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THE NUTRITIONAL CONSULTANT'S DIGEST

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Potassium and It's Benefits During Heat Stress and Milk Fat Depression

There has been a great deal of interest since the early 1990's regarding DCAD balance and potassium (K) and their effect on summer heat stress. Potassium ions participate in many essential biological processes such as the maintenance of osmotic potential within cells, nerve impulse transmission, enzyme reactions in cellular metabolism, the maintenance of normal kidney function, and cardiac, skeletal and smooth muscle function. Because milk is an intracellular fluid, milk contains a large amount of K. As a result, K is the mineral required in the highest amount in lactating cow diets. Heat stress will increase the K requirement as cows lose K through sweating. The 2001 Dairy NRC list the K requirements of lactating cows at about 1.1% of the diet DM and 0.55% for dry cows. Potassium's role in milk production can be tied to the concept of dietary cation anion difference (DCAD). Potassium is a cation that raises the DCAD ((K+Na)-(S+Cl)), which represents interaction among the macrominerals. Interacting effects among the macrominerals Na, K, chloride (Cl), and sulfur (S) have been observed in the pre-calving cow, but little has been written on this subject for the post-calving cow. DCAD affects the cow by altering its acid-base status. Recent research has shown that milk fat depression (MFD) can also be relieved by up to 2% K in the diet or DCAD values in the 40-50 range. Recently, Hu et al., 2007 and Harrison et al., 2012 have shown improved milk yield and milk fat concentration when K rose to 1.75-2.0% and DCAD levels were 51-42 respectively over the control diet (Table 1).

Table 1. The effects of K and DCAD on milk production and components.

	Hu et al	2007	Harrison	et al 2012
Variable	1.28% K	1.85% K	1.28% K	2.07% K
DMI, lb/d	56.5a	62.0b	57.6	59
Milk				
Yield, lb/d	78.8	80.5	86.5	89.8
3.5% FCM, lb/d	78.3a	82.1b	92.8	101.4
Fat, %	3.46a	3.62b	3.94a	4.29b
Protein, %	3.16a	3.24b	2.95a	2.79b
DCAD meq/l	22	51	25	42
Cows/Treatment	24	24	15	15

a,b. Means within rows and within trials are different $P<0.01$

The response of improved milk fat % has received more attention of late, since Jenkins et al., 2012 found a relationship between K levels and the degree of biohydrogenation leading to CLA intermediates in continuous rumen fermentation experiments. They reported reductions in harmful CLA from linoleic acid biohydrogenation in their continuous culture experiments. *Trans*-10 *cis*-12 CLA has been shown to reduce milk fat % by as much as 35% when as little as 7.5 g of this isomer reaches the small intestine (Harvatine et al., 2009). *Trans*-10, *cis*-12 CLA reduces milk fat yield up to 45% at a dose of 0.045 g/kg body weight (about 30 g per day); the response rapidly reaches a low point by 3–4 d and is rescued over a similar time frame when treatment is terminated.

Changes in the ruminal environment initiated through the diet can lead to changes in rumen bacterial populations. These changes are accompanied by a change in the type of CLA produced. For example, low rumen pH can be a key factor contributing to a microbial shift and changes in the type of CLA produced. Dropping pH in continuous cultures of mixed ruminal microorganisms caused an increase ($P < 0.05$) in the concentration of *trans*-10, *cis*-12 CLA (harmful CLA) but no change in *cis*-9, *trans*-11 CLA (Fuentes et al., 2009). The inhibition of milk fat synthesis appears to be at the cellular level. Baumgard et al., 2002, suggested that the *trans*-10 *cis*-12 CLA inhibited milk fat synthesis by decreasing the enzyme activity through the inhibition of gene expression affecting de novo fatty acid synthesis, uptake, and transport.

A series of continuous culture experiments were run at Clemson University to determine if increasing K concentration in the culture contents was associated with a decline in the production of the *trans*-10, *cis*-12 isomer linked to MFD. The addition of potassium carbonate (K_2CO_3) or the strong base sodium hydroxide (NaOH) to continuous rumen cultures caused changes in biohydrogenation intermediates (Jenkins et al., 2010). This suggested that adding K_2CO_3 reduces the accumulation of harmful CLA by raising pH in the rumen. As K decreased ($P < 0.01$) *trans*-10, *cis*-12 CLA, it also increased ($P < 0.05$) the production of *cis*-9, *trans*-11 CLA that is typical of normal biohydrogenation (Jenkins et al., 2011). This pathway is illustrated in Figure 1 adapted from Jenkins et al., 2012.

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Potassium and It's Benefits During Heat Stress and Milk Fat Depression (continued)

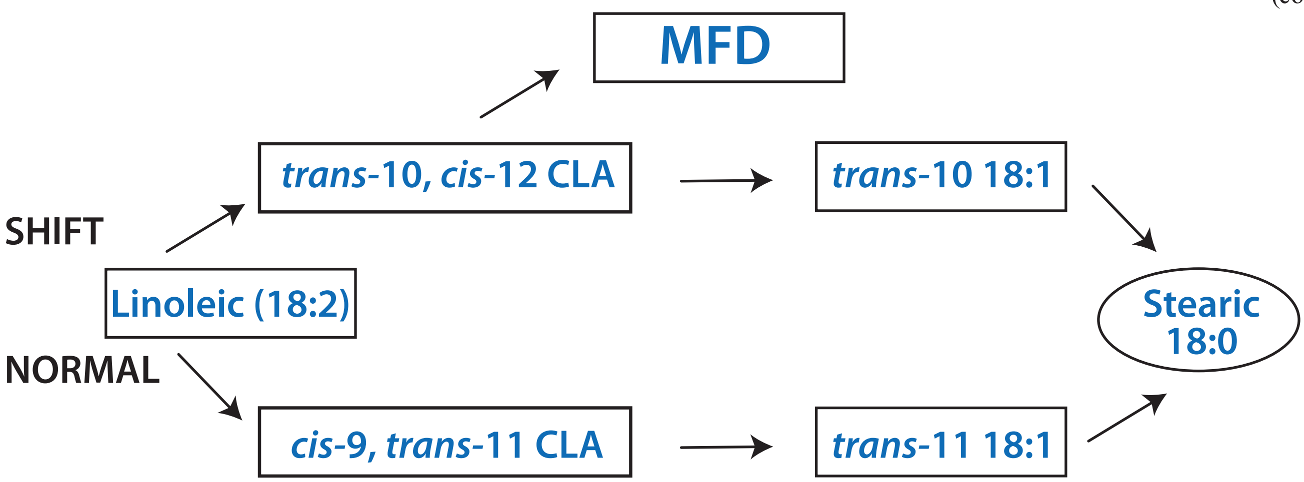

Figure 1. Pathways of ruminal biohydrogenation of linoleic acid and the formation of CLA isomers.

Supplemental K in the form of K_2CO_3 has been shown to be a strategy for alleviating MFD due to harmful CLA production. Levels of 1.75-2.0% K with DCAD level of 25-50 have been successful in improving milk fat percentage. Reducing linoleic acid in the diet should also be recommended during MFD. Feeding a saturated FFA product such as Energy Booster 100 reduces the likelihood of MFD. This coupled with feeding of K_2CO_3 (Potassium Carbonate) is the best research proven choice that dairymen and consultants have for feeding inert fat and for improving improve milk production, milk fat percentage, and body condition during heat stress.

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