

What have we learned about milk quality and udder health in automatic milking systems?

David Kelton,¹ DVM, PhD; Karen Hand,² PhD

¹Department of Population Medicine, University of Guelph, Guelph, Ontario, Canada N1G 2W1

²Precision Strategic Solutions Inc., Puslinch, Ontario, Canada N0B 2J0

Abstract

The adoption of automatic milking systems (AMS) continues to increase across North America. An analysis of milk quality data from more than 3,000 dairy farms in Ontario, Canada suggests that while AMS herds have a slightly higher average raw bacteria count and higher risk of incurring a bacterial or freezing point penalty, the bulk tank somatic cell count is similar among farms using pipeline, parlor and AMS systems. These results indicate that farms milking with AMS can produce milk of similarly high quality as those milking with conventional milking systems (CMS). A panel of individuals shared their opinions about advantages and disadvantages of AMS and CMS, with a number of AMS attributes appearing in both lists, suggesting that the perception will depend on the context and the attributes of the AMS.

Key words: mastitis, milk quality, robots, automatic milking systems, AMS

Introduction

Robotic milking systems, or automatic milking systems (AMS), were first introduced in the Netherlands 30 years ago and in North America about 10 years later. Current industry estimates are that over 15% of Canadian dairy farms and between 2 and 3% of dairy farms in the U.S. milk with AMS, with expectations that these proportions will continue to rise in the foreseeable future. Early adopters of AMS on smaller family farms were drawn by the flexibility in work schedule that the AMS offered,¹ not being required to milk twice a day, 7 days a week, all year. More recently, and on larger farms, AMS offer a viable solution to the milking labor scarcity in many rural communities.

Surveys have been published that describe farm owner operator expectations and experiences related to udder health and milk quality prior to and after transition to AMS. In one such study, 49% of 217 Canadian dairy farms which transitioned to AMS reported a decrease in clinical mastitis rate, while 38% reported no change and 13% reported an increase.² Based on the same survey, 43% reported a decrease in herd bulk tank somatic cell count (BTSCC) while 37% reported no change and 20% reported an increase.³

Milk quality during the transition from a conventional milk system (CMS) to AMS has been reported to deteriorate for a period of 6 months to a year,⁴ but after the transition phase has been reported to be comparable to that of CMS. This is supported by results of the National Dairy Study conducted in Canada in 2015 which reported that farms milking with AMS or pipeline systems had a higher geometric mean BTSCC than parlor milked herds.⁵ Based on the way the data were collected, the sample of AMS farms very likely included a subset that had transitioned to AMS within the previous 6 months. It is very likely that the change in milk quality is likely a function of many changes that are part of such a transition, and not simply

the adoption of AMS.^{6,7} It is also clear that some management practices, including those related to mastitis control, are by necessity or circumstance different in AMS herds.⁸

Comparing key milk quality indicators on AMS and CMS farms

To determine if there are differences in milk quality on farms with AMS and CMS in the Canadian context, we compiled 12 months (June 1, 2021 to May 31, 2022) of milk quality data (BTSCC, bacteria count [Bactoscan], freezing point [FP] for added water and inhibitors) from over 3,000 farms in Ontario Canada, including 625 farms that had started milking with AMS prior to January 1, 2021. We compared their milk quality based on milking system (AMS [n = 625] versus pipeline [n = 1,562] versus parlor [n = 886]).

BTSCC varies by season on many Ontario dairy farms, with highest BTSCC in July, August and September, and lowest in February, March and April. Overall, pipeline herds had the highest milk volume weighted BTSCC (192,000 cells/ml), parlor herds the lowest (159,000 cells/ml) and AMS herds were in the middle (178,000 cells/ml). The BTSCC varied in all groups, with the 10th and 90th percentile for each system being comparable (parlor 10th percentile = 77,000 cells/ml and 90th percentile = 259,000 cells/ml; AMS 10th percentile = 84,000 cells/ml and 90th percentile = 290,000 cells/ml; pipeline 10th percentile = 86,000 cells/ml and 90th percentile = 317,000 cells/ml). In the 12-month period, pipeline milked herds incurred significantly more SCC penalties than either AMS or parlor herds (for details about the Ontario Raw Milk Quality penalty program see the Dairy Farmers of Ontario website⁹).

For total bacteria count, AMS herds had a significantly higher Bactoscan count than did parlor or pipeline herds, and were at a significantly increased risk of incurring a bacterial penalty. AMS herds were also at increased risk of incurring a freezing point penalty than either pipeline or parlor herds. There were no differences in inhibitor penalties among the 3 groups.

Based on our analyses of these data, we conclude that the BTSCC on farms milking with AMS is similar to that on farms milking with CMS (parlor is best, pipeline is worst and AMS falls in the middle for most of the measures). In this dataset, herds milking with AMS had higher raw bacteria counts and were significantly more likely to incur a bacteria count penalty or freezing point penalty during the 12-month period, compared to herds milking with CMS. Nonetheless, it is clear that milking with AMS is not a legitimate excuse for producing milk of inferior quality, and when comparing the herds in the 90th percentile across all systems, they are very capable of producing the highest quality milk.

AMS offer some advantages and disadvantages compared to CMS in many aspects of animal health and management, including udder health and milk quality. An informal poll of researchers, veterinarians and milk quality advisors with extensive experience working with AMS was conducted to identify areas in which AMS in general (manufacturers and models of AMS are not specifically identified as this is a very dynamic arena and each individual system has its own strengths and weaknesses) performs better/worse than CMS with respect to udder health and milk quality, and to assemble a list of key questions that need to be addressed through research in the coming years. In most cases there is little in the published literature to support or refute these perceptions, although ongoing research is addressing at least some of these issues. There was more agreement among the panel about advantages than disadvantages of AMS.

Based on the opinions summarized below, it is clear that some of the attributes of AMS can be considered both superior and inferior to CMS, depending on the circumstances. Further, it is clear that AMS are evolving and improving over time, and that the manufacturers are generally committed to improving all aspects of AMS performance. Finally, it is important to recognize that the AMS is in the end just another milking system and how effectively it is used still depends upon how well the operator is trained, understands the system and responds to the signals/information that the system generates.

Perceived advantages of AMS over CMS:

- The most commonly cited advantage of AMS was the consistency of the milking experience for the cow including pre-milking, during milk harvest, and post-milking, while the milking experience in CMS often varies among milkers and across time. Some respondents believe that while this consistency overall is an advantage, there are instances where the inability to treat individuals differently may be a problem.
- In most AMS, milking is managed at the quarter level, so that cows with fewer than 4 functioning quarters can be easily accommodated, and detachment at the end of milking can accommodate significant between-quarter variation. Data are also collected at the quarter level, allowing for a quarter-level focus on mastitis detection.
- Many AMS have an assortment of sensors built into the system, although the number and type of sensor vary by company, model and purchased options. These sensors generate large volumes of data that, at least in theory, can be used to manage mastitis and milk quality. Use of these data for monitoring milk quality requires that the owner/operator is well trained in how to access and interpret the data, and incorporates this into their management routine.
- AMS programming allows the operator to easily implement individual cow control of production leading up to dry off by reducing milking permissions and AMS feed, thereby decreasing milk production prior to dry-off. The value is based on the effect that level of milk production at the end of lactation can have on mastitis risk during the dry period.¹⁰ Whether implementing this strategy translates into improved udder health in the next lactation is still not clear.¹¹
- AMS can be programmed to reliably and consistently divert milk that is abnormal or from treated cows, provided that all treatments are carefully input into the software. This attribute should decrease the risk of bulk tank milk

contamination and the associated costs. Further, the system can be rinsed following milking of treated cows to further decrease the risk of bulk tank contamination.

Perceived disadvantages of AMS versus CMS:

- While the consistency of the AMS is generally considered an advantage, they do have difficulty identifying and dealing with dirty cows. In this context, maintaining a clean cow environment for cows milked with AMS is critical. We must acknowledge that while human milkers can take extra time to clean the occasional dirty cow, not all of them do.
- Despite the presence of many sensors in AMS, their ability to accurately and consistently identify cows with clinical/subclinical mastitis is still quite poor. The decision algorithms, whether for a single sensor or several combined, perform relatively poorly with many false positives and likely some false negatives as well (these are obviously harder for users to identify). Performance targets for decisions about mastitis management in terms of sensitivity and specificity have been published,^{12,13} but few if any systems meet those targets at this time. While it is possible to get a SCC from every cow at every milking, we don't know how to interpret these data in terms of normal variation, normal cow response to infection/challenge or in gauging positive/negative response to therapy.
- The attachment systems on AMS with their cameras and sensors have evolved and improved substantially over time, but in some cases, they still may not be able to deal with unbalanced udders, so that there are still cows that cannot be accommodated with AMS.
- Some individuals had a strong opinion that AMS contributes to the within herd spread of contagious mastitis, there wasn't total agreement on this point. Based on experience, some suggested that in herds with contagious mastitis pathogens that have not been identified, the prevalence of infected cows can increase quite quickly with dire herd consequences. These individuals felt that systems to clean/flush units on some AMS are not sufficient to prevent cow-to-cow transmission of contagious mastitis pathogens.
- While AMS are improving over time and generations, there is concern that pre- and post-milking teat disinfection in many AMS is poor. Though the process is consistent, in this case, it is consistently poor relative to the expected guidelines and standards. Even the "in cup" systems don't necessarily achieve the coverage that National Mastitis Council (NMC) guidelines recommend, although the new systems are performing much better in this respect.
- Recognizing that each AMS is a combination of hardware and software, there is a general lack of computer software tools in most AMS to monitor udder health indicators over time. In addition to the decision algorithm limitations described above, there are few if any tools that track cow/herd level data over time and use them to proactively identify cows at high risk for mastitis, or herd situations that require prompt attention.
- By virtue of being voluntary milking systems, cows milked in AMS will have irregular milking intervals, but in some cases, they can get extreme due to milking permission settings, cow behaviour, poor robot maintenance, mechanical breakdowns, and herd policies regarding fetching of cows. These more extreme irregular intervals can increase mastitis risk for some cows.

- Compared to CMS, there is a lack of liner choices/options. Characteristics and sizing of liners can have a significant impact on teat and udder health and the lack of commercial options for at least some systems can be a problem
- Over-milking (machine-induced mastitis) can be an issue on some systems based on the default settings. Attention needs to be paid to this issue by the operator and adjustments made to settings.
- Given that there is one “unit” per 60 cows or so, this represents a high number of cows milked per unit. If the unit is malfunctioning, the consequences for the herd as a whole are more serious and impactful than CMS systems where cows per unit is lower on most (small) farms. Some argue that the reliance on the one unit likely means that the malfunction will be identified more quickly than it might be on a single unit in a large parlor, and that this is an advantage for AMS.
- In herds with mastitis problems, collecting aseptic milk samples for culture can be challenging (where to do it, how to do it, how long it takes to get all cows). Further, many herds with AMS move away from milk recording and so advisors don’t have routine access to monthly SCC data to support herd udder health management.

Summary

It is clear that while milk quality varies substantially among dairy farms the world over, the increasing adoption of AMS should not in any way negatively impact the prevalence of mastitis or the quality of milk farms are producing. AMS offers an alternative to CMS that is attractive for many farms, both small and large. Success of implementation of AMS still relies heavily on the knowledge, interest and attention of the operator. The daily contact between people and cows that occurs in CMS is reduced, with an increased reliance on technology to identify cows with abnormal milk. Clearly there are advantages and disadvantages to AMS compared to CMS, and in many cases the same attribute can be viewed as either, depending on the context.

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