

Nonruminant Nutrition: Enzymes

363 Apparent and standardized ileal amino acids digestibility of wheat-distillers dried grains with solubles without or with exogenous protease for broilers and turkeys. A. Adebisi* and O. Olukosi, *Scottish Rural University College, Edinburgh, United Kingdom.*

A total of 84 Ross 308 male broilers (Exp. 1) or 84 BUT 10 male turkeys (Exp. 2) at 28 d of age were used for determination of the apparent (AIAAD) and standardized ileal amino acid digestibility (SIAAD) of wheat distillers dried grains with solubles (wheat-DDGS). The birds in both experiments were allocated to 4 dietary treatments consisting of 2 nitrogen-free diets (without or with protease) and 2 semi-purified diets (without or with protease) in which wheat-DDGS was the only source of amino acids (AA). In each of the 2 experiments, there were 7 replicate pens and 3 birds per replicate pen. Protease was added to the diets at a rate of 4,000 protease units per kg. For both broilers and turkeys, the AIAAD or SIAAD of Lys and Asp were very low regardless of protease supplementation. In Exp 1, AIAAD ranged from 35% (Ala) to 75% (Pro) without added protease whereas the range was 42% (Thr) to 82% (Pro) with protease supplementation. Supplemental protease improved ($P < 0.05$) the AIAAD of only Arg and Pro and tended ($P < 0.10$) AIAAD of Met. Without protease supplementation, SIAAD ranged from 51% (Ala) to 84% (Pro) whereas the range was from 65% (Ala) to 93% (Pro) with added protease. Protease addition improved ($P < 0.05$) the SIAAD of Arg, Leu, Phe, Met, Val and Pro by 21, 14, 13, 26, 13 and 10 percentage points, respectively. In Exp. 2, AIAAD was lower than 50% for all AA except for Glu (70%) and Pro (81%) without supplemental protease. On the other hand, SIAAD ranged from 41% (Thr) to 89% (Pro) without added protease whereas the range was from 56% (Arg) to 88% (Pro) with added protease. With the exception of Cys and Pro, protease supplementation improved ($P < 0.05$) the AIAAD and SIAAD of all other AA from between 5 to 19 percentage points. It was concluded from the current experiments that the AIAAD and SIAAD of wheat-DDGS are quite variable and exogenous protease can improve the utilization of AA in wheat-DDGS for broilers and turkeys.

Key Words: wheat DDGS, amino acid digestibility, protease supplementation

364 Effect of a β -mannanase and a β -glucanase combined with a native β -mannanase in diets containing corn-soybean meal-dried distillers grains with solubles and soybean hulls on nursery pig performance. M. Meyers¹, D. Kelly¹, B. Richert¹, J. Ferrel*², and D. Anderson², ¹Purdue University, West Lafayette, IN, ²Elanco Animal Health, Greenfield, IN.

One-hundred thirty-six weaning pigs (initial BW = 5.44 ± 0.019 kg; 17.9 d age) were used to evaluate the effect of a β -mannanase (HTm) and a β -glucanase combined with a native β -mannanase (ZYM) in a corn-soybean meal-dried distillers grains with solubles diet on nursery pig growth performance. Pigs were allocated in a randomized complete block design into mixed-sex pens, stratified by litter and initial BW to 4 dietary treatments, 6 pens per treatment with 5 or 6 pigs per pen. Dietary treatments included: T1, Positive Control (3519, 3455, 3374, 3400 kcal/kg ME; by phase, respectively); T2, Negative Control (3419, 3355, 3274, 3300 kcal/kg ME; by phase, respectively); T3, T2+HTm (0.04 MU/kg mannanase); T4, T2+ZYM (0.08 MU/kg glucanase, 0.10 MU/kg mannanase). Pigs were fed 4 dietary phases over 5 wk: phase 1 (d 0–5), phase 2 (d 5–12), phase 3 (d 12–19), and phase 4 (d 19–33). Diets contained 0, 5, 10, 20% corn DDGS and 1.65, 1.98, 2.59, 2.29%

soybean hulls by phase, respectively. Individual BW and pen feed disappearance were recorded on d5, 12, 19, and 33 and data were analyzed using GLM procedure in SAS. Phase 1 ADG and G:F increased ($P < 0.05$) for T1 and T3 versus T2 and T4, while T4 had greater ($P < 0.05$) ADG over T2 and similar G:F. BW on d5 was greater ($P < 0.05$) for T3 versus T2 and T4. Phase 2 ADG and ADFI tended to be greater ($P < 0.10$) for T3 and pigs fed T3 were heavier ($P < 0.05$) at the end of phase 2 than all other treatments. Phase 3 G:F tended to be greater ($P < 0.10$) for T4 versus T3. Phase 4 ADG was increased ($P < 0.05$) for T3 versus all other treatments, while T1 and T4 ADG tended ($P < 0.10$) to be greater than T2 (536, 515, 584, 553 g/d, T1-T4, respectively) and ADFI was greater ($P < 0.05$) for T3 versus T1 and T2 (765, 771, 851, 824, g/d, T1-T4, respectively). Overall ADG was increased ($P < 0.05$) for T3 versus all other treatments (363, 345, 396, 374 g/d, T1-T4, respectively), and T3 ADFI was greater than T1 and T2 ($P < 0.05$). Supplementation of diets with β -mannanase alone and in combination with β -glucanase can improve nursery pig growth.

Key Words: swine, β -mannanase, β -glucanase

365 Effects of dietary fiber and a xylanase and β -glucanase blend on performance and jejunal electrophysiological properties and transport associated gene expression in growing pigs. A. K. Agyekum*¹, J. S. Sands¹, A. Regassa¹, E. Kiarie³, D. Weihrauch², W. K. Kim¹, and C. M. Nyachoti¹, ¹Department of Animal Science, University of Manitoba, Winnipeg, Manitoba, Canada, ²Department of Biological Sciences, University of Manitoba, Winnipeg, Manitoba, Canada, ³DuPont Industrial Biosciences, Marlborough, Wiltshire, UK.

The effects of supplementing a high fiber diet with exogenous enzymes on intestinal nutrient uptake and transporter activities have not been investigated. Thus, we evaluated the effects of a high fiber diet and xylanase and β -glucanase blend (XB) on performance, jejunal electrophysiological properties (JEP), and gene expressions of Na-dependent glucose transporter 1 (SGLT1), cationic amino acid transporter ($b^{0,+}$), and a mucin gene (MUC1, as an indicator for endogenous AA losses). Twenty-four growing pigs (22.4 ± 0.7 kg BW) were individually housed and randomly assigned to 3 experimental diets to give 8 pigs per diet. The diets were based on corn and soybean meal with either 0% (CTRL) or 30% co-fermented wheat and corn distillers dried grains with solubles (HF); the third diet was HF supplemented with XB (HF+XB). At the end of the 21-d experiment, BW and feed intake, plasma glucose (GLU), and urea nitrogen (PUN) concentrations were determined. Pigs were then euthanized to determine JEP (transepithelial short-circuit current and conductance) and jejunal gene expression using Ussing chambers and quantitative real-time reverse transcription PCR, respectively. Data were analyzed using Proc GLM of SAS with dietary treatment as the main effect in the model. Dietary treatment had no effect ($P > 0.10$) on feed intake and GLU, but pigs fed the CTRL diet had higher ($P < 0.05$) ADG, G:F, and PUN than pigs fed either HF or HF+XB. Additionally, ADG and G:F of pigs fed HF+XB were not different ($P > 0.10$) from pigs fed the HF diet. Furthermore, dietary treatment had no effect ($P > 0.05$) on JEP or jejunal SGLT1, $b^{0,+}$, and MUC1 gene expression. In the present study, the reduced performance of pigs fed HF and HF+XB could not be explained by the jejunal electrophysiological properties or nutrient transporter gene expression.

Key Words: high fiber, xylanase and β -glucanase blend, jejunal electrophysiological properties

366 Effect of xylanase and β -glucanase on performance, nutrients and energy digestibility and retentions and plasma metabolites in nursery pigs fed wheat-barley diets. E. Kiarie*¹, A. Péron¹, A. Owusu-Asiedu¹, P. H. Simmins¹, and C. M. Nyachoti², ¹Dupont Industrial Biosciences-Danisco Animal Nutrition, Marlborough, Wiltshire, UK, ²University of Manitoba, Winnipeg, MB, Canada.

Two experiments were conducted to investigate the efficacy of xylanase and β -glucanase blend (XB) in wheat and barley-based diets for piglets. In Exp. 1, 48 piglets (7 kg BW) were used to evaluate growth performance and apparent total tract digestibility (ATTD) in a 2 phase feeding program. The diets were (A) basal (Phase I: 29% wheat, 26% barley; phase II: 37% wheat, 28% barley), (B) basal + 50 g XB/ton, and (C) basal + 100g XB/ton. The DE in basal was 3.2 Mcal/kg as fed. The xylanase and β -glucanase blend (Danisco Animal Nutrition, Marlborough, Wiltshire, UK) had guaranteed activity of 12,200 and 1,520 units/g, respectively and chromic oxide was used as indigestible marker. Based on BW and sex, piglets were assigned to pens (n = 2) to give 8 pens per diet. Feed intake and BW were measured weekly and fecal samples were collected on pen basis at the end of each phase. Supplemental XB linearly increased ($P < 0.05$) ATTD of DM, CP and energy in both phases. Trends were observed for increased ADG ($P = 0.07$, quadratic) in the overall linked to trends for higher ADFI ($P = 0.09$, linear) in phase I. In Exp. 2, phase II diets (Exp. 1) were fed to 18 growing barrows (20 kg BW) individually housed in metabolism crates (n = 9) that allowed separate collection of feces and urine to determine energy and N retentions. Pigs were fed (4% BW) their assigned diet twice daily for 5 d of adjustment followed by a 5-d total collection of feces and urine and at the end of the trial pigs were fasted overnight and bled to obtain plasma. A linear response ($P < 0.05$) to supplemental XB was observed for ATTD of energy and CP, ME, N retention and plasma glucose. Specifically, pigs fed diet C had higher dietary DE content (3.80 vs. 3.68 Mcal/kg DM) and plasma glucose (107 vs. 102 mmol/l) than diet A. In conclusion, xylanase and β -glucanase blend tended to improve growth performance and improved nutrients and energy utilization in wheat barley based diet for piglets.

Key Words: xylanase and β -glucanase, piglet performance, nutrient utilization and retention

367 The effect of a combination phytase and carbohydrase enzyme on performance and bone mineralization of pigs from 6 weeks to slaughter at 105 kg. P. G. Lawlor¹, P. Cozannet², D. P. Preveraud*², A. Preynat², W. F. Ryan¹, and P. B. Lynch¹, ¹Pig Production Development Unit, Teagasc, Moorepark, Fermoy, Co Cork, Ireland, ²Adisseo France S.A.S. CERN, Commentry, France.

Experiment was conducted to assess effect of a combination of carbohydrase (from *Penicillium funiculosum*) and 6-phytase (from *Schizosaccharomyces pombe*) enzymes (enz; Rovabio Max, Adisseo, France) on performance and bone mineralization of pigs (n = 192 pairs) fed maize-soybean meal diets. Pigs were selected at 28 d of age, penned in pairs and fed a common diet meeting animal requirements for 14 d. Thereafter, 4 diets were formulated for each of 4 stages to slaughter at 147 d post-weaning: (1) Positive control (PC), formulated to meet the recommendations of the National Research Council (NRC 1998); (2) Negative control 1 (NC1; DE \times 0.98, CP \times 0.98, -1.0 g Ca/kg and -1.2 g dig P/kg), (3) Negative control 2 (NC2; DE \times 0.97, CP \times 0.97, -1.0 g Ca/kg and -1.2 g dig P/kg), and (4) Negative control 3 (NC3; DE \times 0.97, CP \times 0.97, -1.5 g Ca/kg and -1.7 g dig P/kg). NC diets were supplemented with enz (50g/ton of feed) resulting in 7 treatments presented as pellet. Feed disappearance, wastage and individual pig BW were recorded at the beginning and end of each phase. Data were

analyzed using GLM procedures of SAS with pen, sex and treatment as fixed effects. Furthermore, the effect of reformulation and enzyme were tested using orthogonal contrasts. Reductions in dietary constituents in control treatments reduced BW, ADFI, ADG throughout the trial ($P < 0.001$). Differences among PC and NC3 were 50 kg, 228 g/d and 127 g/d, respectively. Intermediate values were obtained for NC1 and NC2. Addition of enz to NC diets increased BW, ADFI and ADG up to slaughter and improved Gain:Feed ($P < 0.001$) to d 112 of the trial. Improvement averaged 30 kg, 463 g/d, 393 g/d and 0.03, respectively. There were increases in area bone mineral density (aBMD) of the foot from d 77 onward ($P < 0.01$) and metacarpal aBMD ($P < 0.01$) from d 112 onwards when enz was added. No effect ($P > 0.05$) was found on metacarpal Ca or P content. Enzyme addition to pig diets of low nutrient density can return the performance of the pigs and metacarpal and foot aBMD to levels reached by pigs fed diets meeting NRC recommendations.

Key Words: performance, phosphorus, enzyme

368 The efficacy of graded levels of a new 6-phytase from *Buttiauxella* spp. expressed in *Trichoderma reesei* on ileal amino acid digestibility in pigs fed a corn-soybean meal-wheat midds-corn DDGs-based diet. S. A. Adedokun*¹, A. Owusu-Asiedu², P. Plumstead², and O. Adeola¹, ¹Department of Animal Sciences, Purdue University, West Lafayette, IN, ²DuPont Industrial Biosciences-Danisco Animal Nutrition, Marlborough, UK.

A total of 16 cannulated pigs were used to evaluate the effect of a new 6-phytase derived from *Buttiauxella* spp. expressed in *Trichoderma reesei* on apparent ileal digestibility (AID) of amino acid (AA), N, Ca, and P. Pigs were fed 4 diets for 2 periods in a crossover design. Within each period, there were 4 blocks of 4 pigs per block with each diet represented within each block. The average initial BW in periods 1 and 2 were 22 and 30 kg, respectively. Each period lasted 9 d with fecal collection on d 5 and 6 and 12-h ileal digesta collection on each of d 7, 8, and 9. Pigs received daily feed allowance of approximately 4.5% BW. The experimental diets were based on corn, soybean meal, wheat middlings, and corn distillers dried grain with soluble. Phytase was added at 0, 500, 1000, or 2000 FTU/kg to the basal diet formulated to contain 189, 9.9, 4.57, and 6.25 g/kg of CP, Lys, P, and Ca, respectively. The addition of phytase improved ($P < 0.05$) AID of DM, N, Ca, and P. Increasing phytase supplementation linearly and quadratically increased ($P < 0.05$) the AID of Ca and P. Phytase supplementation of the basal diet improved ($P < 0.05$) AID of P from 46 to 61%. Contrasts showed that phytase supplementation of the basal diet increased ($P < 0.05$) AID for 5 indispensable AA (Arg, Ile, Leu, Phe, and Val), 5 dispensable AA (Asp, Cys, Glu, Ser, and Tyr) as well as for total AA. Furthermore, phytase supplementation to the basal diet showed a tendency ($P < 0.1$) to increase ileal digestibility of His, Lys, Thr, Ala, Gly, and Pro. Ileal digestibility of Met and Trp was not significantly affected by phytase. Increasing level of phytase supplementation resulted in linear increases ($P < 0.05$) in AID of 5 indispensable AA (Arg, Ile, Leu, Phe, and Val) and 2 dispensable AA (Asp, and Glu). The result from this study showed that in addition to increasing P and Ca utilization, the new *Buttiauxella* phytase expressed in *Trichoderma reesei* enhanced ileal digestibility of N and AA in growing pigs in a dose-dependent manner.

Key Words: amino acid, ileal phosphorus digestibility, phytase

369 Effect of enzyme supplementation on the net energy content of dry extruded-expelled soybean meal fed to growing pigs. D.

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The aim of this study was to determine the effect of a multi-enzyme complex (MC) on the net energy (NE) content of dry extruded-expelled soybean meal (DESBM) fed to growing pigs. Twenty-four barrows (16.9 ± 0.76 kg) were allotted in a completely randomized design to 4 dietary treatments to give 6 replicates per treatment. Dietary treatments were; a corn soybean meal basal diet (Diet A), a diet containing Diet A and DESBM in a 80:20 ratio with a constant corn:soybean meal ratio (Diet B), Diet B + 0.05% MC (Diet C) and Diet B + 0.1% MC (Diet D). The MC used was a mixture of carbohydrases and phytase (Superzyme OM). Pigs were fed in metabolism crates for a period of 16 d at 550 kcal of metabolisable energy (ME)/kg BW^{0.60}/d to determine digestible energy (DE) and ME contents using total collection method. Thereafter, pigs were moved into an indirect calorimeter (IC) where heat production was measured over a 36-h period based on O₂ consumption and CO₂ production. The energy content of DESBM was calculated using the

difference method. The DE and ME contents obtained were 3,365, 3,361, 3,401 and 3,381 kcal/kg DM and 3,260, 3,245, 3,295 and 3,283 kcal/kg DM for Diet A, B, C, and D, respectively. Corresponding values for NE were 2,897, 2,823, 2,848 and 2,842 kcal/kg DM. The heat production values among treatments (i.e., A, B, C and D) were 1,595, 1,606, 1,602 and 1,595 kcal/kg DM and those for fasting heat production were 1,231, 1,184, 1,173 and 1,154 kcal/kg DM, respectively. Thus, the NE content of DESBM was determined to be 2,527, 2,652 and 2,621 kcal/kg DM in treatment B, C and D, respectively. Respective values obtained with published equations were 2,305, 2,435 and 2,362 kcal/kg DM. Data was analyzed using mixed procedure of SAS 9.2. The results demonstrated that enzyme supplementation improved ($P < 0.0001$) the energy content of both diet and test ingredient. In conclusion, supplementation with MC at 0.05% and 0.1% of the diet improved NE values of DESBM by 4.9% and 3.7%, respectively.

Key Words: dry extruded expelled soybean, net energy, pig.