
The objective of this study was to evaluate the effect of supplementation of freeze-dried Lactobacillus reuteri on growth performance, serum indices, and intestinal microflora of weaned piglets compared with antibiotic. The strain was isolated from the cecum mucosa of healthy weanling pigs in our laboratory. Sixty 4 crossbred (Duroc × Landrace × Large White) weaned pigs with (9.02 ± 1.01 kg BW) were randomly distributed to 4 groups comprised of an antibiotic-containing control (Zinc Bacitracin; 1 g/kg) and 3 dietary inclusion levels of L. reuteri (5.6 × 10^6, 2.4 × 10^7 and 1.5 × 10^8 cfu/g of diet). The experiment lasted 30 d. Live weight gain and feed consumption of the weaned pigs were recorded weekly. Blood and fecal samples were collected at the end of the experiment. Viable bacterial counts were estimated by a standard plate counting method. L. reuteri supplementation had the same effect on ADG, ADFI, and FCR compared with the antibiotic control. Supplementation of L. reuteri decreased (P < 0.05) the serum urea nitrogen concentration and increased (P < 0.01) the IFN-γ concentration compared with the antibiotic control. Overall, supplementation with 2.4 × 10^7 cfu of L. reuteri/g produced the greatest improvements (P < 0.05) in serum indices among the 3 different probiotic levels. The number of Lactobacilli in the feces was increased (P < 0.01) by the supplementation of L. reuteri compared with control (2.74 × 10^8, 3.00 × 10^8, 5.35 × 10^8 vs. 1.25 × 10^8 cfu/g). The 2.4 × 10^7 and 1.5 × 10^8 cfu/g L. reuteri supplementation showed lower (P < 0.01) Escherichia coli in the feces compared with control (4.65 × 10^8, 6.75 × 10^8 vs. 4.35 × 10^8 cfu/g), and 2.4 × 10^7 cfu/g supplementation had lower (P < 0.01) Escherichia coli than 1.5 × 10^8 cfu/g. This experiment indicated that L. reuteri at 2.4 × 10^7 cfu/g may be the most appropriate and feasible level with regard to enhance the growth performance, promote the serum indices, and improve the intestinal bacteria of weaned pigs.

Key Words: Lactobacillus reuteri, weaned pigs


The objective of this study was to evaluate the effects of 2 kinds of lactic acid bacteria (Lactobacillus plantarum and Enterococcus faecalis, isolated from small intestinal mucosa of healthy piglets) on the productive performance and intestinal microflora of weaned piglets. Ninety weaned piglets (Duroc × Large Yorkshire × Landrace) at 35 ± 2 d were randomly divided into 4 groups comprising of an antibiotic-containing control (Zinc Bacitracin; 1 g/kg) and 3 dietary inclusion levels of Lactobacillus plantarum (1.0 × 10^7 cfu/g diet), and group C was fed basal diet with Enterococcus faecalis (3.6 × 10^7 cfu/g diet). The concentrations of 2 bacterium were based on the previous study in our lab and were the optimal additional level. The experiment lasted 30 d. All piglets were free access to feed and water. The liveweight gains and feed consumption of the piglets were recorded weekly and fecal samples were collected at the end of the experiment. Data were analyzed using the ANOVA procedures of SPSS 18.0.

Supplementation of Lactobacillus plantarum and Enterococcus faecalis significantly improved ADG (by 7.37% and 8.79% respectively; P < 0.05) and FCR (by 7.28% and 8.05% respectively; P < 0.05) compared with control group. Pigs supplemented with Lactobacillus plantarum and Enterococcus faecalis had lower diarrhea incidence compared with pigs fed basal diet (1.44%, 1.33%, vs. 2.56%, P < 0.05). The result also showed that, compared with basal diet group, there was increase in lactobacillus counts (by 4.18% and 3.96%, P < 0.05) and decrease in E. coli counts (by 9.31% and 10.08%, P > 0.05) in the fecal samples of weaned pigs fed Lactobacillus plantarum and Enterococcus faecalis.

There was no significant difference between group B and C on ADG, FCR, diarrhea incidence, and fecal bacterium. This experiment indicated that supplying 2 kinds of lactic acid bacteria had the same beneficial effect on enhancing growth performance, reducing diarrhea incidence, and improving the intestinal health of weaned piglets.

Key Words: lactic acid bacteria, weaned piglet, intestinal microflora


The objective of this study was to evaluate the probiotic characteristics of Enterococcus faecalis isolated from gastrointestinal tract of healthy piglet and its effect on growth performance of weaned pigs. Acid tolerance of Enterococcus faecalis was estimated by the survival rate when it cultured in simulated gastric fluid with pH of 2.0 and 3.0 after 2 h. Bile salt resistance of this strain was examined in MRS broth containing pig bile salt concentration from 0.1% to 0.3%. The sizes of the inhibitory zone of Enterococcus faecalis against S. aureus, E. coli, and S. choleraesuis were also determined to estimate the inhibition of this strain on pathogenic bacteria. Sixty-four piglets weaned at 28 d of age (8.05 ± 0.47 kg BW), were divided into 4 groups comprising of control with zinc bacitracin at 60 mg/kg, 3 treatments of different Enterococcus faecalis concentration (1.8 × 10^6,6.2 × 10^6,3.1 × 10^8 cfu/g diet). The experiment lasted 4 weeks. Data were analyzed using the ANOVA procedures of SAS. The results showed that Enterococcus faecalis had high tolerance to simulated gastric fluid at pH 2.0 and 3.0 with survival rates were 86.1% and 91.3%, respectively. The viable count of Enterococcus faecalis achieved 10^7 cfu/mL when it cultured in 0.2% pig bile salt medium of MRS 6 h, while the viable count achieved 10^6 cfu/mL cultured in 0.3% medium. Furthermore, Enterococcus faecalis performed well in inhibitory activity to 3 selected pathogens. The feeding trial results exhibited that Enterococcus faecalis supplementation enhanced average daily gain (490, 508, 471 vs. 466 g/d; P < 0.05) and feed conversion ratio (1.59, 1.60, 1.65 vs. 1.76; P < 0.05) in weaned pigs compared with control. The incidence of diarrhea was significantly decreased along with the increase of Enterococcus faecalis concentration in the diet compared with antibiotic control (13.1, 10.4, 9.0 vs. 15.2). It was also showed that there was increase in Lactobacillus counts and a numerical decrease in E. coli counts in the fecal samples of weaned pigs fed Enterococcus faecalis, especially with 6.2 × 10^7 cfu/g of feed. It was concluded from this study that the strain Enterococcus faecalis could be considered as a potential probiotic for weaned pigs.

Key Words: Enterococcus faecalis, probiotic, growth performance
This experiment was carried out with the aim of evaluating apparent digestibility of pre-initial (PI) and initial (I) diets for weanling pigs containing a combination of energetic and protein ingredients to substitute dried whey and lactose. A total of 108 crossbred pigs (Landrace × Large White) weaned at 21 ± 2 d of age with an average of 6.02 kg BW were used in a 4-wk experiment. Pigs were blocked by weight and distributed in a randomized complete block design of 4 treatments and 3 animals per pen: 1) control with dried whey and lactose; 2) whey protein concentrate, maltodextrin and an energetic blend containing maltodextrin and corn oil; 3) gluten meal 60% CP, maltodextrin and energetic blend containing maltodextrin and corn oil; and 4) protein energetic blend containing maltodextrin, corn steep liquor and corn oil. The blends used were obtained by spray dryer. Two digestibility trials were performed with diets containing 0.1% chromium (III) oxide as a digestibility marker starting on the 7th and 19th day of the experiment. Pooled fecal samples were collected from an experimental unit (3 animals per pen) during the 2 periods (12th to 17th and 24th to 29th day post-weaning), and digestibility parameters evaluated included: dry matter (DCDM), ether extract (DCEE), crude protein (DCCP), and gross energy (DCGE); digestible values for dry matter (DMD), protein (PD), ether extract (EED), and energy (ED). Data was statistically analyzed using the GLM models of SAS. Differences were found just for I diet in DCE was higher (P = 0.007) for piglets fed diets 3) and 4) (71.19 and 69.38%, respectively), PD was higher (P = 0.002) for piglets fed diets 1) and 4) (12.35 and 12.03%, respectively), and EED was higher (P < 0.001) for piglets fed diet 3) (4.27%). The ingredient blends tested in this experiment, whether associated or not with vegetable or animal protein sources, were feasible substitutes for dried whey and lactose in PI and I diets. They did not interfere in the digestibility coefficient of dry matter, crude protein and gross energy of weanling pigs aged from 21 to 50 d old.

Key Words: blend, maltodextrin, microencapsulated
understand how to take advantage of the increase in nutrient intake to promote growth recovery, especially in litters composed of small pigs, the target of this technology.

**Key Words:** milk replacer, litter, growth


It is well accepted that there is an optimal dietary protein-to-energy ratio for young pigs. However, there is not a final recommendation and doubts may arise about how to reach this ratio through changes on the dietary levels. The aim of the present study was to determine how a difference in the dietary protein or energy content and their corresponding protein-to-energy ratio affect growth performance in post-weaned piglets. A total of 480 weanling piglets (28d-old, initial BW 7.17 ± 0.1 kg) were distributed according to their BW into 48 pens (10 pigs/pen), and were randomly allotted to 1 of 4 experimental diets formulated to have different protein-to-energy ratios: a high protein (HP, 204 g CP/kg as-fed) and a low protein diet (LP, 142 g CP/kg) with similar DE content (3.60 Mcal/kg), and a low energy (LE, 3.35 Mcal DE/kg) and high energy diet (HE, 3.90 Mcal DE/kg) with similar CP content (190 g/kg). The protein-to-energy ratios were 56.6 and 56.7 g CP/Mcal DE for HP and LE, and 39.4 and 48.7 g CP/Mcal DE for LP and HE. Performance was measured on d 8 and 18 post-weaning. Up to d 8, HP diet promoted a higher ADFI than LP and HE diets (P < 0.05), and a higher ADG and BW than LP; HE and LE diets (P < 0.01). Feed:gain ratio also was more efficient for HP piglets in this period. On d 18, LE diet promoted the highest ADFI and ADG during period 8–18d (P < 0.001). Piglets fed the LE diet had a statistical approach to the highest piglet BW in comparison with piglets fed the HP diet (11.89 vs. 11.42 kg; P = 0.09), however, both treatments were higher than piglets fed the HE diet (10.84 ± 0.13 kg) and piglets fed the LP diet (9.16 ± 0.13 kg), that were the lightest (P < 0.05). Feed:gain ratio of latter piglets was higher than the rest of the experimental diets for this period. Growth results are in accordance with dietary protein-to-energy ratio offered. It is concluded that independently of the nature of the nutrient promoting imbalance, dietary protein-to-energy ratio may determine post-weaning piglet performance.

**Key Words:** protein-to-energy ratio, protein, energy

**M179  Nucleotides in weanling pig diets.** C. Andrade,*1 V. V. Almeida1, M. Shardella1, D. P. Perina1, F. L. Silva1, P. L. Y. C. Chang2, B. Berenchtein3, L. B. Costa4, and V. S. Miyada1, 1USP/ESALQ, Piracicaba, SP, Brazil; 2University of North Carolina, Raleigh; 3USP/CENA, Piracicaba, SP, Brazil; 4UESC, Ilhéus, BA, Brazil.

Nucleotides have been supplemented in weanling pig diets due to their beneficial effects on maintenance of animal health, performance, immune response and on intestinal histology. The purpose of this study was to evaluate the effects of dietary nucleotide levels on performance, diarrhea occurrence, and intestinal histology of weanling pigs fed complex diet based on corn, soybean, dried milk and dried plasma. One hundred and 60 weaned pigs, averaging 6.43 ± 0.71 kg initial BW, were used in a randomized complete block design experiment with 5 treatments, 8 replications per treatment and 4 animals per pen (experimental unit). The treatments were: basal diet with 120 ppm of chloro-hydroxyquinoline (antimicrobial treatment) and basal diet with 0 (control), 100, 150 and 200 ppm of nucleotides. At the end of the experimental period (34th d), an animal per experimental unit was slaughtered for analysis of intestinal histology (villus height and crypt depth) of the duodenum and jejunum. Data were analyzed using the GLM procedure of SAS. For 1–14 d of the experimental period, performance was not affected (P > 0.05) by treatments. For the total experimental period (1–34 d), linear effects of dietary levels of nucleotides on final BW (P = 0.005; 23.08, 24.13, 24.18 and 24.23 kg) and on ADG (P = 0.008; 0.491, 0.520, 0.523 and 0.523 kg) were observed, but not (P > 0.05) on ADFI and G:F. Pigs fed nucleotides had higher (P = 0.0002) diarrhea occurrence (0.89, 1.78, 1.78, 3.57 and 5.36%) from 1 to 14 d than those of control and antimicrobial treatments. However, for the total experimental period (1–34 d), dietary nucleotide levels did not affect (P > 0.05) diarrhea occurrence and intestinal histology. Therefore, added nucleotides up to 200 ppm in weanling pig complex diets showed beneficial effect on growth performance, but not on intestinal histology and diarrhea occurrence.

**Key Words:** feed additives, growth promoter, swine

**M180  Time-related changes of serum amino acids in weanling piglets.** Y. Xiao,* T. Wu, A. Chen, L. Yang, and C. Yang, College of Animal Sciences, Zhejiang University, Hangzhou, Zhejiang, China.

The time-course of serum amino acids following response to early weaning was investigated over a 30 d period in weanling piglets using amino acid analyzer. Eight healthy piglets were selected from 4 litters (one male and one female per litter). The piglets were weaned at 21 d of age and their blood samples were collected on d 0, 1, 3, 5, 7, 10, 15, and 30 post-weaning. Serum concentrations of arginine and its immediate precursors (citrulline and ornithine) decreased (P < 0.05) from d 0 to 5 post-weaning, and increased from d 7 to 30 post-weaning. Serum concentrations of leucine, proline, tyrosine, and taurine decreased (P < 0.05) on d 1 and 3 post-weaning, and increased to the level of d 0 post-weaning on d 30. Serum concentrations of isoleucine, lysine, glycine, and serine were lowest on d 5 post-weaning; histidine, phenylalanine, valine, aspartic acid, and serine were lowest on d 10 post-weaning, which then increased thereafter. Methionine concentration changed slightly (P < 0.05) from d 0 to 3 post-weaning, while it increased by 43.5% (P < 0.05) and 41.1% (P > 0.05) from d 0 to 3 post-weaning, and kept constant thereafter. Serum concentration of threonine increased by 31.6% (P < 0.05) and 79.0% (P < 0.05) on d 3 post-weaning compared with that on d 1 and 3 post-weaning, and kept constant thereafter. Serum concentration of glutamic acid was relatively higher (P < 0.05) from d 3 to 30 than that on d 0 and 1 post-weaning. These findings indicate that the serum levels of amino acids are robustly altered in weanling piglets and the critical phase are from d 3 to 10 post-weaning.

**Key Words:** amino acids, weaning, piglets

**M181  Comparing different copper sources at pharmacological levels in nursery pigs.** J. Zhao,*1 G. Allee2, M. Vazquez-Anon1, and R. J. Harrell1, 1Novus International Inc., St. Charles, MO; 2University of Missouri, Columbia.

Pharmaceutical CuSO₄ is widely used in nursery pigs to promote growth when included beyond Cu requirements as defined by NRC (1998). However, high dietary Cu antagonizes other minerals (Zn and Fe) and nutrient utilization in monogastric animals. The objective of this research was to compare different Cu sources at pharmacological levels in nursery pigs. A total of 616 crossbreed piglets (PIC, 20 d of age, 5.0 ± 0.3 kg) were randomly allocated to one of 4 treatments with 7
replicates per treatment and 22 piglets per pen. The treatments included an inorganic negative control (CuSO₄) at NRC level (6 mg/kg), and a pharmaceutical level (150 mg/kg) of Cu supplemented using CuSO₄, tri-basic copper chloride (Cu₂(OH)₂Cl), or Cu(HMTBa)₂. The Cu(HMTBa)₂ (Mintrex, Novus International Inc., St. Charles, MO) is a chelate of one Cu molecule with 2 molecules of 2-hydroxy-4-methylthio butanoic acid (HMTBa). Pigs were fed typical commercial nursery diets for 21 d. At the completion of 21 d, one median pig per pen was harvested for liver mineral analyses. Pigs fed CuSO₄ and Cu(HMTBa)₂ exhibited 8% and 10% improvements \((P = 0.02)\) in feed efficiency, respectively, compared with pigs fed the negative control. Weight gain tended to be improved by both CuSO₄ and Cu(HMTBa)₂ \((P = 0.07)\). Pigs fed Cu₂(OH)₂Cl were intermediate but were not differ from the negative control. No ADFI differences were observed among treatments \((P = 0.75)\). For liver mineral concentration (dry weight basis), pigs fed Cu(HMTBa)₂ had the highest liver Cu concentration, which was significantly higher than pigs fed Cu₂(OH)₂Cl and the negative control (71% improvement, \(P = 0.02\)). Pigs fed CuSO₄ were intermediate with 39.8, 48.8, 52.1, and 68.2 mg liver Cu per kg dry weight for the negative control, Cu₂(OH)₂Cl, CuSO₄, and Cu(HMTBa)₂, respectively. No differences were observed for liver Fe, Mn, or Zn concentration \((P > 0.28)\). In conclusion, pigs fed Cu(HMTBa)₂ at a pharmacological levels performed the best based on feed efficiency and liver Cu concentration in this trial.

**Key Words:** Mintrex, copper, swine

**Table 1.** Effects of expanded rice, glutamine, and natural vitamin E in diets for weaning pigs

<table>
<thead>
<tr>
<th>Variable</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>SEM</th>
<th>(P)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final wt, kg</td>
<td>27.60b</td>
<td>28.51a</td>
<td>28.80a</td>
<td>27.77b</td>
<td>28.76a</td>
<td>0.39</td>
<td>0.02</td>
</tr>
<tr>
<td>ADG, g/d</td>
<td>493b</td>
<td>514a</td>
<td>521a</td>
<td>497b</td>
<td>521a</td>
<td>9</td>
<td>0.02</td>
</tr>
<tr>
<td>ADFC, g/d</td>
<td>712</td>
<td>746</td>
<td>745</td>
<td>723</td>
<td>711</td>
<td>18</td>
<td>0.28</td>
</tr>
<tr>
<td>Feed:gain</td>
<td>1.45</td>
<td>1.46</td>
<td>1.43</td>
<td>1.46</td>
<td>1.37</td>
<td>0.03</td>
<td>0.40</td>
</tr>
</tbody>
</table>

\(a,b\)Means with different letters in the same line differ \((P < 0.05)\).