

Betaine fed at 0.15% decreased CPK in pigs experiencing heat stress on d 3 but not d 28 (27.8, 12.6, 5.7, and 23.6 U/mL; $P = 0.04$). Heat stress affected growth and blood chemistry, but betaine had minimal impact on alleviating heat stress with the possible exception of early days of heat exposure.

Key Words: betaine, heat stress, pigs

NONRUMINANT NUTRITION: NURSERY MANAGEMENT AND NUTRITION

- 129 **Effect of nursery diet protein quality and fish oil supplementation on growth performance, immune response, and gut morphology in starter pigs.** S. Hooda*, N. Richmond, N. A. Karrow, C. F. M. de Lange, *Department of Animal and Poultry Science, University of Guelph, Guelph, ON, Canada.*

Previous research has demonstrated that diet quality affects growth performance and immune response of starter pigs. This study was conducted to assess the interactive effects of feeding dietary protein quality and oil types on growth performance, immune response, and gut morphology in starter pigs. Newly weaned pigs (21 d age; BW = 6.25 ± 0.83 kg) were randomly assigned to 4 dietary treatments (3 pens/treatment; 10 pigs/pen), as a 2×2 factorial design, with differing diet protein quality (High vs. Low; animal vs. soybean protein) and 5% oil (Fish vs. Corn). Pigs were fed according to a three phase program: diets fed for 7, 14, and 21 d, respectively. On d 6 and 20 postweaning, 12 pigs per treatment were vaccinated with 0.5 mg ovalbumin (OVA), 0.5 mg killed *C. albicans* (CAA), and 0.5 mg Quil A adjuvant in 1 mL saline. Blood samples were collected at d 20 and 34 for determination of anti-OVA antibodies and d 22 and 28 for haptoglobin (Hp) analysis. The delayed type hypersensitivity (DTH) reaction was evaluated on d 17 and 48 using intradermal injection of OVA and CAA in the ear, and ear thickness was measured at 6 h postinjection. Per treatment, 6 pigs were euthanized at 2, 4, and 8 wk postweaning and jejunum samples were collected to evaluate morphology. Data were analyzed as a Mixed model procedure of SAS. There were no significant interactions ($P > 0.10$) between main effects. During the 6 wk starter period, ADG was greater ($P < 0.05$; 422 vs. 385 g) for pigs on High; High- and Fish-fed pigs had greater feed efficiency (G:F) ($P < 0.05$; 0.750 vs. 0.721 and 0.775 vs. 0.695). Diet did not affect ($P > 0.10$) primary or secondary antibody immune response to OVA. At d 17, DTH

Table 130.

								<i>P</i> <		
SID Lys:	High	Low						Phytase		
Phytase, FYT/kg:	250	250	500	1000	2000	3000	SEM	Lysine	Linear	Quadratic
ADG, kg	0.57	0.54	0.55	0.57	0.57	0.55	0.008	0.02	0.10	0.02
ADFI, kg	0.88	0.88	0.88	0.89	0.91	0.88	0.016	0.74	0.44	0.23
G:F	0.644	0.618	0.632	0.636	0.626	0.632	0.007	0.01	0.34	0.29

response to OVA was greater ($P < 0.05$) in pigs fed Low diets. At d 48, DTH response to CAA tended to be lower ($P < 0.10$) for pigs fed Low and Fish diets. The vaccination protocol increased ($P < 0.05$) serum Hp and these were lower in pigs on Fish ($P < 0.05$; 0.40 vs. 0.25 g/L). Diet did not impact villus height or villus height: crypt depth ratio; crypt depth was greater (353 vs. 275 and 345 vs. 282 μ m; $P < 0.05$) at wk 4 in pigs fed Low and Corn. Diet protein quality appears strongly related to growth performance while fish oil improves feed efficiency and attenuates haptoglobin response of starter pigs.

Key Words: fish oil, protein quality, starter pigs

- 130 **Effects of high levels of phytase in low lysine diets on the growth performance of nursery pigs.** J. R. Flohr^{1,*}, R. D. Goodband¹, M. D. Tokach¹, S. S. Dritz¹, J. M. DeRouchey¹, J. Woodworth¹, K. B. Langbein¹, J. R. Bergstrom², ¹Kansas State University, Manhattan, ²DSM Nutritional Products, North America, Marshall, MO.

Two studies were conducted to determine the effects of added phytase in nursery diets formulated at or below their Lys requirement. In both studies, diets with the lowest phytase levels were formulated to meet the available P requirement. In Exp. 1, 360 barrows (PIC 327 $\times$ 1050; initially 12.4 kg) were used in an 18-d study with 5 pigs per pen and 18 pens per treatment in a university research facility. Pens were randomly allotted to diets in a 2×2 factorial with main effects of Lys level (adequate vs. marginal; 1.20 vs. 1.05% standardized ileal digestible [SID] Lys) and phytase level (500 vs. 3000 FYT/kg; Ronozyme®HiPhos®, DSM). Overall (d 0 to 18), there were no ($P > 0.05$) lysine $\times$ phytase interactions and no differences were observed between phytase levels. Pigs fed adequate Lys diets had greater ($P < 0.01$) ADG, G:F, and BW than those fed marginal Lys. In Exp. 2, 2592 nursery pigs (PIC 337 $\times$ 1050; initially 10.4 kg) were fed 1 of 6 diets over 2 phases in a 36-d commercial research study. There were 27 pigs per pen and 16 pens per treatment. Dietary treatments included an adequate Lys (1.20 and 1.10% SID Lys in Phase 1 and 2, respectively) positive control diet containing 250 FYT/kg of phytase or 5 low Lys (1.10 and 1.00% SID Lys in Phase 1 and 2, respectively) diets with 250, 500, 1000, 2000, or 3000 FYT/kg of phytase. Overall (d 0 to 36), pigs fed the positive control had greater ($P < 0.02$) ADG and G:F than pigs fed the low-Lys diet (Table). Increasing phytase increased (quadratic, $P < 0.02$) ADG with maximum response at 1000 FYT/kg. Phytase did not affect G:F. In summary, these studies illustrate the im-

portance of feeding adequate Lys to optimize ADG and G:F. Additionally, the trials show a difference between university and commercial settings because only the commercial study yielded a detectable phytase response, where pigs fed the low-Lys diet with 1000 FYT/kg phytase had performance similar to pigs fed high Lys diets containing 250 FYT/kg phytase.

Key Words: nursery pigs, phosphorus, phytase

- 131 **Effects of diet complexity, antibiotics, and benzoic acid on nursery pig growth performance.** J. E. Nemecek^{1,*}, M. D. Tokach¹, J. R. Bergstrom², J. M. DeRouchey¹, S. S. Dritz¹, R. D. Goodband¹, ¹Kansas State University, Manhattan, ²DSM Nutritional Products, North America, Marshall, MO.

Two 28-d experiments were used to determine the effects of diet complexity, antibiotics, and benzoic acid on nursery pig (PIC 327 × 1050) growth performance. Both experiments were arranged as 2 × 2 factorials with main effects of benzoic acid (Vevovital, DSM Nutritional Products, Parsippany, NJ) and diet complexity (Exp. 1) or antibiotics (Exp. 2). Each experiment had 6 or 7 pigs per pen and 10 pens per treatment. In Exp. 1, 280 pigs (initially 7.0 kg) were used. Benzoic acid levels were 0 or 0.5% fed from d 0 to 28. Diet complexities (simple or complex) were fed from d 0 to 14 followed by a 14-d common diet. Complex diets contained 10% dried whey, 1.25% select menhaden fish meal, 1.25% spray-dried blood cells, and 0.25% zinc oxide and simple diets did not contain lactose, zinc oxide, or specialty protein sources. No interactions were detected between diet complexity and benzoic acid and no benzoic acid main effects were observed. From d 0 to 14, pigs fed simple diets had decreased ($P < 0.001$) ADG (186 vs. 277 g), ADFI (304 vs. 381 g), and G:F (0.612 vs. 0.726). From d 14 to 28, pigs previously fed simple diets tended to have increased ($P < 0.06$) ADG (585 vs. 567 g) and increased ($P < 0.003$) G:F (0.679 vs. 0.651). Overall (d 0 to 28), pigs fed simple diets had decreased ($P < 0.001$) ADG (386 vs. 417 g) and ADFI (581 vs. 626 g). In Exp. 2, 240 pigs (initially 7.3 kg) were used. Benzoic acid levels were 0 or 0.5% fed from d 0 to 28. Antibiotic (carbadox) levels were 0 or 55 ppm from d 0 to 14 and 0 or 27.5 ppm from d 14 to 28. From d 0 to 14, pigs fed diets without antibiotic tended to have increased ($P < 0.07$) G:F (0.736 vs. 0.710). From d 14 to 28, pigs fed diets without antibiotic had decreased ($P < 0.01$) ADG (553 vs. 603 g), ADFI (857 vs. 903 g), and G:F (0.646 vs. 0.668). Overall (d 0 to 28), pigs fed diets without antibiotic had decreased ($P < 0.02$) ADG (422 vs. 449 g) and ADFI (626 vs. 662 g). No main effects of benzoic acid were observed. In conclusion, pigs fed complex diets or antibiotics had improved growth performance, but no differences were observed from including benzoic acid in the diets.

Key Words: benzoic acid, diet complexity, pig

- 132 **Soluble fiber and insoluble fiber sources added to enterotoxigenic *Escherichia coli*-challenged pigs after weaning influence production and β -hemolytic *E. coli* excretion.** J. Pluske^{1,*}, J. C. Kim², ¹Murdoch University, Western Australia, Australia, ²Department of Agriculture and Food, Western Australia, Australia.

Different dietary and/or feeding strategies to ameliorate the postweaning malaise are being examined given increased scrutiny of the use of antimicrobial agents in diets. The extent to which dietary fiber and the balance between soluble and insoluble fiber might modify gastrointestinal tract structure and function to influence performance and health after weaning in the absence of dietary antimicrobials has not been fully established. An experiment using 96 individually housed male pigs was conducted having a 2 × 4 factorial arrangement of treatments, with factors being added (mostly) soluble fiber (approximately 8 versus 48 g/kg) and four levels of high insoluble fiber (added as wood cellulose; 0, 30, 60, and 90 g/kg). Ground white rice was used as the cereal. Antimicrobial-free diets were fed for 2 wk after weaning, after which time all surviving pigs were fed a commercial diet for another week. All pigs were orally inoculated with an enterotoxigenic *E. coli* strain (0149:K91:F4) on d 5, 6, and 7 after arrival to induce diarrhea. On d 8 and 9 after weaning, a subsample of pigs from each treatment was humanely euthanized. There were positive linear effects ($P = 0.046$ and $P = 0.019$) of wood cellulose inclusion level on bodyweight at d 14 and d 21, respectively. In the first 14 d after weaning, each 10 g/kg increase in the analyzed dietary NDF content (to approximately 100 g/kg) increased average daily gain (ADG) and average daily feed intake (ADFI) by 6.4 and 8.1 g/d ($R^2 = 0.84$, $P = 0.085$ and $R^2 = 0.89$, $P = 0.056$, respectively) whilst each 10 g/kg increase in the analyzed dietary ADF content (to approximately 50 g/kg) increased ADG and ADFI by 10.6 and 13.3 g/d ($R^2 = 0.89$, $P = 0.058$ and $R^2 = 0.95$, $P = 0.027$, respectively). There were significant main effects of wood cellulose level on the feed conversion ratio (FCR) in the first 7 ($P = 0.018$) and 14 ($P = 0.028$) d after weaning, but FCR from d 15 through 21 and over the entire 21-d period was determined by an interaction between soluble and insoluble fiber sources ($P = 0.035$ and $P = 0.038$, respectively). At d 9 postweaning, increasing amounts of insoluble fiber linearly decreased ($P = 0.010$) the fecal excretion of β -hemolytic *E. coli*; however, there were no differences ($P > 0.05$) between fiber treatments for the diarrhea index or the number of therapeutic antibiotic treatments given.

Key Words: diarrhea, fiber, weaning