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Cover Page Footnote

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Evaluation of a Medium Chain Fatty Acid-Based Additive for Nursery Pigs[1]

L.L. Thomas, H.E. Williams, J.C. Woodworth, M.D. Tokach, R.D. Goodband, S.S. Dritz,[2] J.M. DeRouchey, and D.J. Mellick[3]

Summary

A total of 350 pigs (DNA 400 × 200, initial BW = 13.8 lb) were used in a 34-d growth trial to evaluate the effects of increasing a medium chain fatty acid (MCFA)-based feed additive in nursery pig diets. Following arrival to the nursery research facility, pigs were randomized to pens (5 pigs per pen) and allowed a 4-d acclimation period. Thereafter, pens of pigs were blocked by body weight (BW) and randomized to 1 of 5 dietary treatments (14 pens per treatment). Treatments were constructed such that a dose response was created including 0, 0.5, 1.0, and 2.0% MCFA-based additive (CaptiSURE, Kemin Industries, Inc., Des Moines, IA) as well as a treatment including a 1.0% MCFA blend of C6, C8, and C10 (1:1:1 ratio; Sigma Aldrich, St. Louis, MO). Treatment diets were formulated and manufactured in two dietary phases (d 0 to 13 and 13 to 34). Overall (d 0 to 34), increasing CaptiSURE increased (linear, $P \leq 0.014$) average daily gain (ADG) and average daily feed intake (ADFI). Feed efficiency improved (quadratic, $P = 0.002$) with increasing CaptiSURE up to 1% of the diet with no benefit thereafter. As a result of these linear improvements in ADG, pigs fed 2.0% CaptiSURE were 4 lb heavier ($P = 0.05$) than pigs consuming diets without MCFA at d 34. There was no evidence for differences between the pigs fed 1.0% CaptiSURE and the 1.0% MCFA blend of C6, C8, and C10 in phase 1, phase 2, or in overall performance.

In summary, the addition of this MCFA-based additive in nursery pig diets resulted in a linear improvement in ADG and ADFI. Based on these results, this MCFA feed additive appears to result in a similar improvement in growth performance as the C6, C8, and C10 MCFA blend when both are added at 1% of the diet. Additional research is warranted under commercial conditions to determine if similar advantages in growth performance are observed and if they provide an economic return.

Introduction

In recent years, there has been increased awareness regarding the addition of medium chain fatty acids (MCFA) in swine feed. Fatty acids consisting of chains between 6 and 12 carbon atoms are considered MCFA. Research has shown that MCFA can be used as

[1]Appreciation is expressed to Kemin Industries, Inc. (Des Moines, IA) for their support in this trial.
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a way to minimize the risk of Porcine Epidemic Diarrhea Virus (PEDV)[4] transmission in feed and ingredients. Further research has evaluated the use of MCFA as growth-promoting feed additives, specifically free fatty acids consisting of blends of 6, 8, or 10 carbon atoms.

Gebhardt et al.[5] concluded that adding a MCFA blend (1:1:1 ratio C6, C8, and C10) to nursery pig diets at 1.5% linearly improved ADG, ADFI, and feed-to-gain ratio (F/G). The authors also investigated the effects of 0.5% of the individual fatty acids (C6, C8, and C10) on nursery pig growth performance and observed that individual MCFA elicit different growth performance responses. Uncertainty still exists about the MCFA growth-promoting mechanism; however, it is speculated that the antibacterial properties of MCFA may reduce the bacterial population within the feed and modify gut bacterial counts, resulting in a healthier pig.[5] Commercial products are becoming available with proprietary blends of MCFA and it is necessary to evaluate their impact on growth performance.[3] Therefore, the objective of this experiment is to determine the effect of supplementing increasing amounts of a MCFA-based additive on growth performance of nursery pigs.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at the Kansas State University Segregated Early Weaning Facility in Manhattan, KS. Each pen contained a 4-hole, dry self-feeder and nipple waterer to provide *ad libitum* access to feed and water. Pens had tri-bar floors and allowed approximately 2.7 ft^2/pig.

Following arrival to the research facility, pigs were randomized to pens and allowed a 4-d acclimation period and provided a commercial starter pellet containing no feed grade antimicrobials. Following acclimation, pens of pigs (DNA 400 × 200, initial BW = 13.8 lb) were blocked by average BW and randomized to dietary treatment with 5 pigs per pen and 14 pens per treatment. Treatment diets were formulated and manufactured in two dietary phases (phase 1 = d 0 to 13; phase 2 = d 13 to 34) and were formulated to meet or exceed NRC[6] requirements (Table 1). Treatments consisted of a basal diet with increasing amounts (0, 0.5, 1.0, and 2.0%) of a novel MCFA-based additive composed of primarily C8 and C10 (CaptiSURE, Kemin Industries, Inc, Des Moines, IA) as well as a diet with 1.0% of added MCFA blend (1:1:1 ratio of C6, C8, and C10; Sigma Aldrich, St. Louis, MO). The MCFA additions were made at the expense of soy oil in an attempt to keep diets isocaloric. Pig weights and feed disappearance were measured on d 0, 7, 13, 21, 28, and 34 to determine ADG, ADFI, and F/G.

[4]Cochrane, R. A., S. S. Dritz, J. C. Woodworth, A. R. Huss, C. R. Stark, M. Saensukjaroephon, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, J. F. Bai, Q. Chen, J. Zhang, P. C. Gauger, R. Main, and C. K. Jones. 2016. Evaluating the inclusion level of medium chain fatty acids to reduce the risk of PEDV in feed and spray-dried animal plasma. J. Anim. Sci. 94 (Suppl 2):50. doi:10.2527/msasas2016-107.

[5]Gebhardt, J. T., K. A. Thomson, J. C. Woodworth, M. D. Tokach, J. M. DeRouchey, R. D. Goodband, and S. S. Dritz. 2017. Evaluation of medium chain fatty acids as a dietary additive in nursery pig diets. *Kansas State Agricultural Experiment Station Research Reports:* Vol. 3: Iss. 7.

[6]NRC. 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington D.C.

Complete diet samples were taken from 5 feeders per dietary treatment 4 times throughout the study. Samples were stored at -20°C until they were homogenized, subsampled, and submitted (Ward Laboratories, Inc., Kearney, NE) for analysis of dry matter, crude protein, crude fiber, calcium, phosphorus, and ether extract. In addition, MCFA concentration of C8 and C10 was also analyzed (Kemin Industries, Inc; Des Moines, IA).

Data were analyzed as a randomized complete block design using the GLIMMIX procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. Weight block was included in the model as a random effect. Within these outcomes, linear and quadratic effects of increasing MCFA, as well as a preplanned pairwise contrast comparing MCFA (CaptiSURE) at 1.0% to the 1.0% 1:1:1 MCFA blend treatment were evaluated. Linear and quadratic contrasts were developed using the IML procedure of SAS, generating coefficients for unequally spaced treatments. All results were considered significant at $P \leq 0.05$ and marginally significant between $P > 0.05$ and $P \leq 0.10$.

Results and Discussion

Analysis of manufactured diets (Table 2) resulted in values consistent with formulation. The results from the analysis of ether extract (fat) indicated a reduction in fat as MCFA inclusion in the diet increased. Recall, MCFA were included in the diets at the expense of soybean oil to keep diets isocaloric. Thus, we expected to see similar analyzed values for ether extract for all dietary treatments. Ether extract was determined through an approved method from the American Oil Chemists' Society (AOCS) utilizing high temperature solvent extraction. These results suggest that the MCFA are not detected by this method of fat analysis. The MCFA analysis results confirm increasing amounts of C8, and C10 as CaptiSURE product inclusion increases.

From d 0 to 13, increasing CaptiSURE increased (linear, $P = 0.001$) ADG (Table 3). Feed efficiency improved (quadratic, $P = 0.093$) up to 1.0% of the diet with no benefit observed thereafter. There was no evidence for differences in ADG, ADFI, or F/G when comparing pigs fed 1.0% CaptiSURE and those fed the 1.0% 1:1:1 MCFA blend.

From d 13 to 34, pigs fed increasing CaptiSURE had increased (linear, $P < 0.05$) ADG and ADFI, as well as improved (quadratic, $P = 0.011$) F/G. Similar to d 0 to 13, F/G improved up to 1.0% CaptiSURE with no benefit observed at 2% of the diet. There was no evidence for differences in growth performance between pigs fed 1.0% CaptiSURE and those fed the 1.0% 1:1:1 MCFA blend.

Overall, ADG and ADFI were increased (linear, $P < 0.014$) with increasing CaptiSURE. Feed efficiency improved from 0 to 1.0% inclusion of CaptiSURE in the diet (quadratic, $P = 0.002$). Pigs fed 1.0% CaptiSURE and those fed the 1.0% 1:1:1 MCFA blend performed similarly, with no evidence for differences between the two treatment groups.

In conclusion, the addition of this particular MCFA-based feed additive in nursery pig diets improved ADG, ADFI, and F/G. The results from this study are similar to those reported by Gebhardt et al.[3] but also demonstrate the continued benefits to nursery pig growth performance as dietary MCFA increased to 2% of the diet. Further research is warranted to evaluate MCFA-based products in a commercial environment to determine if similar advantages in growth performance are realized, and to determine if they provide a positive economic return.

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

Ingredient, %	Phase 1	Phase 2
Corn	54.43	62.07
Soybean meal, 46.5% CP	26.42	31.63
Whey powder	10.00	---
HP 300[2]	2.50	---
Soybean oil	2.00	2.00
Calcium carbonate	0.95	1.00
Monocalcium phosphate, 21%	1.30	1.15
Salt	0.60	0.60
L-Lysine HCl	0.50	0.51
DL-Methionine	0.24	0.23
L-Threonine	0.21	0.21
L-Tryptophan	0.05	0.06
L-Valine	0.15	0.14
Trace mineral	0.15	0.15
Vitamin premix	0.25	0.25
Phytase[3]	0.02	0.02
Zinc oxide	0.25	---
MCFA additive[4]	+/-	+/-
Total	100	100

continued

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

Ingredient, %	Phase 1	Phase 2
Calculated analysis[5]		
Standardized ileal digestible (SID) amino acids, %		
Lysine	1.35	1.35
Isoleucine:lysine	55	55
Leucine:lysine	111	113
Methionine:lysine	37.4	37.3
Methionine and cysteine:lysine	58.1	58.1
Threonine:lysine	63.0	62.0
Tryptophan:lysine	20.1	20.3
Valine:lysine	70.2	70.1
Total lysine, %	1.48	1.49
ME, kcal/lb	1,532	1,530
NE, kcal/lb	1,147	1,139
SID lysine:NE, g/Mcal	5.69	5.63
Crude protein, %	20.6	21.1
Calcium, %	0.75	0.70
Phosphorus, %	0.68	0.63
Available phosphorus, %	0.51	0.42
STTD P, %[7]	0.54	0.47

[1]Phase 1 and 2 diets were fed from approximately 14 to 23 and 23 to 51 lb body weight (BW), respectively.
[2]HP 300 (Hamlet Protein, Findlay, OH).
[3]HiPhos 2700 (DSM Nutritional Products, Parsippany, NJ) provided an estimated release of 0.10% STTD P.
[4]Medium chain fatty acids included as a 1:1:1 blend of C6:C8:C10 (Sigma Aldrich (St. Louis, MO), guaranteed ≥ 98% purity) or CaptiSURE (Kemin Industries, Inc. (Des Moines, IA)), added at the expense of soybean oil.
[6]NRC. 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington D.C.
[7]STTD P = Standardized total tract digestible phosphorus.
ME = metabolizable energy. NE = net energy.

Table 2. Analyzed diet composition (as-fed basis)[1]

	Added MCFA, %				
	CaptiSURE[2]				C6:C8:C10[3]
Analyzed composition, %[4]	0	0.5	1.0	2.0	1.0
Phase 1					
Dry matter	89.73	89.97	89.67	89.19	90.09
Crude protein	20.10	19.85	20.05	20.70	20.10
Crude fat	3.50	3.45	3.30	3.25	3.70
Ether extract	3.95	3.70	3.10	2.40	3.50
Calcium	0.96	0.86	0.92	1.02	1.02
Phosphorus	0.65	0.63	0.62	0.67	0.68
Total MCFA[5]	---	0.43	0.84	1.60	0.63
Phase 2					
Dry matter	89.46	89.04	89.29	88.54	89.62
Crude protein	20.25	19.85	20.55	21.10	20.20
Crude fat	3.40	3.70	4.20	3.95	3.45
Ether extract	4.05	4.20	3.80	2.60	3.30
Calcium	0.93	1.09	1.01	0.91	0.98
Phosphorus	0.59	0.61	0.61	0.60	0.64
Total MCFA	---	0.48	0.89	1.89	0.71

[1]Diets were fed in 2 phases from d 0 to 13 and 14 to 34 for phases 1 and 2, respectively.
[2]Kemin Industries, Inc (Des Moines, IA).
[3]Consisted of a blend of C6, C8, and C10. Sigma Aldrich (St. Louis, MO).
[4]Complete diet samples were taken from 5 feeders per dietary treatment 4 times throughout the study. Samples were stored at -20°C until they were homogenized, subsampled, and submitted to Ward Laboratories, Inc. (Kearney, NE) for proximate analysis and Kemin Industries, Inc. (Des Moines, IA) for medium chain fatty acids (MCFA) analysis performed in duplicate. Reported values are average of duplicate analysis.
[5]Sum of analyzed C8 and C10 MCFA.

Table 3. Effect of medium chain fatty acid (MCFA)-based additives on nursery pig growth performance[1,2]

	Added MCFA, %								
	CaptiSURE[3]				C6:C8:C10[4]		Probability, <		
Item	0	0.5	1.0	2.0	1.0	SEM	Linear[5]	Quadratic[5]	1.0% CaptiSURE vs. 1.0% blend
Body weight, lb									
d 0	13.8	13.8	13.8	13.8	13.8	0.11	0.778	0.927	0.911
d 13	21.8	22.5	22.8	23.0	22.5	0.31	0.002	0.062	0.288
d 34	48.1	50.2	51.2	52.1	51.0	0.72	0.001	0.089	0.838
d 0 to 13									
ADG, lb	0.61	0.66	0.69	0.70	0.67	0.019	0.001	0.063	0.294
ADFI, lb	0.75	0.80	0.78	0.79	0.78	0.022	0.149	0.211	0.912
F/G	1.23	1.21	1.13	1.13	1.16	0.018	0.001	0.093	0.112
d 13 to 34									
ADG, lb	1.25	1.32	1.33	1.38	1.36	0.023	0.001	0.273	0.446
ADFI, lb	1.81	1.84	1.85	1.91	1.88	0.033	0.013	0.974	0.440
F/G	1.45	1.39	1.39	1.38	1.39	0.012	0.001	0.011	0.947
d 0 to 34									
ADG, lb	1.00	1.07	1.09	1.12	1.09	0.020	0.001	0.127	0.779
ADFI, lb	1.40	1.44	1.44	1.48	1.46	0.028	0.014	0.693	0.494
F/G	1.40	1.35	1.32	1.32	1.33	0.010	0.001	0.002	0.401

[1]A total of 350 pigs (DNA 400 × 200; initial BW = 13.8 lb) were used in a 34-d experiment with 5 pigs per pen and 14 pens per treatment.
[2]ADG = average daily gain. ADFI= average daily feed intake. F/G = feed-to-gain ratio.
[3]Kemin Industries, Inc. (Des Moines, IA).
[4]Consisted of a 1:1:1 blend of C6, C8, and C10 (Sigma Aldrich, St. Louis, MO).
[5]Linear and quadratic contrast statements include treatments with CaptiSURE (Kemin Industries, Inc, Des Moines, IA) MCFA.