Managing High-Straw Dry Cow Diets to Optimize Health and Performance

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Take Home Messages

- Controlled-energy, high-straw dry cow diets may be successfully used to minimize body condition change in the dry period and improve metabolic health post-calving.
- Rumen health and energy balance can be improved post-calving by promoting greater and more consistent intake of high-straw diets in the dry period.
- Increasing the physical density of high-straw dry cow diets, by minimizing straw chop length and adding water, will reduce sorting and promote greater intakes.
- Addition of molasses-based liquid feed to high-straw dry cow diets will improve palatability, reduce sorting, and promote greater intakes.
- Proper feed bunk management to ensure good and continuous feed availability and access is essential for maintaining the success of these high-straw dry cow diets.

Introduction

The transition period, typically three weeks pre- and post-calving, is a vulnerable time for the dairy cow because she experiences several physiological, metabolic, and behavioural challenges (Drackley, 1999). At the onset of calving, the cow's nutrient demand drastically increases in an attempt to meet the demands of milk production. At the same time, and in the weeks leading up to calving, cows will reduce their dry matter intake (DMI) due to both behavioural and physiological stressors. Combined, the decrease in DMI prior to calving, the increase in nutrient demand, and the slow rate in which DMI increases in the weeks following calving, put cows into a state of negative energy balance (NEB). This state of NEB is inevitable, and all cows will experience it to some degree simply because energy intake does not match energy output in the weeks following calving. However, the degree to which cows will experience NEB will influence her risk of experiencing metabolic disease (i.e., ketosis) and will ultimately dictate her success through the transition period. Ketosis is a disease experienced in early lactation that affects 26-55% of cows at the subclinical level (McArt et al., 2015), and can result in lower milk production (McArt et al., 2012), reduced reproductive performance and increased risk of other illnesses. The risk of excessive NEB and ketosis in early lactation has been associated with reduced feeding activity, rumination, and DMI in the weeks leading up to calving (Goldhawk et al., 2009; Kaufman et al., 2016a). Similarly, changes in pre-partum feeding behaviour have been associated with greater risk of metritis and other health disorders post-calving (Huzzey et al., 2007; Luchterhand et al., 2016). These findings highlight the importance of maximizing intake in the late dry period, while also promoting desirable feeding behaviours.

One of the risk factors associated with metabolic and infectious disease post-calving, and also associated with reduced DMI, is pre-calving body condition score (BCS) (Invgartsen, 2006; McArt et al., 2012; Roche et al., 2015). Duffield (2000) concluded that cows who were over-conditioned pre-partum were at 1.6x greater risk of developing subclinical ketosis post-partum. This association is thought to be a result of over-conditioned cows tending to eat less because of elevated plasma leptin concentrations. Over-conditioned cows are also more sensitive to lipolytic stimuli, and given that they naturally have more body fat to mobilize, they are at greater risk of excessive body fat mobilization. Increased levels of body fat mobilization can quickly overwhelm the liver and, through a cascade of metabolic processes, can ultimately result in ketosis, decreased DMI, and further metabolic issues. On the other hand, losing BCS during the dry period also has its risks, including poorer reproductive performance post-calving, and increased chances of needing antibiotic treatment (Chebel et al., 2018). Evidently, managing BCS in the dry period such that cows neither lose nor gain, but rather maintain body condition, is a true balancing act that requires careful consideration. Over the past 20 years, extensive research has been focused on feeding dry cows to 100% of their nutrient (primarily energy) requirements (Dann et al., 2006; Janovick et al., 2011). This concept has become very popular in the industry and has resulted in improved energy balance post-calving. This research has provided strong evidence that maximizing DMI, while minimizing body condition loss or gain, is a key area in nutritional management of the transition cow.

▪ High-Straw Dry Cow Diets

One widely accepted strategy to control energy intake in the dry period is to incorporate large amounts of low-nutrient dense feedstuffs, such as wheat, oat, or barley straw, into the diet (Beever, 2006; Dann et al., 2006; Janovick et al., 2011). This type of diet is referred to as a ‘controlled energy dry cow diet’, or is also commonly referred to as the ‘Goldilocks diet’. Similar to the story of Goldilocks and the three bears, these diets are based on the concept of not too much, and not too little, but just the right amount – of energy, that is. The goal of these diets is to control energy consumption and maintain BCS, and thus, promote metabolic health, while also encouraging voluntary intake, feelings of satiety, and rumen fill. Dann et al. (2006) demonstrated that by using this type of controlled energy dry cow diet (cows fed to 100% of their requirements), cows had less fat mobilization and, as result, lower blood beta-hydroxybutyrate (BHB) concentrations in the first ten days post-partum compared with cows that were fed to 150% of their energy requirements. Likewise, Janovick et al. (2011) reported cows that were overfed energy in the dry period had greater blood BHB levels and experienced greater lipid mobilization post-calving. Continued research has supported this concept (Richards et al., 2020); thus, undoubtedly, these diets work from a metabolic standpoint.

However, from a feeding behaviour standpoint, there are areas of concern. For example, straw is considered unpalatable to the cow, which could increase the risk of sorting. Sorting in the dry period not only increases the risk that cows do not end up consuming the intended diet (and thus the targeted nutrient consumption), but if carried over into lactation, could be cause for concern because the risks for poor metabolic health (especially ruminal acidosis) are greater then. Very little research has investigated how pre-calving feeding behaviour influences post-calving feeding behaviour; however, past research with young calves has shown that if calves learn a behaviour prior to a dietary change they are more likely to carry that behaviour over following the transition onto a new diet. Moreover, straw is bulky and when incorporated at high rates, particularly with long particle size, can extend rumen retention time andincrease rumen fill (Drackley, 2007). From a physiological standpoint, this could be beneficial given that the slower passage rate could improve rumen mat formation, but from a behavioural standpoint, the longer the forage remains in the rumen, the less feed the cow can consume (Drackley, 2007). And lastly, large amounts of dry straw make the dry cow diet very different from the fresh cow diet in terms of physical characteristics. The pre-fresh diet is often bulky and lower in moisture content, whereas the fresh cow diet is typically denser with greater moisture content. These differences, coupled with significant drops in DMI in the weeks leading up to calving, can make it particularly difficult for cows to adapt to this dietary change, especially from a behaviour standpoint. Despite this being a challenge of controlled-energy dry cow diets, there are opportunities to make the pre- and post-fresh diets more similar to one another by manipulating certain physical characteristics. Because cows have well-defined feeding patterns, minimizing the behavioural stress associated with the transition from the pre-fresh to the post-fresh diet could also reduce the physiological and metabolic stress cows experience during this period.

▪ Managing Physical Characteristics of High-Straw Dry Cow Diets

In a series of three studies on feeding high-straw dry cow diets we observed that by manipulating forage particle size, moisture content, and overall palatability we can minimize the physical differences between the pre- and post-fresh diets, while making these dry diets more desirable to the cow (Havekes et al., 2020a, Havekes et al., 2020b, Havekes et al., 2020c).

In the first study, we fed dry cows high-straw dry cow diets that were nutritionally the same but differed in the chop length of the wheat straw (Havekes et al., 2020a). Half the cows received a diet with straw that was chopped with a 2.54 cm (1-inch) screen, and the other half received a diet with straw that was chopped with a 10.16 cm (4-inch) screen. Cows were fed their respective diet for the entire dry period, and then fed the same lactating diet for 28 days post-calving. Cows fed the diet with the shorter chopped straw had greater DMI across the dry period. Little research has looked at differing forage particle size in the dry period, but our result is consistent with work on shorter corn silage particle size in lactating diets (Kononoff et al., 2003). Of particular interest in our work was the noticeable difference in intake as cows approached calving (Figure 1). Cows fed the shorter chopped straw were able to maintain more consistent intake in the seven days leading up to calving compared with cows fed the longer chopped straw.

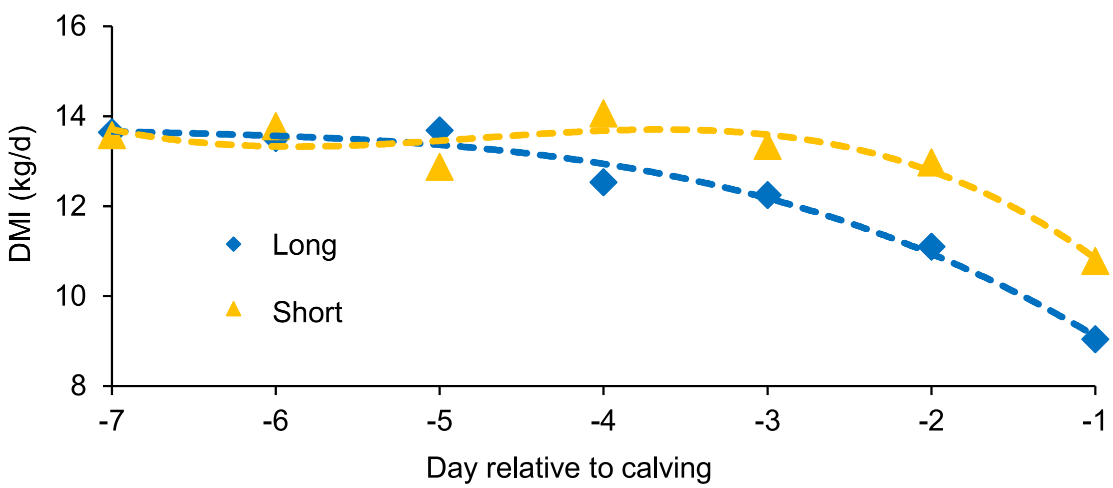

Figure 1. Daily DMI in the week leading up to calving when cows were fed dry cow diets differing in the chop length of wheat straw: 1) chopped with a 2.54-cm screen (Short), or 2) chopped with a 10.16-cm screen (Long). Adapted from Havekes et al. (2020a).

Regardless of chop length, cows sorted against the longest forage particles in the dry diets, but unsurprisingly, cows fed the short-chopped straw sorted less. This result is consistent with past research investigating the impact of straw particle size on sorting behaviour (Coon et al., 2018; Dancy et al., 2019). Interestingly, cows fed the short-chopped straw actually sorted against the fine fraction of the diet during the dry period. This is surprising because the fine fraction typically contains the small grain components that cows deem the most palatable; as a result, we generally see cows sorting in favour of this fraction (Miller-Cushon and DeVries, 2017). This finding may be partially explained by the fact that the short-chopped straw contributed a large amount of straw dust to the fine fraction, presumably making it less appealing to the cow. Similar results were recorded by Montoro et al. (2013), where calves were fed either fine or coarse chopped hay, and calves fed the fine chopped hay sorted more against the fine fraction, and by Coon et al. (2018) when lactating cows sorted against the fine fraction when fed shorter chopped straw. It is noteworthy that rumen health was improved in our study during the first week of lactation for cows fed the short-chopped straw dry cow diet, as evidenced by less of a decline in mean rumen pH level following the transition onto the lactating diet. This may have partially been driven by the consistency in intake for those cows in the week leading up to calving. Moreover, cows fed the short-chopped diet had larger meals throughout the dry period; this may have increased the absorptive capacity of the rumen and primed the rumen for larger meals post-calving. Lastly, the dry cow diet with short-chopped wheat straw resulted in better metabolic health post-calving, as demonstrated by a tendency for cows to have lower blood BHB levels three weeks post-calving. By maintaining a more consistent intake in the week before calving, cows fed the short-chopped straw dry cow diet exhibited improved energy balance post-calving.

Despite the shorter straw particle size in the dry cow diet improving intake, particularly in the week leading up to calving, and minimizing sorting, a significant amount of sorting was still observed in that study (Havekes et al., 2020a). Another strategy thought to minimize sorting activity is water addition because the water may help bind the smaller particles to the larger particles making the diet physically more difficult to sort (Leonardi et al., 2005; Felton and DeVries, 2010; Fish and DeVries, 2012). Reduced sorting was observed by Leonardi et al. (2005) when water was added to a lactating cow diet containing only dry forages. Because controlled energy dry cow diets contain a large proportion of dry forages, they may also benefit from additional water. Another potential benefit is that water addition may help to further minimize the physical differences between the dry and lactating diet by making the DM%, and thus overall density, more similar between the two diets.

In our second dry cow study we fed cows either a high-straw dry cow diet with no water added (DM = 53.5%) or a high-straw dry cow diet with water added to decrease the DM content by approximately 10% (DM = 45.4%). Based on the positive results from our first study, we used straw that was chopped with a 2.54-cm (1 inch) screen. Cows fed the diet with added water had greater intake across the dry period and were able to maintain more consistent intake in the week leading up to calving compared with cows fed the control diet. The hypothesis in our work, as well as the work done with lactating diets, is that water may help bind the smaller ration particles to the larger particles making the diet physically more difficult to sort. In our study, the particle distribution was the same for all four fractions between the two treatment diets, suggesting that water did not have an adhesive effect on the smaller particles. Despite this, water addition did minimize the degree to which cows sorted against the longest forage particles. To our knowledge, no researchers had previously investigated the effects of adding water to a high-straw dry cow diet. When water was added to a lactating ration, Felton and DeVries (2010) reported decreased intake and increased sorting, whereas Leonardi et al. (2005) reported decreased sorting. The inconsistency in results is likely related to the composition and originating DM of the diets, and we may conclude that water addition is more beneficial when working with diets higher in DM and dry forages.

Lastly, cows fed the diet with added water had greater mean rumen pH during the first week post-calving (Figure 2) and tended to have greater mean rumen pH during the second and third week after calving. This finding is also similar to the first study and, once again, may be attributed to more consistent intake (amount and composition because of reduced sorting) in the week leading up to calving, as well as greater intake across the entire dry period. Greater intakes can help develop the rumen papillae and increase the absorptive capacity of the rumen, which in turn can prevent the rumen pH from dropping too low following the transition onto the lactating diet (Kleen et al., 2003; Derakhshani et al., 2017).

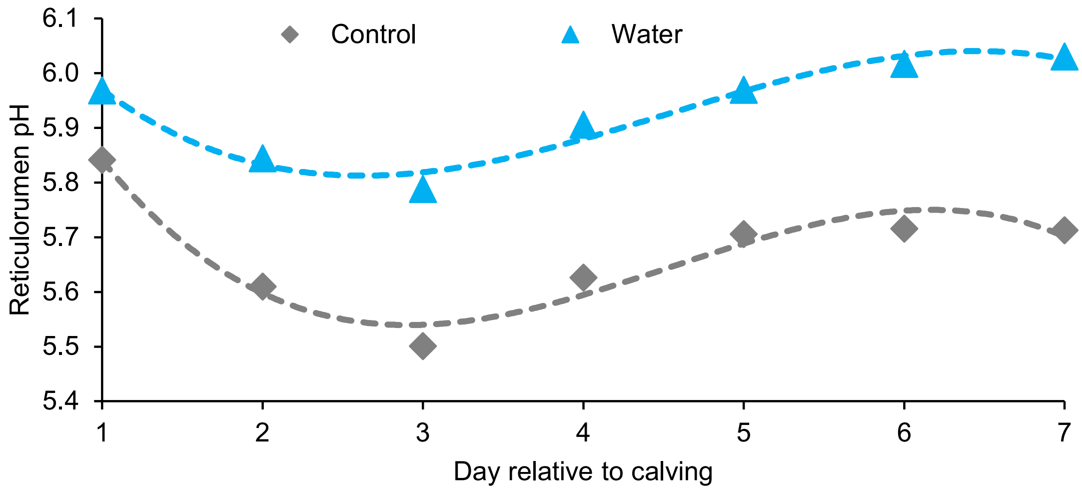

Figure 2. Mean daily reticulorumen pH for cows one-week post-calving when fed dry cow diets that differed in DM content (Control: TMR with 54.5 % DM; Water: TMR with 45.4 % DM). Adapted from Havekes et al. (2020b).

After investigating how manipulating physical characteristics of the dry cow diet (changing density through particle size and water addition) impacted feeding behaviour and performance, we wanted to determine if improving the overall palatability of the diet may have even more beneficial impacts on transition cow performance. Feeding sugar, often in the form of molasses, has been shown to have several benefits for lactating dairy cows. These benefits include improved microbial efficiency, higher intake, and reduced sorting (Oba, 2011; DeVries and Gill, 2012). Molasses also supports fibre-digesting bacteria; given that controlled-energy dry cow diets are high in lesser-digestible fiber, molasses supplementation in these diets could be particularly advantageous. Additionally, dairy cows prefer sweet tasting flavours and may be more likely to have higher intake when fed a diet with added molasses (Chiy and Phillips, 1999). Combined, these benefits could greatly increase the cow's success throughout the transition period, but to our knowledge, very little research had been done to determine the impact of molasses supplementation in dry cow diets.

For our third study, we fed cows a high-straw dry cow diet with either: 1) no liquid feed supplementation, or 2) molasses-based liquid feed supplementation at 1.0 kg/cow/day (DM basis) (Havekes et al., 2020c). When fed the diet with added molasses, cows had greater intake across the dry period and maintained more consistent (and greater!) intake in the week leading up to calving compared with cows fed the control diet (Figure 3). This is consistent with some other research done with molasses supplementation to dry cows (Miller, 2011), but inconsistent with others (Litherland et al., 2013). The differences observed between the research groups are likely related to composition of the diets (including dietary cation-anion difference and starch levels). However, greater intake by cows when fed molasses, especially in high NDF and low fermentable diets, makes sense given the fibre-digesting benefits of sugar.

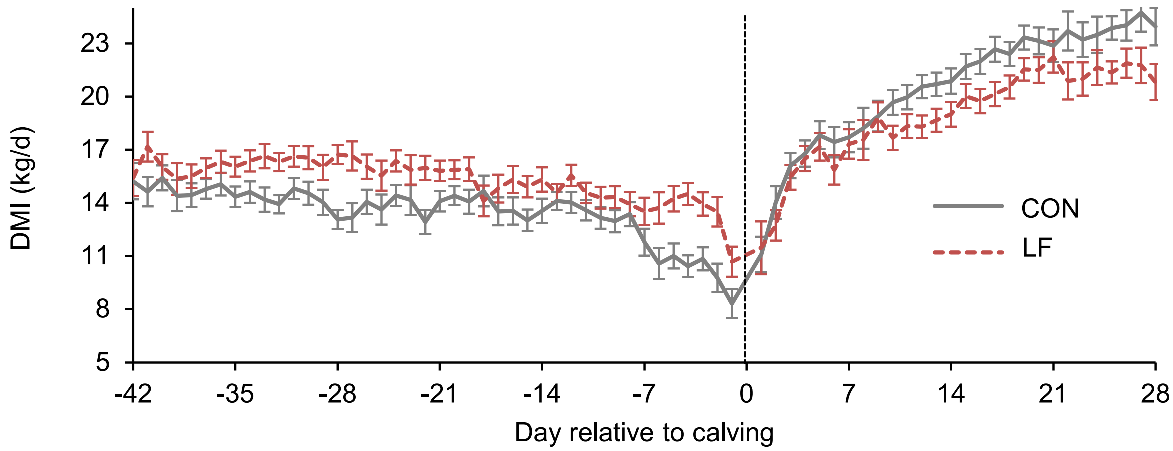

Figure 3. Mean (± SE) daily DMI (kg/d) for cows fed 1 of 2 dietary treatments during the dry period: (CON: dry diet with no molasses supplementation, LF: dry diet with molasses supplementation at a rate of ~2.0 kg/cow/d as fed (1.0 kg/cow/d DM)); upon calving all cows were fed the same lactating cow ration. Vertical line represents calving. Adapted from Havekes et al. (2020c).

Cows fed the molasses also had a faster feeding rate in the dry period. Typically, faster feeding rates are not desirable as they are associated with slug feeding and sub-acute ruminal acidosis (Grant and Albright, 2000; DeVries, 2019). However, these negative consequences are more likely to occur when cows are fed a rapidly fermentable diet, such as the lactating diet, rather than a high-forage dry cow diet. Interestingly, after calving, cows did not carry over this feeding behaviour. The observed increased feeding rate on the dry diet was likely influenced by the fact that cows prefer sweeter tasting flavors and are more likely to consume those feeds faster (Chiy and Phillips, 1999), and spend less time sorting. Regardless of treatment, in the dry period, cows sorted against the long forage particles, but cows fed the diet with added molasses sorted against this fraction less. This finding agrees with DeVries and Gill (2012) where molasses supplementation decreased sorting in lactating diets. Interestingly, in our dry cow study, this sorting behaviour carried through into lactation where we observed that cows previously fed the molasses actually did not sort for or against the long forage particles, but cows fed the control diet continued to sort against this fraction.

During the dry period, cows fed the molasses had higher rumen pH, which is rather surprising given the characteristics of the diets being fed. However, molasses has been shown to improve microbial efficiency and promote fibre-digesting bacteria, which may have promoted a healthier rumen environment (Penner and Oba, 2009; Oba, 2011). Post-calving, cows previously fed the diet containing molasses continued to maintain a more stable rumen environment, as demonstrated by higher mean rumen pH during the first two weeks of lactation. Molasses-fed cows had, on average, lower maximum blood BHB concentrations (0.9 mmol/L) in the first week post-calving. Cows on the control diet had an average maximum blood BHB concentration of 1.5 mmol/L. This maximum BHB level indicates that the control cows were, on average, experiencing subclinical ketosis (typically defined as blood BHB ≥1.2 mmol/L). Recent research suggests that at blood BHB levels ≥1.2 mmol/L cows are anywhere from 4.7 to 14.7 times more likely to develop clinical signs of ketosis (Benedet et al., 2019). This finding could be, in part, related to the lower intake of the control cows in the week leading up to calving; Goldhawk et al. (2009) reported that decreased intake in the week leading up to calving increases the cow's risk of developing ketosis in early lactation. Lastly, we observed a numerical increase of 2.5 kg/d 4% fat corrected milk yield (Figure 4), and 2.8 kg/d energy corrected milk yield, and an increase in efficiency of production (kg of milk per kg of DMI) by 0.2 percentage points for cows fed the diet with molasses. Similarly, Litherland et al. (2013) reported increased 3.5% fat corrected milk yield when cows were fed molasses throughout the dry period and for the first 56 days of lactation.

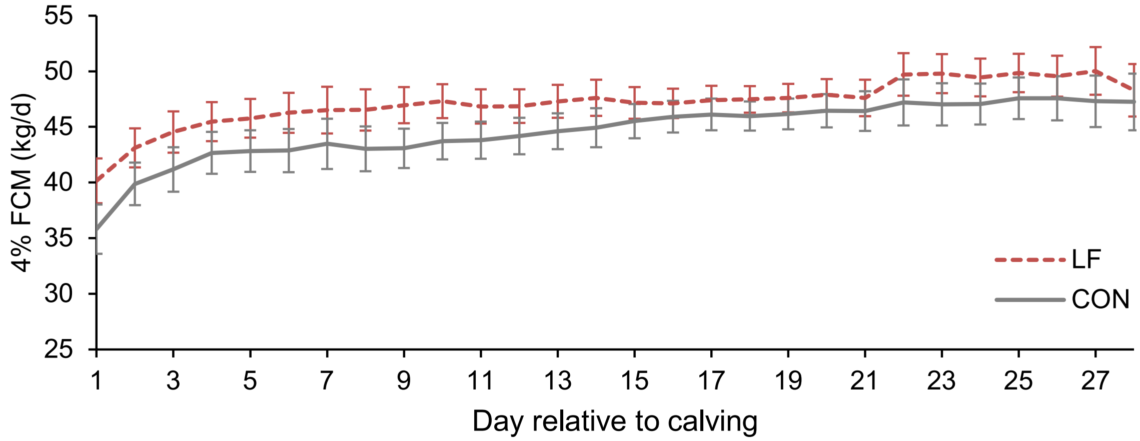

Figure 4. Mean daily (± SE) 4.0% fat-corrected milk yield (FCM; kg/d) for cows fed 1 of 2 dietary treatments during the dry period: (CON: dry diet with no molasses supplementation, LF: dry diet with molasses supplementation at a rate of ~2.0 kg/cow/d as fed (1.0 kg/cow/d DM)); upon calving all cows fed were the same lactating cow ration. Adapted from Havekes et al. (2020c).

▪ Bunk Management of High-Straw Diets

We know that DMI is a function of feeding behaviour (DeVries, 2019), and to increase DMI we need to manipulate one or more aspects of feeding behaviour. Even with excellent nutritional management of controlled energy dry cow diets, outside factors such as bunk management can greatly influence the cow's feeding behaviour and, ultimately, her intake (DeVries, 2019). Much research has been focused on the impact of bunk management during the lactating period, but less research has been focused on this area in the dry period. Arguably the way the bunk is managed in the dry period may be even more critical than how it is during lactation for the cow's success through transition; therefore, it warrants consideration.

Proudfoot et al. (2009) investigated how increased competition at the feed bunk impacted intake and feeding behaviour of prepartum cows. Those researchers concluded that competition (as result of over-crowding the bunk) increased the frequency of displacements from the feed bunk and tended to reduce intake of multiparous cows in the week before calving (Proudfoot et al., 2009). When these close-up cows were fed in a competitive environment, they also had dramatically faster feeding rates compared with non-competitively fed cows (Hosseinkhani et al., 2008). Given the results of our dry cow studies (Havekes et al., 2020a,b,c) and those of Huzzey et al. (2007) and Goldhawk et al. (2009), it is evident that maximizing intake in the dry period, and particularly in the week leading up to calving, is a very important component to metabolic health post-calving. Thus, feed bunk competition should be minimized, ideally during the whole dry period, but especially in the weeks leading up to calving.

Another important component of bunk management that is well-researched for lactating cows is feed availability. Little research has been focused on feed availability in the dry period, but we can hypothesize that the feeding behaviour response would be similar to that in the lactating period. Feeding for no refusals, commonly referred to as 'slick bunk' feeding, is widely used (Silva-del-RÍo et al., 2010); however, this feeding strategy naturally results in cows having little or no access to feed for periods throughout the day. Feed restriction in the lactating period was studied by Collings et al. (2011), who concluded that slick bunk feeding coupled with competition doubled the amount of feed bunk displacements. Feed bunk competition also decreases daily lying time and increases non-feeding standing time (Huzzey et al., 2006; Proudfoot et al., 2009). These findings become increasingly important when we consider how lying activity in the pre-fresh period may influence post-calving performance. For example, Itle et al. (2015) reported that cows diagnosed with subclinical ketosis post-calving spent less time lying pre-calving. We also know that excessive standing time is a risk factor for lameness, which can be detrimental to the success of the transition cow. In support of the potential link between stocking density, time budgets, and risk of excessive NEB, Kaufman et al. (2016b) demonstrated that increasing stocking density by 5% during the week pre-calving increased the risk of ketosis by 10%. Based on these results, and because maximizing DMI in the dry period is so critical, feeding dry cows for a slick bunk, especially under competitive conditions, is not recommended. In vulnerable times, such as the dry period and early lactation, it is recommended to provide ≥ 76 cm (30 inches) of feeding space per cow (DeVries, 2019) with continuous feed availability.

Feed push ups are also an important aspect of feed availability. Pushing up feed continuously throughout the day is critical for ensuring cows consume a balanced diet and that they have continuous access to feed (DeVries, 2019). Push ups can help promote consumption of a balanced diet by mixing up the feed in front of the cows and minimizing any existing locations of sorting. This is increasingly important when cows are fed a diet with ingredients that may be deemed less palatable, such as straw, and when diets are more easily sorted because of their physical characteristics.

Lastly, one final consideration for dry cow diets, especially if water is being added to the diet, is the potential for heating and spoilage. Decreased intake with water addition to lactating diets observed by Miller-Cushon and DeVries (2009) and Felton and DeVries (2010) was attributed to the TMR spoiling. Eastridge (2006) suggested that TMRs greater in moisture content may be less stable and, thus, more prone to spoilage, particularly during periods of warmer weather. To minimize these risks, careful attention must be placed on maintaining silage quality (in bunk and at feed out) and good feeding management. Dry cow diets should be mixed and delivered at least daily, and potentially more often in periods of high environmental temperature and humidity.

▪ Conclusions

Controlled-energy dry cow diets are beneficial from a metabolic standpoint, as demonstrated by supporting research and adoption of this feeding strategy in the industry. Equally important, however, is the role that feeding behaviour plays in the cow's success through the transition period. High-straw dry cow diets are significantly different from the lactating diet in terms of physical characteristics and may be more prone to sorting. Manipulating the physical characteristics (i.e., greater density through smaller straw particle size and water addition) can make these dry diets more physically similar to lactating diets; this strategy has proved to be beneficial from both a behavioural and metabolic health standpoint. Further, improving the palatability of these high-straw diets through the use of a molasses-based liquid feed also proved to be beneficial for optimizing transition cow performance. Finally, nutritional considerations for these diets, albeit important, are only one piece of the puzzle. How these diets are managed at the feed bunk to ensure good and continuous availability and access also play a critical role in the overall success of the transition period.

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