ARIZONA AND NEW MEXICO
DAIRY NEWSLETTER

COOPERATIVE EXTENSION
The University of Arizona
New Mexico State University

FEBRUARY 2005

THIS MONTH'S ARTICLE:

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, Tucson, Arizona

(Reprinted from the 20th Annual Southwest Nutrition & Management Conference Proceedings, February 24-25, 2005, Tempe, Arizona)

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 = feed energy intake – (maintenance requirements + 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 minus orts 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 proprionate 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 postrumen 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 ionophors 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 x fat %) + (0.0547 x crude protein %) + (0.0395 x lactose %) x 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 x fat %) as described by Tyrrell and Reid, (1965).

Energy required for maintenance is based on an equation (net energy for maintenance = 0.08 x 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 <u>calculated</u> 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 (Loor 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 distallate. 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).

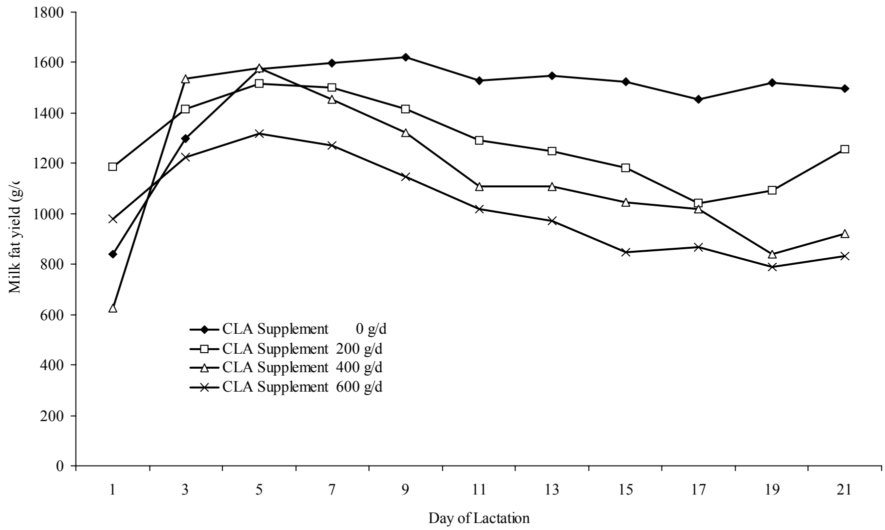

Figure 1. Temporal pattern of milk fat yield from cows fed increasing doses of a rumen inert conjugated linoleic acid (CLA) supplement during early lactation. Values are means, n = 4 for the 0 g/d CLA dose and n = 5 for the remaining CLA doses; SEM averaged 0.37 and ranged fro 0.36 to 0.41 percent and 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 (³ 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.

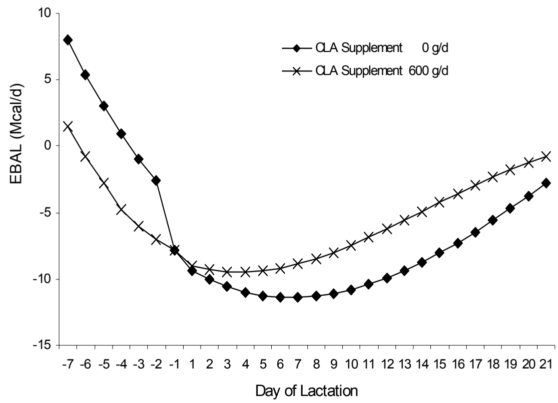

Figure 2. Temporal pattern of calculated net energy balance for cows fed increasing doses of a rumen inert conjugated linoleic acid (CLA) supplement during early lactation. To improve clarity, only the lowest and highest CLA doses are presented. Values are means, n = 4 for the CLA 0 g/d dose and n = 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.

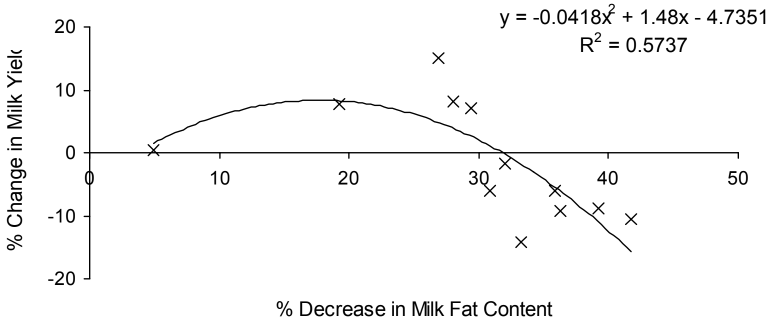

Figure 3. Relationship between RP-CLA induced milk fat depression and milk yield response compared to HYPRO treatment.

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.

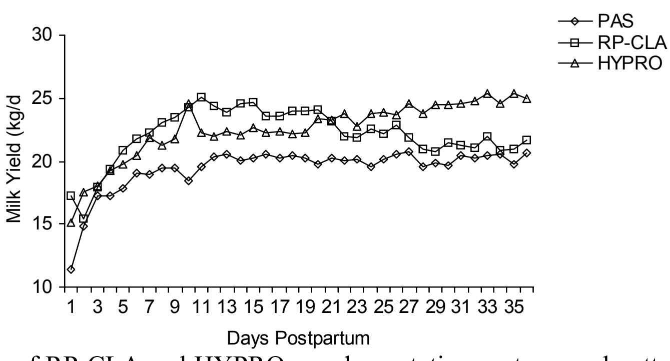

Figure 4. Effects of RP-CLA and HYPRO supplementation on temporal pattern of milk yield during first 36 d postpartum. Values represent least squares means (n = 13/trt); SEM averaged 1.31 and ranged from 1.31 to 1.41

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 loose 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 loose 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 stress 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.

References

Bauman, D.E., C.J. Peel, W.D. Steinhour, P.J. Reynolds, H.F. Tyrrell, C.Brown, and G.L. Harland. 1988. Effect of bovine somatotropin on metabolism of lactating dairy cows: influence on rates of irreversible loss and oxidation of glucose and nonesterified fatty acids. J. Nutr. 118:1031-1040.

Bauman, D.E., B.A. Corl, L.H. Baumgard, and J.M. Griinari. 2001. Conjugated linoleic acid (CLA) and the dairy cow. In: *Recent Advances in Animal Nutrition*, P.C. Garnsworthy and J. Wiseman (ed). Nottingham University Press, Nottingham, UK. pp 221-250.

Baumgard, L.H., M.E. Dwyer, C. Davis, C.E. Moore, H.C. Hafliger, O.B. Mendivil, H. Jensen, B. Christie and M.J. VanBaale 2004. Effects of *Aspergillus oryzae* (Amaferm) on production and metabolic parameters in Holstein cattle during the transition period. J. Dairy Sci. Supplement (1) 87: 303

Baumgard, L.H., B.A. Corl, D.A. Dwyer, A. Saebo, and D.E. Bauman. 2000. Identification of the conjugated linoleic acid isomer that inhibits milk fat synthesis. Am. J. Physiol. 278:R179-R184.

Baumgard, L.H., C.E. Moore, and D.E. Bauman. 2002. Potential application of conjugated linoleic acids in nutrient partitioning. Proc. Southwest Nutr. Conf. pp 127-141.

Beam, S.W., and W.R Butler. 1999. Effects of energy balance on follicular development and first ovulation in postpartum dairy cows. J. Reprod. Fertility 54:411-424.

Bell, J.A., and J.J. Kennelly. 2003. Short communication: Postruminal infusion of conjugated linoleic acids negatively impacts milk synthesis in Holstein cows. J. Dairy Sci. 86:1321-1324.

Bernal-Santos, G., J.W. Perfield II, D.M. Barbano, D.E. Bauman, and T.R. Overton. 2003. Production responses of dairy cows to dietary supplementation with conjugated linoleic acid (CLA) during the transition period and early lactation. J. Dairy Sci. 86:3218-28.

Block, S.S., W.R. Butler, R.A. Ehrhardt, A.W. Bell, M.E.VanAmburgh and Y.R. Boisclair. 2001. Decreased concentration of plasma leptin in periparturient dairy cows is caused by negative energy balance. J. Endocrin. 171:339-348.

Broom, D.M. 1995 Measuring the effects of management methods, systems, high production efficiency and biotechnology on farm animal welfare. In *Issues in Agricultural Bioethics*, pp 319-334. Edited by T.B. Mepham, G.A. Tucker and J. Wiseman. Nottingham University Press, Nottingham, UK.

Butler, W.R. 2000. Nutritional interactions with reproductive performance in dairy cattle. Anim. Reprod. Sci. 60:449-457.

Butler-Hogg, B.W., J.D. Wood, and J.A. Bines. 1985. Fat partitioning in British Friesian cows: the influence of physiological state on dissected body composition. J. Agric. Sci. Camb. 104:519-528.

Chan, S.C., J.T. Huber, K.H. Chen, J.M. Simas and Z. Wu. 1997. Effects of ruminally inert fat and evaporative cooling on dairy cows in hot environmental temperatures. J. Dairy Sci. 80:1172-1178.

Chouinard, P.Y., L. Corneau, D.M. Barbano, L.E. Metzger and D.E. Bauman. 1999. Conjugated linoleic acids alter milk fatty acid composition and inhibit milk fat secretion in dairy cows. J. Nutr. 129:1579-1584.

Coffey, M.P. G. Simm and S. Brotherstone. 2002. Energy balance profiles for the first three lactations of dairy cows estimated using random regression. J. Dairy Sci. 85:2669-2678.

Coffey, M.P., G.Simm, J.D. Oldham, W.G. Hill and S. Brotherstone. 2004. Genotype and diet effects on energy balance in the first three lactations of dairy cows. J. Dairy Sci. 87:4318-4326.

Collier, R.J., L.H. Baumgard, A.L. Lock and D.E. Bauman. 2004. Physiological Limitations: nutrient partitioning. In: Yields of farmed Species: constraints and opportunities in the 21st Century. Proceedings: 61st Easter School. Nottingham, England. J. Wiseman and R. Bradley, eds. Nottingham University Press, Nottingham, U.K. (In Press).

Drackley, J.K. 1999. Biology of dairy cows during the transition period: the final frontier? J. Dairy Sci. 82:2259-2273.

Drackley, J.K., T.M. Cicela, and D.W. LaCount. 2003. Responses of primiparous and multiparous Holstein cows to additional energy from fat or concentrate during summer. J. Dairy Sci. 86:1306-1314.

Dunshea, F.R., A.W. Bell and T.E. Trigg. 1990. Non-esterified fatty acid and glycerol kinetics and fatty acid re-esterification in goats during early lactation. Br. J. Nutr. 64:133-145.

Fox, D.G. and T.P. Tylutki. 1998. Accounting for the effects of environment on the nutrient requirements of dairy cattle. J. Dairy Sci. 81:3085-3089.

Friggens, N.C., K.L. Ingvartsen, and G.C. Emmans. 2004. Prediction of body lipid change in pregnancy and lactation. J. Dairy Sci.87:988-1000.

Gallo, L., P. Carnier, M. Cassandro, R. Mantovani, L. Bailoni, B. Contiero, and G. Bittante. 1996. Change in body condition score of Holstein cows as affected by parity and mature equivalent milk yield. J. Dairy Sci. 79:1009-1015.

Giesy, J.G., S. Viswanadha, T.W. Hanson, L.R. Falen, M.A. McGuire, C.H. Skarie, and A. Vinci. 1999. Effects of calcium salts of conjugated linoleic acid (CLA) on estimated energy balance in Holstein cows early in lactation. J. Dairy Sci. 82 (Suppl. 1):74 (Abst.).

Giesy, J.G., M.A. McGuire, B. Shafii, and T.W. Hanson. 2002. Effect of dose of calcium salts of conjugated linoleic acid (CLA) on percentage and fatty acid content of milk fat in midlactation Holstein cows. J. Dairy Sci. 85:2023-2029.

Goff, J.P. and R.L. Horst. 1997. Physiological changes at parturition and their relationship to metabolic disorders. J. Dairy Sci. 80:1260-1268.
Grummer, R.R., P.C. Hoffman, M.L. Luck and S.J. Bertics. 1995. Effect of prepartum and postpartum dietary energy on growth and lactation of primiparous cows. J. Dairy Sci. 78:172–180.
Heuer C., Y.H.Schukken and P. Dobbelaar. 1999. Postpartum body condition score and results from the first test day milk as predictors of disease, fertility, yield, and culling in commercial dairy herds. J. Dairy Sci. 52:295-304.
Kay, J.K., J.R. Roche and L.H. Baumgard. 2004 Effects of dietary CLA on production parameters in pasture-fed transition dairy cows. J. Dairy Sci. Supplement (1) 87: 95
Kirkland, R.M. and F.J. Gordon. 1999. The metabolisable energy requirement for maintenance and the efficiency of use of metabolisable energy for lactation and tissue gain in dairy cows offered a straw/concentrate ration. Livestock Prod. Sci. 61:23-31.
Knapp, D.M. and R.R. Grummer. 1991. Response of lactating dairy cows to fat supplementation during heat stress. J. Dairy Sci. 74:2573-2579.
Loor, J.J. and J.H. Herbein. 1998. Exogenous conjugated linoleic acid isomers reduce bovine milk fat concentration and yield by inhibiting de novo fatty acids synthesis. J. Nutr. 128:2411-2419.
Lucy, M.C., C.R. Staples, W.W. Thatcher, P.S. Erickson, R.M. Cleale, J.L. Firkins, J. H. Clark, M. R. Murphy and B. O. Brodie. 1992. Influence of diet composition, dry matter intake, milk production and energy balance on time of postpartum ovulation and fertility in dairy cows. Anim. Prod. 54:323-331.
Mackle, T.R., J.K. Kay, M.J. Auldist, A.K.H. McGibbon, B.A. Philpott, L.H. Baumgard and D. E. Bauman. 2003. Effects of abomasal infusion of conjugated linoleic acid on milk fat concentration and yield form pasture-fed dairy cows. J. Dairy Sci. 86:644-652.
Medeiros, S.R., D.E. Oliveira, L.J.M. Aroeira, M.A. McGuire, D.E. Bauman and D.P.D. Lanna. 2000. The effect of long-term supplementation of conjugated linoleic acid (CLA) to dairy cows grazing tropical pasture. J. Dairy Sci. 83 (Suppl. 1):169 (Abst.).
Moallem, U., Y. Folman and D. Sklan. 2000. Effects of somatotropin and dietary calcium soaps of fatty acids in early lactation on milk production, dry matter intake, and energy balance of high-yielding dairy cows. J. Dairy Sci. 83:2085-2094.
Moore, C.E., H.C. Hafliger, III, O.B. Mendivil, S.R. Sanders, D.E. Bauman and L.H. Baumgard. 2004. Increasing amounts of conjugated linoleic acid (CLA) progressively reduces milk fat synthesis immediately postpartum. J. Dairy Sci. 87:1886-1895.
Moore, C.E., J.K. Kay, M.J. VanBaale, R.J. Collier and L.H. Baumgard. 2005a Effect of conjugated linoleic acid on heat stressed Brown Swiss and Holstein cattle. J. Dairy Sci. (in press)
Moore, C.E., J.K. Kay, R.P. Rhoads and L.H. Baumgard. 2005b. A comparison of *trans*-10, *cis*-12 CLA effectiveness at reducing milk fat synthesis in early vs. established lactation. J. Dairy Sci (in press) (Abst).
National Research Council. 1981. "Effect of environment on nutrient requirements of domestic animals." Nat. Acad. Sci., Washington, D. C.
National Research Council. 2001. Nutrient Requirements of Dairy Cattle, 7th rev. ed. Nat. Acad. Press, Washington, DC.
Pedron, O., F. Cheli, E. Senatore, D. Baroli and R. Rizi. 1993. Effect of body condition score at calving on performance, some blood parameters, and milk fatty acid composition in dairy cows. J. Dairy Sci. 76:2528-2535.

Perfield, II, J.W., G. Bernal-Santos, T.R. Overton and D.E. Bauman. 2002. Effects of dietary supplementation of rumen-inert conjugated linoleic acid in dairy cows during established lactation. J. Dairy Sci. 85:2609-2617.

Pryce, J.E. M.P. Coffey and G. Simm. 2001. The relationship between body condition score and reproductive performance. J. Dairy Sci. 84:1508-1515.

Pullen, D.L., D.L Pamquist and R.S. Emery. 1989. Effect of days of lactation and methionine hydroxy analog on incorporation of plasma fatty acids into plasma triglycerides. J. Dairy Sci. 72:49-58.

Roche, J.R., E.S. Kolver and J.K. Kay. 2005. Influence of precalving feed allowance on periparturient metabolic and hormonal responses and milk production in grazing dairy cows. J. Dairy Sci. 88:677-689.

Reist, M., D. Erdin, D. von Euw, K. Tschuemperlin, H. Leuenberger, C. Delavaud, Y. Chilliard, H. M. Hammon, N. Kuenzi and J. W. Blum. 2003. Concentrate feeding strategy in lactating dairy cows: metabolic and endocrine changes with emphasis on leptin. J. Dairy Sci. 86:1690-1706.

Selberg, K.T., A.C. Lowe, C.R. Staples, N.D. Luchini and L. Badinga. 2004. Production and metabolic responses of periparturient Holstein cows to dietary conjugated linoleic acid and trans-octadecenoic acids. J. Dairy Sci. 87:158-168.

Schingoethe, D.J. and D.P. Casper. 1991. Total lactational response to added fat during early lactation. J. Dairy Sci. 74:2617-2622.

Tyrrell, H.F., C.K. Reynolds and H.D. Baxter. 1991. Utilization of dietary energy by Jersey compared to Holstein cows during the lactation cycle. Proc. 12thSymp. Energy Metab. On Farm Anim. EAAP Publ. 58.

Tyrrell, H.F. and J.T. Reid. 1965. Prediction of the energy value of cow's milk. J. Dairy Sc. 48:1215-1223

Veerkamp, R.F. 1998. Selection for economic efficiency of dairy cattle using information on live weight and feed intake: a review. J. Dairy Sci. 81:1109-1119.

Veerkamp, R.F., J.K Oldenbroek, H.J. Van Der Gaast and J.H.J Van Der Werf. 2000. Genetic correlation between days until start of luteal activity and milk yield, energy balance and live weights. J. Dairy Sci. 83:577-583.

Vicini, J. L., B.A. Crooker and M.A. McGuire. 2002. Energy balance in early lactation dairy cows. Cal. Anim. Nutr. Conf. pp 1-8.

Weiss, W.P. 2002. Overview and application of the 2001 NRC energy system. Proceedings 13th Annual Florida Ruminant Nutrtion Symposium. pp 1-15.

HIGH COW REPORT
JANUARY 2005

MILK

Arizona Owner	Barn#	Age	Milk	New Mexico Owner	Barn #	Age	Milk
* Treger Holsteins, Inc.	6646	04-07	49,970	* New Direction Dairy	90 KW	-----	42,760
* Treger Holsteins, Inc.	975	04-03	46,010	Pareo Dairy	8121	05-08	40,484
* Treger Holsteins, Inc.	6617	05-01	44,070	Pareo Dairy	1521	07-07	40,243
* Treger Holsteins, Inc.	1039	03-10	41,120	Pareo Dairy	649	06-10	38,899
* Treger Holsteins, Inc.	964	04-04	39,550	Pareo Dairy	9918	04-10	38,549
* Treger Holsteins, Inc.	1369	03-01	39,370	Pareo Dairy	555	06-08	38,526
* Mike Pylman	5342	06-01	38,970	Ken Miller Dairy	962	04-03	38,426
* Stotz Dairy	15005	05-01	38,240	Pareo Dairy	1016	12-01	37,611
* Stotz Dairy	15746	04-06	36,470	Ken Miller Dairy	928	04-06	37,468
* Stotz Dairy	14648	05-04	36,330	Pareo Dairy	1651	06-04	37,222

FAT

* Stotz Dairy	15005	05-01	1,757	* New Direction Dairy	90 KW	-----	1,550
* Treger Holsteins, Inc.	6646	04-07	1,665	Pareo Dairy	8121	05-08	1,541
* Shamrock Farms	T341	06-04	1,588	Pareo Dairy	1317	06-04	1,468
* Treger Holsteins, Inc.	6617	05-01	1,555	* Goff Dairy	1568	04-03	1,379
* Treger Holsteins, Inc.	975	04-03	1,533	* Do Rene Dairy	5667	05-06	1,365
* Stotz Dairy	14290	05-07	1,474	Pareo Dairy	901	07-07	1,361
* Stotz Dairy	15824	04-05	1,459	Pareo Dairy	1016	12-01	1,333
* Mike Pylman	1324	07-11	1,446	Pareo Dairy	890	05-10	1,325
* Stotz Dairy	15734	04-06	1,380	Pareo Dairy	555	06-08	1,318
* Stotz Dairy	17516	03-02	1,378	Pareo Dairy	1682	06-03	1,309

PROTEIN

* Treger Holsteins, Inc.	6646	04-07	1,378	* New Direction Dairy	90 KW	-----	1,301
* Treger Holsteins, Inc.	6617	05-01	1,289	Pareo Dairy	1256	07-02	1,247
* Treger Holsteins, Inc.	975	04-03	1,272	Pareo Dairy	8121	05-08	1,193
* Treger Holsteins, Inc.	1039	03-10	1,131	Ken Miller Dairy	962	04-03	1,142
* Treger Holsteins, Inc.	1369	03-01	1,105	* Goff Dairy	16314	04-03	1,137
* Treger Holsteins, Inc.	964	04-04	1,092	Pareo Dairy	9918	04-10	1,135
* Stotz Dairy	15005	05-01	1,063	Ken Miller Dairy	928	04-06	1,129
* Mike Pylman	5922	05-01	1,043	Pareo Dairy	1521	07-07	1,111
* Stotz Dairy	15746	04-06	1,042	Pareo Dairy	1016	12-01	1,110
* Mike Pylman	1330	03-10	1,035	Pareo Dairy	1651	06-04	1,093

*all or part of lactation is 3X or 4X milking

ARIZONA - TOP 50% FOR F.C.M.[b]
JANUARY 2005

OWNERS NAME	Number of Cows	MILK	FAT	3.5 FCM	RR
* Stotz Dairy West	2,284	26,425	957	26,939	40
* Triple G Dairy, Inc.	4,566	25,510	955	26,511	38
* Joharra Dairy	1,016	25,002	885	25,157	22
* Red River Dairy	-----	24,389	874	24,713	34
* Mike Pylman	4,342	23,983	864	24,376	33
* Stotz Dairy East	1,031	23,843	843	23,975	28
* Del Rio Holsteins	1,096	23,500	850	23,940	34
* Danzeisen Dairy, Inc.	1,393	22,464	816	22,941	27
* Shamrock Farm	8,496	23,309	795	22,966	28
* DC Dairy, LLC	1,049	22,251	806	22,687	26
* Zimmerman Dairy	1,151	22,415	813	22,871	24
* Butler Dairy	628	23,329	771	22,585	21
* Withrow Dairy	5,130	23,265	748	22,185	28
Paul Rovey Dairy	419	21,676	782	22,049	28
* Dairyland Milk Co.	2,825	22,669	778	22,413	28
* RG Dairy, LLC	1,356	22,278	785	22,358	33
* Saddle Mountain Dairy	2,828	22,954	747	22,034	29
Lunts Dairy	576	21,506	784	22,008	29
* Goldman Dairy	2,181	21,861	773	21,983	29
* Hillcrest Dairy	2,295	21,863	754	21,676	39
* Parker Dairy	4,309	21,387	774	21,794	29
* Treger Holsteins, Inc.	2,070	19,925	710	20,125	40
* Dutch View Dairy	1,596	21,060	739	21,086	31
* Arizona Dairy Company	5,914	23,439	822	23,460	35
* Jerry Ethington	652	20,459	723	20,566	32

NEW MEXICO - TOP 50% FOR F.C.M.[b]
JANUARY 2005

OWNERS NAME	Number of Cows	MILK	FAT	3.5 FCM	DIM
* Pareo Dairy #1	1,469	26,467	949	26,769	207
* Tallmon Dairy	462	25,809	885	25,511	240
Ken Miller	401	24,865	858	24,665	201
* Providence Dairy	2,714	26,064	818	24,535	209
* Macatharn	1,006	24,411	847	24,290	192
* Do-Rene	2,394	23,860	811	23,468	185
* Pareo Dairy #2	3,127	23,158	828	23,440	184
* Goff Dairy 1	4,160	22,941	813	23,103	206
* New Direction Dairy 2	1,849	22,137	816	22,804	208
* Butterfield Dairy	1,763	22,761	797	22,766	198
* Milagro	3,326	22,746	793	22,695	212
* Vaz Dairy	1,672	22,628	793	22,644	204
* Baca Linda Dairy	1,217	22,460	779	22,344	179
* Halflinger Dairy	2,132	21,204	791	21,995	165
Breedyk Dairy	2,688	22,666	747	21,914	209
* Baca Linda Dairy	1,208	22,968	765	22,337	127
Breedyk Dairy	2,688	22,666	747	21,914	146

* all or part of lactation is 3X or 4X milking

[b] average milk and fat figure may be different from monthly herd summary; figures used are last day/month

ARIZONA AND NEW MEXICO HERD IMPROVEMENT SUMMARY FOR OFFICIAL HERDS TESTED JANUARY 2005

		ARIZONA	NEW MEXICO
1.	Number of Herds	49	29
2.	Total Cows in Herd	85,801	51,232
3.	Average Herd Size	1,751	1,767
4.	Percent in Milk	87	87
5.	Average Days in Milk	194	198
6.	Average Milk – All Cows Per Day	60.9	60.6
7.	Average Percent Fat – All Cows	3.6	3.6
8.	Total Cows in Milk	73,230	44,197
9.	Average Daily Milk for Milking Cows	69.1	70.2
10.	Average Days in Milk 1st Breeding	81	73
11.	Average Days Open	154	146
12.	Average Calving Interval	14.2	14.0
13.	Percent Somatic Cell – Low	88	72
14.	Percent Somatic Cell – Medium	8	13
15.	Percent Somatic Cell – High	5	5
16.	Average Previous Days Dry	62	66
17.	Percent Cows Leaving Herd	32	35
		STATE AVERAGES	
	Milk	22,082	22,364
	Percent butterfat	3.57	3.58
	Percent protein	2.96	3.08
	Pounds butterfat	790	795
	Pounds protein	641	680

THE UNIVERSITY OF
ARIZONA®
COOPERATIVE EXTENSION
Department of Animal Sciences
PO Box 210038
Tucson, AZ 85721-0038

Phone: 520-626-9382
Fax: 520-621-9435
Email: ljr22@ag.arizona.edu