MINTREX® TRACE MINERALS

MINTREX® Cattle Publications with Summary of Findings

***Bach, A., A.M. Pinto and M. Blanch. 2015. Association between chelated trace mineral supplementation and milk yield, reproductive performance, and lameness in dairy cattle. Livestock Sci. 182: 69-75.**

In a multi-herd study, 2,880 cows in 27 herds were fed the same base ration supplemented with equal levels (57 ppm Zn, 27 ppm Mn, 9 ppm Cu) of either inorganic trace minerals (ITM) or a combination of ITM and MINTREX® trace minerals in a 5-month study with a 1-month preliminary period. MINTREX® Zn (25 ppm), MINTREX® Mn (10 ppm) and MINTREX® Cu (6 ppm) replaced an equal amount of ITM. Compared to Control cows, cows fed MINTREX® trace minerals for 30 days or more prior to insemination were 1.5 times as likely to become pregnant to 1st service ($P<0.01$) and tended to be 1.4 times as likely to become pregnant at 2nd service ($P=0.07$). **Cows fed ITM had 2.5 times greater odds of being culled ($P<0.05$) due to lameness compared to cows fed the MINTREX®/ITM combination. Compared to month 1, milk production during months 2-5 of the study increased 1.5 kg more in herds fed MINTREX®/ITM than in herds fed ITM ($P<0.02$).**

Bekker, M.S. and H.A. Tucker. 2020. Effects of stabilizing oxidative balance through dietary additives on growth performance, antioxidant metabolites and fertility factors in fast growing, tropically adapted bulls. Australian Assoc. Anim. Sci., 2/2021.

A total of 201 beef bulls (Droughtmaster) were used in a 59-day feeding study and fed a Control diet or the Control diet supplemented with MINTREX® Beef (Zn, Cu, Mn), a selenium yeast antioxidant and AGRADO® Plus feed ingredient, an antioxidant blend, under sub-tropical conditions. Bulls fed the treatment diet exhibited less of an increase in body and scrotal temperature, a trend ($P<0.09$) for a greater increase in scrotal circumference, improved sperm motility and improved profile of serum antioxidant enzymes compared to Controls. **Cattle fed the treatment diet also had improved feed efficiency. Supplementation with trace minerals and an antioxidant blend appeared to ameliorate the effects of heat stress in growing bulls, moderating the increases in body temperature and maintaining fertility and feed efficiency compared to Controls.**

Caldeira, M.O., R.O. Rodrigues, M.R. Waldron and G.I. Zanton. 2014. Contribution of a chelated trace mineral supplement as a methionine source for dairy cows. J. Anim. Sci Vol. 92, E-Suppl. 2/J. Dairy Sci. Vol. 97, E-Suppl. 1847.

Four rumen cannulated mature Holstein cows were used in a 4x4 Latin Square study with 7-day periods. Cows were given 0.08 g/kg body weight each of the following: HMTBa (ALIMET® feed additive) per rumen, CaHMTBa (MHA® feed supplement) per rumen, MINTREX® Zn trace mineral per rumen and HMTBa (ALIMET® feed additive) per omasum. Blood samples were taken from 30 hours prior to 60 hours post-dose and analyzed for HMTBa and methionine. Comparing the plasma response (area under the curve, AUC) it was found that all 3 sources had significant rumen escape values and were not statistically different from each other. **MINTREX® Zn trace mineral had a calculated rumen escape value of 54% which could contribute to the methionine supply of the cow.**

Conti, G., G. Castillo, M. Gallardo, S. Toffano and M. Vázquez-Añón. 2010. Supplementation of methionine hydroxy analogue, trace mineral chelates and dietary antioxidants in the diet of dairy cows for milk production, milk composition, and hoof status. J. Anim. Sci. 88 (E-Suppl. 1) 93: 718.

Dairy cows (n=266) on a commercial farm in Argentina were assigned to either a Control diet or the same diet supplemented with 2 g/d each of MINTREX® Zn, MINTREX® Mn and MINTREX® Cu, 12 g/d MHA® feed supplement and 5 g/d antioxidant. The base diet (corn silage, alfalfa, corn, soybean meal) was balanced to meet 2001 NRC requirements. Cows were on treatment diets for a minimum of 90 and a maximum of 180 days and averaged 132 days in milk at the outset. **Cows fed the supplemented diet produced more milk (32.6 vs. 27.8 kg/d) and fat-corrected milk (30.5 vs. 27.8 kg/d) vs. Control-fed cows (*P*<0.05). Hoof lesions (sole, heel, white line) were reduced (34% vs. 12%) and lameness based on locomotion score was reduced (45.7 vs. 29.2%) (*P*<0.05) in supplemented cows compared to Controls.**

Gallardo, M., G. Conti, G. Castillo and S. Toffano. 2009. Effects of feeding 2-hydroxyl-4-methio butanoic acid and HMTBa chelated trace minerals on dairy cattle production. J. Anim. Sci. 87 (E-Suppl. 1) 92: T299.

First lactation and older cows in mid- to late lactation in a commercial dairy herd in Argentina were used in the study. 100 cows (50 per treatment) were selected from a 160-cow herd. The herd diet contained 30% of dry matter from alfalfa pasture and 70% of DM from a total mixed ration (corn silage, alfalfa hay, high moisture corn, expeller soybean meal, sunflower meal and a vitamin trace mineral premix based on inorganic trace minerals (NRC levels; 47, 11 and 40 ppm Zn, Cu and Mn). To this diet was added 320 mg Zn, 300 mg Cu, 260 mg Mn in HMTBa chelated form (MINTREX® trace minerals) and 8.4 g/d of calcium HMTBa. 24 days were allowed for diet adaptation with 19 days of data collection. **Cows fed the supplement produced 7.4% more milk and 8.2% more milk fat than Controls. Milk protein and solids yield were similar between treatments.**

Harvey, R., Y. Wang, G.I. Zanton, T. J. Wistuba and M.S. Kerley. 2012. Effect of Feeding Chelated Forms of Zn, Cu and Mn in Combination with Methionine on Growth and Reproductive Development of Beef Heifers. J. Anim. Sci. Vol. 90, Suppl. 3/J. Dairy Sci. Vol. 95, Suppl. 2. 590.

Sixty weaned, prepubertal beef heifers were fed 1 of 5 diets: negative Control (no supplement), inorganic trace minerals (ITM), MINTREX® trace minerals, ITM plus 15 g/d MFP® feed supplement and MINTREX® plus MFP®. Both ITM and MINTREX® supplements supplied 30 ppm Zn, 20 ppm Mn and 10 ppm Cu. Cows supplemented with MFP® tended to show improved feed efficiency. **Cows fed the combination of MINTREX® and MFP® showed increased serum antibody titer 4 weeks after standard vaccination.** The study lacked sufficient numbers of animals to clearly assess growth responses.

***Nemec, L.M., J.D. Richards, C.A. Atwell, D.E. Diaz, G.I. Zanton, and T.F. Gressley, 2012. Immune responses in lactating Holstein cows supplemented with Cu, Mn, and Zn as sulfates or methionine hydroxy analogue chelates. J. Dairy Sci. 95: 4568–4577.**

In a 12-week study Holstein cows (n=26) averaging 61 days in milk were assigned to either of 2 diets supplemented with inorganic trace minerals (ITM) or MINTREX® trace minerals (CTM) Zn, Mn and Cu each at the rate of 51, 13 and 10 ppm. At week 8, cows were vaccinated for rabies and blood drawn to assess antibody responses and neutrophil function at weeks 8 and 12. **Cows supplemented with MINTREX® trace minerals produced a significantly greater antibody response to vaccination (*P*<0.01) and tended to have greater neutrophil phagocytosis (*P*<0.15). Milk Cu was significantly higher (*P*<0.01) for cows fed MINTREX®.**

Rathert, A.R., E.L. Stephenson, A.L. Kenny, T. B. Freitas, H.A. Tucker, and A.M. Meyer. 2018. Effects of copper, zinc, and manganese source and concentration during late gestation on beef cow colostrum yield and quality. J. Anim. Sci. 96: Suppl. 1. M253.

Angus-Simmental multiparous beef cows (n=48) were assigned to 1 of 4 diets fed from 90 days before calving to 11 days after calving. Diets were: Control (no supplement); inorganic trace minerals (ITM), MINTREX® trace minerals (CTM) and ITM/CTM. For ITM and CTM addition rate was 22 ppm Zn, 12 ppm Mn and 10 ppm Cu to provide 133% of NRC requirements. The ITM/CTM combination supplied 100% of NRC. **Cows fed MINTREX® trace minerals (CTM) had greater weight (*P*<0.06) and volume (*P*<0.04) of colostrum than other treatments. Cows fed MINTREX® had the largest quantity (*P*<0.04) of Zn delivered by colostrum of all treatments and higher milk lactose percent and yield (*P*<0.04).** Colostrum immunoglobulin levels were similar across treatments.

***Suksombat, W., A. Nanon, P. Klangnork and J. Homkhao. 2011. Effects of Met Hydroxy Analogue plus MINTREX® Dairy Supplementation on Performance of Lactating Dairy Cows. J. Anim. Vet. Adv. 10 (21): 2814-2818.**

Cross-bred Holstein cows (39 days in milk) were blocked into 2 groups of 12 cows and randomly assigned to a Control diet or the same diet with 14 g/day MINTREX® Dairy trace minerals and 22 g/d MHA® feed supplement for 16 weeks under tropical conditions. The diet contained fresh cut grass and concentrate. **Cows fed the MINTREX® and MHA® combination had numerical but not significantly higher yields of milk, fat and protein and reduced somatic cells counts compared to Control cows.**

Stewart, R.L., Jr., T.J. Wistuba, G.I. Zanton and A.I. Jones. 2013. Evaluation of maternal trace mineral source on cow/calf performance and subsequent feedlot performance of beef calves. J. Anim. Sci. 91: E-Suppl. 2. T18.

A University of Georgia beef herd (n=216 brood cows) was used in a 2-year study. Cows were blocked by age and weight and randomly assigned to Control (inorganic trace minerals, ITM) or MINTREX® trace minerals supplied in a free choice mineral formulated to provide 30 ppm Zn, 40 ppm Mn and 15 ppm Cu to total diet. Treatments began 30 days prior to calving in year 1 and continuing through year 2 of the study. Steers were weaned, backgrounded for 45 days then shipped to a common feedlot and fed a common diet until slaughter. Cows supplemented with MINTREX® tended (*P*<0.15) to lose less weight (-9.3 vs. -20.3 kg) and weaned more kg of calf per cow exposed to bulls (*P*<0.01) compared to Controls. **Growth performance of steers was similar but steers from cows supplemented with MINTREX® trace minerals tended to have a higher (*P*<0.07) percent of carcasses grading Choice or higher.**

Thering B.J., R.M. Ehrhardt, T.R. Overton, M. Vázquez-Añón and J.D. Richards. 2007. Effects of trace mineral sources on bioavailability and function in dairy cattle. J. Anim. Sci. 85, Suppl. 1 T369.

Thirty Holstein cows in mid-lactation were fed a common diet supplemented with 47 ppm Zn, 43 ppm Mn and 11 ppm Cu for 21 days followed by a 28-day trial period. Treatments were: Control (base diet), AAC (base diet with added Zn, Cu and Mn from specific amino acid complexes) or MMHAC (MINTREX® trace minerals), with each treatment diet adding 322 mg Zn, 150 mg Cu and 130 mg Mn, 10 mg biotin and 3 mg Se to the base diet. Blood samples and liver biopsies were performed at 0, 1, 2 and 4 weeks. Both sources tended to increase liver trace minerals over the trial period. Cows fed MINTREX® had the greatest ($P<0.05$) increase in liver copper vs. Control and higher ($P<0.05$) milk Mn at 4 weeks vs. Control. Liver metallothionine mRNA, a marker for Zn absorption, was increased by week 4 by 2.6-fold vs. week 0 ($P<0.02$) in cows supplemented with MINTREX®,by 1.9-fold for AAC (NS, $P=0.22$) and remained constant in Control cows. **Milk fat and protein percentage were increased ($P<0.05$) in cows fed MINTREX® trace minerals vs. Control.**

Tucker, H.A., C. Foran, S. Bettis, P. Fisher, J. Xue, K. Wedekind and M. Vázquez-Añón. 2016. Bioavailability of different sources of zinc using stable isotopes in male Holstein calves. J. Anim. Sci, 94, Suppl. 5, 716.

Sixteen male Holstein calves (BW=60 ± 2 kg; mean ± SE) were utilized in a randomized complete block design with 2 treatments. Calves were orally administered 4 or 8 mg of Zn from 2 sources: ^{67}Zn oxide and ^{70}Zn-MHAC (provided as MINTREX® Zn trace mineral). In addition, an intravenous injection of ^{68}Zn oxide was also administered for use as a tracer. Blood was collected via jugular catheter prior to isotope administration (0 hours) and 0.25, 0.5, 0.75, 1, 2, 4, 6, 8, 10, 12, 16, 20, 24, 36, 48 and 72 hours after isotope administration for determination of isotope enrichment. Calves were euthanized 72 hours after isotope administration and target tissues harvested, weighed and sampled for determination of isotope enrichment. **Bioavailability of MINTREX® Zn was significantly ($P<0.05$) greater than Zn oxide, averaging 2.5 times more available to body tissues.**

Tucker, H.A. and A. Provin. 2020. Benefit of Zinc methionine hydroxy analogue chelate to increasing tissue enrichment with dietary antagonism in Holstein calves. J. Dairy Sci. 104 (Suppl. 1) W81.

Thirty weaned male Holstein calves were utilized in a randomized complete block design with 2 dietary treatments fed over 32 days. Dietary treatments consisted of starter differing in sodium sulfate content: Low S: 0.0% of DM and High S: 4.8% of DM as sodium sulfate decahydrate. Calves (n=24) were orally administered 8 mg of Zn from 2 sources on day 30: ^{67}Zn Gly and ^{70}Zn-MHAC provided as MINTREX® Zn trace mineral. An additional group of calves (n=6) were handled in the same manner as the other calves but not administered any Zn. Blood was collected via jugular catheter prior to isotope administration (0 hours) and 0.25, 0.5, 0.75, 1, 2, 3, 4, 5, 6, 8, 10, 12, 24, 36 and 48 hours after isotope administration. Calves were euthanized 48 hours after isotope administration and target tissues harvested, weighed and sampled. **Bioavailability of MINTREX® Zn was greater ($P<.05$) than that of Zn glycinate, averaging 1.47 times more available.**

***Tucker, H.A. and M. Vázquez-Añón. 2018. Altering source of organic trace minerals improves milk fat in commercial dairy. Dairy and Vet. Sci. J., 8(2): 1-7.**

Six pens (3 per treatment) of lactating dairy cows in a commercial herd were fed iso-mineral diets, differing only in supplemental Cu, Mn and Zn source for 7 months. Supplemental Cu, Mn and Zn were provided as metal methionine hydroxy analogue chelate (MMHAC, MINTREX® trace minerals) or metal complexes of methionine and lysine (MMKC, Zinpro 4-Plex). Monthly milk yield, composition and reproduction information were collected and analyzed using SAS/STAT software (Version 9.3; SAS Institute Inc., Cary, NC) with repeated measures as appropriate. No significant effects of treatment were observed for reproductive parameters including conception risk at any breeding (29.9 vs. 29.4%, 95% CI 17.0, 47.0, MMKC and MMHAC respectively) and days open (106.8 vs. 107.8, 95% CI 99.9, 114.2). However, a significant treatment by time interaction was observed for milk yield (40.0 vs. 39.8 ± 4.1, MMKC and MMHAC respectively; P=0.02), percent fat (3.45 versus 3.51 ± 0.20; P<0.01), and percent solids non-fat (8.77 vs. 8.80 ± 0.10; P=0.04). **Increases in milk fat (12.4 g) suggest additional value for MMHAC because of methionine hydroxy analogue ligand.**

Tucker, H.A., J. Chen, S. Bettis, S. Herbstreit, T. Freitas and M. Vázquez-Añón. 2019. Maternal copper and zinc alter epigenetic markers in muscle of offspring. J. Anim. Sci. 98, Issue Suppl_5, 507.

Ewes were allocated by body weight to receive: no additional Cu or Zn (CON), Cu and Zn sulfates supplying 300% of NRC requirement (ITM), or Cu and Zn as chelates (MINTREX® trace minerals) supplying 300% of NRC requirement (MMHAC). Treatments were fed 7 days before conception and through parturition. Following parturition, one lamb from every ewe was weighed and harvested at day 0 of life followed by a second lamb at day 60. Jejunum, longissimus dorsi (LD) and thymus were weighed and sub-sampled from lambs for epigenetic and gene expression measures. Treatment and lamb sex were fixed effects in the model. Lambs harvested on day 0 tended to weigh greater (P< 0.10) when ewes were fed MMHAC compared with ITM. Weight of LD on day 0 tended (P<0.09) to be greater for lambs from ewes fed MMHAC compared with ITM, with no other differences in organ weights observed on day 0 or day 60. Global histone acetylation tended (P< 0.10) to be greater in LD of lambs from ewes fed MMHAC compared with ITM or CON on day 0. Fox03, gene expression marker, on day 0 was significantly (P<0.05) lower in LD of lambs from ewes fed MMHAC and CON compared with ITM. **This data suggests trace mineral supplementation throughout gestation affects progeny muscle development and gene expression.**

***Vázquez-Añón, M., T. Peters, T. Hampton, J. McGrath and B. Huedepohl. 2007. Supplementation of chelated forms of zinc, copper and manganese to feedlot cattle with access to drinking water with high sulfate concentration. Prof. Anim. Sci. 23:58-63.**

The objective of this experiment was to evaluate the effects of supplementing a blend of chelated Zn-(2-hydroxy-4-methylthio butanoic acid; HMTBa)2, Cu-(HMTBa)2 and Mn-(HMTBa)2 to feedlot cattle with access to high sulfate (1,646 mg/kg) drinking well water). A total of 640 weaned calves (BW of 192 ± 12 kg) were allocated to 4 pens per treatment in a randomized complete block design and fed a Control diet or a diet supplemented with 37, 17.5 and 15.2 mg/kg of Zn from Zn-(HMTBa)2, Cu from Cu-(HMTBa)2 and Mn from Mn-(HMTBa)2, respectively, for the entire feedlot period (267 days).

Average daily gain, feed intake and gain to feed ratio were not affected by treatment. However, cattle fed Zn-(HMTBa)2, Cu-(HMTBa) 2 and Mn-(HMTBa) 2 exhibited less mortality (4.7 vs. 2.44%; *P*=0.05) and morbidity (47.1 vs. 37.8%; *P*=0.06). Carcass quality was improved by reducing the dark-cutting carcasses from 3.59 to 0.77% (*P*=0.02) and fat deposition from kidney, pelvic and heart area (*P*=0.05). **Supplementation of Zn-(HMTBa)2, Cu-(HMTBa)2, and Mn-(HMTBa)2 to feedlot cattle with access to water including a high sulfate concentration improved health and carcass quality. The net economic improvement was $17.96 per head when compared with Controls.**

***Wang, F., L. Wang, S. Li, Y. Wang, X. Jin and H. Cao. 2011. Effects of methionine hydroxyl manganese and manganese sulfate sources for dairy cows during peak and mid-lactation. Asian. J. Anim. Vet. Adv. 6(10) 978-991.**

Thirty Holstein cows were blocked on calving date, milk yield and parity and assigned to 3 diets: (1) 14 ppm Mn from sulfate (S). (2) 14 ppm Mn with 7 ppm from Mn sulfate and 7 ppm from Mn methionine hydroxy chelate (SM). (3) 14 ppm methionine hydoxy chelate for 120 days. Milk fat yield and 4% fat-corrected milk were greater for M than S or SM. Total tract organic matter digestibility was numerically but not significantly lower for S.

***Wang, F., S.L. Li, J. Xin, Y.J. Wang, Z.J. Cao, F.C. Guo and Y.M. Wang. 2012. Effects of methionine hydroxy copper supplementation on lactation performance, fertility, nutrients digestibility and some metabolic indices in dairy cows. J. Dairy Sci. 95: 5813-5820.**

Thirty Holstein cows were used in a randomized complete block study with 3 diets: (1) 12 ppm Cu from copper sulfate (S). (2) 6 ppm Cu from sulfate and 6 ppm from Cu2HMTBa (SM). (3) 12 ppm Cu from Cu2HMTBa (M). **Milk production and 4% fat-corrected milk tended to be greater for SM vs. S or M. Total tract digestibility of neutral detergent fiber and acid detergent fiber tended to be greater for SM vs. S.**

***Whitehurst, W.A., J.A. Paterson, M.M. Harbac, M.K. Peterson, G.C. Duff, T.W. Geary, G.I. Zanton and T.J. Wistuba. 2014. Comparison of methionine hydroxy analogue chelated vs. sulfate forms of copper, zinc and manganese on growth performance and pregnancy rates in yearling beef replacement heifers. Prof. Anim. Sci. 30: 62-67.**

Yearling beef heifers (2,480) on 3 commercial ranches were assigned to 4 pens per ranch and fed diets supplemented with either inorganic or organic (metal methionine hydroxy analogue chelate, MMHA) for at least 150 days prior to breeding. Ranches (A, B, C) housed 498, 240 and 1,742 Angus and Angus cross heifers. Ranch A bred heifers with A.I. for 3 days followed by 45 days natural service. Ranch B bred 50 days by natural service and Ranch C bred all heifers once only by A.I. over 14 days. Average daily gains during the pre-breeding period varied by ranch but not by treatment ranging from 0.5 to 0.8 kg/day. Heifers weighed 350-400 kg at breeding. **Feeding MMHA increased (*P*=0.05) percent of heifers pregnant. This was primarily due to Ranch C which bred once by A.I. where percent pregnancy was improved from 59 to 66%. This also resulted in a trend (*P*=0.12) for increased percent pregnant in the first 21-day breeding cycle.**

***Wilson, B.K., M. Vázquez-Añón, D. L. Step, K.D. Moyer, C.L. Haviland, C.L. Maxwell, C.F. O'Neill, C.A. Gifford, C.R. Krehbiel, and C. J. Richards. 2016. Effect of copper, manganese, and zinc supplementation on the performance, clinical signs, and mineral status of calves following exposure to bovine viral diarrhea virus type 1b and subsequent Mannheimia haemolytica infection. J. Anim. Sci. 2016, 94(3): 1123-40.**

Angus steers (n=16) from a single ranch were housed in individual stalls and fed either a Control diet or the same diet supplemented with methionine hydroxy analogue chelated (MMHA) Zn, Cu and Mn for 46 days prior to a disease challenge. Control diet was standard for receiving cattle, containing 47 ppm Zn, 50 ppm Mn and 6 ppm Cu. Treatment diet was supplemented with 320 mg Zn, 150 mg Cu and 130 mg Mn from MMHA resulting in a diet with 100 ppm Zn, 31 ppm Cu and 72 ppm Mn. After 46 days, steers were exposed to a single heifer persistently infected with BVD (bovine virus diarrhea) followed by a gavage challenge with *M. hemolyticia.* **Growth performance prior to challenge was similar between treatments. No differences were found in clinical disease score or body temperature response to disease challenge. Feeding supplemental MMHA Zn, Cu and Mn increased liver Cu and Mn vs. Controls.**

***Yasui, T., R.M. Ehrhardt, G.R. Bowman, M. Vázquez-Añón, J.D. Richards, C.A. Atwell and T.R. Overton. 2019. Effects of trace mineral amount and source on aspects of oxidative status and responses to intra-mammary lipopolysaccharide challenge in mid-lactation dairy cows. Animal 13:5, 1000-1008.**

Multiparous Holstein cows (n=48) at 60-140 days in milk were stratified by milk yield within block and assigned to 1 of 4 treatments with respect to trace mineral supplementation with 2 levels (NRC or Commercial) and 2 sources (sulfates or metal methionine hydroxy analogue chelate, MMHA). During a 4-week depletion period all cows were fed a basal diet (26 ppm Zn, 21 ppm Mn, 5 ppm Cu) with added antagonists (S, Mo, Fe). The cows were fed the base diet without antagonists and supplemented with trace minerals for 6 weeks. All cows were vaccinated against *E. coli* mastitis at end of week 2 and subjected to a mastitis (LPS) challenge at the end of week 5 of the study. NRC level diets contained 55 ppm Zn, 21 ppm Mn and 8 ppm Cu from either sulfate or organic sources. Commercial (COM) diets contained 75 ppm Zn, 35 ppm Mn and 16 ppm Cu coming from either source. Production measures were similar for level and source of trace minerals. Physiological responses to the LPS challenge were also not significantly different. **Cows fed MMHA trace minerals exhibited reduced plasma marker of oxidative stress (TBARS) with a trend at week 1 (P=0.13) and significance (P=0.05) at week 6. Similarly, cows fed MMHA trace minerals had higher plasma IgG over the experimental period with a trend (P=0.13) at week 1 and significance at week 6 (P=0.01).**

Zanton, G.I., D. E. Diaz, M. Vázquez-Añón and J. E. Nocek. 2011. Form of trace mineral supplementation on complete lactation performance, reproduction, and locomotion in Holstein Cows. J. Anim. Sci. 89: E-Suppl.1., 123.

Holstein cows (n=216) housed in 4 pens were studied for a full 305-day lactation while fed diets supplemented with either sulfate or methionine hydroxy analogue chelated (MMHA) Zn, Mn and Cu. The base diet (Zn 29, Cu 7, Mn 34 ppm) was supplemented with sulfates (Zn 44 ppm, Cu 24 ppm, Mn 16 ppm) or MMHA at 50% the rate of sulfates (Zn 22 ppm, Cu 9 ppm, Mn 8 ppm). Milk and component production, body condition, locomotion score and culling risk were similar between treatments. Cows fed MMHA trace minerals had greater odds (P<0.08) of conceiving at earlier inseminations with a 9-percentage unit improvement at 1st service. Milk somatic cells counts tended to be reduced (P<0.10) for MMHA. **Feeding MMHA at 50% the rate of sulfates tended to improve reproductive performance and milk quality while reducing total level of diet supplementation of Zn, Cu and Mn.**

***Zhao, X., Z.P. Li, J.H. Wang, X.M. Xing, Z.Y. Wang, L. Wang and Z.H. Wang. 2015. Effects of chelated Zn/Cu/Mn on redox status, immune responses and hoof health in lactating Holstein cows. J. Vet. Sci. 16(4): 439-446.**

Holstein cows (n=48) were assigned to 1 of 2 treatments based on visual locomotion score (1-5). Twelve healthy (1,2) and 12 lame (3-5) cows were assigned to each treatment group. A base diet (Zn 33 ppm, Cu 8.5 ppm, Mn 32 ppm) was supplemented with 50 ppm Zn, 12 ppm Cu and 20 ppm Mn from either sulfates or methionine hydroxy analogue chelates (MMHA) for 180 days. Hoof hardness (Shore D durometer) was recorded at 0, 90 and 180 days. Cows fed MMHA exhibited higher serum IgA and Type O antibody titer to foot and mouth vaccine than cows fed sulfates. Levels of MDA (TBARS) and arthritic biomarkers were reduced in cows fed MMHA. **Hoof hardness increased significantly in cows fed MMHA vs. Control and locomotion score tended to improve more in cows fed MMHA decreasing from 50% to 29% over the trial while Control cows increased to 54%.**

Uniqueness of MINTREX® Trace Minerals is Proven to

- ⇨ **Support reproductive function[1]**
- ⇨ **Promote hoof health[1,2]**
- ⇨ **Reduce susceptibility to antagonism[3]**
- ⇨ **Support immune health[2,4]**

[1]Bach et al., 2015, [2]Zhao et al., 2015, [3]Tucker and Provin, 2020, Vázquez-Añón et al. 2007, [4]Zanton et al., 2011, Nemec et al., 2021

*published study.

**Studies fed MMHA (mineral methionine hydroxy analogue) or MMHAC (mineral methionine hydroxy analogue chelate) refer to MINTREX® trace minerals.

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