Optimizing Feed Intake: Access and Consumption

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INTRODUCTION

Dairy producers are continually challenged with ensuring adequate, consistent, and balanced nutrient intake in their cows to ensure good health, productivity, and efficiency of production. Total mixed ration (**TMR**) feeding systems are widely recognized as the optimal way to maximize intake and provide the consistent balance of nutrients that dairy cattle need. In theory, TMR are formulated so that producers are confident they are providing their dairy cattle a well-balanced diet. Unfortunately, the full potential of the formulated TMR is not always reached on every farm. We need to consider the TMR that is delivered to the cows, consumed by the cows, and digested by the cows.

This paper will describe the importance of ensuring cows have access to the right ration and consume that ration as it is delivered and in a manner that is good for them. Further, methods to use that knowledge to evaluate nutritional management and housing strategies will be described. It is anticipated that this knowledge may be used to allow cows to fully optimize the potential of the ration provided; thereby improving their health, production, and welfare.

ACCESS TO THE RIGHT RATION

Despite best efforts, the delivered ration on many farms does not accurately match that which was formulated for the cows. In recent research (Sova et al., 2014) we have observed that as the variability between these *rations* and the original formulated ration becomes greater, so does the chance that cows will not perform to expectation. While most of us have always suspected that cows do not always receive the ration exactly as it is formulated for them, this research is some of the first to support this idea and identify the potential consequences of such deviations.

For our study we sampled the mixed and delivered TMR on 22 free-stall, parlor-milked herds for seven consecutive days in the winter and summer months. The nutrient analysis on these feed samples was then compared to that formulated *on paper* for those farms. Across farms, the average TMR fed did not accurately represent that formulated by the nutritionist. The average TMR delivered exceeded TMR formulation for NE_L, NFC, ADF, Ca, P, Mg, and K and underfed CP, NDF, and Na. Theoretically, underfeeding might not be problematic as a safety margin is generally included in formulation to account for uncertainty in ingredient composition. Across farms, however, there was a huge range in this variation, with some farms consistently experiencing a 5 - 10 % discrepancy (both positive and negative) between the fed and formulated ration for nearly all nutrients.

We also investigated the day-to-day consistency in physical and chemical composition of TMR and associations of this variability with measures of productivity. Greatest day-to-day variability was observed for refusal rate, particle size distribution, and trace mineral content. Of interest was the finding that delivery of a more consistent

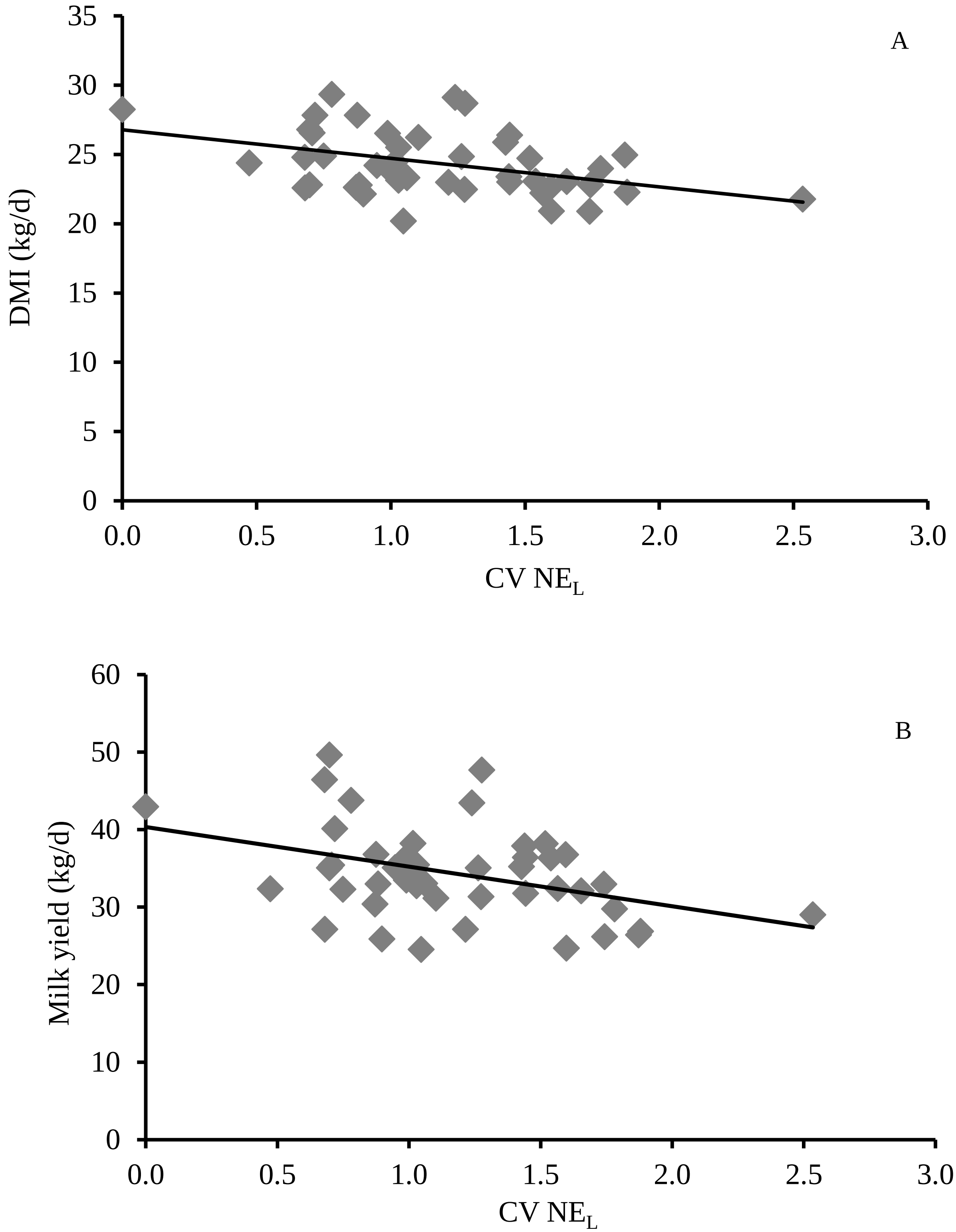

Figure 1. Association between fed ration coefficient of variation (CV) in NE_L and average: a) DMI and b) test-day milk yield. Coefficient of variation was calculated as the standard deviation of NE_L over 7 d divided by the average NE_L over 7 d. Figures adapted from Sova et al., 2014.

ration was associated with improved production. For example, greater dry matter intake (**DMI**; Figure 1a), milk yield (Figure 1b), and efficiency of milk production were all associated with less daily variability in energy content of the ration. Lower daily variability in percentage of long forage particles in the offered TMR was associated with greater milk yield and efficiency of milk production. It is interesting to note that, on average, day-to-day variability was greater for physical characteristics (i.e. particle size distribution) of the ration compared to nutritional composition. Even though this study was not designed to identify the factors that contribute to this variability, this would suggest that this day-to-day variation may have been caused by variability in feed component nutrient and dry matter composition; but probably even more so, by mixing errors associated with operators (timing, sequencing) or equipment. Regardless, these findings suggest that increased surveillance of the TMR composition, in addition to individual feed ingredients, may be helpful as a regular component of feeding management to ensure delivery of TMR with the intended nutrient composition to maintain production and feed intake. Further, this data reinforces the need for standard feeding protocols and training to achieve those protocols, as well as provides support for the use of TMR management programs.

Say we get the TMR right and deliver it as formulated on a consistent basis, it does not mean cows will eat that ration as distributed to them or in a manner that is good for them. The rest of this paper will review scientific evidence for the importance of knowledge of feeding behavior and how we can use that knowledge to improve feed access and consumption patterns.

CONSUMING THE RIGHT RATION IN A GOOD MANNER

Since changes in DMI must ultimately be mediated by changes in feeding behavior (Nielsen, 1999), it is important to understand the factors that influence cow feeding behavior patterns. To date, the majority of research on dairy nutrition has largely ignored how the diet is consumed. Formulating diets has traditionally required little knowledge about how the diet is consumed; it was enough to simply estimate daily DMI without considering what feed was actually consumed, and in what manner.

Total mixed rations are designed as a homogenous mixture with the goal to help minimize the selective consumption of individual feed components by dairy cattle, promote a steady-state condition conducive to continuous rumen function and ingesta flow, and ensure adequate intakes of fiber (Coppock et al., 1981). It is not surprising, therefore, that providing feed as a TMR is standard on most commercial dairies, particularly for the lactating animals. Unfortunately, even when providing feed as a TMR, dairy cattle have been shown to preferentially select (sort) for the grain component of a TMR and discriminate against the longer forage components (Leonardi and Armentano, 2003; DeVries et al., 2007). The sorting of TMR by dairy cows can result in the ration actually consumed by cows being greater in fermentable carbohydrates than intended and lesser in effective fiber; thereby increasing the risk of depressed rumen pH (DeVries et al., 2008). Likely related to this, in two recent studies it has been observed that such sorting of a TMR is associated with producing milk with lower fat percentage (milk fat decreased by 0.15 % for every

10 % refusal of long forage particles in the ration; DeVries et al., 2011; Fish and DeVries, 2012).

Imbalanced nutrient intake and altered rumen fermentation, as result of sorting, has the potential to impact the efficiency of digestion and production. In support of this, Sova et al. (2013) recently found that efficiency of milk production decreased by 3 % for every 1 % of group-level selective over-consumption (sorting) of fine ration particles. Sorting of a TMR can also reduce the nutritive value of the TMR remaining in the feed bunk, particularly in the later hours past the time of feed delivery (DeVries et al., 2005; Hosseinkhani et al., 2008). For group-fed cattle, this may be detrimental for those animals that do not have access to feed at the time when it is delivered, for example when there is high competition at the feed bunk. In such cases, these cattle may not be able to maintain adequate nutrient intake to maintain high levels of production and growth (Krause and Oetzel, 2006). Again, there is evidence to suggest that this sorting behavior may impact production at a herd-level; Sova et al. (2013) showed that every two percentage point increase in selective refusal (i.e., sorting against) of long ration particles on a group level was associated with a per cow reduction of 0.9 kg/d of 4 % fat-corrected milk.

It is not only important to consider what dairy cows actually consume from their provided ration, but the manner in which it is consumed. Under natural grazing conditions dairy cattle will engage in foraging behavior anywhere from 4 to 9 h/d (Hafez and Bouissou, 1975). This feeding time would be split into a number of smaller meals occurring throughout the day, with the largest meals occurring in the early morning and late afternoon. Modern, intensively-housed dairy cattle fed a conserved ration typically consume their daily dry matter intake in up to 6 h/d, spread between 7 or more meals per day (DeVries et al., 2003). Management practices that cause adult dairy cattle to eat fewer and larger meals more quickly have been associated with an increased incidence of sub-acute ruminal acidosis (Krause and Oetzel, 2006). The reason for this risk is that ruminal pH declines following meals, and the rate of pH decline increases as meal size increases and as dietary effective fiber concentration decreases (Allen, 1997). Further, as cows spend less overall time feeding, and increase their rate of feed consumption, daily salivary secretion is reduced (Beauchemin et al., 2008), decreasing the buffering capacity of the rumen and reducing rumen pH. Alternatively, when cows slow down their rate of dry matter consumption, and have more frequent, smaller meals throughout the day, rumen buffering is maximized, large within-day depressions in pH are avoided, and the risk of sub-acute ruminal acidosis is decreased. Thus, to maximize rumen health, efficiency and productivity, it is important to utilize feeding management strategies that promote the frequent consumption of feed in small meals throughout the day.

It is clear that, in addition to properly formulating dairy rations, we need to also consider how the ration is consumed to ensure that the potential of that ration is optimized. There is an increasingly growing body of literature in which the knowledge of feeding behavior can be used to identify nutritional management and housing strategies to maximize ration potential; including ensuring cows have access to fresh feed throughout the day and minimizing feed bunk competition.

IMPROVING ACCESS AND CONSUMPTION

Feed Delivery

It has typically been accepted that dairy cattle exhibit a diurnal feeding pattern where the majority of feeding activity occurs during the day, particularly around sunrise and sunset. However, this observation is almost exclusively based on the feeding patterns exhibited by grazing cattle. DeVries et al. (2003) demonstrated that the diurnal feeding patterns of free-stall housed dairy cows was mostly influenced by the time of feed delivery, feed push-up, and milking. Further, these researchers noted that the most dramatic peaks in feeding activity occur around the time of feed delivery and the return from the milking parlor. In a follow-up experiment, DeVries and von Keyserlingk (2005) separated feed delivery and milking times by 6 h. When animals were fed 6 h post-milking, cows shifted their feeding pattern such that the greatest bunk activity was noted after the feed delivery and not after milking. These results indicate that for group-housed, TMR-fed dairy cattle, feed delivery acts as the primary influence on their daily feeding activity patterns. These patterns are not influenced to the same degree by feed push-up, milking activity, or as seen in grazing cattle, the time of day. As a result, even though dairy cattle may still spread their meals throughout the day, the largest ones will occur right after the delivery of fresh feed.

The delivery of fresh feed is clearly an important factor in stimulating cows to eat. Thus, increased frequency of feed delivery can greatly influence feeding behavior patterns, and thus also affect cow health and productivity. When cows are offered feed only once daily, there are significant peaks in feeding activity in the immediate time period following feed delivery compared to 2X/d feeding (DeVries et al., 2005). This behavioral response elicited by the delivery of fresh feed provided 1X daily could result in slug feeding and predispose cows to sub-acute ruminal acidosis (DeVries et al., 2005) due to large diurnal fluctuations in ruminal pH (Shabi et al., 1999). Inversely, cows fed more frequently (4X and 5X daily) tend to consume feed more evenly after each feed delivery, increasing their feeding time throughout the day (DeVries et al., 2005; Mantysaari et al., 2006). In addition, DeVries et al. (2005) found that subordinate cows were not displaced as frequently when fed more often, indicating that these cows would have greater access to feed, particularly fresh feed, when the frequency of feed delivery is high. Further, providing feed 2X/d or more often has also been demonstrated to reduce the amount of feed sorting as compared to feeding 1X/d (DeVries et al., 2005; Endres and Espejo, 2010; Sova et al., 2013), which would further contribute to more consistent nutrient intakes over the course of the day.

Such desirable feeding patterns are conducive to more consistent rumen pH (French and Kennelly, 1990), which likely contributes to improved milk fat (Rottman et al., 2011); fiber digestibility (Dhiman et al., 2002); and possibly production efficiency (Mantysaari et al., 2006) observed when cows are fed more frequently than 1X/d. Delivering TMR more frequently does also have the potential to impact DMI and milk yield. Hart et al. (2014) recently demonstrated that under 3X/d milking schedules, DMI was greatest in cows fed 3X/d (27.8 kg/d) compared to when fed 2X/d (27.0 kg/d) or 1X/d (27.4 kg/d). This increase in DMI came as a result of increased DMI following the return from milking and the delivery of feed (Figure 2). Interestingly, in a recent field study of free-stall herds in Eastern Ontario, feed delivery of 2X/d compared to 1X/d was demonstrated to be associated with less feed sorting, greater DMI (+1.4 kg/d), and greater milk yield (+2.0 kg/d; Sova et al., 2013).

When fed a TMR, dairy cows have a natural tendency to continually sort through the feed and toss it forward where it is no longer within reach. This is particularly problematic when feed is delivered via a feed alley and, thus, producers commonly push the feed closer to the cows in between feedings to ensure that cows have continuous feed access. Research suggests that feed push-up does not have the same stimulatory impact on feeding activity as does fresh feed delivery (DeVries et al., 2003); nonetheless, push-up does play a vital role in ensuring that feed is accessible when cows want to eat.

Competition for Access

Potential undesirable impacts of nutritional management on the behavior of dairy cows can be intensified under situations where cows do not have good access to their feed (i.e. as a result of higher stocking densities at the feed bunk). When feed bunk competition is high (for example when feed bunk space is limited), increases in aggressive behavior limit the ability of some cows to access feed at times when feeding motivation is high, particularly after the delivery of fresh feed (DeVries et al., 2004; Huzzey et al., 2006). As a result, increased feed bunk competition will increase feeding rate at which cows feed throughout the day, resulting in cows having fewer meals per day, which tend to be larger and longer (Hosseinkhani et al., 2008). Feed bunk competition may also force some cows to shift their intake patterns, such that they will consume more feed later in the day during the later hours after feed delivery after much of the feed sorting has already occurred. These effects of feed bunk competition on feeding behavior patterns, and the potential to reduce DMI, may be greatest for transition dairy cows (Proudfoot et al., 2009).

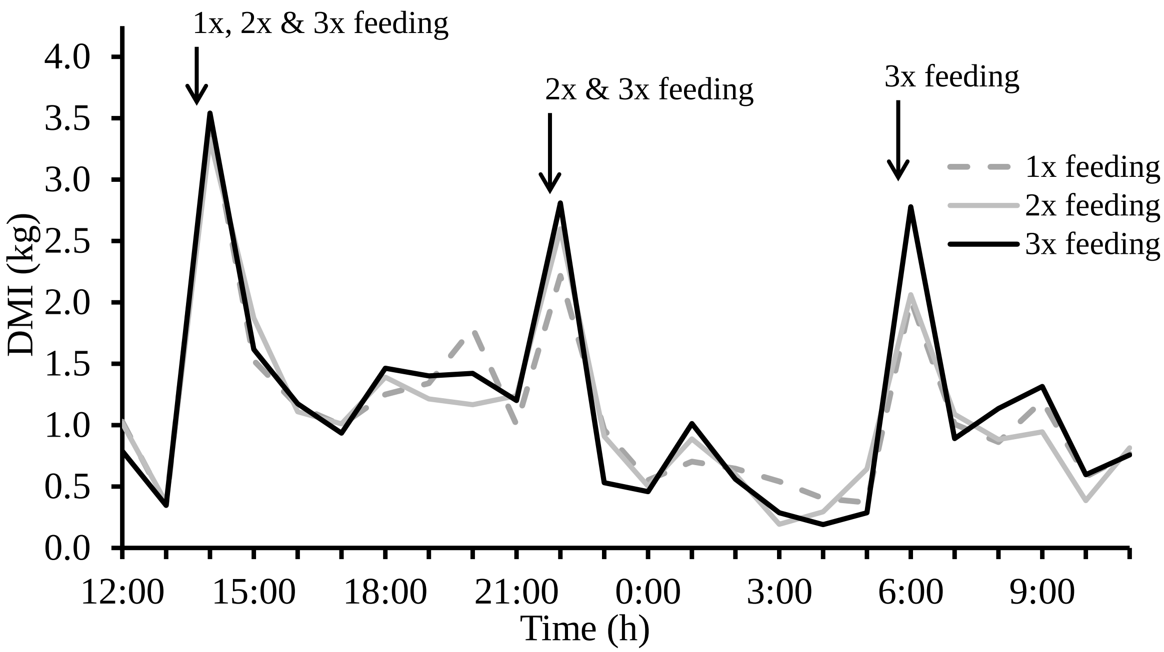

Figure 2. Hourly average DMI (kg) of lactating dairy cows having received feed delivery 1) 1X/d (at 1400 h), 2) 2X/d (at 1400 and 2200 h), or 3) 3X/d (at 1400, 2200, and 0600 h). Adapted from Hart et al., 2014.

Reducing feed bunk competition, by providing adequate feed bunk space (to allow animals to eat simultaneously), particularly when combined with a physical partition (e.g. headlocks or feed stalls), will improve access to feed, particularly for subordinate dairy cattle (Endres et al., 2005; DeVries and von Keyserlingk, 2006; Huzzey et al., 2006). This, in turn, will contribute to more consistent DMI patterns, both within and between animals, as well as promote healthy feeding behavior patterns. It is, thus, not surprising that Sova et al. (2013), found in a cross-sectional study of parlor-milked, free-stall herds that every 10 cm/cow increase in feed bunk space (mean: 54 cm/cow; range: 36 to 99 cm/cow) was associated with 0.06 percentage point increase in group average milk fat and a 13 % decrease in group-average somatic cell count. With greater bunk space, cows are able to consume their feed in a manner much more conducive to stable rumen fermentation, and thus greater milk fat production. Further, with more bunk space cows would not be forced to choose to lie down too quickly after milking rather than compete for a feeding spot, and thus reduce their risk of intramammary infection.

In addition to access to feed, some consideration must also be given to another, typically forgotten, nutrient: water. Water is perhaps the most necessary nutrient (NRC, 2001), yet its quality and availability is often overlooked. Interestingly, in a recent field study of free-stall herds in Eastern Ontario, Sova et al. (2013) found that milk yield tended to increase by 0.77 kg/d for every 2 cm/cow increase in water trough space available on the study herds (mean: 7.2 cm/cow; range: 3.8 to 11.7 cm/cow). This result illustrates the importance of water availability for group housed cows and provides further evidence that resource availability has the potential to greatly impact productivity.

CONCLUSIONS

This paper summarizes a number of studies that have been undertaken that collectively provide us with a basic understanding of how optimizing feed intake involves ensuring cows have consistent access to the feed which is formulated for them, and consume that feed as delivered and in a healthy manner. This firstly involves ensuring rations are delivered accurately and precisely, through regular monitoring of feed components and mixing protocols. Once we are confident that cows are receiving the proper ration, strategies may then be implemented that allow cattle to have good access to that feed and consume it in a manner which is conducive to good health, productivity, efficiency, and welfare. Examples of this include frequent delivery of feed close to the time of milking, frequent feed push-up, and ensuring cows have sufficient space at the feed bunk and water trough.

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