**461P**  Evaluation of increasing levels of zinc methionine hydroxyl analogue chelate on male growth. Austin T. Jasek*SC1, Kyle D. Brown1, Katie Burchfield1, Robert E. Buresh2, Mike Roux3, Christine Z. Alvarado1, Rocky E. Latham1, and Jason T. Lee1, 1Texas AgriLife Research, College Station, TX, 2Novus International Inc., St. Charles, MO.

The effect of increasing levels of zinc methionine hydroxyl analog chelate (ZMHAC) on male broiler growth was evaluated. Three experimental treatments were used in the evaluation; 30 ppm, 40 ppm, and 60 ppm and a control that contained 100 ppm of zinc sulfate. All other trace minerals were fed at consistent concentrations. Each treatment included 15 replicates with 22 chicks per replicate pen. A large basal diet was manufactured free of a trace mineral premix and methionine. Custom trace mineral premixes for each treatment were then added along with methionine as increasing ZMHAC in turn increased the amount of methionine contributed to the diet. Broilers were fed a 3-phase dietary program consisting of a starter fed from d 1 to 15 of age, a grower fed from d 15 to 28 of age, and a finisher fed from d 28 to d 42 of age. Broilers were weighed and feed consumption determined on days of dietary changes. At the conclusion of the trial on d 42, birds were weighed individually to calculate a coefficient of variation for each replicate pen. Regression analysis was conducted to determine effect of increasing ZMHAC level on body weight, feed consumption, mortality-corrected feed conversion ratio (FCR), and flock uniformity. Individual comparisons were conducted between each of the 3 levels of ZMHAC and zinc sulfate. Individual comparisons of each level of ZMHAC to zinc sulfate did not result in any significant differences in final body weight or FCR. During the starter phase of production, increasing ZMHAC level was related to a linear increase in feed conversion ratio and reduction in body weight. Following the starter phase, no linear relationships were observed with increasing ZMHAC level and average male body weight, feed consumption or feed conversion ratio. At the conclusion of the trial, increasing zinc concentration improved pen uniformity evidenced by a linear reduction in coefficient of variation. In conclusion, these data suggest that reducing zinc levels to 30 ppm of ZMHAC does not negatively affect growth performance although increasing that level can result in improved flock uniformity.

**Key Words:** zinc, performance, broiler, uniformity

**462P**  Effects of trace mineral sources on bioavailability and function in broiler chickens. David F. Calabotta*, Kevin C. DeHaan, Troy J. Wistuba, A. Bruce Johnson, Wendell A. Knehans, and James D. Chapman, Phibro Animal Health Corporation Inc., Teaneck, NJ.

Studies utilizing broilers were conducted to determine the effects of trace mineral sources on bioavailability. Mineral bioavailability is an important factor in determining nutrient matrix values used by nutritionists. In trial 1, 1,040 Ross-708 broilers were fed diets at various zinc levels (0, 10, 20, 30, and 40 ppm added Zn) from 3 zinc sources: zinc sulfate (positive control), zinc oxide (negative control), and GemStone Zinc (metal amino acid complex from Phibro). Feeding GemStone resulted in improvements ($P < 0.05$) in body weight, feed intake, bone ash %, liver zinc, and tibia zinc compared with the positive and negative controls. Trial 2 utilized 3,000 mixed-sex broiler chicks in a pen setting to determine the impact of increasing GemStone zinc and manganese on live performance, bone ash and coccidial lesions compared with a negative (100 ppm Zn and Mn as sulfates) and positive (140 ppm Zn and Mn from sulfates) control diet. At 42 d, body weights were significantly increased ($P < 0.05$) and 0–42 d feed:gain decreased ($P < 0.05$) with increasing levels of GemStone when fed at 40 ppm Zn/Mn compared with the negative control. At 49 d, body weights were increased ($P < 0.05$) and 0–49 d feed conversion decreased ($P < 0.05$) with increasing levels of GemStone when fed at 30 and 40 ppm Zn/Mn, compared with the negative control. Day 43–49 data were similar to earlier data. Also, lesion scores were improved ($P < 0.05$) with increasing levels of GemStone over the control at both 21 and 49 d of age. GemStone at 40 ppm Zn and Mn provided better performance ($P < 0.05$) compared with either the negative or positive control. Trial 3 used 12 test treatments with 12 replicates per treatment to compare commercially available sources. Results showed that GemStone, along with other premium chelated mineral sources, improved bioavailability and performance when compared with negative (100 ppm Zn/Mn) and positive controls (140 ppm Zn/Mn). In summary, GemStone provided similar or better bioavailability and performance compared with other organic-trace mineral sources.

**Key Words:** organic trace mineral, bioavailability, zinc, manganese, chelation

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**463P**  Comparison of bone mineralization measured by dual energy X-ray absorptiometry and tibia and toe bone characteristics in broilers fed varying dietary calcium and non-phytate phosphorus levels. Anne-Sophie Valable*SC1,2, Agnès Narcy2, Michel Duclos2, Greg Page3, and Marie-Pierre Letourneau-Montminy1, 1Laval University, Quebec, QC, Canada, 2INRA Poultry Research unit, Nouzilly, France, 3Trouw Nutrition Agresearch, Guelph, ON, Canada.

Different bones and criteria can be used to assess bone mineralization. Whole body bone mineral content (BMC) was compared with tibia ash weight and breaking strength (BS) and toe ash weight. A total of 3,600 Ross 708 broilers were randomly divided into each of 10 replicate pens of 6 dietary treatments. Broilers were fed a common starter diet from d0 to d10. From d 10 to d 21, broilers were fed a positive control (C+: 0.90% Ca, 0.39% nPP), a negative control (C-: 0.71% Ca, 0.35% nPP) or a low Ca and nPP diet (L: 0.60% Ca, 0.30% nPP). From d 21 to d 37, the levels in C+, C- and L diets were respectively 0.85, 0.57 and 0.48% Ca and 0.35, 0.29 and 0.24% nPP. Six dietary sequences were tested: C+C+, C-C-, LC+, LC-, C-L and LL. At d 21 and d 37, 10 birds per treatment were slaughtered, frozen at –20°C and scanned with dual energy x-ray absorptiometry (DXA) to estimate whole-body BMC. Tibia and toe were then collected to assess ash weight and tibia BS. Pearson’s regression analysis was performed to predict whole-body BMC based on other bone criteria as well as the effect of dietary treatments on this relation. For both phases (d10 to d21 and d21 to d37), BMC was best correlated with tibia ash weight (74 and 85%, $P < 0.001$) followed by toe ash weight (50 and 68%, $P < 0.001$) and BS (37 and 51%, $P < 0.01$). Accordingly, BMC was better predicted by tibia ash weight ($R^2 = 0.48, P < 0.001$) than toe ash weight ($R^2 = 0.40, P < 0.01$) or BS ($R^2 = 0.26, P < 0.01$). Dietary treatments influenced the intercept of the relation between BMC and BS at d 21 and d 37 ($P < 0.05$). Whole body BMC was better predicted by tibia ash weight ($R^2 = 0.60, P < 0.05$) than toe ash weight ($R^2 = 0.40, P < 0.05$) or BS ($R^2 = 0.26, P < 0.05$). Whole body BMC was better predicted by tibia ash weight ($R^2 = 0.60, P < 0.05$) than toe ash weight ($R^2 = 0.40, P < 0.05$) or BS ($R^2 = 0.26, P < 0.05$). Whole body BMC was better predicted by tibia ash weight ($R^2 = 0.60, P < 0.05$) than toe ash weight ($R^2 = 0.40, P < 0.05$) or BS ($R^2 = 0.26, P < 0.05$).
increasing body weight (age). In conclusion, tibia ash weight appeared to be a strong predictor of whole-body bone mineralization in broiler

Key Words: bone mineralization, bone ash, dual energy X-ray absorptimetry, bone strength, broiler


Research data has indicated that microminerals provided in the form of proteinates (Bioplex, Alltech Inc.) are more bioavailable than their corresponding inorganic salts. The objective of this study was to evaluate the effect of replacing inorganic microminerals with reduced levels of proteinates in the diets on productive performance, egg characteristics and bone quality of laying hens. Day-old Hy-Line W-36 pullets were fed corn-soybean meal-based diets supplemented with Cu, Mn, Fe and Zn at commercial levels (CL) in the form of inorganic salts or at 20, 25 or 30% of CL in the form of proteinates. At 17 wk of age, 7 groups of 12 pullets from each of the 4 treatments were transferred to layer cages (2 birds/cage) according to a randomized complete block design and switched to layer diets that corresponded with the previous growth period treatment. Dietary treatments continued through 70 wk of production. There were no effects of dietary treatments on overall egg production (average = 80.1%), feed intake (average = 97.4 g/bird/d), and feed conversion ratio (average = 1.46 kg/dz). Egg weight (average = 58.2 g), percent eggshell (average = 8.5%) and eggshell breaking strength (average = 2.70 kg) were not affected by dietary treatments. No effect of dietary treatments on bone ash, bone-breaking strength, the concentration of Zn, Fe and Cu in bone ash or liver was detected. However, the concentration of Mn in bone ash and liver from layers fed diet containing CL in the form of inorganic salts was higher ($P < 0.05$) than that from layers fed the other treatment diets. The results of this study indicate that dietary supplementation of microminerals as proteinates at 20% of the levels of inorganic salts typically found in commercial diets can support egg production, body weight, egg weight and shell and bone quality of white egg laying hens.

Key Words: laying hen, micromineral, proteinates, egg production, shell quality

465P  The effects of zinc supplementation from two sources on egg quality and bone health in laying hens. Kelli M. Martin*,SC, Napoleon Vargas Jurado, and Sheila E. Purdum, University of Nebraska-Lincoln, Lincoln, NE.

The objective of this experiment was to compare Zn sources and levels of supplementation on laying hen production, bone health and egg quality. Bovan White Leghorn hens were fed 1 of 6 dietary treatments in a 2 × 3 factorial arrangement of 2 sources of Zn (AvailaZn or Zn sulfate) and 3 levels of supplementation (40, 80, or 120 ppm). Hens were provided 110 g/hen/day of feed ad lib. Treatments were randomly assigned to 60 cages with 4 hens in each cage. From 19 to 25 wk of age, the hens were housed in a tiered manure belt housing system providing 81.9 cm$^2$/hen. The hens were then moved to another tiered manure belt housing system with 5 hens to a cage in 48 cages providing 97.2 cm$^2$/hen where they remained for the rest of the experiment. Hens were kept in the same dietary treatments and blocks were rearranged to provide 8 replicates per treatment. Data collection included FI, EP, EWt, egg components, eggshell strength, BWt, bone mineral density, and manure Zn content. Data were analyzed using Proc Glimmix in SAS. No significant differences or interactions were found for FI, EP, EWt, % eggshell, BWt gain, or bone mineral density. The source by level interaction for eggshell strength approached significance ($P < 0.08$) with 40 ppm Zn sulfate and 80 ppm AvailaZn showing the highest breaking strength. The moderate level of Zn (80 ppm) showed significantly higher ($P < 0.05$) breaking strength at 36 and 45 wk of age regardless of source. For manure Zn content AvailaZn showed significantly higher amounts of Zn excretion ($P < 0.0001$) for all levels of supplementation. For both sources, the highest level (120 ppm) showed a significant increase in Zn excretion ($P < 0.0001$). Overall, AvailaZn at 120 ppm showed significantly higher ($P < 0.0001$) Zn excretion in the manure than all other treatments. Based on these results AvailaZn fed at moderate levels may improve eggshell breaking strength, but may increase Zn excretion in the manure.

Key Words: zinc, laying hen, nutrition, bioavailability, mineral

466P  Influence of antagonists on broiler performance when fed either an inorganic or organic zinc source. Michael D. Sims1, Jack E. Garrett*,2, and Greg A. Nunney2,1Virginia Diversified Research Corp., Harrisonburg, VA, 2QualiTech Inc., Chaska, MN.

This study was conducted to evaluate the influence of antagonists on the performance of broilers from hatch to 41 d of age. High levels sulfates (dried distillers grains, DDG) and high levels of copper have been observed to influence bioavailability of zinc from the digestive tract. Cobb 500 straight run broiler chicks (7,920 birds) were randomly allotted to 264 pens (30 birds/pen). Each pen contained 1 water fountain and a 50 lb capacity feed tube. Dimensions of the pens were 4′ × 5′ providing 7 ft$^2$/bird. Each pen had approximately 3 inches of new wood shavings at d 0 with 4 lb of used low pathogen load litter added at Day 4 to mimic conditions encountered in commercial poultry houses. Treatments in this study were Zn source [sulfate vs organic; poly-saccharide chelated (SQM)], antagonists (Control, DDG and 250 ppm Cu [HiCu; tribasic copper chloride]) and level of zinc supplementation 0, 20, 40, 60, 80 and 100 ppm. Bird performance was measured at 21 and 41 d of age, including weight, feed efficiency (FCR), and mortality. The study was analyzed as a 2×3×5 factorial model augmented with a control within each antagonist grouping. Bird wt at 21 d of age was improved ($P < 0.06$) by the addition of organic zinc; while HiCu reduced bird wt ($P < 0.01$). Final wt was not significantly improved by zinc source yet showed similar response as 21 d wt; while birds receiving HiCu had lower final wts ($P < 0.01$). FCR and FCR adjusted for mortality showed a trend ($P < 0.10$) and significant ($P < 0.05$) improvement with the addition of SQM, though there was an interaction ($P < 0.01$) with supplementation level; birds receiving DDG had improved ($P < 0.01$) FCR compared with the other treatment although there was a significant ($P < 0.01$) interaction with level of zinc supplementation. Mortality was improved ($P < 0.05$) by HiCu treatment. Results of this study indicated that the addition of an organic Zn source provided better performance than an inorganic Zn source. The influence of antagonists was not clearly defined by the results of this study.

Key Words: zinc, antagonist, broiler, SQM, copper
Effects of dietary calcium, nonphytate phosphorus, and phytase on growth performance and bone ash of Pekin ducks.
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A dose-response experiment with different calcium (Ca) and nonphytate phosphorus (nPP) concentrations and supplementation of phytase was conducted to investigate the effects of Ca × nPP and Ca × phytase interaction on performance of starter Pekin ducks (1–12 d of age; 6 to 7 cages/diet; 22 birds/cage). A total of 15 dietary treatments were used: 12 treatments according to 3 × 4 factorial design with 3 concentrations of Ca (0.75, 1.15, and 1.55%) and 4 concentrations of nPP (0.35, 0.45, 0.55, and 0.65%) and 3 additional treatments containing 1,500 FTU/kg phytase at 0.75, 1.15, and 1.55% Ca with a 0.35% of nPP. An interaction of growth performance between Ca and nPP (P < 0.05) was observed. According to a quadratic broken-line regression, the nPP requirements for BW gain was 0.49% at 0.75% of Ca and 0.56% at 1.15% Ca. However, at 1.55% of Ca, BW gain increased as dietary nPP increased from 0.35 to 0.65% without reaching a plateau. No Ca by nPP interaction was observed for tibia ash. A main effect of Ca, however, was observed with birds fed 0.75% Ca having at least 2.0 percentage units more tibia ash than those fed 1.15 or 1.55% Ca. Supplementation of phytase counteracted the growth suppression caused by a wide Ca:nPP ratio. A significant Ca × phytase interaction was observed for growth performance (P < 0.05); with the supplementation of 1,500 FTU/kg of phytase in 0.35% nPP diets, the BW gain was improved by 32, 53, 74% at 0.75, 1.15, and 1.55% of Ca, respectively. No phytase by Ca interaction was observed for tibia ash, yet phytase supplementation increased tibia ash percentage by 13.2 percentage units over unsupplemented birds. In summary, the nPP requirements of ducks from hatch to 12 d of age increased as dietary Ca increased, and ranged from 0.49 and 0.75% nPP at 0.75 and 1.15% Ca, respectively.

Key Words: duck, calcium, phosphorus, phytase

Effects of available phosphorus source and concentration on sodium phosphate type IIb co-transporter, vitamin D-1α-hydroxylase, and vitamin D-24-hydroxylase mRNA gene expression in broiler chicks.
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This experiment was conducted to study the effects of different levels and sources of available phosphorus on intestinal phosphorus transporters and liver and kidney vitamin D-1α-hydroxylase and 24-hydroxylase activity at 7 d and 14 d of age. The diet containing 0.20% available phosphorus, considered as a negative control (NC) diet with a low concentration of available phosphorus, was formulated without additional phosphorus. The experimental diets were formulated to contain 0.24, 0.28, 0.32 and 0.36% available phosphorus by adding 2 sources of phosphorus (di-calcium phosphate and nano-calcium phosphate). Moreover, the di-calcium phosphate diet containing 0.32% available phosphorus was supplemented with 2 levels of phytase enzyme (500 and 2000 FTU/kg). Chicks were fed 11 dietary treatments. A total of 792, one-day old unsexed broiler chicks (Cobb 500) were used with 72 birds replicated into 8 groups, with 9 birds/replicate. Intestinal sodium phosphorus co-transporter (NaPi IIb) mRNA expression linearly decreased (P < 0.05) when dietary nonphytate phosphorus increased from 0.20 to 0.36% at d 7 and 14 in duodenum. NaPi IIb mRNA decreased with increasing phytase supplementation at d 7 and 14. In liver; amounts of 1α- and 24-hydroxylase mRNA at d 7 and 14 differed (P < 0.0001) between experimental treatments. The expression of 1α- and 24-hydroxylase mRNA amount did not differ (P > 0.05) by phytase supplementation at d 7, but did differ (P < 0.05) at d 14. In kidney, different experimental treatments had no effect (P > 0.05) on amounts of 1α- and 24-hydroxylase mRNA at d 7 and 14. The integration of nanotechnology and gene expression in the present study would give new insights into studying bioavailability of selected minerals in target tissues at both cellular and sub-cellular levels.

Key Words: phosphate, transporter, 1α-hydroxylase, 24-hydroxylase, vitamin D

Withdrawn