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KANSAS STATE UNIVERSITY SWINE INDUSTRY DAY 2024

Evaluating the Effects of Increasing Sodium Diformate on Nursery Pig Growth Performance and Fecal Dry Matter[1]

Katelyn N. Gaffield, Gracie J. Becker, Jessica L. Smallfield, Joel M. DeRouchey, Mike D. Tokach, Jason C. Woodworth, Robert D. Goodband, Troy Lohrmann,[2] Christian Lückstädt,[3] and Jordan T. Gebhardt[4]

Summary

A total of 360 weanling barrows (DNA 200 × 400, DNA; initially 13.1 ± 0.12 lb) were used in a 38-d growth trial to evaluate the effects of dietary sodium diformate on nursery pig growth performance and fecal dry matter. At weaning, pigs were randomly assigned to pens with five pigs per pen and 12 pens per treatment. There were six dietary treatments formulated to provided none, 0.40, 0.60, 0.80, 1.00, and 1.20% sodium diformate (Formi NDF, ADDCON, Nordic AS, Porsgrunn, Norway) added at the expense of corn. Experimental diets were fed in three phases: phase 1 from weaning to d 9, phase 2 from d 9 to 24, and phase 3 from d 24 to 38. From d 0 to 24 (phases 1 and 2), increasing sodium diformate improved (linear, $P = 0.001$) F/G. However, sodium diformate did not affect ($P > 0.10$) ADG or ADFI. From d 24 to 38 (phase 3) and overall (d 0 to 38), there was no evidence of differences ($P > 0.10$) in any of the growth performance criteria. There was no evidence for differences ($P > 0.10$) in fecal DM on d 9. However, fecal DM decreased (linear, $P < 0.05$) as sodium diformate increased on d 24 with pigs fed 0.40% sodium diformate having the highest percentage fecal DM. Additionally, there was evidence for a main effect of day ($P < 0.001$) with fecal DM being lower on d 24 compared to d 9. In conclusion, these data suggest increasing sodium diformate has the potential to improve feed efficiency in the early nursery period but did not affect performance in the late nursery.

Introduction

Organic acids, such as formic acid, are commonly used as acidifiers in swine diets. Dietary acidifiers have the potential to lower gastrointestinal tract pH, which in turn can improve nutrient digestion, growth performance, and alter gut microbiota in nursery pigs. Of the dietary acidifiers, formic acid has one of the lowest acid-binding capacity-4 (ABC-4) values. This high acidification potential indicates formic acid may

[1] The authors appreciate Quality Technology International, US distributor of Formi NDF, and ADDCON for financial support of this project.

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have a strong impact on both swine gastrointestinal health and growth performance. Forms of formic acid can include calcium, sodium, or potassium salts. Although there have been positive results published utilizing potassium diformate in swine diets,[5,6] there is currently limited research evaluating the use of other formic acid salts, such as sodium diformate.

Recently, increasing levels of sodium diformate have shown improvements in growth performance of late finishing pigs.[7] However, data is limited on its effects in nursery pigs. Consequently, feeding an optimal level of sodium diformate throughout the nursery period needs to be evaluated. Therefore, the objective of this study was to investigate the effects of increasing sodium diformate in nursery pig diets on growth performance and fecal dry matter.

Materials and Methods

The protocol for this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. The study was conducted at the Kansas State University Segregated Early Weaning Facility in Manhattan, KS, where pigs were housed in two identical, environmentally controlled barns. Pens (4 × 4 ft) had metal tri-bar floors and housed five pigs per pen allowing approximately 2.7 ft^2/pig. Each pen contained a cup waterer and a 4-hole, dry self-feeder which provided ad libitum access to feed and water throughout the duration of the study.

A total of 360 weanling barrows (DNA 200 × 400, DNA; initially 13.1 ± 0.12 lb) were used in a 38-d growth trial. At weaning, pigs were randomly assigned to pens with five pigs per pen and 12 pens per treatment. The six dietary treatments were formulated to provided none, 0.40, 0.60, 0.80, 1.00, and 1.20% sodium diformate (Formi NDF, ADDCON, Nordic AS, Porsgrunn, Norway) added at the expense of corn. Experimental diets were fed in three phases: phase 1 from weaning to d 9, phase 2 from d 9 to 24, and phase 3 from d 24 to 38. For phase 1 and phase 2, a single base diet was manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS. The base diet was then used to manufacture the six treatment diets through additions of corn and sodium diformate. For phase 3, complete diets were manufactured with a total of two batches per treatment. Diets were fed in meal form and pig weights and feed disappearance were measured on d 0, 9, 18, 24, 31, and 38 to determine ADG, ADFI, and F/G. Feces were collected on d 9 and 24 from three pigs per pen to determine fecal dry matter. Samples were dried at 130°F for 48 h and loss of weight used to determine percentage fecal dry matter.

For the economic analysis, set prices were used to calculate total feed cost, feed cost per lb of gain, total revenue, and IOFC per pig (Table 2). Feed cost per pig was determined by total feed intake × diet cost ($/lb). Feed cost per lb of gain was determined as total

[5] Overland, M., T. Granli, N. P. Kjos, O. Fjetland, S. H. Steien, and M. Stokstad. 2000. Effect of dietary formats on growth performance, carcass traits, sensory quality, intestinal microflora, and stomach alterations in growing-finishing pigs. J. Anim. Sci. 78(7):1875-1884. doi:10.2527/2000.7871875.

[6] Htoo, J. K., and J. Molares. 2012. Effects of dietary supplementation with two potassium formate sources on performance of 8- to 22- kg pigs. J. Anim. Sci. 90(4):346-349. doi:10.2527/jas.53776.

[7] Gaffield, K. N., M. D. Tokach, R. D. Goodband, J. C. Woodworth, J. M. DeRouchey, J. T. Gebhardt, M. B. Menegat, M. Liebenstein, and M. Allerson. 2023. Evaluating the effects of sodium diformate on finishing pig growth performance. Kansas State University Swine Day. Kansas Agricultural Experiment Station Research.

feed cost ÷ total gain per pig. Revenue per pig was calculated as total gain × carcass yield × $0.60/lb carcass price. Finally, income over feed cost was determined as total revenue - total feed cost per pig. All economic analyses were determined on a per pig placed basis.

Statistical analysis

Data were analyzed as a completely randomized design for a one-way ANOVA using the GLIMMIX procedure of SAS v. 9.4 (SAS Institute, Inc., Cary, NC). Pen was considered the experimental unit, barn served as a random effect, and treatment served as the fixed effect. Linear and quadratic contrasts were used to test for the main effects of increasing sodium diformate. Similarly, contrasts were used to test for the main effects of treatment, day, and interaction between treatment and day on fecal DM. Results were considered significant with $P \leq 0.05$ and marginally significant with $P \leq 0.10$.

Results and Discussion

From d 0 to 24 (phase 1 and 2), increasing sodium diformate improved (linear, $P = 0.001$) F/G. However, sodium diformate did not affect ($P > 0.10$) ADG or ADFI. From d 24 to 38 (phase 3) or overall (d 0 to 38), there was no evidence of differences ($P > 0.10$) in any of the growth performance criteria. Overall mortality was 0.8% and was not influenced by treatment.

For economics on a per pig placed basis, increasing sodium diformate in the diets tended to increase (linear, $P = 0.057$; quadratic, $P = 0.095$) feed cost and increased (linear, $P < 0.001$) feed cost per lb of gain. However, there was no evidence of differences ($P > 0.10$) in revenue. Due to the increased feed cost and similar revenue, pigs fed increasing sodium diformate had decreased (linear, $P < 0.05$) IOFC.

There was no evidence ($P = 0.749$) of an interaction between treatment and day for fecal DM. There was no evidence for differences ($P > 0.10$) in fecal DM on d 9; however, fecal DM decreased (linear, $P < 0.05$; quadratic, $P = 0.097$) as sodium diformate increased in the diet on d 24 with pigs fed 0.40% sodium diformate having the highest fecal DM. Additionally, there was evidence for a main effect of day ($P < 0.001$) with fecal DM being lower on d 24 compared to d 9.

In conclusion, these data suggest increasing sodium diformate has the potential to improve feed efficiency in the early nursery period but did not affect performance in the late nursery. Despite the improvement in feed efficiency in early nursery, it is currently not economical to feed sodium diformate throughout the entire nursery period. Additional research is needed on target feeding sodium diformate during specific stages of the nursery and during health challenges.

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Table 1. Diet composition (as-fed basis)[1]

Item, %	Phase 1	Phase 2	Phase 3
Ingredients, %			
Corn	44.85	50.12	64.18
Soybean meal, 46.5% CP	17.41	23.76	31.78
Spray-dried whey	10.00	---	---
Whey permeate, 80% lactose	10.00	10.00	---
DDGS	5.00	7.50	---
Fish meal, 60% CP	2.50	---	---
Fermented soybean meal[2]	4.00	3.85	---
Spray-dried bovine plasma	2.00	---	---
Soybean oil	1.00	1.00	---
Monocalcium P, 21% P	0.80	1.00	1.00
Calcium carbonate	0.41	0.40	0.88
Zinc oxide	0.40	0.25	---
Salt	0.30	0.50	0.60
Vitamin premix	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15
Phytase[3]	0.08	0.08	0.08
L-Lys-HCL	0.40	0.55	0.50
DL-Met	0.19	0.23	0.21
L-Thr	0.17	0.22	0.21
L-Trp	0.02	0.04	0.04
L-Val	0.08	0.12	0.13
Sodium diformate[4]	+/-	+/-	+/-
Total	100	100	100

continued

Table 1. Diet composition (as-fed basis)[1]

Item, %	Phase 1	Phase 2	Phase 3
Calculated analysis			
SID amino acids, %			
Lys	1.35	1.35	1.35
Ile:Lys	57	57	56
Leu:Lys	120	118	115
Met:Lys	36	38	36
Met and Cys:Lys	56	56	58
Thr:Lys	64	63	63
Trp:Lys	19.2	19.2	19.3
Val:Lys	70	70	70
Total Lys, %	1.51	1.51	1.50
NE, kcal/lb	1,154	1,136	1,097
SID Lys:NE, g/Mcal	5.30	5.39	5.58
CP, %	21.5	21.5	21.3
Ca, %	0.66	0.54	0.71
P, %	0.66	0.61	0.61
STTD P, %	0.59	0.51	0.48

[1] Phase 1 diets were fed from 13.1 lb to 15.7 lb, phase 2 diets were fed from 15.7 lb to 29.5 lb, and phase 3 diets were fed from 29.5 lb to 47.9 lb.

[2] MEPro, Prairie Aquatech, Brookings, SD.

[3] Ronozyme HiPhos 2700 GT, DSM Nutritional Products, Parsippany, NJ was included at 2,000 FTU/kg to provide an estimated release of 0.12% STTD P for all diets.

[4] Sodium diformate (Formi NDF, ADDCON, Nordic AS, Porsgrunn, Norway) was included at the expense of corn.

Table 2. Effects of increasing sodium diformate on nursery pig performance and fecal dry matter[1]

	Sodium diformate, %[2]							*P* =	
Item	**0**	**0.40**	**0.60**	**0.80**	**1.00**	**1.20**	**SEM**	**Linear**	**Quadratic**
BW, lb									
d 0	13.1	13.1	13.1	13.1	13.1	13.1	0.12	0.905	0.911
d 24	29.4	29.1	29.6	30.0	29.6	29.3	0.44	0.671	0.630
d 38	47.9	47.5	48.2	48.0	47.7	47.9	0.73	0.980	0.956
d 0 to 24 (Phase 1 and 2)									
ADG, lb	0.68	0.67	0.69	0.71	0.69	0.67	0.019	0.683	0.420
ADFI, lb	0.87	0.85	0.87	0.87	0.86	0.82	0.020	0.356	0.237
F/G	1.29	1.28	1.27	1.24	1.25	1.23	0.013	0.001	0.670
d 24 to 38 (Phase 3)									
ADG, lb	1.32	1.32	1.33	1.29	1.29	1.32	0.035	0.511	0.803
ADFI, lb	1.88	1.91	1.89	1.87	1.87	1.89	0.037	0.822	0.792
F/G	1.42	1.45	1.43	1.46	1.46	1.44	0.021	0.309	0.429
d 0 to 38 (Overall)									
ADG, lb	0.91	0.91	0.92	0.92	0.91	0.90	0.020	0.822	0.626
ADFI, lb	1.24	1.24	1.25	1.24	1.23	1.21	0.024	0.443	0.332
F/G	1.36	1.37	1.35	1.35	1.36	1.34	0.010	0.199	0.319
Fecal DM, %[3]									
d 9	26.26	26.77	26.85	26.91	24.80	25.41	1.146	0.299	0.287
d 24	24.21	25.70	25.32	23.80	21.92	23.41	0.914	0.028	0.097
Economics, $/pig placed[4]									
Feed cost[5]	9.33	9.71	9.94	10.00	10.05	9.76	0.225	0.057	0.095
Feed cost/lb gain[6]	0.273	0.282	0.283	0.287	0.291	0.289	0.002	< 0.001	0.254
Revenue[7]	15.39	15.52	15.80	15.71	15.58	15.22	0.398	0.899	0.275
IOFC[8]	6.06	5.81	5.85	5.71	5.53	5.46	0.196	0.012	0.829

[1] A total of 360 weanling barrows (DNA 200 × 400, DNA; initially 13.1 ± 0.12 lb) approximately 21 days of age were used in a 38-d experiment with five pigs per pen and 12 pens per treatment.

[2] Formi NDF, ADDCON, Nordic AS, Porsgrunn, Norway.

[3] Feces from three piglets from each pen were pooled, weighed, and dried to measure fecal dry matter. Treatment × day, $P = 0.749$; Treatment, $P = 0.120$; Day, $P < 0.001$.

[4] All economic analyses were analyzed on a per pig placed basis.

[5] Market price: corn = $200/ton; soybean meal = $472/ton; DDGS = $180/ton; bovine plasma = $2.40/lb; fish meal = $1.02/lb; fermented soybean meal = $0.73/lb; spray-dried whey = $0.72/lb; whey permeate = $0.50/lb; soybean oil = $1.09/lb; calcium carbonate = $0.02/lb; monocalcium P = $0.60/lb; salt = $0.22/lb; L-Lys HCl = $0.24/lb; L-Trp = $0.24/lb; L-Thr = $0.24/lb; DL-Met = $1.58/lb; L-Val = $0.24/lb; trace mineral premix = $0.61/lb; vitamin premix = $0.75/lb; phytase = $2.87/lb; zinc oxide = $1.34/lb; and Formi NDF= $1.40/lb.

[6] Feed cost/lb gain = total feed cost per pig divided by total gain per pig.

[7] Revenue = (total gain × 0.75) × carcass price. Revenue is based on a $0.60/lb carcass price.

[8] Income over feed cost = revenue – feed cost.