Feeding Management Strategies for Dry Cows

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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 (NRC, 2001). Nutrition and management during the transition period are essential in determining the profitability of the cow for the rest of her lactation. An inadequate transition program may result in cows having inconsistent feed intakes 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 lbs. 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.

There are many excellent reviews detailing the physiological changes associated with the transition period (Block and Sanchez, 2000; Bell et al., 2000; Drackley et al., 2000; Ingvartsen and Anderson, 2000; Goff and Horst, 1997). This paper will examine various feeding management strategies that can impact the nutrient needs, overall management and health of the transition cow. It will focus on the practical aspects of nutritional management strategies for the cow during this very critical period of the lactation cycle.

Economic Impact

Feed related costs typically construe 50-70% of the costs of production on a dairy farm, while the costs associated with a single health problem often are never fully recovered. Because the transition period (three weeks prepartum to three weeks postpartum) has the most impact on health, production and reproduction, the greatest marginal return for an investment that improves dairy cow profitability will occur for changes made during this time. The transition to lactation underscores the importance of gluconeogenesis in ruminants as hypoglycemia, ketosis, and related metabolic disorders are often observed when gluconeogenic capacity fails to adapt to the increased demands for glucose to support lactose synthesis and mammary metabolism. Ketosis is accompanied by fatty liver and cows that develop fatty liver and ketosis have reduced feed intake, lower gluconeogenic capacity (Grummer, 1995), lower milk production, and an increased risk for developing other metabolic and infectious diseases (Curtis et al., 1985). It has been estimated that an incident of ketosis costs the dairy producer $140/cow in treatment costs. Given a ketosis incidence rate of 17% in US cattle (Gillund et al., 2001), a producer milking 120 cows would lose $2,520 annually to clinical ketosis. Subclinical ketosis costs approximately $78/case (Geishauser et al., 2000). Additional losses are realized through lost milk production potential. Reducing subclinical ketosis and fatty liver, such that cows produce a minimum of 0.5 kg more milk at peak lactation, would result in an additional $2,880 of income. In addition, ketosis increases the risk of developing other metabolic diseases such as displaced abomasum ($334/case; Shaver , 1997), retained placenta ($319/case; Enevoldsen et al., 1995), and mastitis ($200/case; Nickerson, 1991) and other metabolic problems. Clearly, feeding management strategies that reduce clinical and subclinical ketosis will directly benefit dairy farm profitability, enhance animal well being and improve cow longevity.

Factors Impacting Nutrient Needs Of The Transition Cow

Pregnancy

Protein. 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 in which dietary nutrients are utilized for conceptus growth. 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 (Van Saun and Sniffen, 1992; NRC, 1989). Little data is available that examines the interaction of maternal energy supply (amount and source) and protein utilization and subsequent requirement in pregnant dairy cows. Maternal hypoglycemia (arising from feeding either low energy dry cow diets or from feeding diets supplying insufficient amounts of glucogenic substrate) increases fetal utilization of amino acids for energy. This in turn decreases the efficiency of utilization of metabolizable protein for pregnancy. Dietary protein requirement is then increased due to the increased catabolic disposal of amino acids (Bell, 1995). Differences in net efficiency of fetal accretion of absorbed protein in pregnancy may result in an increase in dietary protein requirement. Bell (1995) has suggested that the efficiency may be as low as 0.33 and this value has been adopted by the NRC (2001). If 100 g/day is used as an estimate of net conceptus requirement, variations in efficiency can yield a range of metabolizable protein requirement from 154 g/day to 303 g/day. If an assumed efficiency of metabolizable protein yield from CP of 0.7 is used, at a DMI of 11 kg/day, the difference in these estimates translates into CP difference of 213 g/d, or a shift in dietary CP concentration of approximately ± 2% (Burhans, 1999).

Capuco et al. (1997) demonstrated that from -20 to -7 d prepartum mammary parenchymal DNA increased 50% and the mass of mammary parenchymal tissue increased from 14 to 20 kg or 460 g/d. If mammary tissue contains ~20% protein and assuming a 50% efficiency (NRC, 1996), then approximately 184 g of protein accretion per day is needed for mammary gland development. Therefore, as much as 50% of the metabolizable protein needs of the cow are required to meet needs of the conceptus and mammary gland for protein accretion.

Energy. Efficiency of utilization of metabolizable energy for conceptus growth based on several studies is low at approximately 13% (Bell, 1986). 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 700 kg cow delivering a 45 kg calf is almost identical to that proposed by NRC (1989). Moe and Tyrrell (1972) using calorimetry data observed that the efficiency of energy capture by the gravid uterus might 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. (1999) calculated that prepartum mammary gland development might require an additional 3 Mcal NE_l/d, increasing NRC (1989) requirements for metabolizable energy to as high as 9 Mcal/d.

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 (Dann et al.,1999). Likewise increasing the energy density of diets for late-gestation dairy cows reduces fatty liver and improves lactation performance (Minor et al., 1998). 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 (1979) demonstrated that there were no differences in ruminal fill, digesta capacity or ruminal retention time in prepartum vs. postpartum dairy cows. Park et al. (2001) 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

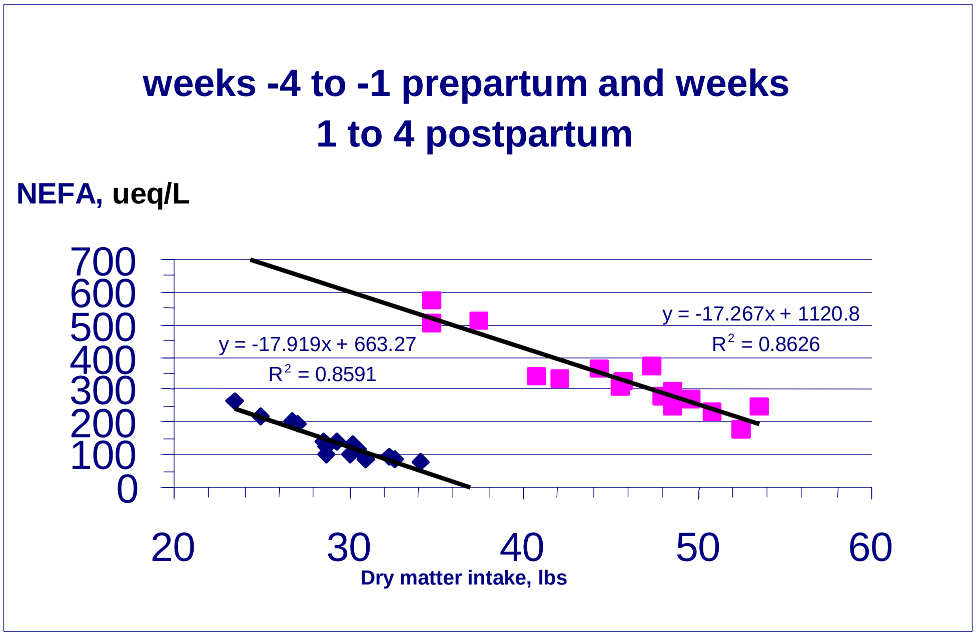

Figure 1. Effect of NEFA concentrations on DMI prepartum and postpartum (Vallimont et al., 2002).

prepartum intake reduction (Ingvartsen et al., 1999). 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 (Peterson and Baumguardt, 1976). Some researchers have actually demonstrated that hypophagia may play an important role in early host defense mechanisms (Murray and Murray, 1979). It is known that during infections cytokines are released that may severely reduce intake. Additionally, feedback signals from the oxidation of nonesterified fatty acids (**NEFA)** are speculated to down regulate intake in late pregnancy and early lactation when mobilization is high (Ingvartsen and Andersen, 2000). 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 1; Vallimont et al., 2002). 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 and feeding fiber sources that are digested and passed through the rumen more rapidly may enhance energy intake. For every unit increase in fiber digestibility Allen and Oba (1996) demonstrated that there was a 0.23 kg increase in DMI and a 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 (Mertens, 1993). Some fibrous feeds, such as cottonseed hulls (**CSH**), do not depress intake in the same fashion as other high fiber, relatively indigestible feeds (Harris et al., 1983; Van Horn et al., 1984; Adams et al., 1995; Gu et al., 1996; Gu and Moss, 1996). 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 (Akinyode et al., 1999). 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 (Figure 2).

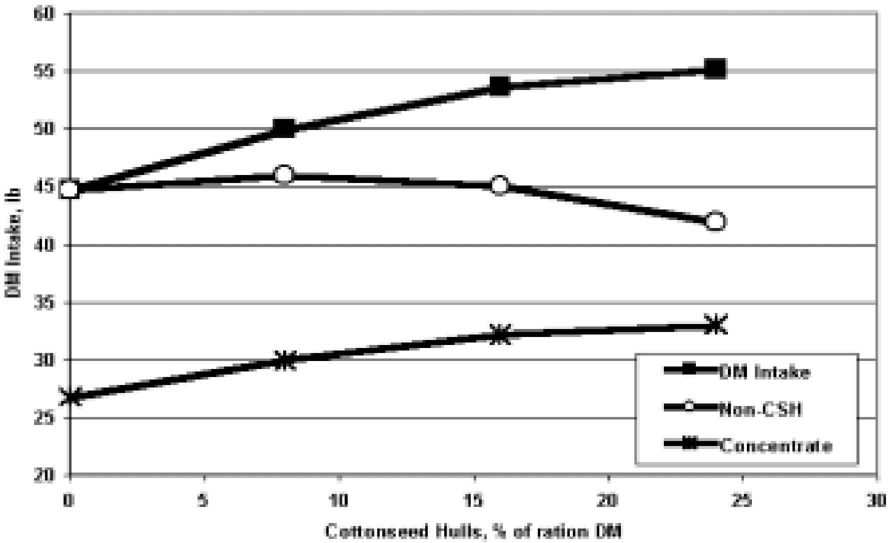

Figure 2. Effect of various levels of cottonseed hull inclusion in the ration on dry matter intake (Akinyode et al., 1999).

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 (1991) 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 (Shaver et al., 1988). 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 (Ordway, 2001) demonstrate that feeding a diet containing NFFS resulted in prepartum DMI that were 20% greater than previous studies conducted (Table 1) and was 2 to 5 kg/d greater than many reports in the literature (Dann et al., 1999; Greenfield et al., 2000). Additional work indicates that byproduct feeds, particularly soyhulls and CSH, can be substituted for forage fiber without negative consequences on rumination activity. Because prepartum intake is correlated with postpartum intake (Putnam and Varga, 1998) 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

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., 2002	34	16.3	1.53

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 (Koong et al., 1982). Rumen, intestines and liver size are significantly less 3 weeks prepartum compared with 3 weeks postpartum (Reynolds et al., 2000) and blood flow through the portal drained viscera is positively correlated with energy intake (Huntington, 1990). Koong and Ferrell (1990) 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. (1988) 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. (2001) 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.

Feeding Strategies and Management of Dry Cows

Evaluation of diets and level of feeding

Mashek and Beede (2001) reported no effect of duration cows were on a close up dry cow diet on milk production. In a trial feeding a 60:40 forage:concentrate (DM basis) of grass silage with barley straw ad libitum, grass silage ad libitum, or 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 (Dewhurst et al., 2000). Holcomb et al. (2001) 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. (1999) 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. (2001) supplemented grass silage based diets with 0 or 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. (2001) reported no advantage of high dry matter intakes prepartum vs. restricted diets on milk production. Van Den Tep et al. (1996) fed diets restricted to the 1989 NRC energy requirements (7 kg/d) or ad libitum (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 intakes 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 abomasums and fatty liver. It is clear that over conditioned cows (>4.0 on a 5.0 scale) have reduced intakes after calving and are more prone to fatty liver disease and ketosis (Fronk et al., 1980). A body condition score between 3.5 and 3.75 appears to be a suitable compromise between adequate and excessive body condition (Shaver, 1993). 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. (1993) found that FCM in the first 90 days of lactation was maximized when body condition score was 3.5 at calving. Putnam et al. (1998) demonstrated that cows with BCS > 3.25 prepartum had higher NEFA and BHBA concentrations, and produced 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. (1999) prepartum NEFA concentrations averaged 151.8 ± 18.3 µeq/L and BCS averaged 3.28 ± 0.08 in comparison to the study conducted by Putnam et al. (1999) where 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 of Putnam et al. (1999) and 2% in the study conducted by Michelone et al. (1999). Both of these studies were conducted at restricted intake to 1.5% of BW and 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 the body condition of the animal and her appetite. Physical facilities and cow comfort during this time period is critical. Buelow (1998) demonstrated that dry cows are more sensitive to overcrowding with 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 (Ordway et al., 2002) 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. These diets were based on corn silage as the primary forage source (40% of ration DM), approximately 20% of the ration DM coming from NFFS such as CSH, soyhulls, and corn cobs, with the remainder from soybean meal, molasses, corn, distillers, vitamins and minerals. Cows consumed on average 3 kg more DMI 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 18 kg of DMI the first two weeks of lactation with minimal health problems and peaked with an average of 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 48 kg of milk the first 7 weeks of lactation, however mature cows had 3 kg more milk when provided the NFFS based ration prepartum and 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 what is critical is 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 (Chandler, 1995). 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 along with management of body condition, cow comfort and excellent quality forages will assure an excellent transition program for the high producing dairy cow.

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