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EFFECTS OF MICROBIAL FEED ADDITIVES ON PERFORMANCE OF STARTER AND GROWING-FINISHING PIGS[1]

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Summary

Three trials were conducted to evaluate the effect of lactic acid-producing microbial feed additives (Probiotics) on performance of starting and growing-finishing pigs. Two commercially available probiotics, Probios (*L. acidophilus*) and Feed-Mate 68 (*Streptococcus faecium* type Cernelle 68), were used. In the first of two starter trials, 192 crossbred pigs (initial weight 7 kg) were used in a 2 × 4 factorial arrangement of treatments, with Probios and antibiotics (ASP-250, lincomycin, tylosin) as the main effects. Addition of antibiotics, regardless of source, improved (P<.05) average daily gain (ADG) and feed conversion (FC). ADG and FC were improved by 2.6 and 3.6%, respectively, with probiotics (P< .10). A suggestion of an additive effect was observed for lincomycin plus Probios. In the second trial, with 224 pigs, virginiamycin was evaluated in combination with Probios, Feed-Mate 68 and DL-lactic acid. The antibiotic effect was not significant; addition of probiotic products and DL-lactic acid improved FC (P<.05). Probios improved ADG 9.7% and FC 4.4%, while Feed-Mate 68 decreased performance. A growing-finishing trial was conducted with 144 crossbred pigs (average initial weight 34 kg) to determine the effect of probiotics, lincomycin or a combination on ADG and FC of growing-finishing swine. Probiotics did not affect performance, but addition of lincomycin increased ADG by 3.6% (P<.05) and FC by 2.5% (P<.10).

(**Key Words:** Swine, Probiotics, Lactobacilli, *Streptococcus faecium*, Antibiotics.)

Introduction

The importance of maintaining an ideal intestinal flora in swine has been recognized for many years. In the past few decades, the most common method of repressing the nondesirable microorganisms has been treatment with antibacterial agents. Since future legislation may prohibit the use of subtherapeutic levels of antibacterials, the use of probiotics as a possible alternative to antibiotics has received renewed interest.

Metchnikoff (1908) speculated on the harmful role of intestinal fermentation caused by proteolytic and putrifying organisms, noting that it can lead to autointoxication. The recommended solution was the addition of lactic acid-producing bacteria (lactobacilli) in an effort to establish a "desirable" microflora population in the intestinal tract.

Several possible modes of action for lactobacilli benefits have been suggested: (1) change in enteric flora and reduction of *E. coli* (Porter and Kenworthy, 1969; Hill *et al.*, 1970a,b; Moon, 1975; Mitchell and Kenworthy, 1976; Muralidhara *et al.*, 1977); (2) production of antibiotic substances (Shahani *et al.*, 1976, 1977); (3) synthesis of lactate with concomitant reduction in intestinal pH (White *et al.*, 1969; Herrick, 1972); (4) adhesion to or colonization in the digestive tract (Fuller and Brooker, 1974; Muralidhara *et al.*, 1977) and (5) prevention of toxic amine synthesis (Hill *et al.*, 1970a,b).

Lactobacillus therapy has been shown to help improve gain and feed efficiency in poultry (Tortuero, 1973; Fuller and Brooker, 1974) and swine (Parker, 1975; Baird, 1977; Hale and Newton, 1979). However, other researchers (Hines and Koch, 1971; Mahan and Newland, 1976; Cline *et al.*, 1976; Holden, 1976) have observed no significant response in swine. The efficacy of lactobacillus products has not been fully elucidated. The objective of this study was to evaluate the effects of two commercially

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available lactic acid-producing bacterial feed additives (probiotics) on gains and feed conversion of starting and growing-finishing pigs.

Experimental Procedure

Starter Trials. Two trials were conducted with young swine. In the first, 192 crossbred pigs (12 pigs/treatment, two replications) approximately 4 weeks old were allotted by initial weight (average 7 kg) to treatments in a 2 × 4 factorial arrangement of treatments, with probiotics and antibiotics as the main effects. Probios[3] (750 mg/kg), a commercial probiotic product, was evaluated in combination with ASP-250[4], tylosin[5] or lincomycin[6] in an 18% crude protein diet (table 1).

The pigs were housed in a conventional nursery with 40% slatted floors and allowed *ad libitum* access to water and feed. The study was started on the day of weaning and terminated 30 days later.

In the second trial, another commercial probiotic product called Feed-Mate 68[7], *Streptococcus faecium* (lactic acid-producing bacteria) Cernelle 68, was evaluated in combination with virginiamycin[8] (110 mg/kg) in a 2 × 4 factorial arrangement of treatments with 224 crossbred pigs (14 pigs/treatment, two replications). DL-lactic acid (LA), added at 220 mg/kg, was also evaluated in an attempt to discover whether the lactic acid produced by these bacterial cultures is the cause of their effect on performance. The experimental treatments were: (1) control, (2) Probios, (3) Feed-Mate 68, (4) LA, (5) virginiamycin, (6) virginiamycin + Probios, (7) virginiamycin + Feed-Mate 68 and (8) virginiamycin + LA. The additives were included in the basal diet (table 1), which was fed *ad libitum* for 28 days in the same nursery in which trial 1 was conducted. Pigs were allotted to the treatments by initial weight (average 7 kg) on the day of weaning.

Growing-Finishing Trial. A growing-finishing trial was conducted to evaluate the effect of *S. faecium* and lactobacillus probiotics in lincomycin-medicated diets on gain and feed efficiency. A 2 × 3 factorial arrangement of treatments was used, with lincomycin and probiotic source as the main effects. The 144 crossbred pigs (six pigs/treatment, four replications) were allotted to treatment by initial weight (average 34 kg) and sex. The pigs were housed in outdoor pens

[3] NuLabs Division, Pioneer Hi-Bred International, Portland, OR.
[4] ASP-250, American Cyanamid Co., Agr. Div., Princeton, NJ.
[5] Tylan 10, Elanco Product Co., Division of Eli Lilly and Co., Indianapolis, IN.
[6] Lincomix 20, TUCO, Division of UpJohn, Kalamazoo, MI.
[7] Feed-Mate 68, Anchor Laboratories, Inc., Division of Phillips Roxane, Inc., St. Joseph, MO.
[8] Statfac, Animal Health Products, Division of Smith Kline Corp., Philadelphia, PA.

TABLE 1. COMPOSITION OF BASAL DIETS

Ingredient, %	Internat'l. Ref. No.	Trial 1	Trial 2
Corn, yellow	4-02-931	42.35	63.41
Soybean meal	5-04-604	24.20	24.00
Oats, ground	4-03-309	10.00	...
Alfalfa meal, dehydrated	1-00-023	5.00	...
Yeast, brewers dried	7-05-527	1.00	...
Dicalcium phosphate	6-01-080	1.10	1.21
Limestone, ground	6-02-632	.60	.63
Alfalfa hay, suncured, ground	1-00-063	...	5.00
Fish solubles	5-01-969	2.00	2.00
Lard	4-00-409	2.50	2.50
Whey, dried	4-01-182	10.00	...
Premix[a]		1.25	1.25

[a]Contained .15% salt, 1% trace mineral mix, 1.0% vitamin premix in finely ground corn. Vitamin premix supplied (per kilogram diet): vitamin A, 4,394 IU; vitamin D, 426 IU; riboflavin, 3.3 mg; niacin, 21.9 mg; pantothenic acid, 4.5 mg; choline, 198 mg; vitamin B_{12}, 9.7 micrograms. Trace mineral mix supplied (milligrams/kilogram): Zn, 200; Fe, 100; Mn, 55; Cu, 11; Co, 1.0; I, 1.5.

TABLE 2. COMPOSITION OF BASAL DIETS

Ingredient, %	Internat'l. Ref. No.	Diet 14%	Diet 16%
Corn, ground	4-02-931	79.25	73.65
Soybean meal	5-04-604	14.80	20.50
Alfalfa, suncured, ground	1-00-063	2.50	2.50
Dicalcium phosphate	6-01-080	1.15	1.00
Limestone, ground	6-02-632	.80	.85
Premix[a]		1.50	1.50

[a]Contained .5% salt, .075% trace mineral mix, .925% vitamin mix with finely ground corn as a carrier. Vitamin premix supplied (per kg) diet, 14%: vitamin A, 2,214 IU; vitamin D, 436 IU; riboflavin, 2.2 mg; niacin, 17.53 mg; pantothenic acid, 9.91 mg; choline, 220 mg; vitamin B_{12}, 24.26 micrograms. Vitamin premix, 16% diet: that in 14% diet plus additional vitamin A, 1,090 IU, vitamin B_{12}, 24.26 mcg; (per kg) diet. Trace mineral mix supplied (mg/kg) diet: Zn, 150; Fe, 75; Mn, 41.25; Cu, 8.25; Co, .75; I, 1.125.

with a concrete apron and shelter, and fed *ad libitum*. The pigs received a 16% corn-soy diet until they reached approximately 57 kg and a 14% diet (table 2) thereafter until termination of the study. The treatments were: (1) control, (2) Probios (500 mg/kg), (3) Feed-Mate 68 (500 mg/kg), (4) lincomycin (110 mg/kg), (5) Probios + lincomycin and (6) Feed-Mate 68 + lincomycin.

Data were analyzed by least-squares analysis of variance (Harvey, 1960). The orthogonal comparison for the main effects and interactions were performed by methods described by Snedecor and Cochran (1967).

Results and Discussion

Starter Trials. The effect of Probios in medicated diets on performance of young pigs is shown in table 3. The addition of antibiotics, regardless of source, improved average daily gain (ADG) and feed conversion (FC) ($P<.05$). There were no significant differences between sources of antibiotics. There was a trend for improved ADG (2.6%) and FC (3.6%) in pigs fed probiotics compared to nontreated animals. In the groups not receiving antibiotics, Probios improved ADG 4.5% and FC 7.2%. When Probios was added to an ASP-250 or tylosin-medicated diet, a reduction in ADG was observed. Lincomycin produced better ADG when fed in combination with Probios than without (.307 *versus* .265 kg), suggesting a possible additive effect.

In the second trial (table 4), virginiamycin was evaluated in combination with Probios, Feed-Mate 68 and DL-lactic acid. The antibiotic effect on gain was not significant, but FC was improved slightly (2.68 *versus* 2.79). The addition of Probios improved ADG by 9.7% and FC by 21.4%, whereas Feed-Mate 68 decreased

TABLE 3. EFFECT OF PROBIOS IN MEDICATED DIETS FOR YOUNG PIGS[a]

Item	Probios[b]	Antibiotic source: None	ASP-250[c]	Tylosin[d]	Lincomycin[e]	Avg
ADG, kg	–	.223	.294	.269	.265	.263
	+	.233	.289	.253	.307	.270
Avg[f]		.228	.291	.261	.286	
Feed to gain ratio	–	2.67	2.11	2.18	2.18	2.28
	+	2.49	2.10	2.28	1.94	2.20
Avg[f]		2.58	2.10	2.23	2.06	

[a]192 crossbred pigs (12 pigs treatment; two replications). Average initial weight, 7 kg; length of study, 30 days.

[b]Probios (MuLabs Division, Pioneer Hybrid International) at 750 mg/kg.

[c]ASP-250 (American Cyanamid) is chlorotetracyclin, streptomycin and penicillin at 110, 110 and 55 mg/kg diet, respectively.

[d]Tylan (Elanco) at 110 mg/kg.

[e]Lincomix (Upjohn) at 110 mg/kg.

[f]Antibiotic effect ($P<.05$).

TABLE 4. EFFECT OF DRIED MICROBIAL CULTURES AND DL-LACTIC ACID IN MEDICATED DIETS FOR YOUNG PIGS[a]

Item	Antibiotic[b]	Additive: None	Lactobacilli[c]	*S. Faecium*[d]	Lactic acid[e]	Avg
ADG, kg	–	.145	.150	.141	.158	.151
	+	.145	.168	.127	.122	.141
Avg		.145	.159	.134	.145	
Feed to gain ratio	–	3.49	2.46	2.88	2.34	2.79
	+	2.68	2.40	2.75	2.87	2.68
Avg[f]		3.09	2.43	2.82	2.61	

[a]224 crossbred pigs (14 pigs/treatment; two replications). Average initial weight 7 kg; length of study, 28 days.

[b]Virginiamycin (Smith Kline Corp) at 110 mg/kg.

[c]Probios (NuLabs) at 750 mg/kg.

[d]Feed-Mate 68 (Anchor Labs) at 1,250 mg/kg.

[e]DL-Lactic Acid added at 220 mg/kg.

[f]Treatment effect (none *versus* additive) P<.05.

ADG. The difference in response between the first trial and second trial may have been partially related to diet. (The diet in the second trial was less complex.)

It has been suggested that the lactic acid produced as a metabolite during fermentation of a lactic acid-producing bacterial culture is the cause of any improvement in performance. The lactic acid treatment without virginiamycin produced the best feed conversion.

Growing-Finishing Trial. The results of the growing-finishing trial in which Feed-Mate 68 and Probios were fed in lincomycin-medicated diets are presented in table 5. Lincomycin was selected as the antibiotic because of the possible additive effect that was observed when it was fed in combination with probiotics in the starter diet in trial 1. The lincomycin-medicated groups showed improved ADG (P<.05) and FC (P<.10) by comparison with the nonmedica-

TABLE 5. EFFECT OF *STREPTOCOCCUS FAECIUM* AND LACTOBACILLUS PROBIOTICS IN LINCOMYCIN MEDICATED DIETS ON PERFORMANCE OF GROWING-FINISHING SWINE[a]

Item	Lincomycin[b]	Probiotic: None	Lactobacilli[c]	*S. Faecium*[d]	Avg
ADG, kg	–	.83	.82	.82	.82
	+	.86	.85	.85	.85[e]
Avg		.84	.83	.83	
Feed to gain ratio	–	3.22	3.22	3.25	3.23
	+	3.12	3.19	3.14	3.15[f]
Avg		3.17	3.20	3.20	

[a]144 crossbred pigs (six/treatment; four replications). Average initial weight, 34 kilograms.

[b]TUCO, Division of UpJohn Co.; added at 110 mg/kg diet.

[c]Probios (NuLabs product) added at 500 mg/kg diet.

[d]Feed-Mate 68 (Anchor Labs) added at 500 mg/kg diet.

[e]Antibiotic effect (P<.05).

[f]Antibiotic effect (P<.10).

ted groups. Although probiotics did not significantly affect performance, a slight reduction in ADG (.83 *versus* .84 kg) and FC (3.20 *versus* 3.17) was observed.

The data suggest that the two commercial probiotic products that were evaluated performed differently. It appears that the lactobacillus product is superior to the streptococcal product as an additive to pig starter diets. A greater response was observed with starting than with growing-finishing pigs.

Baird (1977) conducted three trials with feeder pigs with Probios added at 500 mg/kg and observed an improvement in ADG (10.8%) and FC (7.2%), a finding which is similar to the results observed here. Baird also observed an improvement in ADG (8.45%) and FC (5.8%) in growing-finishing pigs. Other researchers (Hines and Koch, 1971; Holden, 1976; Mahan and Newland, 1976; Cline *et al.*, 1976) have observed no response when Probios was added to swine diets.

With the possibility of discontinued use of subtherapeutic levels of antibacterial agents, probiotics could be an alternative for microbial population control in the digestive tract of swine.

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