

significant; however, only main effects are discussed in this abstract due to space limitations ($P < 0.0001$). Both commercial formaldehyde treatment and organic acid addition decreased RNA concentration of PEDv compared with the control ($P < 0.05$), with the commercial formaldehyde treatment being the most effective on d 0 by decreasing the CT by 1.4 to 2.8 CT compared with the control. Feed matrix appears important in retention of PEDv as RNA concentrations were 1.2 to 3.8 CT higher in the complete swine diet and blood meal than meat and bone meal or spray-dried animal plasma on d 0 ($P < 0.05$). Additionally, PEDv stability over time was influenced by matrix as RNA concentrations only improved 0.7 and 2.9 CT by d 42 for spray-dried animal plasma and meat and bone meal, respectively, compared with 4.1 and 5.6 CT for the complete swine diet and blood meal. In summary, time, formaldehyde, and organic acid treatments all enhance the RNA degradation of PEDv in swine feed and ingredients, but their effectiveness varies within matrix. More research is needed to relate RNA concentration to infectivity and to elucidate the appropriate chemical concentration for each feed ingredient or diet.

Key Words: chemical treatment, feed matrix, PEDv, swine

091 Effects of dietary inclusion of direct-fed microbials on gut health and growth of nursery pigs orally challenged with F18-positive enterotoxigenic *Escherichia coli*. Y. Sun, I. Park*, C. H. Stahl, S. W. Kim, *North Carolina State University, Raleigh.*

This study was to determine the effect of direct-fed microbials (DFM, PrimaLac, Star Labs, Clarksdale, MO) on the growth performance and gut health on newly weaned pigs with an oral challenge of F18+ enterotoxigenic *Escherichia coli* (ETEC). PrimaLac includes *Lactobacillus acidophilus* (2.5×10^7 cfu/gram), *L. casei* (2.5×10^7 cfu/gram), *Bifidobacterium thermophilum* (2.5×10^7 cfu/gram), and *Enterococcus faecium* (2.5×10^7 cfu/gram). Thirty-two pigs (16 barrows and 16 gilts at 6.99 ± 0.33 kg BW) in individual pens were randomly allotted to 4 treatments (2×2 factorial arrangement: first factor was DFM and the second factor was ETEC). Pigs were fed experimental diets based on 2 phases (10 and 15 d, respectively). Direct-fed microbials were supplemented in the feed for Phase 1 (0 or 0.15%) and Phase 2 (0 or 0.10%). Pigs were challenged with ETEC (0 or 2×10^9 CFU) on d 13 of the study. Body weight and feed intake were measured on d 5, 9, 13, 19, and 25. Fecal scores were measured based on the 0 to 3 scale (0 = normal, to 3 = severe diarrhea) on d 2, 3, 5, 9, 12, and daily from d 13. Blood samples were taken on d 19 and 24 to measure tumor necrosis factor-alpha (TNF- α) and malonaldehyde (MDA). On d 25, all pigs were euthanized to obtain tissues (jejunum and ileum) to measure TNF- α , MDA, and morphological evaluation. Digesta (jejunum, ileum, and colon) were also obtained to measure pH. Data were analyzed using the Mixed procedure in SAS except for occurrence of

diarrhea, which was analyzed by Chi-square. Overall, DFM increased ($P < 0.05$) ADG (193 to 308 g/d) and ADFI (354 to 491 g/d). Fecal scores were increased ($P < 0.05$) by ETEC (0.45 to 1.03). The number of pigs with diarrhea was increased ($P < 0.05$) by ETEC (1 to 6 pigs) from d 13 to 25. The crypt depth (255 to 284 μ m) in ileum was increased ($P < 0.05$) by ETEC. There were interactions ($P < 0.05$) between DFM and ETEC on villus height and villus height: crypt depth, indicating that DFM increased villus height and villus height: crypt depth when pigs had ETEC. There was an interaction ($P < 0.05$) on serum TNF- α concentration on d 19 indicating that DFM decreased TNF- α when pigs had ETEC. Collectively, ETEC increased occurrence of diarrhea and caused mild issues on gut health, whereas DFM improved growth performance without affecting gut health.

Key Words: direct-fed microbials, *Escherichia coli*, growth performance, gut health, nursery pigs

092 Effect of standardized ileal digestible tryptophan : lysine ratio on growth performance of 11 to 20 kg nursery pigs. M. A. Goncalves^{1,*}, M. D. Tokach¹, S. S. Dritz¹, N. M. Bello¹, K. J. Touchette², J. M. DeRouche¹, J. C. Woodworth¹, R. D. Goodband¹, ¹*Kansas State University, Manhattan,* ²*Ajinomoto Heartland, Inc., Chicago, IL.*

Two experiments were conducted to determine the standardized ileal digestible (SID) Trp:Lys ratio requirement for 11 to 20 kg pigs. Experiment 1 was conducted to validate the dietary approach, and Exp. 2 was a dose titration. Both experiments used corn-soybean meal based diets with 30% DDGS. Experiments 1 and 2 used 1,188 and 1,088 pigs (PIC 337 \times 1050; initially 13.0 ± 0.16 and 11.2 ± 0.55 kg BW), were 21 d in duration, and had 11 and 6 pens/treatment with 24 to 27 pigs/pen, respectively. In Exp. 1, different SID Trp:Lys ratios (14.5 vs. 20%), CP (26.1 vs. 22.9%), and SID Lys levels (0.97 vs. 1.29%) combined into the following dietary treatments: High CP, High Lys, and High Trp:Lys (HHH); Low CP, High Lys, and High Trp:Lys (LHH); Low CP, Low Lys, and High Trp:Lys (LLH); and Low CP, Low Lys, and Low Trp:Lys (LLL). Lowering CP (HHH vs. LHH) did not significantly influence ($P > 0.05$) ADG, but G:F was greater in HHH compared with LHH. Decreasing lysine (LHH vs. LLH) and Trp:Lys (LLH vs. LLL) reduced ($P < 0.05$) ADG and G:F, respectively. Thus, low-CP diets formulated at 0.97% SID Lys appear to ensure pigs are below their Lys requirement when determining the optimal SID Trp:Lys ratio. In Exp. 2, dietary treatments consisted of SID Trp:Lys ratios of 14.5, 16.5, 18.0, 19.5, 21.0, 22.5, and 24.5% formulated to 0.97% SID Lys and 18.1% CP. Response variables, ADG and G:F, were each fitted using general linear and nonlinear mixed models with heterogeneous residual variances and pen as the experimental unit. Competing models included quadratic polynomial (QP), broken-line linear (BLL), and broken-line quadratic (BLQ).

Table 092.

	SID Trp:Lys, %						
	14.5	16.5	18.0	19.5	21.0	22.5	24.5
ADG, g	369 ± 20.2	428 ± 20.2	442 ± 20.2	432 ± 20.2	453 ± 17.6	451 ± 17.6	435 ± 17.6
G:F	0.543 ± 0.008	0.582 ± 0.005	0.582 ± 0.005	0.578 ± 0.008	0.590 ± 0.005	0.584 ± 0.005	0.580 ± 0.008

For each response, the best fitting models were selected using Bayesian information criterion. Increasing Trp:Lys increased ($P < 0.004$) ADG and G:F in a quadratic manner. For ADG, the best fitting model was a QP $[-317 + 7259 \times (\text{Trp:Lys}) - 17,110 \times (\text{Trp:Lys})^2]$ with maximum ADG at 21.2% SID Trp:Lys and 99% of maximum ADG achieved at 19.5% SID Trp:Lys. For G:F, BLL, and BLQ models had comparable fit and estimated SID Trp:Lys requirements of 16.6 (95% CI: 16.0 to 17.3) and 17.1% (95% CI: 16.6 to 17.7), respectively. In conclusion, the SID Trp:Lys requirement for 11 to 20 kg pigs ranged from 16.6% for G:F to 21.2% for maximum ADG, with 99% of maximum ADG at 19.5% SID Trp:Lys.

Key Words: amino acids, pigs, tryptophan

093 **Withdrawn.**

094 **Effects of an essential oils blend on growth performance of nursery pigs.**

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Three experiments were conducted to evaluate the effects of a proprietary blend of essential oils (CRINA Piglets, DSM Nutritional Products, Parsippany, NJ) on growth performance of nursery pigs. A total of 96, 48, and 48 crossbred nursery pigs with initial BW of 6.62, 7.17, and 7.10 kg were used, respectively. Pigs were blocked by initial BW and sex before randomly allotted to 4 dietary treatments in each of the 3 experiments that were conducted for 35 d using 3 diet phases (7, 14, and 14 d). The dietary treatments were: 1) basal diets with no additive [CON]; 2) CON plus carbadox at 55 ppm [MEC]; 3) CON plus CRINA Piglets at 200 ppm [CRI]; and 4) CON plus carbadox at 55 ppm and CRINA Piglets at 200 ppm [MEC + CRI]. Basal diets were formulated to contain 3335, 3344, and 3329 kcal/kg ME, and 1.62, 1.51, and 1.41% total lysine, for the 3 phases, respectively. Data were checked for normality and pooled for statistical analysis. In total, 12 replicates (pens) were used per treatment, and no experiment × treatment interactions were detected ($P > 0.26$). The 35-d ADG was 493, 514, 510, and 495 g/d for Diet 1 to 4, respectively ($P = 0.25$); the 35-d ADFI was 741, 757, 752, and 741 g/d, respectively ($P = 0.80$); and the 35-d G:F was 0.666, 0.680, 0.678, and 0.667, respectively ($P = 0.55$). The 35-d ADG response demonstrated a significant MEC × CRI interaction ($P = 0.05$), which indicated the numerical improvement of MEC and CRI

might be negated by their combination. The response to both products decreased across the 3 diet phases. Compared with CON, MEC and CRI numerically increased ADG in Phase 1 by 10.43 and 12.27%, respectively (180 and 183 vs. 163 g/d); in Phase 2 by 6.28 and 3.14%, respectively (508 and 493 vs. 478 g/d); and in Phase 3 by 1.93 and 2.37%, respectively (687 and 690 vs. 674 g/d). Likewise, when comparing MEC and CRI to CON, the numerical differences in G:F were 12.40 and 4.75% in Phase 1, respectively (0.734 and 0.684 vs. 0.653); 3.00 and 0.46% in Phase 2, respectively (0.762 and 0.743 vs. 0.740); and -0.16% and 2.11% in Phase 3, respectively (0.624 and 0.639 vs. 0.625). In this study, CRI and MEC numerically improved the growth of nursery pigs in a similar manner, but the responses to each were not additive.

Key Words: essential oils, growth performance, nursery pigs

095 **Comparative effects of dietary Cu, Zn, essential oil, and chlortetracycline on nursery pig growth performance.**

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Weaned pigs (n = 350; PIC 1050; initially 6.05 kg) were used in a 47-d study to compare the effects of feeding antibiotic alternatives (Cu, Zn, and essential oil), alone or in combination, on nursery pig performance. Pigs were allotted to pens at weaning (d 0) and fed a common starter diet with no antimicrobial for 5 d prior to diet treatments. On d 5, pens of 5 pigs were allotted to 1 of 10 dietary treatments balanced on average pen weight in a randomized block design with 7 replications/treatment. Dietary treatments were arranged in a 2 × 2 × 2 + 2 factorial with main effects of added Cu from CuSO₄ (0 vs. 125 ppm Cu), added Zn from ZnO (0 vs. 3,000 ppm Zn from d 5 to 12 and 2,000 ppm Zn from d 12 to 33), and essential oil (0 vs. 0.1% Regano EX containing origanum oil; Ralco Animal Nutrition, Marshall, MN). The 2 additional treatments were sub-therapeutic and therapeutic levels of chlortetracycline (CTC; 55 or 441 mg/kg). All diets contained 16.5 ppm Cu and 165 ppm of Zn from the trace mineral premix. Pigs were fed experimental diets from d 5 to 33 after weaning followed by a common corn-soybean meal based diet without any antimicrobial, essential oil, or pharmacological levels of Cu or Zn from d 33 to 47. To comply with FDA guidelines, CTC was removed on d 19 from the diet of pigs fed 441 mg/kg CTC, then added again from d 20 to 33. During the treatment period, essential oil had