Can chromium help?

Supplemental chromium increases the sensitivity of body tissues to insulin, which can improve dry matter intake and milk production of transition cows.

By MARY BETH DE ONDARZA

AcTATION performance is dependent on the success of the transition period from three weeks before to three weeks after calving (Drackley, 1999). Many programs have been made with dry cow and fresh cow nutrition and management to reduce metabolic diseases during this time.

On many commercial dairies, the incidence of clinical disease during the transition period is low, but there are still ample opportunities to reduce subclinical issues and improve performance.

Negative energy balance

Most transition cows experience some degree of negative energy balance due to their high energy demands and insufficient dry matter intake.

To meet these needs, body fat reserves are mobilized and converted to non-esterified fatty acids (NEFAs) to be used as an energy source. Blood NEFA concentrations are about 0.2 milliequivalents (mEq) per liter for a dry cow and rise three weeks before calving to more than 0.6 mEq per liter on calving day.

High plasma NEFA levels are typically associated with metabolic problems during the transition period (Dyk et al., 1995; Chandler, 1997). Cattle (Staples et al., 2010) sampled from 15 apparently healthy prepartum cows (from 1 to 2 days prepartum) and 15 apparently healthy postpartum cows (0 to 14 days postpartum) from D1 Northeast dairies. Blood NEFA and body composition were correlated with reproduction and productivity.

This work provides targets for optimum milk production, with NEFA concentrations for prepartum cows to be less than 0.3 mEq per liter and for postpartum cows to be less than 0.7 mEq per liter with BHD of less than 10 mg/L.

Targets for optimum reproduction were: NEFA concentrations of less than 0.27 mEq per liter for prepartum cows and NEFA concentrations of less than 0.73 mEq per liter and BHD of less than 10 mg/L for postpartum cows.

Insulin sensitivity

Insulin binds to receptors on the body's cells similarly to a lock and key. Once insulin has "unlocked the door," blood glucose can enter the cell and be used as an energy source to produce adenosine triphosphate or be stored as glycogen.

When a cow is said to have "insulin resistance," the amount of insulin needed to activate the cells decreases, due to changes at the level of the cell or glucose entry.

Several weeks before calving, insulin concentrations in the cow's blood begin to decrease, ending up at half the basal level by calving day (Allen and Bradford, 2009). This increases fat mobilization, resulting in higher plasma NEFA concentrations. At the same time, insulin sensitivity of the cow's tissue is reduced, further increasing fat mobilization (Sano et al., 1993).

Several weeks after calving, insulin levels and insulin sensitivity continue to be low, causing NEFA levels to remain elevated.

According to the hepatic oxidation theory, the breakdown of NEFAs in the liver reduces feed intake and causes insulin resistance. The liver reduces feed intake and causes insulin resistance by producing ketones (acetone, acetoacetate, and BHB). Some tissues can use ketones for energy to help reduce overall glucose usage, but high levels of blood ketones can cause a cow to reduce intake, likely causing additional body fat mobilization, accumulation of liver fat and further inhibition of gluconeogenesis (Overton and Waldron, 2004; Tepferbruck et al., 2003).

Calving stress and the risk of infection are high during the transition period. When immune cells are activated, often due to traumatic or severe infections that occur during the transition period, inflammation occurs (Bradford, 2009). In addition, dietary changes and ruminal acidosis challenges during the transition period can increase blood ketones (Khalifee et al., 2009), which will also affect an inflammation response in the body.

Cytokines produced as a response to inflammation generate more body fat mobilization and reduce insulin sensitivity (Kushibiki et al., 2001) as well as reduce insulin sensitivity (Kushibiki et al., 2001). Cows with excessive body condition are more likely to have metabolic problems during the transition period. Tissues of cows with excessive body condition can have reduced insulin sensitivity (Allen and Bradford, 2009).

Adipose tissue can generate inflammatory cytokine-like tumor necrosis factor-alpha (Hotamisligil et al., 2000) and can cause cardiovascular disease, chronic low-grade inflammation that increases those levels in the blood without a cow having an infection (Bradford, 2009). Furthermore, it has been found that more lipid peroxidation products are produced when liver NEFA levels rise, especially in transition cows with excessive body condition. These lipid peroxidation products can increase insulin resistance (Bradford, 2009).

Glucose concentration and insulin sensitivity are increased by the production of cytokines.

Foodstuffs, September 13, 2010
insulin sensitivity?

In a similar study, Spears et al. (2009) supplemented 0, 3.6, or 9.9 mg of chromium per cow daily. Chromium propionate supplementation increased energy intake and insulin-glucose ratios at 15 minutes after glucose injection, indicating greater insulin sensitivity.

Intake, milk production

Spears et al. (2010) reviewed the literature and concluded that most studies found that supplemental chromium significantly increased or tended to increase milk production and intake. They noted that the increase in milk production associated with the supplemental chromium was in an organic form other than chromium propionate. Researchers at the University of Wisconsin (Hayler et al., 2001) supplemented cows with 0, 0.03, 0.06, and 0.12 mg of chromium as chromium mononitrile per kilogram of dry matter (0.25%, 0.5%, 1.03%, and 2.06 g/kg of dry matter), respectively, for 28 days before and after calving.

In another study, insulin and glucose tolerance was improved between 21 days before calving and 21 days after calving equal to great lactation for a cow (Bryant, 1999). Although progress has been made in improving diets and management of transition cows, it remains a challenge to quickly increase dry matter intake to provide the nutrients needed for milk production.

Supplemental chromium increases the sensitivity of body tissues to insulin, enhancing glucose uptake. Chromium reduces mobilization of body fat, consequently lowering body NEFA levels. By these mechanisms, supplemental chromium can improve dry matter intake and milk production in the early-lactation cow.

Significance

Porcine and ovine models of diabetes and insulin resistance were used to investigate the potential of chromium as a treatment for these conditions. Chromium supplementation improved bodyweight (approximately 0.87 mg/kg bodyweight), glucose tolerance and body fat, consequently lowering body NEFA levels. By these mechanisms, supplemental chromium can improve dry matter intake and milk production in the early-lactation cow.

Relevant studies have been conducted to determine if dietary chromium affects the response of cows to supplemental chromium. Smith et al. (2005) fed a high-concentrate diet (72% of dry matter) or low-starch diet (18% of dry matter) with or without supplemental chromium. After supplementation with 0.03, 0.06, and 0.12 mg of chromium per kilogram of dry matter (0.25%, 0.5%, and 1.03 mg/kg feed) for 28 days before and after calving.

In this study, chromium supplementation had a significant effect on milk production, with cows supplemented with 0.03 mg/kg of chromium producing 2.9 kg more milk than control cows (0.0 mg/kg of chromium). Chromium supplementation increased serum NEFA concentrations, especially one week before calving, and tended to improve pregnancy rates, but no difference in milk response was observed.

Significance

Diabetes producers and their nutritionists know that a great transition period among from 21 days before calving to 21 days after calving equates to great lactation for a cow (Bryant, 1999). Although progress has been made in improving diets and management of transition cows, it remains a challenge to quickly increase dry matter intake to provide the nutrients needed for milk production.

Supplemental chromium increases the sensitivity of body tissues to insulin, enhancing glucose uptake. Chromium reduces mobilization of body fat, consequently lowering body NEFA levels. By these mechanisms, supplemental chromium can improve dry matter intake and milk production in the early-lactation cow.