W201 Effect of a partial replacement of limestone by a $CaSO_4$-zeolite mixture combined with a slight protein reduction on production indices, egg quality and excreta pH in laying hens. C. Romero*[1], E. M. Onyango[2], W. Powers[3], R. Angel[4], and T. J. Applegate[5], *[1]Universidad Politécnica de Madrid, Spain, [2]East Tennessee State University, [3]Michigan State University, East Lansing, [4]University of Maryland, [5]Purdue University, IN.*

A commercial diet (CM diet; 17.4% CP and 4.37% Ca) was compared with a diet with 35% replacement of limestone by a $CaSO_4$-zeolite mixture (5.76% $CaSO_4$ and 1.18% zeolite) and a 0.4 percentage units reduction in protein content (RE diet) in laying hens. Apparent N retention, egg production, egg composition and excreta pH were measured. Previous studies demonstrated that the RE diet reduced ammonia emissions by 48%. Laying hens (192 total; 48 replicate cages per diet with 2 hens per cage; 1441 ± 135 g initial BW) were fed experimental diets from 33 to 49 wk of age. Apparent N retention averaged 48.2% ($P > 0.05$). Egg production (83.6%) and number of shell-less eggs (0.18%) were not affected by the diet. Eggs tended to be heavier (59.4 vs. 58.8 g/egg, $P = 0.06$) and yolk percentage (29.7 vs. 29.0%, $P = 0.013$) was greater with the RE diet. At 48 wk of age, the total solids content per egg was also greater from hens fed the RE diet (13.2 vs. 12.6 g/egg, $P = 0.032$). Other egg components were not influenced by diet (58.1% of albumen and 9.04% of shell). Feeding the RE diet resulted in a higher specific gravity (1.0786 vs. 1.0656 g/g, $P = 0.014$) only when hens were 44 wk-old. At the end of the experiment, excreta were collected from all cages (excreta from 3 cages were mixed and pooled; 16 pools of excreta per diet). At collection, excreta of hens fed the RE diet had lower pH (5.89 vs. 6.54, $P < 0.001$) and higher moisture content (74.0 vs. 70.9%, $P < 0.001$) than those of hens fed the CM diet. After 7 d of storage, excreta pH of hens fed the RE diet continued to be lower (6.30 vs. 8.36, $P < 0.001$). A slight reduction in dietary protein and replacing a portion of the Ca from $CaCO_3$ with $CaSO_4$ did not affect egg production nor did it impair shell quality. Feeding the RE diet to laying hens resulted in a reduction in excreta pH, even after 7 d of storage, as compared with laying hens fed the CM diet.

Key words: calcium sulfate, egg quality, protein reduction

W202 Dietary sources of selenium in nulliparous sows: The importance of vitamin B_6 status for some aspects of antioxidant status and ovulation during the peri-estrus period. M. Roy*[1,2], I. Audet[1], M.-F. Palin[1], H. Quesnel[3], F. Guay[2], and J. J. Matte[2], *[1]Agriculture and Agri-Food Canada, Sherbrooke, QC, Canada, [2]Laval University, Québec, QC, Canada, [3]Institut National de la Recherche Agronomique, St-Gilles, France.*

In this experiment, it was hypothesized that there is an interaction between pyridoxine (B_6) and selenium (Se) metabolisms for an adequate flow of organic Se (Se-cysteine) toward the glutathione peroxidase (GPX) system in response to oxidative pressure induced by the peri-estrus period in sows. Forty-five gilts received one of the 5 dietary treatments (n = 9/group): 1) basal diet (Se = 0.2 mg/kg and B_6 = 2.5 mg/kg) (C); 2) # 1 + 0.3 mg/kg Na-Se ($MSe0B_6$); 3) # 2 + 10 mg/kg B_6 ($MSe10B_6$); 4) # 1 + 0.3 mg/kg Se-yeast ($OSe0B_6$) and 5) # 4 + 10 mg/kg B_6($OSe10B_6$). Treatments started at first pubertal estrus and lasted up to 3 d after fourth estrus. Blood was collected from all gilts at each estrus. At slaughter, liver and kidneys were collected and corpora lutea were counted. At fourth estrus, blood Se was lower in C vs Se gilts and higher in OSe's vs MSe's (229.0, 251.2, 250.7, 288.9 and 282.6 µg/L in groups 1, 2, 3, 4 and 5, respectively, SE = 7.3)($P < 0.01$) while blood GPX activity was higher in MSe vs OSe gilts and both were higher vs C's (117.6, 148.3, 145.6, 125.6 and 131.9 mU/mg hemoglobin in groups 1, 2, 3, 4 and 5, respectively, SE = 6.4)($P < 0.01$). In spite of Se effects (as in blood, $P < 0.01$) on Se in liver (0.7, 0.8, 0.7, 1.0 and 1.0 µg/g in groups 1, 2, 3, 4 and 5, respectively, SE = 0.1) and kidneys (2.5, 2.5, 2.4, 2.7 and 2.7 µg/g in groups 1, 2, 3, 4 and 5, respectively, SE = 0.1), there was no treatment effect ($P > 0.50$) on GPX activity in these tissues. However, gene expressions of cytosol GPX (GPX1) and Se-cysteine oxidase (control of the flow of Se-cysteine to the GSH-Px system) in both liver and kidneys were 50 to 70% higher in $OSe10B_6$ gilts than in others (interaction Se x B_6, $P < 0.01$). Ovulation rate were 17.4, 16.7, 17.7, 16.9 and 21.2 (SE = 0.9) in groups 1, 2, 3, 4 and 5, respectively (B_6 effect $P < 0.01$, Se effect $P < 0.06$ and interaction B_6 x Se, $P < 0.09$). In conclusion, dietary B_6 is a modulating factor of the metabolic pathway of organic Se toward the GPX system and may be involved in ovarian function leading to optimal ovulation conditions.

Key words: selenium, vitamin B_6, gilt

W203 Effects of high dietary selenium supplementation on fasting plasma glucose and lipid profiles of young pigs. E. Isaacs*, K. Roneker, and X. G. Lei, *Cornell University, Ithaca, NY.*

Recent animal and human studies have shown an intriguing pro-diabetic, hyperglycemic, or hyperlipidemic effect of high dietary intakes of Se that are suggested for cancer prevention. This experiment was conducted to establish a pig model to determine whether a high Se concentration in a corn-soybean meal basal diet (BD) affected plasma glucose concentrations and lipid profiles. A total of 16 weanling pigs (BW = 7.47 ± 0.78 kg) were divided into 2 groups (n = 8/group) and fed the BD supplemented with 0.3 or 1.0 mg Se/kg (as sodium selenite) for 8 wk. Growth performance and fasting plasma glucose, total triglyceride, and total cholesterol concentrations were measured at initial and then biweekly. Weekly or overall ADG, ADFI, and gain/feed efficiency were similar between the 2 dietary Se concentrations. There was no significant effect ($P = 0.1$) of dietary Se supplementation on fasting plasma glucose concentrations (mg/L) (from Wk 0 to Wk 8 = 1207.9 ± 336.8 to 727.9 ± 84.5 vs. 1359.9 ± 169.7 to 845.6 ± 195.6). Likewise, fasting plasma concentrations of total triglyceride and total cholesterol were not different ($P = 0.85$) between the 2 dietary Se groups. In conclusion, supplementing the corn-soy diet with 1 mg of Se/kg for 8 wk might not be sufficient to alter fasting plasma glucose or lipid profiles of weanling pigs.

Key words: glucose, lipid, model pigs, plasma, selenium

W204 Bioavailability of zinc from zinc propionate in chicks. M. A. Brooks*, J. L. Grimes, S. Verissimo, K. L. Murphy, and J. W. Spears, *North Carolina State University, Raleigh.*

The purpose of this experiment was to evaluate the relative bioavailability value (RBV) of Zn propionate (ZnProp) relative to feed-grade $ZnSO_4$ using body weight gain and bone zinc as response criteria. One hundred day-old Ross chicks were fed a semi-purified starter diet deficient in Zn for 7 d post-hatching (22 mg Zn/kg). Chicks were randomly sorted into one of 5 treatments (n = 20) with 5 replicate pens of 4 birds per pen. The experimental control diet (20 mg Zn/kg) differed from the starter diet in that ground corn replaced approximately 30% of the

dextrose and starch present in the semi-purified starter diet. Using corn in the diet increased the level of phytate, an important Zn antagonist in nonruminant animals. The control diet was supplemented with 0, 6 or 12 mg Zn/kg from feed grade $ZnSO_4$ or ZnProp. Chicks were housed in heated, thermostatically controlled Petersime batteries with raised wire floors and fed the treatment diets from 8 to 21 d. Feed and water were offered ad libitum. Individual body weights and feed intake (by pen) were measured at 7-d intervals for determination of gain, feed intake, and feed efficiency (feed:gain). At the end of the study, tibia bones were excised and used for Zn determination. Zinc RBV was determined using $ZnSO_4$ as a standard source by multiple linear regression and slope-ratio methodology. Analyzed supplemental Zn intake was used in the regression analysis. As supplemental dietary Zn increased, there was a dose dependent increase ($P < 0.05$) in feed intake, weight gain, total Zn intake, tibia Zn concentration and total tibia Zn. Feed efficiency (feed:gain) was poorer ($P < 0.01$) in the control diet (0 mg supplemental Zn/kg) compared with Zn addition to the diet, but did not show a dose response with additional Zn ($P > 0.05$). ZnProp RBV was 119%, 116% and 116% using weight gain, tibia Zn concentration, and total tibia Zn, respectively. RBV was greater than $ZnSO_4$ ($P \leq 0.04$) for total tibia Zn, but was not different in regards to weight gain and tibia Zn concentration ($P > 0.05$). In summary, based on these results, bioavailability of Zn from ZnProp is greater than $ZnSO_4$.

Key words: poultry, zinc, relative bioavailability

W205 Effects of copper concentration and source on performance, bile components, copper metabolism and gastrointestinal microbial distribution in nursery swine. M. A. Arnold*[1], J. S. Schutz[1], K. Sellins[1], R. J. Harrell[2], and T. E. Engle[1], *[1]Department of Animal Science, Colorado State University, Fort Collins, [2]Novus International Inc., St. Charles, MO.*

One hundred twenty weaned nursery pigs (6.12 ± 0.56 kg) were utilized in this experiment to determine the effects of Cu concentration and source on performance, bile components, Cu metabolism, and gastrointestinal microbial distribution in nursery pigs blocked by weight and gender and placed in pens containing 5 pigs of similar weight distribution per pen. Pigs were fed one of 4 dietary treatments for 21 or 22d. Treatments consisted of: 1) Control (5 mg of Cu/kg from CuSO4); 2) 250 mg of Cu/kg from CuSO4, (250-sulfate) 3) 75 mg of Cu/kg from Cu-Mintrex Cu (75-Min; Novus International, Inc., St. Charles, MO), and 4) 75 mg of Cu/kg from CuSO4 (75-sulfate). On d 22 and 23, equal numbers of pigs per treatment were slaughtered. Post slaughter, blood, liver, intestinal tissue and contents, and bile samples were obtained. Body weights, ADG, and ADFI were similar across treatments ($P \geq 0.20$). Feed efficiency was greater ($P \leq 0.05$) for pigs receiving 250-sulfate compared with controls (0.53 vs. 0.43 ± 0.03, respectively), and pigs fed 75-Min (0.47 ± 0.03) or 75-sulfate (0.44 ± 0.03) were intermediate. Pigs receiving 250-sulfate had greater ($P \leq 0.05$) bile (7.05 vs. 2.06 ± 0.49; respectively) and liver (124.4 vs. 53.3. ± 24.6; respectively) Cu concentrations than controls. Bile components, intestinal bacterial populations, and small intestine gene expression profiles (Ctr-1, Atox-1, Cox-17, ATP7a, and ATP7b) associated with Cu absorption and homeostasis were similar across treatments ($P \geq 0.20$). Antimicrobial effects of bile (determined by measuring the diameter of the zone of inhibition; mm) tended ($P \leq 0.20$) to be higher for 250-sulfate and 75-Min treatments compared with controls. Data from this experiment indicated that Cu dose influenced pig performance, but dose or source did not influence measured bile components, intestinal bacterial populations, or intestinal gene expression profiles associated with Cu absorption.

Key words: nursery pigs, performance, copper

W206 Different levels of chelated selenium (Se) addition on the performance, and internal and external quality of Japanese quail eggs. V. C. da Cruz*[1], L. C. Carvalho[1], G. do Valle Polycarpo[2], L. H. Zanetti[1], R. F. de Oliveira[1], D. D. Millen[1], R. G. A. Cardoso[1], A. L. C. Brichi[1], M. L. Poiatti[1], and O. J. Sabbag[1], *[1]São Paulo State University, Dracena Campus, Dracena, São Paulo, Brazil, [2]São Paulo State University, Botucatu Campus, Botucatu, São Paulo, Brazil.*

To evaluate the performance, and internal and external quality of eggs of Japanese quail fed diets supplemented with chelated Se, this study was carried out at the São Paulo State University, Dracena Campus, Brazil. 240 7-wk-old birds were distributed in an entirely random design with 5 treatments (T1: control; T2: 0.25 ppm of Se; T3: 0.50 ppm of Se; T4: 0.75 ppm of Se; T5: 1.00 ppm of Se), 8 replications and 6 birds per cage. Water and feed were ad libitum. The feeding was done twice/d, at 0800 h and at 1800 h, and only the empty feeders were filled up. The light program was 18 h light and 6 h dark, using 60-W incandescent light bulbs. The obtained results for the performance indexes (average egg weight, egg yield, egg mass, feed intake, feed conversion per egg mass and feed conversion per egg dozen) from 0 to 40 d (76-d of age) did not present differences ($P > 0.05$) among the treatments. When the different levels of chelated Se addition on the internal and external quality of quail eggs were analyzed, the Haugh Unit (HU) presented quartic effect ($HU = -1.9E\text{-}06\ x^4 + 0.0003\ x^3 - 0.0192\ x^2 + 0.2530\ x + 93.2758$, $P < 0.05$), and so did the albumen height (AH) ($AH = -3.5E\text{-}07\ x^4 + 6.6E\text{-}05\ x^3 - 0.0036\ x^2 + 0.0451\ x + 5.1615$, $P < 0.05$). The yolk height (YH) presented cubic effect ($YH = 6.3E\text{-}06\ x^3 - 0.0008\ x^2 + 0.0192\ x + 10.3502$, $P < 0.05$), and the shell weight (SW) had linear effect ($SW = -0.0003\ x + 0.8768$, $P < 0.05$), and in all those variables, the best result was observed for the eggs of birds that received only inorganic minerals (control treatment). In the other evaluated variables, specific egg weight, albumen index, yolk index and shell thickness, there were no differences ($P > 0.05$) among the treatments. In the studied levels, the microminerals of associated organic sources do not affect the bird performance. The diet supplementation of quail with chelated Se was inefficient in the improvement of bird performance, but it influences the internal quality of the eggs.

Key words: *Coturnix coturnix japonica*, chelated mineral

W207 Recovery of bone mineralization and strength after a marginal dietary calcium deficiency in growing pigs. L. A. Iwicki*, J. L. Reichert, J. R. Booth, D. K. Schneider, and T. D. Crenshaw, *University of Wisconsin, Madison.*

During recovery from dietary energy or amino acid deficiency, animals compensate by improved efficiency of nutrient use. The objective was to determine if efficiency of dietary Ca and P improved in growing pigs after 5 wk consumption of a diet with marginal Ca deficiency. In the first 5 wk (P1), 40 kg crossbred pigs (n = 72/diet) were fed diets with either 70% (LCa) or 115% (HCa) of Ca required (50 to 80 kg). All diets provided 98% of P requirement. During wk 5 to 10 (P2, 80 to 120 kg), pigs were allotted to either continue LCa or HCa diets or were switched in a crossover design to the opposite diet to provide 4 dietary groups of LLCa, LHCa, HLCa, or HHCa. Selected pigs from each sex and diet group were scanned at 40 (n = 6), 80 (n = 24), and 120 (n = 48) kg using dual energy x-ray absorptiometry (DXA, GE

Prodigy v11.4) to determine whole body bone mineral content (BMC). Scanned pigs were killed, femurs were collected, scanned for femur BMC (FmBMC), and subjected to a 4-point bending test (Instron, model 5566). At 80 kg pigs fed LCa had 15.9% less ($P < 0.01$) BMC, 15.2% less ($P < 0.01$) FmBMC, and 29.9% lower femur bending moment (yBM) than pigs fed HCa. Ca and P efficiency was calculated as g retained (derived from DXA scans) per g consumed. Pigs fed LCa until 80 kg were 23.5% more ($P < 0.03$) efficient in Ca use than pigs fed HCa, but were 29% less ($P < 0.001$) efficient in P use. Over the entire trial no differences ($P > 0.20$) were detected in growth or feed consumption. Pigs fed LLCa had expected reductions ($P < 0.05$) in BMC (13.2%, 1966 v 2265 g), FmBMC (9.0%, 67 v 74 g), and yBM (23.1%, 294 v 382 kg/cm) with improved Ca efficiency (28.7%, 0.71 v 0.55), but a reduction in P efficiency (16.1%, 0.34 v 0.40) compared with pigs fed HHCa. Pigs fed the LHCa or HLCa diets had reduced ($P < 0.05$) Ca efficiency (16.5%, 0.60 v 0.71), but improved ($P < 0.05$) P efficiency (7.1%, 0.36 v 0.34) compared with pigs fed LLCa. No evidence was identified that supported improvement in P efficiency in pigs during recovery from marginal Ca deficiency.

Key words: bone mineral content, P efficiency, bone strength

W208 Ionomic profile changes in the intestine, liver, kidney, serum and gall bladder contents due to Cu source and concentration. B. Aldridge*[1], R. F. Power[2], K. A. Dawson[2], and S. Radcliffe[1], *[1]Purdue University, Department of Animal Science, West Lafayette, IN, [2]Center for Animal Nutrigenomics and Applied Animal Nutrition, Nicholasville, KY.*

Eighty crossbred barrows were weaned at 20 ± 1 d of age and used in 2 blocks (5 reps/block) of a 2 × 3 factorial experiment to investigate the effects of Cu source ($CuSO_4$ and Bioplex Cu (Alltech Inc.)) and concentration (4, 25 or 125 ppm) on ionomic profile concentration changes in the proximal jejunum (PJ), liver, kidney (KD), serum and gall bladder contents (GBC). Pigs were blocked by BW and randomly assigned to diets offered in 2 daily feedings at 9% of metabolic BW ($BW^{0.75}$) per day for a total of 14 d. Samples from the PJ, liver, kidney, serum and GBC were frozen and stored at −20°C until ICP-MS mineral analysis. The PROC MIXED procedure in SAS was used to determine the main effects of Cu source and concentration and their interactions on other mineral concentrations. In addition, PROC GLM linear and quadratic contrasts were determined for increasing supplemental Cu. Pig served as the experimental unit. Increasing Cu concentration did not affect ($P > 0.05$) proximal jejunal [Se], but linearly increased liver [Se] ($P < 0.001$) for both Cu sources. [Se] was decreased ($P < 0.05$) by 30% in GBC when Cu was fed at 125 ppm. Feeding Cu at 125 ppm tended to increase ($P = 0.06$) PJ [Fe], while liver stores were not altered ($P > 0.05$). As dietary Cu increased from 0 to 125 ppm, kidney [Fe] linearly decreased ($P < 0.02$), while at all levels [Fe] was greater when fed Bioplex Cu versus $CuSO_4$. Changes in other mineral GBC include ($P < 0.03$) [Zn] and [Mn] which doubled at the 4 ppm dietary [Cu], when compared with the 25 or 125 ppm level from either Cu source. Zn concentration in the KD increased ($P < 0.001$) when [Cu] was supplemented at 125 ppm, whereas in the liver, Bioplex Cu quadratically altered [Zn] through a reduction of [Zn] at the 25 ppm concentration. This similar trend ($P = 0.1$) was noted in the PJ for both Cu sources.Other altered mineral concentrations include increasing [Co] in the kidney and serum ($P < 0.001$), as dietary Cu increased. These results indicate protagonistic/antagonistic ionomic effects can occur in various organs at select dietary Cu concentrations, which can differ between Cu sources.

Key words: copper, pig, ionomics

W209 Microarray analysis of commonly regulated genes in the jejunum of weanling pigs given dietary Cu proteinate or $CuSO_4$. B. Aldridge*[1], R. Xiao[2], D. Mallonee[2], R. F. Power[2], K. A. Dawson[2], and S. Radcliffe[1], *[1]Purdue University, Department of Animal Sciences, West Lafayette, IN, [2]Center for Animal Nutrigenomics and Applied Animal Nutrition, Nicholasville, KY.*

To illustrate the effect that Cu has on metabolic processes and commonly regulated genes, 2 different types of Cu were used to demonstrate Cu specific cellular pathway changes. Thirty crossbred barrows (n = 10/trt) were weaned at 20 ± 1 d of age and used to determine the effect of a 2 wk supplementation of 0 or 25 ppm Cu from Cu proteinate (Bioplex Cu, Alltech Inc., Nicholasville, KY) or $CuSO_4$ to weanling pig diets on gene expression in the proximal jejunum using microarray analysis. Dietary $CuSO_4$ and Bioplex Cu altered the expression of 545 and 387 genes ($P < 0.05$, FC > 1.2), respectively, compared with control fed pigs. Of these genes, 71 transcripts were commonly altered by $CuSO_4$ and Bioplex Cu, indicating Cu-specific cellular functions.Network pathways of these Cu-specific genes are involved in hematological system development, immune cell trafficking and inflammatory response, and include genes such as modulator of frizzled homolog 4 (FZD4), protein tyrosine phosphatase, protein phosphatase 2 (PPP2R1B), aptoptosis 1 (MOAP1), mitogen-activated protein kinase 3 (MAPK3), chemokine receptor 7 (CXCR7), chemokine ligand 2 (CXCL2) and cytochrome c (CYCS). Additional biological networks altered following Cu supplementation include cellular assembly and organizational pathways, neurological and inflammatory disease, as well as cell death, growth and proliferation. Select genes involved include cyclin A2 (CCNA2), vascular endothelia growth factor C (VEGFC), protein kinase (PKIA), phosphoinositide-3-kinase C3 (PIK3C3), and the Na^+ coupled neutral amino acid transporter 6 (NAT-1). Links to fatty acid metabolic related genes include peroxisomal trans-2-enoyl-CoA reductase (PECR) and the fatty acid transporter SLC27A6. Potential alterations to gut permeability are suggested by altered channel proteins: K^+ large conductance calcium-activated channel (KCNMB1) and gap junction protein (GJA1). These data represents novel commonly regulated pathways between $CuSO_4$ and Bioplex Cu point to Cu specific genes and verify transcriptionally Cu related functions involved in apoptosis, cell signaling and cellular immune responses in swine.

Key words: copper, pig, microarray