Ruminant Nutrition: Mineral nutrition

706 Organic trace minerals during the transition period: 2. Supplemental Zn, Mn, and Cu from Availa Mins and Co from CoPro have a positive effect on systemic and hepatic indicators of inflammation and oxidative stress in Holstein cows. Fernanda Batistel*[1], Johan S. Osorio[1], Jin Ji[1], Erminio Trevisi[2], James K. Drackley[1], Michael T. Socha[3], and Juan J. Loor[1], [1]*University of Illinois, Urbana, IL,* [2]*Università Cattolica del Sacro Cuore, Piacenza, Italy,* [3]*Zinpro Corporation, Eden Prairie, MN.*

The peripartal dairy cows undergoes a state of reduced liver function linked with increased inflammation and oxidative stress. Objectives were to evaluate hepatic mRNA expression and systemic biomarkers of inflammation and oxidative stress in cows receiving supplementation of inorganic (INO) or organic (AAC) trace minerals. Twenty multiparous cows were assigned in a randomized complete block design to a common prepartal (1.5 Mcal/kg DM, 15% CP) and postpartal (1.76 Mcal/kg DM, 18% CP) diet. Both diets were partially supplemented with an inorganic mineral mix of Zn, Mn, and Cu to supply 35, 45, and 6 ppm, respectively, of the total diet DM. Treatments included cows receiving an oral bolus containing a mix of INO (n = 11) or AAC (n = 9) Zn, Mn, Cu, and Co to achieve 75, 65, 11, and 1 ppm, respectively, in total diet DM. Organic trace minerals were supplied via Availa Zn, Availa Mn, Availa Cu, and CoPro (Zinpro Corp., Eden Prairie, MN). Liver biopsies were collected at d −30, −15, 10 and 30, and blood samples at d −30, −14, 3, 15, and 30 relative to parturition. Although AAC did not affect biomarkers of liver function, an interaction (diet × time; $P < 0.05$) for the concentration of albumin, glutamic-oxaloacetic transaminase (GOT), cholesterol (CHO) and γ-glutamyltransferase (GGT) was observed. The lower GGT at d 15 and 30, and GOT at d 15 in cows receiving AAC suggests a lower degree of liver cell damage. Furthermore, greater albumin concentration at d 15 and 30 ($P < 0.05$), and greater gene expression of albumin (*ALB*; $P < 0.01$) and interleukin 10 (*IL10;* $P = 0.03$) in cows given AAC suggest a less pronounced inflammatory status. An interaction (diet × time; $P < 0.05$) was observed for signal transducer and activator of transcription 3 (*STAT3*) and superoxide dismutase 2 (*SOD2*) because expression increased from d 10 to 30 in cows fed AAC compared with INO. Overall, these data provide some evidence that source of trace mineral during the peripartal period alters immunometabolism.

Key Words: immunometabolism, trace mineral

707 Organic trace minerals during the transition period: 3. Favorable alterations in blood neutrophil (PMN) and endometrial inflammatory and oxidative status in Holstein cows supplemented with Zn, Mn, and Cu from Availa Mins and Co from CoPro. Fernanda Batistel*[1], Johan S. Osorio[1], Cong Li[2], Ed F. Garrett[1], Mohamed M. Elhanafy[1], Jessica Caputo[3], James K. Drackley[1], Michael T. Socha[4], and Juan J. Loor[1], [1]*University of Illinois, Urbana, IL,* [2]*China Agricultural University, Beijing, China,* [3]*University of Milan, Milan, Italy,* [4]*Zinpro Corporation, Eden Prairie, MN.*

Objective was to evaluate mRNA expression of genes associated with inflammation, oxidative stress, eicosanoid synthesis and transcription regulation in PMN and endometrium in cows receiving inorganic (INO) or organic (AAC) trace minerals. Twenty multiparous cows were allocated in a randomized complete block design, and received the same prepartum (1.5 Mcal/kg DM, 15% CP) and postpartum (1.76 Mcal/kg DM, 18% CP) diet. The diets were partially supplemented with an inorganic mineral mix of Zn, Mn, and Cu to supply 35, 45, and 6 ppm, respectively, of the total diet DM. Cows were assigned to an oral bolus administration containing a mix of either INO (n = 11) or AAC (n = 9) Zn, Mn, Cu, and Co to achieve 75, 65, 11, and 1 ppm, respectively, in total diet DM. Treatments began on d −30 and continued through d 30 relative to parturition. Organic trace minerals were supplied via Availa Zn, Availa Mn, Availa Cu, and CoPro (Zinpro Corp., Eden Prairie, MN). Endometrial biopsies were collected at d 14 and 30 postpartum. In PMN, expression of DEAD box polypeptide 58 (*DDX58*) was greater and Z-DNA binding protein 1 (*ZBP1*) was lower in cows supplemented with AAC. In addition, feeding AAC increased expression of genes related to oxidative stress (*MPO*) and eicosanoid metabolism (*PLA2G4A*, *ALOX5AP*). In endometrium, feeding AAC increased expression of genes related to oxidative stress (*SOD1*, *NRF2*), eicosanoid metabolism (*PTGES*) and inflammation (*MYD88*, *STAT3*, *IL10*). An interaction was observed for *IL6* (inflammation) because expression increased from d 14 to 30 in cows fed INO compared with AAC. The decrease in *IL1B, IL10, IL8* (inflammation) and *PTGES* (eicosanoids) expression on d 30 was more pronounced for cows fed AAC, whereas *PPARG* (an anti-inflammatory transcription regulator) increased on d 30. Overall, data demonstrate favorable alterations in PMN and endometrium inflammatory and oxidative status in cows supplemented with organic trace minerals.

Key Words: inflammation, trace mineral

708 Parameterization of a ruminant model of phosphorus digestion and metabolism. Xin Feng*, Katharine F. Knowlton, and Mark D. Hanigan, *Department of Dairy Science, Virginia Polytechnic Institute and State University, Blacksburg, VA.*

The objective of the current work was to parameterize the digestive elements of the model of Hill et al. (2008) using data collected from animals that were ruminally, duodenally, and ileally cannulated, thereby providing a better understanding of the digestion and metabolism of phosphorus (P) fractions in growing and lactating cattle. The model of Hill et al. (2008) was fitted and evaluated for adequacy using the data from 6 animal studies (Feng et al., 2011, Ray et al., 2012b, Feng et al., 2013, Ray et al., 2013, Jarrett et al., 2014, Feng et al., 2015). It was hypothesized that sufficient data would be available to estimate P digestion and metabolism parameters and that these parameters would be sufficient to derive P bioavailabilities of a range of feed ingredients. Inputs to the model were DM intake; total feed P concentration (P_{PtFd}); phytate (Pp), organic (Po) and inorganic (Pi) P as proportions of total P (P_{PpPt}, P_{PoPt}, P_{PiPt}); microbial growth; amount of Pi and Pp infused into omasum or ileum; milk yield; and BW. The available data were sufficient to derive all model parameters of interest. The final model predicted that given a 75 g/d total P input, the total-tract digestibility of P was 40.76%, Pp digestibility in the rumen was 92.4% and in the total-tract was 94.7%. A large proportion of Pi was absorbed from the small intestine (SI), however additional Pi was absorbed from the large intestine (3.15%). Absorption of Pi from the SI was regulated. Salivary recycling of blood P to the rumen was a major source of Pi flow into the SI, and the primary route of excretion. Milk synthesis used 16% of total absorbed P, and less than 1% was excreted in urine. The resulting model could be used to derive P bioavailabilities of commonly used feedstuffs in cattle production.

Key Words: model, phosphorus, digestion and absorption

709 Comparison of predicted ration phosphorus balance using bioavailabilities from the NRC (2001) and Virginia Tech models.
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The objective of the current work was to use digestion coefficients from the Hill et al. (2008) model after parameterization by Feng et al. (2015; VT model) to calculate phosphorus (P) bioavailability (P_{VT}) of common feeds used in dairy production. Compared with the bioavailability calculated by the VT model, using the NRC (2001) P absorption coefficient of 0.64 for forages would underestimate the bioavailabilities of alfalfa hay, alfalfa silage, corn silage, grass hay, mixed mainly legume silage and western hay. For concentrates, using the NRC (2001) P absorption coefficient of 0.70 would overestimate the bioavailabilities of canola, corn grain, dry barley, soybean meal and whole cottonseed but underestimate bioavailability of high moisture corn. Two dairy rations were formulated using nutrient values from the NRC (2001): a standard diet which includes minimal byproducts and a byproduct diet which has reduced corn and soybean meal that was replaced with corn gluten feed, distillers grains, hominy feed and wet brewers grains. For each diet, total bioavailable P was calculated using availability values from the NRC (2001) and the VT models. Comparison of P balance (the difference between required and bioavailable P) for each diet was made using the 2 sets of bioavailabilities for a reference cow weighing 682 kg, producing 38.6 kg of milk/d (3.5% fat and 3.0% true protein, 100 DIM) and consuming 23 kg of DM/d yielding an absorbable P requirement of 59.4 g/d. The standard diet supplied 56.7 g and 53.5 g of bioavailable P per day using bioavailabilities from the NRC (2001) and VT models, respectively, resulting in a P balance of −2.72 and −5.9 g/d. The byproduct diet provided 75.75 and 78.47 g/d of bioavailable P yielding P balances of 16.4 and 19.1 g per day respectively using the 2 sets of bioavailabilities. Thus using P bioavailabilities for individual ingredients that were based on the VT model resulted in different calculated P balances by diet and would result in differing P feeding levels if used in a field setting.

Key Words: phosphorus, balance, bioavailability

710 Effects of Se-fertilization on forage Se concentration and Se status of growing calves consuming these forages.
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The objective of this study was to evaluate the effect of Se fertilization of 'Jiggs' bermudagrass (*Cynodon dactylon* L.) hayfields on the forage Se concentration and subequent Se status of calves consuming the forage. Sodium selenate was dissolved into water (8.8 g/L) and sprayed onto bermudagrass hayfields at a rate of 257 g Se/ha and harvested 8 wk after Na selenate application. Forage fertilized with Na selenate had greater ($P < 0.001$) Se concentration compared with the control forage without Se fertilization (7.7 ± 1.81 vs. 0.1 ± 0.04 mg/kg DM). Control and high-Se hay were fed for 42d to weaned calves (n = 32; initial BW = 176 ± 8.7 kg) stratified by initial BW and randomly assigned to partially covered drylot pens (16 pens; 2 calves/pen). Treatments were randomly assigned to pens, including control hay + high-Se hay, control hay + supplemental Na selenite, or control hay without supplemental Se (n = 7, 7, and 2 pens, respectively). A pair-feeding design was utilized, whereas each pen receiving high-Se hay was paired to a pen receiving Na selenite. Ground, high-Se hay was offered to assigned pens for a 4 h period each morning. Hay intake was measured and total Se intake was estimated. The Na selenite paired-pen was then provided the same daily amount of Se via Na selenite hand-mixed into a limit-fed grain supplement resulting in a range of daily Se intakes of 2.08 to 3.98 mg/d. Liver Se concentrations were greatest ($P \leq 0.004$) on d 42 for calves consuming high-Se hay compared with calves receiving Na selinite or no supplemental Se (2.97, 2.49, and 0.60 mg/kg DM, respectively; SEM = 0.142). Amount of daily Se intake affected Se status, whereas, calves consuming <3.0 mg/d from high-Se hay had 54% greater (P = 0.02) liver Se concentrations compared with calves consuming the same amount of Se from Na selenite. When consuming >3.0 mg/d, there were no differences (P = 0.71) in liver Se concentrations due to Se source. These results imply that Se fertilization of bermudagrass hayfields results in increased Se concentration of harvested forage. Additionally, calves consuming this forage in amounts providing <3.0 mg Se daily have greater Se status compared with calves consuming the same amount of Se from Na selenite.

Key Words: calves, hay, selenium

711 Effect of Cu, Zn, and Mn source on preferential free-choice intake of salt-based supplements by beef calves and precipitation-induced metal loss.
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Two studies were completed to evaluate the effects of Cu, Zn, and Mn source on preferential intake and precipitation-induced metal loss of salt-based mineral supplements. Complete free-choice, salt-based mineral supplements were formulated to contain 2,500, 5,500, and 4,000 mg/kg of Cu, Zn, and Mn, respectively. The supplements differed only by the source of Cu, Zn, and Mn, which were hydroxy, organic, or sulfate sources. In Exp. 1, the 3 formulations were offered simultaneously to preweaned beef calves (4 pasture replications; 17 calves/pasture) within separate stainless steel bowls inside covered cow-exclusion areas. Preferential intake was evaluated weekly for 18 wk. Consumption of mineral averaged 21 ± 2.4 g/d (sum of all 3 sources), with a greater ($P < 0.001$) percentage of the total intake coming from the formulation containing the hydroxy vs. organic or sulfate sources of Cu, Zn, and Mn (42.8, 30.2, and 27.0% of total intake, respectively; SEM = 1.03). In Exp. 2, each of the mineral formulations from Exp. 1, were exposed to a 10.2 cm precipitation event delivered in equal 3.4 cm applications on Monday, Wednesday, and Friday (4 replications/formulation). To accomplish this, 750 g of mineral was placed into Buchner funnels (177 cm^2) on 20 to 25 μ pore filter paper. Deionized water (pH adjusted to 5.6) was poured over the mineral and the leachate collected into volumetric flasks and analyzed for Cu, Zn, and Mn concentration using inductively coupled plasma spectroscopy techniques. Total leaching losses of Cu, Zn, and Mn were less ($P < 0.001$) for formulations containing hydroxy- vs. organic- and sulfate-sources (Cu losses = 0.8, 5.8, and 3.8%, SEM = 0.22; Zn losses = 18.0, 54.6, and 52.3%, SEM = 1.83; and Mn losses = 6.2, 50.1, and 54.8%, SEM = 1.83 for formulations containing hydroxy, organic, and sulfate sources, respectively). These results imply that calves preferentially consume free-choice salt-based mineral supplements formulated with hydroxy vs. sulfate or organic sources of Cu, Zn, and Mn. In addition, hydroxy sources of Cu, Zn, and Mn are less susceptible to precipitation-induced leaching losses compared with sulfate and organic sources.

Key Words: calves, supplementation, trace mineral

712 Effects of trace mineral source on cow performance and mineral status during a production cycle. Deborah M. Price*[1], Kaitlyn M. Havill[1], Alex F. Swain[1], Joseph M. Guevera[2], Carley R. Trcalek[2], Max Irsik[2], Owen Rae[2], Matthew J. Hersom[1], and Joel V. Yelich[1], *[1]Department of Animal Sciences, University of Florida, Gainesville, FL, [2]College of Veterinary Medicine, University of Florida, Gainesville, FL.*

Effect of trace mineral (TM) supplement source on cow performance and TM status over the production cycle were examined. Cows (n = 200, BW = 523 ± 6 kg, BCS = 5.1 ± 0.03) were divided in a factorial treatment arrangement, Angus (AN, n = 99) and Brangus, (BN, n = 101) and TM treatments (TRT; Inorganic = ING, n = 100, and Organic = ORG yeast source, n = 100). Supplementation (3 d/wk, 0.4 kg$\cdot^{-1}$454 kg BW$\cdot^{-1}$d in a pellet) of TM began ≥90 d before expected parturition and continued to weaning. A subset of cows had liver biopsies and serum collected, frozen and analyzed for TM content (Co, Cu, Fe, Mn, Mo, Se and Zn), by ICP-MS at 4 and 6 periods, respectively: start of TM (TMst), pre-calving (PreC), calving (C, serum only), post-calving (PostC, serum only), prebreeding (Pbrd) and weaning. Cow BW and BCS were recorded each period. Data were analyzed in SAS using Proc Mixed and repeated measures, with TRT, breed and time as fixed effects. No 3-way interactions were detected except for serum Cu, Mn and Mo. At PostC, BN were 0.17 BCS greater ($P = 0.03$) than AN. Cow BW and BCS did not differ ($P > 0.21$) by TRT at each period. The AN had greater ($P \le 0.03$) BW change from TMst to PreC (49 vs. 40 ± 2 kg) and from PostC to Pbrd (−44 ± 4 vs. −33 ± 3 kg) than BN. Change in BCS from PreC and Pbrd to weaning were greater ($P < 0.05$) in ING (−0.15 vs. −0.001 ± 0.05 and −0.36 vs. −0.10 ± 0.08, respectively) than ORG. Time ($P \le 0.02$) affected all serum and liver TM concentrations except for serum Fe ($P = 0.13$). Serum Co and liver Cu concentrations were greater ($P < 0.05$) in ING (1.7 vs. 1.3 ± 0.1 ng/mL and 266.4 ± 15.0 vs. 201.2 ± 14.1 µg/g, respectively), while serum Mo was greater ($P = 0.006$), in ORG (2.8 vs. 1.7 ± 0.3 vs. ng/mL). Serum Fe and liver Cu and Mn concentrations in BN (149.1 ± 5.5 µg/dL, 280.9 ± 15.2 and 11.7 ± 0.5 µg/g) were greater ($P < 0.03$) than AN (132.4 ± 5.3 µg/dL, 186.7 ± 13.9 and 9.5 ± 0.5 µg/g). Serum Se was greater ($P = 0.003$) in AN than BN (73.5 ± 1.7 vs. 65.4 ± 1.8 ng/mL). Cow TM status varies over time and is affected by breed and TM source; indicating development of nutritional management strategies can be based on cattle breed.

Key Words: trace mineral, liver, cattle

713 Effect of prenatal trace mineral source on preweaning and weaning calf liver and serum mineral status. Deborah M. Price*[1], Alex F. Swain[1], Meaghan M. O'Neil[1], Joseph M. Guevera[2], Carley R. Trcalek[2], Max Irsik[2], Owen Rae[1], Matthew J. Hersom[1], and Joel V. Yelich[1], *[1]Department of Animal Sciences, University of Florida, Gainesville, FL, [2]College of Veterinary Medicine, University of Florida, Gainesville, FL.*

The effect cow prenatal trace mineral (TM) supplement source has on calf serum and liver TM status from 115 ± 21 d of age through weaning (206 ± 21 d) was investigated. Factorial arrangements [Angus = AN, n = 95 and Brangus = BN, n = 96 cows; Inorganic = ING, n = 98, and Organic = ORG yeast, n = 93] utilized calves born to cows supplemented (3 d/wk at a rate of 0.4 kg$\cdot^{-1}$454 kg BW$\cdot^{-1}$d in a pellet) with TM ≥90 d before expected parturition. All calf (n = 190) BW were collected at d 115 and weaning, while a subset of calves (ING, n = 12, 6/breed, ORG, n = 14, 7/breed) had liver biopsies performed and serum collected by jugular vein puncture. Processed serum and liver samples were frozen at −20°C until analyzed for TM (Co, Cu, Fe, Mn, Mo, Se and Zn), by ICP-MS. Data were analyzed in SAS using Proc Mixed and repeated measures, with TRT, breed and day as fixed effects. With the exception of serum Co, Mn and Mo, there were no ($P \ge 0.08$) 3-way interactions. Calf d 115 BW (149 ± 2 kg) were not affected ($P = 0.65$) by TRT. At weaning, ORG had greater ($P \le 0.02$) BW (226 vs. 216 ± 3 kg), 205 d adjusted BW (227 vs. 216 ± 3 kg), BW gain (190 vs. 181 ± 3 kg) and ADG (0.93 vs. 0.89 ± 0.01 kg) than ING. Serum Co and Zn were affected ($P < 0.001$) by day, while all liver TM except for Co were affected ($P < 0.03$) by day. The ORG calves had greater ($P \le 0.01$) serum Se (29.8 vs. 18.2 ± 1.1 ng/mL), liver Se (0.7 vs. 0.5 ± 0.1 µg/g) and Mn (9.3 vs. 7.8 ± 0.4 µg/g) than ING. The AN had greater ($P \le 0.04$) serum Co (0.8 vs. 0.5 ± 1.2 ng/mL), Se (27.9 vs. 19.4 ± 1.1 ng/mL) and liver Co (0.2 vs. 0.1 ± 0.02 µg/g), Fe (573.5 vs. 435.9 ± 1.1 µg/g) and Zn (128.1 vs. 116.7 ± 1.0 µg/g), while BN had greater ($P < 0.05$) serum Mo (5.0 vs. 2.5 ± 0.6 ng/mL) and liver Mn (9.1 vs. 8.0 ± 0.4 µg/g). Calf BW and ADG at weaning were increased by prenatal ORG TM. These data indicate calf TM status varies by day relative weaning, prenatal TM source and breed. Additional research is needed to determine how TM source affects calf immune function, performance, carcass traits and reproductive potential.

Key Words: trace mineral, prenatal nutrition, weaning