Energy Levels in Transition Diets –Enough But Not Too Much

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Abstract

Dry matter intake may decrease 10 to 30% during the period three weeks prior to calving. During the last 3 weeks prior to calving it is recommended that the energy density be in the range of 1.5 to 1.6 Mcal NE_L/kg dry matter (DM), crude protein (CP) in the range of 13-14%, nonfiber carbohydrate between 33 and 38% and neutral detergent fiber (NDF) 32-50%. More information is needed regarding the metabolizable protein and energy needs of the fetus, placenta, fetal fluids, uterus and mammary gland during the dry period. Proper formulation of rations for protein, energy density, fiber and nonforage fiber carbohydrates will help to increase intake prior to calving. Management of body condition and cow comfort are also critical to assure an excellent transition program.

Introduction

The transition period for dairy cows is generally defined as the time period from three weeks prior to parturition through three weeks after parturition. It is now recognized that defining and meeting the nutritional requirements of the transition dairy cow can greatly impact animal health, production in the ensuing lactation, overall longevity, and animal well-being.[48] Nutrition and management during the transition period influence the profitability of the cow for the rest of her lactation. An inadequate transition program may result in cows having inconsistent feed intake after calving, and metabolic diseases during the transition from dry period to early lactation. Inadequate nutrients provided to the transition cow can result in increased costs for veterinary treatment and loss of production potential. Problems during the transition period often result in the loss of 10 to 20 lb (4.5 to 9.1 kg) of peak milk, which translates into economic losses up to $600 for that lactation. To maximize productivity and ensure successful reproduction, rations fed during this time need to be nutrient dense and allow for proper transitioning of the diet to the lactating cow ration. Maximizing prepartum and postpartum dry matter intake (DMI) is an important key to successful transition cow management.

Metabolic changes that occur during the transition period

It is helpful to understand the metabolic events that occur during the transition period in order to implement nutritional management recommendations.[11,19] Concentrations of progesterone in blood decrease and those of estrogen increase as parturition nears.[22] High circulating estrogen is believed to be one major factor that contributes to decreased DMI around calving.[21] During the last weeks of pregnancy, nutrient demands of the fetus and placenta are the greatest of any point during gestation.[5] However, DMI may be decreased 10 to 30% during the period three weeks prior to calving. After calving, the initiation of milk synthesis and rapidly increasing milk production greatly increases demand for glucose for milk lactose synthesis, at a time when feed intake has not reached its maximum. Dairy cows rely almost exclusively on gluconeogenesis (synthesis of glucose) from propionate in the liver to meet their glucose requirements. Limited feed intake during the prepartum and early postpartal period will result in a reduced supply of propionate for glucose synthesis. Amino acids from the diet or from breakdown of skeletal muscle, as well as glycerol from mobilized body fat, contribute some carbon for glucose synthesis. Supplying adequate glucose for milk synthesis at the time of calving is a tremendous metabolic challenge to cows during the transition period.[12]

Nutrient requirements for pregnancy

Dry cows require nutrients for maintenance, growth of the conceptus and perhaps growth of the dam. Estimation of the nutrient requirements for pregnancy by the factorial method requires knowledge of the rates of nutrient accretion in conceptus tissues (fetus, placenta, fetal fluids and uterus) and the efficiency at which dietary nutrients are utilized for conceptus growth.

There are limited data for dairy cattle. In the mature cow carrying a single fetus, maintenance accounts for at least 60% of the total requirement for energy and most specific nutrients. Conceptus growth may account for about 25% of the total energy requirement.[47,64] Requirements for mammogenesis and prepartum lactogenesis are relatively small in multiparous cows, but more significant in first calf heifers.[36] Requirements for maternal tissue reserves for mature cows should be small as replenishment of body fat and labile protein lost in early lactation should be almost complete by dry-off.[5]

Efficiency of utilization of metabolizable energy for conceptus growth based on several studies is low at approximately 13%.[4] There is a very high energy cost of metabolism in the placenta, a tissue which grows little but is highly active during late pregnancy. If the factor of 13% is applied the derived value of 5 Mcal/d for a 1540 lb (700 kg) cow delivering a 100 lb (45 kg) calf is almost identical to that proposed by the National Research Council (NRC).[47] Moe and Tyrrell,[44] using calorimetry data, observed that the efficiency of energy capture by the gravid uterus may decrease as pregnancy advances. In addition, previous estimates did not include energy requirements if tissue gain by the mammary gland incurred an energy cost. Vandehaar *et al*[61] calculated that prepartum mammary gland development might require an additional 3 Mcal NE_L/d, increasing NRC[47] requirements for metabolizable energy to as high as 9 Mcal/d.

Dietary energy to protein relationships

Strategies that have increased plasma glucose concentrations in late gestation have resulted in reduced concentrations of plasma non-esterified fatty acids (NEFA), ß-hydroxybutyric acid (BHBA) and liver fat and triglycerides.[59] Based on previous research in our laboratory,[53] increasing the supply of protein during late gestation may increase glucose concentrations by providing glucogenic precursors. Glucose concentrations were highest for cows provided a 14.5% crude protein (CP) diet, however this did not effect milk yield or component yields. We further investigated the use of higher protein levels in the diet and found no effect on glucose concentration in blood (13.3 vs 17.8% CP in diet DM). Both the 12.7% CP diet in the previous study, and the 13.3% CP diet in the latter study, provided similar amounts of protein (1422 vs 1370 g/d), while actual intake of CP from the 14.5% CP diet in the previous study, and the 17.8% CP diet in this study, were 1639 and 1878 g/d, respectively. Caloric intake was similar across treatments in both studies, which created a range in energy: CP ratios (Mcal: kg CP). While the groups consuming approximately 1400 g/d of CP had energy to CP ratios approximating 12:1, diets providing 1639 g/d CP had a ratio of 10.6:1, and the group consuming 1878 g/d CP (17.8% CP) had a ratio of 8.8:1. Glucose responses to dietary protein supplementation in late gestation may be limited in part by the availability of energy relative to the energetic costs associated with nitrogen excretion.

Vanderhaar *et al*[61] studied whether nutrient density in prepartum diets improved nutrient balance in peripartum cows. Four diets ranged from 1.30 to 1.61 Mcal NE_L/ kg and 12.2 to 16.2% CP. Energy to protein ratios ranged from 8.6:1 to 10:1. When evaluated using the Cornell Net Carbohydrate and Protein System (CNCPS) model,[17] only the low-protein low-energy treatment was negative in metabolizable protein needs. In addition, the low energy to protein ratio more than likely forced some animals to inefficiently utilize protein as an energy source, thereby confounding the effects of the treatments in terms of energy needs of the prepartum cows in that study.

Energy needs of the transition cow

Carbohydrate metabolism in the early postparturient cow is dominated by the massive requirement for glucose, mostly for lactose synthesis. The challenge posed for liver and other nonmammary tissues comes sharply into focus when the estimated glucose uptake of ~1,800 g/d at day 4 of lactation is compared with the estimated supply of dietary glucose precursors (propionate and amino acids). Even assuming that all of the absorbed propionate and amino acids (minus requirement for milk protein) are available for glucose synthesis, these substrates could account for at most, about 1,200 g/d of glucose equivalents, equivalent to no more than two-thirds of the mammary glucose requirement, to which must be added the mandatory glucose requirements of other tissues, such as the brain.[5] Glycerol and lactate will make up part of the shortfall in glucose precursors.

Energy intake is determined by the amount of dry matter consumed and the energy density of the diet dry matter. The NRC[47] recommendations for energy density of diets fed to dry cows is 1.26 Mcal NE_L/kg. Dry matter intake can decrease as much as 30% three weeks prior to calving; intake may be as high as 33 lb/d (15 kg/d) at three weeks before calving to approximately 22 lb/d (10 kg/d) the week to last few days before calving. Therefore a constant recommendation of 1.26 Mcal NE_L/kg of diet DM would not be adequate, especially the last week prior to calving for most mature cows. Grummer[23] demonstrated that to meet the energy needs for first calf heifers, energy density of the diet would have to be increased almost 30% over current NRC[47] recommendations (Figure 1). In order to acclimate cows to the lactation diet and to adequately meet the needs of all groups of animals, higher density ra-

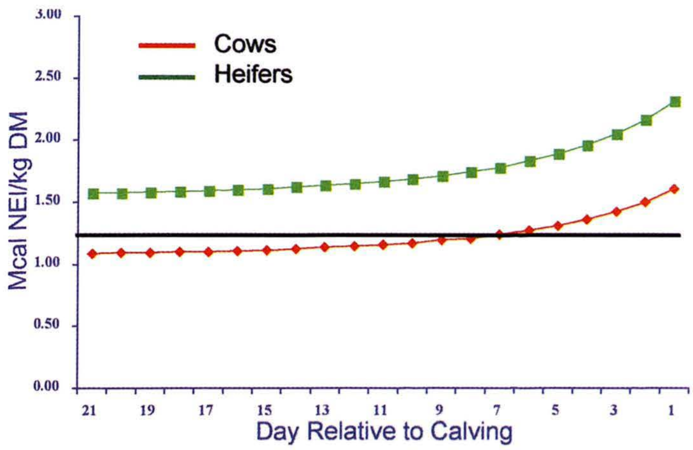

Figure 1. Energy needs of dry cows and heifers.[45]

tions need to be fed.

Diets that are easily degraded by the ruminal microorganisms generally result in the production of more propionic acid. Approximately 80% of propionic acid that is presented to the liver is metabolized to glucose. In order for high rates of gluconeogenesis to be maintained prepartum, highly fermentable carbohydrate sources need to be fed. This may protect the cow from fatty acid infiltration of the liver as well as ketosis in the first few weeks postpartum. In addition, feeding diets prepartum that are higher in nutrient density may enhance feed intake. Feeding diets higher in fermentable carbohydrates during the prepartum period may acclimate the microbial population to the postpartum diet, promote ruminal papillae development, increase absorptive capacity of the rumen epithelium and reduce lipolysis by increasing glucogenic precursors. Dirksen *et al*[10] demonstrated that a decrease in fiber in the prepartum diet promoted development of the ruminal papillae and increased the capacity for VFA absorption. These researchers speculated that development of papillae was essential to minimize VFA accumulation, to minimize a decline in pH, and reduce the occurrence of acidosis when fresh cows were fed high grain diets postpartum. Dann *et al*[8] showed that cows fed steam flaked corn vs dry cracked corn had reduced NEFA prepartum and improved DMI prepartum. The main effects of postpartum health and production were not affected by prepartum rations, however milk yield was higher for cows fed steam flaked corn diet from six to thirteen weeks into lactation.

Does ruminal capacity affect prepartum intake depression?

The fermentative capacity of the rumen has not been characterized adequately through the dry period to lactation. Understanding the dynamics of rumen digestion is critical to developing a mechanistic approach to predicting the nutritive value of feeds for transition dairy cows. During late gestation it has been thought that cows reduce dry matter intake as a consequence of constraints in rumen fill and digestion. This reduction in intake results in the mobilization of body fat and energy stores and to meet tissue energy demands. The combination of these factors often leads to fatty liver and other problems. Increasing the supply of glucogenic precursors, such as propionate, act to minimize the negative impact of reduced feed intake during this period.[8] Likewise increasing the energy density of diets for late-gestation dairy cows reduces fatty liver and improved lactation performance.[43] However, diet modifications that increase energy density through inclusion of rapidly fermentable carbohydrates, such as starch, may increase the incidence of displaced abomasums and acidosis as well as result in over conditioned cows.

Hartnell and Satter[27] demonstrated that there were no differences in ruminal fill, digesta capacity or ruminal retention time in prepartum vs postpartum dairy cows. Park *et al*[50] most recently demonstrated, by measuring ruminal water holding capacity at various times prepartum and postpartum, that physical capacity of the rumen during this time period does not contribute to prepartum intake depression. It becomes very clear as more information of this nature becomes available that to some extent the role of physical constraints has been overemphasized in ruminants, and that metabolic and endocrine changes in late pregnancy and early lactation play an important role in prepartum intake reduction.[35] Actually this intake reduction prepartum is not unique to ruminant animals. This also occurs in rats offered a nutritious diet, even though food consumption was substantially less than what would be expected as their physical capacity.[51] Some researchers have actually demonstrated that hypophagia may play an important role in early host defense mechanisms.[45] It is known that during infections cytokines are released that may severely reduce intake. Additionally, feedback signals from the oxidation of NEFA are speculated to down regulate intake in late pregnancy and early lactation when mobilization is high.[34] We have shown that cows have higher NEFA in blood at the same time as feed intake is reduced, and the effect is similar whether this occurs prepartum or postpartum (Figure 2).[60] Before trying to improve feed management, it might be important to get a better understanding of intake regulation in the periparturient animal.

Ruminal fermentability of carbohydrates

Feed intake for cows in early lactation is limited by physical fill. Feeding fiber sources that are digested and passed through the rumen more rapidly may en-

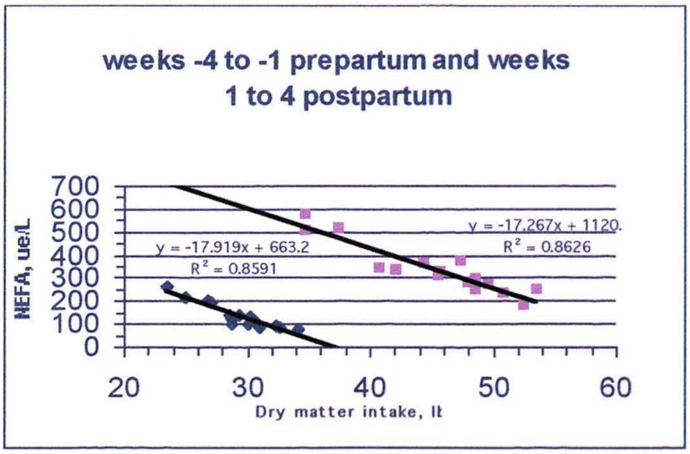

Figure 2. Effect of NEFA concentrations on DMI prepartum and postpartum[54].

hance energy intake. For every unit increase in fiber digestibility, Allen and Oba[3] demonstrated that there was a 0.51 lb (0.23 kg) increase in DMI and a 0.53 lb (0.24 kg) increase in milk yield. Poorly digested, high fiber feedstuffs typically depress DMI as a consequence of indigestible material occupying space in a rumen of limited capacity.[41] Some fibrous feeds, such as cottonseed hulls (CSH), do not depress intake in the same fashion as other high fiber, relatively indigestible feeds.[1,24,25,26,63] Providing a highly fermentable nonforage fiber sources (NFFS), such as CSH, may increase the rate of passage through the rumen of the transition cow and thereby permit her to consume more feed. On relatively low (40% of dry matter) roughage diets, intake increased curvilinearly when CSH were substituted for sorghum silage in diets of 10 lactating Holstein cows[2]. It is interesting that although intake of the non-CSH portion of the diet seemed to decline after the 8% level of CSH, concentrate intake increased with increasing CSH inclusion.

There is quite a range in ruminal fiber digestibility of forage and grain sources (13.5 to 78%). Although fiber digestibility of forages is not constant for all animals and feeding conditions, much of this variation is due to composition and structural differences of the forages, harvest date and height at harvest. The indigestible fraction of neutral detergent fiber (NDF) is a major factor affecting the utilization of fiber carbohydrate sources as it varies greatly and may exceed more than one-half of the total NDF in the rumen. In a study by Huhtanen and Khalili,[32] a negative relationship between the *in vivo* digestibility of cell wall carbohydrates and the corresponding pool size was demonstrated. They found that as fiber digestibility in the rumen increased, total grams of NDF and digestible NDF decreased at a similar rate, while the indigestible NDF fraction declined at a slower rate.

Alternatively, dietary factors that promote decreased cell wall digestion in the rumen by affecting the rumen environment increase the ruminal pool size of cell wall components, especially of the digestible fraction. This can reduce fiber DMI when ruminal fill limits intake, such as in early lactation. For example, at higher levels of fiber in the diet (55% NDF), there is almost one-half the amount of indigestible fiber residue for grass hay versus alfalfa hay.[57] Although information on the size of the indigestible fiber fraction of some forage sources is available, information is still needed on other NFFS as well as on the portion of the potentially digestible fraction that is actually digested.

Dry matter intake of dairy cows can be limited by physical fill in early lactation. Providing a highly fermentable NFFS may increase rate of passage through the rumen and thereby provide the cow the opportunity to consume more feed. Recent studies[49] demonstrate that feeding a diet containing NFFS resulted in prepartum DMI that were 20% greater than previous studies conducted (Table 1), and was 4.4 to 11 lb/d (2 to 5 kg/d) greater than many reports in the literature.[8,20] Additional work indicates that byproduct feeds, particularly soyhulls and CSH, can be substituted for forage fiber without negative consequences on rumination

Table 1. Average dry matter intake 4 weeks prepartum.

Reference	n	DMI kg/d	NEL,Mcal/kg
Dann *et al*, 1999	65	14.1	1.60
Greenfield *et al*, 2000	38	11.7	1.50
Hartnell and Satter, 1979	4	10.8	
Hartwell *et al*, 2000	44	12.4	1.63
Huyler *et al*, 1999	31	10.7	1.34
Minor *et al*, 1998	50	11.6	1.50
Wu *et al*, 1997	24	14.9	1.52
Vallimont *et al*, 2001	63	12.6	1.54
VandeHaar *et al*, 1999	40	11.7	1.42
Ordway *et al*, 2001	34	16.3	1.53

activity. Because prepartum intake is correlated with postpartum intake[53] and milk production is directly related to feed intake, it is critical to devise feeding strategies for transition dairy cows that help to avoid, or minimize, the natural tendency for feed intake depression just prior to calving. Doing so assures that the cow will begin lactation with minimal risk of developing health disorders and will maximize milk production. A strategy to reduce fiber in the diet of late gestation dry cows derived from poor quality silages and long stemmed hay in favor of highly fermentable byproduct feeds appears logical. These rations are likely to be more uniform in chemical composition, more predictable in their fermentation characteristics, more readily consumed by transition dairy cattle and more universally applicable.

How long does it take for animals to adapt to dietary changes?

Approximately 5 weeks are required to change the physiological set point of ruminant animals in response to alterations in nutritional status.[38] Rumen, intestines and liver size are significantly less 3 weeks prepartum compared with 3 weeks postpartum[55] and blood flow through the portal drained viscera is positively correlated with energy intake.[30] Koong and Ferrell[39] demonstrated that fasting heat production could differ up to 40% for animals of the same age and weight, but with different nutritional backgrounds. Huntington *et al*[31] demonstrated the oxygen consumption by the portal drained viscera, as a percentage of whole animal oxygen consumption was 4% greater for orchardgrass silage compared to alfalfa silage. Finegan *et al*[15] most recently demonstrated a role for the gastrointestinal tract contributing to higher thermogenesis observed in ruminants fed forage as opposed to concentrate diets. Taken together these data suggest a minimum of 5 weeks of feeding may be required to establish a new metabolic plateau for liver and intestinal tissues in response to diet. Therefore, the duration of feeding a nutrient dense diet may dictate the adaptive response in gut and liver and their capacity to meet the demands for milk production in the ensuing lactation.

There are many physiological challenges prepartum where we clearly lack adequate information to help guide us in nutritional strategies during the transition period. These include the importance of acclimation of microbial populations to the lactating cow diet, maintaining microbial protein synthesis, assuring maximal absorptive capacity of the ruminal epithelium, liver and gut function set points, quantity of adequate glucogenic precursors, and the additional nutrient needs to meet the demands for protein and energy for growth of the mammary gland.

Evaluation of diets and level of feeding

Mashek and Beede[40] reported no relationship between the time cows were on a close up dry cow diet and milk production. In a trial feeding a 60:40 (DM basis) of grass silage with barley straw *ad libitum*, grass silage *ad libitum*, or 1.1 lb/d (0.5 kg/d) of prairie meal with grass silage *ad libitum* for six weeks prior to parturition, no effect of diet on milk yield was observed.[9] Holcomb *et al*[29] fed diets high (70%) or low (28%) in forage, either restricted or *ad libitum*, for four weeks prior to parturition and reported no significant effects of forage percentage during the prepartum period on milk yield. VandeHaar *et al*[61] fed diets varying in both protein and energy for 25 days prior to parturition and again reported no effect of diet composition on milk or component yield during lactation. Keady *et al*[37] supplemented grass silage-based diets with 0 or 11 lb/d (5 kg/d) of concentrates for four weeks prior to calving and found no effect of treatment on milk and milk protein yield, while milk fat increased significantly with concentrate feeding. Holcomb *et al*[29] reported no advantage of high dry matter intakes prepartum versus restricted diets on milk production. Van Den Tep *et al*[62] fed diets restricted to the 1989 NRC energy requirements (15.4 lb; 7 kg/d) or *ad libitum* (45.3 lb; 20.6 kg/d) for ten to fourteen weeks. Milk production one week postpartum was not different, however production from weeks 2 to 12 postpartum was higher in the restricted cows, but differences were not significant. These studies provide little evidence that close up dry cow diets will promote increased production after calving. In addition, many of these dietary changes were made 3 to 4 weeks prepartum, likely inadequate time for the animal to adjust to a new physiological set point.

Effect of body condition

The outcome of prepartum diet is more likely its effects on metabolic disease, which is much more difficult to measure unless hundreds of animals are evaluated. Heavier cows experience a greater decrease in DMI prior to calving than do cows of thin body condition. In situations in which cows are fat at dry-off, restricting intake during the prepartum period would be beneficial to avoid accumulating more body condition. However there may be increased risk for metabolic disorders after calving such as ketosis, displaced abomasum and fatty liver. It is clear that over conditioned cows (>4.0 on a 5.0 scale) have reduced intake after calving and are more prone to fatty liver disease and ketosis.[16] A body condition score between 3.5 and 3.75 appears to be a suitable compromise between adequate and excessive body condition.[58] However, a recommended average of 3.5 to 3.75 would still mean some cows would have a BCS of 4.0. In a well managed high producing herd, Waltner *et al*[65] found that FCM in the first 90 days of lactation was maximized when body condition score was 3.5 at calving. Putnam and Varga[53] demonstrated that cows with BCS > 3.25 prepartum had higher NEFA and BHBA concentrations, and produced 5.5 lb (2.5 kg) less milk the first 30 days of lactation than cows with BCS < 3.25. In a study conducted by Michelone *et al,*[42] prepartum NEFA concentrations averaged 151.8 ± 18.3 μeq/L and BCS averaged 3.28 ± 0.08. In a study by Putnam *et al,*[54] NEFA concentrations averaged 388.5 ± 71 μeq/L and BCS averaged 3.68 ± 0.11. Incidence of subclinical and clinical ketosis was 20% in the study by Putnam *et al,*[54] and 2% in the study conducted by Michelone *et al.*[42] Both of these studies were conducted at intake restricted to 1.5% of BW, and cows were fed similar diets, indicating that body condition was critical in predisposing the fatter cows to metabolic disease.

Challenges to current dry cow feeding and management concepts

Practical decisions made regarding feeding cows during the dry period are simple: 1) The cow is not lactating, therefore she does not need a nutrient dense ration as when she is lactating. However, during the last 6-8 weeks prior to calving, the fetus is growing at its most rapid rate and has a tremendous demand for glucogenic precursors. It is also the time period that the cow is manufacturing immunoglobulins necessary for the calf at birth. It has been demonstrated that poor nutrition impacts the composition and quantity of immunoglobulins synthesized. The mammary gland, as discussed previously, also requires nutrients in preparation for lactogenesis. 2) Since the cow has reduced nutrient demands, we can feed her cheaper feed sources. It has not been demonstrated that all physiological aspects of the cow's nutrient demands are reduced during this time period. The cow is most immunocompromised at this time and exposure to mycotoxins and inconsistent nutrients as found in poor quality forages is least desired during this time period. 3) The dry cow can be brought to another facility, needs less oversight and therefore less labor. This is the time period when observation is critical, especially regarding body condition of the animal and her appetite. Physical facilities and cow comfort during this time period are critical. Buelow[6] demonstrated that dry cows are more sensitive to overcrowding; they observed an 11% decrease in DMI when numbers went from 88 to 93% of capacity in a headlock pen. 4) Use of a steam up ration 2-3 weeks prior to calving. Many times the lactating cow ration is used without attention to differences in mineral requirements between pre- and postpartum animals. In addition, as discussed previously, 2 to 3 weeks is not adequate time for liver and intestinal enzymes to adjust to the prepartum and postpartum rations.

Is an early and close up ration necessary for dry cows? Can a one group total mixed ration (TMR) be fed during the dry period?

Many producers are successfully feeding a one group TMR during the entire dry period. In a recently completed study,[49] we demonstrated that cows provided corn silage based rations, with a portion of the fiber coming from NFFS, had higher DMI prepartum in comparison to conventionally fed dry cows. Corn silage was the primary forage source (40% of ration DM), with approximately 20% of the ration DM coming from NFFS such as CSH, soyhulls and corn cobs, and the remainder from soybean meal, molasses, corn, distillers, vitamins and minerals. Cows consumed on average 6.6 lb (3 kg) more DM compared to the last five prepartum studies we have conducted feeding conventional dry cow rations (~65% forage) during the last 4 weeks prepartum. Cows were provided the ration the entire dry period, and did not gain any additional body condition compared to cows fed a conventional high forage ration. In addition, cows averaged 40 lb (18 kg) of DMI the first two weeks of lactation with minimal health problems, and peaked with an average of 101 lb (46 kg) of milk at 5 weeks postpartum. We have recently finished a pen feeding study with 36 animals, half of which were heifers, evaluating a conventional dry cow ration with one formulated to contain ~ 35% NFFS. All cows averaged 106 lb (48 kg) of milk the first 7 weeks of lactation, however, mature cows produced 6.6 lb (3 kg) more milk when provided the NFFS based ration prepartum and had less incidence of metabolic problems. The cost associated with feeding one ration throughout the entire dry period is easily offset when considering the costs associated with the treatment and lost production for one case of ketosis.

In any dry cow feeding program, it is critical that ration changes are not drastic. The fresh cow ration should be intermediate between the close up ration and the fresh group ration. A shift should not be greater than a 10% increase in any nutrient when transitioning cows prepartum to the lactating cow ration.[7] For example, if the prepartum ration is 1.55 NE_l Mcal/kg, then the immediate fresh ration should be no greater than 1.71 Mcal NE_l/kg DM. It is recommended that the dry cow ration have an energy density in the range of 1.5 to 1.6 Mcal NE_l/kg DM, CP in the range of 13-14%, NFC between 33 to 38% and NDF >32%.

Conclusions

Nutrition and management during the transition period are essential in determining the profitability of the cow for the rest of her lactation. Stimulation and maintenance of dry matter intake around calving is essential to ensure a high level of productivity and healthy cows. Proper formulation of rations for protein, energy density, fiber and nonfiber carbohydrates will help to increase intake around calving time. This should be combined with management of body condition, cow comfort and excellent quality forages to assure an excellent transition program for the high producing dairy cow.

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