Kansas Agricultural Experiment Station Research Reports

Volume 7
Issue 11 *Swine Day*

Article 17

2021

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Jenna J. Bromm
Kansas State University, jbromm@k-state.edu

Mike D. Tokach
Kansas State University, Manhattan, mtokach@k-state.edu

Jason C. Woodworth
Kansas State University, jwoodworth@ksu.edu

See next page for additional authors

Recommended Citation

Bromm, Jenna J.; Tokach, Mike D.; Woodworth, Jason C.; Goodband, Robert D.; DeRouchey, Joel M.; Hastad, Chad W.; Post, Zach B.; and Gebhardt, Jordan T. (2021) "Use of O3 Trial Feed to Reduce Omega-6:3 Ratio in PRRS-Virus Challenged Nursery Pigs," *Kansas Agricultural Experiment Station Research Reports*: Vol. 7: Iss. 11. https://doi.org/10.4148/2378-5977.8181

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Summary

A total of 1,056 pigs (PIC TR4 × (Fast LW × PIC L02)), originating from an active PRRSV-positive sow farm, were used in a 46-d study to evaluate growth performance of nursery pigs fed diets containing increasing levels of O3 Trial Feed, a source of omega-3 fatty acids (alpha-linolenic acid). At placement in the nursery, pens of pigs were randomly assigned 1 of 4 dietary treatments with 22 pigs per pen and 12 replications per treatment. Treatments were arranged in a completely randomized design. Dietary treatments included increasing levels of O3 Trial Feed (0, 0.75, 1.5, and 3%) with pigs remaining on treatments throughout the 4 dietary phases over the 46-d study. Overall, pigs fed increased O3 Trial Feed had increased (linear, $P < 0.001$) ADG and ADFI and improved (linear, $P < 0.001$) F/G. Pigs fed increasing O3 Trial Feed also had decreased (linear, $P = 0.027$) total removals and mortalities. In summary, O3 Trial Feed improved growth performance and reduced mortality in PRRSV-positive nursery pigs.

Introduction

Omega-3 fatty acids have been found to improve immune function primarily by lessening the febrile response to immune system activation. The mode of action is thought to be through a decrease in the omega-6:3 fatty acid ratio. Research has demonstrated that lowering the ratio of omega-6:3 to a range of 3:1 or 5:1 instead of the normal 10:1 or 20:1 observed in typical swine diets increases the incorporation of omega-3 fatty acids into cell membranes to make it available for improved immune function during an immune challenge.[3]

O3 Trial Feed is a source of omega-3 fatty acids that has been used to increase omega-3 content of pork. The profile of fatty acids makes the product a viable option to improve the omega-6:3 fatty acid ratio for nursery pigs and improve immune status. However, there is no published research available with O3 Trial Feed in nursery pigs. Testing O3

[1] New Fashion Pork, Jackson, MN.

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

[3] Huber, L., Hooda, S., Fisher-Heffernan, R. E., Karrow, N. A, De Lange, C. F. (2018). Effect of reducing the ratio of omega-6-to-omega-3 fatty acids in diets of low protein quality on nursery pig growth performance and immune response. Journal of Animal Science, 96(10), 4348-4359.

Trial Feed under field conditions with pigs exposed to normal production stressors and diseases is needed to determine whether it will improve performance and pig livability. Therefore, the objective of this study was to determine the influence of O3 Trial Feed—a source of omega-3 fatty acids (alpha-linolenic acid)—on nursery pig performance, mortality, and morbidity under field conditions. Our hypothesis was that the addition of omega-3 fatty acids (O3 Trial Feed) would improve growth performance and decrease mortality and morbidity when fed to pigs in the nursery.

Materials and Methods

General

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at the New Fashion Pork Research Nursery in Jackson, MN. At weaning, pigs were moved and housed in a temperature-controlled nursery facility. Each pen (6.2 × 10 ft) consisted of plastic grated flooring, one cup waterer, and one 3-hole stainless steel self-feeder. Access to feed and water was provided *ad libitum.* Pigs were allowed approximately 2.82 ft^2/pig.

Animal and treatment structure

A total of 1,056 weaned pigs (PIC TR4 × (Fast LW × PIC L02)) were used in a 46-d nursery trial. There were 22 pigs per pen (equal mixed sex) and 12 replications per treatment. Pens were randomly assigned to 1 of 4 dietary treatments in a completely randomized design. The dietary treatments included increasing percentages of O3 Trial Feed (0, 0.75, 1.5, and 3%). Omega-6:3 ratios for the 4 treatments within each phase were: Phase 1 (15.1:1, 8.4:1, 5.9:1, 3.7:1); Phase 2 (16.5:1, 9.2:1, 6.4:1, 4.0:1); Phase 3 (20.8:1, 10.4:1, 7.0:1, 4.2:1); and Phase 4 (25.3:1, 12.5:1, 8:3:1, 5.0:1), respectively. Pens of pigs were weighed and feed disappearance was recorded weekly during the course of this study to determine ADG, ADFI, and F/G.

Diet preparation

Pigs were fed experimental diets from d 0 to 46 (Table 1). Pigs were fed on a feed budget (lb/pig): Phase 1, 6; Phase 2, 8; Phase 3, 16; and Phase 4, 32 lb per pig. Phase 1, 2, and 3 diets were formulated to 1.40% SID Lys and phase 4 diet was formulated to 1.34% SID Lys. All other nutrients were formulated to meet or exceed NRC (2012)[4] requirement estimates. All diets were manufactured at the New Fashion Pork Feed Mill (Estherville, IA). All four phases were fed in meal form.

Chemical analysis

Diet samples for each treatment were collected from feeders throughout the study. One complete diet sample was sent to Kansas State University Swine Lab and stored at -4°F until it was homogenized, subsampled, and submitted for analysis. Samples of each dietary treatment were analyzed (NBO3 Technologies LLC; Manhattan, KS) for fatty acid profiles.

Rope test

Ropes were placed in each pen on d 7, 14, 21, 28, 35, and 42 to determine if pigs were positive for PRRSV North American and European strains. A new rope was placed

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

in each pen for 15 minutes on each sample day and then the collected oral fluids from 6 random pens were combined for testing. Samples were processed at New Fashion Pork using the Thermo Fisher real-time NAEU PRRSV PCR-Oral Fluid test procedure.

Economics

For the economic analysis, feed cost, cost per pound of gain, value of gain, and income over feed cost (ICOFC) were calculated on a per pig placed basis. The O3 Trial Feed was assumed to cost $0.43/lb. This resulted in total diet costs of: $472.75, $478.21, $483.66, and $494.57/ton in phase 1; $380.38, $385.83, $391.29, and $402.20/ton in phase 2; $221.67, $227.13, $232.58, and $402.20/ton in phase 3; and $176.49, $181.94, $187.39, and $198.30/ton in phase 4 for 0, 0.75, 1.5, and 3% O3 Trial Feed diets, respectively. Feed cost was calculated by multiplying feed cost per lb by feed consumed in each phase. Value of gain was calculated by total pen gain multiplied by carcass price of 0.91/lb times dressing percentage of 75% to place on a live weight basis. Income over feed cost was calculated by subtracting feed cost from the value of gain.

Statistical analysis

Growth performance data were analyzed using the nlme package of R (Version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria) as a completely randomized design with pen as the experimental unit. Differences between treatments were considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

Oral fluids taken from the ropes hung in pens tested negative for PRRSV North American on d 7 and 14, but tested positive on d 21, 28, 35, and 42. All samples tested negative for PRRSV European on each collection day.

From d 0 to 14 and d 14 to 21, there were no differences observed for ADG or ADFI (Table 2). However, from d 0 to 14, increased O3 Trial Feed resulted in a tendency for a quadratic response for F/G ($P = 0.065$). From 21 to 28, increasing O3 Trial feed increased (linear, $P < 0.035$) ADG and ADFI and improved (linear, $P = 0.010$) F/G.

From d 28 to 35, increased O3 Trial Feed resulted in a quadratic response for ADG ($P = 0.009$) and F/G ($P = 0.004$), with pigs fed the control or 3% O3 Trial Feed having improved performance compared to those fed 0.75 or 1.5%. During this period, increased O3 Trial Feed increased (linear, $P = 0.016$) ADFI. From d 35 to 46, feeding increasing levels of O3 Trial Feed increased (linear, $P < 0.05$) ADG and ADFI, while also improving (linear, $P < 0.05$) F/G.

For overall growth performance, increased O3 Trial Feed increased (linear, $P < 0.001$) ADG, resulting in pigs fed 3% O3 Trial Feed having the greatest growth rate. Increasing O3 Trial Feed also increased (linear, $P < 0.001$) overall ADFI and improved (linear, $P < 0.001$) feed efficiency.

Total removals and mortality percentage for the overall experiment were decreased ($P = 0.027$) with increased levels of O3 Trial Feed. In summary, pigs fed increasing levels of O3 Trial Feed had improved growth performance and reduced total removals and mortality.

For economics, pigs fed increased levels of O3 Trial Feed had increased (linear, $P < 0.001$) value of gain and feed cost. There was no difference (Table 2) in feed cost/lb of gain; however, increasing O3 Trial Feed resulted in an increase (linear, $P < 0.001$) in ICOFC. The reduced removals and mortality and increased performance for pigs fed O3 Trial Feed increased the value of gain and economic return in this study. It is recommended that producers utilize their own current ingredient prices to economically compare these dietary options.

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Table 1. Diet composition[1]

Ingredient, %	Phase 1	Phase 2	Phase 3	Phase 4
Corn	42.46	55.59	52.97	43.46
Soybean meal	18.99	19.99	26.75	26.52
AV-E Digest[2]	17.45	16.05	3.90	---
Dried whey	2.25	---	---	---
Oat groats	5.00	---	---	---
Cereal blend[3]	7.95	3.00	1.40	---
Corn DDGS, 7.5% Oil	---	---	10.00	25.00
Beef tallow	2.50	2.00	1.00	1.00
Monocalcium phosphate, 21% P	---	---	0.40	0.38
Limestone	0.40	0.40	1.15	1.48
Sodium chloride	---	0.16	0.55	0.63
L-Lys-HCl	0.45	0.49	0.58	0.56
DL-Met	0.19	0.22	0.32	0.22
L-Trp	0.05	0.06	0.05	0.04
L-Val	0.11	0.14	0.15	0.06
L-Ile	0.03	0.05	0.06	---
L- Thr	0.22	0.26	0.29	0.20
Tribasic copper chloride	0.04	0.04	---	---
Vitamin premix with phytase	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15
Choline chloride 60%	0.03	0.03	---	---
Zinc oxide	0.35	0.35	0.02	---
Vitamin E 20,000 IU	0.05	0.01	0.01	---
Zinc[4]	---	---	---	0.06
LipoVital GL 90[5]	0.10	0.05	---	---
Blue dye	0.01	---	---	---
FXP[6]	0.20	0.10	---	---
AcidoMatrix GH[7]	0.50	0.50	---	---
N-Hance[6]	0.25	0.10	---	---
AlphaGal 280P[8]	0.03	0.01	---	---
Manganese[9]	0.02	0.02	0.02	0.01
O3 Trial Feed[10]	---	---	---	---

continued

Table 1. Diet composition[1]

Ingredient, %	Phase 1	Phase 2	Phase 3	Phase 4
Calculated analysis				
SID Amino acids, %				
Lys	1.40	1.40	1.40	1.34
Ile:Lys	59	59	60	60
Leu:Lys	111	113	120	141
Met and Cys:Lys	57	59	66	65
Thr:Lys	63	64	64	63
Trp:Lys	19.3	19.1	19.1	19.2
Val:Lys	71	72	72	72
His:Lys	36	36	36	40
Total Lys, %	1.62	1.62	1.58	1.53
NE NRC, kcal/lb	1,023	1,053	1,087	1,094
SID Lys:NE, g/Mcal	6.21	6.04	5.85	5.56
CP, %	23.9	23.5	23.1	24.1
Ca, %	0.87	0.80	0.79	0.80
P, %	0.61	0.58	0.56	0.57
STTD P, %	0.49	0.47	0.44	0.44
Ca:P	1.42	1.38	1.41	1.41
EFA, %	1.67	1.86	1.84	2.17
Linolenic acid %	0.11	0.11	0.08	0.08
Linoleic acid %	1.6	1.75	1.75	2.08
Omega-6:3	15.1	16.5	20.8	25.3

[1]Pigs were fed on a feed budget (lb/pig): Phase 1, 6; Phase 2, 8; Phase 3, 16; and Phase 4, 32 lb per pig.
[2]XFE Products, Des Moines, IA.
[3]Quincy Farm Products, Quincy, IL.
[4]New Fashion Pork Custom Zinc: 210,000 ppm.
[5]Berg & Schmidt Functional Lipids, Hamburg, Germany.
[6]Ani-Tek, Social Circle, GA.
[7]Novus International, Saint Charles, MO.
[8]Kindstrom-Schmoll Inc., Eden Prairie, MN.
[9]New Fashion Pork Custom Manganese - 200,000 ppm.
[10]O3 Trial Feed was added at 0.75, 1.5, and 3% at the expense of corn and soybean meal to form the experimental diets.

Table 2. Analyzed fatty acid composition of experimental diets[1]

	O3 Trial Feed,[2] %			
Fatty acid, %	**0.00**	**0.75**	**1.50**	**3.00**
Phase 1				
Total fatty acid	7.21	8.36	8.17	8.86
Total fat	8.01	9.28	9.07	9.84
Omega-6:3	14.34	10.23	7.65	4.05
C16:0	1.38	1.60	1.51	1.62
C18:1n9c	2.16	2.56	2.36	2.63
C18:2n6c[3]	2.02	2.17	2.22	2.17
C18:3n3[4]	0.14	0.22	0.29	0.54
Phase 2				
Total fatty acid	6.54	6.96	7.92	8.25
Total fat	7.27	7.74	8.80	9.16
Omega-6:3	14.36	9.94	6.44	4.18
C16:0	1.23	1.29	1.45	1.47
C18:1n9c	1.93	2.06	2.31	2.39
C18:2n6c	1.95	2.03	2.24	2.27
C18:3n3	0.14	0.21	0.36	0.55
Phase 3				
Total fatty acid	5.48	5.48	5.60	6.39
Total fat	6.08	6.09	6.23	7.10
Omega-6:3	14.45	8.85	6.46	4.10
C16:0	0.89	0.87	0.88	0.96
C18:1n9c	1.34	1.32	1.31	1.52
C18:2n6c	2.32	2.27	2.31	2.49
C18:3n3	0.16	0.26	0.36	0.61
Phase 4				
Total fatty acid	5.65	5.91	6.15	6.48
Total fat	6.28	6.57	6.83	7.20
Omega-6:3	15.34	10.16	7.53	5.53
C16:0	0.90	0.90	0.93	0.97
C18:1n9c	1.35	1.40	1.46	1.53
C18:2n6c	2.56	2.64	2.68	2.73
C18:3n3	0.17	0.26	0.36	0.50

[1]Complete diets contained trace levels of C12:0, C14:0, C15:0, C16:1n7, C17:0, C18:0, C18:1n9t, C18:1n7c, C18:3n6, CLA 9c, 11t (n7), C20:0, C20:2n6, C22:0, C23:0, and C24:0 of < 0.10%. Other fatty acids levels were too low to be detected in the analysis.

[2]O3 Trial Feed was analyzed to contain 23.77% total FA, 26.41% total fat, 0.37% omega-6:3, 1.43% C16:0, 4.33% C18:1n9c, 4.41%, C18:2n6c, and 12.20% C18:3n3.

[3]Major omega-6 fatty acid.

[4]Major omega-3 fatty acid.

Table 3. Use of O3 Trial Feed to reduce dietary omega-6:3 ratio in PRRSV-challenged nursery pigs[1]

	O3 Trial Feed,[2] %					*P* =	
Item	**0.00**	**0.75**	**1.50**	**3.00**	**SEM**	**Linear**	**Quadratic**
BW, lb							
d 0	16.2	16.1	16.2	16.2	0.21	0.315	0.601
d 14	19.6	19.5	20.0	19.6	0.21	0.735	0.138
d 21	25.1	24.9	25.1	25.0	0.27	0.916	0.980
d 28	29.7	29.9	30.0	30.8	0.37	0.023	0.528
d 35	39.2	38.9	39.4	40.7	0.46	0.006	0.169
d 46	49.4	50.5	51.1	52.9	0.52	< 0.001	0.987
d 0 to 14							
ADG, lb	0.22	0.22	0.26	0.24	0.014	0.139	0.142
ADFI, lb	0.39	0.38	0.39	0.39	0.012	0.508	0.870
F/G	1.81	1.83	1.54	1.68	0.081	0.090	0.065
d 14 to 21							
ADG, lb	0.76	0.74	0.71	0.76	0.021	0.926	0.108
ADFI, lb	1.14	1.09	1.09	1.09	0.023	0.184	0.268
F/G	1.52	1.47	1.53	1.43	0.040	0.233	0.339
d 21 to 28							
ADG, lb	0.67	0.71	0.70	0.84	0.029	< 0.001	0.285
ADFI, lb	1.26	1.33	1.33	1.36	0.031	0.035	0.379
F/G	1.94	1.89	1.90	1.63	0.075	0.010	0.079
d 28 to 35							
ADG, lb	1.36	1.28	1.31	1.40	0.027	0.062	0.009
ADFI, lb	1.76	1.74	1.77	1.85	0.029	0.016	0.251
F/G	1.30	1.37	1.35	1.32	0.016	0.7320	0.004
d 35 to 46							
ADG, lb	0.91	1.01	1.02	1.09	0.028	< 0.001	0.218
ADFI, lb	1.77	1.82	1.86	1.95	0.038	0.001	0.936
F/G	1.96	1.81	1.83	1.79	0.036	0.010	0.077
d 0 to 46 (Overall)							
ADG, lb	0.69	0.71	0.73	0.78	0.012	< 0.001	0.568
ADFI, lb	1.15	1.16	1.19	1.23	0.017	< 0.001	0.844
F/G	1.66	1.64	1.63	1.57	0.015	< 0.001	0.510

continued

Table 3. Use of O3 Trial Feed to reduce dietary omega-6:3 ratio in PRRSV-challenged nursery pigs[1]

	O3 Trial Feed,[2] %					*P* =	
Item	**0.00**	**0.75**	**1.50**	**3.00**	**SEM**	**Linear**	**Quadratic**
Total removals and mortalities, %	11.5	11.9	8.5	6.7	2.14	0.027	0.856
Economics, $/pig placed							
Value of gain[3]	18.71	19.27	20.78	22.69	0.650	< 0.001	0.891
Feed cost	6.11	6.34	6.75	7.25	0.131	< 0.001	0.850
Feed cost/ lb gain[4]	0.22	0.23	0.22	0.22	0.005	0.235	0.606
ICOFC[5]	12.60	12.93	14.03	15.44	0.459	< 0.001	0.835

[1]A total of 1,056 pigs (PIC TR4 × (Fast LW × PIC L02)) were used with 22 pigs per pen and 12 replications per treatment and were fed trial diets for a 46-day period.

[2] Omega-6:3 ratios for the four treatments within each phase were: Phase 1 (15.1:1, 8.4:1, 5.9:1, 3.7:1); Phase 2 (16.5:1, 9.2:1, 6.4:1, 4.0:1); Phase 3 (20.8:1, 10.4:1, 7.0:1, 4.2:1); and Phase 4 (25.3:1, 12.5:1, 8:3:1, 5.0:1), respectively (NBO3 Technologies LLC, Manhattan, KS).

[3]Value of gain = total gain per pen × yield × 0.91.

[4]Feed cost per lb of gain = total feed cost per pen divided by total gain per pen

[5]Income over feed cost = value of gain – feed cost.