

Calculating and Improving Energy Balance During Times of Nutrient Limitations

Chel E. Moore, Jane K. Kay, Matthew J. VanBaale and Lance H. Baumgard

Department of Animal Sciences
The University of Arizona

Summary

- Energy balance can be estimated/assumed using a variety of techniques
 - Change in body weight
 - Change in body condition score
 - Plasma metabolites
 - Calculated using established equations
- Conjugated linoleic acid induced milk fat depression can improve energy balance parameters in lactating dairy cattle
 - During the transition period
 - In TMR and pasture fed cows
 - During periods of nutrient limitation
 - Heat stress
 - Whether the improved energy balance results in enhanced production or reproductive success is currently unknown

Calculating Energy Balance Techniques

Whole animal energy balance (EBAL) is the difference between energy consumed and energy used either for maintenance and/or production (milk, meat etc.). An animal in positive EBAL (PEBAL) should theoretically gain body weight (BW) and conversely, an animal in negative EBAL (NEBAL) should lose BW. Unfortunately, measuring energy balance (via direct or indirect calorimetry) is expensive, labor intensive and logistically impractical; therefore less accurate estimating methods have been developed to predict net EBAL.

Body Weight Measuring BW change is a logical technique to predict whether or not an animal is in PEBAL or NEBAL. Although this method works well in growing animals (especially monogastrics) it doesn't work well in lactating animals, especially the transitioning dairy cow. This is because in early lactation cows are mobilizing tissue (i.e. losing BW) while simultaneously increasing feed intake. Therefore, BW loss (and thus predicted EBAL) would be underestimated because of the concomitant increase in gut fill.

Body Condition Score Probably a more accurate description (compared to BW) of EBAL, and certainly more practical and convenient is the change in body condition score (BCS). The BCS is primarily an assessment of subcutaneous adipose tissue and doesn't effectively account for abdominal or muscular fat depots (two energy storages which are significantly mobilized in early lactation; Butler-Hogg et al., 1985). Importantly, to utilize BCS, repeated scoring is necessary, as a single scoring provides no indication of tissue loss or gain. The change in BCS is thought to be a good indicator of tissue mobilization and thus whole animal EBAL (Moallem et al., 2000; Pryce et al., 2001).

Blood Metabolites Blood levels of metabolites (glucose, ketones etc.) and hormones (insulin, IGF-I, GH, etc.) associated with energy metabolism may be accurate predictors of EBAL. Adipose tissue is mobilized in the form of non-esterified fatty acids (NEFA)

and these are the primary body derived energy products utilized/oxidized by the animal during periods of NEBAL. Blood NEFA levels (more than other metabolites/hormones; Reist et al., 2003) are thought to closely reflect calculated EBAL in lactating cows and goats (Bauman et al., 1988, Pullen et al., 1989; Dunshea et al., 1990). However, plasma NEFA levels don't always reflect calculated EBAL as NEFA levels do not necessarily decrease when calculated net EBAL improves (Grummer et al., 1995; Kay et al., 2004; Moore et al., 2004). Furthermore, accurately determining plasma NEFA concentrations is probably cost-prohibitive to be a daily management tool to monitor EBAL. For a comprehensive review of the changes in metabolites and hormones during the transition period, see the companion paper by Dr. Rob Rhoads.

Calculated: The calculation method obviously depends on accurately quantifying the energy content of feed and milk, determining feed intake and milk produced and estimating the energy required for maintenance (NRC, 2001)

$$EBAL = \text{feed energy intake} - (\text{maintenance requirements} + \text{milk energy})$$

The calculation for determining energy consumed relies on accurately determining feed intake and the net energy for lactation value of the feed. Determining intakes for a pen is relatively easy in a TMR based system, by simply measuring feed offered minusorts to determine feed consumed, and especially easy in research institutes where animals are fed individually using a tie-stall facility or Calan gates. However, even in controlled research facilities, calculated feed intake is probably overestimated as cows spill, toss or in general waste a percentage (highly individual dependent) of feed. Determining intakes in a pasture based system is much more difficult, and is based on estimations of available feed when cows enter a paddock vs. an estimation of feed remaining when cows are removed from the paddock. Recent efforts at increasing the accuracy of determining grazing cow feed intake include utilizing changes in BCS, milk energy, maintenance estimates and pasture energy content (Roche et al., 2005).

The current method of calculating the energy value of a specific feed (NRC, 2001) is based on first estimating digestible energy concentration when fed at maintenance (no loss or gain of body weight) levels. These values are then adjusted (usually down) for intake, to account for the increased passage rate as feed intake typically increases as production increases. The adjusted digestible energy values are then converted to metabolizable energy, which is used to calculate net energy for lactation (Weiss et al., 2002). This system is an improvement on the 1989 NRC system, which was inaccurate if DMI exceeded 3X maintenance, and average Holstein in the U.S. currently consume feed at approximately 3.5X maintenance. Because of this discrepancy, the 1989 NRC often overestimates energy intake (Weiss et al., 2002). For a comprehensive review of the recent changes on how a feedstuff's net energy value is calculated, see the companion paper authored by Dr. Henry Tyrrell.

In addition to the difficulty in estimating the NE_L content of a feedstuff (especially forages; Weiss, 2002; companion paper by Dr. Henry Tyrrell) these values do not include the presumed increase in digestion efficiency due to supplemental dietary performance modifiers. For example, ionophores (recently FDA approved for use in dairy cattle: see companion paper by Dr. Aguilar) alter microbial populations which results in increased propionate and decreased methane production (therefore enhancing energy conservation). In addition, direct fed microbials (DFM: *Aspergillus oryzae*, *Saccharomyces cerevisia*,

Lactobacillus etc.) are thought to stabilize rumen pH, enhance fiber digestion and increase post-rumen nutrient flow (NRC, 2001). The production responses to DFM supplementation are inconsistent and thought to be related to the concentrate levels and differences in the primary forage fed (NRC, 2001). For example, DFM have been demonstrated to be more effective (based upon production) when concentrates are more than 50% of the TMR and more successful at increasing milk yield when alfalfa is the primary forage (NRC, 2001). In addition, when during lactation DFM are fed, probably has a large influence on whether or not a production response will be observed. For example, increasing energy availability (due to increased fiber digestion) would probably only increase milk yield when milk synthesis is limited by energy availability (i.e. periods of NEBAL). This hypothesis is supported by data indicating that feeding *Aspergillus oryzae* through the transition (before and after calving) markedly increased milk yield in early lactation (i.e. 1-40 DIM) but effects on milk yield diminished as lactation progressed (Baumgard et al., 2004). This is similar to the effects observed with ionophores in early lactation (see companion paper by Dr. Aguilar). However, even if a milk yield response isn't observed with ionophores and DFM, the improved digestion causes enhanced feed efficiency (which is desirable in all stages of lactation) and is a variable that may need to be taken into account when balancing rations.

The net energy for lactation content of milk can be accurately calculated (net energy for lactation = $((0.0929 \times \text{fat } \%) + (0.0547 \times \text{crude protein } \%) + (0.0395 \times \text{lactose } \%) \times \text{milk production}$; NRC, 2001) assuming the concentrations of fat, protein and lactose are available. If milk fat is the only variable known, milk energy can be calculated as (net energy for lactation = $0.360 + (.0969 \times \text{fat } \%)$ as described by Tyrrell and Reid, (1965).

Energy required for maintenance is based on an equation (net energy for maintenance = $0.08 \times \text{body weight}^{0.75}$) that has remained unchanged for several years and is considered to be relatively precise (Vicini et al., 2002), at least during periods of thermal neutrality and is independent of production (i.e. milk yield) levels (Tyrrell et al., 1991). Although unchanged for many years, recent data from the UK indicate that maintenance requirements may actually be underestimated in today's genetically superior cows (Kirkland and Gordon, 1999). In addition, estimating maintenance requirements may be inaccurate in early lactation as DMI and gut fill are increasing during this time and thus body weight may be overestimated (Vicini et al., 2002).

Heat Stress and Maintenance Estimating EBAL during heat stress introduces two problems independent of those that are inherent to normal EBAL estimations (Vicini et al., 2002). First, considerable evidence suggest increased maintenance costs are associated with heat stress (7 to 25%; NRC, 1981), however due to complexities involved in predicting upper critical temperatures, no universal equation is available to adjust for this increase in maintenance (Fox and Tylutki, 1998). Not incorporating a heat stress correction factor results in overestimating EBAL and thus inaccurately predicting energy status. Secondly, a proportionate decrease in milk yield (10-15% is not uncommon) causes calculated net EBAL to remain slightly positive and thus feed energy availability appears adequate because of compensating for decreased energy intake with decreased milk yield. However, despite the calculated PEBAL, cows in established lactation from dairy's with modern cooling systems from semi arid environments (i.e. Arizona, Middle East, etc.) will typically lose approximately 20 kg of BW during the course of a summer (before cooling systems were introduced, it wasn't abnormal for cows to lose up to 45 kg of BW during the summer; Dennis Armstrong, personal communication). The loss of body weight indicates heat stressed cows are actually in NEBAL (even though they're in calculated PEBAL) and probably indicates that the correction factor for maintenance cost should be adjusted.

NEBAL Parameters

Frequently in a cows life cycle, there are instances when energy availability, or more specifically a lack of available energy, may limit milk or milk component synthesis, reduce reproductive performance and prevent body condition replacement. Examples include the transition period in both TMR and pasture based systems and adverse environmental situations such as heat stress and draught. The severity and length of NEBAL that occurs during the transition period is associated with an increased risk of metabolic disorders, health problems (Goff and Horst, 1997; Drackley, 1999; Heuer et al., 1999) and reduced reproductive performance (Lucy et al., 1992; Beam and Butler, 1999). In fact, more specifically is the severity and day of NEBAL nadir (~5-10 DIM) that is thought to be highly associated with reproductive events (Beam and Butler, 1999; Butler, 2000).

When do Cows Reenter PEBAL? Because of the strong connection between EBAL parameters and reproductive variables, efforts have been made to determine when (i.e. DIM) NEBAL nadir is established and when (i.e. DIM) animals regain PEBAL. Days to PEBAL can be estimated using the equation discussed earlier, or can be grossly predicted based on BW or BCS changes. Using the calculation method, cows generally return to PEBAL at approximately 35-50 DIM (Pullen et al., 1989; Moallem et al., 2000; Block et al., 2001). Interesting and in contrast to what is often reported (Broom, 1995; Veerkamp, 1998; Veerkamp et al., 2000), genetically superior or higher producing cows have similar calculated NEBAL parameters (severity, magnitude etc.) and blood energetic variables when compared to their lesser producing herd mates (Vicini et al., 2002). The fact that genetic selection for increased milk yield doesn't intensify NEBAL parameters, jeopardize health or cause cow "burn out" is due to natural coordinated homeorhetic mechanisms as we recently described (Collier et al., 2004).

Using the change in BCS (or day of BCS nadir) indicates cows usually reenter PEBAL at ~75-100 DIM (~30-60 days latter than is predicted using the EBAL equation; Pryce et al., 2001; Coffey et al., 2002, 2004; Friggins et al., 2004). In addition, it's approximately ~30-40 days latter than would be predicted using changes in BW or day of BW nadir (Moallem et al., 2000), but as indicated earlier, the loss in BW is confounded by the simultaneous increase in DMI which usually peaks between 75-100 DIM (Moallem et al., 2000). Not surprisingly, first lactation heifers don't usually lose as much BCS as cows and the extent and DIM of BCS nadir is related to production levels (Gallo et al., 1996). This is supported by data indicating that BCS at calving (a static measurement) is not, but changes in BCS are positively associated with peak and total lactation milk yield (Pedron et al., 1993).

Reasons why the EBAL equation and changes in BCS markedly and consistently differ in their ability to predict when cows reestablish PEBAL are not clear. Either the calculated method is overestimating or the BCS method is underestimating actual EBAL. Obviously BCS is a subjective measurement and primarily only concentrates on subcutaneous energy storage. As a consequence, the BCS is probably not sensitive enough to detect small and slow increases in subcutaneous adipose mass (i.e. increases that probably occur prior to visual and/or palpable detection). Furthermore, it is not clear if there is a hierarchy in the order of adipose replenishment once PEBAL is attained, as BCS wouldn't detect changes (maybe even large increases) in abdominal or muscular adipose depots.

Attempts to Alleviate NEBAL

Dietary strategies to alleviate this energy deficit during the transition period (Schingoethe and Casper, 1991; Grummer et al., 1995) as well as during periods of heat stress (Knapp and Grummer, 1991; Chan et al., 1997; Drackley et al., 2003) traditionally include increasing the energy density of the diet with concentrates or fat supplements. Unfortunately, the incidence and severity of NEBAL continues to be the primary issue surrounding transition period failures (Beam and Butler, 1999; Drackley, 1999) and increased energy is unable maintain or rescue production during heat stress. An alternative approach to improving energy status is to reduce milk energy secretion by inducing milk fat depression (MFD) with supplemental rumen inert (RI) conjugated linoleic acid (CLA). Milk fat is the major determinant of milk energy and thus has a large influence on calculated net EBAL. Reducing the nutrient demand for milk synthesis via decreasing milk fat production should therefore alleviate the severity and extent of NEBAL. Improving calculated net EBAL should theoretically reduce the demand for tissue (primarily adipose) mobilization, reduce condition loss, decrease the plasma metabolite levels responsible for fatty liver and ketosis (NEFA) and provide (probably via insulin and/or IGF-I) a signal to stimulate ovarian function and several other dimensions of reproductive performance. For a review of how NEBAL mediates its effects on the reproductive system, see the companion paper authored by Dr. Rob Rhoads.

CLA and EBAL

CLA supplements decrease milk fat synthesis during established lactation (Lor and Herbein, 1998; Chouinard et al., 1999; Giesy et al., 2002; Perfield et al., 2002), but similar amounts of CLA supplements had little or no effect at decreasing milk fat immediately following parturition (Giesy et al., 1999; Bernal-Santos et al., 2003; Selberg et al., 2004; Moore et al., 2005b). In order for supplemental CLA to be used as a management tool to improve EBAL parameters as we hypothesized it must reduce milk fat synthesis immediately postpartum (i.e 1-7 DIM). Our hypothesis was that the early lactating mammary gland is less sensitive to CLA, and theorized that a larger CLA dose is required during this period to achieve milk fat reductions similar to those observed in established lactation.

University of Arizona Studies

Study 1

Objective of this TMR based transition study was to determine the quantity of dietary RI-CLA supplement required to achieve MFD immediately postpartum, theoretically alleviating or reducing the severity and/or duration of NEBAL during the transition period. Experimental conditions have previously been described in detail (Moore et al., 2004), but briefly multiparous Holstein cows (n = 19) were randomly assigned to one of four doses of RI-CLA supplements (0, 200, 400 or 600 g/d) with each dose providing equal amounts of fatty acids by replacing and balancing treatments with a RI supplement of palm fatty acid distillate. Doses provided a total of 468 g fatty acids/d and either 0, 62, 125 or 187 g of mixed (including *trans*-10, *cis*-12) CLA isomers/d, respectively. To capture most of the metabolic changes and large fluctuations in production variables we initiated CLA feeding 10 d prior to anticipated parturition and continued until 21 DIM.

Data from this study demonstrated high doses of RI-CLA supplements (approximately 3-times that used during established lactation) reduced milk fat content and yield immediately postpartum. Effects were apparent at d 1 of lactation, significantly different by d 5, and became more pronounced as DIM increased. During the first 21 d of lactation, RI-CLA supplements decreased milk fat yield by as much as 33% (**Figure 1**).

We 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/or 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, yield and content of milk components other than milk fat were unaltered in this trial, which is similar to results reported in TMR-based CLA studies during established lactation (see review by Baumgard et al., 2002).

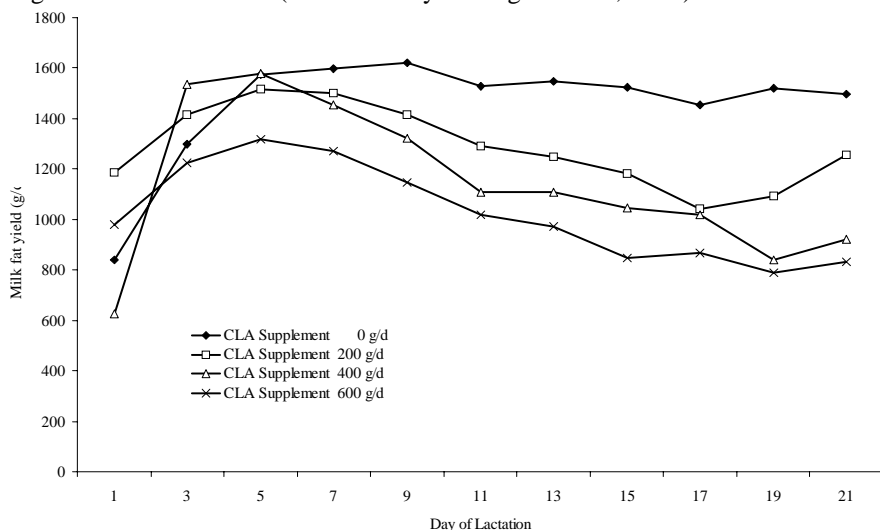


Figure 1. Temporal pattern of milk fat yield from cows fed increasing doses of a rumen inert conjugated linoleic acid (CLA) supplement during early lactation. Values are means, n = 4 for the 0 g/d CLA dose and n = 5 for the remaining CLA doses; SEM averaged 0.37 and ranged from 0.36 to 0.41 percent and averaged 123 and ranged from 119 to 134 g/d for milk fat content and yield, respectively.

Although milk fat synthesis was markedly decreased in the early stages of lactation and there was a numerical improvement (≈ 4 Mcal/d) in EBAL during the 2nd and 3rd wk, overall net EBAL and plasma NEFA levels were unaffected by CLA dose. Although overall EBAL was not statistically different, CLA did decrease days to EBAL nadir compared to controls by 4.7 d for the highest dose (**Figure 2**). This is relevant as recovery of EBAL from its nadir in early lactation provides an important signal for initiating ovarian activity (Lucy et al., 1992; Beam and Butler, 1999) and days to nadir is highly correlated with days to first ovulation (Beam and Butler, 1999). This provides evidence suggesting that feeding RI-CLA supplements during the transition period may positively impact reproduction.

The present study demonstrates that dietary RI-CLA supplements reduce milk fat synthesis at the onset of lactation, but the CLA dose required is much greater (i.e. 3X) than is necessary to cause a similar reduction in milk fat synthesis during established lactation.

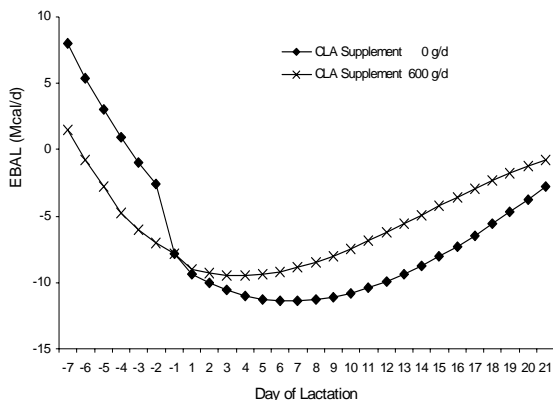


Figure 2. Temporal pattern of calculated net energy balance for cows fed increasing doses of a rumen inert conjugated linoleic acid (CLA) supplement during early lactation. To improve clarity, only the lowest and highest CLA doses are presented. Values are means, $n = 4$ for the CLA 0 g/d dose and $n = 5$ for the 600 g/d CLA doses; SEM averaged 2.6 and ranged from 2.5 to 2.8 Mcal/d.

Study 2

A second transition CLA study was conducted utilizing cows in a pasture based dairying system and data previously presented (Kay et al., 2004). Objectives of the pasture-based transition trial were to determine if a high dietary RI-CLA dose (600 g/cow/d) could induce MFD immediately postpartum and determine if CLA induced MFD would alleviate calculated NEBAL and associated variable (i.e. NEFA, etc.) and improve production parameters (milk and milk component synthesis).

Multiparous Holstein cows ($n = 39$) grazing pasture were randomly assigned to one of three treatments: 1) pasture (PAS), 2) PAS + 540 g/d Hyprofat (palm oil; HYPRO) and 3) PAS + 600 g/d RI-CLA. HYPRO and RI-CLA supplements were isoenergetic, fed 2x/d during milking and provided 0 and 197 g CLA/d, respectively. Treatments began ~21d prepartum and continued until 36 (± 1) DIM.

Data indicate RI-CLA supplementation decreased overall milk fat content and yield with RI-CLA-induced MFD becoming significant by d 3 when compared with PAS and by d 6 when compared with HYPRO. There was little or no overall RI-CLA effect on content or yield of protein and lactose and alkane data collected during wk 4 of lactation indicated no difference in calculated pasture DMI. As a consequence of the similar pasture DMI, consuming additional energy via lipid supplement and severely decreasing milk fat yield, RI-CLA treated cows had a much higher (> 7.5 Mcal) calculated/predicted EBAL compared to PAS cows. Compared to HYPRO, CLA supplemented cows tended to increase (> 4.0 Mcal) EBAL which can be directly attributed to MFD as these cows were producing similar volumes of milk and consuming similar quantities of feed during this portion of the trial (21-28 d). The improved calculated EBAL compared to PAS was corroborated by the reduction (26%) in circulating NEFA levels, which are thought to reflect calculated EBAL. We also anticipated CLA supplemented cows would have decreased NEFA concentration compared to HYPRO, but this was not the case. This result agrees with the TMR based transition period study, but a reason for the lack of effect on NEFA is not clear as reducing energy output without altering other components of the EBAL equation should theoretically reduce the demand to mobilize adipose reserves.

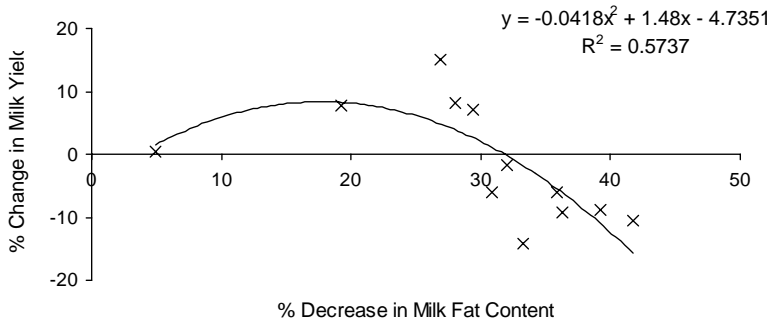


Figure 3. Relationship between RP-CLA induced milk fat depression and milk yield response compared to HYPRO treatment.

As expected due to additional energy intake, both lipid-supplemented treatments produced more overall milk compared to PAS. Although there was no overall milk yield difference between HYPRO and RI-CLA treatments, a quadratic relationship existed between severity of MFD and positive milk yield response (**Figure 3**). RI-CLA cows tended to produce more milk (1.8 kg/d) during the first 20 d postpartum when MFD was moderate (< 35%), however as MFD became more severe (> 35%, ~d 21) the positive response was eliminated and RI-CLA cows tended to produce less milk (2.5 kg/d) during the remainder of the trial (**Figure 4**). This suggests that during a time of energy deficiency (i.e. the transition period), moderate inhibition of milk fat synthesis may spare energy to be partitioned to increased milk yield, however severe MFD may adversely affect cellular mechanisms involved in milk synthesis and/or secretion. The quadratic response in milk yield is similar to a CLA dose response trial which demonstrated an increase in milk yield with moderate CLA-induced MFD, but no milk yield response with a high CLA dose that caused severe MFD in pasture-fed dairy cows in established lactation (Mackle et al., 2003). Similarly, in a CLA dose trial using TMR-fed cows, high CLA doses that resulted in severe MFD, reduced milk yield by almost 3 kg/d (Chouinard et al., 1999). Furthermore, Bell and Kennelly (2003) reduced milk yield by almost 40% when they abomasally infused a CLA dose 4-fold higher than necessary to evoke 40% MFD (Baumgard et al., 2000). Therefore, although the CLA dose did not change during the present study, the milk yield response followed a similar pattern to the aforementioned trials with increasing MFD severity as lactation progressed probably due to the increasing sensitivity of the mammary gland to CLA.

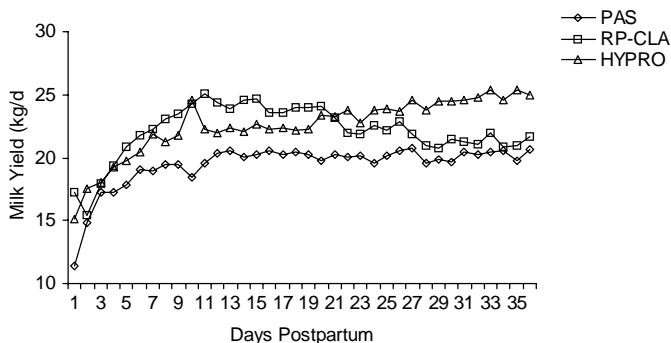


Figure 4. Effects of RP-CLA and HYPRO supplementation on temporal pattern of milk yield during first 36 d postpartum. Values represent least squares means (n = 13/trt); SEM averaged 1.31 and ranged from 1.31 to 1.41

The present pasture study demonstrates that a high dietary CLA dose reduces milk fat synthesis immediately postpartum and may be useful as a management tool to alleviate NEBAL in pasture-fed dairy cows. Moderate MFD appears to have caused a positive response in milk yield, however as lactation progressed and MFD became more severe, the positive milk yield response appears to have diminished. The biological mechanism behind this remains unclear and further research is required to determine why the mammary gland demonstrates decreased sensitivity to *trans*-10 *cis*-12 CLA immediately postpartum and why severe MFD adversely affects milk yield.

Study 3

Heat stress negatively impacts milk synthesis and impairs reproductive performance (Collier et al., 2004). As a consequence, heat stress is a significant financial burden in many dairy-producing areas of the United States and the world. The bioenergetic mechanism by which heat stress impacts production and reproduction is partly explained by reduced feed intake, but also includes an altered endocrine status, a reduction in rumination and nutrient absorption and increased maintenance requirements (Collier et al., 2004) resulting in a net decrease in nutrient/energy availability for production. This decrease in energy results in a reduction in EBAL, and explains why cows lose significant amounts of body weight when heat-stressed. As with pasture-fed cows (Medeiros et al., 2000; Mackle et al., 2003), we hypothesized that reducing milk fat synthesis during heat stress, a time when nutrient availability may limit production, may allow for energy to be partitioned to support increased protein and/or milk synthesis (Bauman et al., 2001; Baumgard et al., 2002; Collier et al., 2004). In addition to enhancing milk yield, inhibiting milk fat synthesis and thus improving energy availability may improve animal well-being and reproductive success during periods of heat stress

Study objectives were to evaluate whether CLA induced MFD during heat stress would allow for increased milk and milk component synthesis. Experimental procedures have been described in detail (Moore et al., 2005a) but briefly, multiparous cows ($n = 12$) averaging 97 ± 17 DIM were used in a crossover design during the summer (mean temperature humidity index = 75.7). Treatment periods were 21 d with a 7 d adaptation period prior to and between periods. During adaptation periods all cows received a supplement of palm fatty acid distillate. Dietary treatment consisted of either 250 g/d of CLA supplement (78.9 g/d CLA, mixed isomers [including *trans*-10, *cis*-12]; RI-CLA) or 242 g/d of palm fatty acid distillate (control) to provide equal amounts of fatty acids.

In agreement with other trials feeding RI-CLA to mid and late lactating cows (see review by Baumgard et al., 2002), milk fat content and yield were decreased (26 and 30%, respectively). However, even though the CLA-induced MFD increased available energy (approximately 3.5 Mcal/d) neither protein nor total milk synthesis increased as hypothesized. Even though this trial was not designed to determine the effects of CLA on reproduction, it is conceivable that improving EBAL could alleviate some of the poor reproductive performance associated with heat stress.

Although cows in this study were experiencing significant heat stress as indicated by THI, respiration rates and skin temperatures, the magnitude of heat stress did not appear extensive enough to induce severe NEBAL (i.e. -10 to -15 Mcal/d). Controls in this experiment had an estimated EBAL of 3.7 Mcal/d and therefore milk and milk component synthesis may not have been limited by energy availability, or limited enough to detect/measure production improvements. However, we must keep in mind, a proportionate

decrease in milk yield during heat stress causes calculated EBAL to remain slightly positive and thus energy availability appears adequate because of this adjusted production level. However, despite the calculated positive EBAL, irrespective of treatment, cows lost approximately 18 kg of BW during this trial. In agreement, cows in established lactation from semi arid environments (i.e. Arizona, Middle East, etc.) typically lose 20 kg of body weight during the course of a summer (Dennis Armstrong, personal communication). In contradiction to the calculated EBAL, the loss of body weight indicates cows in this trial were in NEBAL and illustrates the difficulty in accurately calculating EBAL in heat stressed cows. Furthermore, cows were already heat stressed at trial initiation and it is possible the deleterious effects of heat stress were too severe for 21 days of RI-CLA treatment to overcome. It is of interest to determine if CLA-induced MFD could prevent (in contrast to remedying) the negative effects of heat stress, if provided to thermal neutral animals prior to heat stress initiation.

Summary

Our group is generating evidence suggesting exogenous dietary CLA can improve EBAL parameters during the transition period and when nutrient availability (i.e. heat stress and/or drought) may limit milk synthesis or reproductive variables. Whether or not the improved calculated net EBAL results in increased milk synthesis, reduced metabolic disorders or increased reproductive success remains to be firmly established. We are currently conducting larger and longer-term trials to answer these unknowns.

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