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Cover Page Footnote

Appreciation is expressed to Dr. Jason Swell and Terry Waugh, Nutraferma Inc., Sioux City, IA and Brent Ratliff, Kindstrom-Schmoll Inc., Eden Prairie, MN for their technical support and to Nutraferma Inc., Sioux City, IA for their financial support. Appreciation is expressed to Julie Salyer, Dr. Brad James, and Lorene Parkhurst, Kalmbach Feeds, for their technical support and expertise in conducting the experiment.

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Effect of Feeding Varying Levels of *Lactobacillus Plantarum* on Nursery Pig Performance[1,2]

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Summary

A total of 360 pigs (PIC C-29 × 359, initially 13.1 lb BW) were used in a 42-d growth performance trial evaluating the effects of feeding varying levels of *Lactobacillus plantarum* on nursery pig performance. Pigs were allotted by BW and sex, and randomly assigned to 1 of 4 dietary treatments in a completely randomized design. Experimental diets were fed in three phases (Phase 1, d 0 to 7; Phase 2, d 7 to 21, and Phase 3, d 21 to 42). Treatment diets were formulated to include 0, 0.05, 0.10, or 0.20% *Lactobacillus plantarum* product (LP1; Nutraferma Inc., Sioux City, IA). *Lactobacillus plantarum* is a facultative heterofermentative plant-associated lactic acid bacterium that is tolerant against bile salts and low pH, improving survivability in the GIT (de Vries et al., 2006; da Silva Sabo et al., 2014).[4,5] All experimental diets were pelleted. During Phase 1 and 2, there were no differences in growth performance among dietary treatment. During Phase 3, ADG and ADFI were not influenced by treatment; however, increasing LP1 tended to improve F/G (quadratic, $P = 0.085$) up to the 0.10% level. Overall (d 0 to 42), no differences in growth performance were observed among dietary treatments. In conclusion, increasing dietary levels of LP1 did not impact nursery pig performance.

Key words: *Lactobacillus plantarum*, growth performance, nursery pig, probiotic

Introduction

Growth promotional feed additives continue to be an area of emphasis for evaluation, especially in nursery pig diets. One of the classes of feed additives that has gained sig-

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[2] Appreciation is expressed to Julie Salyer, Dr. Brad James, and Lorene Parkhurst, Kalmbach Feeds, for their technical support and expertise in conducting the experiment.

[3] Department of Diagnostic Medicine/Pathology, College of Veterinary Medicine, Kansas State University.

[4] de Vries, M. C., E. E. Vaughan, M. Kleerebezem, W. M. de Vos. 2006. *Lactobacillus plantarum* – survival, functional and potential probiotic properties in the human intestinal tract.

[5] da Silva Sabo, S., M. Vitolo, J. M. Domínguez González, and R. P. d. S. Oliveira. 2014. Overview of *Lactobacillus plantarum* as a promising bacteriocin producer among lactic acid bacteria. Food Res. Int. 64: 527-536.

nificant interest is probiotics. Probiotics can be defined as live microorganisms which, when administered in adequate amounts, confer a health benefit on the host (FAO/WHO, 2001).[6] Mechanistically, the modes of action of probiotics are likely to include competitive exclusion of pathogenic bacteria, regulation of local cell-mediated immune responses, increasing antibody production, promotion of epithelial barrier integrity, and the reduction of epithelial cell apoptosis (Ng et al., 2009).[7] However, debate still remains within the scientific community on these modes of actions.

Among the diverse bacterial species used for probiotics, the nonpathogenic class of *Bacillus* species are some of the most extensively studied. Of the species, *L. plantarum* has shown some of the more promising beneficial results on the overall gastrointestinal microbiota of nursery pigs (Pieper et al., 2009; Guerra-Ordaz et al., 2013).[8,9] *Lactobacillus plantarum* is a facultative heterofermentative plant-associated lactic acid bacterium that is tolerant against bile salts and low pH, improving survivability in the GIT (de Vries et al., 2006; da Silva Sabo et al., 2014).[10,11] These findings certainly make it a promising bacterial source that could potentially be used in swine diets. However, in the context of these studies, all research has been carried out under highly controlled environments. Research examining its impact in commercial settings is scarce. Thus, the objective of this study was to evaluate the efficacy of *Lactobacillus plantarum* in nursery pigs in a commercial research facility.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol for this experiment. The study was conducted at the Cooperative Research Farm's Swine Research Nursery (Sycamore, OH), which is owned and managed by Kalmbach Feeds, Inc. Each pen had slatted metal floors and was equipped with a 4-hole stainless steel feeder and one nipple-cup waterer for ad libitum access to feed and water. Pens were 5 × 6 ft to allow 3 ft^2 per pig. Nursery rooms were not power washed or disinfected after the previous 6 groups of pigs.

A total of 360 pigs (PIC C-29 × 359, initially 13.1 lb BW) with 10 pigs per pen and 9 replications per treatment were used in a 42-d trial. Pigs were weaned at approximately 16 to 20 d of age and allotted to pens based on initial BW and gender to 1 of 4 dietary

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[6] FAO/WHO (Food and Agriculture Organization/World Health Organization) 2006. Probiotics in food: Health and nutritional properties and guidelines for evaluation. ftp://ftp.fao.org/docrep/fao/009/a0512e/a0512e00.pdf.

[7] Ng, S. C., A. L. Hart, M. A. Kamm, A. J. Stagg, S. C. Knight. 2009. Mechanisms of action of probiotics: Recent advances. Inflamm. Bowel Dis. 15: 300-310.

[8] Pieper, R., P. Janczyk, V. Urubschurov, U. Korn, B. Pieper, and W. B. Souffrant. 2009. Effect of a single administration of *Lactobacillus plantarum* DSMZ 8862/8866 before and at the time point of weaning on intestinal microbial communities in piglets. Int. J. Microbiol.130: 215-236.

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[10] de Vries, M. C., E. E. Vaughan, M. Kleerebezem, W. M. de Vos. 2006. *Lactobacillus plantarum* – survival, functional and potential probiotic properties in the human intestinal tract.

[11] da Silva Sabo, S., M. Vitolo, J. M. Domínguez González, and R. P. d. S. Oliveira. 2014. Overview of *Lactobacillus plantarum* as a promising bacteriocin producer among lactic acid bacteria. Food Res. Int. 64: 527-536.

treatments in a completely randomized design. Pigs and feeders were weighed every 7 d of the trial to determine ADG, ADFI, and F/G.

Experimental diets were fed in three phases (Table 1). Phase 1 was fed from d 0 to 7 d. The second phase was fed from d 7 to 21 (~ 25 lb BW), while phase 3 was fed from d 21 to 42 post-weaning. Treatment diets were formulated to include 0, 0.05, 0.10, or 0.20% of *Lactobacillus plantarum* product (LP1; Nutraferma Inc., Sioux City, IA). All treatment diets within phase were formulated to similar nutrient levels. All experimental diets were fed in pellet form.

Complete diet samples were collected and analyzed for DM, CP, crude fat, Ca, and P (Table 2).

Data were analyzed using the PROC GLIMIX procedure in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. Dietary treatment served as the fixed effect in the model. Linear and quadratic responses were determined for increasing LP1. A P value ≤ 0.05 was considered significant and 0.05 < P ≤ 0.10 was considered a tendency.

Results and Discussion

Chemical analysis of complete diets revealed that analyzed values were similar to calculated values (Table 2).

From d 0 to 7 (Phase 1) and d 7 to 21 (Phase 2), there were no differences in growth performance observed among dietary treatments (Table 3). From d 21 to 42 (Phase 3), ADG and ADFI were not influenced by treatment; however, F/G tended to improve (quadratic, P = 0.085) with increasing LP1 up to 0.10%. Overall (d 0 to 42), there were no differences in growth performance detected between dietary treatments.

The addition of up to 0.20% LP1 used in this study, resulted in no improvements in overall ADG, ADFI, or F/G. Additional research should be conducted to determine if LP1 elicits a response in other diet formulation or health statuses. One possible explanation could be attributed to the fact that the overall health status of the pigs throughout this experiment was very good. This occurred although the room that they were placed into had not been power washed or disinfected after the previous 6 groups of pigs.

Table 1. Phase 1, 2, 3 diet composition (as-fed basis)[1]

Ingredient, %	Phase 1	Phase 2	Phase 3
Corn	35.67	41.45	52.01
Soybean meal, 46.5% CP	30.00	30.00	32.54
Corn DDGS[2]	5.00	10.00	10.00
Spray dried whey	21.74	10.87	---
Fish meal	2.50	3.00	---
Tallow	2.00	2.00	2.00
Limestone	1.06	0.93	1.13
Monocalcium P, 21% P	0.80	0.40	1.09
Sodium chloride	0.25	0.30	0.40
L-lysine HCl	0.22	0.28	0.37
DL-methionine	0.15	0.12	0.14
L-threonine	0.09	0.11	0.15
L-tryptophan	0.01	0.02	0.01
Quantum Blue[3]	0.01	0.01	0.01
Zinc oxide	0.26	0.26	---
Choline chloride, 70% liq.	0.04	0.04	---
Selenium, 0.06%	0.02	0.02	0.02
Trace mineral premix	0.09	0.09	0.09
Vitamin premix	0.10	0.10	0.05
LP1[4]	---	---	---
Total	100	100	100
Calculated analysis			
Standardized ileal digestible (SID) amino acids, %			
Lys	1.40	1.35	1.30
Met:Lys	33	35	35
Met and Cys:Lys	58	58	58
Thr:Lys	65	65	65
Trp:Lys	20	20	18
Val:Lys	70	71	69
ME, kcal/lb	1,530	1,532	1,515
CP, %	23.36	23.92	22.92
Ca, %	0.96	0.91	0.91
P, %	0.85	0.78	0.81
Available P, %	0.59	0.50	0.50

[1]Phase 1 diets were fed from d 0 to 7 (~13.1 to 14 lb BW), Phase 2 diets from d 7 to 21 (~14 to 24 lb BW and Phase 3 diets from d 21 to 42 (~ 24 to 51 lb BW).

[2] Dried distillers grains with solubles.

[3]Quantum Blue (AB-Vista Americas, Plantation, FL) provided 227 phytase units (FTU)/lb of diet, with a release of 0.13% available P.

[4] *Lactobacillus plantarum* (LP1; Nutraferma Inc., Sioux City, IA) was substituted at 0.05, 0.10, and 0.20% of the diet at the expense of corn.

Table 2. Laboratory analysis of Phases 1, 2, and 3 experimental diets[1]

		LP1[2]		
Item, %	Control	0.05%	0.10%	0.20%
Phase 1 diets				
DM	89.68	90.20	90.40	90.66
CP	22.40	22.10	23.20	21.20
Crude fat	4.90	4.70	4.80	4.70
Ca	0.80	0.84	0.75	0.77
P	0.71	0.72	0.70	0.66
Phase 2 diets				
DM	89.87	89.09	88.95	89.53
CP	22.40	21.30	22.40	23.10
Crude fat	5.60	5.30	5.70	5.70
Ca	0.75	0.77	0.78	0.75
P	0.66	0.66	0.64	0.63
Phase 3 diets				
DM	88.35	88.27	88.75	89.16
CP	20.40	22.10	22.80	22.50
Crude fat	5.30	5.20	5.40	5.20
Ca	0.73	0.74	0.72	0.71
P	0.67	0.67	0.68	0.70

[1]Complete diet samples were obtained from each dietary treatment each week during the study and composited. Samples of diets were then submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, CP, crude fat, Ca, and P.
[3]*Lactobacillus plantarum* (Nutraferma, Sioux City, IA).

Table 3. Effect of feeding varying levels of *Lactobacillus plantarum* on nursery pig performance[1]

		LP1[2]				Probability, $P <$	
Diets	Control	0.05%	0.10%	0.20%	SEM	Linear	Quadratic
BW, lb							
d 0	13.1	13.1	13.1	13.1	0.02	0.616	0.455
d 7	14.1	14.0	14.0	14.1	0.10	0.962	0.394
d 21	24.6	24.1	24.1	24.3	0.31	0.601	0.178
d 42	51.9	51.5	51.1	51.1	0.66	0.402	0.612
d 0 to 7							
ADG, lb	0.15	0.13	0.14	0.14	0.014	0.894	0.456
ADFI, lb	0.23	0.22	0.22	0.23	0.010	0.955	0.321
F/G	1.58	1.98	1.78	1.68	0.194	0.986	0.268
d 7 to 21							
ADG, lb	0.75	0.72	0.71	0.73	0.019	0.606	0.209
ADFI, lb	0.90	0.88	0.85	0.87	0.020	0.276	0.260
F/G	1.20	1.23	1.19	1.19	0.017	0.326	0.611
d 21 to 42							
ADG, lb	1.30	1.30	1.29	1.28	0.021	0.405	0.919
ADFI, lb	1.81	1.79	1.77	1.78	0.029	0.451	0.442
F/G	1.40	1.38	1.37	1.39	0.011	0.898	0.085
d 0 to 42							
ADG, lb	0.92	0.91	0.90	0.90	0.015	0.508	0.567
ADFI, lb	1.24	1.22	1.20	1.22	0.020	0.448	0.316
F/G	1.35	1.34	1.33	1.34	0.010	0.783	0.314

[1]A total of 360 pigs (PIC C-29 × 359) were used in a 3-phase nursery trial with 10 pigs per pen and 9 replications per treatment. All experimental diets were fed in three phases (d 0 to 7, d 7 to 21, and d 21 to 42).
[2]*Lactobacillus plantarum* (fed from d 0 to 42) (Nutraferma, Sioux, City, IA).