1372 Effect of calcium on reaction products released during thermolysin hydrolysis of tryptic peptides from β-casein. J.-F. Lapointe*[1], G. Henry[2], D. Molle[2], S.F. Gauthier[1], and Y. Pouliot[1], [1]*Centre de recherche STELA,* [2]*INRA, Laboratoire de Recherches de Technologie Laitiere.*

Thermolysin is a metalloendopeptidase that requires calcium to maintain its structural stability. The objective of this study was to evaluate the effect of calcium ions on the reaction products released during thermolysin hydrolysis of tryptic fragments from β-casein. Tryptic fragments β-CN 1-25 and β-CN 29-99 were isolated from a tryptic hydrolysate of purified β-casein. Both fragments were solubilized (2 $mg.ml^{-1}$) in water or Tris buffer (50 mM) added with $CaCl_2$ (0.1 and 10 mM), then hydrolysed at 40°C with 0.01% of thermolysin. During hydrolysis, aliquots were taken over a 24 hours period and reaction products were identified by mass spectrometry (LC-MS and MS-MS). Results indicated that calcium ions enhanced the kinetics of reaction, and modified the peptidic profile resulting from thermolysin hydrolysis of both fragments. Specifically, the sequence β-CN 6-22 which contains 4 phosphoseryl residues was found in higher proportion in hydrolysate prepared without calcium than in its presence. Also, the presence of calcium seemed to promote the cleavage of the peptidic bound E_{11}-I_{12}, yielding to large amount of the sequence β-CN 6-11. Binding of calcium ions to phosphoseryl residues thus could influence the attack of β-casein by thermolysin and might be use to produce specific peptide sequences during hydrolysis of β-casein with thermolysin.

Key Words: β-casein, Thermolysin, Enzyme specificity

1373 Use of a model system to determine the effects of milk protein and denatured whey protein concentrations on mass balance during cheese making. N. Remillard*[1], G. Trudeau[2], and M. Britten, [1]*FRDC, Agriculture and Agri-Food Canada, St-Hyacinthe, Qc, Canada,* [2]*Agropur, Granby, Qc, Canada.*

The distribution of milk constituents between cheese and whey is a critical issue for cheese factories. A laboratory scale model system has been developed in order to determine mass balance during cheese making. Coagulation vats (12 x 12 cm) with 144 ml capacity were used. A cutting device made of 11 parallel and equally spaced blades produced 1 cm^3 identical coagulum cubes. Curd cooking was performed by placing vats in a water bath under orbital stirring. A screen was placed between the vats and the covers; reversing the vats allowed whey drainage and curd recovery. Drained curds were centrifuged for a second whey extraction. Total mass recovery averaged 98.6%. Composition analyses of cheese milks and wheys allowed calculation of protein and fat retention coefficients. The model system was used to study the effects of milk protein (MP) concentration and the addition of denatured whey protein (DWP) on Mozzarella cheese mass balance. Skim milk true protein concentration was adjusted between 2.7 and 3.3% by the addition of milk ultrafiltration retentate or permeate. Whey protein concentrate was heat denatured, homogenized and added to milk at levels ranging from 0 to 0.3% on a true protein basis. The fat to protein ratio was standardized to 1.4 with cream. Cheese milks were prepared according to a split plot factorial design (2^4) repeated four times. Cheese moisture increased from 44.4 to 46.7% when 0.3% DWP was added to milk. Adjusted yield (Y) increased linearly with MP concentration ($dY/dMP = 3.2$) and DWP level ($dY/dDWP = 1.8$). However, adjusted yield leveled off with DWP higher than 0.2%. When MP concentration was higher than 3.0%, protein retention was not affected by DWP. However at lower MP concentration (2.7%), increasing DWP level reduced protein retention coefficient (from 0.799 to 0.792). Lipid retention tended to increase with increasing MP concentration, which explains the strong effect of MP concentration on adjusted yield compared to the effect of DWP.

Key Words: cheese, mass balance, whey protein

Nonruminant Nutrition
Phytase, Other Enzymes, and Mineral Nutrition

1374 Characteristics of phytase secreted in saliva of the transgenic enviropig^{TM}. M. Cottrill, J. P. Phillips, R. G. Meidinger, M. Z. Fan, R. R. Hacker, and C. W. Forsberg*, *University of Guelph, Guelph, Ontario.*

The Enviropig^{TM} produces a salivary phytase enzyme encoded by the AppA phytase gene from *Escherichia coli*. The objective of this research was to compare the biochemical and catalytic properties of the pig salivary phytase with those of the phytase produced from the same gene expressed in *E. coli*. The phytase in saliva of a transgenic phytase pig from a representative transgenic line and the one from *E. coli* were purified to homogeneity by a series of chromatographic steps and their properties compared. As previously reported the salivary phytase was glycosylated with a molecular mass of 50,844 Da while that produced by *E. coli* was unglycosylated with a mass of 44,708 Da. The salivary phytase exhibited K_m and V_{max} values of 0.27 0.02 mM and 1,400 30 $\mu mol \cdot (mg\ protein)^{-1} \cdot min^{-1}$, respectively, for the hydrolysis of phytate while the phytase produced in *E. coli* exhibited K_m and V_{max} values of 0.29 0.03 mM and 1,775 50 $\mu mol \cdot (mg\ protein)^{-l} \cdot min^{-1}$, respectively. The K_m values were similar but the V_{max} values were different ($P > 0.05$). Both enzymes hydrolyzed phytate with maximum activities at pH 4.5, and both initially cleaved the 6-position of phytate and formed the same intermediate inositol phosphate degradation products. The salivary phytase and the *E. coli* phytase were stable in the presence of pepsin in buffered solutions at pH values of 1.5 and above, but both enzymes lost activity in the presence of stomach contents at pH 1.5, but not pH 2.0 suggesting the presence of a destabilizing factor active in stomach contents at low pH. Because stomach contents are at a pH value above 2.0 during feed consumption and digestion, inactivation of phytase below pH 2 is not a serious concern under normal physiological conditions.

Key Words: Phytase, Saliva, Enviropig^{TM}

1375 Phosphorus associated with soybean meal is completely digested and absorbed in the transgenic phytase growing-finishing enviro-pig^{TM}. A. Ajakaiye*, M. Z. Fan, C. W. Forsberg, J. P. Phillips, R. G. Meidinger, M. Z. Weiderkehr, T. Archbold, S. P. Golovan, R. R. Hacker, and D. Barney, *University of Guelph, Guelph, Ontario, Canada.*

The objectives of this study were to compare true phosphorus (P) digestibility and the endogenous P outputs between the transgenic growing-finishing enviropig^{TM} and the non-transgenic growing-finishing pig by regression analysis technique. Four transgenic G_1 phytase pigs, with average initial and final BW of 31 and 51 kg respectively were fitted with a simple T-cannula at the distal ileum and fed four diets according to a 4 x 4 Latin square design. The diets were cornstarch-based and contained four levels of P (0.99, 1.95, 2.94 and 3.96 g/kg DMI) from soybean meal (SBM). Chromic oxide (0.35%) was added as a digestibility marker. Each experimental period consisted of 8 d with 4-d adaptation and 4-d collection of salivary juice, ileal digesta and fecal samples. There were no effects ($P > 0.05$) of diets and periods as well as circadian rhythm (am vs. pm) on salivary phytase activity (102.8 ± 48.9 - 104.6 ± 69.3 μmol/mg protein/min). Compared with the results of the non-transgenic growing-finishing pig reported in our previous studies (Ajakaiye *et al.*, 2001, J. Anim. Sci. 79 suppl. 1, 397), there were differences ($P < 0.05$) in true ileal (108.5 ± 3.7 vs 59.0 ± 8.3%) and fecal (101.9 ± 3.9 vs 51.3 ± 7.9%) P digestibility values in SBM. However, there were no differences ($P > 0.05$) in the ileal (0.58 ± 0.09 vs 0.58 ± 0.18 g/kg DMI) and the fecal (0.66 ± 0.11 vs. 0.45 ± 0.21 g/kg DMI) endogenous P outputs between the transgenic and the non-transgenic growing-finishing pigs. In conclusion, the transgenic growing-finishing enviropig^{TM} can completely digest and absorb P associated with SBM with no changes in the recycling and outputting the gastrointestinal endogenous P.

Key Words: Phosphorus, True digestibility, Growing-finishing transgenic phytase pig

1376 Efficacy of a new phytase preparation on phosphorus and calcium digestibility and on bone mineralization in weanling piglets. S. Jakob*, R. Maillard, O. Nore, and P.A. Geraert, *Aventis Animal Nutrition, Antony, France*.

An experiment was conducted to evaluate the efficacy of a new phytase preparation (PhyA) in comparison with a commercially available phytase representing the largest share of the phytase market (PhyB). Weanling piglets (n=24, 6.6 kg initial wt.) were divided into 4 groups consisting of 6 animals each. The animals were housed individually in metabolic cages. They were fed *ad libitum* for 27 d 4 different diets based on corn - soybean meal low in digestible P. Dietary treatments were: 1) negative control (NC; .144% dig. P & .76% Ca), 2) NC + 500 U / kg PhyA, 3) NC + 500 U / kg PhyB and 4) positive control (PC; .238% dig. P & .78% Ca). Feces of the animals were collected quantitatively during the last 5 d of the experiment for determination of P and Ca digestibility. The animals were euthanized on the last day of the experiment following the last sampling and the metacarpal of the left foot of each animal was dissected for determination of the bone mineralization (total ash, P and Ca contents). As compared with the NC, supplementing the diets with PhyA or PhyB increased ($P < .01$) the digestibility of P (20.11%, 50.28%, 43.63% resp.) and Ca (34.2%, 48.62%, 50.98% resp.) as well as contents of total ash (10.45%, 13.12%, 12.42% resp.), P (1.66%, 2.18%, 2.04% resp.) and Ca (3.56%, 4.69%, 4.32% resp.)in the bones. The supplementation of the diets with PhyA increased ($P < .01$) digestibility of P and improved bone mineralization as indicated by increased ($P < .01$) contents of total ash, P and Ca when compared with the PC. In comparison with the PC, a supplementation with PhyB increased digestibility for P ($P < .01$) and Ca ($P < .05$) whereas no effect ($P > 0.1$) on bone mineralization was observed. Comparing results obtained in the two groups supplemented with phytase, PhyA showed an increased ($P < .01$) P digestibility which is reflected in tendency by higher ash ($P < .08$) and P ($P < .07$) contents in the bones. In summary, the new phytase preparation (PhyA) effectively improved P and Ca digestibility which is reflected by increased P, Ca and ash contents in the bones.

Key Words: Piglet, Phytase, Phosphorus

1377 The effects of supplemental plant or microbial phytase and organic acid on growth performance and nutrient digestibilities in nursery pigs. O. S. Kwon*[1], I. H. Kim[1], J. W. Hong[1], Y. K. Han[2], J. H. Kim[3], S. H. Lee[1], B. J. Min[1], and W. B. Lee[1], [1]*Department of Animal Resource & Science, Dankook University, Cheonan,,* [2]*Feed Res. Inst., National agri. Coop. Fed.,* [3]*Agribrands Purina Korea, Inc., Seoul, Koera*.

This study was carried out to evaluate the effects of adding phytase and organic acid on growth performance, nutrient digestibility, and inorganic phosphorus and calcium of serum in nursery pigs fed corn-soybean meal diets. A total 60 crossed pigs(average 15.14±0.32kg BW, Landrace×Duroc×Yorkshire) were used in this experiment. Pigs were alloted into five treaments. Each treament had four replicates with three pigs per replicate. This study was carried out for 20 days. The five treatments were Con(Control diet: Diet was formulate with 85% of NRC requirement for P), PP(Control diet+plant phytase 0.8%), MP(Control diet+microbial phytase 0.1%), PMP(Control diet+plant phytase 0.8%+microbial phytase 0.1%) and PMO(Control diet+plant phytase 0.8%+microbial phytase 0.1%+organic acid 2.0%). For overall period, average daily gain was increased by MP compared with PMO($P<0.05$). Gain/feed was successfully improved by PM compared with PMO($P<0.05$). There were no significant differences in DM and N digestibility among the treatments. PP and PM had improved digestibility of Ca compared to PMO($P<0.05$). Pigs fed PP and MP tended to have higher digestibility of P than pigs fed PMO($P<0.05$). Calcium content in serum of PMO was significantly different among the treatments($P<0.05$). However, PM was lower than other treatments on calcium content of serum($P<0.05$). MP was higher in inorganic phosphorus of serum than other treatments($P<0.05$). In conclusion, phytase supplementation in pig diet improved growth performance and nutrient digestibility. However, there was not synergic effect between phytase and organic acid supplementation.

Key Words: Pigs, Phytase, Organic acid

1378 Phytase proved ineffective for young weaned pigs. H. M. Miller[1] and P. Toplis*[2], [1]*University of Leeds, Leeds, UK,* [2]*Primary Diets Ltd, Melmerby, UK*.

European countries are keen to reduce phosphorus pollution and hence favour using phytase in pig diets instead of inorganic phosphates. Although phytase is widely used in grower-finisher diets little published information exists for starter diets. This experiment aimed to investigate the effect of including phytase instead of an equivalent amount of dicalcium phosphate (DCP) in starter diets on their resulting performance. One hundred and twenty eight piglets (62.5% Large White, 25% Landrace, 12.5% Duroc) were weaned, at 23 0.86 days of age and 7.0 0.12 kg BW, into commercial flatdeck accommodation. Eight piglets were allocated to each pen (1.99 m^2) on the basis of weight, litter and sex. Four pens were randomly allocated to one of 4 treatments. Treatments were: 1) standard diets (S), 2) S plus 500 FTU phytase/kg feed (Ph+), 3) S minus 6.3 kg DCP per metric tonne of mixed feed (-DCP) and 4) -DCP plus 500 FTU phytase/kg feed (Ph-). Diets were milk-based and formulated to contain 4,167 kcal DE/kg, 1.75% total lysine in Wk1, and 3,810 kcal DE/kg, 1.6% total lysine in Wk2 and 3. Feed and water were provided *ad libitum*. Piglets were weighed on d0 and 20. Daily FI per pen was recorded from d0 to 20. Data were analysed using the GLM procedure of Minitab 12.2. S pigs grew faster to a heavier d20 weight than Ph+ and Ph- pigs: -DCP pigs performed worst (DLWG 330, 286, 298 and 262 g/d, respectively, SEM 9.0, $P < 0.01$; d20 weight 13.6, 12.8, 13.0 and 12.3 kg, respectively, SEM 0.17, $P < 0.01$). DCP supplemented diets performed best. Removal of DCP reduced performance. This was partly counteracted by phytase inclusion, however, phytase unexpectedly caused a fall in performance when added to the standard diet. This work suggests phytase cannot completely replace DCP in milk-based diets for early-weaned pigs.

Key Words: Phytase, Weaner pig, Growth

1379 Phytase and dietary zinc and copper effects on performance and mineral status of grow-finish pigs. J. W. Spears*[1], M. D. Corns[1], E. van Heugten[1], W. L. Flowers, and G. M. Hill[2], [1]*North Carolina State University,* [2]*Michigan State University*.

Two-hundred and forty pigs (22.4 kg initial wt) were used in a 2 x 5 factorial design to estimate Zn and Cu requirements of grow-finish pigs fed phytase. Zinc was added as $ZnSO_4$ to provide 0, 10, 20, 30 or 60 ppm supplemental Zn and Cu (from $CuSO_4$) was supplemented at 0 or 5 ppm. Two treatments with no added phytase were also included in the experimental design. One non-phytase treatment was supplemented with adequate Zn (60 ppm) and Cu (5 ppm) while the other supplied no supplemental Zn or Cu. The control (no added Zn or Cu) growing and finishing diets analyzed 38 and 34 ppm of Zn and 6.9 and 5.3 ppm of Cu, respectively. Phytase (Allzyme ®) was added to provide 11,500 PTU/kg diet and growing and finishing diets were formulated to contain 0.4 and 0.3% total P, respectively. Phytase addition improved ($P<0.05$) gain (0.84 vs 0.79 kg/d) and gain:feed (0.389 vs 0.375) compared to pigs not receiving phytase and similar levels of Zn and Cu. Plasma P concentrations were higher($P<0.05$) and fecal P concentrations lower ($P<0.05$) in phytase-fed pigs. Pig performance was not affected by dietary Zn or Cu in pigs fed phytase. Plasma, liver and bone Zn concentrations and plasma alkaline phosphatase activity were increased($P<0.05$)by Zn supplementation, primarily due to addition of 10 ppm Zn, with relatively small increases with further supplementation. Copper supplementation increased liver Cu, but did not affect plasma ceruloplasmin or red blood cell superoxide dismutase activity. Addition of 10 to 20 ppm of Zn to a corn-soybean meal based diet with phytase should provide adequate Zn to maximize performance and maintain normal Zn status. The control diet containing 6 ppm of Cu and phytase was adequate to meet nutritional Cu requirements of grow-finish pigs.

Key Words: Zinc, Copper, Phytase

1380 Nitrogen and phosphorus balance in growing pigs fed crude protein-adequate or -deficient, low-phosphorus diets with graded levels of phytase. J.S. Sands*[1], D. Ragland[1], and O. Adeola[1], [1]*Purdue University*.

Growth response, N and P balance were evaluated in pigs fed CP-adequate or reduced, low-P diets with graded levels of supplemental phytase (PT). Forty-eight 10-kg pigs were used in a randomized complete block design with a 2 x 3 factorial arrangement of treatments to

assess the growth response of pigs to diets containing CP at 200 g/kg or 160 g/kg and PT at 0, 600, or 1200 phytase units (PTU)/kg for 28 d in Exp. 1. Pigs fed CP-adequate diets had higher ($p < 0.05$) ADG (0.47 vs 0.42 kg/d), and gain to feed ratio (0.48 vs 0.42) than those fed reduced-CP diets. Phytase linearly increased ($P < 0.001$) BW and ADG, and tended to have a positive, linear effect on ADFI ($P < 0.10$) in CP-adequate but not reduced-CP diets. In, Exp. 2, thirty-six 15-kg pigs were used to evaluate N and P balance. Diets were the same as those used in Exp. 1. Diets were fed for a 5-d adjustment period followed by a 5-d collection period in which total feces and urine were collected separately. Significant CP x PT interactions were observed for N retention. Nitrogen retention was significantly increased from 55.9% to 64.0% with 1200 PTU/kg of diet in pigs fed reduced-CP but not in CP-adequate diets. Phytase supplementation resulted in a linear improvement ($P < 0.001$) in the P digestibility (49.9 to 63.8% and 48.4 to 62.1 % in the CP-adequate and reduced-CP diets, respectively). Consequently, fecal P output was linearly reduced ($P < 0.001$). Retention of P was improved by up to 48% and 30% in pigs fed CP-adequate and reduced-CP diets, respectively. A reduction ($P < 0.01$) in urinary P output by 0.35 g/d led to higher retention of absorbed P in pigs fed the reduced-CP diet. The addition of phytase to reduced-CP, low-P diets further improved N and P balance in growing pigs.

Key Words: Pigs, Nitrogen, Phosphorus

1381 Growth response to phytase and apparent ileal and fecal digestibility of nutrients in pigs fed diets of different intrinsic phytate concentration. J.S. Sands*[1], D. Ragland[1], R.N. Dilger[1], and O. Adeola[1], [1]*Purdue University.*

The purpose of this study was to assess the response to supplemental phytase (PT) in pigs fed diets containing different concentrations of intrinsic phytate (PA). The high PA diet contained 3.9 g/kg and the low PA diets contained 2.2 g/kg with PT added at 0 and 1200 PTU/kg in a 2 x 2 factorial arrangement of treatments. In Exp. 1, a total of 48, 18-kg pigs were assigned to 4 dietary treatments to measure growth response for 28 d. Body weight and ADG were affected by PT ($P < 0.05$), but not by PA. There were no detectable interactions between PT and PA level for any of the growth response criteria measured. In Exp. 2, 8 pigs (28-30 kg BW) were surgically fitted with simple T-cannula approximately 10 cm cranial to the ileo-cecal junction. Pigs were allowed 10 d to recover from surgery and then assigned to metabolism crates in a replicated 4 x 4 Latin square design. Each period consisted of 7 d. Pigs were weighed at the beginning of each period and feed was allotted for the period at a daily rate of 9% of metabolic BW. The apparent total tract digestibility (ATTD) of N was not significantly affected by dietary treatment. The ATTD of P was increased ($P < 0.01$) by the addition of PT to both the low and high PA diets. Significant PT x PA interactions were observed for ATTD and apparent ileal digestibility (AID) of P. The addition of PT increased the ATTD of P from 23.7 to 38.9% and 21.2 to 43.9% in the low and high PA diets, respectively. The AID of amino acids, and N were not significantly affected by intrinsic PA concentration or PT addition. The AID of P was significantly improved ($P < 0.001$) with the addition of PT. The AID of P was increased from 16.3 to 30.5% and 10.6 to 36.1% in the low and high PA diets, respectively. In conclusion, phytase addition to diets high in PA did not improve amino acid or N digestibility, but resulted in a greater increase in P digestibility compared to diets low PA.

Key Words: Amino Acid Digestibility, Phosphorus, Phytase

1382 Digestibility of low phytic acid corn (LPA) and elevated fat and protein corn (EFP) with phytase in finishing pigs. S. L. Hankins*, A. L. Sutton, and B. T. Richert, *Purdue University, West Lafayette, IN.*

Two trials were conducted to compare the effect of four corn hybrids and phytase inclusion on nutrient digestibility and excretion in pigs. In experiment 1 (Exp. 1), 12 crossbred barrows (BW = 95 kg) were used in two replicates for a total of 24 collections (6 pigs/TRT). Pigs were blocked by weight and ancestry and assigned to one of the following TRT: 1) EFP corn based diet (EFP), 2) LPA1 corn diet (LPA1), 3) LPA2 corn diet (LPA2), 4) EFP-LPA1 corn based diet (EFP-LPA1). In experiment 2 (Exp. 2), 24 crossbred barrows (BW=106 kg) were assigned to similar corn hybrids as Exp. 1 and collected in two replicates (6 pigs/TRT). Diets included: 1) EFP, 2) EFP-LPA1, 3) diet 1 with 300 PU/kg, and 4) diet 2 with 300 PU/kg. The EFP and EFP-LPA1 diets were identical in both experiments. Diets were formulated to 0.53% digestible Lys and 0.30% total P with other nutrients meeting or exceeding NRC (1998) requirements. In both studies, pigs were housed in metabolism stalls and had a 5 d adaptation to TRT and stalls followed by a 3 d total feces and urine collection. Pigs were offered TRT diet at 3 times maintenance requirements in two equal feedings with free access to water. In Exp. 1, total N excreted tended ($P < 0.10$) to be lower for pigs fed the EFP-LPA1 TRT (17.3 g/d) compared to pigs fed the LPA1 TRT (23.4 g/d). Pigs fed the EFP TRT had 34-52% greater ($P < 0.05$) fecal P (DM basis) and 33-44% greater fecal water soluble P than the LPA1, LPA2, and EFP-LPA1 in Exp. 1. In Exp. 2, total ammonium N excretion was reduced 9% ($P < 0.01$) from pigs fed the EFP corn diets compared to pigs fed the EFP-LPA1 corn diets. Fecal P was reduced ($P < 0.0001$) when pigs were fed the EFP-LPA1 corn diets (2.2 g/d) compared to the EFP corn diets (4.5 g/d). Total P excreted was reduced ($P < 0.001$) to 2.8 g/d for pigs fed the EFP-LPA1 corn diets compared to 4.6 g/d for pigs fed the EFP corn diets. While phytase addition in Exp. 2 did not effect total P excretion, fecal P was reduced 8% ($P < 0.0001$) with phytase addition to the EFP corn diet. This study suggests that feeding genetically enhanced corn to pigs can reduce nutrient excretion if the increased availability of nutrients is properly accounted for to meet and not exceeed nutrient requirements.

Key Words: Pigs, Digestibility, Phosphorus

1383 The effect of CP level and phytase inclusion on apparent amino acid digestibilities and the estimation of endogenous amino acid losses using an enzymatically hydrolyzed casein diet. J.P. Rice*[1], J.S. Radcliffe[1], R.S. Pleasant[2], and J.L. Pierce[3], [1]*Purdue University, West Lafayette, IN* , [2]*Virginia-Maryland Regional College of Veterinary Medicine, Blacksburg, VA,* [3]*Alltech, Inc., Nicholasville, KY.*

Twelve crossbred barrows fitted with steered ileo-cecal valve cannulas were used in a 6 x 6 Latin square design to test the effects of phytase on amino acid apparent ileal digestibility (AID) and to determine endogenous amino acid digestibilities using an enzymatically hydrolyzed casein (EHC) diet. Pigs were individually housed and allowed ad libitum access to water. Feed was provided at 9% of metabolic BW ($BW^{.75}$) in two daily feedings. Diets were corn-soybean meal based, with the exception of the EHC diet, and contained 0.15% aP, 0.44% Ca, and Cr_2O_3 (0.05%) as an indigestible marker. Diets 1, 2 and 3 contained 13.0, 12.0 and 11.0% CP, respectively. Diets 4, 5 and 6 were Diet 3 with the addition of 250, 500 or 750 U of phytase per kg of diet, respectively. Each period consisted of a 7d adjustment, a 3d total collection, a 12h ileal collection, and a 3d adjustment to the EHC diet followed by a 12h ileal collection. Digesta samples from both collection periods were analyzed for amino acid content using HPLC. The addition of phytase to the low P diet did not improve ($P>0.10$) the AID of Lys, Met, Thr, Trp, or CP. Decreasing the CP content of the diet resulted in a quadratic decrease in Lys ($P<0.08$), Met ($P<0.02$), Thr ($P<0.08$), and CP ($P<0.04$) AID. The quadratic effect was the result of a decreased amino acid AID in the 11.0% CP diet compared to diets containing 12.0% and 13.0% CP. Differences in amino acid AID between the 13.0% and 12.0% CP diet were small, and in many cases slightly higher for the 12.0% CP diet. No effect ($P>0.10$) of dietary CP level was observed for Trp AID. On average, endogenous losses were estimated to be 0.5, 0.2, 0.5, 0.1, and 9.8g/kg of diet consumed for Lys, Met, Thr, Trp, and CP, respectively. As a result, the endogenous fraction of amino acids collected in ileal digesta was proportionally greater in the lower CP diets. Estimates of endogenous amino acid losses fell within the range of those presented in recent literature.

Key Words: Pig, Phytase, Amino acid

1384 Apparent digestibility coefficients of nutrients are improved by phytase supplementation in corn distiller's dried grain with solubles for rainbow trout (*Oncorhynchus mykiss*). Zongjia Cheng* and R.W. Hardy, *University of Idaho, Hagerman Fish Culture Experiment Station.*

Environmental concerns about water pollution caused by excessive nutrient discharges on fish farms are increasing during the last two decades. Phytase supplementation in plant protein-based fish diets may improve

the availability of phytate-phosphorus and other nutrients. In this experiment, corn distiller's dried grain with solubles (DDGS) was supplemented with different dosages of microbial phytase (Natuphos 5000G) to test the effect of phytase on apparent digestibility coefficients (ADCs) of nutrients for rainbow trout. Five diets were pelleted with 0.5% chromium oxide as an inert marker. One diet was a casein-gelatin, semi-purified reference diet, which constituted 70% of the other 4 diets to which DDGS was added and phytase was supplemented. A total of 300 fish (initial mean BW 140.8 11.1 g) were stocked into ten 40-L digestibility tanks with 30 fish per tank. Fish were assigned randomly to each diet. The collection of feces lasted for 2 weeks, feces were collected by the sedimentation technique. Fish were fed once daily at 1330 h, tanks were completely cleaned after feeding, and feces were collected the next day at 1300 h. Results showed that ADCs (%) in DDGS supplemented with 0, 750, 1500, and 2250 FTU/kg diet of phytase were: dry matter, 65.5, 73.4, 76.9, 74.8, respectively (P = 0.0006); crude protein, 90.7, 92.9, 93.2, 93.0, respectively (P = 0.0003); crude fat 83.8, 89.0, 90.9, 90.9, respectively (P = 0.0001); gross energy, 71.8, 78.0, 78.9, 77.8, respectively (P = 0.0026); and phytate-P, 34.9, 91.8, 99.5, 93.9, respectively (P = 0.0001).

Key Words: Apparent digestibility coefficients, Corn dried distiller's grain with solubles, Phytase and rainbow trout

1385 Effect of phytase supplementation on apparent digestibility coefficients of nutrients in soybean meal-based semi-purified diets for rainbow trout (*Oncorhynchus mykiss*). Zongjia Cheng*[1], R.W. Hardy[1], V. Verlhac[2], and J. Gabaudan[2], [1]*University of Idaho,Hagerman Fish Culture Experiment Station* , [2]*Research Center for Animal Nutrition and Health, STE Chimique Roche, Ltd, France*.

Global production of soybean meal (SBM) continues to increase, making it the most promising alternate protein source for fish feeds in terms of future availability. However, the availability of phosphorus (P) and zinc (Zn) in SBM are very low. Phytase supplementation may have an effect on improving availability of P and Zn, and other nutrients. In this study, SBM (50% of the diet) was formulated into a casein-gelatin semi-purified diet and supplemented with 5 dosages of phytase (Ronozyme P (L), Roche Vitamins France). Duplicate tanks were assigned randomly to each diet. Three hundred rainbow trout, mean BW of 100.1 7.4 g, were stocked in ten 40-L tanks. Experimental diets were fed once daily at 1300 h to apparent satiation for one week before fecal collection began. Feces were collected at 0800 h the next day by stripping all fish. Collection of feces was repeated three days until sufficient amount was obtained. The average apparent digestibility coefficients (ADCs, %) of SBM-based semi-purified diets supplemented with 0, 500, 1000, 2000, and 4000 FTU/kg diet were: dry matter, 77.1, 79.0, 78.4, 80.2, 79.2, respectively (P > 0.05); crude protein, 97.1, 97.9, 96.2, 98.5, 98.3, respectively (P < 0.05); lysine, 97.9, 98.8, 97.1, 98.9, 98.9, respectively (P < 0.005); total-P, 39.9, 80.8, 87.9, 91.9, 95.1, respectively (P < 0.0001); phytate-P, 0.5, 52.4, 59.8, 78.3, 67.4, respectively (P = 0.0034); and Zn, 28.7, 52.8, 69.3, 73.4, 81.7, respectively (P < 0.0001).

Key Words: Soybean meal, Phytase, Rainbow trout

1386 Performance of growing-finishing pigs fed diets supplemented with a carbohydrase combination. J. N. Hsu, L. C. Cheng, T. S. Sheu, and C. Y. Liu*, *Animal Technology Institute Taiwan, ROC*.

Fiber-degrading enzymes break down fibrous constituents of dietary ingredients and increase energy utilization and nutrient digestibility in pigs. To evaluate the effect of Safizym (a combination of cellulase, β-glucanase and xylanase) on performance in growing-finishing pigs, two trials were conducted. In trial 1, 48 finishing pigs (average 60 kg; 4 pigs/pen, 4 replicates/treatment) were fed a corn-soybean-wheat bran diet supplemented with 0, 0.04 or 0.08% of Safizym. ADG, ADFI and F/G were: 789, 828, 876 g/d; 2.74, 2.65, 2.85 kg/d; 3.48, 3.23, 3.26, respectively. Although Safizym supplement numerically improved ADG and F/G, there were no significant differences among treatments. Backfat thickness was reduced in pigs fed carbohydrases (2.54, 2.38, 2.23 cm; P < 0.05) with no difference in loin eye area (42.7, 47.7, 48.5 cm^2). Trial 2 involved 60 growing pigs (average 32.7 kg; 4 pigs/pen, 5 replicates/treatment). Control diet (C) was formulated with 3 and 6% wheat bran for growing and finishing phases. Instead 10 and 25% wheat bran was used for separate phase in high fiber diet with (S) or without (F) Safizym (0.08%). At the end of the trial, ADG was lower in pigs fed high fiber diet and recovered by Safizym (for C, F, S; 805, 706, 784 g/d, P < 0.01). In comparison with increased F/G (3.85) in pigs fed high fiber diet, F/G was similar between control and enzyme-supplemented high fiber group (3.14 vs 3.15). There was no difference in backfat thickness among treatments (2.71, 2.66, 2.65 cm); however, loin eye area was smaller in pigs fed high fiber diet (46.7, 42.1, 46.9 cm^2, P < 0.01). The results show that, despite the high inclusion of wheat bran in diets, growth performance and carcass characteristics were improved in pigs fed a combination of carbohydrases.

Key Words: Pigs, Enzymes, Performance

1387 Growth and feed intake of pigs fed wheat-based diets differing in digestible energy content without or with xylanase. W. R. Caine*[1], B. T. Li[1], J. He[2], W. C. Sauer[2], S. Jaikaran[1], and P. H. Simmins[3], [1]*Alberta Agriculture, Food and Rural Development*, [2]*University of Alberta*, [3]*Finnfeeds International Ltd*.

Growing pigs eat to meet their energy requirement, but cannot always compensate the variation of digestible energy (DE) content of wheat in their diet without addition of xylanase. The objective of the study was to evaluate performance of young pigs receiving wheat-based diets differing in DE content supplemented without or with xylanase. Diets were formulated using 672.3 g/kg of one of six wheat sources (W1, W2, W3, W4, W5 and W6) with bulk weights of 67.2, 68.3, 69.9, 75.9, 79.5 and 57.6 kg/hL, respectively. Xylanase (Porzyme® 9300, minimum level of 4000 U/g product; 1 mg/kg of diet) was added into half of each diet. Seventy-two individually penned barrows (10.5 0.6 kg), were fed one of the six diets without or with xylanase. Daily feed intake (FI), ADG and feed conversion efficiency (FCE) of the pigs were measured for 21 d and 7-d fecal collections used to determine dietary DE content. The FI and ADG of pigs fed diets formulated using W1 to W5 were similar and higher ($P < 0.05$) than those of pigs fed the W6-diet without xylanase. Addition of xylanase increased ($P < 0.05$) FI and ADG of pigs fed the W6-diet, although improvements were not apparent ($P > 0.05$) for pigs receiving the other diets. The FCE of pigs were similar among the diets. The DE content of the W1, W2, W3 and W5 diets (range of 3529 to 3569 kcal/kg) were higher ($P < 0.05$) than those of the W4 and W6 diets (range of 3414 to 3457 kcal/kg) with the exception of the W1-diet containing xylanase (3481 kcal/kg). Daily DE intake of pigs fed the W6-diet increased ($P = 0.0001$) by 77 kcal/d with the addition of xylanase, but was not different ($P > 0.1$) for pigs fed W1 to W5 diets. Supplementation of xylanase improves the feed value of wheat sources with low DE content.

Key Words: Pigs, Wheat source, Xylanase

1388 Effect of Rovabio™ Excel AP on nutrient digestibility and on performance of weaned piglets. S. Jakob*[1], G. Gotterbarm[1], and F. X. Roth[2], [1]*Aventis Animal Nutrition, Antony, France*, [2]*Division of Animal Nutrition and Production Physiology, TU-Munich, Weihenstephan, Germany*.

An experiment was conducted to evaluate the influence of a Rovabio™ Excel AP (β-glucanase and xylanase; Aventis Animal Nutrition, Antony, France) addition to a diet for weanling piglets. At 28 d of age, 48 piglets (8.02 ± 1.1 kg) were divided into 2 groups consisting of 24 animals each and assigned to 2 different treatments: 1) a basal diet based on barley and soybean meal (XP 18.5 %, Lys 1.1 %, ME 12.8 MJ / kg) and 2) a experimental diet consisting of the basal diet supplemented with Rovabio™ Excel AP at a level of 50 mg / kg. The piglets were housed individually and fed *ad libitum* for 5 weeks. For the last 12 d of the experiment, the diets of 8 animals of each dietary treatment group were supplemented with .5 % Celite 545 (Merck, Darmstadt, Germany) as digestibility marker. Feces of the animals fed the marker supplemented diet were collected the last 5 d of the experiment. For all animals, average daily weight gain (ADG), final body weight (FBW), daily feed consumption (DFC), feed conversion ratio (FCR) was recorded and additionally in the fecal samples the dry matter (DM), energy and protein digestibility was calculated. The pigs fed the experimental diet supplemented with Rovabio™ Excel AP showed a greater ADG (P < .078) as well as a greater FBW (P < .058). No influence on DFC (P = .139) and FCR (P = .496) was observed. However, energy digestibility was higher (P < .096) for the diet supplemented with Rovabio™ Excel AP. Dry matter and protein digestibility was not influenced (P = .139; P > .9, resp.). In conclusion, our data suggests that a supplementation of a

barley based diet for weaning piglets with .005 % Rovabio^{TM} Excel AP improves zootechnical parameters, namely ADG and FBW, as well as energy digestibility.

Dietary treatment	FBW (kg)	ADG (g)	DFC (g)	FCR	Dry Matter	Digestibility (%) Energy	Protein
Basal	23.04	427	658	1.54	80.9	80.6	78.2
Basal + Rovabio^{TM} Excel AP	24.29	458	691	1.51	82.5	82.5	78.2

Key Words: Piglet, Xylanase, β-Glucanase

1389 Addition of a fungal xylanase to wheat-based diets for growing pigs. M. Cervantes*, M.A. Barrera, A.B. Araiza, N. Torrentera, S. Espinoza, and M. Cervantes, *ICA, Universidad Autónoma de Baja California*.

An experiment was conducted to evaluate the effect of adding a fungal xylanase to wheat-based diets on the performance of growing pigs. Thirty crossbred (Landrace-Hampshire-Duroc) pigs (24.1 kg av. initial body wt.) were randomly allotted to six dietary treatments, based on weight, age, litter and sex, according to a Randomized Complete Block Design. The treatments were: 1) base diet, 96.8% wheat, vitamins and minerals, 2) + 100 ppm xylanase, 3) + 200 ppm xylanase, 4) + 300 ppm xylanase, 5) + 0.53% lysine + 0.12% threonine + 0.05% methionine, 6) control, wheat-soybean meal diet. The basal diet contained wheat as the only source of energy and protein; thus, it was deficient in lysine, threonine and methionine. These amino acids were added to diet 5 to match their content in the control diet, which was formulated to meet the requirements of growing pigs. Vitamins and minerals were added to meet or exceed the requirement. Feed and water were offered ad libitum. Average daily weight gain, feed intake, lysine intake, threonine intake, and feed/gain were: 282, 311, 306, 331, 848, 837 g/d; 1.15, 1.33, 1.31, 1.24, 1.88, 1.81 kg/d; 4.3, 4.9, 4.8, 4.7, 17.0, 16.0 g/d; 4.4, 5.0, 5.0, 4.7, 9.2, 12.0 g/d; 4.50, 4.38, 3.85, 4.49, 2.22, 2.16, respectively. The addition of xylanase did not affect the daily weight gain, but feed/gain tended (P<.10) to improve when 300 ppm xylanase were added. Pigs fed the diet added with crystalline lysine, threonine, and methionine grew faster and more efficiently, and had a higher intake of feed, lysine, and threonine (P<.01) than those fed the basal diet added with the enzyme. No difference was found in weight gain and feed/gain between pigs fed the amino acid added and the control diet. These data show no effect of supplemental xylanase in wheat-based diets, although a slight improvement in feed conversion can be obtained. Also, these data indicate that crystalline lysine, threonine and methionine can replace completely the soybean meal in wheat-based diets for growing pigs.

Key Words: Pigs, Wheat, Xylanase

1390 The effect of multi-enzyme supplementation on the ileal and fecal digestibility of corn-soybean meal based diet in the finishing pigs. B. J. Min*[1], I. H. Kim[1], J. W. Hong[1], Y. H. Han[2], J. H. Lee[3], O. S. Kwon[1], S. H. Lee[1], and W. B. Lee[1], [1]*Department of Animal Resource & Science, Dankook University,* [2]*Feed Res. Inst., National agri. Coop. Fed.,* [3]*EASY-BIO SYSTEM, Inc., Seoul, Korea*.

This experiment was to determine the influence of the addition of a microbial phytase and multiple enzyme(α-galactosidase and β-mannanase) to corn-soybean meal based diets on ileal and fecal digestibility in the finishing pigs. Four Duroc×Yorkshire×Landrace barrows(66.4±0.7kg average initial BW) were surgically fitted a simple T-cannulas approximately 15 cm prior to the ileo-cecal junction. The experimental designs were 4×4 latin squares with pigs and periods as blocking criteria. Each period was 4 d of adjustment to the experimental diets, 3 d of total feces and 2 d(12 h/d) of ileal digesta collection. Dietary treatments included 1) CON(corn-SBM based diet), 2) HME(CON diet+0.1% high level multi-enzyme; phytase 50g+enzyme 350g+carrier 600g), 3) MME(CON diet+0.1% medium level multi-enzyme; phytase 40g+enzyme 280g+carrier 680g), 4) LME(CON diet+0.1% low level multi-enzyme; phytase 30g+enzyme 210g+carrier 760g). Proximate DM and N digestibilities of small intestine for pigs fed multi-enzyme treatments were increased(P<0.05) compared to pigs fed CON diet. However, fecal digestibilities of DM and N were not affected by treatments. Apparent ileal and fecal digestibilities of Ca and P were significantly increased(P<0.05) in multi-enzyme treatments compared to CON treatment. The digestibility of amino acids tended to be higher for the multi-enzyme treatments compared to CON treatment without significant differences except for arginine, asparatic acid and proline. In this study, supplemental multi-enzyme was an effective means of improving ileal digestibility of DM, N, Ca and P by finishing pigs fed corn-soybean meal-based diet.

Key Words: Enzyme, Ileal digestibility, Pigs

1391 Influence of 1-dose Fe dextran administration with organic trace mineral supplementation on the performance of piglets. S. P. Acda[1], J. W. Joo[2], W. T. Kim[2], Y. H. Shim[2], S. H. Lee[2], and B. J. Chae*[2], [1]*Institute of Animal Science, University of the Philippines Los Banos, College, Laguna, Philippines,* [2]*Division of Animal Resources, Kangwon National University, Chunchon 200-701, Kangwon, Korea*.

This study was designed to evaluate the influence of 1-dose Fe dextran with organic trace mineral supplementation on the performance of piglets from dams fed diets with either inorganic (ITM) or organic trace minerals (OTM). It also determined the effect of source of trace minerals on the reproductive performance of sows. The trace mineral premix was prepared using metal proteinates or the corresponding inorganic salts for the OTM or the ITM, respectively. Each mineral premix provided 100 ppm Fe/175 ppm Fe, 35 ppm Cu/170 ppm Cu, 90 ppm Zn/120 ppm Zn, and 40 ppm Mn/35 ppm Mn when added at .20% in sows/piglets' diets, respectively. The first dose of Fe dextran was administered to piglets at 3 d and the second dose at 10 d after birth. One dose Fe dextran supplied 100 mg of Fe. A total of 16 gestating sows (Landrace x Yorkshire x Duroc) in parities 2 to 4 were randomly distributed to four treatments: 1) diet with ITM/1-dose Fe dextran to piglets, 2) diet with ITM/2-dose Fe dextran to piglets, 3) diet with OTM/1-dose Fe-dextran to piglets, and 4) diet with OTM/2-dose Fe dextran to piglets. The total born alive, weaned, body weight at birth and at weaning were not affected by the sow's dietary treatment. Although organic trace mineral supplementation tended to increase milk Fe content (p<.10) at 7 d postpartum, piglets in all treatments equally performed from birth to weaning. The 2-dose Fe dextran neither improved the average daily gain (ADG) nor influenced the survival of piglets from birth to weaning (21 d). Results suggest that 1-dose Fe dextran given to suckling pigs is adequate to sustain their needs for growth throughout the lactation period (21 d). Furthermore, there was a 21% improvement in both the ADG and the average daily feed intake (ADFI) (p<.05) in weaned pigs fed the diet with OTM. Cu and Fe in the liver (p<.01), and Zn in both the bone (p<.01) and the serum (p<.01) were higher in piglets fed OTM than those fed ITM. It would be concluded that 1-dose Fe dextran administration with organic mineral supplementation show similar growth performance compared to 2-dose Fe dextran administration with inorganic mineral supplementation in young pigs.

Key Words: Organic mineral, Fe, Piglet

1392 Effects of feeding organic trace minerals on the production traits of sows and neonates. B. J. Chae*[1] and S. P. Acda[2], [1]*Division of Animal Resources, Kangwon National University, Chunchon 200-701, Korea,* [2]*Institute of Animal Science, University of the Philippines Los Banos, College, Laguna, Philippines*.

A feeding trial using sows and their neonates was conducted to determine the effects of the source and level of organic trace mineral supplementation on the reproductive performance of sows and the subsequent performance of neonates through 2 wk postweaning. A total of 16 gestating sows (Landrace x Yorkshire x Duroc) in parities 2 to 4 were randomly assigned to 4 dietary treatments following a 2 x 2 factorial arrangement in a completely randomized design. One of the two factors evaluated the effect of the source (inorganic vs organic), and the second factor evaluated the effect of the level (low vs high) of trace minerals added to the diet. The trace mineral premixes were formulated to provide low concentration of trace minerals (50 ppm Fe/87.5 ppm Fe, 17.5 ppm Cu/85 ppm Cu, 45 ppm Zn/60 ppm Zn, and 20 ppm Mn/17.5 ppm Mn), or high concentration of trace minerals (100 ppm Fe/175 ppm Fe, 35 ppm Cu/170 ppm Cu,90 ppm Zn/120 ppm Zn, 40 ppm Mn/35 ppm Mn), when included at .20% in sows'/piglets' diets, respectively. The total number born, total born alive and weaned, and the average neonate weight at birth were neither affected by the dietary source nor level of trace minerals, but an interaction effect (p<.05) between the

source and level of trace minerals was observed on the average weight at weaning. The neonates from sows fed the low level of organic trace minerals gained weight at equal rate as those farrowed by sows fed the high level of inorganic trace minerals. Sows fed the organic trace minerals nursed their piglets with milk higher in Fe and Zn ($p<.05$) compared to those fed diet with inorganic trace minerals. Consequently, the weaned pigs fed diet with organic form of trace minerals tended to grow at a faster rate, consumed less feed and tended to utilize their feed more efficiently ($p<.10$). It was further observed that the organic trace minerals significantly increased ($p<.05$) Fe contents in the liver and serum, and Zn in the serum and bone. In conclusion, sows and neonates fed the organic minerals at low level showed similar performance compared to those fed the inorganic minerals at high level as specified in this study.

Key Words: Organic mineral source, Reproductive, Neonates

1393 Evaluation of recombinant human lactoferricin culture as a substitute for antibiotic in pig starter diets. J. W. Hong*[1], I. H. Kim[1], T. H. Moon[2], J. H. Kim[3], O. S. Kwon[1], and S. H. Lee[1], [1]*Department of Animal Resource & Science, Dankook University, Cheonan,* [2]*EASY-BIO SYSTEM, Inc., Seoul,* [3]*Agribrands Purina Korea, Inc., Seoul, Korea.*

Sixty [(Duroc×Yorkshire)×Landrace pigs] (7.63±0.41kg average body weight and 25 d average age) were used in a 20-d growth assay to determine the effects of recombinant human lactoferricin culture (RHLC) on growth performance, digestibility and serum IgG concentration in weaning pigs. Dietary treatments included 1) Negative control (NC : without antibiotic), 2) Positive control (PC : NC diet+0.01% chlortetracycline), 3) RHLC0.3 (NC diet+0.3% RHLC), 4) RHLC0.5 (NC diet+0.5% RHLC). Through entire experimental period, pigs fed RHLC diet grew faster than pigs fed PC diet while no difference was found among other treatments. ADFI of pigs fed RHLC0.3 diet was higher than that of pigs fed PC diet ($P<0.05$). However, pigs fed RHLC0.5 diet had improved gain/feed compared to pigs fed PC diet. Pigs fed PC and RHLC diets was significantly increased in dry matter digestibility compared to pigs fed NC diet ($P<0.05$). However, nitrogen digestibility in pigs fed RHLC0.3 diet tended to increase compared to other treatments without significant difference. There was no significant difference in IgG concentrations of serum. In conclusion, the dietary RHLC seemed to be approximately 0.3% when the pigs fed in the antibiotic-free diet for weaning pigs.

Key Words: Recombinant human lactoferricin culture, Antibiotic-free diet, Pigs

1394 Effects of iron-enriched yeast supplementation on iron utilization in nursery pigs. J. W. Hong*[1], I. H. Kim[1], J. H. Lee[2], O. S. Kwon[1], S. H. Lee[1], B. J. Min[1], and W. B. Lee[1], [1]*Department of Animal Resource & Science, Dankook University, Cheonan,,* [2]*EASY-BIO SYSTEM, Inc., Seoul, Korea.*

Eighty crossbred [(Duroc×Yorkshire)×Landrace] pigs were used to determine the effects of iron-enriched yeast (IEY), fumaric acid and ascorbic acid complex supplementation on iron utilization in nursery pigs fed a corn-SBM based diet. Treatments were 1) CON (basal diet+100ppm ferrous sulfate monohydrate), 2) IEY-A (basal diet+100ppm iron-enriched yeast and fumaric acid complex), 3) IEY-B (basal diet+50ppm iron-enriched yeast, fumaric acid and ascorbic acid complex), 4) IEY-C (basal diet+100ppm iron-enriched yeast, fumaric acid and ascorbic acid complex). Through entire experimental period, pigs fed IEY-C diets were significantly increased in ADG, ADFI and gain/feed compared to pigs fed CON diet ($P<0.05$). Also, apparent digestibility of dry matter in pigs fed IEY-C diet was greater than for pigs fed CON diets ($P<0.05$). However, apparent digestibility of nitrogen was not significantly different among the treatments. Pigs fed IEY-B and IEY-C diets significantly increased their serum iron values compared to pigs fed CON and IEY-A diets ($P<0.05$). However, pigs fed CON diet significantly increased their total iron binding capacity values compared to pigs fed IEY-C diet ($P<0.05$). In conclusion, the availability of iron from IEY, fumaric acid and ascorbic acid complex is significantly better than ferrous sulfate monohydrate supplementation.

Key Words: Iron-enriched yeast, Performance, Pigs

1395 Interaction of chromium methionine supplementattion and feed restriction on reproductive performance of Japanese quail. G. Contreras*, R. Soto, A. Montoya, and R. Barajas, *FMVZ-Universidad Autonoma de Sinaloa (Mexico).*

This study was to determine the effect of chromium methionine supplementation and feed restriction on reproductive performance of Japanese quail. Three hundred twenty Japanese quail breeders (240 females and 80 males; 13 weeks old) were used in a randomized design experiment with 2 x 4 factorial arrangement to test two chromium (from chromium-methionine;Cr) feed supplementary levels (0 and 100 ppb of Cr) and four feed restriction (FR) levels (0, 10, 20, and 30%). Quails in groups of eight (6 females and 2 males) were randomized designated to be placed in 40 wire cages (50 x 60 cm), with automated drinker and fed with a 22% CP and 2.9 ME Mcal/kg diet. Five cages (8 quails) were randomly designated to each of eight treatment resultant of factorial arrangement. After two weeks of starter the trial, eggs were collected across four weeks, select for hatching, placed in hatching machine and incubated. Egg production was diminished ($P< 0.01$) with FR of 30%, Cr had no effect ($P =0.25$). Hatching egg was decreased ($P < 0.01$) by FR-20 and FR-30, Cr tended ($P=0.09$) to improved it, and an interaction Cr x FR was observed ($P < 0.01$), FR-20% with Cr-100 shown similar values than control (70 vs. 66%). Fertility was reduced by FR ($P < 0.01$) at any level, interaction FR x Cr ($P < 0.01$) was observed, FR-20% supplemented with 100 ppb of Cr exhibit similar fertility to the 0% of FR treatment (55 vs. 50%). It is concluded that diet supplementation with 100 ppb of chromium from methionine, helps to maintain the reproductive performance of Japanese quail breeders under up to 20% feed restriction program.

Key Words: Japanese quail, Chromium, Feed restriction

1396 True phosphorus digestibility and the endogenous phosphorus outputs associated with canola meal for growing pigs. M. Z. Fan*, T. Archbold, A. Ajakaiye, Y. Shen, K. Bregendahl, J. L. Atkinson, and R. R. Hacker, *University of Guelph, Guelph, Ontario, Canada.*

The objective of this study was to measure true phosphorus (P) digestibility and the endogenous P associated with canola meal for growing pigs. Four Yorkshire barrows, with average initial and final BW of 30 and 50 kg, were fitted with a simple T-cannula at the distal ileum and fed four diets according to a 4 x 4 Latin square design. The diets were cornstarch-based containing four levels of P from canola meal (2.25, 3.01, 4.38, and 5.54 g/kg DMI). Chromic oxide (0.4%) was included as a digestibility marker. Each experimental period consisted of 8 d with 4-d adaptation and 4-d collection of ileal digesta and fecal samples. The apparent ileal and fecal P digestibility values in canola meal were affected ($P < 0.05$) by P contents in the assay diets. The apparent ileal and fecal P digestibility values changed from 34.3 to 45.2% and from 41.7 to 33.0%, respectively, as the P content increased from 2.25 to 5.54 g/kg DMI. There were linear relationships ($P < 0.05$), expressed as g/kg DMI, between the apparent ileal and fecal digestible P and the total intake of dietary P. There were no differences ($P > 0.05$) in true P digestibility values (42.2 ± 14.0 vs 31.0 ± 4.1%) and the endogenous P outputs (0.49 ± 0.20 vs 0.28 ± 0.06 g/kg DMI) associated with canola meal between the ileal and the fecal levels. Although canola meal is rich in total P content, P associated with canola meal is poorly utilized by growing pigs.

Key Words: True phosphorus digestibility, Canola meal, Growing pigs