Energy and Protein Nutrition for Transition Cows

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FEEDING PREFRESH TRANSITION COWS (Usually 3 Wk Prefresh to Calving)

Energy

For several decades, it was recommended to increase concentrate (grain) feeding during the final 3 wk prior to calving. We often say that we are "steaming up" the cow prior to calving or that we should be feeding a "steam up" diet prior to calving. The origin of the term is attributed to Robert Boutflour who at the World Dairy Congress (1928) first proposed the "steam up" ration as a way to circumvent "the neglect of the preparation of the cows for her lactation period." The term was meant to be an analogy to the preparation of a steam thresher. Essentially, the logic behind this feeding strategy was to adapt rumen microorganisms to higher grain diets that would be encountered by the cow following parturition. By following this practice, it was believed that cows would be less likely to go off feed or experience ruminal acidosis. Over the next decades, other reasons were put forth for steaming up cows prior to calving. These included: maximization of dry matter intake (DMI), provision of more propionate to support gluconeogenesis and decrease fat mobilization from adipose tissue, and increasing rumen papillae length to increase volatile fatty acid absorption from the rumen. However, today, many nutrition consultants and scientists are suggesting not to feed diets moderately high in grain during the prefresh transition period, because practical experience and research over the past 10 to 15 years has not supported the concept.

A summary of 10 studies that examined decreasing the forage-concentrate ratio (increasing non-fiber carbohydrate, NFC) of prefresh transition diets is listed in Table 1. Cows went on to common diets postpartum (except Guo, 2007). In 6 of the 8 studies in which prepartum DMI was measured, there was a significant increase when NFC was increased. Surprisingly, the increase in DMI occurred for sustained periods of time (i.e. 3 wk) even if cows were in positive energy balance at the time additional concentrate was introduced. In other words, there does not seem to be a functional feedback mechanism to maintain energy balance when increasing energy density in the diet during the pre-fresh transition period. The obvious question is: does this increase in prepartum DMI provide some benefit to the cow such that her postpartum health and productivity is increased? Potential benefits include: suppression

Table 1. Effects of increasing prefresh transition diet NFC on pre- and postpartum DMI and postpartum milk yield

Study	Low/high NFC, %	Change in prepartum DMI, kg/d	Change in postpartum DMI, kg/d	Change in milk yield, kg/d
Minor et al., 1998	35/44	+1.9	DNR	DNR
Mashek and Beede, 2000	35/38	DNR	DNR	NS
Keady et al., 2001	13/28	+1.7	NS	NS
Holcomb et al., 2001	25/30	+3.4	NS	NS
Doepel et al., 2001	24/30	NS	NS	NS
Rabelo et al., 2003&2005	38/45	+1.7	NS	NS
Smith et al., 2005	34/40	NS	NS	NS
Kamiya et al., 2006	28/33	+1.7	NS	NS
Guo et al., 2007	26/39	+2.6	NA	NA
Roche et al., 2010	13/32	DNR	DNR	NS

DNR = Did not report, NS = Non-significant difference ($P \geq 0.05$), NA = Non-applicable.

of adipose lipid mobilization as feed intake decreases at calving, stimulation of acid production and rumen papillae growth, and acclimation of rumen microbial population to high starch diets. Data in Table 1 indicate that there were no carry over effects of treatment on postpartum DMI or milk yield (measurement duration varies among studies). Some studies showed a transient increase in DMI immediately postcalving; however, this did not result in beneficial effects on DMI or milk yield measured over a longer duration (i.e., data shown in Table 1). In most of these studies, energy balance was not reported. However, if postpartum DMI and milk yields were not affected, it is unlikely that energy balance would have been affected. Another interesting note is that these studies did not employ sufficient numbers of animals to adequately determine treatment effects on health disorders. Nevertheless, it is unlikely animal health would have been affected without changes in DMI, milk yield, or both.

Nordlund et al. (Univ. Wisconsin, unpublished) developed the Transition Cow Index to monitor transition cow programs on commercial dairy farms. The index uses 14 factors from historical DHIA records of individual cows to project milk yield the next lactation. These projections are then compared to her expected milk yield determined after the first milk test postpartum. Deviations from expectations are calculated for a herd to determine if progress, presumably in the transition cow program, is being made. They surveyed 32 commercial dairy herds and found no relationship between fiber in the prefresh transition diet and herd Transition Cow Index values ($r^2 = 6 \times 10^{-5}$).

Why was steaming up cows regarded so important for success of transition cows for 8 decades and now it is viewed by many as nonessential? There may be several reasons, but as important as any is probably the advent of feeding totally mixed rations (TMR). Feeding TMR allows for small amounts of concentrate being consumed at any particular time. This, in conjunction with gradual increases in feed intake after calving probably allow adequate adaptation to the higher concentrate diets being fed postpartum.

Studies employing other feeding strategies to influence energy intake during the prefresh transition period are shown in Table 2. In the first three studies, forage neutral detergent fiber (NDF) was replaced with nonforage NDF. In the final three studies, feed was restricted to limit intake. With the exception of a small change in blood beta-hydroxybutyrate (BHBA) in one study, there were no responses to treatment. These studies in combination with the studies on altering forage to concentrate ratio provide a convincing picture that prefresh transition diets have very little effect on postpartum cow health and performance! Therefore, there appears to be considerable flexibility in composition of diets fed to prefresh transition dry cows. The most important point is to avoid prolonged (> 2 to 3 d) periods of negative energy balance. Most cows can be fed low energy diets (0.6 Mcal NEl/lb) and still meet energy requirements until a couple of days before calving. If any conditions prevail that lead to poor feed intakes during the prefresh transition period (heat stress, overcrowding, etc.), then steaming up diets may make sense.

Protein

The 2001 Dairy NRC estimated DMI and crude protein (CP) requirements (metabolizable protein [MP] requirement/0.7) for prefresh transition heifers and cows (Figure1). Crude protein percentage needed in the diet to meet the cows' requirement can be calculated ((CP requirement/predicted DMI) x 100) for any day prior to calving. The NRC committee did not have sufficient data for determining the requirement for mammary growth, so estimates from VandeHaar et al. (1999) have been

Table 2. The effects of replacing forage NDF with nonforage NDF or limit feeding energy during the prefresh transition period on postpartum dmi, lactation, and metabolic parameters

Study	Treatment	Response
Chung et al., 2008	Forage v Nonforage NDF	Increase BHBA 1.2 mg/dL NS-DMI, Milk, NEFA, Liver TG
Dann et al., 2007	Forage v Nonforage NDF	NS-DMI, NEFA, BHBA, Liver TG
Smith et al., 2009	Forage v Nonforage NDF	NS-DMI, Milk
Colazo et al., 2005	Ad libitum v Restricted (24% decrease in DMI)	NS-DMI, Milk, NEFA
Dann et al., 2006	Ad libitum v Restricted (80% of NEl requirement)	NS-DMI, Milk, NEFA, BHBA, Liver TG
Holcomb et al., 2001	Ad libitum v Restricted (to 8.2 kg DM/d)	NS-DMI, MILK, NEFA

NS = Nonsignificant, $P \geq 0.10$. NEFA = nonesterified fatty acids.

included for calculating a more liberal estimate of CP needs. Several important points from Figure 1: 1. Heifers require more CP in the diet than cows. This is due to lower feed intakes and higher protein requirements to accommodate growth. Although it appears that cows could be fed diets less than 12% CP for the majority of the prefresh transition period, this is not recommended since it is believed that 12% CP is the minimum needed to maximize fiber digestion and microbial protein synthesis in the rumen. 2. Because the drop in feed intake accelerates as calving approaches, the need for a greater percentage CP in the diet also accelerates. 3. Crude protein requirements for mammary development are not trivial and increase CP needed in diets by 1 to 2 percentage units.

The large increase in percentage CP needed as calving approaches poses an interesting question: what is the appropriate density when formulating a diet for the entire three-week prefresh period? Should the diet be high in CP to minimize the likelihood of the cow or heifer ever experiencing a negative balance for MP? Or should you formulate for a lower level of CP that will meet the needs of the cow or heifer for the majority of the prefresh transition period and minimize the period of time in which she would be overfed protein. Most, but not all (NRC, 2001, Chapter 9) studies have indicated that milk and protein yield of cows is not influenced by prepartum protein content of the diet. In some studies, increasing the CP content of the diet above 12 to 13% has decreased postpartum feed intake (NRC, 2001, Chapter 9). The reason for this is not known, but it may be related to the reduced capacity of the liver to detoxify ammonia during the transition period (Strang et al., 1998). Penn State researchers (Putnam and Varga, 1998) indicated that cows fed 10.5, 12.6, or 14.5% CP during the prefresh transition period were all in positive nitrogen balance.

If cows and heifers are intermingled and fed the same diet prepartum, the diet should be formulated to meet the needs of the heifers. If they are housed separately, then separate diets could be formulated for each group. Considering additional requirements for mammary growth, heifers need approximately 1,000 g of MP per day (or 1,400 g of CP) while cows need approximately 860 g MP per day (or 1,230 g CP). It is best to make measurements of DMI on the farm so that percentage CP in the diet can be calculated, but remember never to go below 12% CP. Typically, cows will need 12% CP in the diet and heifers will need 14% CP. You may see

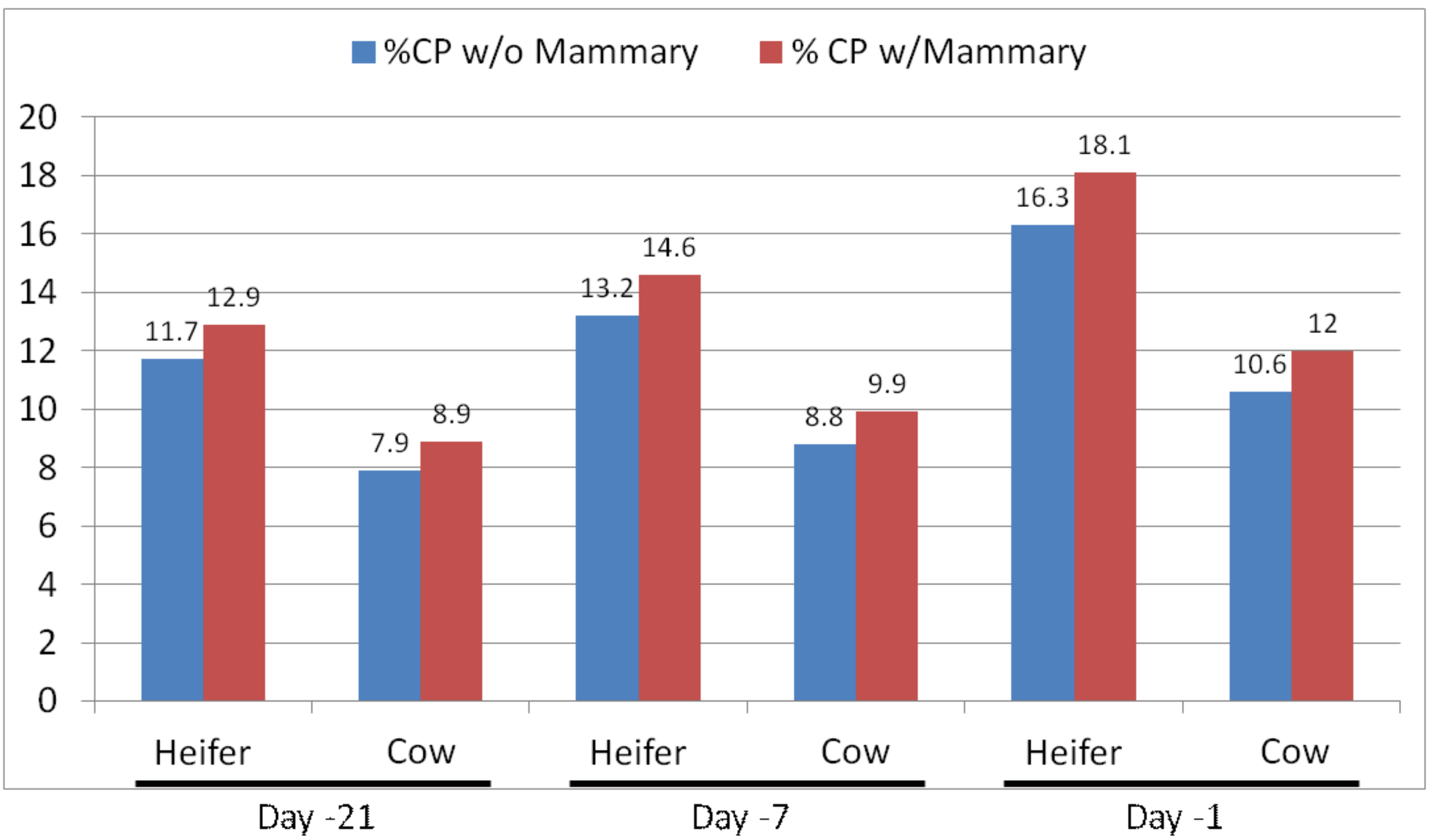

Figure 1. Estimates of the percentage CP needed in the diet to meet the protein requirements of cow and heifers at 21, 7 and 1 d prior to calving (NRC, 2001). Estimates are without or with consideration of potential requirements for mammary growth.

or hear recommendations for greater requirements for MP/CP and possibly the recommendation for inclusion of protein sources that have high levels of rumen undegradable protein (RUP). These higher recommendations are usually made as "safety nets," but research supporting them is lacking. Supplementing protein sources high in rumen RUP may come into play when prefresh diets are high in very poor quality forage, e.g., straw.

FEEDING POSTFRESH TRANSITION COWS (Usually 0 to 3 Wk Postcalving)

Energy

Amazingly, an area of research that has received little attention is feeding of the immediate postpartum cow. Why? Researchers avoid doing studies on fresh cows because tremendous variability amongst cows makes it difficult to design experiments with sufficient replication. Most fresh cow studies are initiated at 3 wk postpartum or later when cow variability is reduced and there is less likelihood of losing a cow from the study! This is unfortunate because it easy to make an argument that nutrition of the cow during the first 3 wk postpartum may be the most important. The most rapid decrease in energy balance and negative energy balance nadir usually occurs during the first 3 wk postpartum. After summarizing 26 studies, Brixy (2005) indicated that positive energy balance was reached by approximately 50 d in milk and the minimum energy balance occurred at about 11 d in milk. We collected data from twenty studies published in peer reviewed journal articles since 1988 (Grummer and Rastani, 2003). The data indicated that there was a stronger relationship between days to positive energy balance and energy density of the diet ($r = 0.57$, $P < 0.0001$) than peak milk yield. This data provides evidence that energy intake may be a more important factor affecting return to positive energy balance than milk yield, because energy intake is a function of DMI and energy density of the diet.

Data from Rabelo et al. (2003, 2005) indicated that energy density of diets immediately postpartum are more critical than energy density of diets immediately prepartum. They utilized a 2 x 2 factorial arrangement of treatments. Cows were fed diets containing 1.55 (Dry Low - DL) or 1.65 Mcal NEl/kg DM (Dry High - DH) for the last 4 wk prior to calving. Following calving, one half the cows from each group were fed diets containing 1.67 (High - H) or 1.74 Mcal NEl/kg DM (Low - L) for the first 3 wk after calving. After that, all cows were fed H. The experiment was designed to determine how best to transition cows from far-off dry cow diets to a high energy lactation diet.

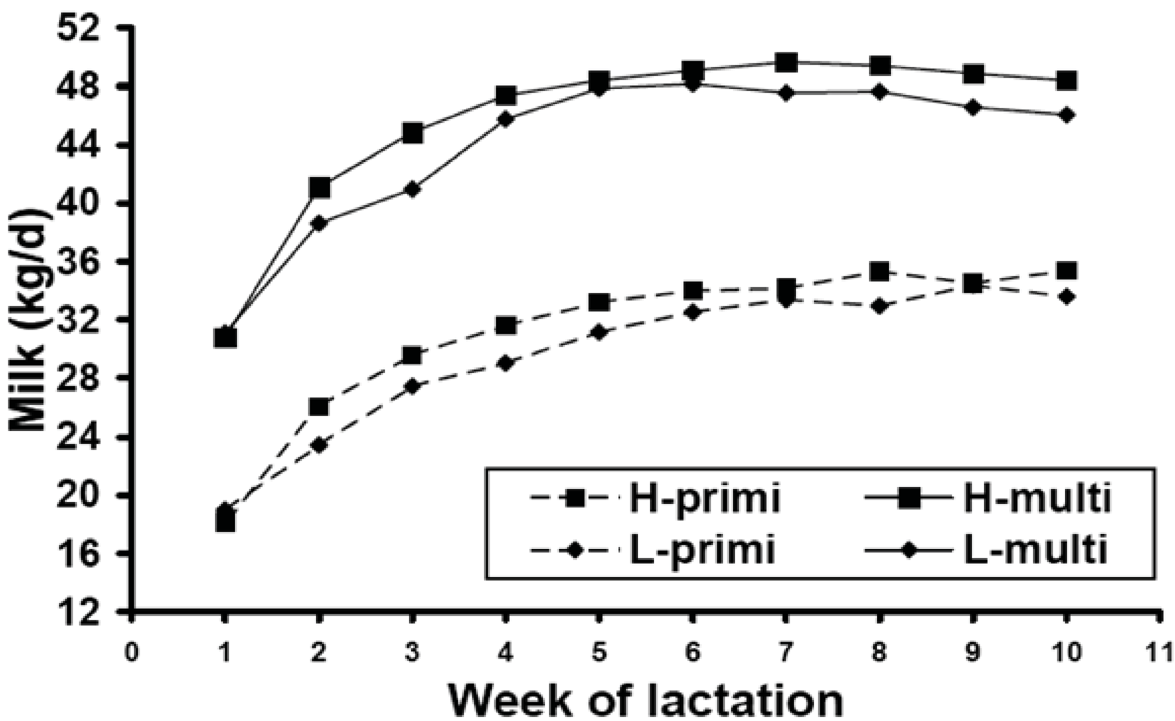

Figure 2. Milk yield of cows fed diet containing 1.67 (High - H) or 1.74 Mcal NEl/kg DM (Low - L) for the first 3 wk after calving. After that, all cows were fed H (Rabelo et al., 2003).

Figure 2 shows the milk production results. There was no effect of prepartum treatment and there was no interaction between prepartum treatment and postpartum treatment. There was no main effect of postpartum treatment, but Figure 2 clearly shows the postpartum treatment by time interaction ($P < 0.001$). There was a divergence of curves until 3 wk postpartum. At that time, treatments were terminated and the milk production difference between treatments was maintained or was narrowed. For the first 35 d postpartum, cows on H were in a more favorable energy status as indicated by higher plasma glucose concentrations (49.2 vs. 45.9 mg/dL; $P < 0.001$) and lower BHBA concentrations (4.1 vs. 6.3 mg/dL; $P < 0.001$). There was no effect of prepartum diet on triglyceride (TG) accumulation in the liver at calving; however, cows fed H postpartum had lower liver TG at the end of the 3 wk treatment period (11.1 vs. 15.6 ug TG/ug DNA; $P = 0.07$). By 35 d postpartum, liver TG was lower and there was no difference between treatments (4.2 vs. 4.7 ug TG/ug DNA; $P = 0.84$). However, it must be kept in mind that cows were on the same diet between 21 and 35 d postpartum. More importantly, energy balance should have been improving during this time; clearly TG was being cleared from the liver from 21 to 35 d postpartum.

Additional research is needed to determine the most appropriate feeding strategies of cows immediately postpartum. Emphasizing feeding NFC at the expense of NDF may reduce the likelihood of fatty liver and ketosis, but increase the likelihood of acidosis and displaced abomasum. Conversely, emphasizing feeding of NDF at the expense of NFC may decrease the likelihood of acidosis and displaced abomasum but increase the likelihood of fatty liver and ketosis. Unfortunately, it is too simplistic to recommend NFC and NDF levels in postfresh diets. NFC and NDF are heterogeneous fractions whose characteristics vary greatly among feeds. Rates of fermentation of NFC/NDF are not consistent across feeds. Likewise, factors such as particle length of NDF-rich feeds are variable and influence the rumen environment and rates of digestion. Unfortunately, inadequate information is available at this time to make precise feeding recommendations for cows during the first 3 wk postpartum. This should be a major emphasis of research going forward, but inadequate herd sizes at most universities make the appropriate studies nearly impossible to conduct. Research on commercial farms with large animal numbers should be considered, but conducting these types of studies can be problematic as well.

Protein

As is the case with energy, protein intake during the first 3 wk postcalving may be insufficient to meet requirements for milk production due to low feed intake. The cow responds to this by mobilizing reserves. However, in contrast to energy, the density of protein in the diet can be increased to reduce metabolic stress associated with mobilizing reserves. Unfortunately, there is little research on which to base protein recommendations for postfresh transition cows. Most studies examining protein or amino acid supplementation of early lactation cows have started treatments beyond the postfresh transition period. In several studies treatments started prepartum and continued postpartum. Due to the potential negative effects of overfeeding protein prepartum, interpretation of results from these studies is difficult because any positive effects of increasing protein feeding postpartum may have been negated by feeding additional protein prepartum. For example, Socha and co-workers (2005) did not observe a response to increasing dietary CP from 16 to 18.5% immediately after calving; however, the prepartum diet contained 15.6% CP. In contrast, Wu and co-workers (1997) observed a 10 lb/d increase in milk production, but only when cows came off a prepartum diet that was low in rumen undegradable protein (14% CP diets with 33.6 vs. 41.4% of CP as rumen undegradable protein). Despite the paucity of research data examining protein feeding during the first 3 wk postpartum, a strong case can be made for not shortchanging cows on protein or amino acids during this period. Figure 3 shows the potential for a negative MP balance for cows producing 60 or 100 lbs milk/d at 7 or 21 d postpartum. Two different postpartum diets were evaluated using the NRC (2001), one with 15.7% CP and the other with 17% CP. Rumen degradable protein (RDP) content of the diets was adequate. The NRC (2001) allowed estimation of DMI and MP balance. A few important points: Assuming NRC predictions are correct, diets will not provide sufficient MP. As time postpartum increases, cows will gradually achieve MP balance due to increased feed and protein intake relative to protein requirements. But, prior to that, cows are likely to be in a negative MP balance and the likelihood is greater with higher levels of production. Consequently, the cow will either mobilize protein to support lactation or milk production will be limited and below the inputs (60 or 100 lbs) used for this simulation using NRC (2001).

The concept of supplementing ruminally protected amino acids to improve MP balance and quality and reduce dietary CP should be as applicable to transition cows as

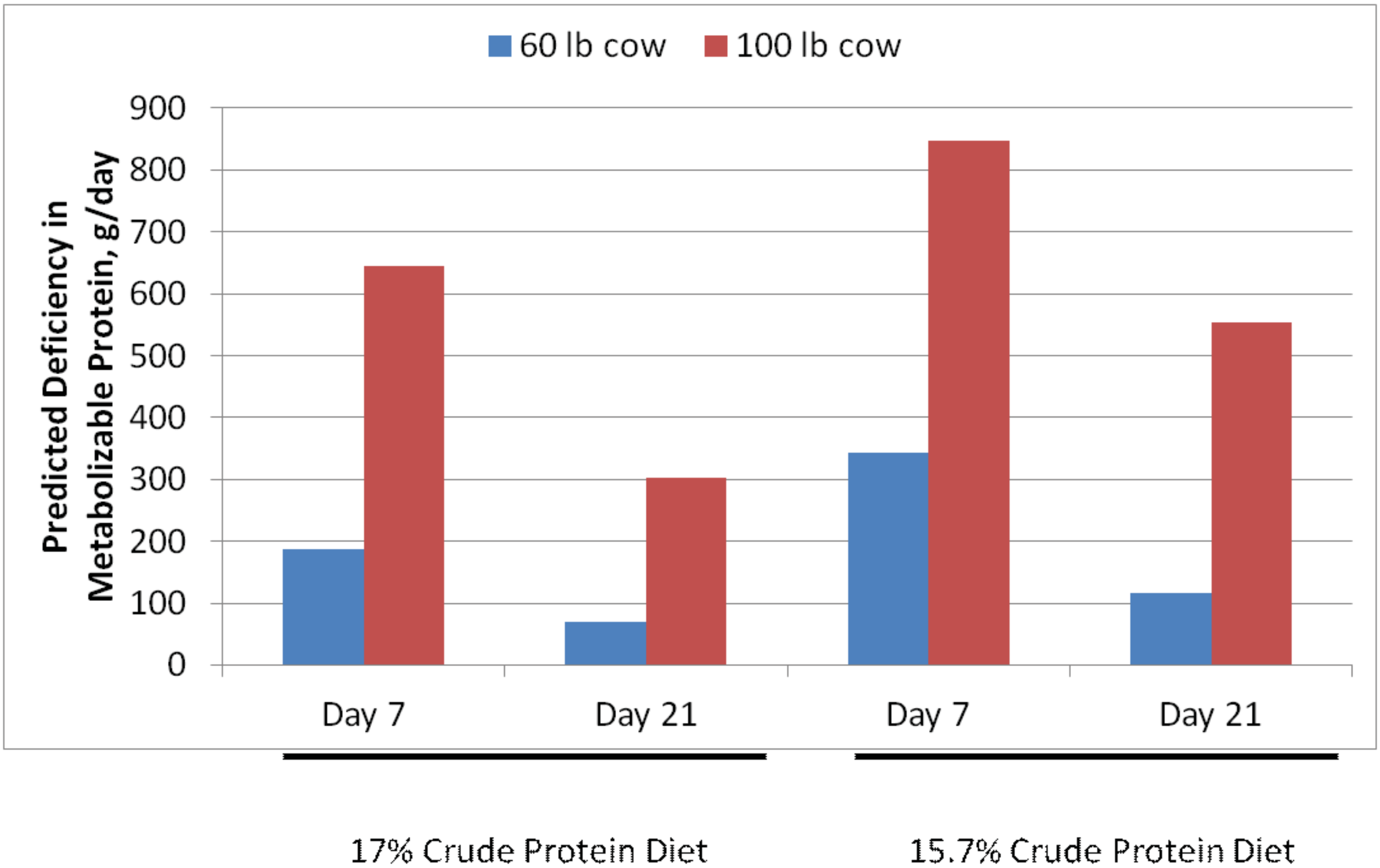

Figure 3. Estimates (NRC, 2001) of potential deficiencies in MP when feeding a 15.7 or 17 percent CP diet to cows producing 60 or 100 lbs of milk. Dry matter intakes of cows were estimated according to NRC (2001).

those later in lactation. Ordway et al. (2009) fed heifers and mature cows a basal prepartum diet beginning 21-d prior to expected calving date containing 13.8% CP (diets averaged 1,200 g/d of MP with an average MP-balance of 313 g/d according to NRC (2001) predictions) with either no additional rumen-protected methionine supplementation (Control) or with additional MP-Methionine supplied by MetaSmart or Smartamine M in amounts required to generate a 3 to 1 ratio of MP-Lysine to MP-Methionine. These same dietary treatments were continued through 140-d postpartum with the basal diet containing 16.4% CP (diets averaged 2,400 g/d MP with an average MP-balance of -145 g/d according to NRC (2001) predictions). The authors observed a linear response in milk protein concentration with the additional MP-Methionine suggesting that cows did benefit from an improvement in amino acid supply as the ratio of MP-Lysine to MP-Methionine was improved to a 3:1 ratio, even on a relatively low CP ration.

Socha et al. (2005) observed that supplementing rumen protected (RP)-Methionine and RP-Methionine + Lysine to cows receiving a basal diet containing 15.6% CP beginning 14-d prepartum and continuing on their respective amino acid treatments for 105-d postpartum when receiving either 16 and 18.5% CP diets was beneficial. These authors concluded that there was no difference between RP amino acid supplemented cows receiving a 16 or 18.5% CP diet and numerically, the RP amino acid supplemented cows on the 16% CP diet consumed more DM, produced greater amounts of energy-corrected milk, and were more efficient at converting dietary N into milk N than cows on the 18.5% CP diet which may indicate that the 16% CP diet was similar and perhaps superior in nutritive content to the 18.5% CP diet. Interestingly, these researchers increased the CP content from 16 to 18.5% by increasing the RDP fraction of the ration rather than the RUP fraction and concluded that this may have been the reason for the lack of difference between the diets. Indeed, the authors of this paper have routinely observed that these dietary differences are quite common on commercial dairy farms , i.e., diets containing higher levels of CP (e.g., > 17.5% CP) contain higher levels of RDP than lower CP diets (e.g., < 17.5% CP) probably because RDP sources have historically been less expensive than

RUP sources. Given the current and, most likely, future high economical and environmental costs associated with all protein sources (both RDP and RUP), the results of Ordway et al. (2009) and Socha et al. (2005) are supportive of the concept of supplementing both RP-Lysine and RP-Methionine in transition cow diets to lower CP levels without sacrificing production or metabolic health.

Due to cost of protein supplements and environmental concerns with overfeeding protein, there is increasing pressure to scale back the percentage of CP in dairy diets. More research is needed, but nutritionists should carefully consider formulating diets for the postfresh transition pens that are of higher amino acid quality relative to other stage of lactation diets. They should concentrate on providing sufficient amounts of RDP and fermentable carbohydrates to stimulate microbial protein production and improve the quality of the RUP by providing highly digestible sources of RUP and supplementing rumen-protected amino acids, such as lysine and methionine. The concept of providing limiting amino acids is probably most applicable to the cow immediately postpartum, particularly if there is any temptation to feed lower protein diets.

CONCLUSION

While much still remains to be uncovered regarding the most effective way to feed transition dairy cows, research indicates that there is no one best approach for feeding prefresh transition cows. In the field, many different nutritional strategies for prefresh transition cows have been demonstrated to be effective or ineffective in maximizing production and health of the postfresh cow depending on environmental conditions and feed management on the farm. Minimizing extent and duration of nutrient deficits postcalving does appear to be critical to achieve optimal production, health, and reproduction. Research to specifically identify feeding strategies for postfresh transition cows (0 to 3 wk postpartum) that minimize nutrient deficits is desperately needed.

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