Feeding the Fresh Cow: What is the Ideal Carbohydrate Mix?

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▪ Take Home Messages

- Based on field observations and limited research, fresh cows should be housed in small, separate groups to minimize social stress, maximize comfort of the physical resting space, provide a feeding area to minimize slug feeding and other undesirable feeding behaviors, and provide a diet that promotes dry matter intake and prevents health problems.
- The nutritional strategy that is used during the transition period of cows is critical for supporting lactation performance while minimizing the risk of ruminal acidosis, controlling inflammation, and improving metabolic health. Thus, the fresh diet should be formulated in the context of the dry and high group diets to provide a smooth nutrient change from one diet to the next.
- The fresh diet should contain an appropriate blend of fermentable carbohydrates (i.e. starch, sugar, and fibre) to contribute to the energy demands of the cows while maintaining the integrity of the rumen epithelium and rumen health.
- The risk of subacute ruminal acidosis and chronic inflammation increases when higher starch fresh diets are fed, especially following lower starch, controlled energy dry cow diets.
- The amount of physically effective fibre that is needed in the fresh diet is influenced by the rumen fermentable starch content of the diet and the dry matter intake of the cow. The role of undigestible fibre in the fresh diet is being defined.

▪ Introduction

Feeding and management practices for transition dairy cows can have a substantial impact on a cow's well-being and farm's profitability. Suboptimal transitions from the dry cow diet to the early lactation cow diet can decrease milk yield, lactation persistency, and reproductive performance. The use of a fresh cow diet can make the transition more successful.

▪ The Fresh Pen

The use of a fresh pen continues to grow in popularity, especially for dairies that are expanding herd size and/or building new facilities. A fresh pen allows a dairy to house fresh cows separately from other cows in the lactating herd to facilitate monitoring of health problems, minimize social stress, and provide a diet specifically formulated for fresh cows.

The optimal duration for cows to remain in a fresh pen is unknown but likely is unique for each dairy and possibly each cow given differences in rate of increase in dry matter intake (DMI) and milk production. An informal survey of dairies suggested that cows remain in a fresh pen anywhere from 10 to 42 days in milk (DIM) with 14 to 21 DIM the most common. Fresh cows that transition successfully are typically ready to move to a high group pen with a more fermentable carbohydrate diet between 10 and 14 DIM. Extended stays in a fresh pen can limit DMI because of gut fill, and increase the risk of health problems, such as primary ketosis. An example of this occurred at Miner Institute where the primary forage in the fresh diet, corn silage, had a lower fibre digestibility than expected based on initial laboratory analysis. Cows increased intake rapidly until 10 to 14 DIM when intake plateaued with milk continuing to increase. The cows were eating as much fibre as a percentage of their body weight as possible. Blood beta-hydroxybutyrate (BHBA) started to rise at a time when it would normally decrease resulting in some cows having subclinical ketosis or showing clinical signs of ketosis. At 22 DIM, cows were switched to a more digestible high group diet that allowed greater intake and the primary ketosis problem resolved.

A fresh pen and its management can greatly influence fresh cow behavior. A fresh pen typically houses a smaller group of cows together than the other lactating groups, which reduces the social activity and possibly leads to less social stress and more resting. This concept was demonstrated in a study (Burow et al., 2009) where the addition of fresh cows to small groups of cows compared to large groups of cows housed at 1 stall per cow resulted in fewer agonistic and non-agonistic interactions within the 3 hours after mixing. Introducing fresh heifers as pairs rather than individuals to a group containing older cows promoted lying behavior after mixing (O'Connell et al., 2008). In another study (Østergaard et al., 2010), cows housed as a separate group for one month after calving with ≥1 stall per cow resulted in improved production and health in primiparous but not multiparous cows. Interestingly, a fresh cow diet was not used in the separate group. An additional benefit of separate grouping may be observed if an appropriate fresh cow diet is used.

The feed bunk of a fresh pen should be understocked and provide at least 76 cm of space or ≥1 headlock per cow. Limited feed buck space increased the number of displacements and feeding rates of cows before and after calving (Proudfoot et al., 2009). Fresh cows that were overcrowded at the feed bunk altered their feeding behavior (e.g. increased feeding rate) and increased the risk for health problems associated with slug-feeding (Krawczel et al., 2009).

Based on field observations and limited research, fresh cows should be housed in small, separate groups to minimize social stress, maximize comfort of the physical resting space, optimize size of the feeding space to minimize slug feeding and other undesirable feeding behaviors, and provide a diet that promotes DMI and prevents health problems.

▪ Fresh Cow Feeding Strategies

There are many studies that have evaluated the carryover effects of dry cow diets on metabolism and performance during early lactation. However, fewer studies have evaluated nutritional strategies immediately after calving to support the metabolic adaptations and performance (e.g. lactation and reproduction) of the fresh cow. In general, early lactation feeding strategies have focused on increasing the dietary energy density, altering the source of fermentable carbohydrates, and changing the availability of glucogenic nutrients relative to lipogenic nutrients (Dann and Nelson, 2011). Many of the fresh cow feeding recommendations are based on field experience and limited research. Typically, the fresh diet has less forage and more fermentable carbohydrates than the dry diet, but the fresh diet does not have as much fermentable carbohydrate as the high diet. Often the fresh diet is a modified high group diet. Common fresh diet adjustments relative to the high group diet include: increasing the fibre content while decreasing the starch content, including ≤1 kg of straw or hay for more physically effective neutral detergent fibre (peNDF), increasing the rumen undegradable protein content to improve metabolizable protein supply, and having targeted inclusion of other nutrients or additives such as rumen inert fat, yeast or yeast culture, rumen-protected choline, and monensin (McCarthy et al., 2015a).

▪ Source of Fermentable Carbohydrates

The optimal dietary concentration of fermentable carbohydrates (i.e. starch, sugar, and fiber) is being refined for early lactation cows, in particular for fresh cows. Fresh cows need to rapidly increase DMI to support lactation performance while maintaining health. Allen et al. (2009) suggested that liver energy status (i.e. oxidation of fuels such as fatty acids, propionate, lactate, and amino acids) is a major controller of DMI in dairy cows. They suggest that limiting dietary starch content and starch fermentabilty may increase DMI during the fresh period since there will be less rapid production and absorption of propionate. Another reason, and possibly a more important reason to limit dietary starch and its fermentability in the fresh period is to minimize the risk of subacute ruminal acidosis (SARA), especially when cows transition from a low starch, controlled energy dry diet. More fermentable carbohydrates (i.e. starch, nonforage fiber sources, and highly digestible forages) should be fed to the cows as lactation proceeds and plasma nonesterified fatty acids (NEFA) and BHBA concentrations decrease, as this is a time period when the lower fermentable fresh diet could limit DMI because of gut fill.

Starch

Dietary starch content and fermentabilty in the fresh period (21-day period) has been summarized (McCarthy et al., 2015a; Table 1) recently for 3 studies conducted at Miner Institute (Dann and Nelson, 2011; Williams et al., 2015) and Cornell University (McCarthy et al., 2015b,c).

Table 1. Comparison of dry and lactation diets from Miner Institute and Cornell studies on varying starch levels in the fresh diet.

Study	Starch, % DM	Fermentable starch, % DM	Fermentable CHO, % DM	Starch/CHO, %
Dann & Nelson, 2011				
Dry	13.5	11.5	39.4	29.7
Low fresh	21.0	16.8	42.4	40.1
High fresh	25.5	20.2	44.1	50.3
McCarthy et al., 2015b,c				
Close-up	17.4	15.3	42.2	36.3
Low fresh	21.5	16.8	39.9	42.1
High fresh	26.2	21.5	40.4	53.2

Dann and Nelson (2011) showed that lactation performance was better when cows transitioned from a 40-day dry controlled energy diet (13.5% starch) to early lactation diets containing either 21% starch (fed for 91 DIM) or 23% starch (fed for 21 DIM) followed by 26% starch (fed for 22 to 91 DIM) compared with 26% starch (fed for 91 DIM). The low starch and step-up starch approaches were effective dietary strategies. In contrast, McCarthy et al. (2015a,b) revealed faster rise of intake and milk production when cows were fed a diet containing 26% compared with 21% starch up to 21 DIM. All cows were fed 26% from 22 to 63 DIM. Interestingly, cows were fed a 17.4% starch diet during the close-up period. Perhaps the difference in starch content between dry and fresh diets may be more important than specific dietary starch content fed to fresh cows. It is likely that the large differences in starch content and fermentability between the dry diet and the high starch fresh diet in the Dann and Nelson (2011) study compromised the transition of cows onto the high starch diet in that study. Likewise, feeding the higher starch close-up diet to cows in the McCarthy et al. (2015b,c) study facilitated the transition onto the higher starch fresh diet. Interestingly, the intake of starch and fiber was lower in the McCarthy et al. (2015b,c) study than the Dann and Nelson (2011) study during early lactation. Given that the fibre digestibility of the diets used in the McCarthy et al. (2015b,c) study were lower than the diets used in the Dann and Nelson (2011) study, it is possible that the McCarthy et al. (2015b,c) cows fed both the low and high starch diets containing 11.5% straw were limited by gut fill during the first 3 weeks after calving. This reinforces the need to use highly digestible fiber sources when lower starch diets are fed.

To better understand the mechanism responsible for the poor transition in the Dann and Nelson (2011) study from a low starch, controlled energy dry diet to a high starch fresh diet, Williams et al. (2015) transitioned cows from a controlled-energy close-up diet (15.5% starch) to 1 of 2 fresh cow diets fed for 21 DIM that varied in starch content (21% vs. 27%) by replacing ground corn with a mixture of soybean hulls and wheat middlings. Measured ruminal pH (Figure 1), ruminal lipopolysaccharide, and serum acute phase proteins (Figure 2) demonstrated that the risk of SARA and inflammation increased with a greater change in dietary starch content and fermentability.

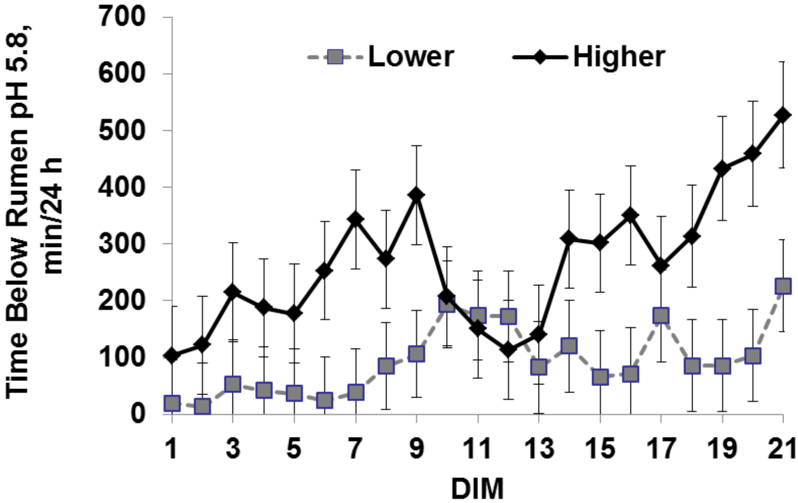

Figure 1. Minutes per 24 hours when rumen pH was <5.8 for cows fed either lower (21%) or higher (27%) starch diets during the first 21 DIM.

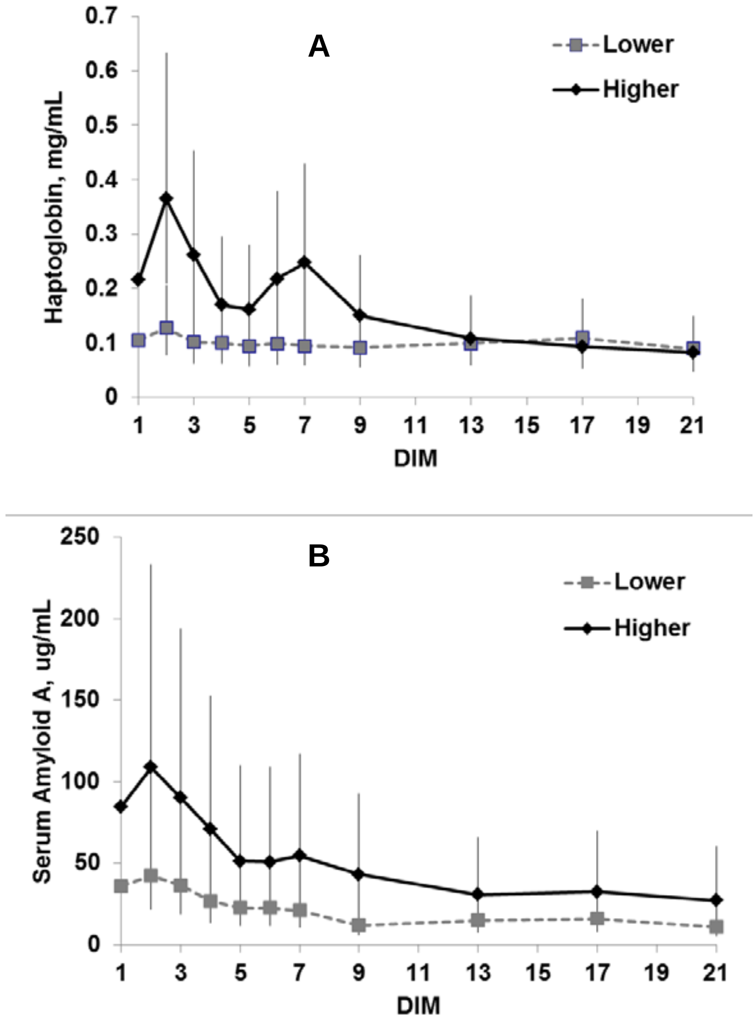

Figure 2. Serum haptoglobin concentration (A) and serum amyloid A (B) for cows fed either lower (21%) or higher (27%) starch diets during the first 21 DIM. (Error bars indicate 95% confidence interval).

Sugar

Sugar ferments faster than starch or fibre in the rumen. However, the rapid fermentation of sugar when it replaces starch in the diet does not typically decrease rumen pH. In mid-lactation cows, additional sugar often increases DMI. Thus, a fresh cow study (Penner and Oba, 2009) attempted to maximize DMI and minimize the risk of ruminal acidosis by partially replacing cracked corn grain with sucrose in barley silage-based diets. Cows that were fed the higher sugar diet (8.7% sugar; 18.5% starch) had more DMI and milk fat yield, but lower plasma glucose and increased plasma NEFA and BHBA than cows fed the lower sugar diet (4.5% sugar; 20.6% starch). The higher sugar diet reduced the severity of rumen acidosis. In alfalfa silage-based diets, replacement of ground corn with 1.5% sucrose caused a transient increase in DMI during the first 14 DIM, but did not affect DMI or milk yield over the first 84 DIM (Nombekela and Murphy, 1995).

Fibre

Fibre affects intake, digestibility, passage, and rumen function in part because it is less fermentable than starch and sugar. In addition, both the chemical and physical form of fibre is important in maintaining rumen function through rumen mat formation, rumen buffering, and stimulation of rumination. Thus, attention is given to the physical form of the forage ingredients and method of mixing the diet. Physically effective neutral detergent fibre (peNDF) is needed to prevent a severe or extended period of low rumen pH in the fresh diet. However, the amount of peNDF needed depends on the content of the rumen fermentable starch or total starch content of the diet and the amount of DMI (Zebeli et al., 2015). Too much peNDF in the diet will be problematic since it will limit DMI because of gut fill and exacerbate the negative energy balance that occurs during the fresh period. A challenge with the use of peNDF in ration formulation is the methodology and definitions used to determine the requirement.

In recent years there has been renewed interest in the role of undigestible fibre (uNDF) with improved laboratory methodology and modeling capabilities. The evaluation and formulation of uNDF in the fresh diet may be just as critical as peNDF (McCarthy et al., 2015a). Undigestible fibre is important for determining the fast and slow fibre pools and their associated rates of digestion along with estimating gut fill maxima and minima. Observations at Miner Institute suggest that dry and lactating cows eat between ~0.26 to 0.41% of body weight as uNDF. Intake becomes gut fill limited as uNDF nears 0.4% of body weight. A Cornell case study (McCarthy et al., 2015a) found that cows had fewer health problems during the fresh period when theywere fed a diet that resulted in a uNDF intake of ~0.36% of body weight vs. ~0.27% of body weight. The addition of straw or other forages with a high uNDF content to the fresh diet is an easy way to increase the uNDF content. Additional research is needed to determine the optimal level of uNDF in the fresh diet. The optimal level is likely associated with rumen fermentable starch, peNDF, and DMI.

▪ Subacute Ruminal Acidosis in Fresh Cows

Fresh cows are susceptible to metabolic disorders and compromised rumen function during the transition period. A common strategy to reduce metabolic disorders, such as ketosis and fatty liver, associated with the negative energy balance after calvingI is to provide more fermentable carbohydrates in the fresh diet relative to the dry diet. However, large changes in dietary composition and DMI during the transition period increase the susceptibility of cows to SARA. Subacute ruminal acidosis is characterized by repeated bouts of low ruminal pH (<5.8). Bouts can last for several minutes or several hours. The bouts that last >3 hours can negatively affect the ability of ruminal epithelium to absorb volatile fatty acids and decrease fibre digestion through changes in the microbial population. Signs of SARA are often varied and ambiguous, but can include decreased or fluctuating intake, decreased cud chewing, inconsistent manure ranging from stiff to loose, high cull rates due to vague health problems, milk fat depression, poor milk production, and lameness.

Interestingly, SARA and poor rumen health have been identified as causing inflammation (Zebeli and Metzler-Zebeli, 2012; Zebeli et al., 2015). Low ruminal pH can result in the death and lysis of gram-negative bacteria that are in the rumen thereby increasing the free bacterial endotoxin, lipopolysaccharide (LPS), in the rumen. Normally, the epithelium of the rumen acts as a barrier to prevent LPS entry into the blood circulation or the lymphatic system. The acidic ruminal environment, changes in osmotic pressure, and ruminal LPS can damage the epithelium and allow the LPS to translocate into the bloodstream. The presence of LPS in the bloodstream stimulates an acute phase response that results in the production of pro-inflammatory cytokines, acute phase proteins, and systemic inflammation. The activation of the acute phase response is viewed as a protective reaction to reestablish the disturbed homeostasis. However, the presence of inflammation over long periods may be associated with negative consequences for the cow, especially the fresh cow. Prolonged systemic inflammation can 1) cause significant changes in the energy and lipid metabolism, 2) lead to the development of refractory states associated with immune suppression and increased susceptibility to various diseases, and 3) increase the cow’s requirements in energy and nutrients, thereby lowering the efficiency of energy and feed use by the cow (Zebeli and Metzler-Zebeli, 2012).

The characterization of SARA and development of feeding strategies for its prevention have been the focus of research for many years (Zebeli and Metzler-Zebeli, 2012; Zebeli et al., 2015). However, most of the research has been focused on mid-lactation cows with little attention given to fresh cows. One study (Penner et al., 2007) with transition heifers found the incidence and severity of ruminal acidosis increased immediately after calving, emphasizing the need to develop and implement feeding strategies that reduce the risk of SARA. Williams et al. (2015) found that the risk of SARA could be reduced in multiparous cows by decreasing the change in starch content and fermentability from the dry diet to fresh diet. This study emphasizes the need to properly feed the fresh cow to maintain integrity of the rumen epithelium and support rumen health.

In addition to diet composition and the concept of a smooth nutrient transition from the dry period to the fresh period, feeding management in the fresh pen is important to minimize the risk of SARA and excessive inflammation (Zebeli et a., 2015). Large meals consumed quickly and infrequently (i.e. slug feeding) reduce salivary secretion and the buffering capacity of the rumen. Facilities and management practices (e.g. understocking the feed bunk) that promote smaller meals consumed more slowly and more frequently are preferred. Minimizing sorting of the diet is critical during the fresh period andcan be achieved by chopping dry forages to small size, adequately mixing the diet, feeding more frequently, and routinely pushing up the diet in the feed bunk.

▪ Conclusions

Early lactation diets, in particular fresh diets, should be formulated to maximize DMI and energy intake, prevent compromised lipid mobilization and SARA, and support a return to positive energy balance in order to optimize lactational and reproductive performance. There is no “one size fits all” fresh cow diet because the interaction of nutrition, environment, and management is unique for every dairy. However, use of a fresh cow group and diet for 10 to 21 DIM is recommended. The fresh diet should be formulated within the context of the dry and high diets. In general, following a low starch controlled or moderate energy dry diet, the fresh diet should not exceed ~25% starch or the amount that will be fed in the high diet, should avoid inclusion of higher fermentable starch sources, and should provide adequate peNDF to maximize DMI while minimizing SARA. The effectiveness of the fresh cow feeding program and management should be assessed by monitoring clinical and subclinical health problems, rumination, and variation in intake, milk yield, and body condition or weight loss.

▪ References

Allen, M.S., B.J. Bradford, and M. Oba. 2009. The hepatic oxidation theory of the control of feed intake and its applications to Ruminants. J. Anim. Sci. 87:3317-3334.

Burow, E., T. Rousing Neilsen, U. Halekoh, and U. Knierim. 2009. Social interactions of dairy cows introduced postpartally to a separated barn section – pilot study. Acta Agric. Scand. Sect A 59:192-196.

Dann, H.M. and B.H. Nelson. 2011. Early lactation diets for dairy cattle – focus on starch. *In*: Proc. Cornell Nutr. Conf. Feed Manuf. East Syracuse, NY. pp. 46-56.

Krawczel, P.D., D.M. Weary, R.J. Grant, and M.A.G. Von Keyserlingk. 2009. Effect of feed bin stocking density on the feeding and standing behavior of postpartum dairy cows. J. Dairy Sci. 92 (E-Suppl. 1):141.

McCarthy, M.M., H .M. Dann, T.R. Overton. 2015a. Feeding the fresh cow. *In*: Proc. Cornell Nutr. Conf. Feed Manuf. East Syracuse, NY. pp. 171-183.

McCarthy, M.M., T. Yasui, C.M. Ryan, G.D. Mechor, and T.R. Overton. 2015b. Performance of early-lactation dairy cows as affected by dietary starch and monensin supplementation. J. Dairy Sci. 98:3335-3350.

McCarthy, M.M., T. Yasui, C.M. Ryan, S.H. Pelton, G.D. Mechor, and T.R. Overton. 2015c. Metabolism of early-lactation dairy cows as affected by dietary starch and monensin supplementation. J. Dairy Sci. 98:3351-3365.

Nombekela, S.W. and M.R. Murphy. 1995. Sucrose supplementation and feed intake of dairy cows in early lactation. J. Dairy Sci. 78:880-885.

O'Connell, N.E., H.C.F. Wicks, A.F. Carson, and M.A. McCoy. 2008. Influence of post-calving regrouping strategy on welfare and performance parameters in dairy heifers. Appl. Anim. Behav. Sci. 114:319-329.

Østergaard, S., P.T. Thomsen, and E. Burow. 2010. Separate Housing for One Month after Calving Improves Production and Health in Primiparous Cows but not in Multiparous Cows. J. Dairy Sci. 93:3533-3541.

Penner, G. B., and M. Oba. 2009. Increasing dietary sugar concentration may improve dry matter intake, ruminal fermentation, and productivity of dairy cows in the postpartum phase of the transition period J. Dairy Sci. 92:3341-3353.

Proudfoot, K.L., D.M. Veira, D.M. Weary, and M.A.G. von Keyserlingk. 2009. Competition at the feed bunk changes the feeding, standing, and social behavior of transition dairy cows. J. Dairy Sci. 92:3116-3123.

William, S.E., H.A. Tucker, Y. Koba, R. Suzuki, and H.M. Dann. 2015. Effect of dietary starch content on the occurrence of subacute ruminal acidosis (SARA) and inflammation in fresh dairy cows. J. Dairy Sci. 98(Suppl. 2):741-742.

Zebeli, Q., K. Ghareeb, E. Humer, B.U. Metzler-Zebeli, and U. Besenfelder. 2015. Nutrition, rumen health and inflammation in the transition period and their role on overall health and fertility in dairy cows. Res. Vet. Sci.103:126-1**3**6.

Zebeli, Q., and B.U. Metzler-Zebeli. 2012. Interplay between rumen digestive disorders and diet-induced inflammation in dairy cattle. Res. Vet. Sci. 93:1099-1108.