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# Evaluation of Different Combinations of Medium Chain Fatty Acids and Monolaurin as a Dietary Additive for Nursery Pigs

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# Evaluation of Different Combinations of Medium Chain Fatty Acids and Monolaurin as a Dietary Additive for Nursery Pigs


## Abstract

A total of 360 pigs (DNA 400 × 200, initial body weight (BW) = 15.0 lb) were used in a 35-d growth trial to evaluate the effects of adding medium chain fatty acids (MCFA) and monolaurin blends to the diet on growth performance of nursery pigs. Monolaurin is a monoglyceride of C12 and is thought to have antibacterial and antiviral properties. 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 BW and randomized to 1 of 6 dietary treatments (12 pens per treatment). Treatments consisted of a basal diet containing no MCFA (control), the control diet with 1.0% added MCFA (a blend of C6, C8, and C10, 1:1:1 ratio; Sigma Aldrich, St. Louis, MO), or a 1.0% inclusion of 4 different blends of MCFA, lactic acid, and monolaurin-based additives (Tech Mix, LLC, Stewart, MN). The 4 blends consisted of 50% C6, 20% lactic acid, and increasing amounts of monolaurin (0, 10, 20, and 30%) at the expense of C12 (30, 20, 10, and 0%). Treatment diets were formulated and manufactured in two dietary phases (d 0 to 14 and 14 to 35). During phase 1, pigs fed the 1.0% 1:1:1 MCFA blend had increased ($P = 0.037$) average daily gain (ADG) compared to the control group. Pigs fed the 1.0% 1:1:1 MCFA blend and the mean of the 4 varying blends of MCFA, lactic acid, and monolaurin had improved ($P < 0.021$) feed-to-gain ratio (F/G) compared to pigs fed the control diet. During phase 2, average daily feed intake (ADFI) and subsequently ADG increased ($P < 0.057$) for pigs fed the 1.0% 1:1:1 MCFA blend compared to the control group. Overall, increased ($P < 0.034$) ADFI and ADG resulted in 2.1 lb greater final BW ($P = 0.014$) for pigs fed the 1.0% 1:1:1 MCFA blend compared to the control group. There was no evidence for differences between the mean of the different blends of MCFA, lactic acid, and monolaurin and the control group.

In summary, the addition of a 1.0% 1:1:1 MCFA blend resulted in improved ADG, ADFI, and F/G compared with pigs fed a control diet. Based on the results of this study, the MCFA, lactic acid, monolaurin blend product improved F/G during phase 1 with comparable growth performance to those pigs receiving no supplementation thereafter. Additional research is warranted to understand if a blend of MCFA, acidifiers, and monoglycerides can be created to achieve similar benefits in growth performance shown from the 1.0% 1:1:1 MCFA blend and provide a beneficial economic return.



## Keywords

Medium chain fatty acids, monolaurin, nursery pigs





## Cover Page Footnote

Appreciation is expressed to Tech Mix, LLC (Stewart, MN) for donating the product used in this trial.



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# Evaluation of Different Combinations of Medium Chain Fatty Acids and Monolaurin as a Dietary Additive for Nursery Pigs

*L.L. Thomas, A.R. Hartman, J.C. Woodworth, M.D. Tokach, R.D. Goodband, S.S. Dritz,[1] J.M. DeRouchey, D.M. McKilligan,[2] and A.M. Jones[2]*

## Summary

A total of 360 pigs (DNA 400 × 200, initial body weight (BW) = 15.0 lb) were used in a 35-d growth trial to evaluate the effects of adding medium chain fatty acids (MCFA) and monolaurin blends to the diet on growth performance of nursery pigs. Monolaurin is a monoglyceride of C12 and is thought to have antibacterial and antiviral properties. 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 BW and randomized to 1 of 6 dietary treatments (12 pens per treatment). Treatments consisted of a basal diet containing no MCFA (control), the control diet with 1.0% added MCFA (a blend of C6, C8, and C10, 1:1:1 ratio; Sigma Aldrich, St. Louis, MO), or a 1.0% inclusion of 4 different blends of MCFA, lactic acid, and monolaurin-based additives (Tech Mix, LLC, Stewart, MN). The 4 blends consisted of 50% C6, 20% lactic acid, and increasing amounts of monolaurin (0, 10, 20, and 30%) at the expense of C12 (30, 20, 10, and 0%). Treatment diets were formulated and manufactured in two dietary phases (d 0 to 14 and 14 to 35). During phase 1, pigs fed the 1.0% 1:1:1 MCFA blend had increased ($P = 0.037$) average daily gain (ADG) compared to the control group. Pigs fed the 1.0% 1:1:1 MCFA blend and the mean of the 4 varying blends of MCFA, lactic acid, and monolaurin had improved ($P < 0.021$) feed-to-gain ratio (F/G) compared to pigs fed the control diet. During phase 2, average daily feed intake (ADFI) and subsequently ADG increased ($P < 0.057$) for pigs fed the 1.0% 1:1:1 MCFA blend compared to the control group. Overall, increased ($P < 0.034$) ADFI and ADG resulted in 2.1 lb greater final BW ($P = 0.014$) for pigs fed the 1.0% 1:1:1 MCFA blend compared to the control group. There was no evidence for differences between the mean of the different blends of MCFA, lactic acid, and monolaurin and the control group.

In summary, the addition of a 1.0% 1:1:1 MCFA blend resulted in improved ADG, ADFI, and F/G compared with pigs fed a control diet. Based on the results of this

[1]Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

[2]Tech Mix, LLC (Stewart, MN). Appreciation is expressed to Tech Mix, LLC (Stewart, MN) for donating the product used in this trial.

study, the MCFA, lactic acid, monolaurin blend product improved F/G during phase 1 with comparable growth performance to those pigs receiving no supplementation thereafter. Additional research is warranted to understand if a blend of MCFA, acidifiers, and monoglycerides can be created to achieve similar benefits in growth performance shown from the 1.0% 1:1:1 MCFA blend and provide a beneficial economic return.

## Introduction

Medium chain fatty acids (MCFA) are saturated, 6 to 12 carbon fatty acids that are receiving increased attention as feed additives due to their antiviral and antibacterial properties. Specifically, MCFA have been effective at reducing the quantity of detectable viral genetic material and reducing infectivity of Porcine Epidemic Diarrhea Virus (PEDV) transmission in feed and ingredients.[3] Further research has investigated MCFA as a feed additive in nursery pig diets and has shown a linear improvement in ADG, ADFI, and F/G with inclusion rates up to 2.0%[4,5] of the MCFA blend. Gebhardt et al.[4] also reported the impact of 0.5% inclusion of individual fatty acids (C6, C8, and C10) on nursery pig growth performance and observed that individual MCFA elicit different growth performance responses. Commercial products are becoming available with proprietary blends of MCFA as well as other ingredients, such as acids and monoglycerides. The addition of acidifiers to nursery pig diets is thought to decrease pH in the stomach and protect the host from pathogenic invasion and proliferation, improving nutrient digestion.[6] Monolaurin is a monoglyceride of C12, and thought to have antibacterial and antiviral effects, like that of MCFA.[7] Therefore, the objective of this experiment was to determine the effect of supplementing varying levels of a MCFA-blend of ingredients 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. 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 = 15.0 lb) were blocked by average BW and randomized to dietary treatment with 5 pigs per pen and 12 pens per treatment. Treatment diets were formulated and manufactured in two

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[3]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.

[4]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.

[5]Thomas, L. L., J. C. Woodworth, M. T. Tokach, R. D. Goodband, S. S. Dritz, and J. M. DeRouchey. 2018. Evaluation of a medium chain fatty-acid based ingredient as a dietary additive for nursery pigs. *Kansas State Agricultural Experiment Station Research Reports:* In press.

[6]Kil, D. Y., W. B. Kwon, and B. G. Kim. 2011. Dietary acidifiers in weanling pigs diets: a review. Rev Colomb Cienc Pecu 24:231-247.

[7]Damen, E. 2017. The power of alpha-monolaurin. Pig Progress. 32(1)24-25.

dietary phases (Phase 1 = d 0 to 14; Phase 2 = d 14 to 35) to meet or exceed NRC[8] requirements (Table 1). Treatments consisted of a control diet containing no added MCFAs or the control diet with 1% added MCFA blend (1:1:1 ratio of C6, C8, and C10, Sigma Aldrich, St. Louis, MO) as well as 1% inclusion of 4 blends (1, 2, 3, and 4) of MCFA, lactic acid, and monolaurin-based additives (Tech Mix, LLC, Stewart, MN). The 4 blends consisted of 50% C6, 20% lactic acid and increasing amounts of monolaurin (0, 10, 20, and 30%) at the expense of C12 (30, 20, 10, and 0%). The MCFA additions were made at the expense of soy oil. 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. Pig weights and feed disappearance were measured on d 0, 7, 14, 21, 28, and 35 to determine ADG, ADFI, and F/G.

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.

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. Estimated means and corresponding standard errors (SEM) are reported for cell means. Pairwise comparisons were conducted on such means using a Tukey adjustment to prevent inflation of Type I error due to multiple comparisons. Linear and quadratic effects of increasing monolaurin, as well as preplanned pairwise contrasts comparing the control group to the 1:1:1 MCFA blend and the MCFA plus acidifier and monolaurin blends. 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.

From d 0 to 14, pigs fed the 1.0% 1:1:1 MCFA blend had increased ($P = 0.037$) ADG compared to the control group (Table 3). Feed efficiency was improved ($P < 0.021$) with the inclusion of the 1:1:1 MCFA blend and the MCFA, acidifier and monolaurin blends. Average daily feed intake and ADG increased numerically as monolaurin level increased within the MCFA and acidifier blends; however, these results were not significant. From d 14 to 35, pigs fed the 1.0% 1:1:1 MCFA blend had increased ($P < 0.057$) ADFI and, subsequently, ADG compared to the control group. Overall, ADFI and ADG were increased ($P < 0.034$) when the 1.0% 1:1:1 MCFA blend was included in the diet, compared to the control group. This increase in ADG resulted in pigs fed the 1.0% 1:1:1 MCFA blend being 2.1 lb heavier ($P = 0.014$) than the control group on d 35 of the study. There was no evidence for differences between the control group and the 1.0% inclusion of the MCFA, acidifier and monolaurin blends.

In conclusion, the addition of 1.0% of a 1:1:1 blend of C6:C8:C10 in nursery pig diets improved ADG, ADFI, and F/G compared with control-fed pigs. In this study, altering

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

the blend of individual fatty acids and adding lactic acid and monolaurin showed similar nursery growth performance to those pigs fed the control diet. Additional research is warranted to understand if a blend of MCFA, acidifiers, and monoglycerides can be created to achieve similar benefits in growth performance shown from the 1.0% 1:1:1 MCFA blend, and provide a beneficial economic return.

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

| Ingredient, % | Phase 1 | Phase 2 |
|---|---|---|
| Corn | 54.43 | 62.07 |
| Soybean meal, 46.5% crude protein | 26.42 | 31.63 |
| Whey powder | 10.00 | --- |
| 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[2] | 0.02 | 0.02 |
| Zinc oxide | 0.25 | --- |
| HP 300[3] | 2.50 | --- |
| MCFA products[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 | 4.00 | 4.00 |
| Crude protein, % | 20.6 | 21.1 |
| Calcium, % | 0.75 | 0.70 |
| Phosphorus, % | 0.68 | 0.63 |
| Available phosphorus, % | 0.51 | 0.42 |
| STTD P, %[6] | 0.54 | 0.47 |

[1]Phase 1 and 2 diets were fed from approximately 15 to 22.5 and 22.5 to 48.6 lb body weight, respectively.
[2]HiPhos 2700 (DSM Nutritional Products, Parsippany, NJ) provided an estimated release of 0.10% STTD P.
[3]HP 300 (Hamlet Protein, Findlay, OH).
[4]Products included either a blend of C6:C8:C10 (1:1:1; Sigma Aldrich (St. Louis, MO); guaranteed ≥ 98% purity) or blends of C6, C12, lactic acid, and monolaurin supplied by Tech Mix, LLC (Stewart, MN) added at the expense of soybean oil.
[5]NRC. 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington D.C.
[6]STTD P = standardized total tract digestible phosphorus.
ME = metabolizable energy.
NE = net energy.

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

| | | 1% MCFA[2] | 1% MCFA, lactic acid, monolaurin blend | | | |
|---|---|---|---|---|---|---|
| Analyzed composition, %[4] | 0 | C6:C8:C10 | 1 | 2 | 3 | 4 |
| Phase 1 | | | | | | |
| Dry matter | 90.55 | 90.43 | 90.51 | 90.89 | 90.47 | 90.79 |
| Crude protein | 20.10 | 20.70 | 20.50 | 20.10 | 20.80 | 20.75 |
| Crude fat | 1.80 | 1.95 | 1.75 | 1.70 | 1.95 | 1.95 |
| Ether extract | 3.85 | 3.80 | 3.40 | 3.70 | 3.70 | 3.75 |
| Calcium | 0.86 | 0.82 | 0.79 | 0.85 | 0.90 | 0.96 |
| Phosphorus | 0.64 | 0.67 | 0.66 | 0.61 | 0.71 | 0.70 |
| Phase 2 | | | | | | |
| Dry matter | 89.97 | 89.68 | 89.64 | 90.04 | 89.99 | 89.89 |
| Crude protein | 21.65 | 21.35 | 20.65 | 22.00 | 21.70 | 21.25 |
| Crude fat | 2.75 | 2.10 | 1.65 | 1.95 | 1.65 | 1.70 |
| Ether extract | 4.70 | 3.90 | 2.85 | 3.35 | 3.15 | 3.45 |
| Calcium | 0.91 | 0.89 | 0.72 | 0.50 | 0.83 | 0.68 |
| Phosphorus | 0.65 | 0.64 | 0.55 | 0.52 | 0.57 | 0.53 |

[1]Diets were fed in 2 phases from d 0 to 14 and 14 to 35 for phases 1 and 2, respectively.
[2]Consisted of a blend of C6, C8, and C10. Sigma Aldrich (St. Louis, MO).
[3]TechMix, LLC (Stewart, MN).
[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. Reported values are an average of duplicate analysis.
MCFA = medium chain fatty acids.

**Table 3. Effect of medium chain fatty acids (MCFA) on nursery pig growth performance[1,2]**

| | | 1% MCFA[2] | 1% MCFA, lactic acid and monolaurin blends[3] | | | | | Probability, $P <$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | Control | C6:C8:C10 | 1 | 2 | 3 | 4 | SEM | Control vs. 1% C6:C8:C10 | Control vs. blends | Linear[4] | Quadratic[5] |
| BW, lb | | | | | | | | | | | |
| d 0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 0.10 | 0.918 | 0.943 | 0.730 | 0.303 |
| d 14 | 21.9 | 23.0 | 22.4 | 22.4 | 22.6 | 22.8 | 0.37 | 0.042 | 0.132 | 0.355 | 0.802 |
| d 35 | 47.6 | 49.7 | 48.0 | 48.5 | 48.7 | 49.0 | 0.62 | 0.014 | 0.134 | 0.267 | 0.840 |
| d 0 to 14 | | | | | | | | | | | |
| ADG, lb | 0.50 | 0.57 | 0.53 | 0.53 | 0.54 | 0.56 | 0.025 | 0.037 | 0.127 | 0.304 | 0.750 |
| ADFI, lb | 0.63 | 0.67 | 0.62 | 0.62 | 0.63 | 0.66 | 0.025 | 0.223 | 0.887 | 0.204 | 0.676 |
| F/G | 1.28[a] | 1.19[ab] | 1.18[b] | 1.19[ab] | 1.17[b] | 1.19[ab] | 0.024 | 0.007 | <0.001 | 0.713 | 0.783 |
| d 14 to 35 | | | | | | | | | | | |
| ADG, lb | 1.22 | 1.27 | 1.22 | 1.24 | 1.24 | 1.25 | 0.020 | 0.057 | 0.366 | 0.402 | 0.600 |
| ADFI, lb | 1.70 | 1.81 | 1.73 | 1.75 | 1.75 | 1.75 | 0.031 | 0.015 | 0.206 | 0.641 | 0.822 |
| F/G | 1.39 | 1.42 | 1.41 | 1.40 | 1.40 | 1.40 | 0.015 | 0.231 | 0.443 | 0.631 | 0.742 |
| d 0 to 35 | | | | | | | | | | | |
| ADG, lb | 0.93 | 0.99 | 0.94 | 0.96 | 0.96 | 0.97 | 0.017 | 0.014 | 0.149 | 0.202 | 0.796 |
| ADFI, lb | 1.27 | 1.35 | 1.28 | 1.30 | 1.30 | 1.32 | 0.026 | 0.034 | 0.382 | 0.359 | 0.932 |
| F/G | 1.37 | 1.36 | 1.36 | 1.35 | 1.35 | 1.35 | 0.012 | 0.872 | 0.373 | 0.617 | 0.745 |

[1]A total of 360 pigs (DNA 400 × 200; initial body weight (BW) = 15.0 lb) were used in a 35-d experiment with 5 pigs per pen and 12 pens per treatment.
[2]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed-to-gain ratio.
[2]Consisted of a 1:1:1 blend of C6, C8, and C10 (Sigma Aldrich, St. Louis, MO).
[3]Consisted of a blend of C6, C12, lactic acid, and monolaurin (Tech Mix, LLC, Stewart, MN). The 4 blends consisted of 50% C6, 20% lactic acid, and increasing levels of monolaurin (0, 10, 20, and 30%) at the expense of C12 (30, 20, 10, and 0%). Monolaurin addition increased from products 1 through 4 replacing C12.
[4]Linear effects of increasing monolaurin, at the expense of C12, within the 1% MCFA, lactic acid, and monolaurin blend.
[5]Quadratic effects of increasing monolaurin, at the expense of C12, within the 1% MCFA, lactic acid, and monolaurin blend.