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Comparing the Effects of Butyric Acid Source and Level on Growth Performance of Nursery Pigs

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Abstract

A total of 398 pigs (PIC 19 × 1050 or PIC 3 × C29, initially 13.56 ± 0.02 lb) were used in a 42-d growth study to compare the effects of increasing two different sources of encapsulated butyric acid on growth performance of nursery pigs fed meal diets. Dietary treatments were arranged as a 2 × 2 + 1 factorial with main effects of butyric acid source (ButiPEARL vs. ButiPEARLZ; Kemin Industries, Des Moines, IA) and level (low (1 or 1.38 lb/ton) vs. high (2 or 2.76 lb/ton) respectively) plus a control diet without any butyric acid. The inclusion rates of each product were established such that the same amount of butyric acid was contributed from each source for the low or high levels, respectively. Experimental diets were fed in three phases from d 0 to 7, 7 to 21, and 21 to 42. Pens of pigs (6 barrows and 4 gilts) were balanced by initial BW and randomly allotted to treatments, with 8 replications (pens) per treatment. From d 0 to 7, a source × level interaction ($P < 0.05$) was observed for ADG, ADFI, and F/G, with pigs fed diets containing ButiPEARL having improved performance at the low inclusion, but with those fed high butyric acid not different from the control. However, pigs fed ButiPEARLZ had poorer growth performance at the low level, with the high level having performance similar to the control. In Phase 2 (d 7 to 21), ADG and ADFI were not influenced by butyric acid source or level, but an interaction ($P = 0.001$) was observed for F/G as pigs fed ButiPEARL had poorer F/G as level increased; whereas pigs fed increasing ButiPEARLZ had improved F/G. For Phase 3 (d 21 to 42), increasing either butyric acid source tended ($P = 0.060$) to decrease ADG. Overall (d 0 to 42), butyric acid source or level did not affect ADG, ADFI or F/G. In conclusion, this study showed that pigs fed low ButiPEARL in Phase 1 (d 0 to 7) had improved growth performance compared to other treatments with only minor treatment effects observed thereafter. More research is warranted to determine if the butyric acid sources used in this experiment would elicit different responses in pelleted nursery diets.

Keywords

butyric acid, growth, nursery pigs

Cover Page Footnote

Appreciation is expressed to Kemin Industries, (Des Moines, IA) for financial support of this experiment and to Julie Salyer of Kalmbach Feeds, Upper Sandusky, OH, for assistance in conducting this experiment.

Authors

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Comparing the Effects of Butyric Acid Source and Level on Growth Performance of Nursery Pigs[1]

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Summary

A total of 398 pigs (PIC 19 × 1050 or PIC 3 × C29, initially 13.56 ± 0.02 lb) were used in a 42-d growth study to compare the effects of increasing two different sources of encapsulated butyric acid on growth performance of nursery pigs fed meal diets. Dietary treatments were arranged as a 2 × 2 + 1 factorial with main effects of butyric acid source (ButiPEARL vs. ButiPEARLZ; Kemin Industries, Des Moines, IA) and level (low (1 or 1.38 lb/ton) vs. high (2 or 2.76 lb/ton) respectively) plus a control diet without any butyric acid. The inclusion rates of each product were established such that the same amount of butyric acid was contributed from each source for the low or high levels, respectively. Experimental diets were fed in three phases from d 0 to 7, 7 to 21, and 21 to 42. Pens of pigs (6 barrows and 4 gilts) were balanced by initial BW and randomly allotted to treatments, with 8 replications (pens) per treatment. From d 0 to 7, a source × level interaction ($P < 0.05$) was observed for ADG, ADFI, and F/G, with pigs fed diets containing ButiPEARL having improved performance at the low inclusion, but with those fed high butyric acid not different from the control. However, pigs fed ButiPEARLZ had poorer growth performance at the low level, with the high level having performance similar to the control. In Phase 2 (d 7 to 21), ADG and ADFI were not influenced by butyric acid source or level, but an interaction ($P = 0.001$) was observed for F/G as pigs fed ButiPEARL had poorer F/G as level increased; whereas pigs fed increasing ButiPEARLZ had improved F/G. For Phase 3 (d 21 to 42), increasing either butyric acid source tended ($P = 0.060$) to decrease ADG. Overall (d 0 to 42), butyric acid source or level did not affect ADG, ADFI or F/G. In conclusion, this study showed that pigs fed low ButiPEARL in Phase 1 (d 0 to 7) had improved growth performance compared to other treatments with only minor treatment effects observed thereafter. More research is warranted to determine if the butyric acid sources used in this experiment would elicit different responses in pelleted nursery diets.

Key words: butyric acid, growth, nursery pigs

[1] Appreciation is expressed to Kemin Industries, (Des Moines, IA) for financial support of this experiment and to Julie Salyer of Kalmbach Feeds, Upper Sandusky, OH, for assistance in conducting this experiment.

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

Introduction

With evolving research on feed additives in the nursery, there is an interest to determine which products are effective at increasing growth and efficiency of weaned pigs. One such feed additive is butyric acid, which is a short chain fatty acid that is used by the gastrointestinal tract to promote growth of the intestinal epithelium in monogastric animals. Due to the pungent odors commonly associated with it, and to make it easier to handle in feed mills, it is often encapsulated. Encapsulation is a process where a liquid can be captured inside of a shell through a spray freezing technology. The shell, which consists of a fat matrix, ensures that the ingredient is not digested immediately and can be released in the intestinal tract. Kemin Industries (Des Moines, IA) manufactures and markets an encapsulated butyric acid product called ButiPEARL. Recently, the company has developed a next generation encapsulated butyric acid product called ButiPEARLZ, which is suggested to have differing butyric acid release rates from the encapsulation matrix, that might impact growth performance. No data are available to compare the two products. Therefore, the objective of this study was designed to compare the two sources and levels of butyric acid, in meal diets on the growth performance of nursery pigs.

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. To better reflect the increased challenge of rearing pigs in a commercial environment, rooms were not washed before the experiment to increase bacteria load.

A total of 398 pigs (PIC 19 × 1050 or PIC 3 × C29, initially 13.56 ± 0.02 lb) were used in a 42-d growth study. Pens of pigs (6 barrows and 4 gilts) were balanced by initial BW and randomly allotted to treatments with 8 replications (pens) per treatment. The 5 dietary treatments were initiated immediately after weaning and were arranged as a 2 × 2 +1 factorial with a control diet, the control + ButiPEARL (1 or 2 lb/ton; Kemin Industries, Des Moines, IA), and control + ButiPEARLZ (1.38 or 2.76 lb/ton). The inclusion rates of each product were established such that each source contributed the same amount of butyric acid for the low or high levels, respectively. Experimental diets (Tables 1 and 2) were fed in 3 phases from d 0 to 7, 7 to 21, and 21 to 42. Feed was manufactured at the Kalmbach Feeds feed mill and fed in meal form. Multiple feed samples were collected at the feeder during each phase and analyzed for CP, Ca and P (Ward Laboratories, Inc., Kearney, NE). Pig weight and feed disappearance were measured on d 0, 7, 14, 21, 28, 35, and 42 to determine ADG, ADFI, and F/G.

Data were analyzed using the PROC MIXED procedures of SAS (SAS Institute Inc., Cary, NC) in a randomized design with pen serving as the experimental unit. The main effects of butyric acid source and level, and their interactions, were tested with results considered significant at $P \leq 0.05$ and a trend at $P \leq 0.10$.

Results and Discussion

During Phase 1 (d 0 to 7), a source × level interaction ($P < 0.05$) was observed for ADG, ADFI, and F/G (Table 3). This was the result of pigs fed diets containing ButiPEARL having improved performance at the low inclusion level, with the high level no different than control; however, pigs fed ButiPEARLZ had poorer performance at the low level, with the high level having performance similar to the control (Table 3). Also, pigs fed diets containing ButiPEARL had improved ($P \leq 0.005$) ADG and ADFI and tended to have improved ($P = 0.083$) F/G compared to those fed ButiPEARLZ.

During Phase 2 (d 7 to 21), an interaction ($P = 0.001$) was observed for F/G, with pigs fed increasing ButiPEARL having improved F/G; whereas pigs fed increasing ButiPEARLZ having poorer F/G. No main effects of source or level were observed. In Phase 3 (d 21 to 42), ADG tended to be greater ($P = 0.060$) for pigs fed either low dietary butyric acid levels, than for those fed the high levels. Overall (d 0 to 42), there were no differences observed among treatments.

Previous research demonstrated that *n*-butyrate is the main energy substrate for colonocytes, where 75% of oxygen consumed by colonocytes is from metabolism of *n*-butyrate (Roediger, 1980[3]). Furthermore, when diets included tributyrin (a compound composed of butyric acid and glycerol) and were fed with lacitol, this increased the mucosal thickness and villus length in the cecum (Piva et al., 2002[4]).

In summary, this study shows that low levels of ButiPEARL will elicit improved growth performance of pigs the first week after weaning. More research is warranted to determine if the butyric acid sources used in this experiment would elicit different responses in pelleted nursery diets.

[3] Roediger, W. E. 1980. Role of anaerobic bacteria in the metabolic welfare of the colic mucosa in man. Gut. 21:793-798.

[4] Piva, A. A., Prandini, L. Fiorentini, M. Morlacchini, F. Galvano, and J.B. Luchansky. 2002. Tributyrin and lacitol synergistically enhanced the trophic status of the intestinal mucosa and reduced histamine levels in the gut of nursery pigs. J. Anim. Sci. 80:670-680.

Table 1. Diet composition (as-fed basis)

Ingredients, %	Phase 1[1]	Phase 2	Phase 3
Corn	38.50	50.88	62.05
Soybean meal	21.50	30.10	32.23
Dried whey	20.90	10.15	---
Cheese plus[2]	7.30	---	---
Spray dried plasma	4.00	---	---
Fish meal	2.50	3.25	---
Tallow	2.00	2.00	2.00
Limestone	1.02	1.03	1.08
Monocalcium phosphate, 21% P	0.91	1.07	0.83
Salt	0.25	0.25	0.50
L-Lysine HCl	0.19	0.30	0.34
DL-Methionine	0.17	0.17	0.15
Threonine	0.09	0.11	0.12
Copper sulfate	0.09	0.09	0.09
Zinc oxide	0.26	0.26	0.26
Trace mineral premix	0.09	0.09	0.09
Selenium 0.06%	0.02	0.02	0.02
Vitamin premix	0.05	0.05	0.05
Biotin 100 mg/lb	0.08	0.08	0.08
K-Vitamin E-20,0	0.06	0.06	0.06
Choline chloride, 70%	0.05	0.05	0.05
Quantum Blue[3]	---	---	0.01
ButiPEARL[4]	---	---	---
ButiPEARLZ[5]	---	---	---
Total	100.0	100.0	100.0

continued

Table 1. Diet composition (as-fed basis)

Ingredients, %	Phase 1[1]	Phase 2	Phase 3
Calculated analysis			
Standardized ileal digestible (SID) amino acids, %			
Lys	1.52	1.35	1.25
Met:lys	34	37	36
Met and cys:lys	58	58	58
Thr:lys	65	65	65
Trp:lys	18	18	18
Val:lys	68	67	68
Total lys, %	1.68	1.50	1.25
ME, kcal/lb	1,587	1,534	1,530
CP, %	23.2	22.0	20.7
Ca, %	0.90	0.90	0.85
P, %	0.77	0.73	0.71
Available P, %	0.55	0.45	0.40

[1]Phase 1, 2, and 3 diets were fed from d 0 to 7, 7 to 21 and 21 to 42, respectively.
[2] Cheese Plus (International Ingredient Corporation, St. Louis, MO).
[3]Quantum Blue (AB Vista Americas, Plantation, FL) provided 227 FTU/lb of diet, with a release of 0.13% available P.
[4]ButiPEARL (Kemin Industries Inc., Des Moines, IA) encapsulated butyric acid was included in the diet at the expense of corn at low (1.0 lb/ton) or high (2.0 lb/ton) levels.
[5]ButiPEARLZ (Kemin Industries Inc., Des Moines, IA) encapsulated butyric acid was included in the diet at the expense of corn at low (1.38 lb/ton) or high (2.76 lb/ton) levels.

Table 2. Chemical analysis of diets (as-fed basis)[1,2]

	Phase 1					Phase 2					Phase 3				
		ButiPEARL[3]		ButiPEARLZ[4]			ButiPEARL		ButiPEARLZ			ButiPEARL		ButiPEARLZ	
Item,%	Control	Low	High	Low	High	Control	Low	High	Low	High	Control	Low	High	Low	High
DM	90.01	90.68	90.39	90.94	90.81	89.28	89.60	89.29	89.14	89.81	87.95	87.82	88.36	87.94	88.06
CP	22.4	22.9	22.6	23.3	23.1	23.1	19.9	21.2	22.0	21.9	19.9	19.8	18.4	19.5	18.4
Crude fiber	1.5	1.3	1.8	2.2	2.2	1.8	3.3	2.3	2.1	2.7	2.2	3.5	2.6	2.2	2.5
Ca	0.91	0.98	1.03	1.27	1.11	0.92	1.25	1.03	0.96	0.91	0.71	0.81	0.81	0.66	0.74
P	0.77	0.79	0.79	0.81	0.84	0.71	0.76	0.75	0.69	0.70	0.56	0.58	0.55	0.53	0.51
Ash	7.56	7.07	7.12	7.70	7.27	6.08	7.10	6.29	6.21	5.89	5.10	5.17	5.17	5.02	4.95
Ether extract	5.9	5.8	5.6	5.6	5.8	4.9	4.3	4.6	4.5	4.8	4.2	5.1	4.7	4.6	4.3

[1]Phase 1, 2, and 3 diets were fed from d 0 to 7, 7 to 21, and 21 to 42, respectively.
[2]Values represent a subsample from a composite sample collected at multiple feeders per treatment.
[3]ButiPEARL (Kemin Industries Inc., Des Moines, IA) encapsulated butyric acid was included in the diet at low (1.0 lb/ton) or high (2.0 lb/ton) levels.
[4]ButiPEARLZ (Kemin Industries Inc., Des Moines, IA) encapsulated butyric acid was included in the diet at low (1.38 lb/ton) or high (2.76 lb/ton) levels.

Table 3. Effects of butyric acid source and level on performance of nursery pigs fed meal diets[1]

		ButiPEARL[2]		ButiPEARLZ[3]			Probability, $P <$		
Item	Control	Low	High	Low	High	SEM	Source × level	Source	Level
BW, lb									
d 0	13.58	13.58	13.57	13.55	13.56	0.025	0.616	0.505	0.911
d 7	15.24[b]	15.83[a]	15.23[b]	14.94[b]	15.24[b]	0.135	0.002	0.002	0.279
d 21	26.91	25.25	25.15	24.66	24.85	0.403	0.737	0.308	0.914
d 28	34.89	34.38	33.20	32.94	32.79	0.557	0.367	0.112	0.252
d 42	58.16	57.56	55.79	55.44	55.18	0.846	0.377	0.118	0.242
d 0 to 7									
ADG, lb	0.24[b]	0.31[a]	0.24[b]	0.20[b]	0.24[b]	0.017	0.002	0.003	0.413
ADFI, lb	0.31[b]	0.37[a]	0.32[b]	0.29[b]	0.31[b]	0.014	0.020	0.002	0.430
F/G	1.31[a,b]	1.21[b]	1.38[a,b]	1.48[a]	1.34[a,b]	0.062	0.018	0.083	0.822
d 7 to 21									
ADG, lb	0.83	0.67	0.71	0.69	0.69	0.027	0.425	0.986	0.615
ADFI, lb	0.95	0.88	0.87	0.85	0.88	0.029	0.459	0.708	0.871
F/G	1.14[c]	1.32[a]	1.22[b]	1.23[b]	1.28[a,b]	0.022	0.001	0.404	0.344
d 21 to 42									
ADG, lb	1.49	1.53	1.46	1.47	1.43	0.026	0.488	0.101	0.060
ADFI, lb	2.22	2.21	2.15	2.12	2.10	0.044	0.694	0.126	0.387
F/G	1.49	1.45	1.48	1.45	1.46	0.015	0.677	0.759	0.109
d 0 to 42									
ADG, lb	1.06	1.04	1.01	1.00	0.98	0.020	0.694	0.130	0.260
ADFI, lb	1.48	1.45	1.42	1.39	1.39	0.030	0.581	0.135	0.532
F/G	1.39	1.40	1.41	1.40	1.41	0.012	0.621	0.799	0.264

[1]A total of 398 pigs (PIC 19 × 1050 or PIC 3 × C29, 13.56 ± 0.02 lb) were used in a 42-d growth trial with 10 pigs per pen and 8 replications per treatment.
[2]ButiPEARL (Kemin Industries Inc., Des Moines, IA) encapsulated butyric acid was included at low (1.0 lb/ton) or high (2.0 lb/ton) levels.
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