Using differential somatic cell count to improve udder health

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Background

Milk recording organizations and milk laboratories have offered individual cow mastitis screening using Somatic Cell Count (SCC) analysis for over 30 years. As management practices have improved so has udder health and herds have seen a decrease in cases of mastitis. US dairy farms have seen a steady decline in bulk tank SCC values. Although significant improvements have been made, mastitis is still one of the costliest disease farms have to deal with. A possible opportunity to improve udder health may lie in the new Differential Somatic Cell Count (DSCC) measurement that is offered through the Fossomatic 7 DC from Foss Denmark. The DSCC represents the combined proportion of Polymorphonuclear Neutrophils (PMN) and lymphocytes in percent. The percentage of macrophages is 100 – DSCC. DSCC values can be provided for cows that have a SCC value that exceeds 50,000. Past research projects have shown the positive correlation between increased DSCC values as cows are subjected to mastitis causing pathogens.

Materials and Methods

In order to build a practical application it was necessary to learn more about the data and any trends we could discover before specific areas of value could be determined. Two tracks of exploration were chosen. The first track involved a preliminary data analysis of 124,747 monthly individual cow milk samples with 39,135 cows that had two or more consecutive SCC/DSCC observations. The second track involved a six week research trial collecting weekly milk samples from a single herd that included 10,964 records on 2,080 cows from which 1,591 cows had six consecutive weeks of data. Cows of interest were selected for follow-up PCR to determine if specific pathogens were present. Using cow data from the field trial, a machine learning approach was used to determine if the combination of SCC and DSCC has any predictive characteristics to determine the future health status of the cow.

Results

Using the monthly data set, the correlation between SCC and DSCC for cows with a SCC value greater than 50,000 was only 0.17, indicating that the relationship is not as high. Based on the percent of PMN and macrophages, one of the values DSCC could provide is the early indication that a cow may be potentially infected but has not elevated the SCC value to a level it would raise concern and place the cow on an attention list. A second value would be in determining if an infected cow is healing or responding to treatment that is not captured in the SCC value.

Results in figure 1 show that as DSCC increases, a higher percent of cows considered healthy return the next month with a SCC above the threshold of 200,000. This could provide some early insights that cows with SCC <200,000, but DSCC above 70, do not require intervention right away rather should be more closely monitored.

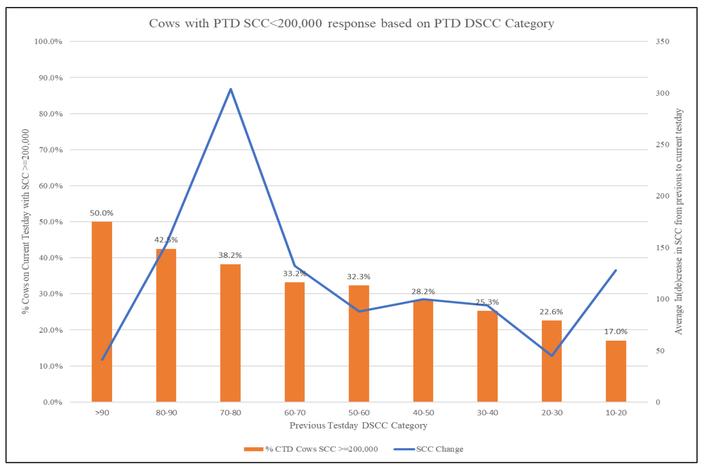
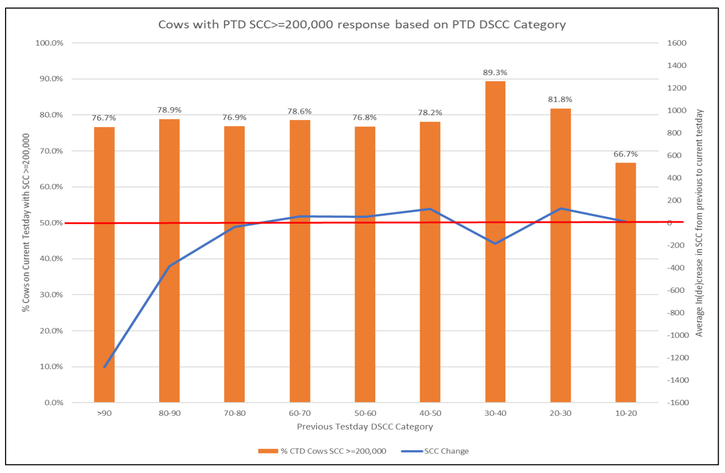


Figure 1. SCC response for clean cows from previous to current test day based on previous test day DSCC



Results shown in figure 2 indicate that regardless of DSCC category, almost the same percentage (75%) of cows have SCC greater than 200,000 on the next test day. Although the percent is similar across DSCC categories, the cows that had the highest previous test day DSCC (DSCC greater than 80) showed the greatest reduction in SCC while cows with low DSCC (DSCC less than 70) showed little or no improvement. This raises the question if cows have a SCC of, for example, 1,000,000 or higher, but a DSCC value between 40 and 60, are these cows healing or more likely to return the next month as still infected?

Figure 2. SCC response for infected cows from previous to current test day based on previous test day DSCC

Utilizing the results from monthly SCC and DSCC data some early insights were gained in regards to which areas DSCC may provide additional value. Correlations between the SCC and DSCC values for the weekly samples were 0.3. Based on this information cows were grouped in several categories shown in table 1. PCR analysis was used to determine if cows in the different categories had any environmental or contagious pathogens present. Figure 3 shows the relationship between the weekly SCC and DSCC values for each cow as they fit in the five categories listed in table 1.

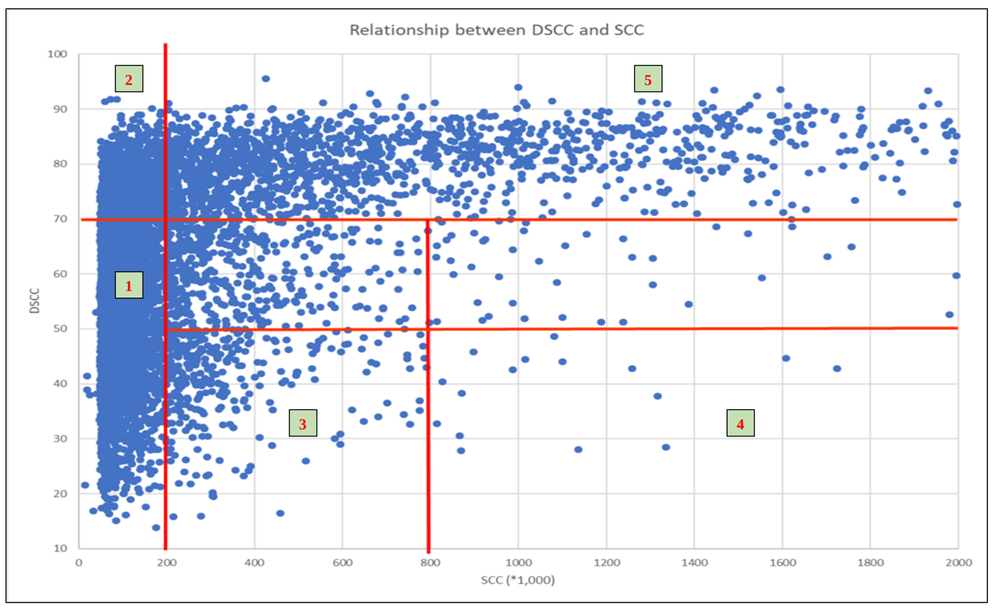


Figure 3. Relationship of DSCC and SCC and udder health category

Table 1. DSCC impact matrix

Category	SCC	DSCC	Possible Impact
1	Low (<200,000)	Low (~<70)	Healthy
2	Low (<200,000)	High (~>70)	Early warning
3	Medium (200,000-800,000)	Low (~<50)	Chronic problem
4	High (>800,000)	Low (~<50)	Not responding
5	Medium and High (>200,000)	High (~>70)	Responding to infections

Using week 4 SCC and DSCC data, cows were selected based on the criteria in table 1. PCR analysis was performed on week 5 pooled milk samples. The process was repeated with cows selected on week 5 and samples collected on week 6 were run for PCR analysis. The week 6 samples were pooled and upon detection of any pathogens in the pooled sample individual cows were tested. The goal of the PCR analysis was to determine if any pathogens could be detected and if these were environmental or contagious. Results from week 6 showed that all pools tested positive for Enterococcus pathogen. No additional pathogens were found in the cows in category 2. Category 3 had two cows that tested positive for Strep Uberis and one tested positive for Staph Aureus. Category 4 showed no additional pathogens and category 5 showed cows positive for Staph Aureus and Strep Uberis.

Weekly observations were used to develop predictive models for flagging animals based on their previous weekly records. This was set up as a classification problem. The target variables were created by mapping the observed SCC to 0 and 1. 0 was used for healthy cows (SCC < 200,000) and 1 was used to signal cows at-risk for mastitis (SCC >= 200,000). Input data included SCC, DSCC, LACT, DIM, age (days), age at calving, linear score, macrophage, and PMN counts and preceding health events (abortion, displaced abomasum, ketosis, mastitis, metritis, milk fever, retained placenta). To be able to classify the current SCC category, 3 lagged variables of key features including SCC, DSCC, and linear score were created. These variables were simply the data from the previous records up to 3 weeks prior to the current test. Furthermore, mean and standard deviation of SCC, linear score, DSCC, PMN and Macrophage counts, which include all the previous records of individual animals (excluding the last weekly record), were added to the dataset.

Different classification algorithms were applied to the training data and the models were evaluated according to their F1-score (weighed harmonic mean of recall (sensitivity) and precision). From all the models tested the best model was the Gradient Boosting classifier. Results showed that the most important features for classifying healthy and at-risk cows in the current model setting was mean linear score, mean SCC and their standard deviation, which means the cows previous average weekly SCC values is the most significant predictor of its future values. In this model, the addition of DSCC added very little to the predictions. However, if we do not consider the mean and standard deviation of previous records in the model, previous test SCC alongside PMN counts (generated from DSCC) were important.

Conclusion

Based on the monthly and weekly data analysis, so far no conclusive results have been reached regarding the use of DSCC. Although patterns in the data suggest that SCC combined with DSCC can identify some cows that may be considered healthy based on SCC alone the addition of DSCC can in some cases point to cows at risk. Using the data collected so far, a machine learning approach predicting the future status of a single cows was not able to prove that DSCC provides a significant contribution over using SCC only. Future efforts will focus on collecting more weekly milk samples and look for additional relationships between DSCC and health status of the cow. Repeat analysis of monthly milk samples on the same cow will also increase the understanding of SCC and DSCC as it relates to parity and stage of lactation. Further understanding of the impact of different environmental or contagious pathogens, or impact of other (non-udder) health conditions on SCC and DSCC will be helpful in determining where DSCC can provide additional value.