

Nonruminant Nutrition: Enzymes 2

1104 Effects of protease supplementation on growth performance of broilers fed corn-soy-DDGS based diets. F. Yan^{*1}, L. Garibay², J. Arce², C. Lopez-Coello², D. Camacho¹, M. Vazquez-Anon¹, M. Manangi¹, N. Odetallah¹, and S. Carter¹, ¹Novus International Inc., St. Charles, MO, ²Universidad Michoacana de San Nicolas de Hidalgo, Morelia, Mich, Mexico.

A floor pen study was conducted to determine the effects of a protease enzyme (CIBENZA DP100, Novus International Inc.) on growth performance of broilers fed corn-soy-DDGS based diets from 1 to 46 d of age. Four treatments in a 2 × 2 factorial arrangement were evaluated with 2 levels of CP (positive control and 7.5% reduction) with or without protease at 0.05%. The positive control diet was formulated with corn soybean meal and 14% DDGS to contain 22%, 21%, and 18.5% CP for starter (1–21 d), grower (22–35 d), and finisher (36–46 d) respectively, and the 7.5% reduction in CP along with the limiting amino acids Lys, Met, and Thr, were achieved primarily through decreasing amount of soybean meal and adjusting supplemental synthetic amino acids. A total of 1400 Ross male broilers were randomly distributed into 28 pens (50 birds per pen) at 1 d of age with 7 pens per treatment. Birds were weighed at 7, 14, 21, 28, 35, and 46 d; feed conversion ratio (FCR), feed intake, and mortality were also determined at each weigh day. Body weights were significantly reduced by lowering dietary CP at 14, 21, 28, 35 and 46 d ($P < 0.05$), and protease supplementation significantly increased body weights at 35 d ($P < 0.05$) regardless of dietary CP levels. A significant interaction was observed between dietary CP and protease for FCR at 14 and 21 d where protease improved FCR when it was added to the diet with the control CP level ($P < 0.05$), but not to the diet with the reduced CP level. At 35 and 46 d of age, protease significantly improved FCR by 5.2 and 4.3 points respectively ($P < 0.05$), irrespective of dietary CP level. Regardless of protease supplementation, reducing dietary CP level increased mortality. In summary, use of a protease in a corn-soy-DDGS based diets improved FCR of broilers throughout the trial, and the effect was independent of dietary CP levels at 35 and 46 d of age.

Key Words: protease enzyme, amino acids, broiler

1105 Effects of a novel phytase on phosphorus digestibility in corn-soybean meal diets fed to weanling and growing pigs. F. N. Almeida^{*} and H. H. Stein, *University of Illinois, Urbana.*

Two experiments were conducted to evaluate the effects of a novel bacterial 6-phytase expressed in a strain of *Aspergillus oryzae* (Ronozyme HiPhos, DSM Nutritional Products, Parsippany, NJ) on the apparent total tract digestibility (ATTD) of P in corn-soybean meal diets fed to weanling and growing pigs. In Exp. 1, 6 diets were formulated. The positive control (PC) was a corn-soybean meal diet that contained dicalcium phosphate to bring the total concentration of P to 0.66%. A negative control (NC) diet (0.36% P) without dicalcium phosphate was also formulated. Four additional diets similar to the NC diet were formulated to contain microbial phytase at levels of 500, 1,000, 2,000, or 4,000 phytase units (FYT) per kg. The 48 weanling pigs (initial BW: 13.5 ± 2.45 kg) were placed in metabolism cages and randomly allotted to the 6 dietary treatments in a randomized complete block design. Feces were collected for 5 d. The total P output and the P concentration in feces were reduced (linear, quadratic, $P < 0.01$) as phytase was added to the NC diet. The ATTD of P was greater ($P < 0.01$) for the PC diet (60.5%) than for the NC diet (40.5%) and increased (linear, quadratic, $P < 0.01$) as phytase was added to the NC diet (40.5 vs. 61.6, 65.1, 68.7, and 68.0%). The breakpoint for the ATTD of P (68.4%) was reached

at a phytase inclusion level of 1,016 FYT/kg. In Exp. 2, 6 diets were formulated as in Exp. 1. A total of 24 growing pigs (initial BW: 36.2 ± 4.0 kg) were randomly allotted to the 6 dietary treatments in a balanced 2 period changeover design. The total P output and P concentration in feces were reduced (linear, quadratic, $P < 0.01$) as phytase was added to the NC diet. The ATTD of P was greater ($P < 0.01$) for the PC diet (59.4%) than for the NC diet (39.8%) and increased (linear, quadratic, $P < 0.01$) as phytase was added to the NC diet (39.8 vs. 58.1, 65.4, 69.1, and 72.8%). The breakpoint for the ATTD of P (69.1%) was reached at a phytase inclusion level of 801 FYT/kg. Ronozyme HiPhos effectively improved the ATTD of P and reduced P excretion in both weanling and growing pigs.

Key Words: phosphorus, pigs, phytase

1106 Enzyme complex containing NSP-enzymes and phytase improves the growth performance and bone mineralization of piglets fed wheat and barley-based diet. A. Preynat^{*1}, J. M. Gomez², and G. Uzu¹, ¹Adisseo France SAS, 92160 Antony, France, ²PRIMEX SAS, La Gare de Baud, BP21, F-56440 Languilic, France.

The experiment was conducted to investigate the benefits of a multi-enzyme complex (Rovabio Max) containing carbohydrases and phytase activities on the performance and bone mineralization of piglets. A total of 240 weaned 28 d-old piglets (Pietrain x Landrace x Large White) were allocated into 4 experimental treatments (10 replicates per treatment, 6 animals per pen) in a randomized complete block design. The animals were fed according to 2 phases: weaner (28–42d) and starter (43–70d) diets. Diets were formulated as follow: a positive control (PC) diet formulated to be adequate in nutrient and a negative control (NC) diet with a decrease in digestible phosphorus (–1.5 g/kg digP), total calcium (–1.0 g/kg Ca) and net energy (–70 kcal/kg). NC diet was supplemented or not with enzymes at 2 rate of incorporation (0.2 and 0.3 L/t). Bodyweight and feed intake were determined at 28, 42 and 70 d. One femur bone from 10 pigs per treatment was collected for ash content determination at 70 d. During the weaner period, feed to gain ratio of NC groups was degraded compared with PC group ($P < 0.01$). During the starter period, animals fed NC diet had the lowest performances (average daily feed intake (ADFI) and average daily gain (ADG); $P < 0.01$) than PC group. ADFI and ADG were significantly improved irrespective of the level of enzyme supplementation of the NC diets. On total period, ADFI (775, 731, 782 and 771 g/d for PC, NC, NC+0.2 and NC+0.3, respectively; $P < 0.05$), final body weight (31.3, 29.4, 31.3 and 31.1 kg; $P < 0.01$) and ADG (566, 518, 566, 561 g/d; $P < 0.01$) were comparable between NC+enzyme to those observed in the PC group. Moreover, the ash content was fully compensated by enzyme supplementation: 14.7, 11.2, 14.0 and 14.4 g/100g. These results confirm the efficiency of multi-enzyme complex to reduce the digP, Ca and energy specifications of wheat and barley-based diets without performance losses in piglets.

Key Words: NSP-enzymes, phytase, piglets

1107 Effect of dietary calcium concentration and microbial phytase addition on P utilization and growth performance in weaned pigs. A. Narcy¹, M. P. Letourneau Montminy^{*2}, E. Bouzouagh^{1,4}, N. Meme¹, M. Magnin³, and J. Y. Dourmad⁴, ¹INRA UR83, Nouzilly, France, ²Agriculture and Agri-Food Canada, Sherbrooke, Qc, Canada,

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The study was conducted to assess the effect of microbial phytase according to various dietary calcium (Ca) concentrations on growth performance, femur characteristics and phosphorus (P) digestive and metabolic utilization in piglets fed with low-P diets (available $P = 0.22\%$). After a 5-d adaptation period on a standard diet, 40 male piglets weaned at 28 d of age (initial BW = 8.7 ± 0.8 kg) were blocked by weight and allotted to one of the 6 dietary treatments in a 29-d experiment. A 3x2 factorial arrangement was used with maize-soybean meal 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/kg of Natuphos microbial phytase. Increasing dietary Ca concentration linearly reduced ($P < 0.05$) final BW (19.4, 19.1, 18.7kg) and BW gain (406, 396, 379 g/d) whereas feed intake was unaffected by the diet. Phytase significantly improved ($P < 0.001$) femur dry matter, ash weight and ash concentration (9.53, 20.1 and 9.71% respectively). P digestibility increased ($P < 0.001$) in diets supplemented with phytase (55.1 vs. 75.2%) whereas it decreased linearly ($P < 0.001$) when dietary Ca increased (67.4, 65.0, 63.1%). The lack of interaction between dietary Ca concentration and phytase addition indicate that Ca equally depressed P digestibility in diets supplemented or not with phytase. As a result, Ca did not modify the release of phytate-P by phytase. However, in piglets receiving diets with phytase, P urinary losses increased 13-fold when Ca was reduced from 1.0 to 0.5% (CaxPhytase, $P < 0.001$) while P retention was reduced by 8.3% (CaxPhytase, $P < 0.01$). These results suggest that although decreasing dietary Ca concentration can ameliorate P digestibility, it may also cause an imbalance between metabolic Ca and P that leads to extra P urinary losses and impairs P retention.

Key Words: calcium, phytase, piglet

1108 The role of sodium in the physiological response of growing broilers to phytate and phytase. A. J. Cowieson^{*1}, M. R. Bedford¹, P. H. Selle³, and V. Ravindran², ¹AB Vista, Marlborough, Wiltshire, UK, ²Massey University, Palmerston North, New Zealand, ³University of Sydney, Sydney, New South Wales, Australia.

A total of 240 Ross 308 broilers were used to investigate the effect of sodium (0.15 or 0.25%), phytate-P (0 or 0.32%) and phytase (0 or 500FTU/kg; $2 \times 2 \times 2$ factorial) on endogenous amino acid flow using the enzyme-hydrolyzed casein method. The ingestion of phytate increased endogenous amino acid flow (~30%; $P < 0.001$) compared with the phytate-free control diets. Phytase reduced endogenous amino acid flow only when fed in concert with phytate resulting in a significant phytate \times phytase interaction. Instructively increasing dietary sodium concentration from 0.15% to 0.25% reduced ($P < 0.001$) endogenous amino acid flow by around 10%. This blunting of endogenous flow was particularly evident in diets which contained phytate, resulting in a significant sodium \times phytate interaction for several amino acids including Thr and Ser. Further, high sodium concentrations muted the effect of phytase resulting in a significant sodium \times phytase interaction for some amino acids. Three-way interactions were rare. The concentration of Asp, Thr, Ser and some other amino acids was increased in the endogenous protein in response to the ingestion of phytate. Both sodium and phytase essentially restored the composition of endogenous protein to that of the phytate-free control. Further, as both sodium and phytase had similar effects there were significant interactions between sodium and phytase for most amino acids, such that one was only effective in the absence of the other. These data confirm previous reports that phytate is a nutritional aggressor causing quantitative and qualitative changes in endogenous protein flow. However, this is the first report

which has shown that dietary sodium concentrations play a role in the severity of this antinutritional effect and consequently may blunt the efficacy of exogenous phytase. The mechanism is obscure though it has been previously demonstrated that sodium can disrupt phytate:protein complexes, thus mitigating one of the mechanisms by which phytate exerts its antinutritional effect.

Key Words: phytate, phytase, sodium

1109 Effect of a thermo-tolerant xylanase on performance in broilers fed diets with different energy and amino acid densities. C. L. Wyatt^{*1}, T. J. Walsh¹, M. R. Bedford¹, A. J. Cowieson¹, and S. Davis², ¹AB Vista, Chapel Hill, NC, ²Colorado Quality Research Inc., Wellington, CO.

A total of 1632 Ross 708 male broilers were used to investigate the effect of feeding a thermo-tolerant xylanase (XYL; ECONASE XT) in pelleted diets with different energy and amino acid densities on performance and carcass yield to d49. All diets contained Quantum Phytase. This was a 2 by 2 by 2 factorial design with 2 energy (HiE; LoE -96 kcal/kg), 2 AA (HiAA; LoAA -15%) and 2 XYL levels (0 or 100g/mt) fed with 12 reps/trt containing 17 birds/pen. Significant main effects for dietary energy and XYL ($P < 0.10$) were found for FCR but not bwt gain. Significant interactions were found for AA by XYL, and E by AA by XYL ($P < 0.10$) for FCR. Birds fed HiE and HiAA diets containing XYL had 5 pts better FCR compared with birds fed the LoE and LoAA diets with XYL. There were no significant effects on bwt gain and mortality. Percent breast yield and % hot carcass were significantly improved with the HiAA diets compared with the LoAA diets but there was no effect of dietary E or XYL. There was an interaction between dietary E \times AA for yield with birds fed HiAA and LoE diets having better % yield compared with birds fed the LoAA and LoE diets. The data would support previous findings from our holo-analysis that there are several key dietary factors impacting the response to feeding XYL in a corn based diet on FCR with a significant improvement in high density diets.

Key Words: xylanase, broilers, dietary energy

1110 Additions of glucanase, xylanase and phytase to low-energy low-lysine diets for broilers including canola meal and DDGS as alternative ingredients. S. Gómez^{*1,2} and M. L. Angeles¹, ¹INIFAP, Ajuchitlán, Colón, Qro, México, ²FESC-UNAM, Ajuchitlán, Colón, Qro, México.

An experiment was carried out to evaluate the productivity, ileal digestibility of nutrients and villi morphology of broilers fed diets based on sorghum and soybean meal (SSBM) including canola meal (CM) and DDGS and added with glucanase, xylanase and phytase enzymes. One hundred and 20 Ross B308 males, individually fed, from 35 to 49 d were assigned to 6 dietary treatments: 1) SSBM diet including 10% CM and 8% DDGS containing 3218 kcal of ME and 0.91% digestible Lys, 2) SSBM, 10% CM, 8% DDGS low-energy (2900 kcal of ME/kg) low-Lys (0.82%) diet, 3) As 2, added with 300 ppm glucanase (Ronozyme VP), 4) As 2) added with 300 ppm of xylanase (Ronozyme WX), 5) As 2) added with 150 ppm of glucanase and 150 ppm of xylanase, and 6) As 5) plus 150 ppm of phytase (Ronozyme-P (CT); Ca and available P were also adjusted in this diet. The daily weight gain was lower and feed conversion ratio was higher ($P < 0.05$) for broilers fed diet 2) with no added enzymes compared with broilers fed diet 1); these variables were partially recovered with added glucanase and xylanase and almost fully recovered when glucanase, xylanase and phytase were combined (Diet 6). The ileal digestibility of dry matter, ashes and nitrogen were lower ($P < 0.05$) for diet 2) compared with diet 1), and

were improved for glucanase, xylanase and glucanase-xylanase added diets. The greatest ashes digestibility was for the glucanase, xylanase and phytase added diet (6) and there was a trend for greater dry matter and nitrogen ileal digestibility in broilers fed the enzyme combination. The height, thickness and area of the villi were reduced in diet 2 ($P < 0.05$), but were totally recovered when the enzymes were combined. In the duodenum, maltase and saccharase specific activities were increased ($P < 0.05$) when enzymes were combined. In summary, the addition of glucanase, xylanase and phytase to low-energy, low-Lys diets including canola meal and DDGS improved the growth, nutrient digestibilities, villi morphology and endogenous enzymes activities in the duodenum of broiler chickens.

Key Words: broilers, enzymes, growth

1111 Allzyme SSF increased AME_n of the corn-soy diet and improved performance of broilers. T. Ao*, J. L. Pierce, B. Hoskins, M. Paul, A. J. Pescatore, A. H. Cantor, M. J. Ford, and W. D. King, *Alltech-University of Kentucky Nutrition Research Alliance, Lexington, KY.*

Allzyme SSF is a naturally fermented product with activities of multiple enzymes such as carbohydrase and phytase. A study was conducted to investigate the effect of supplementing Allzyme SSF on AME_n and retention of P and DM of the diets and growth performance of broiler chicks in a 21d period. Dietary treatments included: 1) corn-soy reference diet containing 3150 kcal ME_n /kg and 0.45% nonphytate P; 2) corn-soy low P and ME diet containing 3000 kcal ME_n /kg and 0.25% nonphytate P; 3) diet 2 + 200 g Allzyme SSF /MT diet; 4) diet 2 + 400 g Allzyme SSF /MT diet. A total of 192 1-d old chicks were randomly assigned to 4 dietary treatments with 8 replicate groups of 6 chicks per treatment. Chicks were housed in starter cages in an environmentally controlled room with an ad libitum access to feed and water. Celite (acid-insoluble ash) was used as an internal marker with an inclusion rate of 1% for the assay of AME_n and retention of P and DM on d 20 by using 24h fecal collection. Chicks fed the low P and ME diet had lower ($P < 0.01$) weight gain and higher ($P < 0.01$) feed to gain ratio compared with other treatment groups. Dietary supplementation of Allzyme SSF in low nutrient diet at both levels increased ($P < 0.01$) weight gain and decreased ($P < 0.01$) feed to gain ratio of chicks. AME_n of the low nutrient diet was increased ($P < 0.01$) by supplementing Allzyme SSF at both levels. The retention of P and DM was significantly increased by supplementing 400 g/MT Allzyme SSF. Data from this trial indicate that supplementation of Allzyme SSF in corn-soy diet can improve the performance of broiler chicks by increasing AME_n value and retention of P and DM of the diet.

Key Words: AME_n , broiler, Allzyme SSF

1112 Effects of multiple dietary manipulations on the mass balance of N and P during the swine finishing phase. T. Walraven*, S. Carter, J. Jarret, M. Bible, and H. Kim, *Oklahoma State University, Stillwater.*

Eighty-eight crossbred (D \times (L \times Y)) pigs (32 kg BW) were used to evaluate the effects of reducing dietary CP, Ca, and P with the addition of phytase on the mass balance of N and P during a 94-d finishing period. Pigs were stratified by sex, weight, ancestry, and randomly allotted to 1 of 2 dietary treatments. Pigs were housed in an environmentally controlled building with 4 identical rooms (22 pigs/room, 2 rooms/treatment). Dietary treatments consisted of a fortified corn-soybean meal diet and a Reduced Excretion (REx) diet. REx had a 3.0% unit reduction in CP with Lys, Thr, and Met added as needed and a reduction of available P of 0.10% with phytase inclusion. Also, in the REx

diet, monocalcium phosphate replaced dicalcium phosphate and CaCl replaced 50% of $CaCO_3$. Diets were formulated to similar SID lysine. The estimation of mass balance, on a per pig basis, assumed that N and P entered the finisher via the feed and pigs, and exited via the slurry, exhaust air, and pigs. On d 0 and 94, 6 and 24 pigs (6/room), respectively, were ground to estimate initial and final body composition. Feed intake and composition were used to estimate N and P entering via feed. Slurry volume and composition, and NH_3 -N emission were used to estimate N and P exiting via slurry and air. The amount of N and P entering via pigs was similar ($P > 0.10$). However, N (5.4 vs. 4.5 kg) and P (1.0 vs. 0.81 kg) in the feed were reduced ($P < 0.03$) for the REx diet. Thus, REx reduced total N (6.4 vs. 5.4 kg; $P < 0.08$) and P (1.2 vs. 0.98 kg; $P < 0.04$) entering by 15 and 20%, respectively. REx did not affect ($P > 0.10$) the amount of N and P exiting via the pigs. However, N (3.2 vs. 2.3 kg) and P (0.64 vs. 0.40 kg) exiting via slurry and NH_3 -N (0.27 vs. 0.15 kg) in exhaust air were reduced ($P < 0.05$) for pigs fed REx. Thus, REx reduced total N and P exiting by 16 and 20%, respectively. The proportion of N and P entering the finisher that exited via the pigs increased from 47 to 55% for N and 49 to 60% for P for pigs fed REx compared with those fed the control diet.

Key Words: pig, nutrient, mass balance

1113 Predicting variations in total and phytic phosphorus in raw materials of plant origin. C. Gady*¹, S. Viriden², and P. A. Geraert¹, ¹Adisseo SAS, Antony, France, ²Adisseo USA Inc., Alpharetta, GA.

The assessment of phosphorus value of ingredients contributes to the optimization of phosphorus nutrition and reduction of phosphorus release into the environment. The main objectives of this study were to measure phytic phosphorus (phytic P) in relation to the total phosphorus (total P) in a range of ingredients and to investigate the prediction of those variations by near infrared spectroscopy (NIRS). A total of 227 samples mainly representing cereals, cereals by-products, oilseeds and oil meals were collected worldwide during one year. All samples were analyzed for their concentrations in total and phytic P using mineralization and enzymatic methods respectively. Additionally, using NIRS, these samples were also analyzed for their absorbances from 1100 to 2500 nm. For all the analyzed samples, prediction models were then calculated to determine correlation between absorbances to both total and phytic P, using mPLS regression. Due to the wide range of ingredients studied, results showed that phytic P content represents from 18% (cassava) to 83% (rice bran) of the total P content. There were also large variations intra-species in the ratio phytic P/total P (and corresponding concentrations in phytic P in % as fed) which ranged from 64 to 87% (0.14-0.30) in corns, from 64 to 80% (0.16-0.27) in wheats, from 66 to 95% (0.54-0.98) in rapeseed meals and from 59 to 69% (0.36-0.57%) in soybean meals. Prediction models developed using NIRS explained 93 and 92% of the variations measured in total and phytic P with standard error of 0.05 and 0.04%. When comparing nonphytic phosphorus calculated from chemistry vs. NIRS of samples external to database, we confirmed differences by 0.01, 0.02, 0.07 and 0.02% as fed for corn, wheat, rapeseed meals and soybean meals respectively. This study confirmed the need for better qualifying major ingredients for their nonphytic phosphorus contribution to feed formulation. With respect to the range measured among ingredients, the feasibility study using NIRS showed that the tool may contribute to better mastering those variations.

Key Words: total phosphorus, phytic phosphorus, near infrared reflectance spectroscopy

1114 A heat-tolerant β -mannanase: Its biochemical properties and effect on broiler growth performance. H. Y. Hsiao*, D. M. Anderson, L. Liu, and M. E. Jackson, *ChemGen Corp., 211 Perry Parkway, Gaithersburg, MD.*

β -Mannanase from *Bacillus lentus* has been shown to improve broiler growth performance and body weight uniformity as well as reduce circulating acute phase protein levels when fed a diet containing soybean meal. Due to its sensitivity to heat, the application of β -mannanase to pelleted feed is limited to spraying liquid enzyme post-pelleting; therefore, improved thermal tolerance would greatly expand its application. Recently, a heat-tolerant β -mannanase (HT) from *Bacillus lentus* is selected and its biochemical properties are described here. The heat tolerance of β -mannanase-HT in a dry formulation was evaluated at the feed mill of Kansas State University. β -Mannanase-HT is shown to have retained 95% and 90% activity when conditioned at 88°C (190°F) with 30 and 60 s of residence time, respectively. β -Mannanase-HT was also found to retain 60% of its activity after incubation under simulated

conditions of the gizzard (pH 3.0, 40°C for 60 min with the presence of 2.8 mg/ml pepsin) and intestine (pH 6.7, 40°C for 120 min with the presence of 1.8 mg/ml pancreatin), consecutively. This result, along with the fact that the pH optimal of β -mannanase-HT is 6.5, suggests that β -mannanase-HT might remain active for a longer duration in a bird's digestive tract. A 42-d male broiler (Cobb \times Cobb) trial was conducted to determine the dosage effect of β -mannanase-HT. The testing diet was a typical corn and soybean meal-based diet. Two thousand chicks were allocated in a randomized complete block design to five treatments, with 8 pens per treatment. The mortality and weight adjusted feed conversion (WAF) of birds supplemented with β -mannanase-HT at four different levels of 22, 44, 66 and 88 MU/ton of feed were determined to be 1.784, 1.770, 1.772 and 1.765, respectively; each of the enzyme groups was significantly better than the WAF of the Control group at 1.927 (linear, $P < 0.05$). It can be concluded that a newly developed form of β -mannanase is heat stable and efficacious in raising broilers.

Key Words: heat-tolerant, β -mannanase, broiler