Implications of dietary potassium and potassium salts on production performance, carcass characteristics and serum mineral chemistry of broiler chickens reared under phase feeding system. M. M. H. Mushtaq*, University of Agriculture, Faisalabad, Punjab, Pakistan.

Response of one-day-old straight-run Hubbard broiler chicks (n = 1656) to 4 dietary potassium (dK) levels (0.86, 1.02, 1.18 and 1.34%) and 2 sources of potassium salts (K2CO3 and K2SO4) with the concept of dietary electrolyte balances (DEB) were evaluated in 4 × 2 factorial arrangement. The 4 dK levels corresponded to DEB values of 200, 240, 280 and 320 mEq/kg, respectively. Each of the 9 dietary treatments (one basal diet without dK supplementation along with 8 experimental diets) was randomly allocated to 4 replicates each having 46 birds. Body weight gain (P < 0.03) and feed:gain (P < 0.05) was improved at 1.20% dK during 32 to 42 d of age. Feed intake during 1 to 10 d (P < 0.05) and water intake during 34 to 42 d (P < 0.04) and during 1 to 42 d (P < 0.03) was increased in K2SO4 supplemented diets. Water intake was increased linearly with increasing dK when supplemented by K2CO3 whereas these were decreased linearly with increasing dK with that of K2SO4 during 11 to 20 d (P = 0.002) and 1 to 42 d (P = 0.04). The K2SO4 supplemented diets increased the mortality during 1 to 42 d (P < 0.02), and lowered blood pH (P < 0.001), dressing (P < 0.04), abdominal fat (P < 0.03) weights and shank length (P < 0.02). A significant salt × dK effect was observed where low levels of dK with K2CO3 and high levels with K2SO4 exhibited lower litter moisture during all phases. Increasing serum cations is compensated by increased concentration of serum anions at the end of the experiment. The results of the experiments depicted the importance of dK for better BW gain and feed efficiency in later stages of production. K2CO3 increased survivability and dressing responses but both dK levels and salts played important role for water intake, litter condition and carcass characteristics.

Key Words: potassium, dietary electrolyte balance, salt, broiler, phase feeding


In this study, 2 dietary sources of cholecalciferol (vitamin D3) in the form of stabilized gelatin beadlets were evaluated for their effect on broiler growth performance and bone strength characteristics. A total of 250 one-day old Ross x Cobb broiler chickens were fed a commercial-type corn soy broiler starter diet for a 3-week rearing period. A custom vitamin premix containing no vitamin D3 was used to formulate a single mash basal diet for all treatment diets, with vitamin D3 supplemented at 0, 50, 100, 200, 400 and 800 IU D3/kg after the diets were sub-divided into each separate treatment. All birds were fed 0 IU D3/kg treatment diet for the first 7 d to deplete vitamin D3 stores and were then fed the various treatment diets for 14 d. On d 21, the birds were killed and the right leg from each chick was removed at the tibia-femur joint. Feet were removed at the tibia-metatarsal joint distal to the spur for ashing. Muscle tissue and fibula were dissected from tibia bones, which were analyzed for breaking strength using an Instron machine. After breaking, tibias were also ashed. Data were analyzed as a 2 × 6 factorial design using GLM procedure of SPSS with means separated using Duncan’s Multiple Range Tests. Outliers were identified and excluded from the statistical analysis using the Outlier Box Plot procedure of JMP statistical software. There were no significant differences (P ≤ 0.05) between the 2 dietary sources of vitamin D3 stabilized gelatin beadlets for any of the variables measured. Treatment level had a significant effect on average body weight per bird, productivity index, foot ash and tibia bone ash (as both a percent of dry bone weight and as total mg of ash), and tibia breaking strength, which were all of the variables measured except for feed conversion ratios. For none of the variables measured there was a significantly greater response than in the 200 IU D3/kg treatment level. This clearly confirms the NRC 1994 vitamin D3 requirement of 200 IU D3/kg.

Key Words: vitamin D3, tibia ash, foot ash, broiler

Iron bioavailability in lentil based diets: Studies in poultry and in vitro digestion/Caco-2 model. E. Tako*, A. Vandenberg2, D. Thavarajah2, P. Thavarajah2, and R. Glahn1, 1USDA/ARS, Robert W. Holley Center for Agriculture and Health, Cornell University, Ithaca, NY, 2University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

Lentils (Lens culinaris) are a pulse crop that is relatively high in Fe concentration (50–100 ppm) and consumed worldwide. As such lentils are an excellent candidate for Fe biofortification. We measured Fe bioavailability and Fe concentration of 20 commercial lines of lentils from a major lentil production region in Saskatchewan, Canada. Using an in vitro digestion/Caco-2 cell model for Fe bioavailability screening, we found that significant differences in Fe bioavailability exist within the commercial lines. Fe concentration was also found to differ, ranging from 55 to 95 ppm. Therefore, we selected 3 lentil varieties to determine if the high-Fe lentils would improve the Fe status of our animal model (broiler chickens) when fed over a 30 d period. We formulated diets containing 50% lentils, broiler hatchlings were divided into 3 groups (n = 10), and were fed the following: lentil 1 (“Red berry” ,95ppm Fe), lentil 2 (“Red berry,”75ppm Fe) or lentil 3 (“Milestone,”55ppm Fe). Diets had no supplemental Fe and were differenter in Fe content (65, 55, 45 ppm Fe, respectively). For 4 wks, hemoglobin (Hb), Fe and body weights were measured. Results showed significantly higher hemoglobin values and total body Hb-Fe values in “Lentil 1” group vs. “Lentil 3” (P ≤ 0.05). We conclude that the in vivo results support the in vitro observations, ie. the 40ppm difference in lentil Fe provides significantly more bioavailable Fe.

Key Words: lentil, iron bioavailability, broiler, Caco2 model

Intra amniotic administration and dietary inulin affect the iron status and intestinal functionality of iron-deficient broiler chickens. E. Tako* and R. Glahn, USDA/ARS, Robert W. Holley Center for Agriculture and Health, Cornell University, Ithaca, NY.

Inulin, a linear β fructan, is present in a variety of plants. It exhibits prebiotic properties and enhances mineral absorption and beneficial bacteria in the colon. Our objective was to assess the effect of intra amniotic administration and dietary inulin on selected intestinal iron transporters and binding proteins gene expression and on intestinal iron uptake. In this study, inulin solution (4% inulin in 0.85% saline) vs. saline solution as control (0.85% saline) were injected into the naturally consumed amniotic fluid of 17d old chicken embryos (n = 60). Upon hatch, and from each treatment group 10 chicks were killed and their small intestine, liver and cecum were removed for mRNA abun-
Blood samples were collected every 5 min and for 90 min post injection and analyzed by ICP-MS for 58Fe concentrations. At the end of the procedure, animals were killed and cecum contents and duodenum and liver samples were taken. DMT1, Dcytb and ferroportin mRNA levels and liver ferritin amounts were measured in the injected birds compared with the controls. Body weights and hemoglobin concentrations were higher in the injected groups vs. control (as from d 14 post hatch, P < 0.05). In addition, the cecal content microflora was examined using 16S ribosomal DNA (rDNA) targeted probes from bacterial DNA. The Blifidobacterium population was increased in the inulin injected groups (P ≤ 0.05) vs. the control group. These results indicate that dietary inulin might trigger an upregulation of genes encoding for iron transporters in the enterocyte. Thus providing a greater and overall health advantage to the broiler.

Key Words: broiler, intestine, iron, inulin


The skeletal system is dependent upon minerals such as Ca, P, Cu, Mn or Zn for its proper development. Research in our lab showed that on 19E the levels of Zn, Cu, Mn, and P in the yolk (The major mineral reserve) decreased significantly; to 3.17, 5.68, 10.61 and 13.46% of their levels at day of set. This leaves the embryo with low mineral reserves. Respectively, the uptake of Zn, Cu, Mn, and P between 19E and day of hatch was low. The purpose of this study was to examine the effect of in ovo enrichment on yolk mineral levels and uptake and on bone mechanical and structural properties. For that purpose, 300 eggs were incubated and divided to 2 groups: Enriched (on 17E with a solution containing minerals, vitamins and carbohydrates using the in ovo Feeding method) and control. Eight eggs from each group were randomly selected on 18E, 19E, 20E and 21E. Their yolk was examined for its mineral content using ICP-AES and tibia bone was taken for further analysis. Hatchings were raised and tibiae from 8 chicks from both groups were taken on 7d, 14d, and 28d for biomechanical testing using a micromechanical testing device. Additionally, for structural analysis, cortical and cancellous bone of tibiae were scanned in a high-resolution micro-CT, reconstructed and analyzed. Results show that the enriched groups had higher yolk P, Cu, Mn and Zn and exhibited higher uptake than the control. Tibia analysis show that on day of hatch, the enriched group tibia’s had higher stiffness, load-to-fracture and ultimate load than the control group. On 7d the Tibiae trabecular bone of the enriched group had higher trabecular thickness and bone percent than the control. On 14d, the enriched group had higher load-to-fracture and ultimate load than the control group, additionally; the cortical bone medullary area was higher than the control. On 28 d the enriched group showed higher bone mineral density than the control. This study demonstrates that in ovo enrichment with minerals, vitamins and carbohydrates elevated the mineral content and uptake in the yolk of broiler embryos and can influence and improve bone properties at least until 28d.

Key Words: mineral, bone, tibia, in ovo


The effects dietary 25-OH vitamin D3 (25D3) on male turkey live performance, breast yield, innate immunity and bone quality to 12 weeks of age were studied. Hybrid Conventional male turkey poult's were placed in 42 floor pens at d of hatch (n = 6 pens per treatment; 32 turkeys/pen). Each pen was randomly assigned to 1 of 5 dietary treatments to 12 wk of age: 1. Control (3,680 IU vitamin D3/kg feed); 2. 25D3 (92 μg/kg 25D3); 3. D3 + 25D3 (Control + 92 μg/kg 25D3); 4. D3X2 (Control + 3,680 IU vitamin D3/kg); 5. 25D3 Early (Control + 92 μg/kg 25D3 for 6 wk; Control thereafter). BW gain, feed consumption, and feed conversion ratio were assessed for each of the 4 dietary phases to 12 wk of age. Whole blood was obtained at 8, 29 and 43 d of age to assess the number of cells able to engulf at least one Escherichia coli (% phagocytosis), average number of E. coli/cell (phagocytic capacity), and E. coli bactericidal capacity in vitro. At 9 and 12 wk, breast yield was determined, and femur quality assessed using quantitative CT. There were no effects of diet on turkey performance to 12 wk of age, or on breast yield at 9 or 12 wk of age (P > 0.05). Turkeys fed the D3 + 25D3 treatment had among the greatest % phagocytosis (P = 0.06) and phagocytic capacity (P = 0.07) at 8 d of age, whereas the turkeys on the 25D3 treatment had a lower % phagocytosis than the turkeys on the D3 + 25D3 treatment (P = 0.06), and among the highest mean phagocytic capacity (0.07). At 43 d, the turkeys from the 25D3 treatment had among the greatest % phagocytosis (P = 0.04), although lower phagocytic capacity (P = 0.02). There was no effect of diet on E. coli killing (P > 0.05). There were no effects of diet on femur bone mineral density or cross-sectional area at 9 wk (P > 0.05). Dietary 25D3 supported equivalent turkey performance to the control treatment. The combination of D3 + 25D3 or 25D3 alone in the young turkey promoted a stronger innate immune response and indicates the ability of vitamin D3 and 25D3 to alter the bird’s immune function.

Key Words: turkey, 25-hydroxy vitamin D, vitamin D, innate immune function, growth


The effects dietary 25-OH vitamin D3 (25D3) on male turkey live performance, leg and bone quality and carcass composition from 14 to 22 wk of age were studied. Hybrid male turkey poult's were randomly placed at day of hatch in 42 floor pens (n = 6 pens per treatment; 32 turkeys/pen). Each pen was randomly assigned 1 of 7 dietary treatments to 22 wk of age: 1. Control (3,680 IU Vitamin D3/kg feed); 2. 25D3 (92 μg/kg 25D3); 3. D3 + 25D3 (Control + 92 μg/kg 25D3); 4. D3X2 (Control + 3,680 IU vitamin D3/kg); 5. 25D3 Early (Control + 92 μg/kg 25D3 for 6 wks; Control thereafter); 6. 25D3 Recommended (Control + 92 μg/kg 25D3 for 12 wks; Control thereafter); 7. 25D3 Reduced (Control + 92 μg/kg 25D3 to 12 wks; Control + 46 μg/kg 25D3 from 13 to 22 wk). BW gain, feed consumption, and FCR were assessed for each of the 4 dietary phases from 14 to 22 wk. At 14, 16, 19 and 22 wk, carcass and portion yields were assessed. At each processing age, bone mineral density of the right femur was assessed by quantitative CT. A subjective gait analysis was performed at 17 and 22 wk. Neither dietary vitamin D form nor level affected turkey performance. At 14 wk, Control, 25D3 and 25D3 Reduced birds had the greatest % whole
carcass weight ($P = 0.05$) and the 25D$_3$ Reduced birds had the greatest % of thighs ($P = 0.09$). At 16 wk, the 25D$_3$ and 25D$_3$ Reduced turkeys consistently had the greatest or among the greatest absolute weight of the P, major, P. minor, thighs and drums ($P < 0.05$). The 25D$_3$ birds also had the greatest % P. major ($P < 0.05$). At 22 wk, the 25D$_3$ birds had the greatest % drum yield ($P = 0.07$). Turkeys fed the 25D$_3$ recommended and the 25D$_3$ Reduced diets had increased walking ability at 22 wk of age ($P = 0.07$). There were no effects of diet on femur bone mineral density or cross-sectional area at 19 or 22 wk ($P > 0.05$). Although 25D$_3$ in the diet throughout the growing period affected turkey carcass traits, it was not necessary to have a full dose (92 µg/kg of feed) throughout life, as similar processing results were observed for the 25D$_3$ Reduced treatment.

**Key Words:** turkey, vitamin D, 25-hydroxy vitamin D, growth, carcass yield

### 307 Evaluation of five proprietary vitamin-mineral premixes in Ibadan, Nigeria for broiler production. O. A. Ogunwol*1, E. O. Kolade1, M. O. Olumide1, A. O. Akinsoyinu1, A. A. Mako2, O. Aiolu-Olagunju1, and O. A. Adebiyi1, 1Department of Animal Science, University of Ibadan, Ibadan, Nigeria, 2Tai Solarin University of Education, Ijebu-Ode, Nigeria.

The relative efficacy of 5 common commercial vitamin-mineral premixes in Ibadan, Nigeria was evaluated using 280 d old Arbor acket strain. The chicks were randomly allotted to 6 treatments comprising 48 chicks and each treatment- a replicate of 16 chicks. They were brooded on a partitioned deep litter house at the Teaching and Research Farm, University of Ibadan, Ibadan. Six isocaloric and isonitrogenous diets were formulated. Diet 1 was the control without any vitamin-mineral premix while diets 2, 3, 4, 5 and 6 each had Daramvita, Biorganic, Hinutrient, Optimix and DSM-Nutripoulit broiler vitamin-mineral premixes respectively added at 0.25%. The design of the experiment was a completely randomized design. There were significant variations ($P < 0.05$) in the values obtained for feed intake and weight gain. So also, the feed conversion ratio values of 3.62, 3.35, 2.64, 2.58, 2.61, and 2.57 for birds on diets 1, 2, 3, 4, 5 and 6 respectively varied significantly ($P < 0.05$). Haematological indices of the chickens both at the starter and finishers phases were within the reference range for broilers. Serum total proteins (g/dl) varied and weight gain. So also, the feed conversion ratio values of 3.62, 3.35, 2.64, 2.58, 2.61, and 2.57 for birds on diets 1, 2, 3, 4, 5 and 6 respectively varied significantly ($P < 0.05$). At 16 wk, the 25D$_3$ and 25D$_3$ Reduced treatments.

**Key Words:** tribasic manganese chloride, bioavailability, broilers

### 308 Relative bioavailability of tribasic manganese chloride for broiler chickens. R. Pourleslami1, L. Koutsos2, and A. B.Batal1, 1University of Georgia, Athens, 2Micronutrients, Indianapolis, IN.

Manganese (Mn) is an essential micronutrient for birds. Manganese is involved in different metabolic pathways as an enzyme activator and as an essential part of metalloenzymes. According to NRC (1994), the broiler Mn requirement is 60 mg/kg. Based on the recent studies on heart MnSOD gene expression, dietary Mn requirement is proposed as 130 mg/kg. Corn-soybean meal diet is deficient in Mn and needs to be supplemented with a source of Mn. Two commercial sources of Mn, organic and inorganic sources are available in the market. A new hydroxy source of Mn (tribasic manganese chloride; TBMC; Mn2(OH)3Cl) has been recently developed. The objective of the present study was to investigate the relative bioavailability of TBMC for broiler chickens. At hatch, Cobb 500 male broiler chicks were placed in battery cages. During the first week, birds were fed a corn-soybean meal basal diet without Mn supplementation. The diet was formulated to meet or exceed the requirements of broilers except for Mn. At d 8 of age, a total of 448 chicks were randomly divided into 8 treatment groups with 8 replicate cages (7 birds/cage) for each treatment in a completely randomized design involving a 2 × 4 (source × level) factorial arrangement of treatments. Test sources of Mn (TBMC and MnSO4.H2O) were fed at 60, 120, 180 and 240 mg/kg diet. At d 21 of age, birds were weighed and one bird per cage was euthanized. The heart was immediately excised, a sub-sample was immediately placed into RNA stabilization solution for MnSOD gene expression study. A second sub-sample was snap frozen in N for determination of protein concentration. Body weight gain and gain:feed ratio of broiler chicks were not significantly influenced by supplemental Mn source, level of inclusion or their interaction. However, birds fed TBMC (120 mg/kg) recorded a relatively higher feed intake, body weight and lower gain:feed ratio when compared with the other dietary groups. Several markers of Mn bioavailability including heart MnSOD activity, MnSOD gene expression and protein concentration will be determined in the next step of this project.

**Key Words:** trisbasic manganese chloride, bioavailability, broilers

### 309 Maternal broiler breeder flock age and dietary Cu, Zn and Mn form affect embryonic bone development. C. A. Torres*1 and D. R. Korver, University of Alberta, Edmonton, AB, Canada.

Copper, Zn and Mn are important for skeletal development. Organic trace minerals (OTM) in the hen diet can have higher bioavailability than inorganic (ITM) sources and may influence embryo growth. We investigated the effects of maternal dietary Cu, Zn and Mn form and level on embryo bone traits at 15 (E15), 17 (E17) and 20 (E20) days of incubation from Early (32 wk), Mid (45 wk) and Late (59 wk) hen ages. Broiler breeder hens (n = 18/diet) were individually housed and fed a basal diet low in Cu, Zn and Mn to which minerals were added as either: 1) Control: ITM; mineral sulfates at industry levels (100 ppm Zn, 120 Mn, 10 Cu); 2) OTM: Zn, Mn and Cu chelated by 2-hydroxy-4-(methylthio) butanoic acid (HMTBA) at NRC (1994) levels (50 ppm Zn, 60 Mn, 10 Cu); 3) OTM+ITM: Diet 1 plus an additional 40 ppm Zn, 40 Mn and 20 Cu as OTM; 4) High ITM: Diet 1 plus 40 ppm Zn, 40 Mn and 20 Cu as ITM. At each embryonic age (except E15 from Early hens), egg and embryo weights were recorded and the right tibia and femur dissected (n = 10 embryos/hen age per diet). Bone length, width and mineralization ((calcified tissue/whole bone)*100%) were measured from bones stained with Alcian Blue and Alizarin Red S for collagen and mineralized tissue, respectively. Weekly egg production and bone traits were analyzed using repeated measures of SAS at a significance level of $P < 0.05$. Embryo weight was used as a covariate for bone traits. Maternal diet did not affect total or settable egg production to 60 wk of age. At E15, OTM and OTM+ITM embryos had 1.8 and 3.3% longer femurs than High ITM embryos, regardless of hen age. At E17, embryos from Mid hens fed OTM+ITM had 6% thicker tibias than embryos from Control hens. Bone mineralization was not affected by mineral form or level at any embryonic age. We previously reported that the maternal OTM treatment increased tibia and femur thickness in newly hatched chicks from Early and Mid hens. In spite having lower levels of Cu, Mn and Zn than the other groups, the OTM
group, as well as the OTM+ITM group, appeared to increase embryonic bone development.

**Key Words:** embryo, organic trace minerals, broiler breeder, bone development, 2-hydroxy-4-(methylthio) butanoic acid

### 310 Effects of calcium and phosphorus levels during the finisher phase on Heritage broilers: II. Leg health and bone characteristics

M. R. Dalmagro*1, E. O. Oviedo-Rondón1, P. L. Mente1, A. Mitchell2, H. Engster1, and R. Mitchell3, 1North Carolina State University, Raleigh, 2USDA-ARS, Beltsville, MD, 3Perdue Farms Inc., Salisbury, MD.

One experiment was conducted to evaluate the effects of Ca and P levels during the finisher phase on leg abnormalities and bone traits of Heritage broilers. Common starter and grower diets were fed from 1 to 17 and 18–35 d of age, respectively. The experimental finisher diets (35–49 d of age) were formulated to contain combinations of 4 levels of Ca (0.38, 0.54, 0.70, 0.86%) and 4 levels of nPP (0.17, 0.25, 0.33, 0.41%). There were 6 replicate pens per treatment and each pen received 8 male and 8 female chicks. At 35 d of age, before initiate the experimental period, broilers with leg problems were culled and the lack of differences in BW among treatments verified. Pens were adjusted to have 7 males and 7 females at the beginning of the finisher phase. Leg abnormalities were evaluated at 49 d of age by assessing the prevalence of valgus/varus, crooked toes, and twisted legs. Legs were collected and shanks used for bone mineral content and density (BMC and BMD). Bone strength in 3-point bending test and dyshondroplasia (TD) score were performed using tibias. Thighs were mechanical deboned. Data were analyzed as a CRBD by response surface methodology. The log odds of probabilities were modeled within factorial effects to obtain the likelihood of observing each leg or bone condition using GLIMMIX of SAS. Male BMC and BMD were affected linearly by Ca (P < 0.05). There was an interaction effect of Ca and P on female BMD (P < 0.1). Levels of Ca had a quadratic effect on the occurrence of crooked toes and valgus (P < 0.05). Varus prevalence was affected quadratically by P levels (P < 0.1). The interaction between Ca and P levels affected the probability of occurring TD (P < 0.1). Bone breakage during mechanical deboning was affected quadratically by P levels (P < 0.1). Bone strength results indicated a linear effect of Ca in males only (P < 0.05). It was concluded that levels of Ca and P in finisher diets affect the prevalence of leg problems and also the bone biomechanical parameters of Heritage broilers.

**Key Words:** calcium, phosphorus, leg health, bone strength

### 311 Zinc’s impact on growth and barrier function during coccidial challenge

C. Troche* and T. A. Applegate, Purdue University, West Lafayette, IN.

A study was designed to evaluate the effects of Zn supplementation on growth and intestinal function. Three dietary treatments were formulated: a basal diet with no supplemental Zn (Basal), and 2 Zn diets formulated to provide 100ppm total dietary Zn from either zinc sulfate (ZnSO4), or a 50:50 blend of ZnSO4 and a Zn-AA complex (AvailaZn100; Blend). An oral gavage of a coccidial vaccine was administered weekly at 10 times the recommended dosage (10XCV) to determine the effects of Zn status to challenge (6 replicate cages per diet and challenge status; 6 chicks/cage). From 0 to 14d broilers consuming ZnSO4 and Blend had improved body weight gain (BWG) and feed intake (FI; P < 0.0001) over broilers consuming Basal. Administering 10XCV significantly reduced BWG and FI (P < 0.0001) and negatively impacted feed conversion ratio (P = 0.0043). Challenge depressed BWG in both ZnSO4 and Blend fed groups. However, BWG of challenged ZnSO4 or Blend birds was equal to un-challenged Basal treatments. The same was true for FI from 0 to 14d, with challenged ZnSO4 birds having improved FI over challenged Basal birds. From 14 to 28d the effect of challenge did not significantly affect BWG or FI. Both BWG and FI were greater in ZnSO4 broilers versus Basal (P < 0.002). On d 27 through 29 Ussing chamber analysis was performed to determine the effects of Zn on treatment on active nutrient transport (Isc) and membrane integrity (Rt). Jejunal tissues ISC of birds consuming Basal were 10 times more responsive (0.349 vs. 0.0355, respectively P < 0.0001) to the addition of a Zn nutrient spike than either ZnSO4 or Blend. Challenged tissues were 5 times less responsive to the nutrient addition than unchallenged tissues (0.148 vs. 0.028 ISC, respectively; P < 0.0001). Jejunal cells were evaluated for intracellular Zn and phagocytic response on d 30 and 31. Intracellular Zn levels were increased 3 fold (30.96% positive for marker vs. 11.6% positive, respectively P = 0.0004) with 10XCV. Phagocytic response was 1% lower in birds consuming ZnSO4 compared with Blend or Basal levels (98.25% positive for marker vs. 99.24% positive; P = 0.008). Dietary inclusion of Zn and supplemental Zn source can impact growth and immune response.

**Key Words:** zinc, coccidia, broilers

### 312 Mutual antagonism of feeding organic zinc and organic copper in broiler chickens

S. D. Bun* and Y. M. Guo, China Agricultural University, Beijing, China.

An experiment was conducted to determine whether the antagonism occurs between organic Zn and organic Cu. Growth performance (0 to 42 d post-hatch) and mineral status on d 42 were measured during the 6-wk study. A total of 168 one-d-old female broilers were assigned to 4 treatments consisting of 7 replicates of 6 chicks each in a 2 × 2 factorial arrangement. The levels of zinc (methionine hydroxyl analog-Zn chelate) used were 20 and 200 mg/kg and those of copper (methionine hydroxyl analog-Cu chelate) were 4 and 100 mg/kg of diet. Dietary zinc and Cu levels had no effect on feed intake (P > 0.05). Weight gain tended to increase at zinc inclusion of 200 mg/kg of diet (P = 0.06) and feed per gain was significantly improved at Cu inclusion of 100 mg/kg of diet (P < 0.05). Metallothionein (MT) concentration in the mucosa of the duodenum was induced with increasing dietary Zn or copper levels. Copper dietary supplementation at 100 mg/kg of diet did not influence liver MT content (P > 0.05), but it significantly inhibited liver MT mRNA expression (P < 0.01). Similarly, liver ceruloplasmin (CP) and liver CP mRNA were significantly reduced when dietary zinc level was increased and those tendencies were further decreased when both high zinc and high Cu levels were included (P < 0.01). Liver MT concentration (P < 0.01) and liver MT mRNA (P < 0.001) were significantly increased with increasing dietary zinc levels. Copper dietary supplementation at 100 mg/kg of diet did not influence liver MT content (P > 0.05), but it significantly inhibited liver MT mRNA expression (P < 0.01). Similarly, liver ceruloplasmin (CP) and liver CP mRNA were significantly reduced when dietary zinc level was increased and those tendencies were further decreased when both high zinc and copper inclusions were added (P < 0.01). The data suggest that mutual antagonism occurred when high organic Zn or high organic Cu levels were included in diet of broiler chickens.

**Key Words:** antagonism, growth performance, broilers, organic zinc, organic copper