132 Determination of endogenous intestinal losses of Ca and digestibility of Ca in canola meal fed to growing pigs. J. C. Gonzalez-Vega*[1], C. L. Walk[2], and H. H. Stein[1], *[1]University of Illinois, Urbana, [2]AB Vista, Marlborough, UK.*

An experiment was conducted to test the hypothesis that endogenous Ca is lost from the gastrointestinal tract of growing pigs. The objective was to determine the apparent total tract digestibility (ATTD) and the true total tract digestibility (TTTD) of Ca in canola meal without and with added microbial phytase. Retention of Ca from canola meal was also determined. Forty 8 growing barrows (average initial BW: 16.72 ± 2.52 kg) were allotted to a randomized design with 8 dietary treatments and 6 pigs per treatment. Diets were based on sucrose, cornstarch, potato protein isolate, corn gluten meal, and canola meal. Diets were formulated to contain 0.08, 0.16, 0.24, or 0.32% Ca from canola meal, respectively. All diets were formulated with 0 or 1,500 units per kilogram of microbial phytase (Quantum, AB Vista, Marlborough, UK) and contained 0.32% digestible P. Feces and urine samples were collected from d 6 to d 11. Results indicate that feed intake, Ca intake, P intake, and P excretion increased ($P < 0.05$) by increasing the level of Ca in the diets. The ATTD of Ca and Ca retention increased ($P < 0.05$) if dietary Ca increased and also if phytase was added to the diets. The TTTD of Ca increased ($P < 0.01$) if phytase was used, but was not affected by the level of Ca in the diets. Total endogenous losses of Ca were determined using the regression procedure. Regression analyses indicated that apparent total tract digested Ca increased (linear, $P < 0.05$) as dietary Ca intake increased. The estimated total endogenous loss of Ca was 0.160 and 0.189 mg/kg DMI for canola meal without and with microbial phytase, respectively, and these values were not different. In conclusion, endogenous Ca is lost from the gastrointestinal tract of growing pigs, and values for TTTD of Ca are, therefore, different from values for ATTD of Ca. Values for ATTD of Ca are influenced by the level of dietary Ca, but that is not the case for values for TTTD of Ca. Microbial phytase increases the digestibility of Ca in canola meal, but does not influence the endogenous loses of Ca.

Key Words: calcium, endogenous losses, pigs

133 The effect of supplemental vitamin D_3 as an oral dose or in early nursery pig diets on pig growth performance and serum 25(OH)D_3 concentrations. J. R. Flohr*[1], M. D. Tokach[1], S. S. Dritz[1], S. C. Henry[2], M. L. Potter[2], N. S. Shelton[1], L. L. Greiner[3], J. Connor[3], R. D. Goodband[1], J. L. Nelssen[1], and J. M. DeRouchey[1], *[1]Kansas State University, Manhattan, [2]Abilene Animal Hospital, Abilene, KS, [3]Innovative Swine Solutions, Carthage, IL.*

A total of 400 barrows from 80 litters (PIC 1050, initially 7 d of age) were used in a 38 d study in a 2 × 2 factorial to determine the effects of vitamin D_3 supplementation from either a single oral dose or from high levels of vitamin D_3 in early nursery diets on pig performance and serum 25(OH)D_3. On d 7 after birth, matched pairs of pigs within litters were randomly allotted to 1 of 2 oral dosages (none or 40,000 IU vitamin D_3) in a RCBD. Pigs were weighed at d 7 and weaning (d 21). Following weaning, a subset of 300 barrows were used from d 21 to 45 to determine the effects of the previously administered oral vitamin D_3 and 2 levels of dietary vitamin D_3 (1,378 or 13,780 IU/kg; 0.80% Ca and 0.63% available P) from weaning to d 31 on pig growth and serum 25(OH)D_3. A common diet containing 1,378 IU/kg of vitamin D_3 (0.70% Ca and 0.47% available P) was fed from 31 to 45 d of age. Barrows were allotted to pens based on their respective vitamin D_3 dose with pens randomly allotted to dietary treatments. There were no dose × diet interactions ($P > 0.09$). Serum 25(OH)D_3 was increased ($P < 0.01$) on d 21 and tended to be increased on d 31 by dosing pigs with vitamin D_3 before weaning. On d 31, serum concentrations increased with increasing dietary vitamin D_3 levels ($P < 0.01$). Weaning weight was not influenced ($P > 0.17$; dosed 5.26 kg vs. undosed 5.18 kg) by the oral dose of vitamin D_3. Supplementing vitamin D_3 by either dose or diet did not influence ($P > 0.23$) nursery performance. In conclusion, supplementing vitamin D_3 either orally or in the nursery diet increased serum 25(OH)D_3, but did not influence nursery pig growth performance.

Table 1.

Dosage:	No vitamin D_3		40,000 IU D_3			*P*-value		
Phase 1 Diet:	1,378 IU	13,780 IU	1,378 IU	13,780 IU	SEM	Dose × diet Interaction	Dosage Effect	Diet Effect
Item								
25(OH)D_3, ng/mL								
weaning	7.8	7.9	26.8	21.6	2.6	0.30	<0.01	0.32
d 31	21.3	33.5	28.6	35.6	2.6	0.33	0.08	<0.01
d 45	10.1	14.3	15.6	13.7	2.6	0.25	0.35	0.66
Nursery performance								
ADG, g	311	306	305	308	8	0.59	0.83	0.92
ADFI, g	386	378	380	388	9	0.28	0.83	0.99
G:F	0.80	0.81	0.80	0.79	0.01	0.65	0.57	0.84

Key Words: nursery pig, vitamin D, 25(OH)D_3

134 Carbohydrase and phytase complex improves performance and bone mineralization of pigs fed wheat-soybean base diet. P. Cozannet[1], R. Gerritsen[2], R. Maillard[1], E. Devillard*[1], and A. Preynat[1], *[1]Adisseo France SAS, CERN, Malicorne, France, [2]Schothorst Feed Research, Lelystad, Netherlands.*

The trial was carried out to investigate the effects of a multi-enzyme (enz) complex containing carbohydrases (from *Penicillium funiculosum*) and 6-phytase (from *Schizosaccharomyces pombe*) on performance and bone mineralization of growing-finishing pigs fed a wheat-soybean meal diet. Gilts [360; Talent × (GYz × Finnish Landrace)]; 7 wk; 25 kg BW) were assigned to 1 of 3 treatments according a randomized block design with 12 replicates (10 gilts/pen) for 100 d. The positive control (PC) diet was a standard diet, formulated to meet the requirement of all nutrients during growing and finishing period (NE = 8.92/8.95 MJ/kg and lys dig = 0.98/0.56 g/MJ NE, respectively), while the negative control (NC) diet was formulated with reductions in energy (0.42 MJ NE/kg), available phosphorus (av P; 0.10%) and calcium (Ca; 0.08%). NC diet was supplemented or not with Rovabio Max (1,100 endo-β-1,4-xylanase visco units, 100 endo-1,3(4)-β-glucanase units and 500 Phytase units /kg of feed; 50 g/ton of feed). Animal feed intake and BW were recorded at the end of each period. Front left meta-carpi of one pig per pen were collected for bone ash percentage (BAP) measurement at the end of the experiment. Results were analyzed in Genstat (ANOVA) and means compared using LSD test. During the 5 weeks growing period, no treatment effect was observed. During finishing period, ADFI was not affected by treatments ($P = 0.29$).Gilts had higher ADG (887 vs. 818

g/day; $P < 0.05$) when they received PC compared with NC whereas enz addition in NC diet partly restored ADG to PC level (857 vs. 887 g/day; $P < 0.05$). FCR was similar for PC and NC + enz with values lower than NC (2.45 vs. 2.58; $P = 0.01$). Considering overall period, pig fed NC diet were 2.6 ($P < 0.05$) and 4.6 ($P < 0.005$) kg lighter than pig fed NC + enz and PC diet, respectively. Moreover, as expected, BAP was negatively affected by mineral depletion (53 vs. 56%; $P < 0.05$) and fully compensated by enz addition as suggested by no difference between PC and NC + enz ($P > 0.05$). These results demonstrate the efficiency of enz complex to balance av P, Ca and NE depletion on wheat-based diet.

Key Words: pig, carbohydrase, phytase

135 Modulation of phosphorus digestive utilization in weanling pigs: influence of dietary calcium and phytase on gastro-intestinal digesta pH and mineral solubility. A. Narcy[1], M. P. Létourneau-Montminy*[2], E. Bouzouagh[1], N. Même[1], M. Magnin[3], and J. Y. Dourmad[4], *[1]INRA, UR83 Recherches Avicoles, Nouzilly, France, [2]Agriculture et Agroalimentaire Canada, Sherbrooke, QC, Canada, [3]BNA-NA, Chateau-Gontier, France, [4]INRA-Agrocampus Ouest, UMR 1348, Saint Gilles, France.*

The study was conducted to evaluate the impact of dietary calcium (Ca) concentration, added in the form of calcium carbonate (CaCO3), on phosphorus (P) digestibility and gastro-intestinal digesta pH and soluble mineral concentration in weanling pigs fed diets with or without microbial phytase. A 3 × 2 factorial arrangement was used with maize-soybean meal based diets formulated to contain combinations of 3 concentrations of Ca: 0.50, 0.75 and 1.00% with or without the addition of 1000 FTU of microbial phytase/kg. After a 5-d adaptation period under a standard diet, 40 male weanling pigs were blocked by weight and allotted to one of the 6 dietary treatments in a 29 d experiment. The addition of microbial phytase improved ($P < 0.001$, +20.1 points) P digestibility regardless of dietary Ca concentration. In addition, P digestibility was linearly decreased ($P < 0.001$, −4.30 points) when increasing dietary Ca. Dietary Ca concentration and microbial phytase did not affect the pH of the different digestive compartments. Nevertheless, the pH of the different segments followed an increasing proximo-distal gradient (segment, $P < 0.001$): 4.69, 5.62, 6.66 and 7.10 pH units respectively for the stomach, the duodenum, the jejunum and the ileum. A negative quadratic relation was observed between the gastric pH and the proportion of soluble inorganic P (iP) and Ca. In the same segment, phytase improved the solubility of iP depending on dietary Ca concentration (Ca x phytase, $P < 0,001$). Indeed, the addition of microbial phytase increased the proportion of soluble iP (% total P) by 20.2, 9.30 and 8.90 points in diets containing 0.50, 0.75 and 1.00% of dietary Ca respectively. The present results suggest that the increase of dietary Ca concentration may affect the solubility of phytates in the stomach reducing in this way their hydrolysis by phytase. Nevertheless, this step did not appear to be limiting regarding the enzyme efficacy in ameliorating P digestibility.

Key Words: phosphorus, calcium, pig

136 Phosphorus utilization in finishing broiler chickens: Effect of dietary calcium and microbial phytase. X. Rousseau*[1,2], M. P. Letourneau-Montminy[3], M. Magnin[1], N. Même[2], Y. Nys[2], and A. Narcy[2], *[1]BNA NA, Château-Gontier, France, [2]INRA UR83 Recherches avicoles, Nouzilly, France, [3]Agriculture and Agri-Food Canada, Lennoxville, Québec, Canada.*

The optimization of phosphorus (P) utilization is crucial to ensure poultry production sustainability. This is particularly the case in finishing broilers (21 to 38 d of age) considering that about 70% of the overall feed intake occurs during the last phase, which also leads to high P excretion, approximately 50% of the P intake being lost in the environment. Response to dietary P in broilers chickens were shown to be dependent on a balance between dietary Ca and P including also P released by microbial phytase. This experiment was carried out to evaluate the response of 144 finishing broilers, reared in individual cages, to 12 dietary treatments differing in dietary Ca (0.37; 0.57; 0.77%), non-Phytate P (nPP; 0.18 or 0.32%) and microbial phytase (0 or 500 FTU/kg). Growth performances, P and Ca retention and bone mineralization were determined. Dietary treatments had no significant effect on ADG, ADFI and FCR. Tibia ash deposition decreased with reduction in dietary Ca at the highest nPP, but improved with reduction in dietary Ca at the lowest nPP (Ca × nPP; $P = 0.035$). Birds fed P-deficient diets used P more efficiently for tibia ash deposition if dietary Ca was sufficient (Ca × nPP; $P < 0.001$). Birds response to microbial phytase was greater with lower level of nPP in terms of P retention and tibia ash content (nPP × phytase; $P = 0.009$ and $P = 0.021$ respectively). Birds could have developed regulative process to cope with P and/or Ca deficiency. Nevertheless, a balanced supply between Ca and P must be considered to ensure optimal utilization of these minerals especially for bone mineralization.

Key Words: phosphorus, calcium, finishing broiler

137 The effect of dietary levels of copper and zinc on rate and efficiency of growth by rainbow trout. E. S. Read*[1], W. M. Sealey[2], F. T. Barrows[3], M. K. Petersen[4], and J. A. Paterson[1], *[1]Montana State University, Bozeman, [2]US Fish and Wildlife Service, Bozeman, MT, [3]US Department of Agriculture, Agriculture Research Service, Bozeman, MT, [4]US Department of Agriculture, Agriculture Research Service, Miles City, MT.*

The objectives of this factorial experiment were to determine if interactions existed between dietary Cu and Zn levels on rate and efficiency of growth and whole body element retention in growing trout. After 6 wk of feeding a diet deficient in Cu (9.4 ppm) and Zn (37.7 ppm), 600 fish (avg wt of 40 g) were randomly assigned to diets with supplementary $CuSO_4$ or $ZnSO_4$ added to provide diets with 0 or 10 ppm added Cu and 0, 30, 300 or 1500 ppm added Zn. There were 25 fish per tank with 3 replications per diet. Diets were formulated to contain 40% CP from soybean meal and corn protein concentrate and 20% crude lipid. Fish were fed experimental diets for 12 wk. The main effects of dietary Cu level, Zn level and the potential interaction on growth and mineral retention were tested. After 6 and 12 wk, 3–5 fish from each tank were sacrificed to determine liver and whole body concentrations of Cu and Zn. Cataracts were observed at 12 wks in 69% of fish fed the Cu and Zn deficient diet compared with an average of 0.01% for all other treatments. Dietary Zn ($P = 0.002$) but not dietary Cu ($P = 0.263$) increased 12 wk weight gain. An interaction ($P = 0.008$) between dietary Cu and Zn was observed for 12 wk weight gain. Slowest gains (19 g/d) were for the Cu and Zn deficient diet and fastest gains (45 g/d) were in the 10 ppm Cu and 1500 ppm Zn diet. Dietary Zn ($P = 0.001$) but not dietary Cu ($P = 0.996$) increased 12 wk whole body Zn levels. Dietary Cu ($P = 0.094$) or Zn ($P = 0.095$) did not alter whole body Cu levels and no interactions were observed ($P = 0.806$). Results of this study indicate rainbow trout fed plant-based diets require Zn supplementation to obtain sufficient growth. Level of supplemented Cu did not improve weight gain. However, the level of Zn did improve weight gain, at the higher levels (300 and 1500 ppm) of Zn. The highest levels of Zn supplementation did not impair Cu uptake in rainbow trout. Diets without additional

Cu or Zn caused increased incidence of cataracts compared with diets with added Cu and Zn.

Key Words: copper, zinc, rainbow trout

138 Varied sources of conjugated linoleic acid (CLA) does not alter bone mineral density (BMD), bone mineral content (BMC), or body fat content in postmenopausal ovariectomized rats. K. M. Kanosky,* Z. D. Callahan, M. A. Brown, C. S. Perkins, E. A. Benavides, D. H. Keisler, and B. R. Wiegand, *University of Missouri, Columbia.*

Altering dietary fat source has been shown to change the fatty acid profile in non-ruminant animals; subsequently changing downstream metabolic events such as bone remodeling, which is influenced by inflammatory prostaglandin E2 (PGE2). Excess production of PGE2 is linked to osteoporosis and associated with postmenopausal bone loss. One potential anti-inflammatory agent is conjugated linoleic acid (CLA). Previous studies have reported that CLA feeding in rats resulted in decreased PGE2 production, thus improving bone mineral density (BMD). The objective of this study was to determine if body fat content, specific organ weights, bone mineral content (BMC) and BMD were altered if aged, ovariectomized female rats were fed varied sources of CLA. All procedures were performed according to University of Missouri Animal Care and Use Committee Approved Protocol. Retired breeder (365 ± 28 d of age and 4.5 ± 0.5 parity), Sprague Dawley, female rats (n = 86) were randomly assigned to ovariectomy (OVX) or sham (SHAM) surgeries. Rats were fed 4% soy oil (CON) for 14 d. For an additional 70 d, within surgery groups, rats were randomly allotted to dietary treatments: CON, 0.6% CLA + 3% soy oil (CLA), 0.6% CLA from cheddar cheese powder + 3% soy oil (CC), or 0.3% CLA + 0.3% CLA from cheddar cheese powder + 3% soy oil (CCCLA). Feed intake and body weight were measured weekly. Dual-energy x-ray absorptiometry (DEXA) scans were performed to measure body fat content and bone composition before dietary treatments and post-mortem. At the end of the feeding period rats were sacrificed, blood was collected, and livers, thigh muscles, peritoneal fat, femurs, and tibias were removed and weighed. There were no significant effects of treatment on bone mineral content (BMC, g), bone mineral density (BMD, g/cm^2), or body fat content (%). Compared with SHAM, rats that were OVX had lower BMD ($P < 0.01$) and femur weights ($P < 0.01$), therefore resulting in less dense bones. However, fat content ($P < 0.001$), ADG ($P < 0.0001$), and ADFI ($P < 0.05$) increased in OVX rats. Unlike growing finishing pigs, 0.6% CLA inclusion in rat diets may not be enough CLA for this enhanced anti-inflammatory response. In conclusion, we were able to make an appropriate postmenopausal rat model that exhibited a decrease in BMD, which may be beneficial in future osteoporosis research.

Key Words: linoleic acid, rats, bone

139 Effects of selenium-enriched exopolysaccharide produced by *Enterobacter cloacae* Z0206 on growth performance, immunity and antioxidant activities in broiler chickens. Z. Q. Lu,* Y. M. Wang, M. Huang, and Y. Z. Wang, *Institute of Feed Science, Zhejiang University, National Engineering Laboratory of Bio-feed Safety and Pollution Prevention, Key Laboratory of Animal Nutrition and Feed science of Ministry of Agriculture, Hangzhou, Zhejiang Province, China.*

Enterobacter cloacae Z0206 (*E. cloacae* Z0206), a recently discovered bacterial strain, could produce huge amount of exopolysaccharides. Our previous studies found that *E. cloacae* Z0206 could accumulate selenium (Se) in the form of Se-enriched exopolysaccharide (Se-ECZ-EPS) efficiently in medium enriched with selenium. Se-ECZ-EPS contained 535.7 mg/kg Se and has been proven to possess immunostimulatory function in mice. However, little was known about the bioactive activities of Se-ECZ-EPS in chickens. Thus the present study was conducted to investigate the effects of Se-ECZ-EPS on growth performance, serum cytokine concentrations and antioxidant enzyme activities in broiler chickens. Two hundred forty Avian broiler chickens were allocated randomly into 5 groups with 4 replicates in each group and 12 chickens in each replicate. Control group was fed with basal diet containing 0.15 mg/kg Se (Na_2SeO_3), and the another 4 groups were fed with diets supplemented with Se-ECZ-EPS at the level of 280 mg/kg (0.15 mg/kg Se), 560 mg/kg (0.30 mg/kg Se), 840 mg/kg (0.45 mg/kg Se) and 1120 mg/kg (0.60 mg/kg Se), respectively. The results showed that average daily gain and feed conversion ratio in 840 and 1120 mg/kg groups were significantly enhanced from 0 to 42 d compared with the control group ($P < 0.05$). And the serum concentrations of TNF-α, IFN-γ, IL-2 and IL-6 showed positive responses in 1120 mg/kg group ($P < 0.05$). Furthermore, administration of Se-ECZ-EPS at the level of 560, 840 and 1120 mg/kg significantly increased activities of glutathione peroxidase and superoxide dismutase, and decreased malondialdehyde production ($P < 0.05$). These results implicated that Se-ECZ-EPS can improve the growth performance, and enhance immune and antioxidant functions by stimulating secretion of cytokine and improving antioxidant enzyme activities in broilers.

Key Words: exopolysaccharide, immunity, broiler