Feeding Behavior, Feed Selection and Risk of Digestive Problems in Dairy Cattle

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Introduction

In dairy cattle, the rumen environment is designed to function optimally within a pH range of 6.2 to 7.2. To maintain healthy rumen function, dairy cows require diets that contain adequate amounts of physically effective neutral detergent fiber (peNDF). Ensuring adequate intake of peNDF can, however, be difficult because most commercial dairy rations, designed to maximize milk production, contain high levels of concentrate and high quality forages that are often limiting in peNDF (Beauchemin and Yang, 2005). When ruminants consume excessive amounts of rapidly fermentable (non-fiber) carbohydrates, combined with low intake of peNDF, cows are not able to maximize their rumination time and salivary buffer flow to the rumen, and thus ruminal pH drops below normal physiological levels. Sub-optimal ruminal pH (e.g., pH 5.2 to 5.8) is often referred to as sub-acute ruminal acidosis (SARA) (Owens et al., 1998).

Sub-acute ruminal acidosis is a major concern in terms of both productivity and animal welfare. Rumen pH < 5.8 is harmful to ruminal cellulolytic bacteria (Russell and Wilson, 1996) and, thus, SARA is detrimental to fiber digestibility. As result, dairy cattle with SARA are less productive because of poor feed efficiency, reduced feed digestibility and protein synthesis, reduced milk fat, inconsistent dry matter intake (DMI), as well as face increased incidence of diseases, including diarrhoea, ruminal ulcers, parakeratosis, liver abscess, and laminitis (Krause and Oetzel, 2006; Plaizier et al., 2008). Losses to the dairy industry arising from lost production efficiency and increased treatment costs associated with animals suffering from SARA have been estimated to be between $500 million to $1 billion a year (Donovan, 1997).

One of the major concerns with SARA is the lack of clinical symptoms (Garrett et al., 1999). Symptoms that are identifiable, such as a depression of DMI (Plaizier et al., 2008), are difficult to detect in animals that are group-fed. Many dairy nutritionists consider a dairy herd to have healthy rumen function when at least 40% of the cows are ruminating at any given time (Eastridge, 2006). This guideline was recently confirmed in a study by DeVries et al. (2009). Interestingly, these researchers found that detecting suboptimal rumen function (i.e. a herd-level acidosis event) via decreased observed percentages of cows ruminating cannot be performed through a single observation of a herd. Rather, this detection would require that numerous observations be taken to accurately estimate the percentage of cows ruminating within a herd. Such a task may appear onerous; however, new technologies that allow for the objective and repeatable

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automatic capture of behavior are becoming available. An electronic rumination monitoring system, as recently validated by Schirmann et al. (2009), would allow for easy detection of changes in both individual cow, as well as herd rumen health, and thus allow for the detection of a bout of acidosis.

Despite our vast knowledge of the etiology of this digestive problem, and its consequences, the prevalence of SARA, which is estimated to range from 19 to 29% in lactating dairy cows (Garrett et al., 1997; Krause and Oetzel, 2006), increases as we try to maximize milk production through encouragement of maximum intake of diets containing high proportions of highly-fermentable carbohydrates (Krause and Oetzel, 2006). This review will shed light on how SARA risk is not only related to what a cows eats, but how she eats it. Specifically, I will discuss how feeding behaviour patterns and sorting behaviour may increase the risk of SARA, and review those dietary and management factors that can be used to minimize this risk.

Risk Factors for Sub-acute Ruminal Acidosis

Feeding Behavior Patterns

Dairy cattle are foragers and, as such, under natural grazing conditions would engage in foraging behavior for 4 to 9 hours per day (Hafez and Bouissou, 1975). Modern, high-production dairy cows typically consume their daily DMI in 3 to 5 hours per day, spread between 6 to 10 meals. These meals may be spread throughout the day, with the largest ones occurring particularly after the delivery of fresh feed (DeVries et al., 2003; DeVries and von Keyserlingk, 2005). It has been suggested that management practices that cause adult dairy cattle to eat fewer and larger meals more quickly may be associated with an increased incidence of SARA (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). This will, as result, decrease the buffering capacity of the rumen and cause depressions in rumen pH. Alternatively, when cows slow down their rate of DM 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 SARA is decreased.

Dietary Selection

Total mixed rations (TMR) 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 cows 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). 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 SARA (DeVries et al., 2008). 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 (Figure 1; DeVries et al., 2005; Hosseinkhani et al., 2008). For group-fed cows, this may be detrimental for those cows 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 cows may not be able to maintain adequate nutrient intake to maintain high levels of milk production (Krause and Oetzel, 2006).

Minimizing Risk Factors of Sub-acute Ruminal Acidosis

Dietary composition

As previously mentioned, the high-energy diets, which are low in neutral detergent fiber (NDF) and high in starch, that are typically fed to lactating dairy cows can put the cows at risk of experiencing SARA. Interestingly, recent research indicates that lactating dairy cows demonstrate higher degrees of sorting against longer forage particles and for smaller grain concentrate particles when fed such a lower forage diet (DeVries et al., 2007; 2008). This is particularly troublesome for early lactation cows, for which greater sorting of a higher concentrate, lower fiber diet, coupled with rapidly increasing DMI (Kertz et al., 1991), will exacerbate the intake of highly fermentable carbohydrates and refusal of peNDF. Furthermore, lower forage diets are also consumed at a faster rate (DeVries et al., 2007) and ruminated less, resulting in lower salivation rates and, thus, may decrease the buffering capacity of the rumen (Maekawa et al., 2002; Beauchemin et al., 2008). It stands to reason that these effects of feeding a lower ration may contribute to the rapid increase in severity and occurrence of ruminal acidosis that has been documented in early lactation cows (Penner et al., 2007).

Despite these concerns, feeding rations with a large proportion of highly-fermentable carbohydrates remains common in effort to maximize production. Alternatives to outright changing dietary composition are, therefore, needed to reduce the potentially negative effects such rations may have on rumen health. It is commonly believed that adding water to a dry TMR will help bind particles together and make it harder for dairy cattle to sort out smaller particles. Leonardi et al. (2005) demonstrated that reducing TMR DM concentration from 80 to 64% through water addition resulted in a reduction in the extent of feed sorting against long particles and for short particles, a tendency for increased NDF intake and greater milk fat percentage (3.41 vs. 3.31%). Interestingly, the ration tested in that study was much drier than that typically utilized for high-production dairy herds (40 to 60% DM; Eastridge, 2006), particularly those utilizing no dry forages in their TMR. Interestingly, Miller-Cushon and DeVries (2009) recently found that reducing the DM concentration from 57.6 to 47.9%, through water addition, for a TMR containing primarily haylage and silage forage sources, actually encouraged greater feed sorting and reduced DMI. In can be concluded that the effect water addition

may have on reducing feed sorting may hinge on the original DM content of the ration, and whether or not dry forage was included in that ration. It would be recommended that in situations where sorting is evident, producers try add water to their TMR, however be careful to monitor the effects that this may have. In cases where sorting increases with additional water, it would be recommended to stop this practice.

Feed bunk management

Beyond dietary factors, there are factors associated with feed bunk management which may influence the level of feed sorting, feeding behavior patterns, and thus risk of acidosis. For group-housed dairy cattle, the act of feed delivery acts as the primary stimulus by which dairy cows are attracted to the feed bunk (DeVries and von Keyserlingk, 2005). In a study by DeVries et al. (2005) it was demonstrated that frequency of feed delivery influences the ability of cows to access feed, particularly fresh feed. More frequent feed delivery not only results in cows spending more time at the feed bunk, but also results in a more even distribution of feeding time over the course of the day. Further, it was shown in that study that increasing the frequency of feed delivery from once to twice per day reduces the amount of feed sorting (Figure 1). These results suggest that higher frequencies of feed delivery alter feeding behavior and that, in turn, reduces the variation in diet quality consumed by the cows within the group. Further, frequent feed delivery promotes a more consistent and balanced intake of nutrients over the course of the day, and thus promotes healthier rumen fermentation patterns.

Another management practices which can influence feed sorting is the feeding amount. Leonardi and Armentano (2007) found that cows, fed a TMR with a high proportion of dry forage, sorted against long ration particles more extensively when they are overfed (i.e. fed for a higher level of orts). In a recent study, Miller-Cushon and DeVries (in press) found that increasing the feeding amount of a ration containing no dry forage, with a small proportion of long particles, promotes greater sorting of medium and short length ration particles, while encouraging greater DMI. From these studies it can be concluded from that increasing the feeding amount may, with certain rations, promote more feed sorting, less balanced nutrient intake, and greater risk of rumen acidosis. Alternatively, a higher feeding amount can promote greater DMI, while maintaining a balanced intake of nutrients for those rations not heavily sorted against the longer particles that are high in effective fiber, or sorted for the shorter particles that are high in fermentable carbohydrates.

Other feed bunk management aspect that interacts with feeding behavior and feed sorting are the amount of available feed bunk space per animal and the design of the feeding area. Recent observations have suggested that at the current industry standard of 24 inches of feeding space per cow not all animals can access feed at the same time (DeVries et al., 2003). As social animals, cattle tend to synchronize their behavior, including a strong desire to access the feed bunk as a group. When space is reduced, this behavior increases competition for access when, for example, you deliver fresh feed and cows are highly motivated to head for the bunk. As available feed bunk

space is reduced, competition increases and feed access decreases (DeVries et al., 2004; Huzzey et al., 2006). Hosseinkhani et al. (2008) recently demonstrated that competition at the feed bunk dramatically increased the feeding rate at which cows feed throughout the day (Figure 2). These researchers also found that competitively-fed cows have fewer meals per day, which tend to be larger and longer. In the study by Hosseinkhani et al. (2008) it was also found that competition changed the distribution of DMI over the course of the day, resulting in higher intakes during the later hours after feed delivery after much of the feed sorting had already occurred (Figure 3). Thus, increased competition promotes feeding behavior that forces subordinate cows to consume more of their feed after the dominant cows have sorted the TMR. These results suggest that increased competition at the feed bunk promotes feeding behavior patterns that will likely increase the between-cow variation in composition of TMR consumed and the risk of SARA. Providing more space than the current industry norm has been shown to improve feed bunk access; this increases feeding times and decreases competition, with subordinate cows showing the greatest responses (DeVries et al., 2004; Huzzey et al., 2006). This change will help reduce the variation in the composition of feed cows consume as subordinate cows will be able to access the feed prior to it being sorted through by those dominant cows.

In addition to increasing the amount of available feed bunk space, competition for feed can also be reduced through design of the feeding area. Researchers have shown that a headlock system greatly reduces competition at the feed bunk compared with a post-and-rail system (Endres et al., 2005; Huzzey et al., 2006). Another option to reduce competition is the use of partitions (feed stalls) between the bodies of adjacent cows at the feed bunk. DeVries and von Keyserlingk (2006) demonstrated that feed stalls resulted in increased feeding time and decreased competition (Figure 4), particularly for subordinate cows. Their results suggest feed stalls provide additional protection for feeding cows, and improved access to feed beyond that provided by simply increasing the amount of space per animal.

Diet Selection to Maintain Rumen Health

We typically discuss feed sorting in negative terms. There is growing evidence, however, that cows will select feeds with high rumen buffering capacity in attempt to alleviate the effects of SARA. Researchers have previously shown that ruminants will alter their diet selection in response to low ruminal pH, including the selection of sodium bicarbonate (Cooper et al., 1996; Phy and Provenza, 1998), preferring long hay over pelleted forage (Keunen et al., 2002), and sorting a TMR for long particles when fed diets that caused low ruminal pH (Beauchemin and Yang, 2005, Yang and Beauchemin, 2006). DeVries et al. (2008) also recently demonstrated that lactating dairy cows experiencing a bout of ruminal acidosis will, at times, alter their sorting behavior to select in favor of long forage particles, rather than against these particles as they typically would. Interestingly, these researchers also provide some evidence to suggest that the severity of acidosis will influence the extent by which lactating dairy cows will sort their TMR to attenuate this condition. These data suggest, therefore, that obvious

changes in the diet selection patterns of cows within a herd may indicate that they are experiencing some level of ruminal acidosis.

Conclusions

In summary, there is a growing literature base how feed sorting and feeding behavior patterns of lactating dairy cows can affect rumen health. Much sorting against long forage particles as well as the rapid consumption of feed in few, large meals per day will increase the risk of SARA, particularly on high-energy rations, which are low in NDF and high in starch. Researchers have demonstrated that feed sorting may be reduced through adding water to dry diets, controlling feeding levels, and by increasing the frequency of feed provision. Providing feed more often will also increase feeding time throughout the day, thus promoting a more consistent and balanced intake of nutrients over the course of the day. Providing more feed bunk space than traditionally recommended—particularly when combined with a physical partition, such as feed stalls—will reduce competition at the feed bunk, especially for subordinate cows, and allow cows' better access to the feed provided to them. Overall, reduced sorting and improved feed access will help reduce the variation in the composition of rations cows consume and reduce the risk of SARA.

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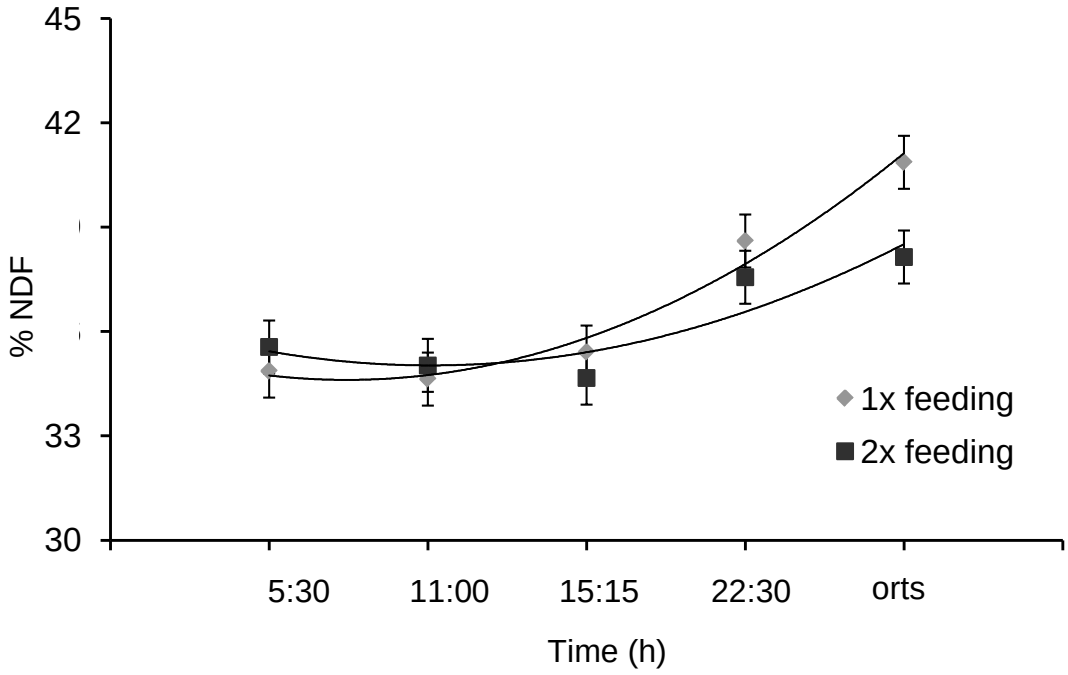

Figure 1. Percentage NDF (DM basis) of the TMR in the feed bunk over the course of the day for 1x feeding (at 0530 h) and 2x feeding (at 0530 and 1515 h) (from DeVries et al., 2005).

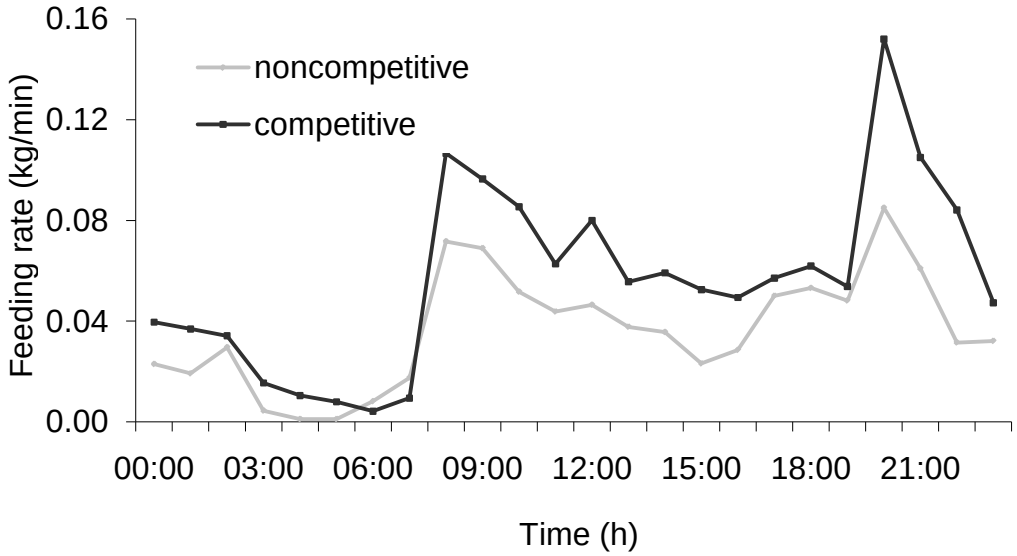

Figure 2. Average hourly feeding rate (kg/min) for cows fed noncompetitively (1 cow/feed bin) or competitively (2 cows/feed bin) (from Hosseinkhani et al., 2008).

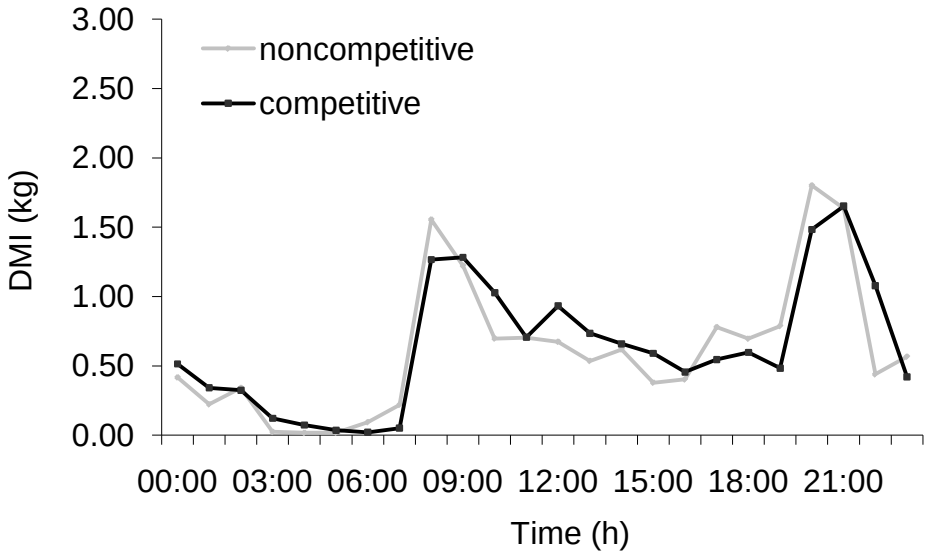

Figure 3. Average hourly dry matter intake (DMI; kg) for cows fed noncompetitively (1 cow/feed bin) or competitively (2 cows/feed bin) (from Hosseinkhani et al., 2008).

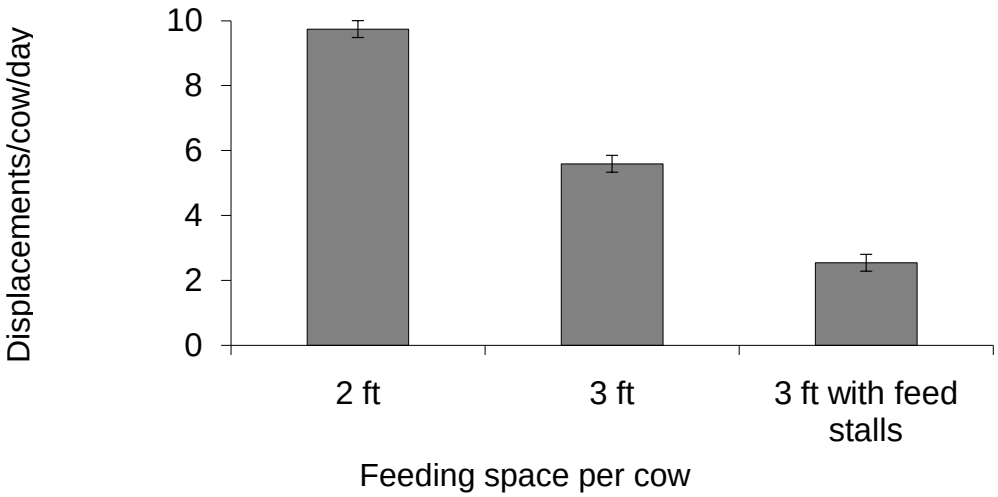

Figure 4. Daily number of displacements per cow at three different levels of feed bunk space (adapted from DeVries and von Keyserlingk, 2006).

SESSION NOTES