Feeding Cows in a Robotic Milking System

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Summary

There has been a rapid growth on the number of farms using robotic milking systems (**RMS**) in the USA. This growth is expected to continue. It is more challenging to feed cows in RMS as the complexity of balancing the ration that is offered in the feed bunk (a partially mixed ration, PMR) and the pelleted feed offered in the milking station can be a difficult task. Additional challenges exist for pasture-based systems as it is necessary to entice cows from pasture to the milking station barn. Important factors affecting feeding success in RMS include feeding a high quality pellet and achieving excellent feeding management. Research shows that pellets are better than meal and that a very hard pellet made from highly palatable ingredients will minimize fetch cows. It is important to balance energy in the PMR with pellets fed through the milking station to optimize visits and minimize the number of fetch cows. A focus should be on optimizing milking station visits and health of early lactation cows and heifers. It is also important to have adequate cow comfort and good hoof health.

Introduction

Dairy producers choose to install RMS for a variety of reasons, but surveys have shown that one of most common reasons relates to labor (flexibility maybe more than labor cost) and lifestyle or quality of life. de Jong et al. (2003) conducted a survey of North American dairy producers who had implemented RMS. They reported that for many smaller farms, using RMS improved flexibility of their schedule and reduced the physical intensity of labor, which was primarily provided by the family owning the farm. In fact, 84% of the producers surveyed mentioned having a more flexible work schedule as a reason for making the decision to install RMS. However, producers did not report a reduction in hours of work on the farm, but they did have a reduction in physical labor, and decreased cost of hired labor was reported by 70% of farms. We found similar results in our survey of RMS dairy farms in Minnesota and Wisconsin. For larger farms, RMS may be a means to reduce hired labor and to provide an improved quality of life to the employees they hire. There are signs that larger farms will adopt RMS, as some have done so already. Notable recent announcements from TDI Farms in Michigan to install 24 DeLaval (Tumba, Sweden) VMS units to milk 1,500 cows; and Chilean Dairy, Fundo El Risquillo, planning to milk 4,500 cows with 64 DeLaval VMS units (http://www.delaval.com). Other examples include Hemdale Farms in New York with 19 Lely (Maassluis, Netherlands) RMS and Corner's Pride in British Columbia with 30 Lely RMS (to be installed by June 2017; http://www.Lely.com).

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It appears that growth in RMS in the USA is a given fact, and one of the most important factors for success in these systems is how cows are fed. When we feed dairy cows, we aim to develop a low cost diet that meets the nutritional requirements of cows while optimizing milk production and cow health. In most conventional confinement herds, this is accomplished by feeding a totally mixed ration (**TMR**) where all the ingredients are mixed together and delivered to the cows. For RMS herds, a PMR containing all the forage and some of the concentrate is offered in the feed bunk. An additional amount of concentrate is fed through the RMS milking station; this amount varies according to the cow's stage of lactation. This appears on the surface to be a simple concept, but achieving the optimal combination of nutrients from the PMR and the concentrate pellet is not necessarily an easy task and it takes some trial and error in some instances.

Enticing Cows to the RMS Milking Station is a Key for Success

The major motivating factor to attract cows to consistently visit the RMS milking station is the pelleted concentrate that is offered in the RMS milking station, not the fact that cows 'feel' they need to be milked at that time. However, cow's attendance to the milking station is not only dependent on the PMR delivered in the feed bunk and pellets offered in the RMS, but also on feeding management, cow comfort, cow health, and social interactions among cows. In a survey we conducted with RMS herds, nutritionists indicated that quality of the pellet offered in the milking station and consistency of the PMR were the 2 most important feeding factors contributing to RMS success.

Rodenburg and Wheeler (2002) showed that in a free flow RMS, feeding a high quality pellet (hard pellet with few fines made from palatable ingredients) increased the number of voluntary milkings from 1.7 to 2.1/cow per day compared with feeding a low quality pellet. We observed that at start-up of a new RMS, nutritionists and farmers focused on developing a pellet formula that encouraged milking station visits. Once they had a pellet that worked well, other factors became more important. Many producers commented that even minor changes in the PMR moisture, consistency of the mix (i.e., long hay that is difficult to process to a consistent length), and changes in forage quality affected visits. Visits may drop if forage moisture changes and rations are not adjusted promptly. The drop in visits will result in a decrease in milk production and an increase in the number of fetch cows. The increase in fetch cows may disrupt other cow behaviors, resulting in even greater decreases in visits and milk production, leading to a downward spiral that creates much frustration for the producer. It is crucial to have consistent feeding in order to maintain high production and minimize the number of fetch cows.

Differences Between Free Flow and Guided Flow RMS Barns

In barns with free flow traffic, cows can access all areas of the barn without restriction. In guided flow traffic, one-way gates and selection gates are used to guide cows to milking, feeding, and resting areas. Free flow traffic was associated with greater milk yield per cow per day (Tremblay et al., 2016) compared to guided flow; their study included only Lely RMS farms. Guided flow was associated with increased number of milkings per day and reduced number of cows being overdue for milking and needing to be fetched (Bach et al., 2009). Cows managed in a guided flow system consumed less meals per day but larger meals with longer meal duration when they visited the feed bunk, resulting in no difference in total eating time, eating rate, or average daily DM intake (Bach et al., 2009).

There are two types of guided flow traffic - milk first and feed first. In the milk first system, cows leaving the resting area must pass through a pre-selection gate that determines if she is eligible for milking. If she meets the requirement to be milked, she is guided to a commitment pen that contains the RMS milking station. If she is not eligible for milking, she is allowed to enter the feed bunk area and can only enter the resting area through a one-way gate. In the feed first system, cow traffic is the reversal of the milk first system. After eating the PMR, cows enter a selection gate that determines if she is eligible for milking. The gate either guides her to the commitment pen for milking or to the resting area. Farmer comments and our observations indicate that the milk first system is superior with the US style of dairying where economics demand high milk production. In feed first systems, cows consume the PMR and tend to stand in the feed alley or commitment pen ruminating without visiting the RMS milking station.

Independent of type of flow used in the RMS, efficient cow flow through the RMS milking station is an important factor influencing the availability of the RMS for milking. This can be inhibited by cows hesitating to leave the RMS milking station, cows remaining in the exit lane, and cows blocking the exit lane outlet. Jacobs and Siegford (2012) reported that cows exited the milking station slower when they were not milked (sufficient time from the previous milking had not lapsed) compared to cows who were successfully milked. Cows were more hesitant in the exit lane if another cow was blocking her exit from the lane on the other side of the exit lane one-way gates, or if other cows were in the area at the exit of the milking station. Later lactation and mid lactation cows were also more likely to hesitate in the exit lane than cows in early lactation. Interestingly, heifers were more often the cause of blocking events than mature cows. Additionally, lighter heifers were more often the cause of blocking events than heavier heifers.

Free flow system feeding strategies

Our survey indicated that the amount of pellets offered through the milking station in free flow system farms averaged 11 lb/cow per day and ranged from 2 to 25 lb/cow per day. The PMR was balanced for milk production levels of 10 to 30 lb less than the herd's bulk tank average milk production.

Lead feeding is generally used in early lactation. To 14 to 28 days in milk, cows are fed for 75 to 90 lb/day of milk. From 14 to 28 days in milk through peak lactation, cows continue to be fed nutrients that support 75 to 90 lb/day of milk or for actual milk production, whichever is higher. After this time, the feed delivery changes to feed cows for actual milk production and regaining body condition. Some farms with very high producing late lactation cows close to dry-off develop a feed table for late lactation cows that decreases RMS station feed so cows drop in production before dry off. One challenge of free flow systems is that late lactation cows can become fetch cows. A key to preventing this is to have an excellent reproductive program that maintains high milk production through the end of lactation.

Guided flow system feeding strategies

Feed first and milk first guided flow RMS use different feeding strategies. Feed first systems use a feeding strategy that is very similar to free flow milking systems and will not be discussed further.

Our survey indicated that most milk first guided flow system dairy producers have a different feeding philosophy than free flow. The

amount of feed offered in the milking station is minimal and only used to entice cows to attend the milking station. A higher percentage of the cow's feed intake is delivered through the PMR. One main reason farmers install guided flow RMS is the desire to feed less of the more expensive pelleted feed in the milking station. Farmers with milk first guided flow systems were feeding from 2 to 12 lb of pellets/cow per day. The average amount fed across all herds was approximately 8 lb/cow per day. Commonly, 1.5 to 3 lb of pellets was fed at every milking visit. Because earlier lactation, higher producing cows are guided to the milking station more frequently, they receive more RMS pelleted concentrate.

The PMR in guided flow systems tended to be slightly higher in energy (0.015 Mcal net energy for lactation/lb DM) and lower in neutral detergent fiber (2.1% of DM) than the PMR in free flow systems. For guided flow herds, the PMR was balanced for 9 to 20 lb less milk production than the average of the herd. This difference should be expected between free flow and guided flow systems. Using a high energy density PMR in free flow barns may lead to more fetch cows or decreased milking frequency, resulting in less milk production per cow, whereas in guided flow barns, cows are guided to the milking station using selection gates.

Other Feeding Considerations

PMR composition and physical characteristics

Table 1 summarizes key PMR nutrient concentrations from our Minnesota/Wisconsin survey and a 2013 Ontario survey (T. Wright, Ontario Ministry of Agriculture, personal communication). Wright also evaluated the PMR particle size using the Penn State Particle Separator and reported a higher percentage of particles on the top screen and a lower percentage on the bottom screen than recommended in a TMR (average 13.1% on the top sieve). This is expected considering some of the concentrate is fed in the milking station separate from the PMR.

Pellet composition and physical characteristics

Pellets that are made from high quality, palatable ingredients and with a very hard sheer force promote increased visits and more rapid feed consumption. Nutritionists need to pay special attention to manufacturing processes to produce a consistent pellet with a high sheer force. Milking station pellets should be designed to complement the farms' forages and other ingredients in the PMR. For example, if the PMR is high in corn silage and thus high in starch, a pellet with highly digestible NDF from by-products should be considered to minimize the risk of sub-acute ruminal acidosis.

Using pelleted feed of different ingredient inclusion rates could be beneficial to more precisely feed individual cows. Halachmi et al. (2006) found that both pellets high in starch (high inclusion of ground barley, corn, sorghum, and wheat bran) and pellets high in digestible neutral detergent fiber (high inclusion of soy hulls, corn gluten feed, and soybean meal) could be used successfully to attract cows to the RMS. The 2 pellets resulted in similar daily milk visits, milk yield, and fat-corrected milk yield. However, concentrate allowance was kept low. Miron et al. (2004) reported a difference in milk components with a higher concentrate allowance - concentrates high in starch resulted in greater milk protein percentage; whereas, concentrates high in digestible fiber resulted in greater milk fat percentage. However, results of these studies may indicate that palatability can be maintained even when significant changes

are made to the ingredient composition of the pelleted concentrate.

Precision Feeding

One potential advantage of RMS is the opportunity to feed each cow closer to her nutrient requirements by providing nutrients through a combination of the PMR and milking station pellet. Even though RMS allow for feeding more than one concentrate feed in the milking station, many producers in our survey only used one feed. Some producers are more recently using more than one feed to better target cows' nutrient requirements. Feeding a combination of concentrates in the milking station at different proportions and amounts according to milk yield, body weight, stage of lactation, and potentially milk components may maximize returns from RMS (Bach and Cabrera, 2017). These authors suggested that concentrate meal sizes should be limited to about 3 lb or less per visit so that cows consume all the feed that is allocated to them at each visit (Bach and Cabrera, 2017).

Fresh Cow Management

Most RMS facilities do not have a separate fresh/early lactation group. Suggestions to consider that may increase the likelihood that all cows have a successful transition and high milk production include:

1. Use of multiple feeds through the milking station which allows the producer to use feed additives specifically targeted to fresh cows. As mentioned earlier, this will allow more precise targeting of nutrients to meet the cow's needs.

2. Special observation and monitoring of fresh cows. Fresh cows that are not feeling well may continue to consume all the milking station pellet but decrease intake of the PMR. This can potentially lead to sub-acute rumen acidosis, digestive upsets, and increase the risk for other diseases.

3. Rumination and activity on all fresh cows should be observed daily. The RMS software (depending on the system) creates a daily list of cows that are not meeting rumination and activity goals compared to herd mates. If these metrics are deteriorating, producers need to intervene rapidly and consider making adjustments to the milking station feed offered.

4. It is important to have a high quality PMR to encourage intake at the feed bunk.

5. Frequent fetching of fresh cows should be a priority. Research has shown that high milking frequency in early lactation increases milk production throughout lactation.

Feeding Consistency

Cows like consistency. This is even more important in a RMS herd. Farmers that achieve consistently high milk production achieve these goals:

1. Consistent PMR (PMR is adjusted to maintain nutrient concentration as forage DM changes) that is well balanced and composed of high quality ingredients.

2. Consistent mixing and delivery of the PMR.

3. Consistent feed push ups.

4. Consistent, high quality RMS milking station pellet.

Considerations for RMS in Grazing Herds

When RMS is used in grazing herds, there is an additional challenge of enticing cows to leave the pasture and voluntarily attend the RMS milking station. In pasture-based systems, there appears to be a relatively large percentage of cows with long milking intervals (defined as greater than 16 hours). Lyons et al. (2013) found 47 and 38% of milking intervals exceeded the 16-hour threshold in groups of cows fed a PMR and concentrate pre and post milking, respectively. Cows fed pre milking returned from pasture to the milking barn sooner (11.9 hours) than cows fed post milking (13.3 hours); however, the cows fed pre milking spent more time in the feeding and waiting areas before entering the RMS platform (voluntary rotary RMS), resulting in a decreased average milking frequency compared to those fed post milking (1.6 vs. 1.7 milkings per day for groups fed pre and post milking, respectively). It is important to note that while there were differences in cow behavior, no differences were found in daily milk yield between the 2 feeding management systems. Davis et al. (2005) also reported a low milking frequency per cow in a pasture-based system with an average of 1.1 milkings per day (range of 0.9 to 1.9).

Conclusions

Feeding cows in RMS requires adjustments on ration formulation to address the need to entice cows to the milking station. Many factors affect attendance to the RMS and influence milk production. Along with balancing the PMR and concentrate pellet for the targeted milk production goal of the farm, factors related to feeding management, cow comfort, and transition cow programs also play a major role. The use of multiple feeds at the milking station (both amount and composition) to more closely match the nutrient needs of individual cows is an area that has not yet been extensively implemented in US herds and could be beneficial to the success of RMS.

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Table 1. Range of select partially mixed ration nutrient values on two surveys of RMS farms.

Item	Univ. of MN Survey	Ontario Survey[1]
Net energy for lactation, Mcal/lb	0.60 to 0.78	0.63 to 0.81
Neutral detergent fiber, % of DM	28 to 40	30 to 50
Crude protein, % of DM	12.0 to 17.7	13 to 18

[1]Tom Wright, Ontario Ministry of Agriculture, personal communication.