

Managing Energy Balance During the Transition Period

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Abstract

The period immediately prior to and following calving, is associated with extensive biological and logistical adaptations. During this time frame, cows and heifers must adjust to the physical and biological transition from pregnancy to lactation as well as environmental changes such as new rations (ingredient and energy density alterations) and pen relocation. In addition, cows in this transition phase characteristically secrete more energy (fat, protein and lactose) in their milk than they consume via the diet. As a consequence, animals experience a substantial negative energy balance (**NEBAL**), which is associated with an increased risk of metabolic disorders and health problems (milk fever, ketosis, fatty liver, displaced abomasums, etc.) as well as reduced reproductive performance (days to first service, conception rates, etc.). For decades the primary management method utilized to alleviate the magnitude of NEBAL was feeding additional energy in the form of either grains or fats. Unfortunately, the incidence and magnitude of NEBAL continues to be the primary issue surrounding transition period failures. Transition period failures are economically costly for producers. A decrease in milk yield combined with an increase in health care, labor and animal replacement costs can reduce or even eliminate potential net income. Recent research at The University of Arizona indicates that energy balance parameters can be improved during the transition period providing producers with a potential management tool to reduce transition period failures and consequently increase profits.

Introduction

Milk is a valuable source of nutrients providing energy, high quality protein, and essential minerals and vitamins. Fat is the foremost energy component in milk and it accounts for many of the physical properties, manufacturing characteristics and taste qualities of milk and milk products. Milk fat is also the most energetically and economically expensive milk component for dairy cows to synthesize. Therefore, depending upon variables such as feed costs and milk fat value, economics may favor either increased or decreased production of milk fat.

Recently in the USA, the economic value of milk fat has declined, relative to that of other milk components, and in Canada and many European countries, producers are faced with quotas for the quantity of saleable milk fat. These economies favor milk production with a higher protein and lower fat content and have stimulated interest in discovering a method of regulating milk fat synthesis. In addition to economic gains, reducing milk fat synthesis during specific stages of lactation may be biologically advantageous to the dairy cow due the reduced energy costs. The NEBAL traditionally associated with early lactation adversely affects reproduction and increases the incidence of metabolic disorders, thereby limiting milk yield over the entire lactation. Reducing milk fat synthesis during this early lactation stage may alleviate the severity of NEBAL and thus improve performance and animal well-being over the entire lactation. In addition to early lactation, there are times during the year when grazing cows may have an inadequate energy supply due to poor weather conditions and thus synthesis of milk and milk components will be limited. Heat stress is an additional weather-induced condition which results in reduced feed intake and thus decreased energy availability. Again, reducing milk fat synthesis during such periods of energy insufficiency could alleviate the energy deficit and may even allow for a more efficient use of nutrients for synthesis of other milk components (e.g. protein).

Conjugated Linoleic Acid

As a consequence of the numerous positive health effects associated with conjugated linoleic acid (CLA; see 2002 Arizona Production Conference proceedings), there has been a large effort to increase CLA content in milk, thus increasing the value of milk and milk derived products. However, in an attempt to enhance milk fat CLA it was discovered that providing CLA dramatically reduces milk fat percentage and yield (Chouinard et al., 1999; Loor and Herbein, 1998). Subsequent studies confirmed that a supplemental mixture of CLA significantly reduced milk fat yield (Kraft et al., 2000; Loor and Herbein, 2003; Mackle et al., 2003). Rumen-protected CLA (RP-CLA) also decreased milk fat when fed to cows consuming either a TMR or rotationally grazed (Geisy et al., 1999; Medeiros et al., 2000; Perfield et al., 2002). In general, depending upon amount fed, RP-CLA supplements decrease milk fat content and yield by 15-50% (Baumgard et al., 2002).

Effects of CLA on milk fat are rapid and apparent within 24 hr. Equally important is that milk fat production returns to normal levels within a few days after CLA removal. Effects also appear to be specific for fat, as other milk components have not changed. Most CLA trials have been short term (4 -5 days) and have utilized cows in mid to late lactation, and in these trials milk yield, milk protein, milk lactose and feed intake have generally been unchanged (Baumgard et al., 2000, 2001; Chouinard et al., 1999; Loor and Herbein, 1998, 2003). Therefore, decreasing milk fat secretion without reducing feed intake during periods of limited energy availability would cause a more positive energy balance. CLA could therefore benefit production and animal well being by improving whole animal energy status during specific stages of lactation and at certain times of the year. As will be discussed in the following sections these benefits may include increased milk yield, increased synthesis of other milk components, decreased metabolic disorders and improved reproductive efficiency.

Milk fat is the most variable milk component and its synthesis can be influenced by many factors including diet and environment. Production of low fat milk can be easily accomplished by a number of dietary situations including low fiber/high concentrate rations, small fiber particle size and the inclusion of certain oils. However, often a negative side effect of diet-induced milk fat depression is the increased risk of metabolic disorders including rumen acidosis, ketosis, displaced abomasums and lameness. Therefore, utilizing CLA to reduce milk fat synthesis while maintaining animal well-being and production offers an exciting new management tool for dairymen. For a review of milk fat depression and CLA role in diet-induced milk fat depression see review by Bauman et al. (2000, 2001).

Transition Period

The period immediately prior to and following calving is associated with large metabolic adaptations. Characteristically, cows in this stage of lactation are secreting more energy (in their milk) than they can consume in feed (Drackley, 1999). As a consequence, animals experience a severe NEBAL, which is associated with an increased risk of metabolic disorders and health problems (Drackley, 1999; Goff and Horst, 1997), decreased milk yield and reduced reproductive performance (Beam and Butler, 1999; Lucy et al., 1992). Improving energy balance immediately after calving has been intensely studied, and traditional methods include increasing dietary concentrates and feeding supplemental fat. However, NEBAL remains a problem that reduces economic return for producers.

Milk fat is the major determinant of milk energy and thus largely influences animal energy balance. Reducing the nutrient demand for milk synthesis via inhibiting milk fat production should therefore alleviate the severity of NEBAL. Improving energy balance will decrease the demand for fat mobilization and thus decrease blood NEFA concentrations thereby reducing the incidence of fatty liver and ketosis.

The extent of NEBAL during the first few weeks postpartum also negatively influences ovarian activity and largely determines the length of time to first estrus cycle after calving. Recovery of energy balance from its most negative level in early lactation toward a more positive balance provides an important signal for initiation of ovarian activity (Beam and Butler, 1999; Lucy et al., 1992). Reduced milk fat yield early in lactation may increase energy balance and allow a more rapid return of ovulatory estrous cycles. Similarly, conception rates are affected by energy balance (Lucy et al., 1992) and may be improved by a CLA-induced reduction in milk fat. Therefore, an improvement in energy balance during early lactation may have positive effects on several dimensions of

reproductive performance. Consistent with this, recent studies indicate that cows fed RP-CLA during early lactation, which caused a minor reduction in milk fat yield, tended to have improved reproductive success including days to first ovulation and conception rates (Bernal-Santos et al., 2003).

University of Arizona Preliminary Data

Transitioning physiological states, from gestation to lactation, requires extensive metabolic adaptations and many cows do not successfully complete the transition. It is thought the magnitude and duration of NEBAL mediates or at least is strongly associated with transition failures (Goff and Horst, 1997; Drackley, 1999). In addition, reduced reproductive performance has been strongly linked not only with the extent, but also the timing of when NEBAL reaches its lowest level (Lucy et al., 1992; Beam and Butler, 1999). To capture most of the metabolic changes and large fluctuations in production variables we (C. E. Moore PhD experiment) initiated CLA feeding 10 d prior to anticipated parturition and continued until 21 DIM. To determine if CLA could reduce milk fat synthesis in early lactation, we fed four different amounts of RP-CLA in increasing increments. Prior research involving RP-CLA during the transition period has been unsuccessful in achieving a decrease in milk fat production. The present study was the first to examine the effects of larger RP-CLA doses to achieve a substantial decrease in milk fat synthesis in early lactation.

Data from this study (Moore et al., submitted) showed there were no differences in dry feed intake (42 lbs/d), milk yield (75 lbs/d), protein content (3.74), lactose percentage (4.61) or yield of these milk components (Table 1). RP-CLA supplementation decreased overall milk fat content in a dose responsive manner and milk fat yield showed the same progressive decline (Figure 1). The dose dependent decrease in milk fat content was evident during the first week of lactation and became highly different during weeks 2 and 3 (Figure 1). The milk fat yield response pattern was similar with the highest RP-CLA supplement decreasing fat yield by 44% during week 3.

We have hypothesized that reducing milk fat synthesis in early lactation, a time when nutrient availability may limit production, may allow for energy partitioning to support increased protein and milk synthesis (Bauman et al., 2001; Baumgard et al., 2002) as has been observed from cows on pasture in established lactation (Medeiros et al., 2000; Mackle et al., 2003). However, no effects on the yield of milk or milk protein were observed in the current study. A lack of an effect may in part be due to our study containing a small number of animals, in addition to being conducted during the rapid incline phase of milk yield and it is possible an effect will not be detected until milk production peaks and plateaus.

Body weight and body condition score at calving were similar among all four RP-CLA treatments and the loss of body weight and decrease in body condition score during the 21 d trial were also similar across treatments (Table 1). Although milk fat synthesis was markedly decreased in the early stages of lactation (Figure 1) and there was a visible improvement (≥ 4 Mcal/d) in energy balance during the 2nd and 3rd wk, overall net energy balance was not statistically affected by RP-CLA (Table 1). This was surprising as milk fat yield decreased and milk yield, dry feed intake and other milk components (Table 3) were unaltered, but this is probably explained by the small number of animals in each dose (4 or 5) and the large variation typically observed in calculated energy balance (Vicini et al., 2002). From the data obtained in the present study, we would expect significant improvements in energy balance in a study utilizing a larger number of animals in which energy balance was the primary measurement in question.

Although overall energy balance was only visibly different, RP-CLA did decrease days to when energy balance reached its lowest level, compared to the control diet by 3 and 5 d for the two highest RP-CLA doses, respectively (Table 1). This is relevant as recovery of energy balance from its lowest level in early lactation provides an important signal to initiate reproductive activity (Lucy et al., 1992; Beam and Butler, 1999) and the time point when energy balance is at its lowest is highly correlated with days to first ovulation (Butler, 2001). This provides strong evidence to suggest that feeding RP-CLA supplements during the transition period may positively impact reproduction.

Conclusions

Data from the present study (Moore et al., submitted) demonstrates that dietary RP-CLA supplements can cause a reduction in milk fat at the onset of lactation, but the CLA dose required is much greater than is necessary to cause a similar reduction in milk fat synthesis during established lactation. Additional studies are required to determine if RP-CLA can be utilized as a management tool to manipulate energy balance and thus improve production, enhance animal well-being and increase reproductive parameters during the transition period, ultimately resulting in increased income for the producer.

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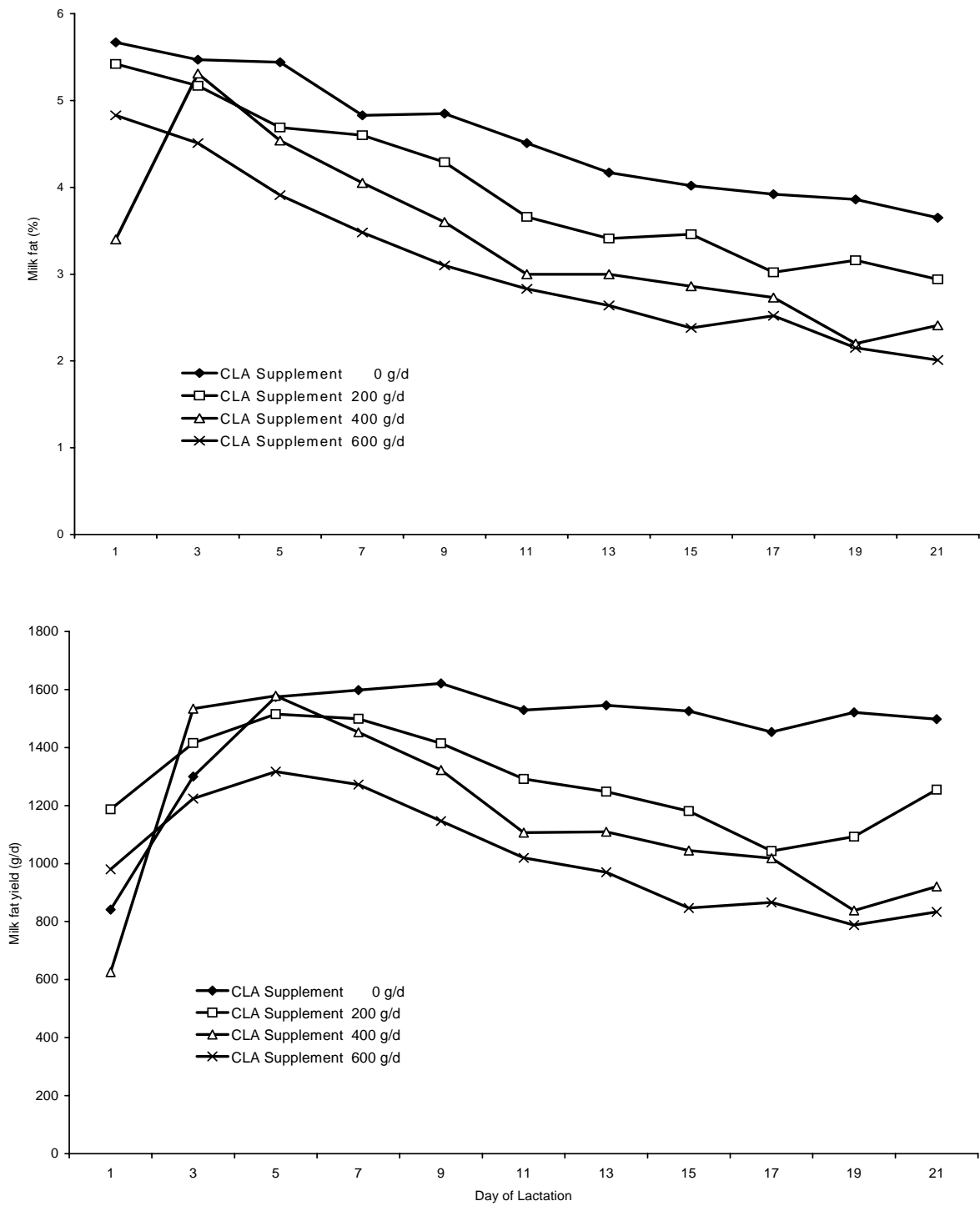


Figure 1. Effects of increasing amounts of rumen protected CLA on milk fat content and yield during the transition period. Adapted from Moore et al., submitted.

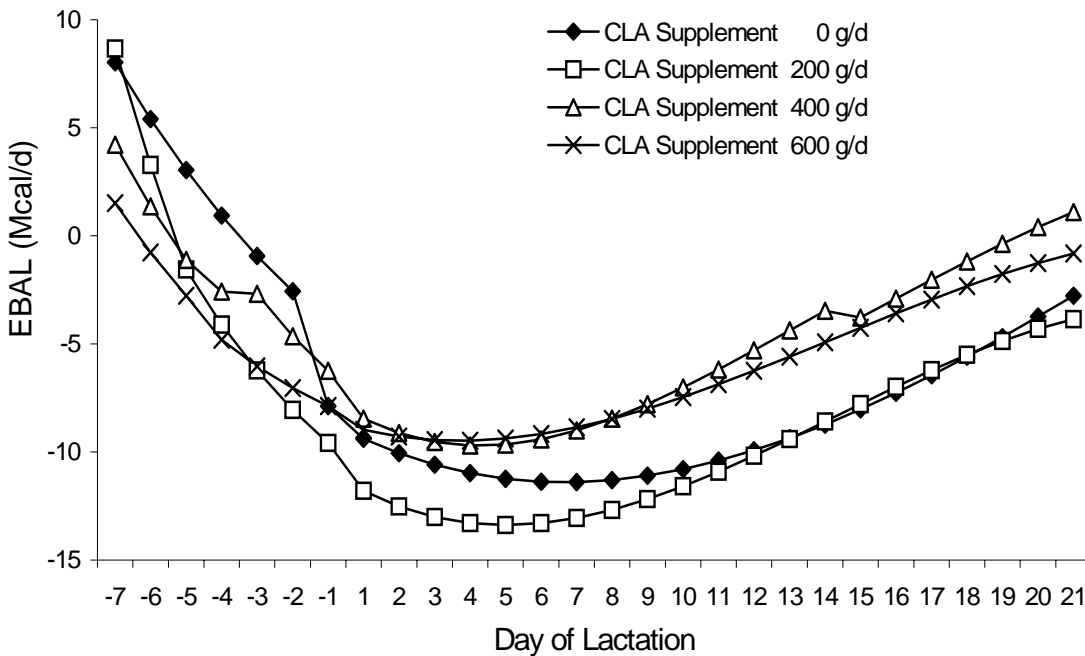


Figure 2. Effects of increasing amounts of rumen protected conjugated linoleic acid on energy balance during the transition period. Adapted from Moore et al., submitted

Table 1. The effects of increasing doses of a conjugated linoleic acid (CLA) supplement¹ on production variables in lactating dairy cows².

Parameter	CLA Supplement, g/d				SEM	P
	0	200	400	600		
DMI, lbs/d	39.0	36.1	40.0	35.2	4.6	0.81
Milk yield, lbs/d	73.5	74.1	78.1	75.6	5.5	0.94
Milk fat						
%	4.57 ^a	3.97 ^{a,b}	3.32 ^b	3.10 ^b	0.30	0.02
lb/d	3.2 ^a	2.8 ^{a,b}	2.5 ^{a,b}	2.2 ^b	0.2	0.02
Milk protein						
%	4.02	3.49	3.76	3.68	0.17	0.24
lb/d	2.7	2.6	2.7	2.7	0.2	0.99
Milk lactose						
%	4.67	4.53	4.64	4.60	0.10	0.79
lb/d	3.5	3.4	3.6	3.5	0.2	0.95
Milk SNF ³						
%	9.56	8.89	9.28	9.18	0.25	0.36
lb/d	6.8	6.6	7.0	6.9	0.5	0.93

^{a,b}Different superscripts within a row indicates a *P*-value <0.05.

¹Represent amount of calcium salts of CLA, actual amounts of dietary CLA were 0, 62, 125 and 187g/d, respectively.

²Data in this table represents weekly means from the entire postpartum period (21 d).

³Solids Nonfat.

Adapted from Moore et al., submitted