New Concepts in Dry and Fresh Cow Management

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TAKE HOME MESSAGES

- Transition cow nutritional management strategies have evolved significantly over the past 10 yr and continue to evolve.
- Many herds, even those with low clinical milk fever rates, have significant opportunities for improved management of hypocalcemia to improve milk yield and reproduction, as well as decrease subclinical disorders.
- Feeding anionic diets before calving improves blood calcium status post-calving and increases post-calving dry matter intakes and milk yield.
- Controlling energy intake before calving improves postpartum energy balance and decreases subclinical ketosis; while feeding adequate metabolizable protein before calving helps maintain high milk yield after calving.
- Excellent feeding management (managing chop length of bulky forage and moisture of the total mixed ration) of transition rations is critical for on-farm success; many dairy farms have opportunities for improved feeding management of these rations.
- Recent research suggests that there are interactions of starch levels pre- and post-calving; cows fed low starch pre-calving rations should be fed lower starch diets after calving; whereas cows fed moderate starch rations pre-calving can likely be fed starch levels more typical of high cow rations after calving.
- *High bulk, high fermentability* fresh cow rations may improve feed intakes after calving.
- There may be additional opportunities for protein and amino acid nutrition adjustments in the fresh cow ration to improve post-calving performance.

INTRODUCTION

Nutritional management strategies for transition cows have evolved significantly over the past 10 yr in the dairy industry. Ongoing research and experience continue to refine our recommendations for nutritional management of dairy cows during both the prepartum and postpartum periods. Our high performing herds combine high milk production with modest loss of body condition score (**BCS**) (no more than 0.50 or so units during early lactation), low incidence of metabolic and immune function-related diseases, excellent reproductive performance during early lactation, and calves born alive and ready to thrive. In this paper, we will outline several areas that have received significant research attention during the past several years along with some areas of research that are currently very active that likely will lead to continued evolution of nutritional recommendations for transition cows.

FEEDING STRATEGIES FOR THE DRY COW

Management of Hypocalcemia – An Old Topic Made New Again

Clinical milk fever is a thing of the past on many dairies. Research over the past 5 yr has shifted the hypocalcemia focus to include management of not only clinical cases of milk fever, but also cows that experience subclinical drops in blood calcium (**Ca**) postpartum. Even in herds with very low milk fever incidence, subclinical hypocalcemia (**SCH**) after calving can affect 50 % or more of the herd, predisposing cows to infectious and metabolic disease and reducing their productive and reproductive potential (Reinhardt et al., 2011; Chapinal et al., 2012; Martinez et al., 2012). As these associations continue to be researched, the need for strategies to reduce SCH incidence is becoming more evident. Reducing the dietary cation anion difference (**DCAD**; Na + K – Cl – S = mEq/100 g DM) of the prepartum ration is a tried and true method for decreasing rates of clinical milk fever (Block, 1984; Gaynor et al., 1989). Strategies for implementing this approach can range from minimizing the dietary potassium (**K**) (aiming for a low but still positive DCAD) to varying inclusion rates of anion supplements to reach a negative DCAD.

Recent work in our group at Cornell aimed to determine if benefits in Ca status and production parameters increased when anion inclusion rate was incrementally increased (and therefore, DCAD decreased) in a low potassium (**K**) prepartum ration (Sweeney et al., 2015a; 2015b). Three experimental groups included a low K control ration (+18.3 mEq/100 g DM), partial anion supplementation (+5.9 mEq/100 g DM) and full anion supplementation (-7.4 mEq/100 g DM). Diets were managed to maintain urine pH of the full anion supplemented group between the target of 5.5 to 6.0. Ultimately, as prepartum DCAD was decreased in this trial, average postpartum plasma Ca was increased, indicating that the greatest benefit in Ca status postpartum was seen in cows fed the lowest DCAD. Interestingly, an effect of parity was seen such that older cows (3^{rd}+ lactation) benefited the most when fed the lowest DCAD (Sweeney et al., 2015a). Increases in postpartum dry matter intake (**DMI**) and milk yield (**MY**) were seen for cows fed decreasing DCAD. Cows fed the lowest DCAD ration prepartum produced over 7 lb/d more milk in the first 21 d compared to cows fed the low K control ration (Sweeney et al., 2015b). This study indicates that implementing a more aggressive DCAD prepartum can yield the greatest benefits postpartum when compared to a low K control approach.

Measuring urine pH is an essential component of monitoring prepartum DCAD, and can also provide valuable information about feeding management (Jardon, 1995; Charbonneau et al., 2006). Urine pH should be measured in midstream urine samples from approximately 12 to 15 cows weekly. It is important that the time relative to feeding is consistent from week-to-week, since urine pH response may fluctuate throughout the day. Large variation from cow-to-cow within a week may indicate undesirable consumption of the ration, whether that be a result of overcrowding, social factors, or sorting due to poor diet mixing. Variation in average urine pH from week-to-week can indicate inconsistency in ration mixing or changes in feed ingredient composition. This information can be used to improve feeding and management strategies to increase transition cow success.

Dry Period Plane of Energy and Effects on Health, Production, and Reproduction

Since the early 2000s we have largely abandoned the historically proposed *steam-up* approach to dry cow feeding. With increasing evidence from research conducted at the University of Illinois, a controlled energy strategy to feeding dry cows was proposed (Drackley and Janovick Guretzky, 2007). Lower postpartum concentrations of non-esterified fatty acids (**NEFA**) and ketone bodies (e.g. ß-hydroxybutyrate or **BHBA**) were observed with these controlled energy diets and the incidence of metabolic disease was decreased (Dann et al., 2006; Janovick et al., 2011). However, detrimental effects on early postpartum milk production were observed in some studies, particularly in those that restricted energy intake below requirements. Relatively little attention was paid to controlling for adequate protein supply when controlling energy intake.

Cornell research (Mann et al., 2015) investigated the effects of 3 different dietary energy strategies during the dry period. A bulky, high fiber, controlled energy diet (approximately 100 % of energy requirements); a high energy diet (approximately 150 % of energy requirements); and a step-up approach where the controlled energy diet was fed during the first 28 d after dry off after which cows were fed an intermediate diet (approximately 125 % of energy requirements) for the remainder of the dry period (28 d before expected calving). All diets were fed ad libitum and predicted metabolizable protein (**MP**) supply was formulated for approximately 1300 g/d. Our observations confirmed that feeding a controlled energy diet prepartum was associated with lower postpartum concentrations of markers of negative energy balance, such as NEFA and BHBA; whereas milk production was not different between the groups. In addition, as previously observed by others (Janovick et al., 2011; Cardoso et al., 2013), glucose and insulin concentrations remained higher postpartum in the controlled energy group (Mann et al., 2016b). This is of great importance for the fresh cow as glucose is necessary for normal immune cell function and insulin prevents excessive breakdown of adipose and muscle tissue due to its direct inhibitory effects on these processes. Furthermore, high concentrations of BHBA and NEFA as well as lower circulating concentrations of glucose and insulin, as observed in cows overfed energy prepartum, have been associated with decreased reproductive success in a number of studies (Lucy, 2008; Cardoso et al., 2013; Ospina et al., 2013).

Metabolizable Protein in the Dry Period

The drop in DMI around the time of calving, as well as the relatively slow increase in intakes in early lactation, do not only affect the energy balance of fresh cows, but also their protein balance. Protein and amino acids are instrumental to many physiological functions, particularly cell renewal and immune system function, both of which are particularly important in the transition cow as this is the highest *at risk* period for infectious diseases such as metritis and mastitis. Research shows that protein mobilization starts in the last 2 wk before calving and carries on until about wk 6 postpartum. A majority of mobilized protein is used for milk protein synthesis, with a smaller proportion being used for glucose synthesis. Our current recommendation for an adequate protein supply during the close-up period is 1,200 to 1,400 g/d of predicted MP. Particularly with controlled energy diets, adequate sources of rumen undegradable protein (**RUP**) should be included in the diets to achieve this goal. No beneficial effects on postpartum performance or health have been observed when higher than recommended amounts of MP were fed. When considering the cost of protein feed sources and environmental implications of excess N excretion, feeding protein in great excess of requirements is unwarranted.

Effects of Dry Period Plane of Energy on Colostrum Composition

Most of the research on the effect of prepartum diet on colostrum composition of cattle stems from research in beef cattle. Few studies have evaluated the effect of feeding dairy cows either a controlled or higher energy diet on colostrum quality and quantity while controlling for adequate protein supply. Our research showed that cows fed a controlled energy diet for the whole duration of the dry period (approximately 57 d) had a greater concentration of immunoglobulin G (**IgG**) in colostrum (96 g/L) than those fed a higher energy diet (72 g/L) during the dry period. At the same time colostrum volume was not significantly different (13 vs. 16 lb) (Mann et al., 2016a). Higher concentrations of IgG in colostrum allow for a higher amount of antibodies to be administered to the calf in one feeding, which we consider beneficial for passive transfer of immunity. In our opinion and according to experiences shared by others, it is important to allow for an adequate supply of MP prepartum while controlling the diet for energy to prevent a drop in colostrum volume.

Feeding Management of Dry Cow Rations

Even the best formulated rations will not be effective if they are not well-implemented. Bulky rations with the forage base consisting of either straw or mature, low K hay blended with corn silage and a grain mix can be easily sorted by cows if the straw or hay is not chopped, ideally prior to mixing into the TMR. In new research conducted by our group (Lawton et al., 2015) and involving 72 commercial dairy farms in New York and Vermont, only 25 % of the pre-fresh TMR had particle size within recommended ranges (10 to 20 % on the top screen; 50 to 60 % in the middle; and < 40 % in the pan) using the Penn State Particle Separator (**PSPS**). We recommend chopping the straw or hay such that the long particles are no more than 1.5 inches (33 % on each of the three sections of the PSPS). Often, addition of water or another wet ingredient to decrease the ration dry matter (**DM**) into the 46 to 48 % range is also required for optimal effectiveness of these rations. Accuracy and consistency in feed delivery and composition are paramount to a successful transition feeding program.

EMERGING CONCEPTS IN FEEDING THE FRESH COW

Ironically, the vast majority of transition cow nutritional management research conducted over the past 20+ yr has focused almost exclusively on the dry cow. In most studies focused on transition cow nutrition, dietary treatments were imposed during the prepartum period only and cows were fed a common diet during the post-calving period. Fresh cow rations are common in the dairy industry, although often they are modest variations of the high cow ration, perhaps with slightly higher fiber content and/or the inclusion of modest amounts (1.5 lb or less) of straw or hay, lower starch content, additional RUP, increased amounts of supplemental fat, or targeted inclusion of other nutrients or additives (e.g., rumen-protected choline, additional yeast or yeast culture, additional monensin). Success of these strategies was gauged largely at the farm level, because until recently very few controlled research studies examined these factors in the ration fed during the immediate post-calving period.

Starch and Fiber Interactions during the Pre-calving and Post-calving Periods

The research groups at Cornell and Miner Institute have completed 3 experiments evaluating starch content of the postpartum diet (Dann and Nelson, 2011; Williams et al., 2015) and starch content of the postpartum diet and monensin supplementation throughout the periparturient period (McCarthy et al., 2015b, 2015c). Dann and Nelson (2011) fed 72 multiparous Holstein cows a controlled energy diet during a shortened (40 d) dry period and then one of 3 dietary starch regimens during early lactation – a low starch (21.0 % starch) diet for the first 91 d postpartum, a medium starch (23.2 % starch) diet for the first 21 d postpartum followed by a high starch (25.5 % starch) diet through 91 d postpartum, and a high starch diet (25.5 % starch) for the first 91 d postpartum. Cows fed the low starch and medium-high starch diets after calving had similar DMI and performance post-calving; whereas cows fed the higher starch diet post-calving had lower DMI and lower MY.

McCarthy et al. (2015b, 2015c) fed primiparous (n = 21) and multiparous (n = 49) Holstein cows diets containing either 26.2 % or 21.5 % starch from calving through d 21 postpartum; beginning on d 22 postpartum all cows were fed the diet containing 26.2 % starch through d 63 postpartum. Cows were also fed either 0 or 400 mg/d of monensin beginning 21 d before expected calving and either 0 or 450 mg/d of monensin beginning at calving and continuing through d 63 postpartum. In contrast to the Miner Institute study, cows fed higher starch diets had faster increases in MY and DMI along with lower plasma NEFA and BHBA, consistent with better energy status. Cows fed monensin had higher postpartum DMI and MY and lower plasma BHBA, regardless of starch level in the postpartum diet.

The Miner and Cornell studies suggest apparently opposite responses to feeding low- and high-starch diets during the fresh period. However, the pre-calving diets were very different between the 2 studies. In the Miner study, cows were fed a typical low starch (13.5 % of DM), controlled energy diet for the entire 40 d dry period; whereas in the Cornell study, cows were fed a moderate starch close up diet (17.4% of DM). We speculate that the differences in starch levels between pre-calving and post-calving diets should be no more than 8 to 10 percentage units. Cows fed lower starch diets (12 to 14 %) immediately before calving should be transitioned onto a fresh diet containing no more than 21 to 22 % starch. On the other hand, cows fed higher starch rations before calving (16 to 18 % starch) likely can be transitioned onto fresh rations containing 26 to 27 % starch as long as there is sufficient physically effective fiber in the fresh cow diet.

Based upon some case study work as part of a controlled experiment (McCarthy et al., 2015a), we also speculate that there are interactions between starch and fiber levels in the post-calving diet. When we had insufficient physically effective fiber in the fresh diet, DMI was higher for cows fed a lower starch diet. However, when straw was increased to levels higher than typical (~ 11 % of diet DM compared to typical 2 to 4 %), DMI was higher for cows fed the higher starch diet. We are currently following up this work with controlled research to further understand the role of fiber in the fresh cow ration.

Additional Requirements for Metabolizable Protein and Amino Acids in Fresh Cows?

In addition to being in negative energy balance, cows also are in negative protein balance during early lactation. This negative protein balance reaches its low point at about 7 d after calving, and cows likely reach positive protein balance by about 21 d after calving (Bell et al., 2000). Cows compensate for this negative protein balance in part by mobilizing body protein post-calving, although we understand this process much less than we do the mobilization of body fat during early lactation.

Recently, Larsen et al. (2014) employed an innovative experimental approach in which they estimated the negative MP balance in cows during the postpartum period and then infused casein into the abomasum in order to eliminate the deficit in MP. Controls received a water infusion and treatment cows received casein planned to supply 360 g at 1 d postpartum and 720 g at 2 d postpartum, followed by daily reductions of 19.5 g/d ending at 194 g/d at 29 d postpartum. The casein infusion resulted in a high and nearly constant supply of MP from 2 to 29 d postpartum. Although the number of cows in this experiment was very small (n = 4/treatment), cows infused with casein produced an impressive 7.2 kg/d (~ 16 lb/d) more milk than controls during the experimental period. Further research is needed to evaluate cow responses to supplies of both total MP and individual AA during the postpartum period.

CONCLUSIONS

Nutritional management strategies for transition cows have evolved significantly over the past 10 yr and continue to evolve. A summary of our current recommendations are in Appendix A. Formulation and implementation of anionic diets pre-calving improves both Ca status and performance (feed intake and milk production) post-calving. Controlled energy diets prepartum moderate the dynamics of DMI, BCS, and fat mobilization; effective implementation of these diets through excellent feeding management improves metabolic health of fresh cows. Although research focused specifically on nutrition of the fresh cow is limited, new results suggest that there are interactions between starch levels pre-calving and post-calving along with opportunities to combine higher fermentability with higher effective fiber levels to maintain rumen stability. Furthermore, there appear to be opportunities to focus on MP and amino acid nutrition not just during the pre-calving period, but also during the immediate post-calving period.

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NUTRIENT RECOMMENDATIONS FOR DRY AND LACTATING HOLSTEIN COWS

Appendix A

Authors: T. R. Overton, M. E. Van Amburgh, and L. E. Chase, Cornell University

Updated 6/2016

Item	Units	Far-off Cows	Close-up Cows	Fresh Cows	High Cows
General					
DMI	lb/d	28 - 30	28 - 30	42+	52+
DMI	kg/d	13 - 14	13 - 14	19+	23+
ME (CNCPS 6.55)	Mcal/lb	0.80 to 0.90	0.90 to 1.0	~ 1.0 to 1.1	~ 1.1 to 1.2
ME (CNCPS 6.55)	Mcal/kg	1.8 to 2.0	2.1 to 2.2	~ 2.3	~ 2.4 to 2.6
ME balance	% of req.	100 to 120%	110 to 130%	80 - 90%	100 - 110%
Protein					
Crude protein	% DM	< 16	<15	<18	15 - 17%
Rumen NH3 balance (CNCPS 6.55)	%	<200%	<180%	110 - 150%	110 - 150%
Metabolizable protein	g/d	1000 - 1100	1200 - 1400	N/A	~2750-3200
Metabolizable protein balance	% of req.	110 to 120%	110 to 130%	95 to 110%	100 to 110%
MP from bacteria (CNCPS 6.55)	% of MP	no guideline	>50%	> 45%	> 45%
MP allowable milk (CNCPS 6.55)	% of req.	N/A	N/A	90 - 105%	100 - 110%
Urea cost	Mcal/d	no guideline	< 0.5 Mcal	< 0.5 Mcal	< 0.5 Mcal
Methionine (CNCPS 6.55))	% of MP	no guideline	2.60 - 2.80%	2.60 - 2.80%	2.60 - 2.80%
Lysine (CNCPS 6.55)	% of MP	no guideline	6.80 - 7.00%	6.80 - 7.00%	6.80 - 7.00%
Methionine (CNCPS 6.55))	g AA / Mcal ME	no guideline	no guideline	~ 1.12-1.14	~ 1.12-1.14
Lysine (CNCPS 6.55)	g AA / Mcal ME	no guideline	no guideline	~ 2.7 times g Met	~ 2.7 times g Met
Carbohydrate					
Forage aNDFom, optimum	% BW	0.7 - 0.8	0.65 - 0.75	0.8 to 0.9	0.9 - 1.2
peNDF	% DM	30 - 40	28 - 35	23 - 24	22 - 23
Total aNDFom	% DM	46 - 54	40 - 45	28 - 35	28 - 35
Starch	% DM	< 13	16 - 18	22 - 28	24 - 28
Sugar	% DM	<3	3 - 7%	4 - 7%	4 - 7%
NFC	% DM	20 - 30	30 - 34	35 - 42	35 - 42
Fat					
Total fat, optimum	% DM	3.5	3.5	4.0 to 4.5	4.5 to 5.0
Total fat, maximum	% DM	4.5	4.5	5.0 to 5.5	5.5 to 6.0
Macrominerals					
Calcium (Ca)*	% DM	0.5 - 0.7	0.9 - 1.1	0.9 - 1.0	0.65 - 0.80
Phosphorus (P)	% DM	0.3 - 0.35	0.30 - 0.40	0.35 - 0.42	0.35 - 0.40
Magnesium (Mg)	% DM	0.2 - 0.25	0.45 - 0.50	0.35 - 0.45	0.25 - 0.35
Potassium (K)	% DM	< 2.0	< 1.3	1.5 - 2.0	1.5 - 2.0
Sodium (Na)	% DM	< 0.10	0.10 - 0.15	0.3 - 0.6	0.25 - 0.4
Chloride (Cl)*	% DM	0.4 - 0.8	0.4 - 0.8	0.3 - 0.4	0.25 - 0.35
Sulfur (S)	% DM	0.3	0.3	0.20 - 0.25	0.20 - 0.25
Trace Elements					
Selenium (Se)**	PPM	0.3	0.3	0.3	0.3
Cobalt (Co)	PPM	0.3	0.4	0.25 - 0.35	0.20 - 0.30
Iodine (I)	PPM	0.8	0.8	0.7 - 0.9	0.4 - 0.6
Copper (Cu) ***	PPM	15 - 20	15 - 20	15 - 20	15 - 20
Manganese (Mn) ***	PPM	60 - 80	60 - 80	50 - 60	40 - 50
Zinc (Zn) ***	PPM	60 -80	60 -80	70 - 80	55 - 70

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Appendix A

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Updated 6/2016

Item	Units	Far-off Cows	Close-up Cows	Fresh Cows	High Cows
Iron (Fe)****	PPM	50	50	50	50
Vitamins					
A	IU	100,000	125,000	90,000 - 125,000	90,000 - 125,000
D	IU	25,000	30,000	30,000 - 40,000	30,000 - 40,000
E	IU	1000	1800	1200	500 - 700

NOTES:

* If DCAD formulation in close-up diet, increase Ca to 1.4 to 1.5%, increase S to 0.35 to 0.45% and use S and Cl sources to titrate urine pH to as low as 5.5 to 6.0

** FDA limit for added selenium (recommend improved sources if available for dry and fresh cows)

*** Total diet concentration (prefer use of improved sources)

**** Iron will generally not be added to the diet and diets will generally contain higher levels of iron than these (soil contamination)