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KANSAS STATE UNIVERSITY SWINE INDUSTRY DAY 2023

Evaluating the Effects of Sodium Diformate on Finishing Pig Growth Performance[1]

Katelyn N. Gaffield, Mike D. Tokach, Robert D. Goodband, Jason C. Woodworth, Joel M. DeRouchey, Jordan T. Gebhardt,[2] Mariana B. Menegat,[3] Mary Liebenstein,[3] and Matt Allerson[3]

Summary

A total of 2,200 pigs (Duroc sire (PIC 800 or DNA 600) × PIC Camborough; initially 53.4 ± 0.66 lb) were used to conduct a 117-d growth trial to evaluate the effects of dietary sodium diformate level on grow-finish pig growth performance and carcass characteristics. Pens of pigs (25 pigs per pen) were randomly assigned to 1 of 4 dietary treatments in a randomized complete block design with 22 replicates per treatment. Dietary treatments were corn-soybean meal-based with the addition of none, 0.25, 0.50, or 0.75% sodium diformate (Formi NDF; ADDCON Nordic AS, Porsgrunn, Norway). Diets were fed in 6 phases from 53 to 75, 75 to 145, 145 to 195, 195 to 245, 245 to 265, and 265 to 310 lb. From d 60 to 93, increasing sodium diformate increased (linear, $P < 0.01$) ADG and ADFI. Additionally, from d 93 to 117, increasing sodium diformate in the diets increased (linear, $P < 0.05$) ADG, ADFI, and improved (linear, $P < 0.05$) feed efficiency. For the overall period (d 0 to 117), pigs fed increasing sodium diformate had increased (linear, $P < 0.01$) ADG and a tendency for increased (linear, $P = 0.075$) ADFI; however, there was no evidence for differences ($P > 0.05$) in feed efficiency. For carcass characteristics, no evidence of differences ($P > 0.10$) was observed for any criteria. For economics, increasing sodium diformate in the diets increased (linear, $P < 0.001$) feed cost and feed cost per lb of gain in both low and high price scenarios. However, there was a tendency for a quadratic effect ($P = 0.059$) for revenue, with pigs fed 0.25% sodium diformate generating the greatest revenue in both the low and high price scenarios. Due to the increased feed cost and quadratic response in revenue, pigs fed increasing sodium diformate had a quadratic ($P < 0.05$) response in IOFC, with pigs fed no sodium diformate having the greatest IOFC. In conclusion, these data suggest that feeding increasing levels of sodium diformate improved ADG and ADFI after d 60 (~180 lb) in the grow-finish period. However, it is currently not economical to feed sodium diformate throughout the entire grow-finish period.

Introduction

Formic acid is an organic acid commonly used as an acidifier in swine diets. Formic acid has been shown to lower the pH of the stomach, increase the apparent total tract

[1] Funding, wholly or in part, was provided by the National Pork Checkoff. The authors appreciate Quality Technology International, US distributor of Formi NDF, for the donation of test materials.

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digestibility of protein, and significantly alter intestinal microbial concentrations and diversity.[4,5] Formic acid is frequently fed in the form of calcium, sodium, or potassium salts. There have been multiple studies on feeding potassium diformate which resulted in increased average daily gain and feed efficiency.[6,7] However, there is currently limited research analyzing the effects of various levels of the formic acid salt, sodium diformate, fed throughout the finisher phase. Therefore, the objective of this study was to investigate the effects of increasing levels of sodium diformate in grow-finish diets on growth performance and carcass characteristics.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol for this experiment. Two rooms at a commercial research grow-finish site located in south-central Minnesota (Holden Farms, Northfield, MN) were used for this experiment. Barns had completely slatted, concrete flooring and contained pens (10 × 18 ft) equipped with a three-hole feeder (Thorp Equipment, Inc., Thorp, WI) and double-sided pan waterer. Pigs were provided *ad libitum* access to feed and water. A computerized feeding system (FeedPro; Feedlogic Corp., Willmar, MN) provided daily feed additions.

Animals and diets

A total of 2,200 pigs (Duroc sire (PIC 800 or DNA 600) × PIC Camborough; initially 53.4 ± 0.66 lb) were used to conduct a 117-d growth trial. Pens of pigs (25 pigs per pen) were randomly assigned to 1 of 4 dietary treatments in a randomized complete block design with 22 replicates per treatment. Dietary treatments were corn-soybean meal-based with the addition of none, 0.25, 0.50, or 0.75% Formi NDF (ADDCON Nordic AS, Porsgrunn, Norway). This product is a combination of 57% sodium formate and 38.5% formic acid. All diets were manufactured at Bixby Feed Mill, Inc. (Blooming Prairie, MN). Diets were fed in 6 phases from 53 to 75, 75 to 145, 145 to 195, 195 to 245, 245 to 265, and 265 to 310 lb. Nutrients for all treatment diets were formulated to meet or exceed the NRC[8] requirements for growing-finishing pigs in each appropriate weight range (Table 1).

Pens of pigs were weighed every two weeks and feed disappearance was measured to determine ADG, ADFI, and F/G. Two weeks prior to the end of the experiment, 4 pigs per pen were weighed and marketed. The remaining pigs were weighed and marketed at the completion of the study. Pigs were transported to a U.S. Department of Agriculture-inspected packing plant. Hot carcass weight, loin depth, and backfat measurements

[4] Canibe, N., O. Hojberg, S. Hojsgaard, and B. B. Jensen. 2005. Feed physical form and formic acid addition to the feed affect the gastrointestinal ecology and growth performance of growing pigs. J. Anim. Sci. 83(6):1287-1302. doi:10.2527/2005.8361287x.

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[6] 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.

[7] 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.

[8] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.

were collected. Carcass yield was determined using the pen average HCW divided by the pen average final live weight. A proprietary equation from the packing plant was used to calculate the percentage lean.

For the economic analysis, high- and low-priced scenarios were used to calculate total feed cost, feed cost per lb of gain, total revenue, and IOFC per pig. High-priced diets were determined using the following ingredient costs: corn = $6.00/bushel ($214/ton); soybean meal = $400/ton; DDGS = $240/ton; L-Lys HCl = $0.80/lb; L-Trp = $5.00/lb; Thr Pro = $0.80/lb; and Formi NDF = $1.61/lb. Low-priced diets were determined using the following ingredient costs: corn = $3.00/bushel ($107/ton); soybean meal = $300/ton; DDGS = $140/ton; L-Lys HCl = $0.65/lb; L-Trp = $3.00/lb; Thr Pro = $0.80/lb; Formi NDF = $1.61/lb. Feed cost per pig was determined by total feed intake × diet cost ($/lb). Feed cost per lb of gain was determined as the total feed cost divided by total gain per pig. Revenue per pig was calculated for both low- and high-priced scenarios as total gain × carcass yield × $0.60/lb carcass price, or total gain × carcass yield × $0.88/lb carcass price, respectively. Finally, income over feed cost was determined as total revenue minus total feed cost per pig. All economic analyses were determined on a per pigs placed basis.

Statistical analysis

Data were analyzed using the GLIMMIX procedure of SAS (v. 9.4, SAS Institute, Inc., Cary, NC) in a randomized complete block design for a one-way ANOVA. Pen served as the experimental unit, treatment served as the fixed effect, and initial body weight served as a blocking factor. Contrasts were used to test for the main effects of the different sodium diformate feeding levels (0, 0.25, 0.50, and 0.75%). Results were considered significant with $P \leq 0.05$ and marginally significant with $P \leq 0.10$. Contrasts were also used to analyze carcass characteristics including backfat, loin depth, and percent lean with HCW weight serving as a covariate.

Results and Discussion

For period 1 (d 0 to 32), increasing sodium diformate tended to decrease (quadratic, $P = 0.081$) ADFI up to the 0.50% inclusion level. Furthermore, increasing sodium diformate had a quadratic ($P < 0.001$) effect on feed efficiency with the best F/G at the 0.25% inclusion level. There was no evidence of differences ($P > 0.05$) in ADG. For period 2 (d 32 to 60), there was no evidence for differences ($P > 0.10$) in ADG or ADFI; however, there was a tendency for a quadratic effect ($P = 0.092$) on feed efficiency, with the 0.25 and 0.50% inclusion of sodium diformate having the lowest F/G. For period 3 (d 60 to 93), increasing sodium diformate increased (linear, $P < 0.01$) ADG and ADFI. However, there was no evidence for differences ($P > 0.10$) in feed efficiency. For period 4 (d 93 to 117), increasing sodium diformate in the diets increased (linear, $P < 0.05$) ADG, ADFI, and improved (linear, $P < 0.05$) feed efficiency.

For the overall period (d 0 to 117), pigs fed increasing sodium diformate had increased (linear, $P < 0.01$) ADG and a tendency for increased (linear, $P = 0.075$) ADFI; however, there was no evidence for differences ($P > 0.10$) in feed efficiency. Increasing sodium diformate increased (linear, $P = 0.005$) final BW on d 117.

For carcass characteristics, no evidence for differences ($P > 0.10$) was observed for HCW, carcass yield, backfat, loin depth, or lean percentage due to increasing sodium

diformate. There were also no differences ($P > 0.10$) in removals and mortalities observed from increasing sodium diformate in the diet.

For economics on a per pig placed basis, increasing sodium diformate in the diets increased (linear, $P < 0.001$) feed cost and feed cost per lb of gain in both low and high price ingredient scenarios. However, there was a tendency for a quadratic effect ($P = 0.059$) of revenue, with pigs fed 0.25% sodium diformate generating the greatest revenue in both the low and high price scenarios. The revenue was greatest for the 0.25% sodium diformate treatment due to increased market weight compared to the control treatment, while having numerically lower mortality than the other sodium diformate treatments. However, mortality in this study was low compared to industry standard. Due to the increased feed cost and quadratic response in revenue, pigs fed increasing sodium diformate had a quadratic ($P < 0.05$) response in IOFC, with pigs fed no sodium diformate having the greatest IOFC.

In conclusion, these data suggest that feeding increasing levels of sodium diformate improved ADG and ADFI after approximately 180 lb in the grow-finish period. However, due to the increased feed cost, it is currently not economical to feed sodium diformate throughout the entire grow-finish period. Therefore, further research is needed to investigate the addition of sodium diformate only in the late finisher phase to understand if pigs will have similar improvements in growth performance with reduced overall feed cost.

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Table 1. Composition of experimental diets (as-fed basis)[1]

Item	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Ingredients, %						
Corn	42.96	52.96	60.73	64.54	69.38	82.73
Soybean meal (46.5% CP)	24.50	14.50	6.75	3.00	3.25	15.50
DDGS	30.00	30.00	30.00	30.00	25.00	---
Monocalcium P (21% P)	0.05	---	---	---	---	0.05
Limestone, ground	1.20	1.10	1.10	1.10	1.10	0.80
Salt	0.50	0.50	0.50	0.50	0.50	0.50
L-Lys-HCl	0.36	0.49	0.51	0.49	0.45	0.19
Thr[2]	0.06	0.12	0.12	0.11	0.11	0.07
L-Trp	0.00	0.03	0.05	0.05	0.04	0.00
Vitamin premix	0.20	0.15	0.13	0.13	0.10	0.10
Trace mineral premix	0.15	0.13	0.10	0.10	0.08	0.08
Copper sulfate	0.03	0.03	0.03	---	---	---
Sodium diformate[3]	+/-	+/-	+/-	+/-	+/-	+/-
Total	100	100	100	100	100	100
Calculated analysis						
Standardized ileal digestible (SID) amino acids, %						
Lys	1.15	1.02	0.86	0.75	0.72	0.72
Ile:Lys	68	61	58	58	58	66
Leu:Lys	167	166	177	191	189	163
Met:Lys	30	29	31	33	33	30
Met and Cys:Lys	57	56	59	63	63	60
Thr:Lys	63	63	63	64	65	65
Trp:Lys	18	18	18	18	18	18
Val:Lys	78	73	72	75	74	76
His:Lys	46	43	43	44	44	47
Total Lys, %	1.34	1.18	0.99	0.88	0.83	0.79
NE, kcal/lb	1,118	1,129	1,136	1,140	1,149	1,181
SID Lys:NE, g/Mcal	4.67	4.11	3.42	3.00	2.83	2.76
CP, %[4]	23.2	19.5	16.4	15.0	14.0	13.2
Ca, %	0.64	0.58	0.53	0.51	0.49	0.43
STTD P, %	0.41	0.38	0.35	0.34	0.31	0.26

[1]Phases were fed from approximately 53 to 75, 75 to 145, 145 to 195, 195 to 245, 245 to 265, and 265 to 310 lb body weight, respectively.
[2]Thr Pro; CJ America-Bio, Downers Grove, IL.
[3]Formi NDF (ADDCON Nordic AS, Porsgrunn, Norway) at 0.25, 0.50, and 0.75% of the diet was included at the expense of corn.
[4]CP = crude protein.

Table 2. Effect of increasing sodium diformate on growth performance and carcass characteristics of grow-finish pigs[1]

	Sodium diformate, %[2]					*P* =	
Item	**0**	**0.25**	**0.50**	**0.75**	**SEM**	**Linear**	**Quadratic**
BW, lb							
d 0	53.4	53.4	53.5	53.4	0.66	0.808	0.538
d 32	117.7	117.9	117.4	117.4	0.88	0.445	0.834
d 60	180.3	181.3	180.7	180.5	1.03	0.954	0.359
d 93	256.3	258.1	257.9	258.2	1.05	0.118	0.338
d 117	306.0	308.2	309.1	309.5	1.54	0.005	0.307
Period 1 (d 0 to 32)							
ADG, lb	2.00	2.01	1.99	1.99	0.012	0.287	0.641
ADFI, lb	3.80	3.75	3.74	3.78	0.031	0.424	0.081
F/G	1.89	1.86	1.88	1.89	0.009	0.688	< 0.001
Period 2 (d 32 to 60)							
ADG, lb	2.23	2.26	2.26	2.24	0.017	0.646	0.166
ADFI, lb	5.42	5.46	5.44	5.44	0.039	0.810	0.580
F/G	2.43	2.41	2.41	2.43	0.011	0.648	0.092
Period 3 (d 60 to 93)							
ADG, lb	2.30	2.31	2.34	2.35	0.014	0.004	0.970
ADFI, lb	6.62	6.67	6.71	6.74	0.035	0.008	0.817
F/G	2.88	2.88	2.87	2.87	0.017	0.475	0.833
Period 4 (d 93 to 117)							
ADG, lb	2.36	2.41	2.43	2.46	0.034	0.003	0.708
ADFI, lb	7.90	8.00	8.00	8.07	0.048	0.017	0.798
F/G	3.36	3.33	3.30	3.28	0.039	0.033	0.822
Overall (d 0 to 117)							
ADG, lb	2.21	2.23	2.24	2.24	0.009	0.004	0.236
ADFI, lb	5.73	5.76	5.77	5.79	0.030	0.075	0.905
F/G	2.60	2.58	2.58	2.59	0.013	0.321	0.189
Carcass characteristics							
HCW, lb	224.2	225.8	227.3	225.7	1.33	0.168	0.107
Carcass yield, %	73.4	73.3	73.4	72.9	0.22	0.117	0.334
Lean, %[3]	57.3	57.3	57.3	57.2	0.08	0.719	0.383
Backfat, in.[3]	0.52	0.51	0.51	0.51	0.006	0.207	0.380
Loin depth, in.[3]	2.87	2.88	2.86	2.85	0.018	0.220	0.545
Removals, %	1.82	0.91	0.91	1.46	0.570	0.666	0.144
Mortality, %	1.09	0.91	1.09	1.46	0.511	0.545	0.562
Mortality and removals, %	2.91	1.82	2.00	2.91	0.717	0.934	0.133

continued

Table 2. Effect of increasing sodium diformate on growth performance and carcass characteristics of grow-finish pigs[1]

	Sodium diformate, %[2]					*P* =	
Item	**0**	**0.25**	**0.50**	**0.75**	**SEM**	**Linear**	**Quadratic**
Economics, $/pig placed[4]							
Low price scenario[5]							
Feed cost	46.99	50.09	52.37	54.92	0.446	< 0.001	0.401
Feed cost/lb gain[6]	0.192	0.201	0.211	0.221	0.0010	< 0.001	0.175
Revenue[7]	107.87	109.64	109.47	108.58	0.738	0.526	0.059
IOFC[8]	60.88	59.52	57.10	53.66	0.465	< 0.001	0.025
High price scenario[9]							
Feed cost	80.21	83.67	85.75	88.26	0.737	< 0.001	0.380
Feed cost/lb gain[6]	0.328	0.336	0.345	0.356	0.0017	< 0.001	0.172
Revenue[7]	158.21	160.81	160.56	159.25	1.082	0.526	0.059
IOFC[8]	78.00	77.11	74.81	71.00	0.662	< 0.001	0.024

[1]A total of 2,200 pigs (initially 53.4 ± 0.66 lb) were used in a 117-d growth trial with 25 pigs per pen and 22 replicates per treatment.

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

[3]Adjusted using HCW as covariate.

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

[5] Market price for the low price scenario: Corn = $3.00/bushel ($107/ton); soybean meal = $300/ton; DDGS = $140/ton; L-Lys HCl = $0.65/lb; L-Trp = $3.00/lb; Thr Pro = $0.80/lb; Formi NDF = $1.61/lb.

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

[7] Revenue = (total gain × carcass yield) × carcass price. Revenue is based on a $0.60/lb or $0.88/lb carcass price for low- or high-priced scenarios, respectively.

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

[9] Market price for the high price scenario: Corn = $6.00/bushel ($214/ton); soybean meal = $400/ton; DDGS = $240/ton; L-Lys HCl = $0.80/lb; L-Trp = $5.00/lb; Thr Pro = $0.80/lb; Formi NDF = $1.61/lb.