Feeding Direct-Fed Microbials to Piglets from Lactation Through the Nursery Phase on Nursery Pig Performance

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Story in Brief

An experiment evaluated the impact of specifically selected direct-fed microbials administered to piglets during the lactation and nursery phase of production on nursery pig performance. At farrowing, 252 pigs were provided milk supplementation with or without *Lactobacillus brevis* (1E-1) via an in-line system. Treatments were continued during the nursery period, in which pigs provided 1E-1 via milk supplementation continued to receive 1E-1 through the watering system. Pigs were fed a basal diet, the basal diet with *Bacillus* cultures, or the basal diet with antibiotics during Phase 1 (d 0 to 14 post-weaning), Phase 2 (d 14 to 28 post-weaning), and Phase 3 (d 28 to 37 post-weaning), in a 2 x 3 factorial design. Pigs supplemented with 1E-1 had greater ($P < 0.05$) ADG and ADFI for the overall nursery period and were 3.5 lb heavier by the end of the nursery period compared to pigs not receiving 1E-1. Pigs supplemented with antibiotics during the nursery had greater ($P < 0.05$) ADG during Phase 2 and the overall nursery period, and greater ($P < 0.05$) ADFI during Phase 3 and for the overall nursery period than pigs fed the negative control or *Bacillus* diets. Antibiotic supplementation to pigs improved ($P < 0.05$) feed/gain during Phase 2, while *Bacillus* supplementation improved ($P < 0.05$) feed/gain during Phase 3. This study indicates that direct-fed microbial supplementation of *L. brevis* and *Bacillus* improves growth performance of pigs during the nursery period.

Introduction

Subtherapeutic levels of antibiotics are used in livestock animals to improve growth and feed efficiency of these animals (Gustafson and Bowen, 1997); however, there is a growing concern that the use of antibiotics in livestock feeds to enhance growth and prevent disease may cause an increase in antibiotic resistant human and animal pathogens (Turner et al., 2001). As a result, scientists have begun to investigate natural alternatives, such as, direct-fed microbials (DFM) to replace conventional antibiotics in swine diets. The administration of DFM such as *Lactobacillus brevis* (1E-1) and *Bacillus* may be an effective way to promote growth in newly weaned pigs. The mechanism by which DFM affect growth of the young animal may be attributed to improvements in the indigenous microbial balance, production of compounds that are inhibitory toward pathogens, competition with deleterious species for adhesion sites, and enhancement of the immune response in the animal (Collins and Gibson, 1999). These putative mechanisms of action could be a means to improve swine growth and feed efficiency particularly during the weaning period. Therefore, an experiment was conducted to evaluate the impact of antibiotics vs. specifically selected direct-fed microbials administered to piglets during the lactation and nursery phases of production on pig performance.

Experimental Procedures

Animals, Housing, and Environment. Thirty litters from one farrowing group were fed a milk replacer devoid of antibiotics with and without a direct-fed microbial supplement *Lactobacillus brevis*(1E-1) via a liquid feeding system during the lactation period. Pigs were farrowed in an environmentally controlled farrowing room containing 30 crates, each equipped with an in-line milk replacer system. One-half of the litters within the farrowing group received 1E-1 by supplementing the commercial milk replacer (Litter-Gro, Merrick's, Inc., Union Center, Wis.) with a total of 7.5×10^{11} cfu of 1E-1 daily (estimating that pigs received 3.8×10^{10} cfu/pig/d), while the remaining litters received milk replacer devoid of 1E-1. Milk replacer was supplied to the pens by two 113.55 L tanks. Each tank was equipped with a hydro pump and a pressure regulator that pumped the milk supplement to the pen as needed. A bowl with a baby pig nipple was available in each crate, allowing milk to flow only when touched by a pig's nose to minimize spillage and waste of milk supplement. The entire system was flushed daily with hot water to remove spoiled milk or sediment, and fresh milk was prepared daily.

Following the lactation phase, a total of 252 pigs (126 from each lactation treatment) were blocked by BW in a 2 x 3 factorial arrangement of treatments and were moved to a wean-to-finish facility. Pigs were housed seven pigs per pen in slatted pens (5.07 ft x 10.17 ft) equipped with radiant heaters and a two-hole nursery feeder. Pigs administered milk replacer with and without 1E-1 supplement prior to weaning were maintained on their same treatment through the nursery period by administering 1E-1 through the watering system. During the post-weaning period, 126 pigs received 1E-1 through the waterline using a proportioner (Dosatron Dosing Systems, Clearwater, Fla.) and 1E-1 intake was estimated at 10.3×10^8 cfu/pig/day.

Diets and data collection. Three dietary treatments were fed during the nursery period: 1) control diet devoid of antibiotic or *Bacillus*; 2) control diet with added *Bacillus* (7.5×10^5 cfu/g feed); and 3) control diet supplemented with antibiotics (Table 1). Dietary treatments were offered ad libitum during Phase 1 (d 0 to 14 after weaning), Phase 2 (d 14 to 28 after weaning), and Phase 3 (d 28 to 38 after weaning) of the nursery period. Pigs receiving diets containing *Bacillus* and 1E-1 were separated from those fed diets devoid of the microbials to eliminate microbial exposure to control pigs. Pig BW and feed intake were measured weekly during the nursery period to calculate ADG, ADFI and feed-to-gain (F/G) for each phase.

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Statistical Analysis. Performance data were analyzed as completely randomized block with treatments arranged as a 2 x 3 factorial design with pen as the experimental unit. Analyses of variance were performed using the GLM procedure of SAS (SAS Inst., Inc., Cary, N.C.). When a significant interaction was observed, treatment means were separated using the PDIFF option of the LSMEANS statement, whereas, main effect means were evaluated when the interaction was not ($P > 0.05$) significant.

Results and Discussion

The supplementation of 1E-1 during lactation and throughout the nursery period increased piglet ($P \leq 0.05$) ADG, ADFI and BW (Table 2). The administration of 1E-1 resulted in a 3.5 lb improvement ($P < 0.05$) in BW at the end of the nursery compared to pigs not receiving 1E-1. These results are similar to those of Brown et al. (2002), who observed that pigs receiving 1E-1 during lactation had improvements in ADG and F/G and lower jejunal *E.coli* populations during the nursery period when compared to control pigs. This evidence suggests that 1E-1 may impact host performance by colonizing sites of the digestive tract and thereby exclude potential invading pathogens such as *E. coli*, resulting in improved pig performance.

In the present study, antibiotic supplementation increased ($P < 0.01$) ADG and ADFI during the overall post-weaning period and pigs were 4.55 lb heavier ($P < 0.05$) by the end of the nursery period when compared to the average of pigs fed *Bacillus* or the negative control diets (Table 3). Similarly, it has been shown that antibiotic feed additives can promote growth and feed efficiency when added at low concentrations to the diets of growing swine (Gustafson and Bowen, 1997). With increasing pressure on the livestock industry to decrease or discontinue these additions because of the human health risk from the over-use of antibiotics, researchers are investigating alternatives methods to improve growth and efficiency of livestock production.

Supplementation of *Bacillus* cultures was reported to improve growth performance in weanling pigs (Yang et al., 2003); however, results were variable. In the current study, feed-to-gain was improved ($P < 0.05$) in pigs fed *Bacillus* cultures by phase 3 when compared to pigs fed antibiotic or the negative control diets (Table 3). Since *Bacillus* is not a known component of the indigenous microflora (Fuller, 1989) and was only added during the post-weaning period, it may need time for the spores to inoculate the gastrointestinal tract before it can impact performance. Furthermore, it has been suggested that the concentration of viable bacteria is crucial to obtain the desired effects (Ouwenhand et al., 2002). Cell count was not conducted to check the viability of *Bacillus* cells after pelleting nor did we test for bacterial concentrations in the feces, which may explain variability in the observed effects of *Bacillus* cultures. The results of the present study indicate the efficacy of *L. brevis*(1E-1) and antibiotics to improve the growth rate of nursery pigs. Furthermore, *Bacillus* cultures should be explored further to determine their ability to impact growth of newly weaned pigs.

Implications

If there becomes a ban on the use of antibiotics as growth promotants in livestock feeds due to antibiotic-resistant bacteria, the administration of direct-fed microbials, such as, *Lactobacillus brevis*(1E-1) and *Bacillus* cultures during the lactation and nursery phases of production shows promise as alternative feed supplements to enhance growth performance of nursery pigs.

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Table 1. Composition of experimental Phase 1 (d 0 to 14 post-weaning), Phase 2 (d 14 to 28 post-weaning) and Phase 3 (d 28 to 37 post-weaning) diets. of corn for Antibiotic-fed pigs.

Item, %	Control, Phase 1	Control, Phase 2	Control, Phase 3
Yellow corn	44.25	49.58	61.85
Steam rolled oats	5.00	0.00	0.00
Whey	6.00	0.00	0.00
Lactose	11.00	8.10	0.00
Soybean protein concentrate	7.45	0.00	0.00
Soybean meal, 48% CP	7.63	30.50	30.50
Plasma protein (MP-722)	5.00	1.00	0.00
Cells spray dried, AP-301	1.75	1.50	0.00
Select menhaden fish meal	4.50	2.00	0.00
Soybean oil	4.00	0.00	0.00
Fat, Darling	0.00	4.00	4.00
Ethoxyquin	0.03	0.03	0.03
Lysine-HCl	0.16	0.14	0.15
Methionine	0.13	0.11	0.03
Bacillus culture[a]	0.00	0.00	0.00
Antibiotic (Carbadox)[b]	0.00	0.00	0.00
Mineral premix (NB-8534)[c]	0.15	0.15	0.15
Isoleucine, 85%	0.10	0.00	0.00
Vitamin premix (NB-157C)[d]	0.20	0.25	0.25
Dicalcium phosphate	1.50	1.30	1.70
Calcium carbonate	0.57	0.76	0.80
Threonine	0.08	0.08	0.04
Salt	0.50	0.50	0.50
Calculated composition, %			
Lysine	1.50	1.45	1.20
Met + Cys	0.85	0.82	0.68
Threonine	0.97	0.94	0.78
Tryptophan	0.27	0.28	0.24
Ca	0.90	0.80	0.80
Available P	0.57	0.38	0.38
Lactose	14.91	8.02	0.00
Metabolizable energy, kcal/lb	1,546	1,565	1,562

[a]Bacillus was provided at 7.5 x 105 cfu/g to the control Phase 1, 2 and 3 diets at the expense of corn for Bacillus-fed pigs.

[b]Carbadox (antibiotic) was provided at 50 g/ton to the control Phase 1, 2 and 3 diets at the expense of corn for Antibiotic-fed pigs.

[c]Supplied 0.30 mg of Se as sodium selenite, 40 mg of Mn as manganous oxide, 165 mg of Zn as zinc oxide, 165 mg of Fe as ferrous sulfate, 17 mg of Cu as copper sulfate, and 0.30 mg of I as calcium iodate per kilogram of feed.

[d]Supplied 11023 IU of vitamin A, 1653 IU of vitamin D_3 as D-activated animal sterol, 44 IU of vitamin E, 4.4 mg of vitamin K as menadione sodium bisulfite complex, 33 mg of pantothenic acid as D-calcium pantothenate, 55 mg niacin, 10 mg of riboflavin, and 44 μg of vitamin B_{12} per kilogram of feed.

Table 2. Main effects of *Lactobacillus brevis* (1E-1) administration in milk replacer during lactation and via the waterer system during the post-weaning period on ADG, ADFI, F/G and BW of pigs during Phase 1 (d 0 to 14 post-weaning), Phase 2 (d 14 to 28 post-weaning) and Phase 3 (d 28 to 37 post-weaning) of the nursery period.

	Treatment			
Item	1E-1 (+)	1E-1 (-)	SE	P-value
ADG, lb				
Phase 1	0.22	0.20	0.02	0.51
Phase 2	0.73	0.63	0.03	0.01
Phase 3	1.18	1.12	0.04	0.26
Overall	0.74	0.68	0.02	0.05
ADFI, lb				
Phase 1	0.28	0.28	0.00	0.13
Phase 2	0.77	0.67	0.05	0.17
Phase 3	1.37	1.24	0.04	0.03
Overall	0.84	0.76	0.03	0.04
Feed/gain				
Phase 1	1.48	1.63	0.19	0.57
Phase 2	1.08	1.12	0.07	0.64
Phase 3	1.18	1.14	0.03	0.14
Overall	1.15	1.14	0.03	0.93
Weight, lb				
Initial	17.4	17.3	0.02	0.09
Phase 1	19.6	19.3	0.20	0.24
Phase 2	29.9	28.1	0.49	0.01
Phase 3	47.3	43.8	0.82	< 0.01

Table 3. Main effects of *Bacillus* and antibiotic in the diet during the nusery period on ADG, ADFI, F/G and BW of pigs during Phase 1(d 0 to 14 post-weaning), Phase 2 (d 14 to 28 post-weaning) and Phase 3 (d 28 to 37 post-weaning) of the nursery period.

	Dietary treatment				
Item	Control	Bacillus	Antibiotic	SE	P-value
ADG, lb					
Phase 1	0.18	0.22	0.24	0.02	0.21
Phase 2	0.64^{b}	0.58^{b}	0.82^{a}	0.03	< 0.01
Phase 3	1.13	1.12	1.19	0.05	0.51
Overall	0.68^{b}	0.66^{b}	0.78^{a}	0.03	< 0.01
ADFI, lb					
Phase 1	0.28	0.28	0.28	0.00	0.12
Phase 2	0.68	0.71	0.76	0.06	0.66
Phase 3	1.28^{b}	1.15^{b}	1.49^{a}	0.05	< 0.01
Overall	0.78^{b}	0.74^{b}	0.88^{a}	0.03	0.02
Feed/Gain					
Phase 1	1.79	1.60	1.28	0.23	0.28
Phase 2	1.10^{a}	1.24^{a}	0.96^{b}	0.050	0.06
Phase 3	1.14^{b}	1.02^{c}	1.27^{a}	0.035	<0.01
Overall	0.87	0.88	0.89	0.025	0.80
Weight, lb					
Initial	17.4	17.3	17.4	0.02	0.92
Phase 1	19.2	19.3	19.7	0.24	0.24
Phase 2	28.0^{b}	27.7^{b}	31.2^{a}	0.60	< 0.01
Phase 3	44.1^{b}	44.0^{b}	48.6^{a}	1.01	< 0.01

[a,b]Within a row, means with no superscripts in common differ ($P < 0.05$).