

## Nonruminant Nutrition: Enzymes

**M203 Effects of dietary enzyme fermented wheat on growth performance, nutrient digestibility, blood characteristics, and fecal noxious gas emission in growing pigs.** X. Y. Guo\*, H. Y. Baek, and I. H. Kim, *Dankook University, Cheonan, Choongnam, South Korea.*

This research was conducted to evaluate the effect of dietary enzyme fermented wheat (FW) on growth performance, nutrient digestibility, blood characteristics, and fecal noxious gas in growing pigs. A total of 120 pigs with initial BW of  $29.6 \pm 1.9$  kg [(Landrace  $\times$  Yorkshire)  $\times$  Duroc] were randomly allotted into 1 of 5 dietary treatments with 6 replicate pens per treatment and 4 pigs per pen. Every pen was equipped with semi-automatic feeder and nipple drinker. The pigs were housed in an environmental controlled, slatted-floor facility in 30 adjacent pens and were allowed ad libitum access to feed and water. The temperature and humidity of animal house were maintained at 24°C and 60%, respectively. This experiment lasted for 6 wk. Pigs were fed a common corn-soybean meal based diet for a 3 d adjustment period and then fed experiment diets. The experiment diets were formulated based on corn-soybean meal with FW at different levels of 0%(FW0), 5%(FW5), 10%(FW10), 15%(FW15) and 20%(FW20). All experiment diets contained a total of 20% of wheat. The FW were treated by protease (26,014 U/g), amylase (7,176 U/g) xylanase (799 U/g), cellulose (5,204 U/g) and a-galactosidase (176 U/g) for 72 h. Pigs fed FW15 diet had higher ADG than pigs fed FW0 diet ( $P < 0.05$ ), however, no difference was observed in ADFI and G:F among all dietary treatments ( $P > 0.05$ ). Apparent total tract digestibility (ATTD) of DM and N in FW10, FW15 and FW20 treatments were higher (84.63, 84.60, 84.47 vs. 82.40%,  $P < 0.05$ ) than that in FW0 group. Concentrations of blood glucose, RBC, WBC and lymphocyte percentage were not affected ( $P > 0.05$ ) by dietary FW. There was no difference ( $P > 0.05$ ) in fecal noxious gas concentration ( $H_2S$ , Acetic acid and  $NH_3$ ) among all treatments. In conclusion, ADG can be improved by FW15 and ATTD of DM and N can be enhanced by FW10, FW15 and FW20.

**Key words:** fermented wheat, growing pigs, growth performance

**M204 The effect of enzyme fermented corn on growth performance, nutrient digestibility, blood profile, and fecal gas emission in growing pigs.** P. Y. Zhao\*, S. C. Kim, and I. H. Kim, *Dankook University, Cheonan, Choongnam, South Korea.*

This study was conducted to evaluate the effect of fermented corn (FC) on growth performance, nutrient digestibility, blood profile, and fecal gas concentration in growing pigs. A total of 96 pigs [(Landrace  $\times$  Yorkshire)  $\times$  Duroc] with an average initial BW  $24.4 \pm 1.1$  kg were used in a 6 wk trial. All pigs were randomly allotted to 1 of 4 treatments (6 replicate pens per treatment with 4 pigs per pen). The experiment lasted for 6 wk. Treatments included: 1) CON (0% FC), 2) FC1 (10% FC), 3) FC2 (20% FC) and 4) FC3 (30% FC). All treatment diets contained 30% corn. The FC was pre-treated xylanase, cellulose and hemicellulase. Data were subjected to the GLM procedures and Duncan multiple range test was used to compare the means of the treatments. The FC were treated by protease (26,014 U/g), amylase (7,176 U/g) xylanase (799 U/g), cellulose (5,204 U/g) and a-galactosidase (176 U/g) for 72 h. There were no differences on growth performance among all dietary treatments during the overall period. Apparent total tract digestibility (ATTD) of DM and energy were higher in FC2 than CON, FC1, and FC3 throughout the experiment (83.37 vs. 81.36, 80.17, 81.72; 86.81 vs. 84.01, 82.59, 84.28%;  $P < 0.05$ ). Blood glucose concentration in FC1 treatment was decreased compared with CON treatment (106.75

vs. 114.72 mg/dl;  $P < 0.05$ ) and there were no differences on white blood cells (WBC), red blood cells (RBC) counts, and lymphocyte percentage among all the dietary treatments. Fecal  $H_2S$  measured on d 5 and 7 was reduced (6.7, 6.6 vs. 8.6; 6.9, 7.0 vs. 8.6 mg/kg;  $P < 0.05$ ) in FC2 and FC3 treatments compared with CON. Acetic acid was lower (21.8, 23.5 vs. 25.8 mg/kg;  $P < 0.05$ ) in FC2 and FC3 treatments than CON treatment on d 7. In conclusion, feeding enzyme fermented corn in growing pig diet improves nutrient digestibility without any negative effect on growth performance and meat quality. Furthermore, fermented corn can reduce fecal noxious gas emission content.

**Key words:** fermented corn, growing pigs, nutrient digestibility

**M205 Effects of enzyme fermented oat on growth performance, digestibility, blood profile, and fecal gas emission of growing pigs.** S. Zhang\*, J. M. Lee, and I. H. Kim, *Dankook University, Cheonan, Choongnam, South Korea.*

The objective of this study was to evaluate the effects of enzyme fermented oat (FO) on growth performance, digestibility, blood profile, and fecal gas in growing pigs. A total of 125 pigs [(Landrace  $\times$  Yorkshire)  $\times$  Duroc] with an average initial BW of  $20.5 \pm 0.8$  kg were used in a 6 wk growth trial, and were allotted to 5 dietary treatments in a randomized complete block design. There were 5 pens per treatment with 5 pigs per pen. Dietary treatments included: 1) CON (100% nature oat), 2) FO1 (75% nature oat + 25% FO), 3) FO2 (50% nature oat + 50% FO), 4) FO3 (25% nature oat + 75% FO) and 5) FO4 (100% FO). The oats, before added to diets, were treated by protease (26,014 U/g), amylase (7,176 U/g) xylanase (799 U/g), cellulose (5,204 U/g) and a-galactosidase (176 U/g) for 72 h. Data were subjected to the GLM procedure of SAS. In result, there was no difference in growth performance (ADG, ADFI, and G:F) among dietary treatments ( $P > 0.05$ ). Apparent total tract digestion (ATTD) of DM was higher in FO2 group than CON group throughout the experiment ( $P < 0.05$ ), as well as no difference was observed among FO2, FO3 and FO4 groups ( $P > 0.05$ ). ATTD of energy was higher in FO2, FO3 and FO4 than CON group, throughout the experiment ( $P < 0.05$ ). Plasma glucose concentration, red blood cell (RBC) and white blood cell (WBC) counts, and lymphocyte percentage did not differ among treatments. No difference was observed in fecal gas ( $H_2S$ , Acetic acid,  $NH_3$ ). In conclusion, the FO has a beneficial effect on the ATTD of DM and energy.

**Key words:** fermented oat, growing pigs, growth performance

**M206 Effects of emulsifier and multi-enzyme on growth performance, organ weight, meat quality and blood characteristics in broilers.** S. C. Kim\*, H. J. Kim, and I. H. Kim, *Dankook University, Cheonan, Choongnam, South Korea.*

This study was conducted to evaluate the effects of emulsifier and multi-enzyme on growth performance, organ weight, meat quality and blood characteristic in broilers. A total of 672 Ross 308 broilers with an initial BW of  $34 \pm 5$  g were allotted into 1 of the 6 treatments (16 broilers per pen and 7 replicate pens per treatments). Dietary treatment included: 1) PC (basal diet), 2) NC (basal diet - 100 kcal down spec.), 3) R05 (NC + 0.05% emulsifier), 4) R10 (NC + 0.10% emulsifier), 5) E05 (NC + 0.05% multi-enzyme), and 6) E10 (NC + 0.10% multi-enzyme). The experiment lasted for 35 d. Data were subjected to the GLM procedures and Duncan multiple range test was used to com-

pare the means of the treatments. Overall the experiment, BWG was higher in R10 and E10 treatments than NC treatment (1,454, 1,446 vs. 1,358 g;  $P < 0.05$ ). Liver weight was higher in E10 treatment than NC and R10 treatments (3.75 vs. 2.45, 2.54%;  $P < 0.05$ ). Spleen weight was increased in R05, E05 and E10 treatments compared with PC, NC and R10 treatments (0.16, 0.14, 0.18 vs. 0.09, 0.10, 0.10%;  $P < 0.05$ ). Breast muscle weight was higher in PC, R05 and E05 treatments than E10 treatment (9.86, 9.28, 9.20 vs. 7.24%;  $P < 0.05$ ). Abdominal fat weight was greater in E10 treatment than other treatments (2.12 vs. 1.28, 0.51, 1.24, 1.16, 1.12%;  $P < 0.05$ ). NC treatment had a higher WHC than other treatments (80.67 vs. 73.83, 69.71, 68.08, 63.86%;  $P < 0.05$ ). Lightness of breast meat was higher in NC treatment than that in PC, R10 and E05 treatments (64.33 vs. 57.12, 57.92, 58.17%;  $P < 0.05$ ). In drip loss, NC treatment was higher compared with PC, R05, R10 and E05 treatments on d1 (6.52 vs. 2.70, 3.51, 3.56, 2.97%;  $P < 0.05$ ), NC treatment was higher compared with PC and E05 treatments on d3 (14.74 vs. 8.75, 8.26%;  $P < 0.05$ ), and NC treatment was higher compared with PC treatment on d5 (18.29 vs. 10.50%;  $P < 0.05$ ). In conclusion, the dietary supplementation emulsifier and multienzyme can bring benefit on BWG, relevant organ weight, WHC, breast meat color and drip loss.

**Key words:** broilers, emulsifier, multi-enzyme

#### M207 Hydrolysis of native starches by gastric enzymes in vitro:

**1. Relationship between starch hydrolysis and organic matter digestibility.** O. O. Adeleye<sup>\*1</sup>, A. D. Ologhobo<sup>1</sup>, P. A. Iji<sup>2</sup>, and O. A. Adebisi<sup>1</sup>, <sup>1</sup>Department of Animal Science, University of Ibadan, Department of Animal Science, University of Ibadan Ibadan, Oyo State, Nigeria, <sup>2</sup>School of Environmental and Rural Sciences, University of New England, School of Environmental and Rural Sciences, University of New England Armidale, NSW, Australia.

An investigation was carried out using a 2-step enzymatic model simulating foregut digestibility to study the relationship between starch hydrolysis and organic matter digestibilities of different native starches. Starches of sago, rice, wheat, corn, sweetpotato, arrowroot and potato as well as sweetpotato meal, cassava pulp and tapioca were selected based on their starch content ranging from 575.1 to 846.3mg/g OM. Substrates were incubated in a pepsin/HCl solution for 1.5 h and subsequently in potassium phosphate buffer containing pancreatin and amylase for 1, 2, 3 and 6 h. Hydrolyzed starch and residual organic matter were measured at each time point. Starch hydrolysis ranged from 9.8% in potato starch to 85.5% in sago starch with their corresponding organic matter digestibilities of 22.36% and 95.04% respectively at 6 h of incubation. Relationship between starch hydrolysis and organic matter digestibility for all substrates could be described by: Starch hydrolysis (mg/g OM) =  $-93.1 + 0.91 \times$  organic matter digestibility at incubation time  $t$ ,  $R^2 = 0.8$ . While relationship between starch hydrolysis and organic matter digestibility for individual substrates were described with  $R^2$  ranging from 0.8 to 0.99. Organic matter digestibility was also seen to precede the take off of starch hydrolysis for all substrates studied confirming that digestion of non-starch fractions occurred prior and simultaneously with starch hydrolysis. Variations in starch hydrolysis for the different substrates were attributed to their granular sizes and crystalline structures.

**Key words:** starch hydrolysis, organic matter digestibility, in vitro

#### M208 Performance of 1- to 42-day-old broilers fed diets containing multienzyme complex and lipid sources.

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This work was carried out at the São Paulo State University, Botucatu Campus, Brazil, with the aim of evaluating the performance of broilers fed diets containing a multienzyme complex (MeC) and different lipid sources from 1 to 42 d of age. A total of 840 1-d-old male Cobb chicks were housed, allotted in a completely randomized design featuring a  $2 \times 2+2$  factorial arrangement, 2 lipid sources (soybean oil and poultry fat) with 2 inclusion levels (2% and 4%) in feeds supplemented with MeC; and 2 control treatments without added lipids – a positive control using MeC-supplemented feed, and a negative control without added MeC. There were 4 replications with 35 broilers per experimental unit (density = 14 birds/m<sup>2</sup>). Mean initial chick weight was 44.55 g. The different feeds featured similar energy and AA levels within each breeding phase, and were formulated based on corn and soybean meal. Water and feed were supplied ad libitum. There was no interaction ( $P > 0.05$ ) between lipid source and inclusion level for the following studied variables: BW, ADG, ADFI and G:F. Birds fed diets containing lipids in feed showed greater ( $P < 0.01$ ) BW and ADG than those fed lipid-free diets. Lipid sources did not influence ( $P > 0.05$ ) broiler performance, which can be attributed to the higher ratio of unsaturated and polyunsaturated fatty acids in poultry fat as compared with other animal fat sources, making it an excellent alternative to soybean oil. The inclusion of 4% lipid in feed led to greater ( $P < 0.01$ ) BW (2.812 g vs. 2.701 g), ADG (2.768 g vs. 2.657 g) and ADFI (4.827 g vs. 4.579 g) compared with 2% inclusion, which demonstrates that incorporating higher levels of oil into feed benefits growth and increases intake. G:F was not influenced ( $P > 0.05$ ) by the treatments. The inclusion of 4% lipid in feed increases ADG and BW of birds, regardless of lipid source. Diets without lipid inclusion – with or without MeC – show inferior performance to the others.

**Key words:** poultry fat, soybean oil

#### M209 Carcass and cuts yield, and abdominal fat level in 42-day-old broilers subjected to diets containing multienzyme complex and lipid sources.

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This work was carried out at the experimental slaughterhouse of the São Paulo State University, Botucatu Campus, Brazil, with the aim of evaluating carcass yield, cuts and abdominal fat level in broilers fed diets containing multienzyme complex (MeC) and different lipid sources at 42-d of age. A total of 840 1-d-old male Cobb chicks were housed in 24 boxes at an experimental aviary, with density equal to 14 birds/m<sup>2</sup>. The broilers were raised from 1 to 42 d of age in a completely randomized design featuring a  $2 \times 2+2$  factorial arrangement, 2 lipid sources (soybean oil and poultry fat) with 2 inclusion levels (2% and 4%) in feeds supplemented with MeC; and 2 control treatments without added lipids – a positive control using MeC-supplemented feed, and a negative control without added MeC. There were 4 replications with 35 broilers per experimental unit. The different feeds featured similar

energy and AA levels within each breeding phase, and were formulated based on corn and soybean meal. Water and feed were supplied ad libitum. At 42 d of age, 5 birds per replication were slaughtered following an 8-h fast to determine carcass and cuts yield, and abdominal fat percentage. Carcass yield was determined by considering the weight of the dressed and eviscerated carcass (without feet, head and neck) in relation to live fasting weight obtained just before slaughter. For the other cuts (breast, drumstick and thigh, back and abdominal fat), yield was calculated in relation to eviscerated carcass weight. The treatments did not influence ( $P > 0.05$ ) any of the variables. Multi-enzyme complex and lipid sources do not influence carcass and cuts yield, or abdominal fat level of broiler chickens.

**Key words:** poultry fat, soybean oil

**M210 Effect of dietary phytase on performance, digestive enzymes and intestinal morphology in weaned pigs.** M. C. Shields<sup>\*1</sup>, E. van Heugten<sup>1</sup>, C. H. Stahl<sup>1</sup>, A. J. Moeser<sup>2</sup>, P. W. Plumstead<sup>3</sup>, and M. H. Borgmann<sup>1</sup>, <sup>1</sup>Department of Animal Science, North Carolina State University, Raleigh, <sup>2</sup>Department of Clinical Sciences and Molecular, Biomedical Sciences, College of Veterinary Medicine, North Carolina State University, Raleigh, <sup>3</sup>Danisco Animal Nutrition, Marlborough, Wiltshire, UK.

This study was designed to evaluate the effect of an *E. coli* phytase on weaned pig performance, trypsin and chymotrypsin activity in the small intestine, and intestinal morphology. Pigs ( $n = 40$ ; BW =  $9.72 \pm 0.36$  kg) were weaned at 21 d of age and housed individually. Pigs were acclimated and fed a common starter diet for 14 d before being assigned to 1 of 5 dietary treatments. Treatments consisted of a positive control diet (PC) without phytase (0.6% total P and 0.29% available P) and a negative control diet (NC) (0.45% total P and 0.14% available P) supplemented with 1 of 4 levels of phytase (0, 500, 1000, 2000 FTU/kg). Diets were corn-soybean meal based with 1.2% SID lysine and fed in mash form for 2 wk. Phytase supplemented at 2000 FTU/kg diet tended to increase ADG in a step-wise manner with increasing phytase dose ( $P = 0.10$ ) to the highest phytase dose of 2000 FTU/kg. Increasing dietary phytase content linearly improved G:F ratio ( $P < 0.05$ ; 0.52, 0.57, 0.59, 0.78 for 0, 500, 1000 and 2000 FTU of phytase, respectively). Phytase supplementation also tended to decrease linearly ADFI ( $P = 0.07$ ; 0.78, 0.73, 0.73, 0.67 kg/d). As dietary phytase increased, there was a numerical increase in duodenal trypsin activity (quadratic  $P = 0.13$ ; 79.3, 97.8, 133.7, 108.9 units/mg protein). Phytase supplementation did not impact ileal trypsin ( $P = 0.83$ ) or chymotrypsin activity ( $P = 0.44$ ). Phytase linearly decreased duodenal villi height ( $P = 0.03$ ; 310, 191, 193, 177  $\mu$ m). Ileal villi height was lower for PC than NC ( $P < 0.05$ ; 150.3 vs. 177.8  $\mu$ m), and duodenal ( $P = 0.07$ ; 55.6 vs. 67.0  $\mu$ ) and ileal ( $P = 0.09$ ; 54.2 vs. 62.3  $\mu$ ) villi width tended to be lower for PC compared with NC, but they were not impacted by phytase. Dietary treatments did not impact crypt

depth in the duodenum ( $P = 0.84$ ) or ileum ( $P = 0.19$ ). Phytase supplementation did not affect pH in the stomach ( $P = 0.92$ ), duodenum ( $P = 0.38$ ) or ileum ( $P = 0.29$ ). Duodenal pH was increased ( $P = 0.05$ ) in PC (5.92) when compared with NC (5.62). In conclusion, phytase improved nursery pig performance, increased trypsin activity in the duodenum, and decreased duodenal villi height in weaned pigs.

**Key words:** phytase, pigs, enzymes

**M211 Effect of carbohydrase complex and phytase combined in corn-soybean meal diet for pigs.** M. Ceccantini<sup>\*1</sup>, B. V. Freitas<sup>2</sup>, M. M. Mota<sup>3</sup>, N. B. Petrolí<sup>3</sup>, C. C. Silva<sup>3</sup>, C. S. S. Araujo<sup>2</sup>, and L. F. Araujo<sup>3</sup>, <sup>1</sup>Adisseo, Sao Paulo, SP, Brazil, <sup>2</sup>FMVZ/USP, Pirassununga, SP, Brazil, <sup>3</sup>FZEA/USP, Pirassununga, SP, Brazil.

This experiment was conducted to evaluate the effect of a multiple enzyme complex containing carbohydrases and 6-phytase (Rovabio Max AP, Adisseo) on the performance and carcass characteristics of pigs fed a corn-soybean meal diet. 96 barrows (7 wk old) were assigned to a randomized block design and fed 3 experimental diets with 8 replicates (4 pigs/pen) for 100 d. The positive control diet was a standard diet formulated to meet the requirement of all nutrients, while the negative control diet was reformulated with reductions in energy (85 kcal ME/kg at initial phase, and 65 kcal ME/kg at the other phases), 3% of protein, 3% of digestible AA, 0.15% of Av.P, and 0.10% of Ca. The treatments were: T1- Positive control diet, T2 - Negative control diet supplemented with enzyme, T3- Negative control diet. At 100 d, one barrow/pen was slaughtered and fat thickness, muscle thickness, lean meat and muscle color were measured. For the purpose of distribution of pig carcasses into commercial classes according to SEUROP system methods, which is a method that classifies carcass according to lean percentage, all carcass sides were categorized into different classes (S, > 60%; E, 55 to 60%; U, 50 to 55%; R, 45 to 50%; O, 40 to 45%; and P, < 40% carcass lean). Barrows fed a diet supplemented with enzymatic complex showed better ADG (0.875, 0.913, and 0.856, respectively), G:F (2.44, 2.34, 2.46, respectively), and lower fat thickness (29, 24, and 26 mm respectively) than other treatments ( $P < 0.05$ ). None of treatments resulted in classification of carcasses into the meat class of highest meat ratio (S) or lowest meat ratios (P). However, the use of the enzyme complex resulted in higher carcass ratio U (12.5, 37.5, and 12.5% respectively) than other treatments, and positive control treatment showed higher carcass ratio O (75, 25, and 37.5%, respectively). There was no difference to the other characteristics. The results indicated that dietary enzyme supplementation in corn and soybean meal based diet is efficient in reducing costs, by reducing nutrients requirements, without compromising performance and carcass characteristics.

**Key words:** carcass characteristics, enzymatic complex, performance