Get to know about supplementing chromium: Metabolic effects and potential benefits

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Supplementation of dairy cattle diets with chromium propionate has considerable potential to improve glucose and NEFA (non-esterified fatty acid) metabolism, dry matter intakes and milk yields, particularly in transition cows (**Figure 1**). Improvements in glucose and NEFA metabolism also have implications for better reproduction. The largest benefit may be in reducing the incidence of periparturient diseases, such as ketosis, displaced abomasums, fatty liver, metritis and mastitis.

How does chromium affect glucose and NEFA metabolism?

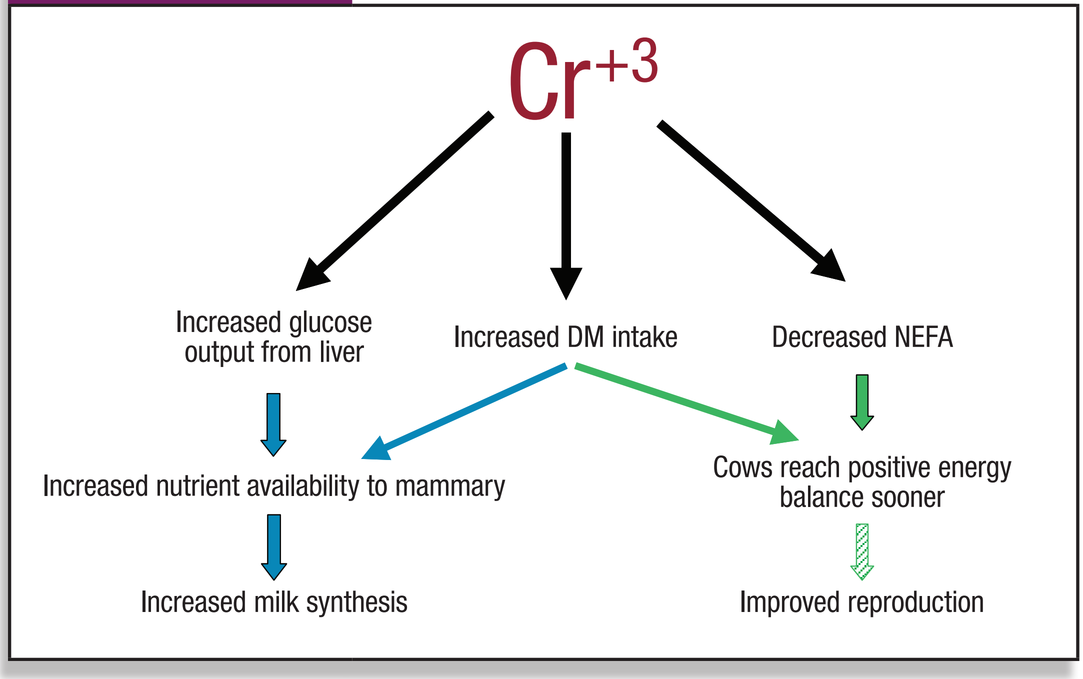
Trivalent chromium has received a lot of attention in human nutrition and medicine throughout the past 50 years, particularly in regard to glucose homeostasis and management of Type II diabetes. Trivalent chromium increases the insulin sensitivity of some peripheral tissues including adipose and muscle. Because glucose transport in mammary tissue is not insulin-regulated, glucose transport by mammary would not be altered by trivalent chromium. This is important, as glucose is the major substrate for lactose synthesis, and lactose is the primary determinant of milk volume.

Trivalent chromium may also alter the insulin sensitivity of liver. If insulin and peror glucagon responsiveness were altered by trivalent chromium supplementation, we would expect to see alterations in rates of gluconeogenesis. In a study with primiparous cows, those that were supplemented with trivalent chromium had significantly higher rates of gluconeogenesis and peror glycogenolysis in their livers. In another study with multiparous cows, trivalent chromium supplementation increased rates of gluconeogenesis measured in vitro when cows were fed a pre-partum diet low in non-fiber carbohydrates.

The increase in insulin responsiveness of adipose tissue observed with trivalent chromium supplementation would be expected to result in increased rates of lipogenesis and decreased rates of lipolysis. Lower serum NEFA concentrations would be correlated with decreased lipolytic rates, and several studies have shown decreased NEFA in the prepartum period in cattle supplemented with trivalent chromium. After calving, the response in NEFA levels to trivalent chromium supplementation appears to reflect the cows' energy balance statuses. NEFA levels in the first few weeks after calving are lower in chromium-supplemented cattle than in cows fed an unsupplemented diet.

Figure 1

Supplementation with trivalent chromium alters glucose and NEFA metabolism in the transition dairy cow and increases dry matter (DM) intake.



The chicken and the egg: DMI and milk yield

With recombinant bovine somatotropin (rBST) treatment in lactating dairy cattle, it is well known that increases in milk yield precede the increases in dry matter intake (DMI). With trivalent chromium supplementation, it is not clear which comes first, DMI or milk yield, largely due to the fact that most of the studies reported start supplementation in late gestation. Of the seven experiments in the scientific literature where trivalent chromium supplemented during the transition period, two observed significantly increased DMI during the pre-partum period, while the other five observed no difference compared to the unsupplemented cows. Lack of significant differences in pre-partum DMI in response to chromium supplementation in the studies above does not necessarily rule out that increases in DMI occurred; lack of significance could be due to the high variation in DMI within and between individual cows during this period and the lack of adequate animals (experimental units) to detect treatment differences.

Out of nine experiments, six had significantly increased DMI post-partum in the chromium- supplemented cows and the other three had non-significant differences compared to the unsupplemented cows. The unweighted average across the nine experiments is 2.7 pounds per day DMI, with a range from less than 1.1 pounds to more than 7.5 pounds per day. Milk yield responses paralleled the DMI response, with the studies that observed significant increases in DMI also having significant increases in daily milk production. On average (unweighted), there was a 3.9-pounds-per-day increase in milk yield, ranging from less

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than 1.0 to more than11.0 pounds per day.

Because the increases in milk yield and DMI to trivalent chromium supplementation parallel each other, feed efficiency is unchanged. Milk composition has also been unchanged with chromium supplementation. These observations support the concept that chromium supplementation elicits metabolic and endocrine changes in a homeorhetic manner, similar to rBST.

How can these metabolic changes impact reproduction?

In concert with the improved DMI observed with trivalent chromium supplementation during the early lactation period, cows appear to reach a positive energy balance sooner, as reflected in lower NEFA levels. Calculated net energy balance (NEB) was statistically improved in one study and numerically improved in four studies with trivalent chromium supplementation. Most of these studies had small numbers of animals per treatment (10 to 20) and calculated NEB over the entire period of supplementation rather than focusing on the first few weeks post-calving. As cows reach positive energy balance sooner after calving, improvements in ovulation rates, expression of heats and conception occur. Accordingly, days open and services per conception decrease and pregnancy rates are expected to increase.

Research studies designed to examine the impact of nutrition on reproduction require large numbers of animals, typically more than the 10 to 20 animals per treatment used in feeding and metabolism studies. Of the feeding studies in the chromium supplementation literature, most do not report any results on reproductive performance. Only two had sufficient numbers of animals to be able to detect a difference in pregnancy rates. Both studies noted improved pregnancy rates in the first 28 days following the end of the voluntary waiting period. In one study, trivalent chromium was supplemented only in the prepartum period, and thus the improvement in reproduction reflects a carryover effect into lactation and the breeding period. In another study, trivalent chromium was supplemented through 84 DIM, which is likely to have overlapped with the beginning of breeding. The length of the voluntary waiting period was not reported in this study.

Lower incidence of infectious and metabolic diseases in the transition period is also correlated with better reproduction. With the alterations in glucose and NEFA metabolism that occur with trivalent chromium supplementation and improved DMIs observed, incidences of ketosis, fatty liver and displaced abomasums would be expected to decrease as well. The studies summarized here for DMI and milk yield showed mixed results for incidences of metabolic and infectious (metritis and mastitis) diseases. It is likely that research trials with larger numbers of animals would be needed to investigate the impact of chromium supplementation on the epidemiology of periparturient diseases. Trivalent chromium supplementation may have positive impacts on immunity through reducing cortisol levels and improving immune responses. This has important implications in livestock nutrition during stress, as well as the peripartum transition period in sows and dairy cows. If overall immunity and peror responses to specific immune challenges such as metritis and mastitis are improved in the transition period with trivalent chromium supplementation, then this would also be expected to lead to reduced incidences of infectious diseases and better reproduction in dairy cattle.

Determining whether chromium supplementation is needed

The chromium status of animals is difficult to evaluate. Serum and tissue levels are not good indicators as chromium turns over quickly, and urinary clearance rates are increased by stress. The best test to evaluate chromium status of individual animals appears to be the glucose challenge or glucose tolerance test. However, this test is not feasible in a commercial dairy herd setting. Determining chromium status and intake is further complicated by the difficulty of obtaining feed samples without contamination from other sources of chromium or laboratories having sensitive enough equipment. Little data is available on chromium levels in common feedstuffs, and whether it is an inorganic or organic form. At the herd level, circulating NEFA levels in the first few weeks post-calving, DMI and milk yield (daily and peak) would be the best variables to evaluate whether chromium supplementation is beneficial to transition dairy cows.

Trivalent chromium is a dietary required nutrient in humans and laboratory rodents. However, due to limited research available, the NRC has not established a dietary requirement in swine or cattle, including dairy.

In 2009, the U.S. Food and Drug Administration (FDA), Center for Veterinary Medicine (CVM) issued a regulatory discretion letter that permits the use of chromium propionate as a source of chromium in cattle diets, up to 0.5 mg Cr per kilograms (500 ppb) in the complete diet.

Risk-to-benefit perspective

Based on the literature reviewed, supplementing transition dairy cows with chromium propionate would be expected to increase milk yields and income over feed costs more than 75 percent of the time. At April 2010 feed and milk prices, an increase of 2 pounds milk per head per day with an associated 0.7 pound per head per day increase in DMI in response to supplementation with chromium propionate would expect to net $720 per 100 cows per month in IOFC (income over feed costs, not including the chromium). The cost to supplement chromium propionate during the close-up period and the first month post-calving to 100 cows would be less than $500.

However, the largest economic benefit to trivalent chromium supplementation may be realized through reduced incidence of periparturient diseases and improved reproduction in the dairy herd. With the caveat that the data available in the current scientific literature is not adequate to estimate the probabilities of success or failure for these responses to chromium supplementation, we can only speculate at what the economic benefits would be. At costs of $200 to $400 per case for the various metabolic diseases, a reduction of one to two cases per 100 cows would justify the cost of supplementing chromium propionate during the periparturient period. If improvements in herd reproduction occur with chromium supplementation, this would also increase the return. With new pregnancies having a value of $278, a reduction of involuntary culling due to not being bred by 2 percent would make chromium supplementation worthwhile. Improved reproduction would also be reflected in reduced days open. At a conservative cost of $2 per cow per day open, reducing days open by three days in a group of 100 cows would be worth $600. Note that these two approaches to valuing improvements in herd reproduction are not additive; both account for cull value, replacement costs and persistency in milk yield. In contrast to these potential benefits, the cost of failure (no response to supplementation) is the cost of feeding chromium propionate to 100 cows. ***PD***

References omitted due to space but are available upon request.

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