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Mini Review

Transition Cattle Benefit from Chromium Supplementation

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Abstract

Dairy cows start producing milk at the same time as they give birth from pregnancy, and about 30 to 60 days after giving birth, the uterus regresses, ovarian activity recovers, and the estrous cycle returns. During the transition period, many endocrine and metabolic functions associated with the birth of calves and the initiation of milk production change, and cattle undergo major metabolic adaptations to glucose, fatty acid, and mineral metabolism. Some cows that are unable to respond to these changes can cause fatty liver, ketosis, dysregulation of inflammation, immunosuppression and ultimately postpartum metabolic or infectious disease.

Trace minerals play important roles in dairy cow energy metabolism, immune function and oxidative metabolism, especially during the transition period. Chromium (Cr), in particular, is a trace mineral that plays an important role in the metabolism of human and animal carbohydrates and lipids. Cows fed a Cr-supplemented diet have been shown to increase milk yield and improve energy metabolism. Chromium can improve insulin sensitivity by binding to intracellular insulin receptor sites and enhancing insulin signaling.

Chromium supplementation can affect fertility through effects on energy metabolism during the transition period. This is because the higher production of NEFA and ketones in the cow circulation during the transition period is associated with lower reproductive performance.

Keywords: *Chromium; Transition Cattle; Reproduction; Cytological Endometritis; Metabolism*

Dairy cows undergo a physiological transition from pregnancy to lactation during the last few weeks before and the first few weeks after calving. This period represents the most critical timespan of the lactation cycle in dairy cattle because it represents the period of most dramatic and dynamic change in nutrient requirements. During the transition period, cattle undergoes major metabolic adaptations to glucose, fatty acid, and mineral metabolism, resulting in changes in many endocrine and metabolic functions associated with calf birth and initiation of milk production [1]. Calf production requires nutrients from conception to lactation, but cows in pre and post partum may experience a decrease in energy intake shortly before calving. During the late pregnancy, the use of glucose and amino acids fatty acids (FA) and minerals as well as glucose hastens once the milk production begins. The required glucose increases by 4 times from prepartum to early lactation in dairy cows [2].

Volatile fatty acids (VFA) released from the fermentation processes in the rumen serve as a major energy source. In addition to that, glucose is resynthesized in the liver from VFA, amino acids, and glycerol using a process called gluconeogenesis which is a critical process for ruminants because most ingested carbohydrates are fermented to VFAs in the rumen. The liver adjusts to the high rate of postpartum gluconeogenesis by increasing the expression of key gluconeogenic enzymes. However, the significant increase in hepatic gluconeogenesis immediately after delivery can lead to insulin resistance, impeding the accumulation of glycogen in muscles and liver and stopping the use of glucose for adipose tissue (Lipogenesis).

In addition to milk synthesis, postpartum dairy cows also require glucose for a variety of other tissues including those involved in reproduction [3]. Compared to cows that became pregnant and non-pregnant after the first artificial insemination (AI), cows with high blood glucose levels three days after calving had a higher pregnancy rate [4]. Hypoglycemia during early lactation causes infertility in dairy cows [5]. Failure to meet auxotrophy affects reproduction, including hormone synthesis and secretion, follicular ovulation, implantation and embryonic development.

Glucose regulates changes in endocrine hormones such as insulin and insulin-like growth factor 1 (IGF-1) to coordinate metabolism throughout the body [6]. Insulin stimulates the liver to release IGF-1 into the circulating blood [7]. Glucose stimulates the release of insulin which distribute nutrients to adipose tissue and muscle.

During postpartum, the hasten demand of glucose and other nutrients to meet the requirements for the synthesis of colostrum and milk associated with decreased feed intake, leads to negative energy balance (NEB) and micronutrient shortage. The NEB force cows to break down glycogen in the liver and muscles and to mobilize body fat in the form of non-esterified fatty acids (NEFA). Cattle breaks down triglyceride (TG) stored in adipose tissue and use it as an energy source followed by the releases of fatty acids and glycerol into blood circulation. The fatty acid (FA) and glycerol then oxidize in the liver forming acetyl-CoA. Under normal conditions, carbohydrate is metabolized and gives the pyruvic acid which provides sufficient oxaloacetate that is combined with acetyl-CoA as an essential step in tricarboxylic acid (TCA) cycle to form citrate. However, both the limited energy intake and the glucose shortage limit the production of TCA cycle intermediates particularly oxaloacetate leading to ketone body formation and increased concentrations of ketone bodies (acetoacetic acid, β-hydroxybutyric acid/BHBA, and acetone) in body fluids. These changes are normal adaptive process in high producing cows and if they are unable to respond to these metabolic changes in the postpartum period, fatty liver, ketosis, dysregulation of inflammation, immunosuppression, and ultimately metabolic or infectious disease may occur [8].

Trace minerals play crucial roles in aspects of energy metabolism, immune function and oxidative metabolism of dairy cattle, especially during the transition period.

Chromium (Cr) is a trace mineral that plays an important role in human and animal carbohydrate and lipid metabolism. The high requirement of Cr is classically associated with the nutritional, metabolic, and physical stress [9]. Several studies showed that cows fed diet supplemented with Cr have increased milk yield [10] and improved energy metabolism, as measured by lower circulating concentrations of NEFA or BHBA during the transition period [11].

Chromium can improve insulin sensitivity by binding to the intracellular insulin receptor site and enhancing insulin signaling [12], thereby enhancing carbohydrate metabolism.

Chromium supplementation can affect reproductive performance through its impact on energy metabolism during the transition period. Higher production of NEFA and ketone bodies in cow circulation during the transition period was coupled with reduced reproductive performance in a largescale study [13]. Cheong., *et al*. [14] showed that this reduction can be partially explained by the development of cytological endometritis (CE) as it was highly associated with cow suffering from ketosis. Cytological endometritis can affect postpartum reproductive performance by decreasing the first-service conception rate [15] and lowering the probabilities for pregnancy at first insemination [16] in cows with CE compared with cows without CE.

Chromium supplementation in transitional cows can be expected to alleviate the adverse effects of metabolic stress on cows, improve health and milk production.

Conclusion

Cows with ketosis are more likely to develop cytological endometritis (CE). Chromium supplementation will reduce NEFA and ketone bodies during the transition period and reduce the incidence of cytological endometritis (CE). Chromium supplementation to transitional cows can be expected to reduce the adverse effects of metabolic stress on cows and improve health and milk production.

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