SOMATIC CELL COUNTS: MEASURES OF FARM MANAGEMENT AND MILK QUALITY

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SCC (somatic cell count) has become the "gold standard" measure of milk quality. The herd SCC level is dependent on the number and duration of infections present plus rate of new infections. Since mammary gland infection is multi-factorial, the epidemiological principle of "sufficient cause" has bearing on whether or not exposure to mastitis pathogens will cause mammary gland infection. For example, in order for a new mammary gland infection to occur, there not only must be teat exposure to a mastitis pathogen but also a circumstance (i.e., air slips) that results in the pathogen penetrating the teat canal. Even then, the pathogen must be of sufficient dose and virulence to overwhelm the cow's immune system allowing establishment of an infection. The sum of all these factors result in "sufficient cause" for an infection to occur. The whole thrust of mastitis control has been to identify those critical factors necessary for infection to occur and block them by strategic intervention (i.e., teat dipping) so that infection does not occur. However, it is only by consistent application of control practices that high quality, safe milk is produced.

BTSCC as a Measure of Mastitis, Milk Quality and Herd Management

A low BTSCC (bulk tank somatic cell count) not only consistently correlates with low level mammary gland inflammation but also with other important milk quality factors such as microbiological quality (Plate counts, PI counts, Coliform counts) (4, 21). Food safety and the relative risk of antibiotic residue can be positively correlated to rising BTSCC (20).

Numerous studies have shown a correlation between established mastitis control practices and SCC (3, 6, 7, 10, 13, 14, 15, 17, 18, 25). The NMC five-point control plan: post milking teat dipping, dry cow therapy, pre-milking hygiene, and proper function and operation of milking equipment, as well as appropriate treatment of clinical cases, all have been proven effective in lowering SCC. Most of these studies were done comparing BTSCC of less than 400,000 with BTSCC greater than 400,000 to 1,000,000. Today's SCC standards in most of the world are more stringent requiring that BTSCC be no greater than 400,000. While this does not invalidate these practices as being effective in reaching the lower BTSCC levels, it does raise the question of whether there are additional practices associated with reaching lower BTSCC expectations of today. During the past dozen years, environmental factors such as freestall and bedding management have also been recognized as important factors effecting BTSCC (12). Barkema et al. (1) differentiate management practices between "low" BTSCC ($<$150,000), "mid" BTSCC (150-250,000) and "high" BTSCC (250-400,000). They found that that those management practices known to be important for managing "high" BTSCC ($>$250,000) herds, such as post milking teat dipping, dry cow therapy, milking technique and antibiotic treatment of clinical cases, were also important in differentiating the "mid" and

"low" category BTSCC herds. In the "low" (<150,000) category herds, significantly more attention was paid to general hygiene ($p < 0.05$) than the higher BTSCC herds. For example, herds with BTSCC <150,000:

- cows were cleaner and drinking cups were cleaner
- were more likely to remove udder hair
- had cleaner free stalls and cleaned the free stall more frequently each day
- used more bedding
- dry cows were more often checked daily for evidence of clinical mastitis
- had cleaner calving pens as rated by a standardized hygiene scoring system
- had cleaner milking parlors as rated by a standardized hygiene scoring system
- kept milk from fresh cows out of the bulk tank longer
- were more consistent in the use of post milking teat dipping and had utilized the practice longer than other herds
- were more consistent in dry cow treating all cows and had been using the practice longer than other herds
- clinical cases were treated for a longer duration
- were more apt to provide nutrient supplementation for springing heifers, dry and lactating cows

Hutton et al. also found similar subtle differences in management detail and consistency between low BTSCC herds and higher BTSCC herds (13). These findings are not surprising, only vindication for those who have been emphasizing these points for many years.

Management Attitude a Determining Factor

Management attitude and the application quality of management practices are not always easy to determine. Seabrook (21) found in comparing dairies with the exact same facilities, feed, genetic base and environmental circumstance often resulted in differing productivity. The only difference between these herds was the herd manager; thus implicating management as the main cause of productivity difference. Although common sense tells us that those farms that visually appear to be neat and tidy are usually at a higher plane of sanitation, this is not entirely accurate. Tidiness does not always coincide with low BTSCC. There are some untidy farms that succeed in consistently producing high quality low BTSCC milk and vice versa. Bennett found, however, that BTSCC level is a dependable predictor not only of milk quality but also of general herd management (4).

The bottom line reflecting differences in management attitude are captured in the following questions: Are you just milking cows or are you producing quality milk? Are you just dipping teats or are you using a dip cup to completely immerse teats? There is an attitude difference and the resulting behavior is reflected in BTSCC. Whether or not high quality milk is produced depends on whether milk quality management practices are consistently and accurately implemented. The idea that attitude is a determining factor in success is nothing new to any of us. There has been some indirect implication of an attitude effect on milk quality. Recent surveys of U.S. dairies show that, in general, large herds have lower BTSCC

than small herds (19, 24). The 1998 Chicago regional market data also showed lower BTSCC for larger herds (20). While care must be taken not to surmise cause and effect relationships from any observational study, these observations hint that there may be a basic attitude difference between management of small and large herds. Grade A milk producers in Wisconsin produced milk with BTSCC 92-132,000 lower than Grade B producers (20). This is also suggestive that there may be a different milk quality mind set among Grade A producers than Grade B producers. The relative risk of an antibiotic residue increased with increasing BTSCC (20,21). There are reports correlating sloppy treatment record keeping with increases in antibiotic residue (20). In addition, these same herds with antibiotic residue violations tend to be herds with higher BTSCC. Certainly there have been many studies that indirectly implicate management attitude as a factor in the production of quality milk. However, there have been few studies that have attempted to directly correlate attitude and behavior with milk quality. Barkema et al. (2) may be one of the first studies where there has been demonstrated a direct and significant BTSCC difference between dairy farmers who were categorized by their management style as "clean and accurate" (BTSCC $<$150,000) and those categorized as "quick and dirty"(BTSCC 250-400,000). The association between management style and BTSCC was high ($p < 0.001$). Seventy-three percent of the high BTSCC (250-400,000) herds were categorized as “quick and dirty” and 74% of those farms with low BTSCC ($<$150,000) were categorized as “clean and accurate. The farmers categorized as “clean and accurate” were characterized as younger, more education minded, better record keepers and more hygienically meticulous. The most striking difference between the “clean and accurate” farmers and the “quick and dirty” farmers was that the former preferred to work precisely while the latter preferred to work quickly. For example, “clean and accurate” farmers:

- were more likely to use records daily
- rarely forgot to take milk samples for culture on the clinical cases
- enjoyed milking more
- were more likely to believe it is important to work hygienically with clean hands, boots, etc.
- less likely to start milking later than planned
- kept farmyard, milking parlor and bulk tank room cleaner as determined by a standardized hygiene scoring system

Deming (23) suggested that attitude is the key component in the quest for “continuous improvement” for any process. He maintained that every process is one of four states: *Ideal State, Threshold State, Brink of Chaos, and State of Chaos* (Figure 1). A process in the *Ideal State* is a process "in control" and is meeting performance expectation 100% of the time. "In control" meaning that the outcome of the process is predictable and, in the case of the *Ideal State* is meeting performance expectations all the time. The process in the *Threshold State* is also "in control" but does not meet performance expectations 100% of the time. The *Brink of Chaos* process is "out of control" because performance outcome is not always predictable but since performance standards are lower, performance expectations are still met 100% of the time. A process in a S*tate of Chaos* is "out of control". The performance outcome is always unpredictable and the performance standards are not being met.

It would be rare and probably impossible to find a dairy operation with all of its processes in the *Ideal State*. It is obvious from study of herd records that the best farms will have proportionately more of the production system processes in the *Ideal State* and fewer in the *State of Chaos* than poorly managed farms. The objective of excellent herd management is to move each production system process toward the *Ideal State*. However, there are universal forces acting on every process that over time will cause deterioration, decay, wear and tear, breakdown and failure. This is called entropy. Morris et al. (16) recognized that the difficulty of maintaining mastitis control measures is almost inevitable. Turnover in employees, taking shortcuts on established protocols, wearing out of equipment and facilities, and running out of critical supplies are all examples of process entropy. Without attention, all processes will eventually migrate to a *State of Chaos*. The only way to overcome this natural phenomenon is to continually repair the effects of process entropy. Routine repair and maintenance of equipment and facilities, as well as motivation and training of employees, are examples of process entropy repair. The more proactive and consistent (i.e., "clean and accurate") the dairy is in maintaining optimum function of each process, the more likely they will succeed in reaching and maintaining the *Ideal State*.

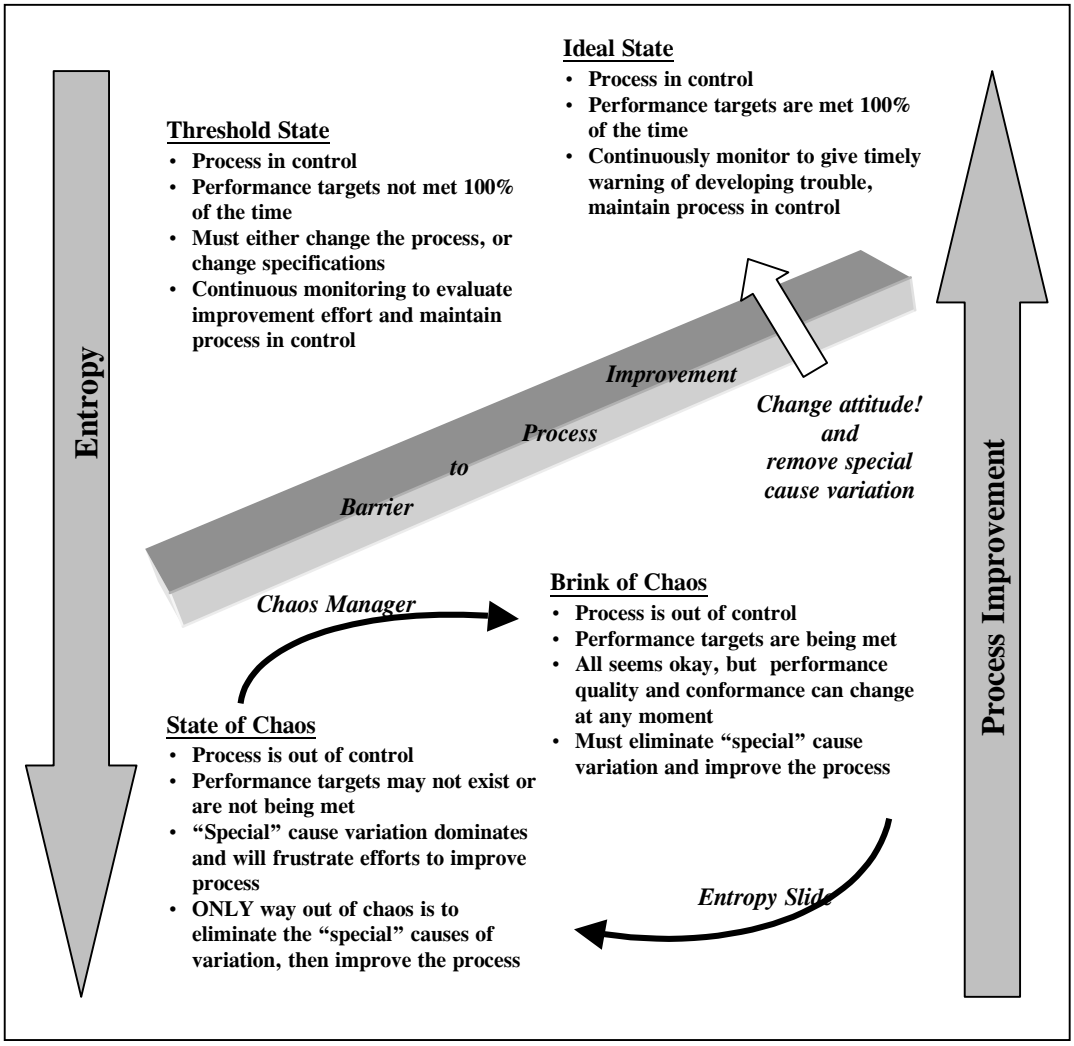

Figure 1. Process status in a dairy production system.
(Adapted from Wheeler and Chambers, 1992.)

Frequently, veterinarians, milk plant field staff and state milk inspectors are called to a farm to respond to a process in a *State of Chaos*. The farm has a situation in which they know they are in trouble. For example, the BTSCC has just exceeded the legal limit, the farm has been issued an ultimatum to lower the BTSCC or face the consequences of losing their market. The producer is asking you to be a chaos manager. The producer's expectation is for you to get the SCC down to legal limits as soon as possible. Using your diagnostic skill you identify the chronically high SCC cows and may recommend culling some of those cows and to use a quarter milker on a few other high SCC quarters. The goal was achieved. With your assistance, the farm is now able to sell their milk again. The farmer is happy and feels temporarily out of trouble. However, even though the milk now conforms to the legal standards, in reality the processes that govern milk quality have not changed and are still likely "out of control". Your intervention as a chaos manager has moved the situation from a *State of Chaos* to the *Brink of Chaos*. However, without further intervention to ***change the attitude and the processes***, this herd is doomed to slip back into a "state of chaos" and the cycle of despair continues.

The greatest barrier to achieving the quality of management depicted by the process in the Ideal State is attitude. The only way to sufficiently overcome process entropy and reach the more desirable "threshold" and "ideal" states is by commitment to the concept of continuous process improvement and a continuous monitoring system that alerts the herd manager to the effects of process entropy. The causes of abnormal variation must be found and eliminated and then emphasis must be placed on process improvement. This is why it is critically important that the herd manager and the herd consultants have a shared vision of what the goals are and a firm commitment to the long-term process of continuous improvement. Not only must the goal to produce quality milk be clear, the attitude reflected in management behavior must demonstrate consistent application of quality milk management practices.

Consistency Factor

Deming once said, "If I had to reduce my message to management to just a few words, I'd say it all has to do with reducing variation." It is clear that understanding variation is the key to successful herd management. A sure signal of process improvement is a reduction in variation. Reducing variation in the BTSCC requires accurate and consistent application of milk quality management practices. Figure 2 is a statistical process control (SPC), control chart of a large Wisconsin dairy that had kept their BTSCC under 200,000 for 20 years. During the period between January 1 through mid-February, 1999, the BTSCC was averaging 140,000 and was "in control". However, the herd manager felt that the herd BTSCC should be 100,000 or less, as had been the case during previous years. During the March 21, 1999 meeting with the milking parlor staff there was a consensus reached:

- that more attention be placed on pre-milking teat end sanitation, and
- that cows with extremely high SCC quarters would be identified with a leg band so that the high SCC quarters could be milked into a quarter bucket

The plan was implemented immediately. Did the program work? Study of Figure 2 clearly indicates a dramatic and significant decline in herd BTSCC. Using routine control chart

interpretation, by March 26 the herd manager knew with 95% certainty that the plan was working and could use the chart as positive feedback to the parlor crew to reinforce their dedicated effort. This chart illustrates two points. First, when the milking process was improved, the BTSCC variation was reduced. Secondly, use of statistical process control is effective in monitoring daily BTSCC for the purpose of quality improvement.

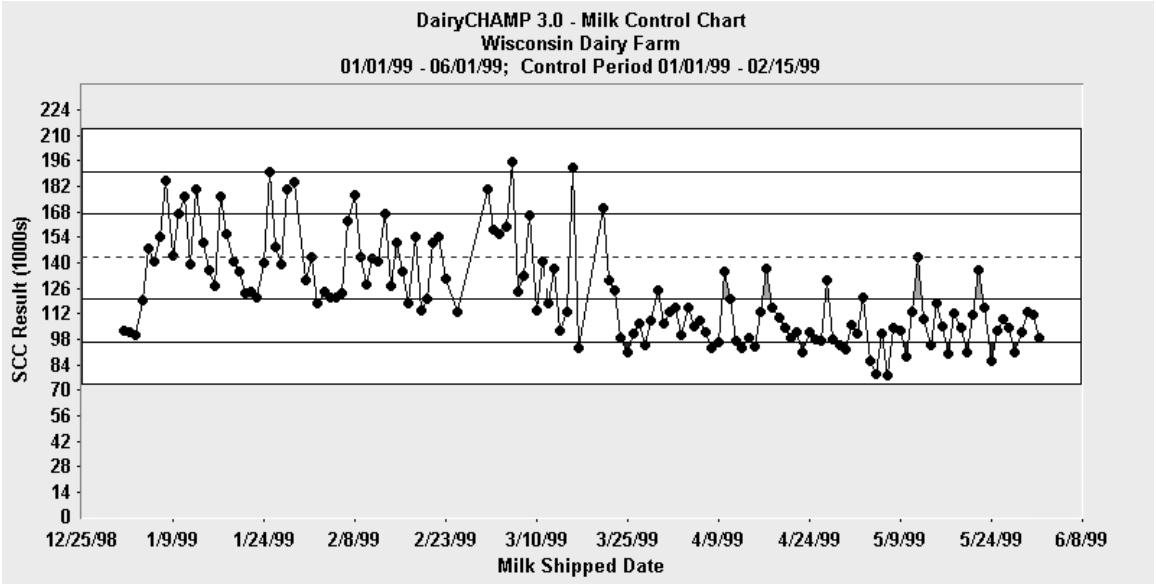

Figure 2. Control chart of a Wisconsin dairy demonstrating the effectiveness of a milking routine change in reducing BTSCC and variation in BTSCC.

Quality Milk Motivation

What motivates dairies to produce high quality low BTSCC milk: education, incentives, or penalties? Is education the answer? The theory being that if they know what to do, they will do it. Not always! Knowledge is power only where it is put to use. Much of what is known today about mastitis control has been common knowledge for many years. Frustration with the total lack of interest by dairy farmers in applying the NIRD research led Morris (16) in 1971 to conclude that as long as farmers could get paid the same price for tainted milk as higher quality milk, there would be little incentive to adopt mastitis control practices. Booth (5) also concluded in 1975, "…it appears that any real impact in controlling mastitis will only be created by direct financial incentives. Penalties, which would only directly affect a small proportion of farmers at the worst end of the scale, are unlikely to result in any significant improvement in control of mastitis nationally." Dramatic reductions were realized in the U.K. when quality incentives were introduced. Recognition that high SCC milk reduced cheese yield stimulated the beginning of quality premium incentives in the upper Midwest. Quality premium incentives offered by Wisconsin Dairies in 1979 had a marked effect on BTSCC from 1979 to 1988 and clearly demonstrated that monetary incentives did stimulate dairies to produce low BTSCC milk (8). Penalty programs also can work. Canadian milk pricing penalty program has had a significant impact on BTSCC (11, 21). Both quality premiums and

penalty programs are examples of extrinsic motivations. Tangible extrinsic motivators (money, promotions, awards) will work but may be more short-lived and are incentive dependent. Upon removal of the extrinsic based incentive, process entropy is almost certain to occur. For example, when Upper Midwest milk processors began component pricing, the price adjustments placed somewhat less economic incentive on low BTSCC. Whether it is cause and effect we cannot be sure but it appears that during this period of time there has been a plateau in BTSCC improvement. Intrinsic motivation, on the other hand, are intangible feelings of an internal desire to do things right or to be the best at something. Those driven by intrinsic incentives (i.e., the "clean and accurate" producers) will likely continue producing high quality milk regardless of whether quality premiums are offered. In the context of quality performance, it should be obvious that the most powerful motivation is intrinsic development of a "milk quality mind set".

The question is, how do we develop a "milk quality mind set"? It is a fair assumption that education will continue to be the foundation of developing a "milk quality mind set". However, it is doubtful that education and just knowing the "why" and "how" of producing quality milk will be enough. The concept of an epidemic may provide some insight. Malcolm Gladwell (9), in his book "The Tipping Point", points out that epidemiological principles apply to how ideas and products are spread as much as how disease is spread. All epidemics have a tipping point, that is a point where the disease begins to spread rapidly in epic proportions in a contagious manner. The "tipping point" is that point when the circumstance is "right" for the epidemic to occur. Gladwell says it takes three factors are needed to start an idea epidemic:

- **The Law of the Few:** It only takes a few very dedicated, enthusiastic and persistent people to make a difference.
- **The "Stickiness" Factor:** It is not what you say, but how you say it. The key to making a message contagious is to make it memorable (i.e., "Winston taste good like a cigarette should").
- **The Power of Context:** The time/circumstance is right for a mindset to change, not gradually but in a dramatic moment and in geometric progression. Educationally, we might call this "the teaching moment".

Conclusion

Consistent production of quality milk is dependent on quality attitude and quality application of mastitis control practices. The greatest impact will probably result from development of a "milk quality mind-set" through a balanced program of education and encouragement of quality premium payments under the simultaneous pressure of regulation and consumer demands. Whatever the mechanism, we need to create a "milk quality mind set" epidemic. The time is right and the need is clear.

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