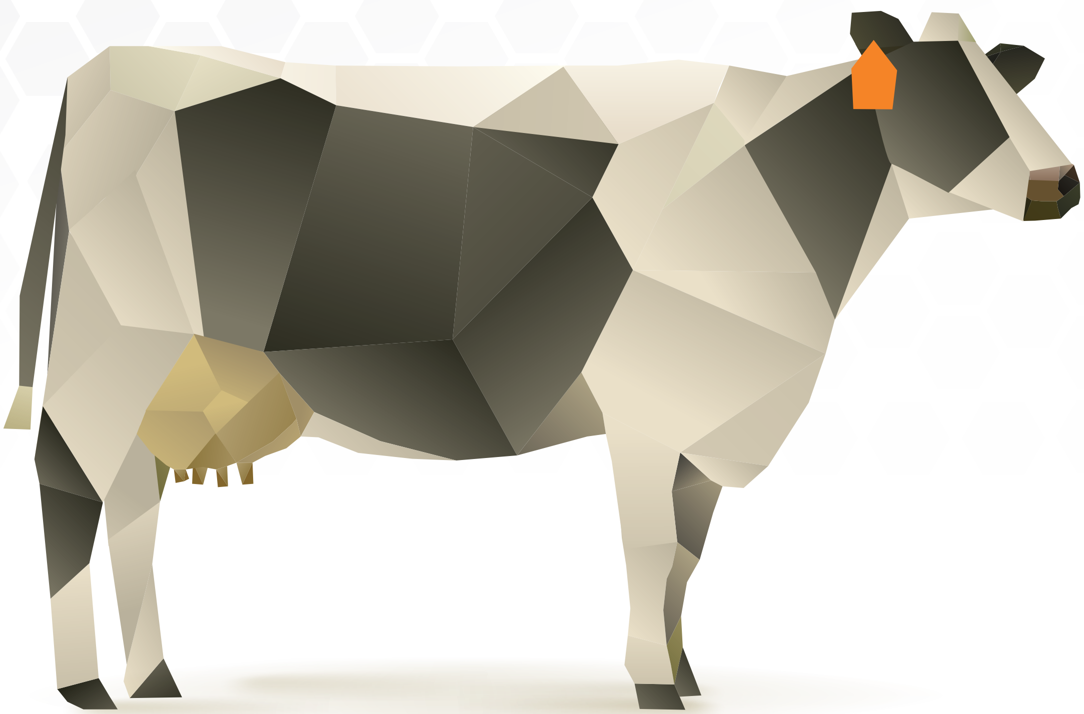
# KemTRACE® CHROMIUM: ESSENTIAL FOR YOUR DAIRY



SAFE

QUALITY

EFFICACIOUS

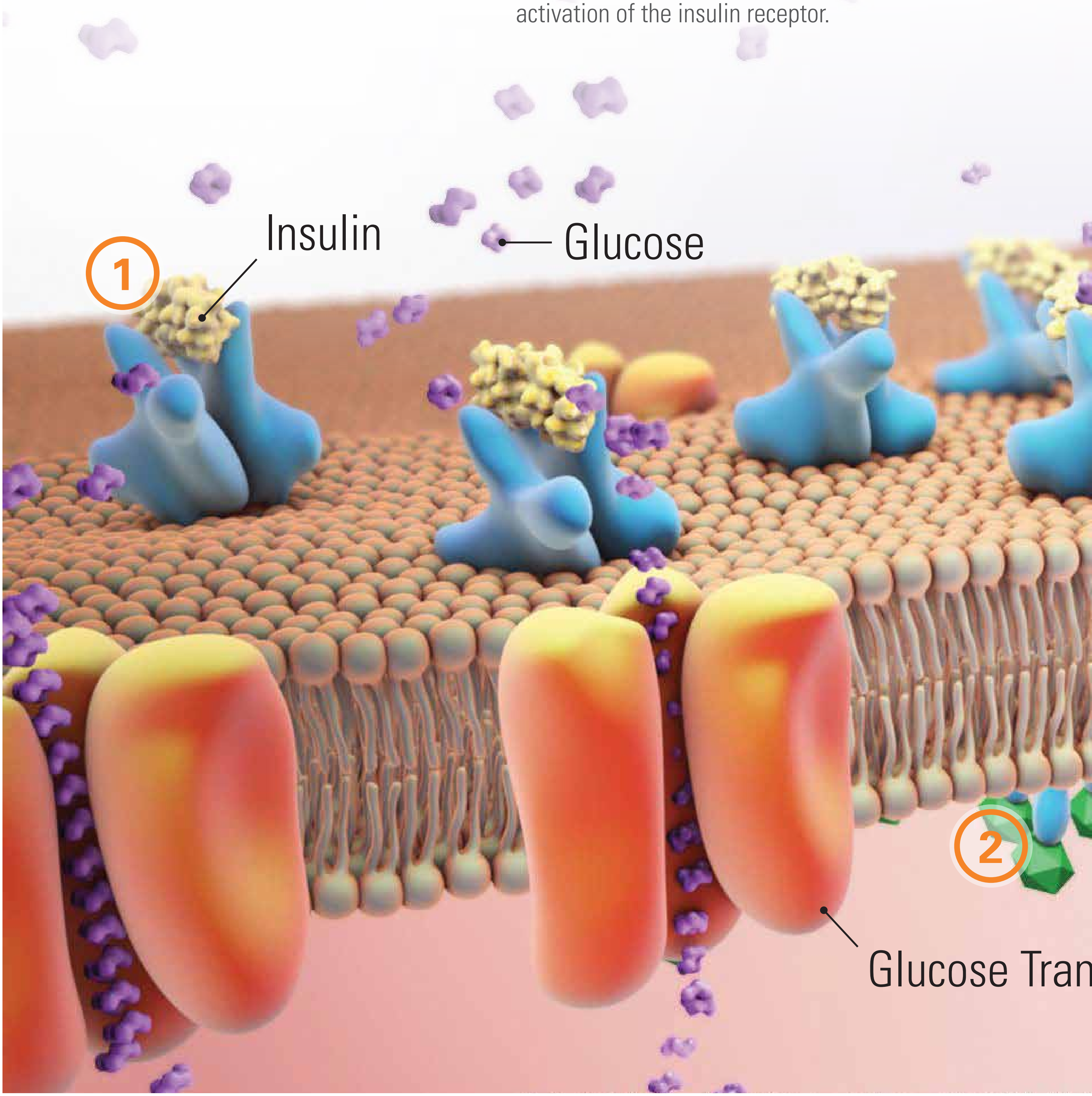
PROFITABLE

Kemin.com/Chromium

# KemTRACE® Chromium Mode of Action

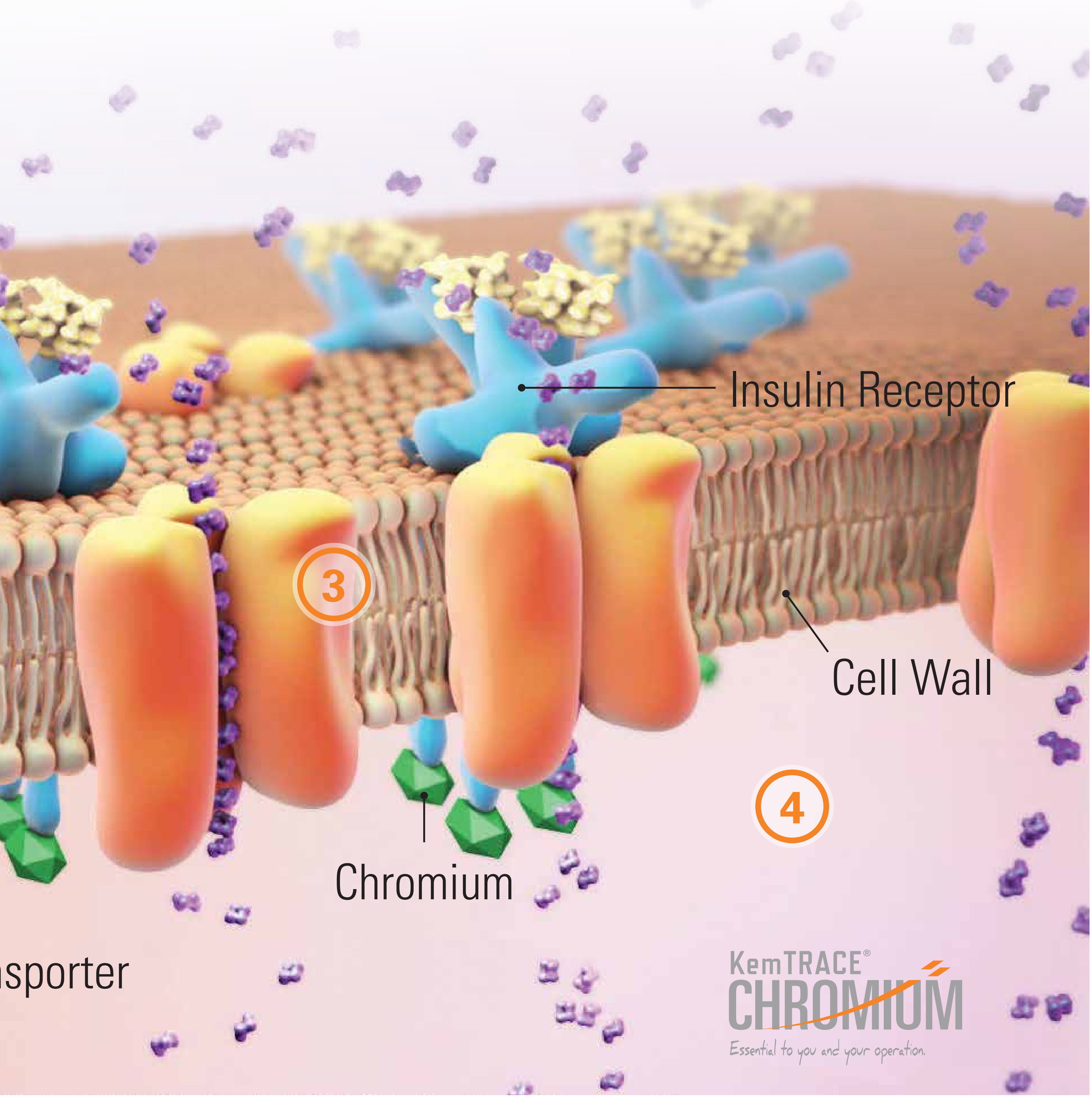
1. Insulin stimulates glucose uptake.[1]

2. Readily available chromium propionate from KemTRACE® Chromium is necessary to optimize the activation of the insulin receptor.



3 Glucose uptake by the cell.

4 The additional glucose will allow for more energy to be available for proper cell function.




1. Weekes, T. E. C. 1991. Hormonal control of glucose metabolism. In Proceedings of 7th International Symposium on Ruminant Physiology (ed. T. Tsuda, Y. Sasaki, and R. Kawashima), pp. 183. Academic Press, San Diego, CA, U.S.A.

# Trace Mineral Nutrition

One of the most important micro minerals for dairy cattle is quite possibly the least utilized due to its recent entry into the market. In 2009, chromium propionate was permitted by the FDA for use in U.S. cattle. Since then, research discoveries indicate there are enormous nutritional and financial benefits for dairy when chromium propionate is added to the diet. Minerals required by cattle, in microgram or milligram amounts per day for optimal nutrition and performance, are called trace minerals.[2] The nine trace minerals considered essential for cattle are:

- Chromium (Cr)[3]
- Cobalt (Co)
- Copper (Cu)
- Iodine (I)
- Iron (Fe)
- Manganese (Mn)
- Molybdenum (Mo)
- Selenium (Se)
- Zinc (Zn)[4]

# Hierarchical Needs

In a perfect world, dairy cattle would never be under stress. However, they are presented with daily challenges impacting health and performance. One of the most significant factors in animal health and performance is response to stress. Stress causes the body to redistribute nutrients to maintain and support life. The utilization of glucose by the animal's body is governed by specific hierarchical processes and is dependent on the type of stress the animal is facing.

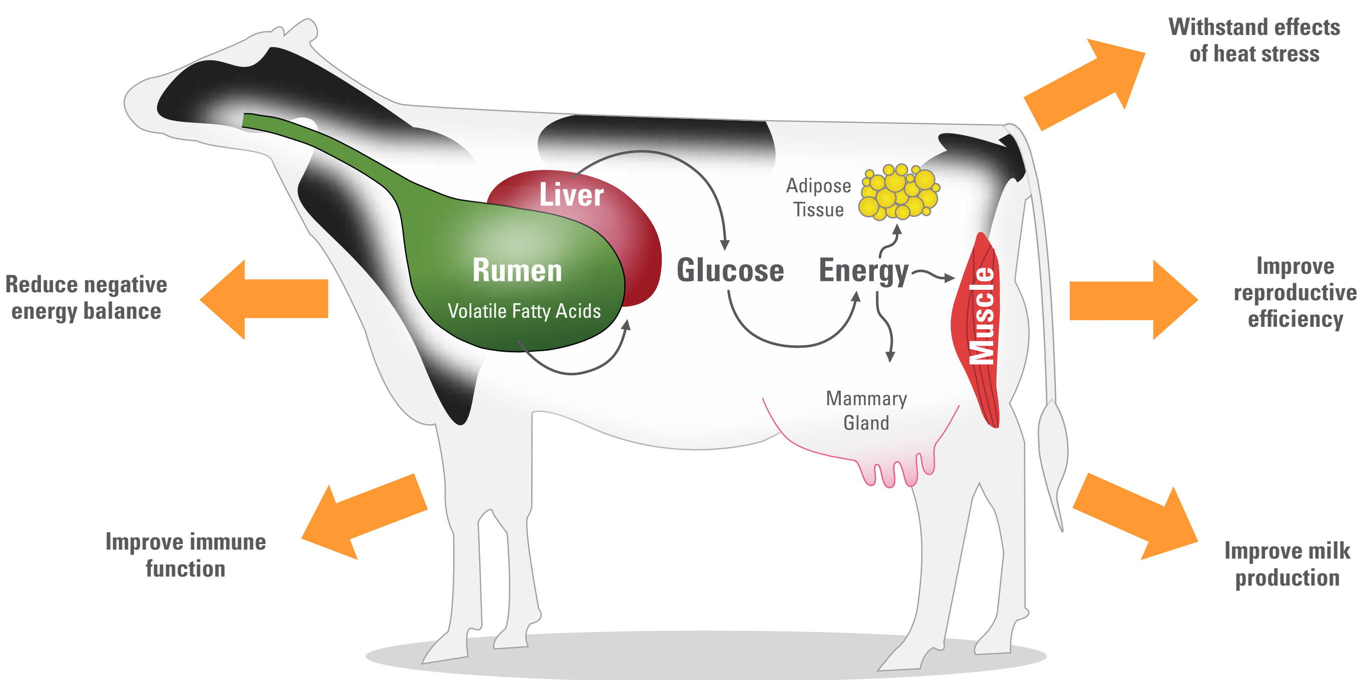



*Figure 1: What can a cow do with more energy?*

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2. NRC. 2000. Nutrient Requirements of Beef Cattle (7th Ed.). National Academy Press, Washington, D.C. 3. Up to Date Recommendations for Vitamins and Trace Minerals for Dairy Cows. Bill Weiss, Ohio State University. 2017 Southwest Nutrition Conference 4. Calder, P. C. Curr. Opin. Clin. Nutr. Metab. Care. 2007 Jul. 10(4):531-40.

# Effect on Neutrophils

Immune cells (specifically macrophages and neutrophils) are insulin sensitive and proper insulin signaling is necessary for leukocyte function.[4-6] Chromium has shown to increase neutrophil numbers under stress conditions in other animal models.[7,8] Thus, in addition to influencing glucose homestasis and post-absorptive carbohydrate metabolism, chromium may be able to mediate changes to systemic nutrient partitioning following a immune system activation where glucose utilization is critical to mounting and sustaining proper immune response.

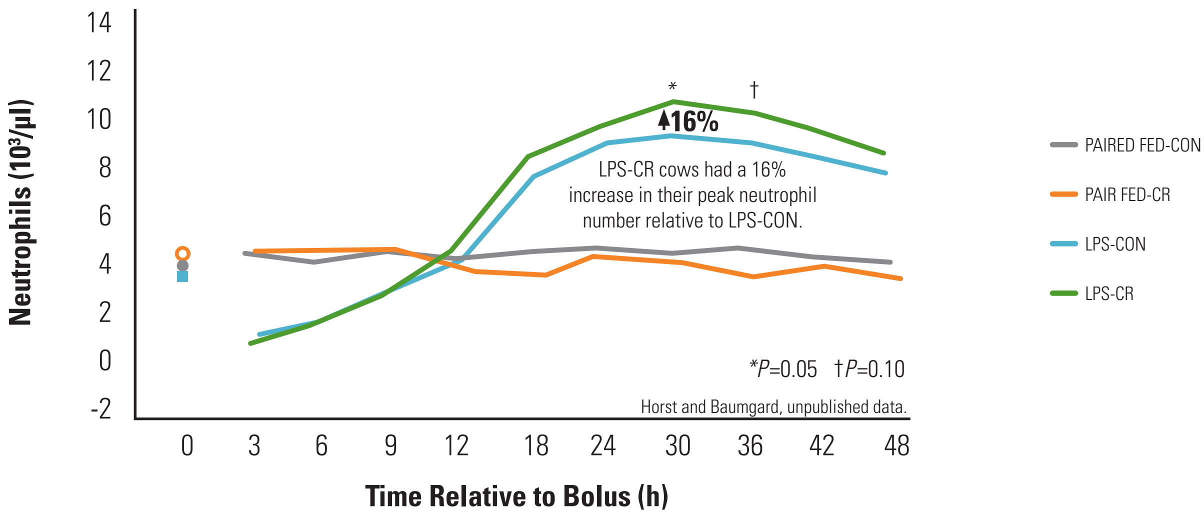



*Figure 2: Effect of chromium supplementation on circulating neutrophils following a LPS challenge or pair-feeding in lactating dairy cows.[9]*

# Effect on Immunity

Animals experiencing frequent immune challenges may have decreased growth, inefficient feed utilization, poor reproduction and increased health costs. Lymphocytes under stimulation from pathogens require large increases in glucose for their proliferative, biosynthetic and secretory activities. Research conducted at Cornell University suggests that chromium propionate supplementation enhanced immune responses in early lactation cows to uterine bacterial infections by increasing neutrophil proliferation (Table 1). Increased neutrophil proliferation more effectively cleared infections, which resulted in fewer cows with subclinical endometritis (Table 1).[7] Subclinical endometritis is a leading cause of reduced first service insemination conception rates.[7]

*Table 1: Effect of chromium supplementation on endometrial cytology.[7]*

| | Treatment | | | |
|---|---|---|---|---|
| **Item** | **Control** | **Cr-Pro** | **SEM** | **P-Value** |
| | ------- **Mean** ------- | | | |
| **7 d postpartum** | | | | |
| **% of Neutrophils** | 32.8 | 41.1 | 4.1 | 0.15 |
| **40 to 60 d postpartum** | | | | |
| **Subclinical Endometritis[1] (# head)** | 16 | 8 | -- | 0.02 |
| **Head (# head)** | 11 | 20 | | |

[1]Neutrophil > 10%


5. O'Boyle, N. J., G. A. Contreras, S. A. Mattmiller, and L. M. Sordillo. 2012. Changes in glucose transporter expression in monocytes of periparturient dairy cows. J. Dairy Sci. 95:5709-5719. 6. Smith, K. L., M. R. Waldron, J. K. Drackley, M. T. Socha, and T. R. Overton. 2005. Performance of dairy cows as affected by prepartum dietary carbohydrate source and supplementation with chromium throughout the transition period. J. Dairy Sci. 88:255-263. 7. Yasui, T., J. A. A. McArt, C. M. Ryan, R. O. Gilbert, D. V. Nydam, F. Valdez, K. E. Griswold, and T. R. Overton. Effects of chromium propionate supplementation during the periparturient period and early lactation on metabolism, performance, and cytological endometritis in dairy cows. J. Dairy Sci. 97:6400-6410. 8. Mayorga, E. J., S. K. Stoakes, J. Seibert, E. A. Horst, M. Abuajamieh, S. Lei, L. Ochoa, B. Kremer and L. H. Baumgard. 2016. Effects of dietary chromium propionate during heat stress on finishing pigs. J. Anim. Sci. 94(E-Suppl. 1):334. 9. Kemin Internal Document, 17-00542. 10. W. R. Butler, Cornell University 2012. The role of energy balance and metabolism on reproduction of dairy cows. Presented January 31, 2012, at Florida Ruminant Nutrition Symposium.

# Effect of Insulin Resistance on Reproduction

Research suggests that the onset of negative energy balance (NEB) can have detrimental effects on metabolic health and reproductive performance. Negative energy balance during early lactation is related to decreased feed intake prepartum, delays in early ovulation, recovery of postpartum reproductive function, as well as negative carrier carryover effects on oocytes and uterine conditions that reduce fertility during the breeding period.[10] Chromium supplementation has been shown to reduce insulin resistance in periparturient dairy cows under negative energy balance.[11] Studies with chromium have also shown to reduce subclinical metritis,[12] improve conception rates (Figure 3) and pregnancy rates (Figure 4), reduce days to first service[14] and increase the number of viable oocytes in cows supplemented high energy diets.[15]

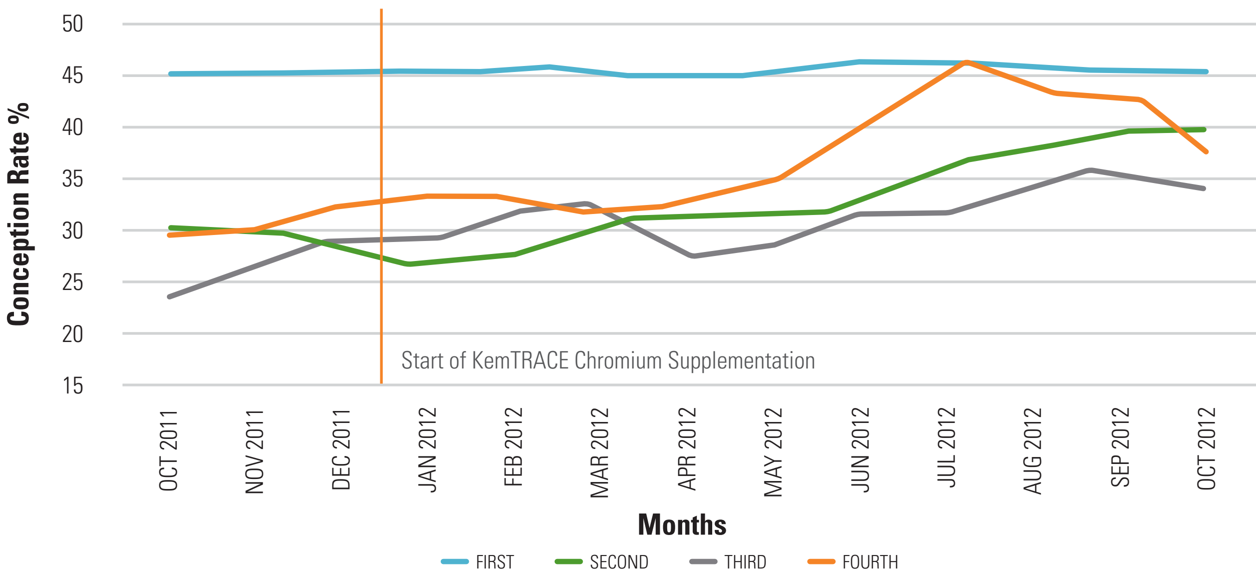



*Figure 3: Effect of chromium supplementation on conception rates in a high-producing Holstein commercial dairy herd.[15]*

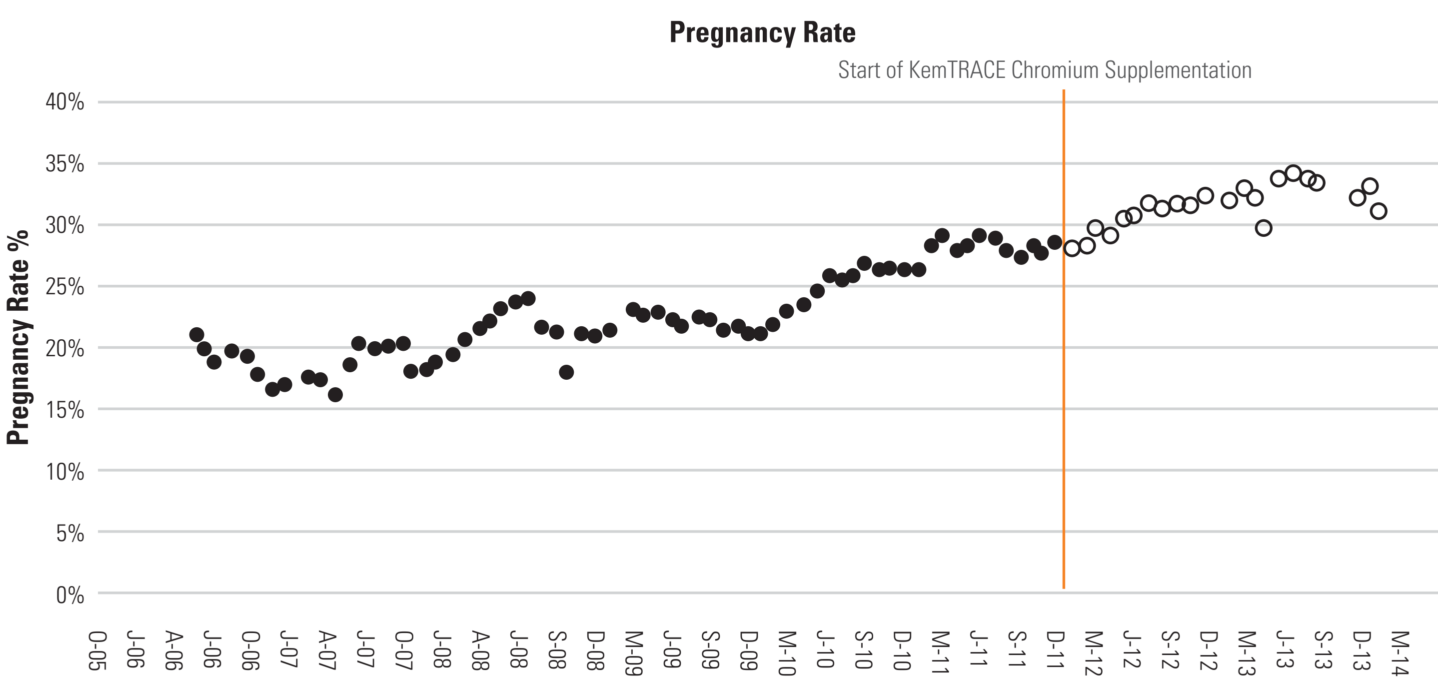



*Figure 4: Effect of chromium supplementation on pregnancy rate in a high-producing Holstein commercial dairy herd.[15]*

10. W. R. Butler, Cornell University 2012. The role of energy balance and metabolism on reproduction of dairy cows. Presented January 31, 2012, at Florida Ruminant Nutrition Symposium. 11. Hayirli et al., 2001. J. Dairy Sci. 84:1218-1230. 12. Lavin-Garza et al., 2007. J. Dairy Sci. 90(Supp. 1): 359. 13. Leiva et al., 2014. J. Dairy Sci. 97(E-Supp. 1):705. 14. Yasui, T., et al., 2014. J. Dairy Sci. 97:1-11. 15. Ferguson et al., 2013. J. Dairy Sci. 96:(E-Supplement 1):127.

# Effect on Milk Production

Figure 5 demonstrates the effects of supplementing chromium on milk production in university-controlled studies with dairy cows since 2000. The graph depicts the milk yield response to chromium supplementation within a study in comparison to the control (i.e. no chromium supplementation).

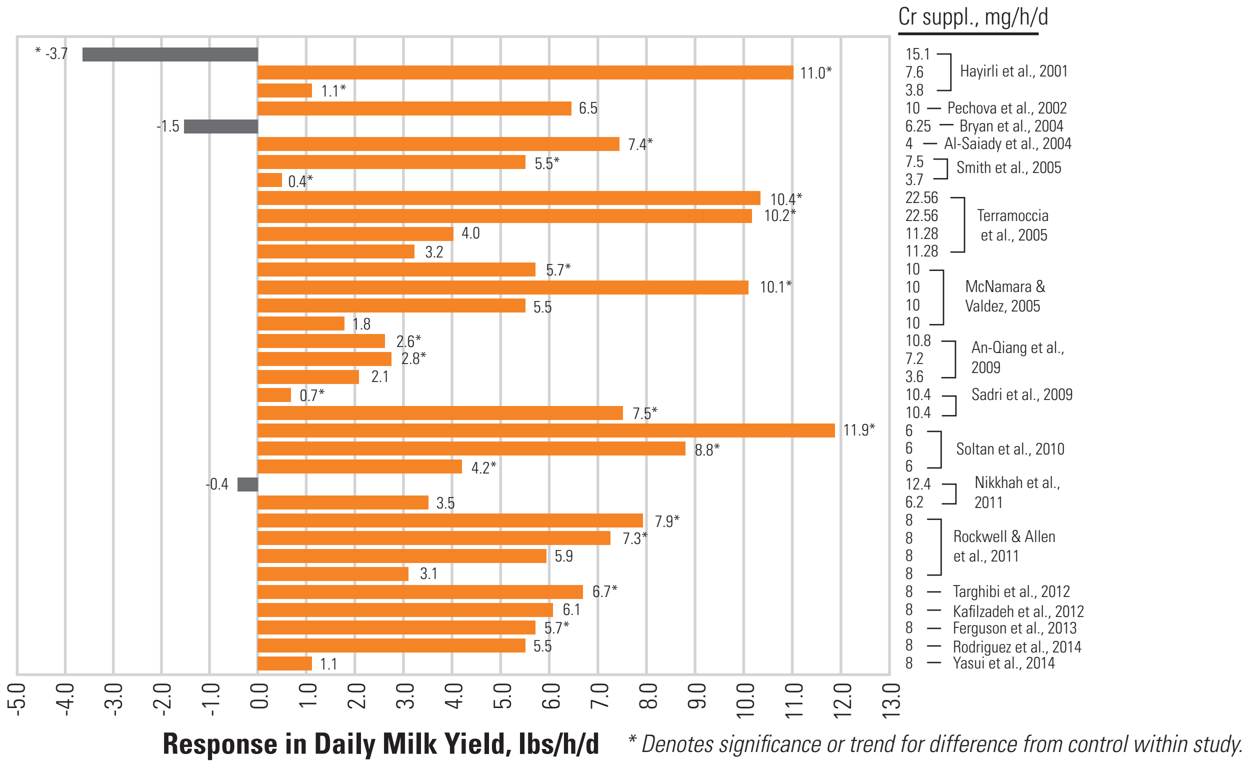



*Figure 5: Effect of chromium supplementation in lactating dairy cow diets on response to daily milk yield, lbs/h/d.*[16]

# Effect on Milk Production Relative to Days in Milk

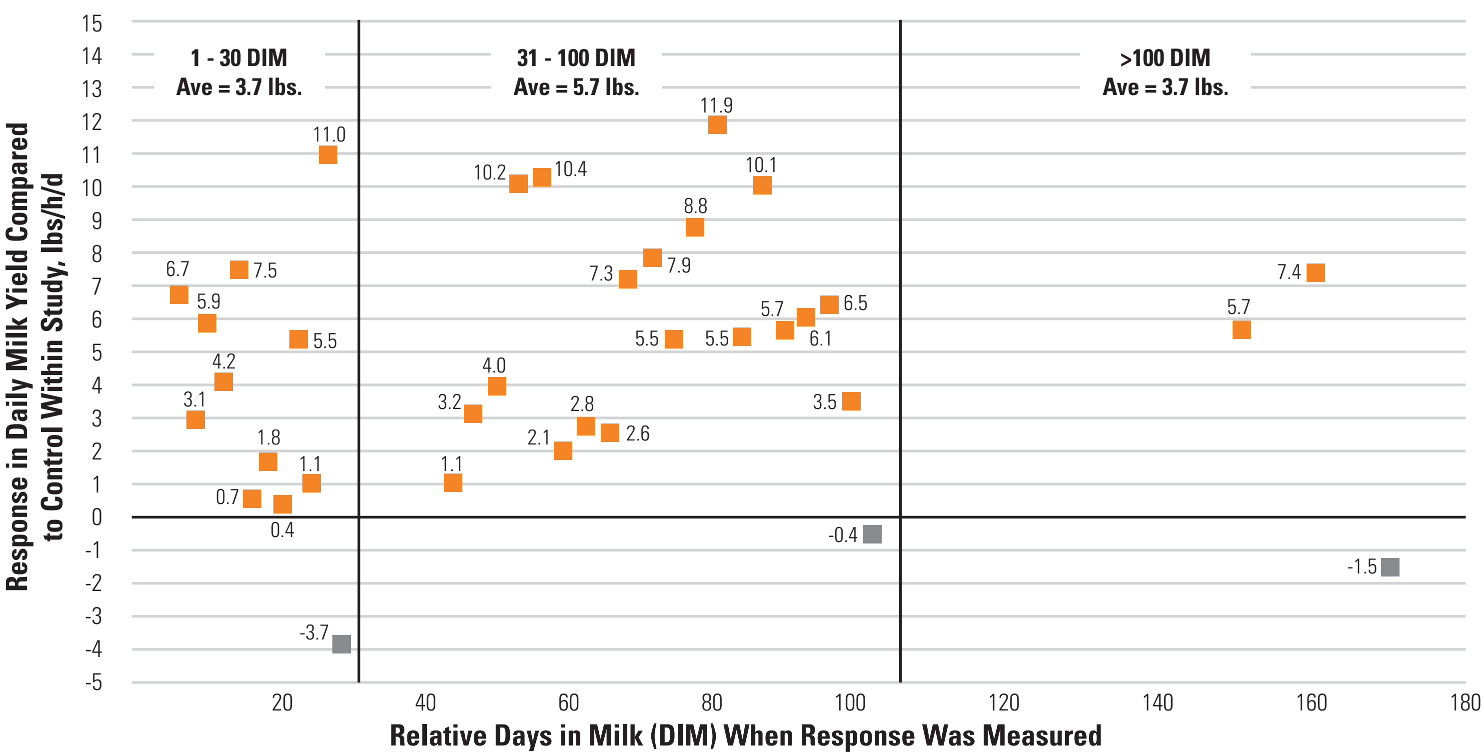
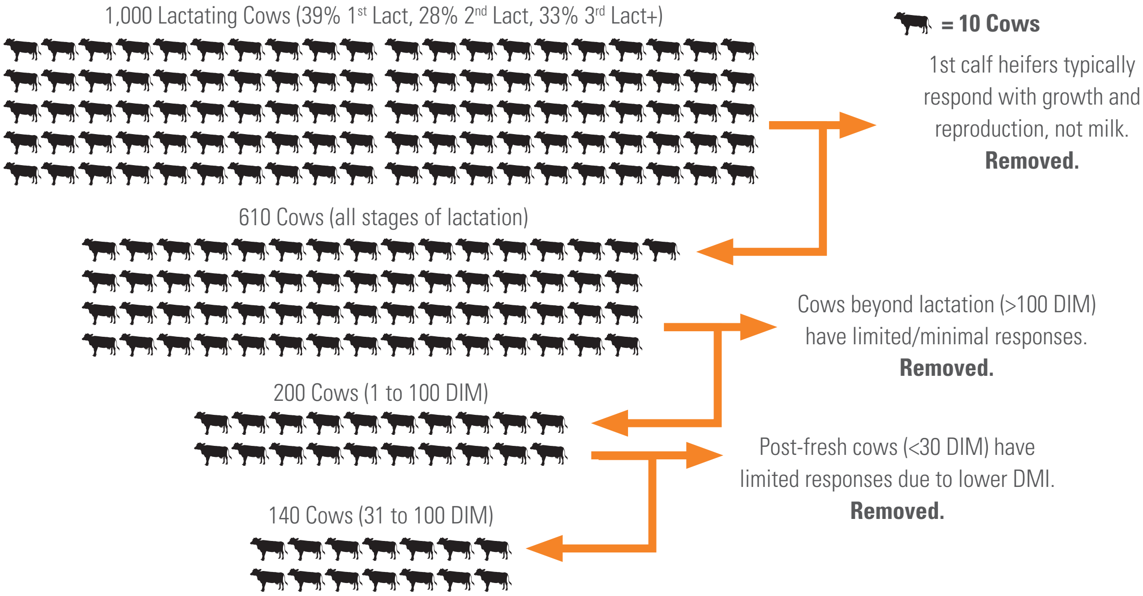



*Figure 6: Effect of chromium supplementation in lactating dairy cow diets on response to daily milk yield, lbs/h/d, relative to days in milk.*[17]

16. KemTRACE Chromium Milk Yield One Pager, BR-2018-00150.
17. Effects of Chromium Supplementation in Lactacting Dairy Cow Diets on Response to Daily Milk Yield, INF-2015-00033.

# Understanding Milk Response in the Bulk Tank




**Looking for an "instant" response:** If early lactation cows consistently produce 8 lbs. more milk/d on a product, the extra milk must be spread across the entire herd's production. So, 8 lbs./cow/d X 140 cows = 1,120 lbs./d ÷ 1,000 cows = 1.1 lbs./cow/d for the entire herd.

**Understanding the long-term benefit:** For every 1 lbs. at peak, a cow produces 200-250 lbs. more milk per lactation. If 83 percent of cows typically complete a lactation within one year, then a 1,000-cow herd would produce an extra 1,037,500 lbs. of milk for that year.[18]

*Figure 7: Understanding milk response in bulk tank (Image created courtesy of Dr. Ken Griswold).*

# Effect of Chromium Supplementation Differs with Lactation Number

Glucose will be utilized by a dairy cow in a hierarchical manner depending on needs. Those needs may be different in a mature cow compared to a heifer. A study was conducted with chromium propionate supplementation in early lactation (0 to 120 days in milk) to determine effects on milk production and reproductive efficiency (Table 2). The study found that mature cows increased peak milk by 10.6 lbs. and reduced days to first service by nine days. Heifers reduced days to peak milk by 30 days and services per conception by 0.5 services.[19]

*Table 2: Milk and reproductive performance of treatment groups.[19]*

| | All Cows | | Multiparous Cows | | Primiparous Cows | |
|---|---|---|---|---|---|---|
| **Measurement** | No Cr | Cr | No Cr | Cr | No Cr | Cr |
| **Number of Animals** | 72 | 75 | 34 | 39 | 38 | 36 |
| **Peak Milk Yield (lbs)** | 100.0 | 103.0 | 115.2$^{a}$ | 125.8$^{b}$ | 80.6 | 82.0 |
| **Days to Peak Milk Yield** | 100$^{a}$ | 83$^{b}$ | 92 | 96 | 100$^{a}$ | 70$^{b}$ |
| **Services Per Conception*^** | 2.18 | 1.85 | 2.00 | 1.76 | 2.40$^{c}$ | 1.60$^{d}$ |
| **Days to First Service^** | 60$^{c}$ | 55$^{d}$ | 58$^{c}$ | 49$^{d}$ | 62 | 62 |

*Services per conception of bred cows.
^ Multiparous and primiparous data sets analyzed independently of all cows.
$^{a,b}$ Values with different superscripts within production groups are different ($P<0.05$).
$^{c,d}$ Values with different superscripts within breeding groups are different ($p<0.05$).

18. Fresh cows must hit their peak. Hoards Dairyman. Published 1-30-15. Date accessed 3-9-17. 19. Lavin-Garza, B., A. Garza et. al., 2007. Milk yield and reproductive performance in Holstein cows supplemented with Chromium in early lactation. J. Animal Sci. 85(Supp. 1), Abs. T370.

# Chromium Excretion in Response to Stress

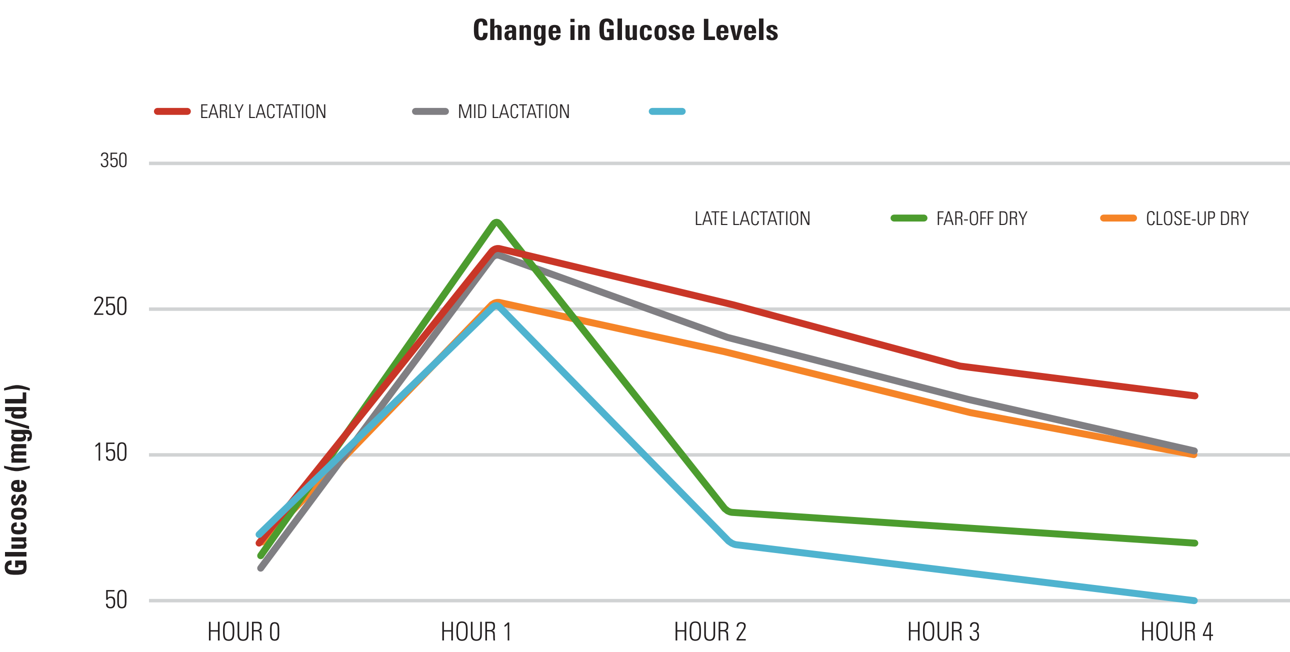
The body stores chromium in very small levels (parts per billion).[22] Escalating this issue is the rapid loss of chromium when the animal is placed under stress. After tissue cells complete their life cycle and are replaced, chromium stored within those tissues' cells does not return to the body and is lost through urinary excretion. Research conducted in humans has shown chromium is not stored in the body and is excreted during stress, "Urinary chromium excretion may increase 10-300 times in stressful situations or due to a diet rich in carbohydrates (Table 3)."[23]

*Table 3: Chromium excretion in response to stress factors.[23-25]*

| Stress Factor | Cr in Urine (µg/day) | Reference |
|---|---|---|
| Basal state (no stress) | 0.16 +/- 0.02 | Anderson et al. (1982, 1983) |
| Acute stress | 0.30 +/- 0.07 | Anderson et al. (1982) |
| Diet rich in carbohydrates | 0.28 +/- 0.01 | Kozlowski et al. (1986) |
| Lactation | 0.37 +/- 0.02 | Anderson et al. (1983) |

# When Does a Cow Experience Insulin Resistance?

Historically, transition cows (-21 to 21 DIM) have been viewed as having insulin resistance. This is due to lower levels of circulating insulin as well as insulin sensitive tissues (e.g., adipose, muscle, etc.) becoming insulin resistant.[9] However, new data suggests that insulin resistance can be a problem outside of transition (Figure 10). Insulin resistance has been shown to occur in high-producing dairy cows during the close up dry (-30 to calving), early lactation (0 to 100 DIM) and mid-lactation (101 to 200 DIM) stages of the lactation cycle.[20]



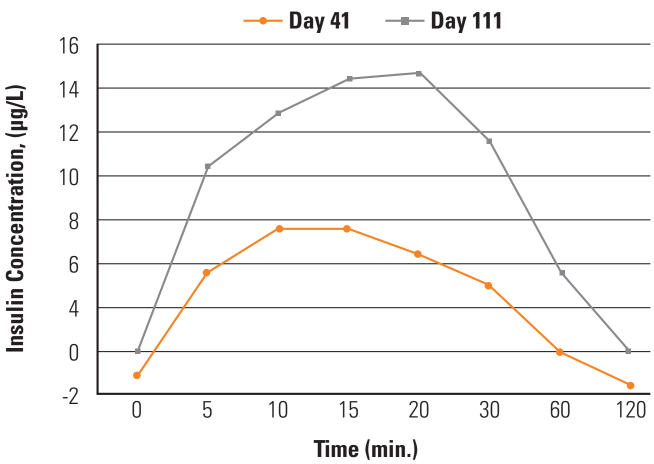

** A glucose tolerance test (GTT) was conducted; blood samples collected at 0, 1, 2, 3 and 4 hours post glucose infusion.*

*Figure 8: Insulin resistance in different physiological states of high producing dairy cows.[20]**

20. Chalmeh et al., 2015. Acta Scientiae Veterinariae. 43:1255.

# Insulin Response Versus Days on Feed

Research conducted at The Ohio State University in feedlot animals demonstrated a positive correlation between days on feed and insulin response. As days on feed increased, the insulin response to the glucose tolerance test increased dramatically. The insulin needed to clear glucose during a glucose infusion was nearly double on Day 111 versus Day 41 (Figure 9).[21] The longer cattle are on feed, the more insulin resistance increases.




| Glucose | Day 41 | Day 111 | *P*-Value |
|---|---|---|---|
| Fasted, mg/dL | 95.6 | 96.5 | 0.84 |
| Clearance, mg/min | 0.93 | 1.17 | <0.001 |
| Total AUC | 16,143 | 17,365 | 0.02 |
| **Ins: Glc AUC** | **0.023** | **0.049** | **0.0002** |

Area Under the Curve (AUC)

*Figure 9: Insulin response versus days on feed.[21]*

# Effects of High Energy Intake and Supplementation with Chromium Propionate on Insulin Resistance

Research has shown that chromium propionate may have an effect on insulin resistance parameters in dairy cattle fed high energy diets (Figure 10).[26] Figure 10 demonstrates the effects of high energy intake and supplementation with chromium propionate on insulin resistance. The diets were fed to 1) meet the animals' metabolizable energy (ME) requirements without chromium (Cr) supplementation (MAN), 2) diet to provide 160 percent ME requirements without chromium supplementation (HIGH) and 3) diet to provide 160 percent ME requirements with chromium supplementation (HIGHCR). Chromium propionate supplementation significantly reduced the insulin required to clear glucose during a glucose tolerance infusion test.

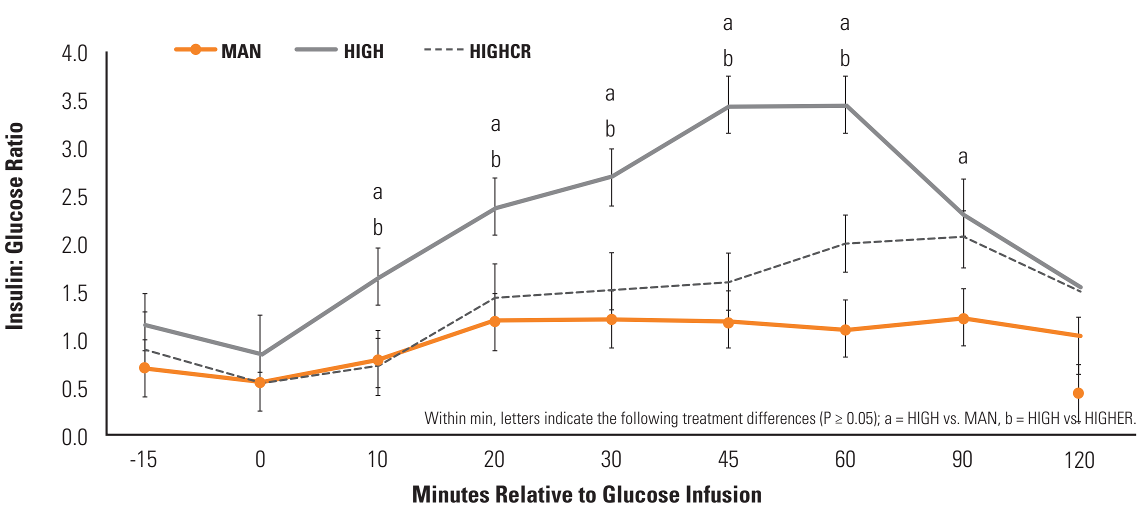



*Figure 10: Effects of high energy intake and supplementation with chromium propionate (HIGHCR) on insulin resistance.[26]*

21. Radunz, A. E., F. L. Fluharty, A. E. Relling, T. L. Felix, L. M. Shoup, H. N. Zerby, and S. C. Loerch. 2012. Prepartum dietary energy source fed to beef cows: Effects on progeny postnatal growth, glucose tolerance, and carcass composition. J. Anim. Sci. 90:4962. 22. Lloyd, K. E., V. Fellner, S. J. McLeod, R. S. Fry, K. Krafka, A. Lamptey, and J. W. Spears. 2010. Effects of supplementing dairy cows with chromium propionate on milk and tissue chromium concentrations. J. Dairy Sci. 93:4774-4790. 23. Kozlovsky, A., P. B. Moser, S. Reiser, R. A. Anderson. 1986. Effects of diets high in simple sugars on urinary chromium losses. Metabolism. 35:515-8. 24. Anderson, et al., 1983. Effects of Cr supplementation on urinary Cr excretion of human subjects and correlation of Cr excretion with selected clinical parameters. Nutrition. 113:276-281. 25. Anderson, R. A., M. M. Polansky, R. A. Bryden, E. E. Roginski, K. Y. Patterson, D. Reamer. 1982. Effect of exercise (running) on serum glucose, insulin, glucagon and chromium excretion. Diabetes. 31:212-16. 26. Leiva et al., 2014. J. Dairy Sci. 97(E-Suppl. 1):705.

# Effect on Chromium Supplementation on Heat Stress

The influence of chromium on milk production has been attributed to its effects on energy metabolism reflected through decreased mobilization of NEFA from adipose tissue and increased insulin sensitivity. During extended periods of heat stress at different stages of lactation, increased glucose availability and utilization may have significant benefits to milk production. Research studies, designed to test the effect of chromium on milk yield under heat stress conditions, have shown cows supplemented with chromium have increased dry matter intake and yield more milk than control cows (Figure 11).[27]

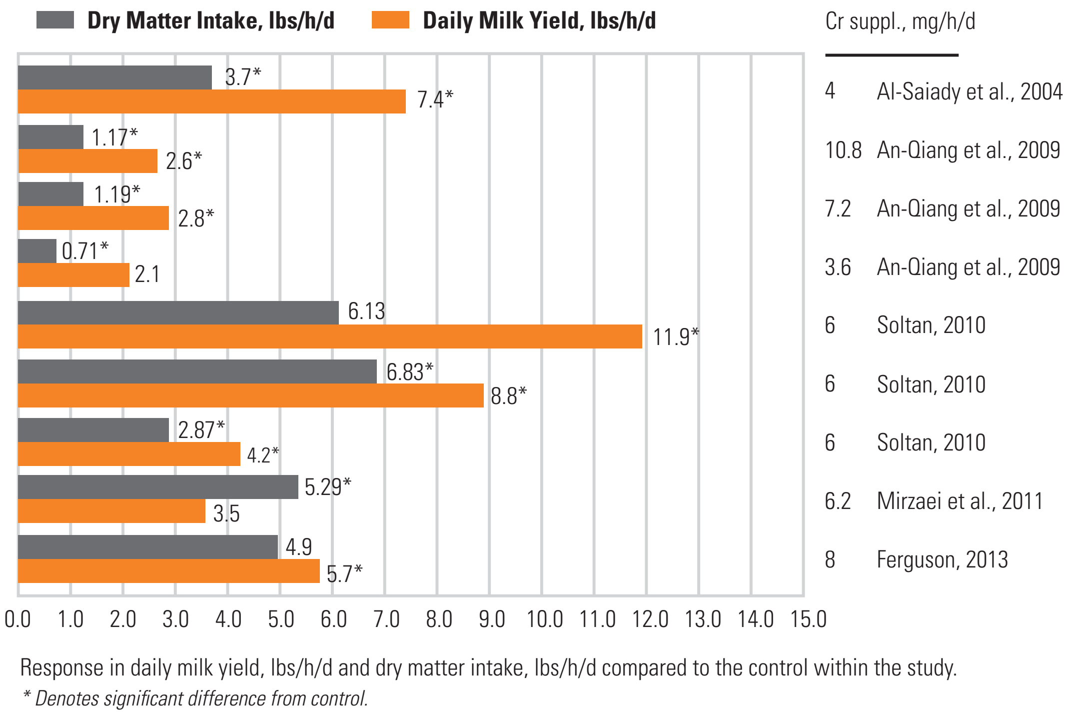



*Figure 11: Effect of chromium supplementation in lactating dairy cow diets on response in daily milk yield and dry matter intake, lbs/h/d under heat stress conditions.[27]*

# Summary

The dietary trace element, chromium, is necessary to optimize the activation of the insulin receptor so that more glucose can get into the cell. Adding supplemental KemTRACE® Chromium to the diet provides the additional chromium for insulin receptor activation. Chromium enhances this reaction, causing glucose transporter activation, allowing additional glucose to enter the cell. The additional glucose will allow for more energy to be available for proper cell function.

- Chromium is a trace mineral required by cattle, in microgram or milligram amounts per day, for optimal nutrition and performance.[3]
- Chromium propionate is a highly bioavailable, organic source of chromium that optimizes how animals process glucose.
- Optimized glucose utilization can result in better animal maintenance, production, reproduction, growth and immunity.
- KemTRACE Chromium is the only chromium source currently permitted by the U.S. FDA for use in cattle.
- Kemin is currently the only company in the U.S. marketplace with a chromium product that meets the food additive standards published in 21 CFR 573.304.
- Efficient and easy to incorporate with premixes and other feed ingredients.
- Made in the U.S.A. and available in two product concentrations:
    - 0.04% - for use in complete diets
    - 0.4% - for use in a premix prior to inclusion in complete diets

27. KemTRACE Chromium - How Does Supplemental Chromium Impact Milk Yield During Heat Stress? BR-2015-00066.

KemTRACE®
CHROMIUM
Essential to you and your operation.

# KemTRACE® CHROMIUM: DESIGNED FOR YOU

Our commitment to chromium promises to provide you with a high **quality**, **safe** and **efficacious** product to help your animals reach their optimal performance while maintaining **profit**. It's what makes KemTRACE Chromium essential to you and your operation.

**KEMIN KNOWS CHROMIUM**. Only Kemin has devoted more than 20 years of research to the benefits of chromium propionate while bringing this essential trace mineral to millions of animals around the globe. See the science at Kemin.com/Chromium.

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Kemin understands your need to raise healthy livestock that give consumers the nutritional and health benefits they are looking for, while also returning a profit. We focus our products and services to help you achieve optimal:

- Nutrition
- Feed Quality
- Gut Health
- Pathogen Control

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