Meeting the Energy and Protein Challenges of Post-Fresh Transition Cows

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INTRODUCTION

Over the past two decades there has been considerable research on feeding transition dairy cows. This has been prompted by efforts to reduce the negative energy balance (**NEB**) and related health and reproductive problems that occur early postpartum. The overwhelming majority of this research has focused on dry cow nutrition, particularly during the *close-up* period or final 3 wk of pregnancy. The assumption being that diets fed during this period of time will have carry over effects on the next lactation. There have been two major findings from this research. First, in contrast to a decades-long commonly held belief that cows should be *steamed up* (fed additional concentrate) during the close-up period, it appears that neutral detergent fiber (**NDF**)/nonstructural carbohydrate (**NSC**) levels of the diet have very little carry over effects on postpartum cows (Grummer, 2011). At least this appears to be the case when feeding a total mixed ration (**TMR**). Elimination of slug feeding concentrate may be the reason why we no longer need to adapt cows to concentrates prior to freshening. Second, prolonged excessive overfeeding of cows during the dry period may be detrimental to animal health (Drackley, 2008).

Even during the late stages of gestation, the nutrient requirements for maintenance, growth, and pregnancy are quite low and are easily met, except for a few days before calving when intake is likely to decrease as physiological changes occur in preparation of parturition and lactation. This is in contrast to the early postpartum period, or the post-fresh transition period, when it is very difficult to meet the cow’s nutrient requirements for a prolonged period of time because of low feed intakes relative to nutrient requirements needed to support lactation. Perhaps we have focused too much of our energies, both in research and practice, on the dry period and not enough of our energies on nutrition of the post-fresh transition cow? This is not to say that dry cow nutrition is not important, but when problems occur, perhaps we are too quick to scrutinize dry cow diets while neglecting close examination of diets being fed to fresh cows. This review will emphasize the tremendous nutritional challenges of the post-fresh transition cow and report on the nutrition research that addresses this critical period of time.

ENERGY

Background

Unfortunately, there is a paucity of research on post-fresh transition cows. Cow variation is high during this time, which means that a lot of cows are needed to detect significant treatment effects. Cows may be lost from experiments due to the challenges of this period and universities tend not to have large enough herds to supply sufficient animals for adequate replication. Consequently, most nutrition research on early lactation cows begins at 4 to 5 wk post-calving. That is too late, because the period of extreme nutrient deficits are over by that time. Negative energy balances of 10 Mcal NE_l/day or greater are common and the nadir usually occurs between 10 to 18 d postpartum (Senatore et al., 1996; Beam and Butler, 1998). A survey of the literature (Grummer and Rastani, 2003) indicates that positive energy balance is reached, on average, by 45 d postpartum. We desperately need more research on best feeding practices to meet energy requirements of post-fresh cows, and trials need to begin at calving and not 28 to 35 d postpartum.

There are lots of questions that need to be answered. For example, should cows be fed a post-fresh transition diet prior to receiving a high group TMR? Should that diet contain straw? Perhaps some baled hay should be fed? Does this decision depend on the diet fed pre-fresh? Does starting cows on a high group TMR immediately after calving *push* cows too hard. Does it result in greater displaced abomasums, acidosis, and severe NEB leading to fatty liver, ketosis, and poor health and reproduction? Conversely, does feeding straw postpartum restrict energy intake and exacerbate NEB? What about the hepatic oxidation theory (**HOT**; Allen et al., 2009)? Can post-fresh diets be too fermentable and result in excessive propionate production that might ultimately result in depressed feed intakes?

There are plenty of questions! The following is a summary of research that might help address these questions.

Effects of the Amount and Type of Carbohydrate on Milk Production and Feed Intake

To test whether cows should be transitioned onto a high energy diet post-calving, cows were fed a high (47 % NFC, 25 % NDF) or low (41 % NFC, 30 % NDF) NFC diet for the first 3 wk postpartum prior to all cows going onto the high NFC diet thereafter (Rabelo et al., 2003, 2005). Figure 1 clearly shows the postpartum treatment by time interaction ($P <$ 0.001) for milk production. Cows fed the high NFC diet made increasingly more milk until 3 wk postpartum. At that time, treatments were terminated and the milk production difference between treatments was maintained or was narrowed slightly. Dry matter intake and calculated energy balance were not significantly affected by treatment. However, for the first 35 d postpartum, cows on high NFC appeared to have a more favorable energy status as indicated by higher plasma glucose concentrations (49.2 vs. 45.9 mg/dl) and lower beta-hydroxybutyrate (**BHBA**) concentrations (4.1 vs. 6.3 mg/dl). Cows fed high NFC postpartum had lower liver triglyceride (**TG**) at the end of the 3 wk treatment period (11.1 vs. 15.6 µg TG/ µg DNA). By 35 d postpartum, liver TG was lower and there was no difference between treatments (4.2 vs. 4.7 µg TG/ µg DNA), however, cows were on the same diet between 21 and 35 d postpartum. More importantly, energy balance was improving during this time; clearly TG was being removed from the liver from 21 to 35 d postpartum. In this experiment, *transitioning* cows after calving was not advantageous. It should be noted that pre-fresh cows were fed a diet higher in NFC than the far-off dry period diet, so this may have eliminated the need to have a post-fresh transition diet.

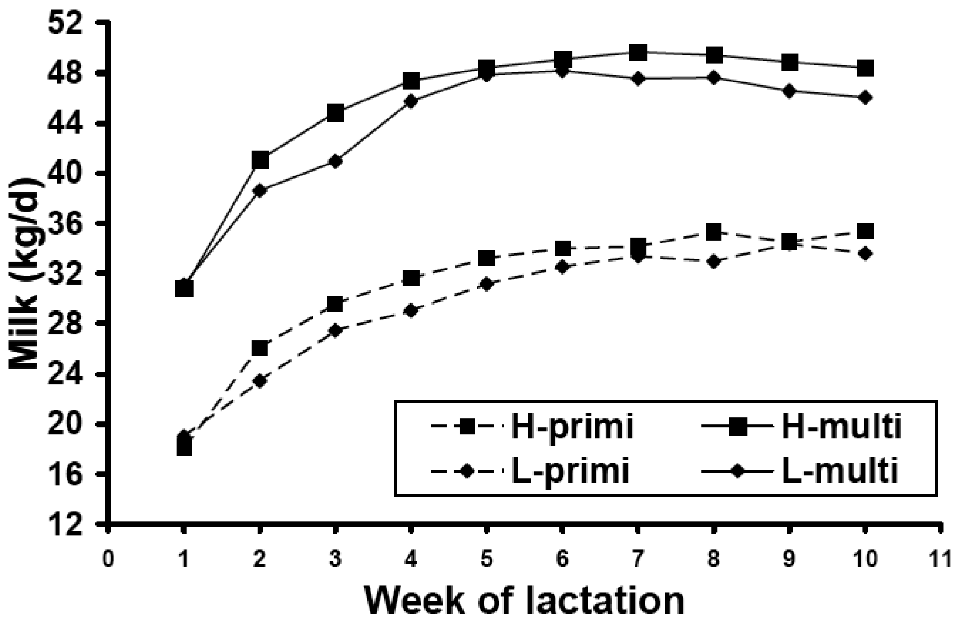

Figure 1. Milk yield of cows fed diets containing 1.67 (Low - L) or 1.74 Mcal NE_l/kg DM (High - H) for the first 3 wk after calving. After that, all cows were fed H (Rabelo et al., 2003).

Cows fed a 25 % concentrate (barley-based) diet during the dry period were continued on that diet after calving or were fed a 75 % concentrate diet (Anderson et al., 2003). Neutral detergent fiber content of the low and high concentrate diets was 35.0 and 34.6 %; starch content was 17.8 and 26.7 %. Dry matter intake (**DMI**) for the first 8 wk postpartum tended to increase for cows fed the high concentrate diet (17.3 vs 16.3 kg/d) and milk (40.2 vs 34.1 kg/d) and energy-corrected milk yields (39.4 vs 35.0 kg/d) were increased. Cows fed the high concentrate diet lost less body condition.

Nelson et al. (2011) formulated three iso-energetic lactation diets that were low (**L**-21.0 %), medium (**M**-23.2 %), or high (**H**-25.5 %) in starch. Two feeding periods were defined: 0 to 21 d postpartum and 22-91 d postpartum. Cows were assigned to one of three treatment schemes: L for entire 91-d period (**LL**), M for the first period and H for the second (**MH**), and H for the first period and H for the second (**HH**). Dry matter intake was greatest for cows fed LL (25.2 kg/d), lowest for cows fed HH (23.7 kg.d) and intermediate for cows fed MH (24.9 kg/d). Milk yield was greatest for cows fed MH (49.9 kg/d), lowest for cows fed HH (44.2 kg/d) and intermediate for cows fed LL (47.9 kg/d). The researchers suggested diets containing less than 23 % starch can be fed successfully to early lactation cows as long as energy density of the diets was not altered.

Direct inclusion of 4 % corn starch by replacing barley silage increased DMI (18.4 vs 19.2 kg/d) and milk yield (35.8 vs 38.3 kg/d) for the first 70 days in milk (**DIM**), but the means were not significantly different (Dyck et al., 2001). Milk components were not affected by treatment.

Processing grains can result in greater rumen fermentation of the starch granules. Cows fed steam-flaked corn for the first 63 DIM tended to have lower DMI (19.3 vs 20.9 kg/d) but higher milk production (45.2 vs 43.0 kg/d) than cows fed cracked corn (Dann et al., 1999). Fat-corrected milk yield was not different between treatments due to a tendency for lower milk fat from cows fed steam-flaked corn (3.27 vs 3.53 %). Testing the HOT, Rockwell and Allen (2011) fed dry corn or more highly fermentable high moisture corn for the first 28 d postpartum. After that, a common diet was fed. Dry matter intake was not affected during the treatment period. Milk yield was increased through 42 DIM by feeding high moisture corn (57.0 vs 48.0 kg/d) but that advantage was gone by 84 DIM. Steam-flaked sorghum or steam-rolled corn was fed at 39 % of diet DM from 5 to 50 d postpartum to examine if fermentability of starch could influence early lactation performance (Santos et al., 1999). Starch hydrolysis *in vitro* for 30 min was 67 or 47 % for the steam-flaked sorghum and steam-rolled corn. Cows tended to eat more (20.1 vs 19.1 kg DM/d) when fed the steam-flaked sorghum, but milk production and components were not different.

Speculating that feeding sugar would stimulate intake and fresh cow performance, Penner and Oba (2009) replaced cracked corn (4.8 % of diet DM) with a sugar/urea/canola oil blend for the first 28 DIM. This reduced starch in the diet from 20.6 to 18.5 % and increased sugar content from 4.5 to 8.8 %. Feeding sugar increased DMI (18.3 vs 17.2 kg/d), but the increase in milk yield was not significant (34.4 vs 33.0 kg/d). Milk components were not affected. In contrast to what the authors expected, rumen pH was improved by feeding the sugar. Blood BHBA was increased 67 % by feeding sugar. Although not measured, this may have reflected greater butyrate production in the rumen.

Adin et al. (2009) replaced forage (corn silage and vetch hay; 14.5 % of DM) with soybean hulls to increase NDF digestibility and hopefully increase feed intake of fresh cows. The NDF content of the diet was reduced from 18.7 to 12.8 % and NDF digestibility was increased from 61.7 to 65.4 % by the inclusion of soybean hulls. Feeding soybean hulls for the first 90 DIM increased DMI (26.9 vs 25.1 kg/d) and milk yield (52.1 vs 48.5 kg/d) but did not affect milk components.

Health and Reproduction?

Incidences of heath disorders and most key reproductive measures (e.g. first service conception rate or percent pregnant by 150 DIM) are binomially distributed. In other words, they are measured as yes or no. When that is the case, large numbers of animals are needed to obtain sufficient statistical power to detect treatment differences. The studies cited above did not have sufficient replication to assess these types of variables. Consequently, important questions regarding postpartum energy feeding remain. There is evidence that feeding diets which stimulate propionate production in the rumen and insulin levels in blood may hasten the resumption of ovarian cyclic activity and that the response may be independent of energy balance (Gong et al., 2002; Garnsworthy et al., 2009; van Knegsel et al., 2007). Likewise, fat supplementation may enhance reproductive performance and the response seems to be independent of energy balance and may be related to the provision of key fatty acids (Santos, 2008).

Conclusions - Energy

From the limited amount of research available, it appears that early lactation cows respond with more milk production when energy density of the diet is increased by increasing NFC and decreasing NDF (Anderson et al., 2003; Rabelo et al., 2003, 2005). In general, other strategies to increase energy availability to the early postpartum cow (e.g. increase starch content, increase starch fermentability, increase NDF digestibility) have not had negative effects on intake or lactation performance and in many cases have had positive effects (Dann et al., 1999; Adin et al., 2009; Rockwell and Allen, 2011). The one exception is the trial by Nelson et al. (2011) in which lowering starch content for the first 21 d postcalving, while maintaining NE_l/kg DM, improved feed intake and milk yield. Early postpartum transition cow trials examining diets with differing capacities to produce propionate in the rumen do not provide sufficient evidence to support the HOT. Trials examining the effects of postpartum diets on health and reproduction are lacking. Based on indirect evidence such as feed intake and milk yield responses, it seems unlikely that diets designed to increase energy availability to the early postpartum cow are having negative effects on animal health. There is some evidence that diets which favor propionate production may enhance the insulin status of cows and favor earlier return to ovarian cyclicity.

With the caveat that more research is needed, at this time there is little evidence that we should *hold back* cows and feed them a lower energy density diet immediately postpartum before moving them to a *high group* diet. It is important to remember that NEB is more closely related to DMI than milk yield. Some may argue that with increasing use of low energy diets for the entire dry period and the absence of a pre-fresh transition diet, there should be a post-fresh transition diet. That hypothesis has not been tested. Additionally, all the research trials cited above employed a TMR. Conclusions from these studies may not apply when feeding management deviates from that, e.g., feeding concentrates separate from forage.

PROTEIN

Background

Similar to energy, protein intake during the first 3 wk post-calving will be insufficient to meet requirements for milk production due to low feed intake. The cow responds to this by mobilizing protein, but the amount is not sufficient to meet requirements. Although the NRC (2001) provides an estimate of how much protein the cow mobilizes with body weight loss, it does not specify how much of the reserve is oxidized for energy, converted to glucose, or serves as an amino acid precursor for milk protein synthesis. In fact, when the NRC estimates body weight loss to support lactation, it assumes the mobilized protein is being used as energy. In contrast to energy, density of protein in the diet can be increased to reduce metabolic stress associated with mobilizing reserves. If protein content of the post-fresh diet is increased and is no longer a bottleneck for milk production, how will the cow respond? Will energy become limiting such that the cow will not respond? Will she mobilize more fat to facilitate greater milk production? Perhaps she will increase intake? Because of financial and environmental concerns, there is increasing pressure to decrease crude protein (**CP**) in diets fed to lactating cows. Is that a wise move for post-fresh transition cows?

We know milk production and DMI varies greatly among early postpartum dairy cows. This may be due to genetic variation among cows, differences in parity, and perhaps differences in breed. If we attempt to feed early postpartum dairy cows lower levels of CP and metabolizable protein (**MP**), do we balance rations based on the lowest levels of milk production and DMI, the highest levels, or somewhere in between? Or do we balance for the lowest level of intake matched with the highest level of production? Doing so could greatly increase ration costs; however, if high producing cows are held back because of an underbalanced diet, the lost benefits in milk production, health, and reproduction may far outweigh the increase in ration costs. In contrast, if diets are balanced based on highest intakes and lowest levels of production, then many fresh cows having low intakes relative to production may experience low milk production and health and reproduction may suffer. Perhaps the best solution is to create an immediate post-fresh group even if it's only for cows less than 2 wk into lactation. This should maximize the likelihood of meeting the protein needs of the early postpartum cow that is limited on intake, yet still capable of producing large amounts of milk. Unfortunately, there is little research on which to base protein recommendations for post-fresh transition cows; therefore, much of the discussion below will be conceptual in nature.

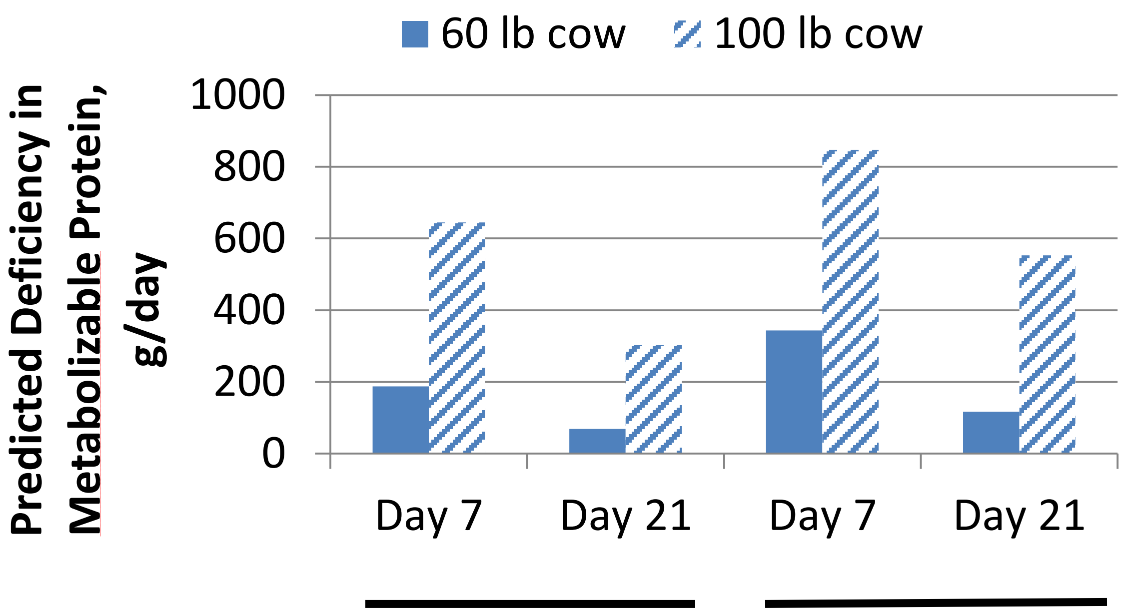

Figure 2. Estimates (NRC, 2001) of potential deficiencies in MP when feeding a 15.7 or 17 % CP diet to cows producing 60 or 100 lb of milk. Dry matter intakes of cows were estimated according to NRC (2001).

Postpartum Protein Status and Supplementation

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 2 shows the potential for a negative MP balance for cows producing 60 or 100 lb 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 17.0 % CP. Rumen degradable protein (**RDP**) content of the diets was adequate. The NRC (2001) provided estimates for DMI and MP balance. A few important points: Assuming NRC (2001) predictions are correct, the 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. 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 below the inputs (60 or 100 lb) used for this NRC simulation.

Most studies examining protein or amino acid supplementation of early lactation cows have started treatments beyond the post-fresh transition period. In several studies, treatments started prepartum and continued postpartum. Interpretation of results from these studies is difficult because any positive effects of increasing protein feeding postpartum may have been offset by feeding too much protein prepartum (NRC, 2001). For example, Socha et al. (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 et al. (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 (**RUP**; 14 % CP diets with 33.6 vs. 41.4 % of CP as RUP).

The concept of supplementing rumen protected (**RP**) amino acids to improve MP balance and quality and reduce dietary CP should be as applicable to transition cows as those later in lactation. Beginning 21 d prior to expected calving date, Ordway et al. (2009) fed heifers and mature cows a basal prepartum diet containing 13.8 % CP (diets averaged 1200 g/d of MP with an average MP balance of 313 g/d according to NRC (2001) predictions) with either no additional RP-methionine supplementation (control) or with additional RP-methionine supplied by MetaSmart® or Smartamine® M (Adisseo, Antony, France) in amounts required to generate a 3 to 1 ratio of metabolizable lysine to 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 RP-methionine, suggesting that cows did benefit from an improvement in amino acid supply as the ratio of metabolizable lysine to methionine was improved to a 3:1 ratio, even on a relatively low CP ration.

Socha et al. (2005) supplemented RP methionine and RP methionine + lysine for cows receiving a basal diet containing 15.6 % CP beginning 14-d prepartum and cows continued on their respective amino acid treatments for 105-d postpartum when receiving either a 16 or 18.5 % CP diets. There was no difference between RP amino acid supplemented cows receiving a 16 or 18.5 % CP diet; however 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 nitrogen into milk nitrogen than cows on the 18.5 % CP diet. This 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 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. 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.

Conclusions - Protein

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 post-fresh pens and formulating diets for cows in these 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 while providing high quality RUP sources along with encapsulated lysine and methionine sources to more efficiently meet the MP-Lys and MP-Met requirements of the animal. 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 because intake is generally limiting during this time period. Providing the most nutrient dense ration possible will ensure that every bite the cow consumes will provide her with the maximum amount of nutrients. In addition, there may be significant merit in creating an immediate post-fresh group (< 21 DIM) to better meet the nutrient needs of this critical time period. If this is not possible, then perhaps it is best to balance rations based on low estimates for intakes and high estimates for milk components and production.

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