Pros and cons of automatic milking in Europe

K. M. Svennersten-Sjaunja and G. Pettersson

Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, Kungsängen Research Centre, SE-753 23 Uppsala, Sweden

ABSTRACT: During the last several decades, new milking management systems have been introduced, of which development of automatic milking (AM) systems is a significant step forward. In Europe, AM has become an established management system and has shown to be much more than milking management. Factors such as milking, milk quality, feeding, cow traffic, grazing, and animal behavior are essential elements of AM. This system offers possibilities for more frequent milking and can be adapted to lactational stage. Increased milk yield with AM has been observed, but lack of increased production has also been reported from the field, probably due to less attention paid to the total management system. The AM system provides consistent milking routines, with those for teat stimulation and feeding during milking giving an adequate oxytocin release and milk ejection. Initially, reduced milk quality, such as increased FFA, total bacteria count, and somatic cell count (SCC), was observed. Increased FFA could be due to increased milking frequency or handling of the milk, although this has not yet been determined. The elevated total bacteria count was probably due to mismanagement because later studies indicated that teat cleaning in AM is sufficient to reduce spores and dirt on the teats. Significant positive effects on udder health and teat treatment were observed in some studies, possibly as an effect of quarter milking, a procedure whereby an individual teat cup is detached when milk flow is below the preset level for detachment. Well-functioning cow traffic is a prerequisite for successful AM system performance to obtain an optimal number of visits to the feeding area and the milking parlor for all cows. Technical stoppages in the AM system (i.e., the milking unit) increased milk SCC, and the variation and length of the milking interval seem to contribute to elevated SCC. Grazing is a common management routine in many countries. Different ways to motivate the cows to visit the milking parlor, such as shorter distance between barn and pasture, supplement feeding, access to water, and use of acoustic signals, have been tested. It was concluded that use of AM and grazing systems together is possible as long as the distance from the milking parlor to pasture is short. With proper management routines, it is possible to achieve a production level and animal well-being in AM systems that are at least as good as in conventional milking systems.

Key words: animal welfare, automatic milking, cow traffic, milk quality, milking frequency

INTRODUCTION

The first automatic milking (AM) systems were introduced on dairy farms in the Netherlands in 1992. Until 1998, about 250 farms worldwide had AM systems in operation. Thereafter, the number of farms with AM grew considerably, with the real breakthrough coming at the end of 1990s (de Koning and Rodenburg, 2004). Today, about 8,000 AM units are in use on approximately 5,500 farms worldwide (O. Markusson, DeLaval, Tumba, Sweden; personal communication).

It soon became apparent that AM is much more than milking; it is an entirely new management system in which consideration must be given to milking, milk quality, feeding, cow traffic, cow behavior, grazing, and animal welfare, just to mention some aspects. Problems with poor milk quality and increased somatic cell count (SCC), were reported initially (Jepsen and Rasmussen, 2000; Klungel et al., 2000), but also the vast potential of AM management was highlighted, where success would depend on farm conditions and the herd manager's management skill (Rossing et al., 1997; Lind et al., 2000; de Koning et al., 2002).

The AM system is now an established management system in Europe. The main markets for AM systems...
are found in countries with high-yielding cows, high milk prices, and high labor costs (Lind et al., 2000). Originally, AM was targeted for small family farms with 50 to 150 dairy cows. However, with continuous technological progress and increased management skills, AM nowadays is installed on larger farms with more than 500 cows per herd and this trend is increasing, although the largest market remains for 1 to 2 AM single stall units, (O. Markusson, DeLaval, Tumba, Sweden, personal communication).

Research on AM has identified the pros and cons of using the system. Herein, we discuss some of the pros and cons of AM, with focus on milking frequency, milk quality, cow traffic, and animal welfare.

**MILKING FREQUENCY**

Two great advantages with AM systems include reducing the heavy workload of milking and milking more often than twice daily without incurring extra labor costs. Replacing hired labor with AM may result in substantial financial savings per cow annually (Dijkstra et al., 1997). Furthermore, the cows can be milked at frequencies predetermined by the herd manager, whereby milking frequency can be adapted to stage of lactation or management system.

Milking frequencies of more than twice daily are desired in high-yielding cows because 3 milkings daily are expected to enhance lactation milk yield by 10 to 15% on average (Klei et al., 1997; Österman and Bertilsson, 2003). When AM and twice-daily parlor milking were compared within the same herd, the average milking frequency under AM rose to almost 2.5 milkings per day. Milk production increased from 2% (Wagner-Storch and Palmer, 2003) up to 7% (Svennersten-Sjaunja et al., 2000) and 8% for multiparous cows (Speroni et al., 2006). Data from the National Dutch data file further supports the expectation of an increase in milk yield after introduction of AM (Kruip et al., 2002). Average daily milk yield was greater for cows milked with AM compared with twice-daily conventional milking (CM), but was not as great as for those herds where thrice-daily CM was practiced.

With AM it is possible to control milking frequency at different stages of lactation. Increased milking frequency during early lactation increased total milk production significantly (Svennersten-Sjaunja and Pettersson, 2005). Data were collected in an AM system with primiparous and multiparous cows. In the analyses, parity groups were divided into 4 groups depending on milking frequency (Table 1). Cows milked more frequently throughout lactation produced greater quantities of milk compared with the other groups irrespective of parity. Noteworthy was that a low milking frequency during early lactation could not be fully compensated by increased frequency after peak lactation. This probably was due to the fact that increased milking frequency during early lactation influences the cellular dynamics within the mammary gland. Increased milking frequency during early lactation increased cell proliferation (Hale et al., 2003), and apoptosis seems to be sensitive to number of milkings per day (Stefanon et al., 2002).

Milking frequency with AM is dependent on several factors, which the herd manager can control. Cow traffic, free or forced, is one significant factor and will be discussed subsequently. Free traffic gives more freedom for the cows to perform synchronized behavior (Hurnik, 1992), and this must be considered in the management routines. Further, it was reported that the milking interval is related to the individual cow (de Koning and Ouweeltjes, 2000), and the effect of milking interval on milk yield is dependent on the level of milk yield (Hogeveen et al., 2001). Thus, the manager must control the length of milking intervals during lactation.

Some commercial farms have reported that the expected increase in milk yield failed to appear after installation of AM. The lack of increase in milk production could partly be due to a reduction in lactation length (Billon and Tournaire, 2002). Irregular intervals between milkings and failure of teat cup attachment could be other reasons for failure of AM to increase milk yield (Bach and Busto, 2005). Long intervals between milking have been reported to decrease mammary blood flow (Delamaire and Guinard-Plament, 2006a), and downregulate the udder’s ability to extract nutrients from the blood (Delamaire and Guinard-Plament, 2006b), 2 factors that greatly influence milk synthesis.

**THE MILKING PROCESS**

In AM systems, the milking process is consistent. In a CM system, the success of the milking process is dependent on the milker. It has been reported that the milker’s behavior affects the cow’s milk production (Seabrook, 1994). It is assumed that stressed cows have disturbed milk ejection from the alveolar compartments and mainly cisternal milk is recovered (for review, see Bruckmaier and Blum, 1998). This negatively affects milk production and lactational persistency. This assumption is strengthened by the observation that the presence of people that handled cows roughly during milking caused a 70% increase in the cows’ residual milk (Rushen et al., 1999). In a working AM system, the animals are treated in the same way at each milking and the routines are predictable for the cows. Consistent milking routines have been reported to significantly increase milk production (Rasmussen et al., 1990).

A successful milking event requires that both cisternal and alveolar milk are obtained. The milk stored in the alveolar compartments is only available if milk ejection occurs (Bruckmaier and Blum, 1998). To completely evoke milk ejection, oxytocin must be released from the pituitary gland and be transported to the udder where it acts on the myoepithelial cells to pro-
showed no differences between the milking systems for milk quality on farms with AM. Therefore, several research projects were initiated to understand and solve the problem with deteriorated consequences for the farmer and for the dairy industry. Such effects have significant negative aspects. In the earliest reports on this topic, issues about the effect of AM on milk quality, such as poor milk fat quality and increased SCC and TBC in the milk, were raised (Klungel et al., 2000; Rasmussen et al., 2002). Such effects have significant negative consequences for the farmer and for the dairy industry. Therefore, several research projects were initiated to understand and solve the problem with deteriorated milk quality on farms with AM.

**MILK QUALITY**

Milk quality includes both compositional and hygienic aspects. In the earliest reports on this topic, issues about the effect of AM on milk quality, such as poor milk fat quality and increased SCC and TBC in the milk, were raised (Klungel et al., 2000; Rasmussen et al., 2002). Such effects have significant negative consequences for the farmer and for the dairy industry. Therefore, several research projects were initiated to understand and solve the problem with deteriorated milk quality on farms with AM.

**Milk Fat Quality**

A comparison of CM and AM in a long-term study showed no differences between the milking systems for gross composition, such as fat and protein contents (Svennersten-Sjaunja et al., 2000). However, in milk collected from farms that had introduced AM, the levels of milk FFA were increased compared with farms using CM (Justesen and Rasmussen, 2000) or when compared with levels of milk FFA before AM was introduced (Klungel et al., 2000; de Koning et al., 2003). Elevated FFA content is undesirable in milk because it causes rancid flavors in dairy products (Tuckey and Stadhouders, 1967) and decreases the ability to convert milk into processed dairy products (Sapru et al., 1997).

It is not yet fully understood why the content of milk FFA increased when cows were milked with AM. Increased levels of milk FFA have been reported as a result of increased milking frequency (Ipema and Schuiling, 1992; Klei et al., 1997) or short milking intervals (AhmÈ and Bjö rk, 1985). The typically greater than twice daily milking frequency or the irregular milking intervals in dairy herds where AM is practiced can partly explain this phenomenon. Moreover, it has been observed that the duration of the milking interval was important because FFA increased after short intervals (i.e., 4 or 6 h) irrespective of the duration of the preceding milking interval (i.e., if the short milking interval was preceded with an 8 or 12 h milking interval; Wiktorsson et al., 2000).

Membrane material covering the fat globules is important for protecting milk fat globule from lipolysis. The activity of various enzymes present in the milk fat globule membrane can indicate whether there is enough membrane material to cover newly formed fat globules and restrict lipolysis. One enzyme present in the milk fat globule membrane is γ-glutamyl transpeptidase (Baumrucker, 1979). The activity of this enzyme has been used as a marker when testing whether lack of membrane material could be the reason for increased milk FFA when cows are milked more frequently. In a recent study, no indications were found that supported the hypothesis that lack of membrane caused elevated FFA when milking more than twice daily (Wiking et al., 2006).

Another reason for the increased FFA content could be the fat globule size (Wiking et al., 2006). Four milkings daily resulted in much higher levels of FFA compared with twice-daily milking. The increase was only

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<tr>
<td>Milk yield of primiparous cows</td>
<td>29.2a</td>
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<td>26.4b</td>
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<td>Milk yield of multiparous cows</td>
<td>33.2a</td>
<td>30.5b</td>
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<td>29.4c</td>
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*a,bMeans within rows bearing different superscripts differed (P < 0.05).

1Data from Svennersten-Sjaunja and Pettersson (2005).

2Milking frequency during wk 1 to 10 or wk 11 to 40: high = 3 milkings daily, low = 2.5 milkings daily.
detected in milk after storage at 4°C for 24 h, indicating a weakness in the fat globule membrane; however, that increased milking frequency resulted in milk fat globules with larger average diameters was noteworthy (Wiking et al., 2006). This observation agrees with others who have reported a tendency toward larger fat globules with shorter milking intervals, although results were not always statistically significant (Svennersten-Sjaunja et al., 2004; Abeni et al., 2005). Larger fat globules have been observed to be more susceptible to lipolysis than smaller ones (Wiking et al., 2003). When the milk was exposed to mechanical stress by pumping, milk with the largest fat globules also had the highest FFA levels (Wiking et al., 2003), indicating that the membrane covering the larger fat globules was less stable.

Increased FFA content in milk is a drawback for AM system; however, Hamann et al. (2004) concluded that the levels of FFA in milk collected after extreme milking intervals were in the same range as for conventional bucket milking systems because milking intervals of <6 h and >12 h resulted in FFA levels of 0.31 and 0.24 mmol/L, respectively, with an average value of 0.28 mmol/L. However, corrections were not made for fat content, which also varied due to milking interval. The FFA content in bulk milk has been studied under better understood. However, it has been proposed that milk

**Milk Somatic Cell Count**

Concern was raised about the AM system regarding udder health and milk SCC when it was observed that bulk SCC increased after introduction of AM (Klungel et al., 2000; Rasmussen et al., 2001, 2002; Kruip et al., 2002). However, it was also shown that AM does not increase the incidence of intramammary infections and SCC or promote deterioration of teat tissue condition when cow health status and herd management are good from the beginning (Zeconi et al., 2003). In a later Danish study where SCC was followed for 1 yr after installation of AM, a slight increase in SCC was observed initially during the 3 first months, but later on no differences were found in the SCC when the year before installation was compared with the year after installation and no increase in clinical mastitis was detected (Bennedsgaard et al., 2006). Therefore, elevated SCC probably was due to factors other than the AM system per se.

It was observed that cows managed in the AM system leak milk between milkings more frequently than cows in a CM system (Persson Waller et al., 2003). Increased milk leakage is related to a higher risk for mastitis. Cow-related factors for increased milk leakage include high peak milk flow and teat canal protrusion (Klaas et al., 2005). Why cows leak milk more frequently between milkings in AM systems is not fully understood. However, it has been proposed that milk
leakage in cows might be due to large amount of cisternal milk creating a high udder pressure followed by milk leakage (Rovai et al., 2007) rather than a result of milk ejection evoked between milkings. Noteworthy is that Persson Waller et al. (2003) observed that 62% of the primiparous and 28% of the multiparous cows were leaking milk at least once during the study. Primiparous cows usually have smaller cisternal compartments compared with older cows (Pfeilsticker et al., 1996).

Technical stoppages of the MU in the AM system have been reported to increase milk SCC. When a stoppage occurs in a CM system, all cows can be milked in a rather short time, while in an AM system, only 1 cow at a time can be milked and some cows can experience extremely long intervals between milkings. After rather long stoppages of up to 4 h, the bulk milk SCC increased from 50,000 to 250,000 cells/mL. If the stoppage was repeated, the bacteria count was increased also (Pettersson et al., 2002). This indicates the importance of service and spare parts being available within a short time to minimize downtime of AM systems.

Data from commercial farms further indicated that SCC in bulk milk was markedly higher in herds where the cows had a high variation in milking interval, a standard deviation >3 h. The importance of arranging for milking intervals to be within 12-h margins was also stressed because data from commercial farms revealed that farms on which most of the cows were milked within 12-h intervals also had a lower SCC bulk (G. Pettersson, unpublished results).

However, it has also been reported that AM does not increase SCC. In a 25-wk-long study in which the milk SCC was compared in CM and AM in animals from the same herd, milk SCC in quarter strip milk were significantly lower in AM cows compared with cows in a CM system (Berglund et al., 2002). This observation was further confirmed by Hamann and Reinecke (2002). In AM, the teats cups are detached from the individual teat as soon as the milk flow reaches the predetermined level for detachment (referred to as quarter milking), thereby reducing the overmilking of teats. Overmilking has negative effects on teat end quality, such as hardness and discoloration (Hillerton et al., 2002). Berglund et al. (2002) also found that AM seemed to be gentler to the teats compared with CM.

An AM system consists of one stationary milking unit that can be provided with different types of sensors for milk quality control, including sensors for detection of mastitis. Measurement of milk yield and milk composition (Linzell and Peaker, 1972) and electrical conductivity (Linzell and Peaker, 1975) also can be used as chemical sensors (Mottram et al., 2007). It can be questioned if electrical conductivity alone could be a sufficient tool for detection of udder health problems because several other factors in milk, such as fat globule size and air bubbles, interfere with the measurements. A detection model for mastitis has been described where both electrical conductivity and milk yield on a quarter level basis is considered in time-series models (de Mol and Ouweltjes, 2001). Possibilities for detection of abnormal milk for separation have been discussed (Rasmussen, 2004). Deviations in some of the milk components, such as lactose, lactate, and N-acetyl-β-D-glucosaminidase have been proposed for detection of udder health disturbances (Hammann et al., 2004). Lactose decreased markedly in udder quarters where SCC increased (Berglund et al., 2007). Lactose is of special interest for detection of udder disturbances because it is a stable milk component with a low relative day-to-day variation and has an osmotic regulatory property. Recently, on-line somatic cell counter for use in AM systems were introduced to the market. The measurement principle has been evaluated. It was shown that repeatability (0.99) and recovery rate (99.3%) were sufficient for identifying the SCC in milk samples (Sarikaya and Bruckmaier, 2006). An index of measurements including milk yield, milk components, and SCC should give the most reliable indication of udder health because short lasting increases of milk SCC can be due to other reasons than bacteria infection like effect of physical stress (Yagi et al., 2004).

**COW TRAFFIC**

Well-functioning cow traffic is a prerequisite for a successful AM system. This includes an optimal number of visits both to the feeding area (number of meals) and to the MU for all cows in the herd when cows are kept indoors, as well as during grazing. Several PhD theses have been published in which different aspects of cow traffic systems, feeding, and milking performance were highlighted (Ketelaar-de Lauwere, 1999; Olofsson, 2000; Harms, 2004; Melin, 2005; Oostra 2005; Wredle, 2005). Cows housed in a free stall barn with voluntary visits to feeding and milking areas develop individual patterns of eating and diurnal activity over time. This presents a great potential for control and decision making in individual management systems (Stefanowska et al., 1999b, Melin et al., 2005).

Free, semiforced, and forced cow traffic systems have been tested in full-scale experiments by Forsberg et al. (2002) and Harms (2004). These authors observed that free traffic resulted in the lowest milking frequency compared with forced or semiforced traffic systems. The free traffic system also had the highest frequency of cows needed to be fetched for milking due to long milking intervals. On the other hand, the number of meals was much higher with free traffic, but the feed consumption was almost the same. It was noteworthy that there were only 4 or fewer meals per cow each day in the forced traffic system. Milk yield did not differ much but tended to be higher during free traffic. Harms (2004) reported that, in all traffic systems, repeated lack of feed at a certain period of the day (e.g., late evening) resulted in a decrease in
number of milkings during the same period. An explanation for why cows in free traffic tended to have higher milk yield might be that more frequent meals result in a more effective utilization of the feed, indicating that when milking frequency is influenced by the cow traffic system, even the feeding management must be considered.

The traffic system influences the behavior of the cows beyond the number of feeding and milking visits. Ketelaar-de Lauwere et al. (1998) found that cows in forced traffic spent more time standing in the feeding area than cows in the free traffic. In the experiments by Forsberg et al. (2002), the effect of increased restrictions in the traffic systems due to use of controlling gates was especially negative for the low-ranked cows because they spent more time in the milking queue compared with high-ranked cows. Queuing in front of the MU increased and resting time in the cubicles decreased when the traffic system changed from free to semiforced and forced. Hermans et al. (2003) found that cows in semiforced traffic spent more time in the feeding area, less time standing in the free-stalls, and visits to the MU were more evenly distributed among these cows than those in the forced traffic system. The placement of the selection gate is also important in the semiforced traffic system. Stefanowska et al. (1999a) concluded that a passage with walk-through selection should be located so cows can pass the selection in a straight line between the lying and the feeding areas.

Studies have shown that AM and traditional grazing can be combined. In CM systems, the herd manager brings the cows in twice daily for milking, whereas in a herd with AM, the cows are presumed to visit the MU voluntarily. It is quite possible to reach a milking frequency of 2 or more milkings daily when AM is combined with grazing (Ketelaar et al., 2000; Spördly and Wredle, 2004). However, it has been reported that the distance to pasture seems to influence the number of visits to the MU (Spördly and Wredle, 2004).

Different methods to optimize milking frequency in AM systems during grazing have been experimentally evaluated. Supplemental feeding of silage indoors did not improve milking frequency or milk yield (Spördly and Wredle, 2004). The availability of the drinking water has also been used to improve the milking frequency in AM systems. However, no effects were seen on milking frequency or milk yield between cows offered drinking water both in the barn and on pasture compared with drinking water only in the barn (Spördly and Wredle, 2005). The use of an acoustic signal to increase the motivation of cows to visit the MU has been tested. The cows were trained using operant conditioning and, from the results, it was concluded that cows could be trained to approach a MU following an acoustic signal (Wredle et al., 2004), though cows on pasture displayed a low response compared with when they were kept indoors (Wredle et al., 2006). Based on the studies performed so far, it can be concluded that grazing can be used with AM as long as the distance from MU to pasture is relatively short.

New cows, mostly heifers, will continuously be introduced into an AM herd. Upon arrival, cows must find their social rank in the herd, and in forced cow traffic systems, become accustomed to controlling gates in different forms and in all cow traffic systems, to the MU. Hamilton (2007) studied the effect of introduction of heifers prior to calving in an AM barn with semiforced cow traffic. In total, 109 heifers were studied, of which 66 heifers had been in the barn for at least 7 d before calving and the others were introduced after calving. During the first 10 wk after calving, the trained group had shorter milking and feeding intervals, which means that they visited the milking unit and feeding area more frequently and the duration of visit was shorter. From wk 11 to 20, there were no differences between the groups in these variables. Probably due to the increase in number of feeding visits and milkings during early lactation, the daily milk yield was 1.5 kg greater in the trained group during the entire study.

**ANIMAL WELFARE**

Questions have been raised as to whether the AM system influences the cows’ well-being. Cows usually perform their activities, such as eating and resting, synchronously. In an AM barn, cows are forced to carry out eating, milking, and resting activity separately and line up in front of the MU to be milked individually. This raises the question of whether the low-ranked cows adapt to a situation where they must compete in the queuing order with the other high-ranked cows.

Hagen et al. (2005) observed that the cows kept in an AM system displayed an increased chronic stress, measured as heart rate variability, compared with cows kept in a loose housing system. Elevated levels of cortisol can be used to indicate stress in animals. However, stress, as determined heart rate measurements, was not observed during milking (Hagen et al., 2005), which agrees with Gygax et al. (2006) who could not find any differences in milk cortisol between cows milked in an AM vs. a CM system. Hopster et al. (2002) also did not find any significant differences in behavioral or physiological responses of cows during milking in an AM vs. a CM system.

Weiss et al. (2004) evaluated the effect of the conversion from conventional parlor milking to AM on physiological responses of cows. Most cows adapted to the new system within days, but there was wide individual variation among cows. During the first visit to the MU in an AM system, the heart rate was noticeably greater than during parlor milking but during the second visit to the MU, the heart rate was similar to that during milking in the CM parlor. The cows’ adaptability to AM seemed to be related to the individual sensitivity of their adrenal cortex to ACTH. In AM systems, there
is a risk for failure of milking, such as missed attachment of the milking cluster. How failed milking influences cow behavior was experimentally tested by Stefanowska et al., 2000. They found that a missed milking negatively influenced cow behavior, such as less time spent lying and more frequent urinating (Stefanowska et al., 2000).

**PROS AND CONS**

It first must be concluded that AM is not only a new milking system, but rather a completely new management system. The most important components of the system are the cows, the management routines, and to some extent, the MU. The success of AM requires active cows that frequently and regularly visit the feeding area and the milking station. When this is achieved, cows can be milked more frequently without extra labor costs and with consistent milking routines. With increased milking frequency, milk production is enhanced and, in well managed systems, udder health can improve. Poor management routines, technical problems in the MU, or other factors inhibiting the motivation of the cows will all work in the opposite direction and limit the success of AM. The AM is a process running 24 h/d. Those operators who recognize the interactions among variables within the system can see the pros of AM, whereas those who only see AM as a different way of milking may only see the cons.

A key factor in AM is well-functioning cow traffic for all cows, which can be achieved when feed is always available. This demands investment in feeding equipment, such as automatic feed wagons or feeding troughs. Lack of feed during parts of the day will increase the synchronized behavior among cows, resulting in queuing problems in front of the MU, lower milking frequency, increased variations in milking intervals, and increased labor costs for fetching cows for milking.

Relative to CM management, the milking process in AM is consistent and the milking routines are predictable for the cows, which is a prerequisite for successful milking. Crucial parts of the milking process are teat localization and teat cup attachment. These processes can be disturbed by a malfunctioning robotic arm, misplaced teats or abnormal udder shape, dirty teats, or a restless cow leading to an incomplete milking of one or more quarters. A high frequency of milkings that end abnormally may increase udder health problems and reduce milk quality.

Increased FFA content in milk from AM has been reported in several studies, as discussed previously. Although the increase compared with CM is relatively small, it is a potential problem because the increased FFA content appears in stored milk. The final solution to the problem remains to be found.

In AM, many cows are milked in the same milking stall provided with 1 milking unit. In this stall, technical equipment, including sensors, can be installed to give unique opportunities for management decisions and production and health control of the individual cow.

Maintenance requirements for AM systems are higher compared with CM systems because of the level of technology is higher and relies on a more skilled operator for daily maintenance. A highly skilled technician must also be available on short notice (within a few hours) and with a ready supply of spare parts to avoid extended periods of inactivity in the AM unit. Even the herd manager must be able to visit the AM barn any time of the day to fix stoppages in the MU and alarms from the AM.

From the literature, it can be concluded that successful AM depends on farm conditions and the knowledge and management skills of the herd manager. Finally, humans can never be replaced with technical equipment; herd managers must supervise and manage the system.

**LITERATURE CITED**


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