Antibiotics have been common feed additives in poultry rations as growth promoters to improve performance via reducing burden of pathogens. However, it has been increasing pressure to reduce or even eliminate antibiotic usage in poultry feed due to the negative human health issues of antibiotic resistance. Safe broiler production without medication and vaccination was conducted at present study. The effect of vitamins and minerals deficiency was also investigated. One hundred eighty-day-old male broilers were used on a randomized complete block design experiment with treatment consisting of 3 replication and 10 chicks per pen. The birds were housed in floor pens. The experiment was designed as following groups: 1) negative control (not receiving any drugs, growth promoters, vaccines, feed additives, extra vitamins or minerals); 2) basal diet + vaccines: IB, ND and IBD; 3) basal diet + multivitamins (2.5%) and multiminerals (2.5%) (Razak Co., Tehran, Iran); 4) basal diet + multivitamins (2.5%); 5) basal diet + chelated minerals (QM) and selenium yeast (SeY) at 22% (T5) of the average percentage of IM ensures the same performance and tissue mineral levels of the diets containing IM from 1 to 42d (T1) and 21 to 42d (T2), and provides less excretion of micro minerals that pollute the environment.

### Table 1. Performance and mineral concentration in litter

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Performance Parameter</th>
<th>Litter (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fl(kg)</td>
<td>WG(kg)</td>
</tr>
<tr>
<td>1</td>
<td>3.50</td>
<td>2.04</td>
</tr>
<tr>
<td>2</td>
<td>3.52</td>
<td>2.03</td>
</tr>
<tr>
<td>3</td>
<td>3.46</td>
<td>1.92</td>
</tr>
<tr>
<td>4</td>
<td>3.49</td>
<td>1.98</td>
</tr>
<tr>
<td>5</td>
<td>3.53</td>
<td>2.03</td>
</tr>
<tr>
<td>6</td>
<td>3.50</td>
<td>2.01</td>
</tr>
<tr>
<td>7</td>
<td>3.54</td>
<td>2.02</td>
</tr>
<tr>
<td>8</td>
<td>3.54</td>
<td>2.04</td>
</tr>
</tbody>
</table>

P-value 0.1815 0.0004 0.0292 0.0955 0.0060 0.0000 0.0075

A-D Different superscript letters in the same column are statistically different by the SNK test ($P < 0.05$).

**Key Words:** inorganic mineral, chelated mineral, selenium yeast, performance, environmental pollution.


With the objective of evaluate the use of nutritional programs containing chelated minerals (QM) and selenium yeast (SeY) in the diet of broilers, 1760 male broiler were randomized into 8 treatments and 10 replicates of 22 birds. The treatments consisted of diets with inorganic micro minerals (IM) from 1 to 42 d (T1- Zn:90mg, Mn:90mg, Cu:10mg, Fe:60mg, I:1mg, Se:0.4mg), a diet with IM from 21 to 42 d (T2) at the same levels as in T1, a diet with no micro mineral supplementation (T3), and 5 diets containing QM (Zn, Mn, Fe, Cu) and SeY in which the micro minerals were supplemented at different levels and average of 11, 22, 33, 45 and 56% (T4 to T8) of the concentration of IM (T1). From 1 to 21 d, all the birds in treatments 2 to 8 were fed diets supplemented exclusively with QM and SeY at 33% of T1. The performance parameters assessed were: weight gain (WG), feed intake (FI), feed conversion (FCR) and livability (LIV). At the end of each phase, 2 birds from each experimental unit were slaughtered and tissue samples were collected for further analysis of the concentration of minerals in tibia, breast, and liver. Samples of the excreta (litter) were also collected to assess mineral levels. The use of the QM and SeY at 22% (T5) of the average percentage of IM ensures the same performance and tissue mineral levels of the diets containing IM from 1 to 21d (T1) and 21 to 42d (T2), and provides less excretion of micro minerals that pollute the environment.
performance than the other sources. The MMPA and MDPA resulted in higher bone mineralization of broilers than the other phosphates. The MMPA and MDPA phosphorus sources presented few differences in the values of relative bioavailability of phosphorus when considering the body gain as a parameter, 100.00% and 98.80% respectively, but higher than the MPB and MDPB, 94.30% and 96.35% respectively. The MDPA resulted in the highest P availability (102.25%) considering the concentration of P in the tibia. Considering the response for bone ashes, P concentration in the tibia and body weight gain, the MDPA is a better P source due to the higher availability of this mineral.

**Key Words:** bioavailability, bone ash, performance, phosphorus source

**P427** Evaluation of inorganic (sulfates) and organic (SQM) trace minerals zinc, copper and manganese in caged and colony laying hens. J. A. Garrett*, M. D. Sims*, and G. A. Nunnery*, 1Qualitech Inc., Chaska, MN, 2Virginia Diversified Research Corp., Harrisonburg, VA.

This study was conducted to determine if performance and quality of eggs produced over a 12 week period by “individually caged” and “colony group” laying hens 40 - 51 weeks of age were affected by poly­saccharide organic trace minerals (OTM) when compared with sulfate class Inorganic trace minerals (ITM). Hens were housed 1/pen among 40 individual bird (IB) cage-type pens or 52/pen among 4 colony bird (CB) pens. Hens were fed a single basal corn/soy/DGDS diet (15.15% CP and 2,804 Kcal ME/kg) supplemented with ITM or OTM to provide levels of 40 ppm Zn, 25 ppm Cu and 40 ppm Mn. The CB pens provided 2.5 ft²/hen and the IB pens provided 2.25 ft²/hen (3.38 ft³ living space/hen). Eggs from all 44 study pens were counted and weighed each day. Eggs were sampled at 14d intervals for: candling, shell strength, shell thickness, separated albumen/yolk weights and other egg quality traits. Feed intake (FI) was measured daily for CB pens and weekly for IB pens. Egg production % and total egg weights of all OTM hens were greater (P ≤ 0.05) than those of ITM hens. Among the IB pens, FI of OTM pens was lower (P ≤ 0.05) than FI of ITM pens. The FI/pen of both the OTM and ITM CB pens were not different (P > 0.05) as each pen received 118 g of feed/hen every morning and no orts remained 24h later. Feed conversion per dozen eggs was significantly better (P ≤ 0.05) for OTM hens than ITM hens. Egg mass, shell strength and shell thickness of eggs from OTM pens were greater (P ≤ 0.05) than those of ITM pens. Yolk color and albumen height were not different (P > 0.05) between OTM and ITM hens whereas % of grade AA eggs was best (P ≤ 0.05) for OTM hens. Neither separated yolk nor albumen weights were different (P > 0.05) between OTM and ITM hens whereas the shell weights of those same eggs were heaviest (P ≤ 0.05) for OTM hens. There were no differences (P > 0.05) between candled ITM and OTM eggs. These data suggest that Week 40 - 51 performance and egg quality of OTM hens were optimized on comparison to ITM hens under both cage systems.

**Key Words:** avian, bone, mineral, nutrition

**P429** Effect of dietary zinc levels in bone mineralization of broilers chickens. D. E. Faria*, B. H. C. Pacheco¹, P. T. Bravo¹, K. M. R. Souza¹, A. C. P. Carao¹, and V. S. Nakagi¹, 1Faculty of Animal Science and Food Engineering, Pirassununga, Sao Paulo, Brazil, 2Faculty of Veterinary Medicine and Animal Science, Pirassununga, Sao Paulo, Brazil.

Zinc is a constituent of the metalloenzyme carbonic anhydrase and serves on acid-base balance in the body and in bone calcification. When there is deficiency of this trace element in the diet of birds, it can cause problems such as abnormalities of legs and fingers, demonstrating their important role in the formation of skeletal birds. This study aimed to estimate the zinc optimal level in bone mineralization of broilers at 21 and 42 d of age and to compare methods to quantify the degree of mineralization of bone (tibia, tarsus-metatarsals and phalanges), evaluate test reliability, execution time and the effect of extraction of fat in determining these characteristics. Three hundred 20 d-old chicks were distributed in a completely randomized design with 8 treatments and 5 replicates of 8 birds each. One diet did not include manganese and the other diets included levels of manganese sulfate (inorganic) were 65 and 105 mg/kg and manganese methionine (organic) were 25, 45, 65, 85, 105 mg/kg. Regardless of source and level, manganese did not interfere in the evaluated bone characteristics (weight, length and width of the tibia, the weight of the tarsus – metatarsus and the weight of the phalanges). The degree of bone mineralization increased in accordance to increased concentration of manganese in the diet, regardless the source in which those micro mineral were studied. Comparing the different methodologies there was an effect (P < 0.0001) of manganese organic at 21 d between the tibias, which also differed from tarso-metatarsal and the phalanges. For the organic manganese at 42 d and inorganic at 21 and 42 d, the degree of mineralization found in the tibias (with and without fat extraction) differ from the tarso-metatarsal and the phalanges (with fat extraction). Therefore, there is no need for the extraction of fat of the tibia, obtaining lower execution time. The most appropriate method for determining the manganese content is through the use of tibia.

**Key Words:** bone, mineral, zinc, bioavailability, organic and inorganic
Therefore, there is no need for the extraction of fat of the tibia, obtaining lower execution time. The most appropriate method for determining the zinc content is through the use of tibia.

Key Words: avian, bone, mineral, nutrition

P430 Availability of dietary manganese levels for broilers chickens at 17 and 38 days of age. D. E. Faria*, 1, B. H. C. Pacheco1, K. M. B. Souza1, M. Pavesi1, M. T. Antunes2, and P. T. Bravo1, 1Faculty of Animal Science and Food Engineering, Pirassununga, Sao Paulo, Brazil, 2Faculty of Veterinary Medicine and Animal Science, Pirassununga, Sao Paulo, Brazil.

Organic minerals are alternatives to the inorganic minerals. They are characterized by being linked to organic molecules, usually amino acids, which ensures better absorption. The objective of this study was to evaluate levels of manganese, organic and inorganic, on its availability in broilers at 17 and 38 d of age. Three hundred 20 d-old chicks were distributed in a completely randomized design with 8 treatments and 5 replicates of 8 birds each. One experimental diet did not include manganese and the other diets included levels of manganese sulfate (inorganic) at 65 and 105 mg/kg and manganese methionine (organic) with 25, 45, 65, 85, 105 mg/kg. There were no effects (P > 0.05) on dry matter intake of this mineral for birds at 17 and 38 d. There was an effect (P < 0.0001) for the consumption of manganese and manganese excreted/bird (P < 0.0001) in both age groups. The higher inclusion of organic mineral in the diets, induced higher manganese excretion rate at both ages. At 38 d, the amount of manganese (105 mg/kg) excreted from an organic source was lower in comparison to the same minerals in an inorganic source. Therefore, these findings suggest a better absorption of the organic micro mineral.

Key Words: avian, excreta, mineral, nutrition

P431 Comparison of the effect of organic and inorganic selenium in diet of male broiler breeders on egg fertility, hatchability and embryonic mortality. M. Gholami*, 1, A. Golian1, and S. A. Mirmohseni2, 1International Campus of Ferdowsi University of Mashhad, Iran, 2University of Tabriz, Iran.

An experiment was designed to compare the effect of organic and inorganic selenium in diet of male broiler breeders on fertility, hatchability and embryonic mortality. Each diet was randomly offered to 3 houses with 500 males each during the 42 to 49 weeks of age. Every house contained 6000 female broiler breeders of similar age. Inorganic (sodium selenite) and organic Se (Sel-Plex) was added at the rate of 0.3 mg/kg of male diet. Fertility and hatchability of eggs were significantly increased when males fed diet supplemented with Sel-Plex as compared with those fed inorganic Se diet during the 42–49 weeks of age, whereas the exploded eggs in the incubator were similar (P > 0.05). The percent of first grade hatched chicks (high quality) were not influenced (P > 0.05) by the male dietary Se supplementation. Addition of Sel-Plex to diet of male breeders significantly increased the rate of embryonic mortality in the first 2 d of incubation, but not in other days of incubation period (P > 0.05).

Key Words: organic selenium, inorganic selenium, male broiler breeder diet, fertility, hatchability

P432 Influence of early feeding and complexed zinc supplementation on breast muscle satellite cell numbers. J. B. Hess*, W. D. Berry, and S. F. Bilgili, Auburn University, Auburn, AL.

This trial examined satellite cell proliferation in pectoralis major muscle of broiler chickens provided with or without access to feed and water in the hatcher before placement (Early Feeding) or fed a diet with or without a supplemented complexed zinc source (Availa Zn, Zinpro Corp., Eden Prairie, MN) to assess breast muscle growth. Treatments included A, Control; B, Early Fed; C, Added Complexed Zinc; D, Added Complexed Zinc and Early Fed. Each of the 4 trt was represented by 8 pens of 10 male Ross × Ross 708 broilers. This required the placement of 1000 hatching eggs into 4 designated (A-D) and separated groups of 250 eggs each. As the birds hatched, groups B and D were provided the appropriate diets (and water) in hatching trays. All chicks were placed in Petersime batteries and fed a starter diet to 21 d. At 2 and 7 d, 2 birds per pen were weighed and euthanized. Breast muscles were excised, weighed, frozen, sectioned and stained for estimation of satellite cell number. At 21 d of age, remaining birds were transferred to 32 floor pens and reared to 42 d. At 28, 35 and 42 d, 2 birds per pen were euthanized to measure breast meat development as a proportion of live body weight. Body weight was not increased by early feeding, but was increased in birds fed complexed zinc, particularly at 35 d. Satellite cell numbers at 2 d (% of total cells) were higher in birds given access to feed and water in the hatching trays (P < 0.0757) and in birds fed complexed zinc from placement (P = 0.0634), although birds fed complexed zinc in the hatchers and during growout did not show the same trend. Satellite cells at 7 d were lower than at 2 d and no differences were noted between treatments. It is likely that satellite cell incorporation into myofibers ensued and cell hypertrophy had taken over as the sole mode of breast muscle growth by 7 d. Limited yield data did not capture expected improvements in breast meat yields at later ages with increased satellite cell recruitment.

Key Words: satellite cell, breast muscle, broiler, complexed zinc

P433 Riboflavin requirement of white Pekin ducks in corn-soybean meal diet. M. Xie*, 1, 2, J. Tang1, 2, Z. G. Wen1, 2, W. Huang1, 2, and S. S. Hou1, 2, 1Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, China, 2State Key Laboratory of Animal Nutrition, Beijing, China.

A 21-d dose-response experiment was conducted with starter White Pekin ducks fed corn-soybean meal diet to reevaluate the riboflavin requirement of modern stain ducks. The analyzed riboflavin content of basal corn-soybean meal diet with no supplemental riboflavin was 1.69 mg/kg. A total of 512 male one-day-old White Pekin ducks was assigned to 8 dietary treatments with 8 replicate pens of 8 birds per pen and these birds were given 0, 0.7, 1.4, 2.1, 2.8, 3.5, 7, 14 mg of supplemental riboflavin/kg of feed, respectively. Feed and water were provided ad libitum from hatch to 21 d of age. At 21 d of age, the weight gain, feed intake, feed/gain, and plasma and liver riboflavin of ducks from each treatment were measured. In our study, the growth depression, high mortality, and low plasma and liver riboflavin were observed in riboflavin-deficient ducks and these ill effects could be reduced by increasing dietary riboflavin levels. According to broken-line regression analysis, the riboflavin requirements of modern White Pekin ducklings fed corn-soybean meal diets from hatch to 21 d of age for weight gain, feed/gain, plasma riboflavin, and liver riboflavin were 2.77, 2.61, 3.81, 3.19 mg/kg, respectively.

Key Words: duck, riboflavin, requirement

P434 Dietary calcium and phosphorus requirements of broiler chickens in the starter phase. E. Jiménez-Moreno1, C. R. Angel*, 1, W. Li1, S.-W. Kim1, M. Proszkowiec-Weglarz1, and N. E. Ward2, 1Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, China, 2State Key Laboratory of Animal Nutrition, Beijing, China.
P435 Dietary calcium and phosphorus requirements of broiler chickens in the grower phase. E. Jiménez-Moreno1, C. R. Angel*, W. Li1, S.-W. Kim1, M. Proszkowiec-Weglarz1, and N. E. Ward2. 1University of Maryland, College Park, 2DSM Nutritional Products, Parsippany, NJ.

More closely defining the Ca and P requirements of broilers for grower phase is essential for the optimization of bone development and growth performance as well as for optimum use of phytases in broiler diets. An experiment was done to determine the Ca and non phytate P (nPP) requirements for 2 broiler strains: Ross 708 (R) and Cobb 500 (C) from 11 to 18 d of age. The treatments were a factorial arrangement of 3 Ca (0.60, 0.80, and 1.00%) and 5 nPP (0.24, 0.30, 0.36, 0.42, and 0.50%) concentrations. Starting and ending BW of birds were 246 and 605 g for R and 250 and 625 g for C. Requirement ranges were determined and estimated recommendations are shown below in parenthesis. Based on BWG, Ca requirements were the same for R and C (0.95%) and nPP ranged from 0.16 to 0.34% (0.23%) for R and 0.21 to 0.42% (0.34%) for C. Based on toe ash percent, Ca requirements ranged from 0.85 to 1.00% for both R and C (0.95% for R and 0.95% for C) and nPP from 0.36 to 0.46% (0.42%) for R and 0.36 to 0.46% (0.42%) for C. Ca requirements as mg Ca consumed/g BWG, ranged from 11.4 to 13.9 (11.4) for R and C, and nPP as mg nPP consumed/g BWG, from 2.68 to 5.98 (3.62 mg nPP consumed/g BWG). Based on BWG, Ca requirements ranged from 0.54 to 1.00% (0.72%) and nPP as mg nPP consumed/g BWG, ranged from 0.36 to 0.42% (0.36% for R and 0.42% for C). Based on toe ash percent, Ca requirements were the same for R and C (0.95%) and nPP ranged from 0.46 to 0.48% (0.47%) for R and from 0.42 to 0.48% (0.42%) for C. Based on tibia ash percent, Ca requirements ranged from 0.85 to 1.00% for both R and C (0.90% for R and 0.95% for C) and nPP from 0.42 to 0.48% (0.42%) for R and 0.36 to 0.46% (0.42%) for C. Ca requirements as mg Ca consumed/g BWG, ranged from 11.4 to 13.9 for both R and C (13.0 for toe- and tire.12 mg Ca consumed/g BWG for tibia ash for R, and 13.1 for both toe and tibia ash for C). Based on toe ash percent, nPP requirements as mg nPP consumed/g BWG, was of 6.3 for R and ranged from 5.6 to 6.4 (5.6) for C and based on tibia ash percent, from 5.6 to 6.4 (5.6) for R and 4.8 to 6.3 (5.6) for C. Ca to nPP ratios (g consumed/g consumed) and based on requirements for BWG were 2.39 and 2.05 for R and C, respectively. For bone ash percent, the ratios were 2.06 for toe ash and 2.19 for tibia ash for R and 2.35 for both toe and tibia ash for C.

Key Words: calcium, phosphorus, performance, starter phase, broiler

P436 Efficacy of a novel phytase on performance, mineral digestibility and retention and bone mineralization of broiler chickens in the prestarter phase. E. Jiménez-Moreno1, C. R. Angel*, S.-W. Kim1, M. Proszkowiec-Weglarz1, W. Li1, and N. E. Ward2. 1University of Maryland, College Park, 2DSM Nutritional Products, Parsippany, NJ.

The effect of phytase and dietary Ca concentration on performance, Ca and P digestibility and retention and bone mineralization was studied in Ross 708 broiler chicks from hatch to 212 g of BW and 250 g of FI. The experiment consisted of a factorial arrangement of 2 phytase supplementations levels (0 and 500 Enzyme HiPhos FYT/kg of diet, DSM Nutritional Products) and 3 Ca concentrations (0.85, 1.00, and 1.15%). The diets contained 0.59% P and 0.29% non phytate P (nPP). Two extra diets were formulated with mono calcium phosphate to achieve 0.38 and 0.48% nPP at each Ca concentration to allow for regressions on the impact of nPP for phytase efficacy determinations. Each treatment was replicated 6 times (20 chicks/pen). A 2-way ANOVA was run with Ca concentration and phytase supplementation as fixed effects and their interaction tested. Performance, toe and tibia ash (%), Ca and P retention and apparent ileal digestibility were determined at d10. BWG and FI were reduced (P < 0.05) as Ca increased. Phytase supplementation increased (P < 0.01) BWG and FI. Neither Ca nor phytase supplementation had an effect on FCR. Toe and tibia ash (%) were reduced (P < 0.01) with phytase supplementation. Neither Ca nor phytase supplementation improved (P < 0.01) P digestibility. Ca and P retention were impaired (P < 0.01) as Ca increased whereas these improved (P < 0.01) with phytase supplementation. Diet Ca concentration impacted phytase efficacy as determined based on toe ash with a greater efficacy determined in the diet with 0.85% Ca vs the diet with 1.00% Ca.

Key Words: phytase, calcium, performance, bone mineralization, broiler
libitum consumption for 32h following which the distal ileal content was collected for apparent Ca and P digestibility determinations. In diets without phytase, P digestibility and analyzed diet Ca were negatively correlated ($R^2 = 0.78$) with intercept of 73.5 and slope of $-52.07$ at Ca concentrations up to 0.78% after which P digestibility did not change. P digestibilities were 60.1, 47.4, 41.9, 28.2, and 28.9% for diets containing 0.17, 0.40, 0.55, 0.70, and 0.85% formulated Ca, respectively. Phytase addition improved P digestibility ($P < 0.05$) regardless of diet Ca, but increasing Ca concentration reduced P digestibility in the phytase treatments. P digestibilities were 74.5, 68.2 and 67.6% for 0.55, 0.70 and 0.85% Ca, respectively ($P < 0.05$; $74.5 > 67.6$%). This study confirms that a negative correlation exists between Ca concentration and P digestibility and that the dietary Ca is influential on improvements in P digestibility from phytase.

**Key Words:** calcium, phosphorus, phytase, digestibility, broiler

P438 Method development to determine digestible calcium and phosphorus in single ingredients for poultry 1: Performance, blood and bone measures. M. Proszkowiec-Weglzarz*1, R. Angel1, E. Jimenez-Moreno1, S.-W. Kim1, K. Miska2, and P. W. Plumstead3, 1University of Maryland, College Park, 2USDA-ARS, Beltsville, MD, 3Danisco Animal Nutrition, DuPont Industrial Biosciences, Marlborough, United Kingdom.

Little information is available on digestible Ca (dCa) and P (dP) values of individual feed ingredients for poultry, which is essential to maximize P utilization as well as phytase efficacy. To develop appropriate in vivo methodologies to determine Ca and P digestibility values, the optimum time of deficiencies of Ca or P on their metabolism and associated changes on bone mineralisation has to be understood. To determine the time course of changes associated with Ca and P deficiencies and imbalances in diets, birds were fed one of 6 diets for 96h starting at 11 or 25d of age: SBM (soybean meal), LM (limestone), MCP (monocalcium phosphate), SBM/LM/MCP, SBM/LM and NFD (nitrogen, Ca and P free) diets containing 0.11, 0.65, 0.63, 0.63, 0.35 and 0% Ca, and 0.26, 0, 0.86, 0.47, 0.26 and 0% total P, respectively. BW, FI, Ca and P intake (CaI and PI, respectively), plasma Ca (pCa) and P (pP), toe (ToA) and tibia ash (TbA) were measured at 0, 8, 16, 24, 32, 40, 48, 60, 72 and 96h. Birds fed SBM, SBM/LM/MCP and SBM/LM had higher ($P < 0.05$) BW and FI than birds fed LM, MPC or NFD at both ages. No patterns in plasma Ca, P and PTH concentrations were seen. Increases ($P < 0.05$) in ToA over time was observed only at d11. Differences in ToA, d11 were detected by 24h and then plateaued. AdCa of SBM/LM ranged ($P < 0.05$) from 39% (24h) to 78% (40h) and AdP from 50% (24h) to 82% (60h). Increases ($P < 0.05$) in AdCa and AdP of SBM/LM/MCP were observed at 16 and 40h (57 to 74% and 56 to 70%, respectively). AdCa in LM decreased from 64% to 37% (24–32h) and 48% (72–96h). AdCa in MCP increased at 24–32h (64 to 81%). At d25, SBM/LM AdCa averaged 53% while AdP increased ($P < 0.05$) over time from 53 to 69% (48–60h). AdCa decreased at 24h (34%) in comparison to 8–16 and 32–40h (55%) in SBM/LM/MCP fed birds while no changes in AdP were observed. AdCa for LM fed birds decreased until 24h and then plateaued. AdCa in MCP fed birds varied ($P < 0.05$) from 70% (16h) to 35% (96h) and AdP ranged from 78% (16h) to 59% (96h). In summary, both time and diet had significant effects on dCa and dP.

**Key Words:** Ca, P, digestibility, deficiency, nutrition


A 21-d experiment was carried out with 1440 Cobb 500 broilers. Broilers were raised in 48 floor pens and at the age of 14 d, 6 birds per replicate were selected according to the pen weight average and moved to 48 suspended cages. Eight diets were arranged in a factorial system of 4×2 with 6 replicates per treatment. The corresponding factors were diet phosphorus source, microgranulated monocalcium phosphate A (MMPA) with 21% of P and 18% of Ca, microgranulated dicalcium phosphate A (MDPA) with 18.5% of P and 22.5% of Ca, monocalcium phosphate B (MPB) with 20% of P and 20.5% of Ca, microgranulated dicalcium phosphate B (MDPB) with 18% of P and 23% of Ca, and 2 levels of available phosphorus (0.35, 0.45). The other nutrients were given to attend or succeed the NRC (1994) requirements. Mineral utilization of broilers was determined at the 18–21 d of ages by total excreta collection and the performance (weight gain, feed intake, feed conversion) was recorded at 21 d of age. Experimental data was subjected to ANOVA using the GLM procedure of SAS with P source, P level and their interactions as fixed effects and cage as a random effect. Treatment effects were considered significant at $P < 0.05$. No interaction was found for any parameters evaluated. The performance of the broilers was worst when supplementing the feed with 0.35% of available P. The use of MMPA and MDPA resulted in better performance than the other sources. Although the absolute retention (g/bird/day) of Ca and P increased, the retention (as a proportion of intake) decreased with increasing diet P content at all sources. The digestibility of Ca and P increased when adding 0.45 of available P compared with 0.35. The digestibility of Ca was higher when using the MMPA and MDPA. The MPB resulted in the worst P
P441 Effect of different supplemental level of zinc from organic or inorganic sources on laying performance, eggshell quality and key factors of eggshell formation in laying hens. Y. N. Zhang*, S. G. Wu, H. J. Zhang, H. Y. Yue, J. Wang, and G. H. Qi, Key Laboratory of Feed Biotechnology of Ministry of Agriculture, Feed Research Institute, Chinese Academy of Agricultural Sciences, Beijing, China.

The purpose the current study was to evaluate the effect of different levels and sources of zinc on laying performance, eggshell quality and key factors of eggshell formation in laying hens. Five hundred four 54-wk-old Hy-line laying hens were fed a basal diet with Zn level at 29.07 mg/kg for 4 wks and then randomly allocated into one of the 7 treatments: one basal diet (control) and 6 treatments supplemented with 35, 70, 140 mg/kg of zinc from either inorganic or organic sources. Each treatment had 6 replicates with 12 hens each. Experiment duration was 8 wks. Egg production, feed intake and feed efficiency were not affected by treatments ($P > 0.05$). During the period of 5–8 wk, egg weights were markedly decreased in 70 or 140 mg/kg of zinc treatments compared with control or 35 mg/kg of zinc treatment ($P < 0.05$). Eggshell thickness was markedly improved with the increase of zinc addition irrespective of zinc sources ($P < 0.05$). Zinc addition had no effect on eggshell strength or eggshell stiffness ($P > 0.05$). Eggshell strength was higher in inorganic source than organic source at the end of 8 wk ($P < 0.05$). Eggshell index and percentage of shell were both increased with the increase of zinc level, and eggshell index from inorganic source were markedly higher than organic source at the end of 8 wk ($P < 0.05$). The carbonic anhydrase (CA) activity in serum and eggshell gland were noticeably improved by zinc addition ($P < 0.05$). The highest CA activity was found in the treatment with 70 mg/kg of zinc. The CA mRNA levels of the eggshell gland in 70 or 140 mg/kg treatments were higher than that of the control and 35mg/kg treatment ($P < 0.05$). The osteopontin (OPN) mRNA levels were noticeably influenced by both the source and levels of zinc ($P < 0.05$), and treatment with 70 mg/kg of zinc from inorganic source had the most abundant OPN mRNA. It is reasonable to assume that proper level and source of zinc could promote calcium deposition in eggshell by elevation of CA and OPN mRNA expression, and hence contribute to the improvement of eggshell quality.

Key Words: zinc, supplementation level, source, laying hen


This study was conducted to evaluate the effects of different mineral sources and levels in hematological parameters of Dekalb White hens 40 to 52 weeks of age. A total of 192 birds were housed in a completely randomized design in plots subdivided in 3 cycles of 28 d each. The following treatments were applied: 1) without trace mineral supplement (0% Min); 2) 100% inorganic trace mineral (100% ITM); 3) 100% organic trace minerals (100% OTM); 4) 75% organic trace minerals (75% OTM); 5) 50% organic trace minerals (50% OTM); 6) 25% trace minerals (25% OTM). Each treatment consisted of 8 replicates of 4 birds each. At the end of each cycle, blood samples were collected by puncture of brachial vein and stabilized by EDTA.5%. Hemoglobin (Hb), packed cell volume (PCV), red blood cells (RBC's), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), and total plasma protein (TPP) were measured. There was no interaction between age of hens and the minerals studied. The minerals affected the PCV values. Higher PCV was observed in hens fed 75% OTM whereas hens fed without trace mineral supplement (0% Min) showed the lowest PCV ($P < 0.0001$). Age effects on hematological parameters PCV, Hb, MCHC, MCV and TPP were observed. The PVC values were reduced ($P = 0.0081$) in the first 2 cycles of laying, followed by a return to normal in the last cycle assessed. A decline ($P < 0.001$) in Hb and MCHC was observed with birds increasing age. Moreover, both MCV ($P = 0.0004$) and TPP ($P = 0.0116$) were higher in hens at 52 weeks of age (last cycle). This study showed that different source and levels of organic trace minerals did not alter blood count of laying hens, but the age of birds induces changes in hematological parameters. These latest results are consistent with previous studies that showed effects of age of laying hens and climate on hematological variables.

Key Words: organic trace mineral, hematological parameter, laying hen


Vitamin D$_3$ acts by regulating calcium concentrations in animal blood and muscles; moreover, it is a potent immunomodulator and is important for the development of the small intestine. Vitamin D$_3$ must be metabolized following ingestion into 25-hydroxycholecalciferol (25(OH)D$_3$) in the liver and subsequently into its active metabolite 1,25-dihydroxycholecalciferol (1,25(OH)$_2$D$_3$) in the kidneys. These metabolites are currently commercially available as 1-α-hydroxycholecalciferol (1α(OH)D$_3$), a synthetic analog of the active metabolite 1,25(OH)$_2$D$_3$, which is converted into its active form in the liver. The aim of this experiment was to evaluate the effect of different vitamin D metabolites on immune response and intestine morphometrics of broiler chickens. A total of 952 1-d-old male Cobb chicks were used, distributed in a completely randomized design with 4 treatments, 7 replications and 34 birds each. Four different metabolites of vitamin D were evaluated: D$_3$, 25(OH)D$_3$, 1,25(OH)$_2$D$_3$ and 1α(OH)D$_3$, providing 2000 and 1600 IU/kg feed of vitamin D in the initial and grower periods, respectively. The different vitamin D metabolites did not affect the relative weight of the organs, except for the weight of the intestine and liver at 21 and 42 d. There was a significant effect ($P < 0.05$) of the different vitamin D$_3$ metabolites on villus length of the jejunum and ileum at 7 d, between animals fed with 1,25(OH)$_2$D$_3$ and 1α(OH)D$_3$ for the jejunum and 1,25(OH)$_2$D$_3$ and vitamin D$_3$ for the ileum ($P < 0.05$). There were no differences ($P > 0.05$) in the weight of lymphoid organs, cutaneous basophil hypersensitivity reaction, macrophage activity assessment, measurement of nitric oxide and the heterophil-to-lymphocyte ratio. The different sources of vitamin D affected intestine morphometrics in the initial phase, but the effect was not observed in other phases. Immunological parameters were not affected by vitamin D$_3$ metabolites.

Key Words: broiler, cholecalciferol, macrophage
Incubation temperatures (TEM) and dietary trace mineral (TM) sources and levels of inclusion have been reported to impact broiler performance. One experiment was conducted to evaluate the effects of 2 TEM profiles and 2 TM sources on broiler performance at 21 d. One thousand eggs of Ross 708 breeders were divided in 2 groups and incubated following 2 TEM profiles to either maintain eggshell TEM at 38.0 ± 0.3°C (S) or have eggshell TEM similar to the ones observed in multistage machines (LH). This second profile had low (36.9 ± 0.3°C) eggshell TEM for the first 3 d, and standard TEM until the last 3 d when they endured elevated (38.9 ± 0.3°C) eggshell TEM. At hatch 168 males per TEM were weighed, identified with a neck tag and placed in 24 battery cages with 7 chickens per cage. The 48 cages were then assigned to 2 TM dietary treatments, one with inorganic sources of Zn, Cu, and Mn (ITM) at commercial levels of inclusion (120, 10, 20ppm, respectively) and other with an organic (OTM) source of these minerals chelated with 2-hydroxy-4-(methylthio)butanoic acid (HMTBA) using reduced levels of inclusion (32, 8, 32ppm, respectively). Individual BW and group feed intake (FI) were obtained at 7 and 21 d of age to obtain BWG and FCR. Data were analyzed in a CRBD with a 2x2 factorial design with incubation TEM profile and TM source as main factors. Results indicated that LH chickens were heavier (P < 0.01) than S chickens at hatch, but with more residual yolk. Though, S TEM chickens were heavier (P < 0.05) at 7 and 21 d. Furthermore, FCR was improved (P < 0.05) when chickens were incubated under S. Effects (P < 0.05) of dietary treatments were observed at 7 d. The ITM diets increased BW and BWG at 7 d but these differences were no longer significant (P < 0.05) at 21 d. No significant interactions were observed, nor effects of TM on FCR. It was concluded that incubation temperatures affect broiler performance at 3 weeks of age. Additionally, it was observed that reduction of TM levels when using an organic source chelated with HMTBA did not affect chicken live performance.

Key Words: incubation profile, trace mineral, broiler performance

A 42-d trial was conducted to determine the response of Mintrex (metal methionine hydroxy analog chelate) vs. industry levels of ITMs (inorganic trace minerals) on performance, immune response, and litter minerals concentration. A total of 2,100 Ross 308 male broiler chicks were randomly assigned to 6 treatments with 10 pens/treatment and 35 chicks/pen. The wheat–SBM based basal diet (T1) was devoid of any added Zn, Cu or Mn. T2, T3 and T4 received incremental levels of chelated minerals at 16–4–16, 32–8–32, and 48–16–48 ppm of Zn-Cu-Mn, respectively. T5 and T6 received industry levels of trace minerals (70–20–80 ppm of Zn-Cu-Mn) either as chelates (T5) or as ITMs (T6). End of the study results indicate significant treatment effects for weight gain (P = 0.002), immune response, and litter minerals concentration. The chicks fed 32–8–32 ppm or higher levels of Zn-Cu-Mn as chelates gained 38g more weight (P < 0.05) compared with T1 whereas chicks in T2 and T6 performed the same as T1 (Basal diet). Chicks fed higher levels (T4 and T5) of chelated trace minerals gained 34 to 40g more weight compared with T6 (P < 0.05) but performed the same as T3 (P > 0.05). Infectious Bronchitis antibody titers measured at d 35 indicate significant improvement (P < 0.05) in litter response for T3 compared with T5. As expected increasing levels of dietary trace minerals resulted in increased levels of trace minerals in the litter. In summary, the present data indicate that the supplemental ITMs were effectively replaced with reduced levels (32–8–32ppm of Zn-Cu-Mn) of chelates without compromising bird immune response while achieving improvement in weight gain and reduction in litter trace mineral concentration.

Key Words: zinc, copper, manganese, broiler, chelate

Bioavailability of commercial zinc sources in growing chicks. S. J. Rochell, L. L. Utterback, H. L. Spangler, C. K. Parr, M. C. Parsons, University of Illinois, Urbana, Micronutrients, Indianapolis, IN.

An experiment was conducted to determine the relative bioavailability of 2 commercially available zinc sources. Two-hundred and 80 male crossbred chicks were housed in stainless steel brooder battery cages (4
chicks/cage) from 1 to 22 d of age. Chicks received a common starter diet from 1 to 7 d of age and were randomly assigned to 1 of 10 dietary treatments (7 reps/treatment) at 8 d of age. Ten dietary treatments included a zinc-deficient soy concentrate-dextrrose basal diet and the basal diet supplemented with 3, 6, or 9 mg/kg zinc from either zinc sulfate, zinc hydroxochloride (IBZn), or an organic zinc source (OrgZn). Body weight gain (BWG) and feed intake were determined from 8 to 22 d of age. Chicks were euthanized at 22 d of age and right tibias were collected from each chick. Zinc concentration of each tibia was analyzed to allow for calculation of total tibia zinc content. Responses of BWG and total tibia zinc to supplemental zinc intake were determined, and slope-ratio analysis was utilized to evaluate bioavailability of IBZn and OrgZn relative to zinc sulfate. Body weight gain ($P < 0.001$) and total tibia zinc ($P < 0.001$) increased linearly with supplemental zinc intake. The response of BWG to supplemental Zn intake resulted in relative bioavailability values of 167.4 and 176.5% for IBZn and OrgZn, respectively. Using total tibia zinc as the response variable, relative bioavailability values were determined to be 143.5 and 141.9% for IBZn and OrgZn, respectively. These results indicate that the bioavailability of zinc in IBZn and OrgZn were similar to each other and both IBZn and OrgZn were superior to zinc sulfate in zinc bioavailability.

Key Words: zinc, bioavailability, tibia ash, slope-ratio, mineral

P448 Feeding diets differing in concentrations of calcium, phosphorus and calcium/phosphorus ratios to Hy-Line CV-22 and Brown laying hens on egg production and quality. G. Barahona1, O. Machado1, A. Gernat1, J. Arango2, and N. O’ Sullivan2, 1Escuela Agricola Panamericana/Zamorano, Tegucigalpa, Honduras, 2Hy-Line International, Dallas Center, IA.

Breeding companies make recommendations based on practical experience to ensure that Calcium (Ca) and available phosphorus (AP) requirements are in agreement with each strains egg production (EP) potential. The objective of this study was to measure EP and egg quality (EQ) variables with diets differing in concentrations of Ca and AP, and their ratio to Hy-Line CV-22 (HCV) and Hy-Line Brown (HB) hens. The study consisted of 7 treatments used on both HCV and HB strains. All diet treatments were formulated to meet or exceed Hy-Line’s management guide recommendations (MGR). Treatment (T) 1 was formulated to offer 100% levels of Ca and AP for each variety and diet phase; T2 Ca level to 80% of MGR; T3 AP level to 80% of MGR; T4 Ca and AP level to 80% of MGR; T5 Ca level to 60% of MGR; T6 AP level to 60% of MGR and T7 Ca and P level to 60% of MGR, respectively. Production performance and EQ were measured from 18 to 32 weeks of age (phase 1) for both strains. At 18 wk of age, hens were weighed and randomly allocated to 4 replicate groups (7 hens per cage of the HCV, 60.9 ± 50.8 cm and 6 hens per cage of the HB, 60.9 ± 50.8 cm) in a complete randomized block design. No significant differences were found for EP parameters for HCV. HB showed lower ($P < 0.0001$) EP for T5 and 7, and feed consumption T7 and conversion T5, 6, and 7. Mortality was higher ($P < 0.0001$) for T5 and 7. The HCV showed lower ($P < 0.04$) egg weights (EW), albumin height for T7; lower specific gravity for T5 and 7 and lower egg breaking strength for T5. Lower ($P < 0.001$) EW was observed for T7 and higher percent cracks for T5 and 7 in the HB birds. Decreasing the amount of Ca and AP to levels lower than the recommended did not show major differences in production performance in the HCV birds but did have more of an impact on the HB birds. Diets deficient in Ca and AP affected EQ for both strains to a greater extent.

Key Words: laying hen, calcium, phosphorus, egg.

P449 Effect of 25-hydroxycholecalciferol on bone growth and mineral metabolism in broilers fed diets containing adequate levels of calcium and phosphorus. R. Adhikari1, M. Radfar1, H. Salim1, A. Rogiewicz1, B. J. Turner2, B. Slominski1, and W. K. Kim1, 1University of Manitoba, Winnipeg, MB, Canada, 2DSM Nutritional Products Inc., Parsippany, NJ.

A study was conducted to evaluate the effect of different levels of 25-hydroxycholecalciferol (25-OH D$_3$) on bone growth and development, mineral utilization, and growth performance in broilers fed diets containing adequate levels of calcium (Ca) and phosphorus (P). Two hundred day-old broilers housed in 40 pens (5 birds/pen) were randomly allocated to 4 dietary treatments that contained 200 IU/kg (control), 2,760 IU/kg (T1), 5,000 IU/kg (T2), and 10,000 IU/kg (T3) of 25-OH D$_3$. All 4 diets were formulated to be iso-caloric and contained 1% Ca and 0.5% available P, so that Ca and P were not the limiting factors. Feed conversion ratio was significantly lower ($P < 0.05$) in 3 different levels of 25-OH D$_3$ as compared with the control diet. Feed intake in T2 and T4 were significantly lower ($P < 0.05$) than the control group. Body weight gain was significantly lower ($P < 0.05$) in T3 as compared with the control, T1 and T2. In femur, bone mineral content increased significantly ($P < 0.05$) in all 3 treatments than the control group. Bone mineral density and bone area significantly increased ($P < 0.05$) in T1 and T2 compared with the birds fed control diet; however, T3 did not have any significant effect compared with the control, T1 and T2. No significant difference ($P > 0.05$) was observed between the treatments for apparent total tract Ca and P digestibility. The results indicate that even though there was no significant difference in Ca and P utilization when adequate levels of Ca and P were supplied in diets, vitamin D$_3$ significantly increased bone growth and development. This study suggests that vitamin D$_3$ may have direct effect on bone cells enhancing bone formation and skeletal integrity apart from its effect on Ca and P utilization.

Key Words: broiler, Ca and P utilization, skeletal integrity, 25-hydroxycholecalciferol

P450 Influence of calcium levels and source and phytase supplementation on calcium and phosphorus digestibility during natural necrotic enteritis in broilers. D. Paiva1, C. Wals2, and A. McElroy1, 1Virginia Polytechnic Institute and State University, Blacksburg, 2AB Vista, Marlborough, United Kingdom.

In the past 20 years, several feed enzymes have been introduced into poultry diets to improve nutrient availability and digestibility. However, little is known about how these enzymes influence nutrient digestibility during intestinal disease. The objective of this study was to determine the influence of Ca source, phytase supplementation, and dietary levels of Ca on Ca and P digestibility during necrotic enteritis (NE). Cobb 500 male broilers were weighed and randomized into 8 treatment groups (9 pens/treatment; 30 birds/pen) at day of hatch. The 21 d trial was designed as a 2 x 2 x 2 factorial, which included 2 dietary levels of Ca (0.6% and 0.9%), 2 Ca sources [limestone and calcified seaweed (HSC)], and 2 levels of an E. coli phytase (0 and 1,000 FTU/Kg). Birds were placed on dirty litter from a previous flock that exhibited clinical signs of NE to induce a natural infection. On d7, 14, and 21 birds were euthanized by cervical dislocation, and ileal digesta was collected. Ileal digesta samples were pooled per pen and frozen until further analysis. Significance is reported at $P < 0.05$. Birds began exhibiting clinical signs of NE on d9, and elevated NE-associated mortality persisted until the end of the trial. A 3-way interaction of Ca source, Ca level, and phytase inclusion was observed for P and Ca digestibility on all sampling days. Optimal
P digestibility was observed when broilers were fed 0.6% Ca diets formulated with limestone and supplemented with phytase. Overall, a significant decrease in P digestibility was observed when broilers were fed 0.9% Ca, regardless of Ca source and phytase supplementation. On d7, Ca digestibility was improved by phytase supplementation in broilers fed the 0.6% Ca diets formulated with limestone and 0.9% Ca diets formulated with HSC. On d14 and d21, 0.6% Ca diets resulted in improved Ca digestibility, regardless of Ca source or phytase supplementation. In conclusion, Ca and P digestibility were significantly improved when diets were formulated with lower levels of Ca and supplemented with phytases during the NE occurrence.

**Key Words:** calcium, phytase, digestibility

P451 The effect of Intellibond C plasma on broiler macrophage nitric oxide production. V. J. Iseri*1, J. Cohen2, and K. C. Klasing1, 2University of California, Davis, 2Micronutrients, Indianapolis, IN.

When fed at high levels, copper has positive effects on growth and intestinal health. However, the effect of copper on phagocyte effector functions has not been thoroughly investigated. Thus, primary macrophages were isolated from peripheral blood of chicks fed either no supplemental copper (NegCont; 15ppm) or Intellibond C (IBC; 185ppm) a form of tribasic copper chloride. Macrophages were either unstimulated or stimulated with lipopolysaccharide (LPS; 2 μg/mL) and nitric oxide (NO) was measured 24 hr post-LPS. In Experiment 1, macrophages were cultured with graded levels of plasma isolated from chicks fed the same diet. Non-stimulated IBC macrophages cultured in 6–12% IBC plasma had higher NO levels compared with NegCont macrophages cultured in the same levels of NegCont plasma. LPS-stimulated IBC macrophages cultured in 3–12% IBC plasma had higher NO levels compared with stimulated NegCont macrophages. In Experiment 2, the effects of plasma source on macrophages isolated from chicks fed NegCont or IBC were compared. There was no effect of plasma source on NO levels from NegCont or from IBC macrophages (P > 0.20). In Experiment 3, NegCont or IBC macrophages were cultured with graded levels (0–12%) of FBS. LPS-stimulated macrophages from IBC fed chicks had higher NO levels at all levels of FBS. These data demonstrate that IBC modulates the response of macrophages to LPS; however the effect is not due to the regulatory factors in plasma.

**Key Words:** Intellibond C, macrophage, plasma