) is used as a key indicator in mastitis screening programs typically applied in the frame of dairy herd improvement (DHI) testing programs. A major problem of the spread and persistence of mastitis within a dairy farm is subclinical mastitis [1].

Subclinical mastitis (SM) is a condition where the udder and the milk appear normal, although the udder is inflamed or infected. Subclinically infected udders of the cows act as a reservoir for bacteria, resulting in a spread of mastitis bacteria to healthy cows [2] [3], causing additional losses in those cows. Consequently, SM results in considerable economic losses in dairy herds worldwide [4].

The effectiveness of control is highly dependent on how fast the cows with SMA are detected and hence, also on the efficacy of the udder health monitoring program [5].

Somatic cell counts in milk provide an indication of the inflammatory response in the udder of dairy cows.

The optimal SCC cutoff point to distinguish between infected and uninfected of the individual cow level has been established at 200.000 ml cells/mL [6].

Primiparous cows are an important part of the dairy herd. Around 30% to 35% of the cows are primiparous cows.

Scientific studies have found that it is not uncommon for primiparous cows to have clinical or subclinical mastitis already during the first week or month of lactation [7] [8]. The incidence of clinical mastitis and the prevalence of subclinical mastitis could be high in heifers around calving, and the effect on heifers is more severe than in older cows [9]. Overall, mastitis is more common in multiparous cows compared with primiparous cows. Several studies have found the opposite during the first week or month after calving [7] [10] [11].

Several cow- and herd-level risk factors for mastitis in primiparous cows have been identified [12] [13]. The heifer is most at risk for clinical mastitis during the periparturient period, and risk factors found are related to diet, mammary gland factors such as edema and leaking of milk, and factors associated with a change in management and introduction of the heifer to the milking herd.

The magnitude of the effect of heifer mastitis on an individual animal is influenced by the form of mastitis (clinical versus subclinical), the virulence of the causative pathogen(s) (major or minor), the time of onset of infection relative to calving, cure or persistence of the infection when milk production has started, and the host's immunity [13].

Compared with other inflammatory markers, the SCC is considered as the best

indicator of intramammary infections (IMIs).

Lundberg *et al.* (2016) [14] found that the composite somatic cell count (CSCC) at the first milk recording after calving is a good indicator of IMI at calving.

Milk urea content is an indicator of the relation between feed protein content and energy level, and also reveals information about the utilization of crude protein in the feed. It has been recommended that milk urea content should be evaluated in combination with parity, days in milk, season, daily matter intake and dietary nutritional components in order to improve the management and economic benefits of dairy form.

Milk urea content was included as a standard part of milk recording systems.

The main aim of this study was to investigate the prevalence of an IMI in early lactation of primiparous cows using milk recording (SCC categories), combining the first 2 milk recording results after calving.

Another aim was to evaluate the milk urea content as a potential supplementary indicator to SCC or CSCC for the identification of IMI in primiparous cows after calving.

2. Materials and Methods

2.1. Primiparous Cow Data

This research was conducted at the experimental farm of the Agricultural Research and Development Station (ARDS), Simnic-Craiova, Romania. The Holstein Friesian dairy herd is affiliated with the Romanian official milk production control. Milk yield, composition, and somatic cell count (SCC) records of primiparous cows were used as the study material (test-day records at the first 2 milk recording after calving).

The SCC data for primiparous cows with their first milk recording 5 to 35 days (d) after calving and their second milk recording 28 to 56 days in milk were identified. Based on composite somatic cell count (CSCC) from the 2 milk recordings, each of 158 primiparous cows was assigned to a CSCC category (low-low, low-high, high-low, high-high) based on the following cutoffs: low SCC ≤ 150,000 cells/ml and high SCC ≥ 150,000 cells/ml. all primiparous cows were selected from January 2016 to December 2021. The selection of CSCC cutoffs was based on the results from previous studies [15] [16] on CSCC at the first and the second milk recording after calving for noninfected and infected primiparous cows. Association of SCC with milk urea content (MU, mg/dl) was made to find if MU content has the potential as a supplementary indicator to SCC or CSCC for identification of IMI in early lactation primiparous cows.

2.2. Statistical Analysis

The data were entered into Microsoft Excel computer program 2007. STATA version 14 was used to summarize the data and descriptive statistics were used to express the results.

3. Results

The mean number of primiparous cows present in the data set was 26.3 (median 26) ± 1.6 standard deviation (sd), for each year (2016-2021). These animals represented a mean of 82% of all primiparous cows of the herd.

The mean days in milk (DIM) at the first and the second milk recording after calving for all years (2016-2021) was 22 and 51, respectively.

The proportion of primiparous cows in the SCC categories (low and high) at the first milk recording, and in the CSCC categories (low-low, low-high, high-low, high-high) after the second milk recording is presented in Figure 1.

From all primiparous cows (n = 158) at the first milk recording, a proportion of 63.29% (n = 100) was in low SCC category and the rest (36.71%) in the high SCC category. At the second milk recording, the proportion of primiparous cows in CSCC categories was 54.49%, 3.80%, 27.85% and 8.8% in low-low, low-high, high-low and high-high, respectively (using a cutoff Low ≤ 150,000 and high > 150,000 cells/mL of milk). At the second milk recording, a proportion of 12.66% (3.80% + 8.86%) (n = 6 + 14 = 20) and a proportion of 87.34% (59.49% + 27.85%) (n = 94 + 44 = 138) of the all primiparous (n = 158) indicating a poor and a good health, respectively (Figure 1).

The mean of SCC at the first milk recording (143,437 cells/mL) was higher than at the second milk recording (109,076 cells/mL).

At the first milk recording (5 to 28 days after calving), the mean SCC in the low category was 112,000 (±15,900) cells/ml of milk (median 114,500 cells/ml), and 192,200 (±19,300) cells/ml (median 189,500 cells/ml) in the high category using a cutoffs: for Low ≤ 150,000 cells/ml and for high > 150,000 cells/ml (Table 1).

At the second milk recording (29 to 56 days after calving), the mean SCC in the low-low, low-high, high-low and high-high categories was 81,400 (±24,600) cells/ml (median 83,500 cells/ml), 200,000 (±14,000) cells/ml (median 202,500 cells/ml), 114,400 (±15,800) cells/ml (median 115,500 cells/ml) and 239,300 (±10,500) cells/ml (median 237,000 cells/ml), respectively.

The range coefficient of variation (CV) for the different CSCC categories was between 4.4% and 30.2%. The mean CV for the low-low, low-high, high-low and high-high categories was 30.2%, 7.0%, 13.8% and 4.4%, respectively, at the second milk recording. At the first milk recording, the CV in low and high SCC categories was 14.2% and 10%, respectively. A lower CV indicates less variability of the data and is more stable. For each SCC category at the first milk recording and for each CSCC category at the second milk recording, we recorded the values of milk urea (MU) content (mg/dl) (Table 1). The mean value of MU (mg/dl) at the first milk recording associated with low SCC category and with high SCC category was 25.0 (±6.9) mg/dl (median 25.9 mg/dl) and 36.6 (±5.7) mg/dl (median 38.8 mg/dl), respectively (Table 1). The mean value of MU content (mg/dl) at the second milk recording associated with CSCC categories: low-low, low-high, high-low, high-high was 30.2 (±6.2) mg/dl (median 31.7 mg/dl), 23.5 (±5.2) mg/dl (median 23.2 mg/dl), 25.8 (±5.8) mg/dl (median 26.1 mg/dl) and 25.6 (±3.3) mg/dl (median 24.9 mg/dl), respectively (Table 1).

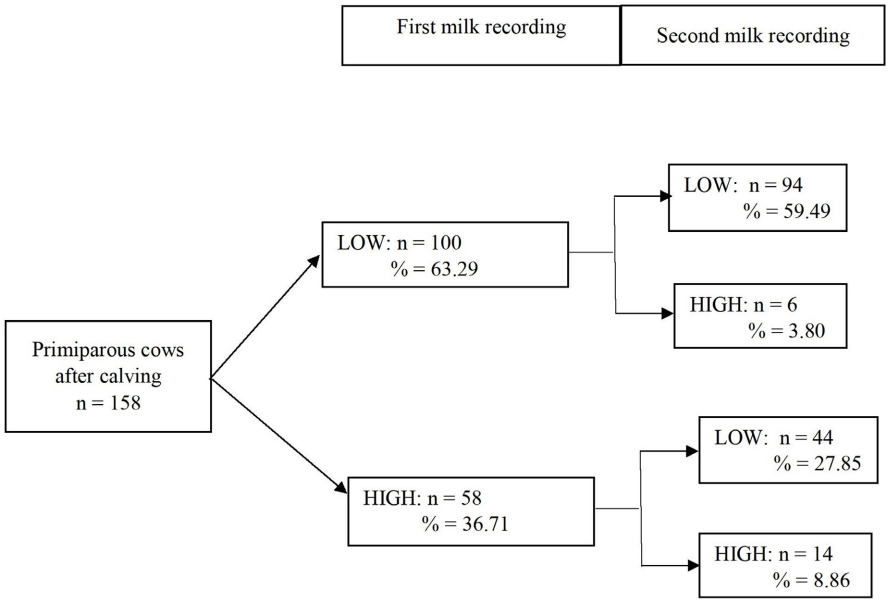

Figure 1. Distribution (n, %) of primiparous cows based on cow composite SCC at the first and the second milk recordings after calving in years 2016-2021. Low ≤ 150,000 cells/mL; high ≥ 150,000 cells/mL.

Table 1. Descriptive statistics of cow composite SCC and milk urea content of the first and the second milk recording after calving in primiparous cows.

Item		Somatic cell count (×1000)				Milk urea content mg/dl				Correlation coefficient
		Mean	±sd	Median	CV%	Mean	±sd	Median	CV%	
First milk recording	Low	112	15.9	114.5	14.2	25	6.9	25.9	27.6	+0.49
	High	192.2	19.3	189.5	10	36.6	5.7	38.8	15.6	−0.97
Second milk recording	Low-low	81.4	24.6	83.5	30.2	30.2	6.2	31.7	20.5	+0.24
	Low-high	200	14	202.5	7	23.5	5.2	23.2	22.1	−0.33
	High-low	114.4	15.8	115.5	13.8	25.8	5.8	26.1	22.5	+0.24
	High-high	239.3	10.5	237	4.4	25.6	3.3	24.9	12.9	−0.46

Optimal urea content in cow milk is between 25 and 35 mg/dl. A level lower than 25 mg/dl indicates that the diet is low in protein. A level greater than 25 mg/dl indicates that the diet is too high in protein. Overall in this study, the mean MU contents at the first milk recording was 29.24 mg/dl and at the second milk recording 28.27 mg/dl, and the difference was not significant. At the first milk recording, the low SCC category (mean 112,000 cells/ml) was associated with the low content (mean 25 mg/dl) of MU, and the correlation was positive (+0.49; moderate correlation). The association of high SCC category (mean 192,200 cells/ml) with high content (mean 36.6 mg) of MU was negative (−0.97; strong correlation) (Table 1).

At the second milk recording, the correlation coefficients between CSCC categories and MU contents were: +0.24, −0.33, +0.24 and −0.46 in low-low, low-high,

high-low, and high-high, respectively.

4. Discussion

In this study, a proportion of 36.71% of the primiparous cows was categorized as high SCC category (*i.e.* above 150000 cells/ml) at the first milk recording 5 to 28 dim, indicating an intramammary infection (IMI). Bludau *et al.* (2014) [17] and Person Waller *et al.* (2020) [18] reported 20.6% and 32% using a cutoff of ≥100,000 cells/ml of milk using a cutoff of 25.5% on the first test day after calving. Approximately 94% of ≥150,000 cells/ml, Santman-Bereads *et al.* (2012) [19] reported 25.5% on the first test day after calving. Approximately 94% of the primiparous cows with the low SCC category at the first milk recording were categorized as low-low CSCC category (*i.e.* not having IMI) and 6% as low-high CSCC category (*i.e.* IMI occurring after the first recording). Some of the previous studies [20] [21] showed that cows with low SCC at the first milk recording were likely to move to low-high category at the following second milk recording.

This can suggest that a very low SCC may indicate the immune system of these cows is not working well with a higher chance of these cows developing IMI late in lactation.

In our study, six primiparous cows with low SCC (<80,000 cells/ml) were with IMI occurring after the first milk recording.

In the experimental studies, it was shown that factors such as ketosis, low peripheral leukocyte count, and low SCC were associated with a more severe mastitis response [22] [23]. Approximately 76% of the primiparous cows with high SCC category at the first milk recording were categorized as high-low CSCC category (*i.e.* mostly having a transient IMI), when combining the first milk recording results. Previous studies indicated that many IMIs of newly calved primiparous cows disappear within a few weeks after calving [18] [24] [25] [26].

The analyses revealed some interesting associations between CSCC categories and MU contents.

At the first milk recording, SCC showed a negative relationship with MU content in high SCC category, Jonson and Young (2003) [27], reported same result.

Eicher *et al.* (1999) [28] reported no significant association of SCC with MU content. In low SCC category at the first milk recording, the relationship with MU content was positive (+0.49). Significant increase in SCC (from mean of 111,980 cells/ml to a mean of 292,224 cells/ml) at the first milk recording is associated with abnormalities in udder health.

At the first milk recording after calving, all primiparous cows were categorized in 2 different udder-health groups: A (healthy/normal-with SCC < 150,000 cells/ml and with MU content between 12 to 38 mg/dl) and B (with IMI – with SCC > 150,000 cells/ml and with MU content between 22 to 43 mg/dl).

At the second milk recording, all primiparous cows were also categorized in 2 different udder-health groups C (healthy) and D (with IMI). Combining the first and the second milk recording, all primiparous cows were categorized AC

(healthy-healthy), AD (healthy-IMI), BC (IMI-healthy) and BD (IMI-IMI).

At the second milk recording after calving, the proportion of primiparous cows in udder-health group (UHG) A decreased by 6%. Six primiparous cows with low SCC at the first milk recording were categorized with IMI.

The question is: are udders with low SCC at greater risk for developing intramammary infections? Further information is needed with large data sets to answer the question.

In our study, we choose to work with fixed cutoffs for SCC and CSCC to categorize primiparous cows' different udder health groups.

At the second milk recording after calving, also the proportion of primiparous cows in UHG B decreased. Approximately 76% were categorized healthy (*i.e.* immune response), and 24% with IMI (*i.e.* persistent mastitis).

The results revealed that only 13% of all primiparous cows were identified as problem cows, and 87% as healthy cows, and this probably derives from consistency in management and housing factors, indicating that combining the first 2 milk recording results can be used to identify success and problems cows for udder health in primiparous cows in early lactation.

Our investigation of differential MU contents as a potential supplementary indicator of SCC or CSCC for the identification of IMI was inconclusive. These are mainly three sources of urea in milk: 1) end product of protein, 2) non-protein-nitrogen (NPN) digestion, and 3) amino acid catabolism in the mammary gland.

After the first milk recording, a strong negative relationship was found in the high SCC category. The SCC followed MU concentrations in an inverse order. Milk urea is related to protein and NPN supply and their utilization rate in the rumen; SCC reflects the degree of irritation in the udder.

5. Conclusions

The prevalence of IMI in early-lactation primiparous cows indicated by CSCC categorization of the 2 first monthly milk recordings after calving was low. Only 13% of all primiparous cows were considered infected based on the SCC cutoffs ≤150,000 cells/ml and >150,000 cells/ml of milk.

Combining the first 2 milk recordings after calving as CSCC categories may be a useful tool for identifying IMI in the early lactation of primiparous cows.

The association of SCC with MU content as a potential supplementary indicator for the identification of IMI was inconclusive.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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