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The Effect of Live Yeast Probiotics in Lactation Diets with and without a Yeast Prebiotic in Nursery Diets on Lifetime Growth Performance, Antibody Titers, and Carcass Characteristics[1]

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Summary

A total of 28 mixed parity sows (Line 241 DNA) and their offspring were used in a farrow-to-finish study to evaluate the effect of live yeast supplementation during lactation with or without yeast extract supplementation during the nursery period on sow and litter performance and lifetime growth performance, serum antibody titers, and carcass characteristics. Sows were blocked by parity and BW on d 110 of gestation and allotted to 1 of 2 dietary treatments which consisted of a standard corn-soybean meal lactation diet with or without yeast-based probiotics (0.10% Actisaf Sc 47 HR+; Phileo by Lesaffre, Milwaukee, WI). Following weaning, a total of 350 pigs (241 × 600 DNA; initially 13.5 ± 0.05 lb) were randomly assigned within sow treatment to 1 of 2 nursery diets which consisted of a control diet or a diet that contained yeast prebiotics (0.10% MS309; Phileo by Lesaffre, Milwaukee, WI) for 42 d after weaning (d 59 of age). After this time, two nursery pens of the same treatment were combined into one finishing pen and pigs were fed common diets until market. There were no significant effects of live yeast supplementation on lactation performance ($P > 0.079$). A sow × nursery diet interaction ($P = 0.024$) was observed during the nursery period where pigs from sows fed Actisaf had improved ADG when fed the control nursery diet compared to pigs from control sows that were fed the control nursery diet. Pigs fed MS309 in the nursery from either sow treatment were intermediate. Pigs from Actisaf sows tended to be heavier at marketing ($P = 0.067$) with heavier HCW ($P = 0.101$) but there were no differences in overall finishing growth performance with the inclusion of live yeast in lactation diets or yeast prebiotics in nursery diets ($P > 0.100$). Subsets of pigs were bled on d 22, 38, 50, 66, 78, 101, and 162 of age to determine porcine circovirus type 2 (PCV2) and *Mycoplasma hyopneumoniae* antibody sample-to-positive (S/P) ratios and on d 50, 66, 78, 101, and 162 of age to determine the percent inhibition of *Lawsonia intracellularis*. An S/P ratio

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is representative of antibodies present in the blood for that specific pathogen. There was a tendency for a sow diet × day interaction for the PCV2 S/P ratio ($P = 0.097$) where offspring from sows fed live yeast had higher PCV2 S/P ratios at 101 d of age compared to offspring from control sows ($P = 0.046$). There was a nursery diet × day interaction for the PCV2 S/P ratio ($P = 0.036$) where pigs fed MS309 during the nursery period had reduced PCV2 S/P ratios at 66, 78, and 162 d of age ($P < 0.022$). In conclusion, feeding a yeast prebiotic in the nursery did not affect performance or immune parameters. Conversely, feeding a live yeast probiotic during lactation resulted in a tendency to improve ADG during the nursery period, final BW, and numerically improve HCW.

Introduction

Recent interest in non-antibiotic feed additives has increased drastically. Yeast products are among those feed additives investigated as there may be an impact on gut health, immune regulation, nutrient digestibility, and growth performance.[4] Previous research has demonstrated an improvement in nursery pig growth performance with the inclusion of live yeast in lactation diets but has shown no further improvement in performance with the addition of yeast prebiotics and β-glucans in nursery pig diets.[5] Live yeast supplementation in gestation and lactation has been shown to increase immunoglobulin A and G concentrations in colostrum and piglet serum at weaning and throughout the nursery period.[6,7] However, little research has been conducted to determine if supplementation during only lactation can give rise to the same response. Due to the improvement in immunological criteria found when supplementing live yeast in lactation diets and yeast prebiotics in nursery diets, it was hypothesized that yeast supplementation would improve specific immune response post vaccination. The objective of this study was to determine if yeast supplementation during the lactation and nursery periods would result in improvement in lifetime growth performance, serum antibody titers, and carcass characteristics.

Procedures

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 Swine Teaching and Research Center. All diets were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center (Manhattan, KS).

[4] Liu, Y., C. D. Espinosa, J. J. Abelilla, G. A. Casas, L. V. Lagos, S. A. Lee, W. B. Kwon, J. K. Mathai, D. M. D. L. Navarro, N. W. Jaworski, and H. H. Stein. 2018. Non-antibiotic feed additives in diets for pigs: A review. Animal Nutrition. 4:113–125. doi:10.1016/j.aninu.2018.01.007.

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[6] Jang, Y. D., K. W. Kang, L. G. Piao, T. S. Jeong, E. Auclair, S. Jonvel, R. D'Inca, and Y. Y. Kim. 2013. Effects of live yeast supplementation to gestation and lactation diets on reproductive performance, immunological parameters and milk composition in sows. Livestock Science. 152:167–173. doi:10.1016/j.livsci.2012.12.022.

[7] Xia, T., C. Yin, M. Comi, A. Agazzi, V. Perricone, X. Li, and X. Jiang. 2022. Live Yeast Supplementation in Gestating and Lactating Primiparous Sows Improves Immune Response in Dams and Their Progeny. Animals. 12:1315. doi:10.3390/ani12101315.

Animals and treatment structure

A total of 28 mixed-parity sows (DNA 241 DNA; Columbus, NE) were used in a batch farrowing group at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. Sows were weighed and moved into the farrowing house on d 110 of gestation. Sows were blocked by parity and body weight and assigned to 1 of 2 treatments which consisted of a standard corn-soybean meal diet or a diet that contained the live yeast probiotic, *Saccharomyces cerevisiae* strain NCYC Sc 47 (0.10% Actisaf Sc 47 HR+; Phileo by Lesaffre, Milwaukee, WI). Sows were each fed approximately 6 lb/day of their treatment diet from d 110 until farrowing. After farrowing, sows had *ad libitum* access to their treatment diet. Feed additions were recorded to determine daily feed intake. Treatment diets were formulated to meet or exceed NRC (2012)[8] requirement estimates (Table 1).

Sow BW was measured on d 110 of gestation and at weaning. Sow backfat depth (measured 4 in. from the midline at the 10th rib) and caliper score were measured on d 110 of gestation and at weaning. Piglets were cross fostered within 48 h of birth within sow treatment to equalize litter size. Litters were weighed on d 2 and at weaning.

Following weaning, a total of 350 weaned pigs (241 × 600 DNA; initially 13.5 ± 0.05 lb) were used in a 54-d nursery study. Pigs within the same sow treatment were kept together and allotted to pens, with pens then allotted to treatment with 5 pigs per pen and 17 or 18 replications per treatment. Nursery treatments were arranged in a 2 × 2 factorial with main effects of sow treatment (previously described) and nursery treatment (control vs. yeast additives; 0.10% MS309 from d 17 to 59 of age; Phileo by Lesaffre, Milwaukee, WI). Pigs were fed experimental phase 1 diets from placement on d 17 of age until d 27, phase 2 diets from d 27 to 40, and phase 3 diets from d 40 to 59. Following phase 3, pigs were placed on a common phase 4 diet from d 59 to 71. Pigs were individually weighed and feed disappearance was measured weekly during this study to determine ADG, ADFI, and F/G.

After the nursery period, a total of 336 pigs (initially 80.4 ± 10.3 lb) of the original 350 weaned pigs were followed for an additional 94 days until marketing. Two nursery pens of pigs were combined into one finishing pen to create 8 or 9 replications per treatment with 9 or 10 pigs per pen. All pigs were fed a common diet in 3 phases that were formulated to meet or exceed NRC[8] requirement estimates, throughout the grow-finish period. Pigs and feeders were weighed at the completion of each phase to determine ADG, ADFI, and F/G. At 165 d of age, final pen weights and individual weights were taken, and pigs were transported to a commercial packing plant (Triumph, St. Joseph, MO) for processing and carcass data collection. Data collected included hot carcass weight, backfat thickness, loin depth, and percent lean. Carcass yield was calculated as HCW divided by final live weight taken at the farm.

On d 5 post-weaning (22 days of age), one average weight gilt was selected from each pen to be bled. A sample of serum from each female was sent to the Iowa State University Veterinary Diagnostic Laboratory (Ames, IA) for porcine circovirus type 2 (PCV2) and *Mycoplasma hyopneumoniae* antibody analysis. All pigs were vaccinated for porcine circovirus type 2 (PCV2) and *Mycoplasma hyopneumoniae* (Circumvent PCV-M G2,

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

Merck, Rahway, NJ) following the first blood draw. Blood was collected from the same average weight gilts, and the antibody analysis was conducted 6 more times on d 38, 50, 66, 78, 101, and 162 of life. At 50 d of age, and at all successive bleeding events, serum was analyzed for the percent inhibition of *Lawsonia intracellularis*. All pigs were vaccinated for *Lawsonia intracellularis* (Porcilis Ileitis vaccine, Merck, Rahway, NJ) on d 50 following blood collection. Serum samples collected on d 22 and 50 were also used for analysis of immunoglobulin A and immunoglobulin G using an ELISA assay.

Statistical analysis

Performance data for the sow portion of the trial were analyzed using the lme4 package of R (Version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria) as a randomized complete block design. Blocking structure accounted for parity and BW. Sow served as the experimental unit. Treatment was included as a fixed effect and block was included as a random effect. Count data were analyzed using a Poisson distribution using a log link function. Proportion data—including litter born alive, stillborn, born mummified, and pre-weaning mortality—were analyzed using a binomial distribution using a logit link function. Performance data for the nursery and finishing portions of the trial were analyzed using the lme4 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. The main effects of sow treatment and nursery treatment, as well as their interactions, were tested. For analysis of carcass data, individual carcass served as the observation and pen was included in the model as a random effect. Hot carcass weight was used as a covariate for analysis of percentage lean, loin depth, and backfat.

Antibody titer data and immunoglobulin A and G concentrations were analyzed using the GLIMMIX procedure of SAS OnDemand for Academics (SAS Institute, Inc., Cary, NC). Fixed effects of the model included sow diet, nursery diet, day, and their second- and third-order interactions. A Kenward-Rogers adjustment was used in the statistical model, as well as a Tukey multiple comparison adjustment. For analysis of immunoglobulin and vaccine titer data, repeated measures over time were modeled using a first order antedependence covariance parameter matrix structure. For both immunoglobulin analyses, sow and ELISA plate also served as a random effect. Differences were considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

Growth performance

The addition of yeast probiotics to the lactation diet that was fed from d 110 of gestation until weaning resulted in no statistical differences ($P > 0.100$) in sow BW, caliper score, or back fat as well as no differences in ADFI or wean to estrus interval (Table 2). There were no statistical differences ($P > 0.100$) in litter birth characteristics, litter size, or pre-weaning mortality. Litters from control sows tended to be heavier at weaning ($P = 0.079$) but mean piglet body weight at weaning was not statistically different ($P = 0.858$).

During the nursery treatment period, there was a tendency for an interaction between sow and nursery diet for ADG and ADFI ($P \leq 0.073$; Table 3). Numerically, pigs from sows fed Actisaf that were fed either the control or MS309 diets in the nursery, and pigs from control sows that were fed MS309 in the nursery had increased ADG and ADFI when compared to pigs from control sows that were fed the control diet during the nursery treatment period. However, pairwise comparisons revealed no means separation for ADG or ADF in the nursery treatment period.

At the completion of the nursery treatment period there was an interaction between sow treatment and nursery treatment for BW ($P = 0.047$). Numerically, pigs from Actisaf sows that were fed the control diet during the nursery period had a heavier BW when compared to pigs from control sows that were fed the control diet during the nursery period. Pairwise comparisons revealed no means separation for BW at the conclusion of the nursery treatment period. There was a tendency for an interaction for ADG during the common nursery period ($P = 0.099$) between sow treatment and nursery treatment, where pigs fed the control diet during the nursery period that were from Actisaf sows had increased ($P < 0.050$) ADG compared to pigs from control sows fed control nursery diets, with pigs fed MS309 during the nursery period intermediate, with no difference in ADG based on sow diet.

There was a significant main effect of sow treatment on ADG and ADFI in the common nursery period, where pigs from sows fed Actisaf had increased ADG and ADFI when compared to pigs from sows fed the control diet ($P < 0.032$).

There was an interaction between sow diet and nursery diet for overall nursery period ADG ($P = 0.024$) where pigs from Actisaf sows fed the control nursery diet performed better than pigs from control sows fed the control nursery diet ($P < 0.050$), with the other two treatments intermediate. Pigs from Actisaf sows tended to exhibit improved ADG during the overall nursery period when compared to offspring from control sows ($P = 0.073$). There was an interaction between sow and nursery treatments for overall nursery period ADFI ($P = 0.048$). A numerical increase in ADFI was seen in pigs from Actisaf sows that were fed the control diet during the nursery period compared to pigs from control sows that were on the control diet during the nursery. Pigs from either Actisaf or control sows that were fed MS309 during the nursery treatment period were intermediate. However, pairwise comparisons revealed no means separation between treatments.

At the completion of the finishing period, pigs from Actisaf sows tended to have heavier final BW ($P < 0.067$) and HCW ($P = 0.101$) when compared to pigs from control sows. There were no main effects of sow treatment or nursery treatment as well as no interactions between the two on overall finishing period growth performance ($P > 0.100$). There was an interaction between sow and nursery diets on backfat depth at harvest ($P = 0.034$). Numerically, pigs from Actisaf sows that were fed the control nursery diet had decreased backfat depth compared to pigs from control sows that were fed the control nursery diet, or pigs from Actisaf sows that were fed MS309 during the nursery treatment period. However, pairwise comparisons revealed no means separation between the treatments.

Antibody titers and immunoglobulin concentrations

Immunoglobulins (Ig) are antibodies found that can be passively acquired through the ingestion of colostrum and milk, or actively produced in response to disease challenge or vaccination. Thus, a higher immunoglobulin concentration is indicative of a more robust immune system. There were no sow diet or nursery diet effects on $\log_{10}$ immunoglobulin G concentrations on d 22 or 50 of age, as well as no significant second or third order interactions ($P > 0.100$; Figure 1). For $\log_{10}$ IgA concentration, there was an interaction between sow and nursery diet ($P = 0.029$; Figure 2). Pigs from Actisaf sows tended to have decreased $\log_{10}$ IgA concentration when they were fed MS309 during the nursery treatment period, when compared to those fed the control diet during the nursery period ($P = 0.051$). There was a significant day effect on both IgG and IgA concentrations, where IgG concentration was lower at 50 d of age and IgA concentration was higher at 50 d of age as compared to concentrations at 22 d of age ($P < 0.001$).

There was a nursery diet × day interaction for porcine circovirus type 2 (PCV2) S/P ratio ($P = 0.036$; Figure 3). Pigs fed MS309 tended to have a higher PCV2 S/P ratio at 22 d of age ($P = 0.050$). However, at d 66, 78, and 162 of age, pigs fed MS309 during the nursery period had lower PCV2 S/P ratios than pigs fed the control diet during the nursery period ($P \leq 0.022$) and tended to have lower PCV2 S/P ratios on d 50 and 101 of age ($P < 0.093$). There was a tendency for a sow diet × day interaction for the PCV2 S/P ratio ($P = 0.097$; Figure 4). Pigs from Actisaf sows had a higher PCV2 S/P ratio at 101 d of age when compared to pigs from sows fed the control diet ($P = 0.046$), with no evidence of a difference at all other sampling points. There was a tendency for a sow diet × nursery diet interaction on *Lawsonia intracellularis* inhibition ($P = 0.071$; Figure 5). Pigs from Actisaf sows that were fed the control diet in the nursery had numerically the highest percentage inhibition on d 66, 78, 101, and 162. However, pairwise comparisons revealed no means separation within day of serum collection. For both antibody titers and *Lawsonia intracellularis* inhibition, there was a significant day effect ($P < 0.001$). For *Lawsonia intracellularis*, percentage inhibition rose drastically after vaccination on d 50 of age until d 78 of age, following which, the percent inhibition began to plateau. *Mycoplasma hyopneumoniae* S/P ratio peaked at d 22 of age, then following vaccination, the S/P ratios dropped until d 38 and then began to rise until d 78 of age, after which the S/P ratios decreased once more until marketing. Porcine circovirus type 2 S/P ratios decreased following vaccination until d 38 of age, after which the S/P ratios rose until d 66 of age and then began to decrease until marketing (Figure 6).

In conclusion, there were no effects of added live yeast in the lactation diet on lactation performance. However, pigs fed the control diet during the nursery period tended to have improved ADG during the overall nursery period if they were from sows fed Actisaf, compared to offspring from control sows. Conversely, there was no difference based on lactation diet in nursery ADG for pigs fed MS309. While sow diet × day and nursery diet × day interactions were observed in antibody titer analysis, the overall impact of yeast probiotics in sow lactation diets and yeast prebiotics in the nursery diet was minimal. There were no differences in overall finishing growth performance with the inclusion of live yeast in lactation diets or yeast prebiotics in nursery diets; however, pigs from Actisaf sows tended to have a higher final BW and numerically higher HCW.

Table 1. Diet composition (as-fed basis)

		Nursery[1]				Finisher[2]		
Ingredient, %	**Lactation**	**Phase 1**	**Phase 2**	**Phase 3**	**Phase 4**	**Phase 1**	**Phase 2**	**Phase 3**
Corn	66.55	44.15	57.10	66.85	72.10	77.90	83.35	86.10
Soybean meal, 46.5% CP[3]	27.70	18.10	25.75	29.10	24.40	19.05	14.00	11.70
Whey powder	---	25.00	10.00	---	---	---	---	---
Fish meal	---	4.50	2.00					
Enzymatically treated soybean meal[4]	---	3.75	---	---	---	---	---	---
Soybean oil	2.00	1.50	1.00	---	---	---	---	---
Calcium carbonate	1.10	0.25	0.50	0.85	0.85	0.90	0.90	0.88
Monocalcium P, 21.5% P	1.20	0.55	1.15	1.00	0.70	0.68	0.38	0.25
Sodium chloride	0.50	0.30	0.55	0.60	0.50	0.35	0.35	0.35
L-Lysine-HCl	0.28	0.43	0.51	0.52	0.50	0.45	0.42	0.32
DL-Methionine	0.05	0.22	0.22	0.20	0.17	0.10	0.06	0.02
L-Threonine	0.10	0.19	0.23	0.22	0.20	0.16	0.14	0.10
L-Tryptophan	0.01	0.06	0.06	0.06	0.04	0.04	0.04	0.03
L-Valine	---	0.15	0.17	0.14	0.11	0.08	0.05	---
Trace mineral premix	0.25	0.15	0.15	0.15	0.15	0.15	0.15	0.13
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.15	0.13	0.10
Phytase[5]	---	0.08	0.08	0.08	0.04	0.04	0.04	0.04
Zinc oxide	---	0.40	0.27	---	---	---	---	---
Actisaf[6]	+/-	---	---	---	---	---	---	---
MS309[7]	---	+/-	+/-	+/-	---	---	---	---
Total	100	100	100	100	100	100	100	100

continued

Table 1. Diet composition (as-fed basis)

		Nursery[1]				Finisher[2]		
Ingredient, %	**Lactation**	**Phase 1**	**Phase 2**	**Phase 3**	**Phase 4**	**Phase 1**	**Phase 2**	**Phase 3**
Calculated analysis								
SID amino acids, %								
Lys	1.07	1.40	1.35	1.30	1.17	1.00	0.85	0.72
Ile:Lys	64	56	54	54	54	54	54	58
Leu:Lys	134	109	110	114	118	126	134	152
Met:Lys	29	38	37	36	36	33	31	30
Met and Cys:Lys	54	57	57	57	57	56	56	58
Thr:Lys	63	64	64	63	63	63	63	65
Trp:Lys	21	20	20	20	19	19	19	19
Val:Lys	70	70	70	70	68	68	68	69
His:Lys	42	32	34	36	36	37	39	43
Total Lys, %	1.20	1.54	1.49	1.44	1.30	1.11	0.95	0.81
ME, kcal/lb	1,525	1,552	1,515	1,488	1,496	1,501	1,507	1,510
NE, kcal/lb	1,144	1,168	1,134	1,104	1,121	1,137	1,154	1,161
SID Lys:NE, g/Mcal	4.24	5.44	5.40	5.34	4.73	3.99	3.34	2.81
CP, %	19.1	20.9	20.4	20.3	18.4	16.2	14.1	13.1
Ca, %	0.80	0.70	0.72	0.70	0.63	0.61	0.53	0.48
P, %	0.63	0.69	0.71	0.60	0.51	0.48	0.40	0.36
STTD P, %	0.50	0.61	0.59	0.47	0.39	0.38	0.31	0.28

[1]Phase 1 diets were fed from d 17 to 27 of the nursery period (approximately 13.5 to 16.6 lb BW). Phase 2 diets were fed from d 27 to 40 (approximately 16.6 to 28.6 lb BW). Phase 3 diets were fed from d 40 to 59 (approximately 28.6 to 56.1 lb BW). Phase 4 diets were fed from d 59 to 71 (approximately 56.1 to 80.4 lb BW).
[2]Phase 1 diets were fed from d 71 to 100 of the finishing period (approximately 80.4 to 148.2 lb BW). Phase 2 diets were fed from d 100 to 128 (approximately 148.2 to 215.5 lb BW), Phase 3 diets were fed from d 128 to 165 (approximately 215.5 to 291.4 lb BW).
[3]CP = crude protein.
[4]HP 300 (Hamlet Protein, Findlay, OH).
[5]Ronozyme HiPhos GT 2700 (DSM Nutritional Products, Parsippany, NJ) provided a 0.14 release of STTD P % with 2,027 FTU/kg in the nursery, and 0.13 release of STTD P % with 1,000 FTU/kg in the finisher.
[6]Actisaf 47 HR+ (Phileo by Lesaffre, Milwaukee, WI) was added at 0.1% at the expense of corn from the experimental diets.
[7]MS309 (Phileo by Lesaffre, Milwaukee, WI) was added at 0.1% at the expense of corn from the experimental diets.

Table 2. Evaluation of Actisaf on sow lactation performance[1]

Sow treatment[2]:	Control	Actisaf	SEM	$P =$
Sow BW, lb				
Entry	590.9	591.5	17.02	0.943
Wean	504.6	515.9	19.07	0.228
Change (entry to wean)	-86.2	-75.6	8.97	0.363
Sow back fat, in.				
Entry	0.60	0.60	0.025	0.923
Wean	0.56	0.57	0.025	0.859
Change (entry to wean)	-0.04	-0.04	0.010	0.824
Sow caliper score[3]				
Entry	17.4	17.3	0.26	0.655
Wean	16.0	16.0	0.43	1.000
Change (entry to wean)	-1.4	-1.3	0.31	0.747
Sow ADFI, lb				
Pre-farrow	5.7	5.7	0.14	0.895
Farrow to wean	16.3	16.1	0.56	0.717
Wean to estrus interval, d	5.2	5.3	0.14	0.826
Litter size, n				
d 0	15.2	13.9	1.04	0.373
d 2	13.9	13.1	1.00	0.572
Wean	13.4	12.9	0.98	0.677
Litter weight, lb				
d 2	53.2	50.0	1.74	0.144
Wean	177.8	169.3	3.46	0.079
Mean piglet BW, lb				
d 2	3.9	3.9	0.17	0.937
Wean	13.3	13.4	0.36	0.858
Litter ADG d 2 to wean, lb/d	7.14	6.95	0.142	0.353
Piglet ADG d 2 to wean, lb/d	0.53	0.55	0.021	0.523
Preweaning mortality, %				
Birth to d 2	4.0	4.3	1.64	0.876
d 2 to wean	3.8	2.5	1.64	0.457

[1]A total of 28 mixed-parity sows (Line 241, DNA, Columbus NE) and litters were used from day 110 of gestation until weaning. Litters were cross fostered within treatment group to equalize litter size up to 48 h post farrowing.
[2]Sow treatment consisted of providing a control diet or the control diet with the inclusion of Actisaf at 0.1% of diet (Phileo, Milwaukee, WI) from entry into the farrowing house (d 110 of gestation) until weaning.
[3]A caliper score of 18 was used for sows that had a caliper score that was too large to be measured by the device (> 18). Caliper scores at entry > 18: Control: n = 7; Actisaf: n = 3. Caliper score at weaning > 18: Control: n = 2; Actisaf: n = 1.

Table 3. Interactive effects of Actisaf in lactation diets and MS309 in nursery diets on growth performance of nursery and finishing pigs[1,2]

Sow treatment[3]:	Control		Actisaf			*P* =		
Nursery treatment[4]:	Control	MS309	Control	MS309	SEM	Sow × nursery	Sow	Nursery
BW, lb								
d 17 (Weaning)	13.5	13.5	13.4	13.5	0.05	0.876	0.512	0.988
d 59	54.7	56.7	56.9	56.1	0.70	0.047	0.268	0.381
d 71	78.7	80.7	81.9	80.3	0.91	0.047	0.123	0.783
d 165	286.4	289.7	293.6	293.0	2.83	0.470	0.067	0.628
d 17 to 59 (Nursery treatment period)								
ADG, lb	0.98	1.03	1.03	1.02	0.016	0.052	0.214	0.334
ADFI, lb	1.47	1.53	1.53	1.51	0.022	0.073	0.565	0.404
F/G	1.50	1.49	1.48	1.48	0.013	0.549	0.177	0.652
d 59 to 71 (Common nursery period)								
ADG, lb	1.98[b]	1.99[ab]	2.08[a]	2.01[ab]	0.028	0.099	0.032	0.313
ADFI, lb	3.36[b]	3.38[ab]	3.54[a]	3.43[ab]	0.046	0.140	0.013	0.328
F/G	1.70	1.70	1.70	1.71	0.014	0.736	0.601	0.928
d 17 to 71 (Overall nursery period)								
ADG, lb	1.20[b]	1.24[ab]	1.27[a]	1.24[ab]	0.016	0.024	0.073	0.729
ADFI, lb	1.89	1.94	1.98	1.93	0.026	0.048	0.157	0.882
F/G	1.57	1.56	1.56	1.56	0.009	0.474	0.348	0.618
d 71 to 165 (Overall finishing period)								
ADG, lb	2.19	2.22	2.25	2.24	0.028	0.570	0.149	0.720
ADFI, lb	5.77	5.82	5.91	5.93	0.080	0.870	0.127	0.627
F/G	2.63	2.62	2.63	2.64	0.014	0.386	0.592	0.677
Carcass data								
HCW	213.8	216.9	218.1	220.4	2.40	0.852	0.101	0.249
Carcass yield, %	75.0	74.9	74.5	74.9	0.21	0.269	0.317	0.534
Lean, %[5]	55.1	55.2	55.3	55.0	0.14	0.146	0.662	0.417
Loin depth, in.[5]	2.64	2.65	2.62	2.61	0.022	0.594	0.246	0.961
Back fat depth, in.[5]	0.60	0.59	0.57	0.60	0.009	0.034	0.425	0.202

[a-c]Means within row with different superscripts differ ($P < 0.05$).
[1]A total of 350 weaned pigs (initially 13.5 ± 0.38 lb) were used in a 54-day nursery trial with 17 to 18 replications per treatment and 5 pigs per pen.
[2]A total of 336 pigs (initially 80.4 ± 10.3 lb) were used in a 94-day finishing trial with 8 to 9 replications per treatment and 10 pigs per pen.
[3]Sow diet consisted of a control diet or a diet with inclusion of Actisaf at 0.1% of diet (Phileo by Lesaffre, Milwaukee, WI) from d 110 until weaning.
[4]Nursery treatment consisted of a control diet or a diet with the inclusion of MS309 at 0.1% of diet (Phileo by Lesaffre, Milwaukee, WI) in phases 1, 2, and 3.
[5]Adjusted using HCW as a covariate.

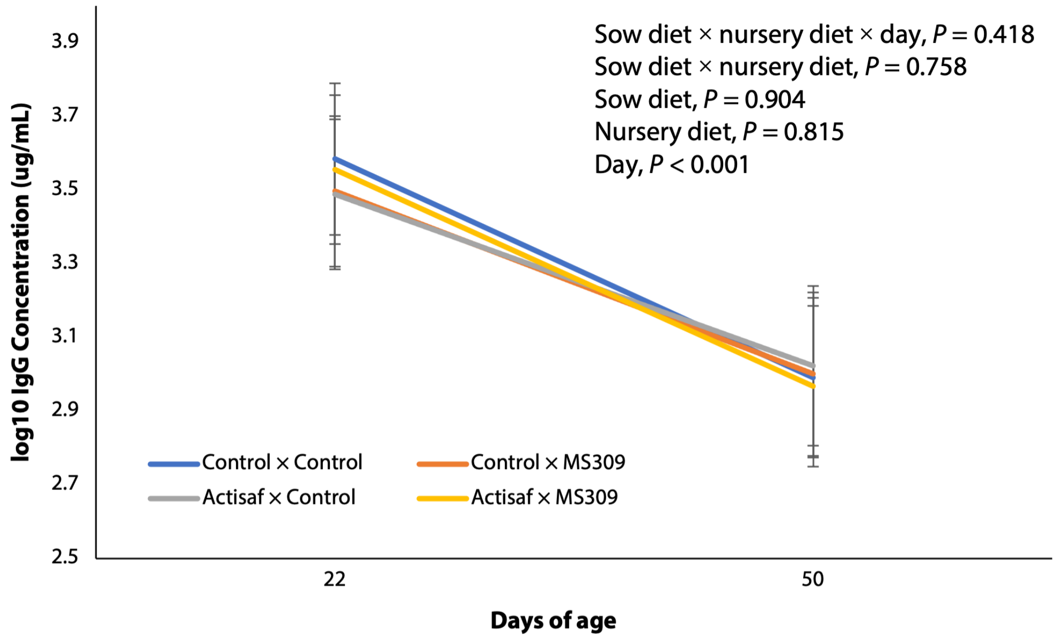

Figure 1. Effect of sow and nursery diet on $\log_{10}$ immunoglobulin G concentration.

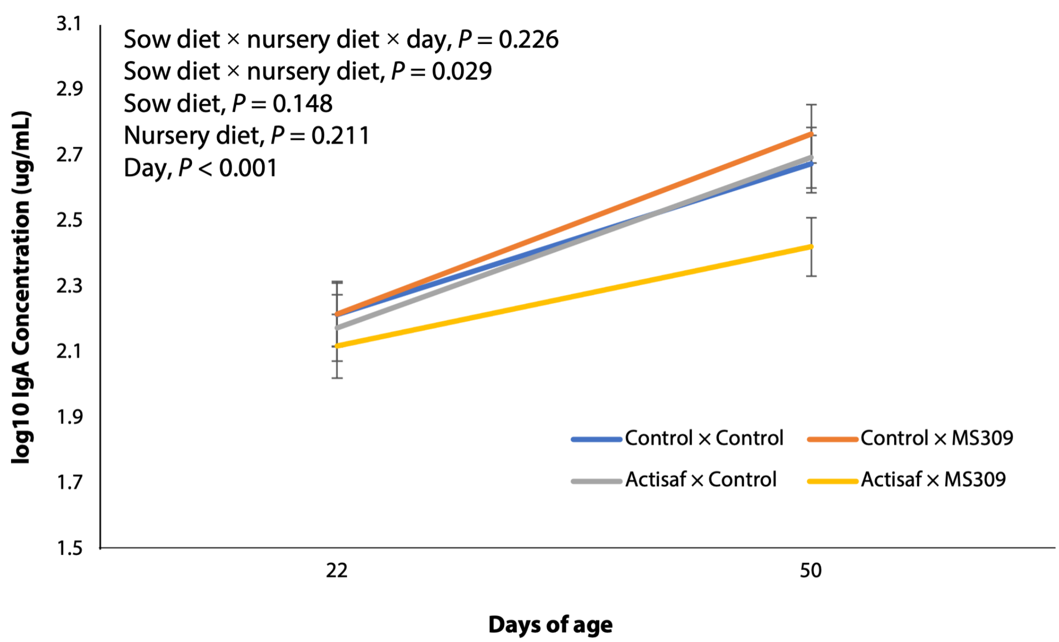

Figure 2. Effect of sow and nursery diet on $\log_{10}$ immunoglobulin A concentration.

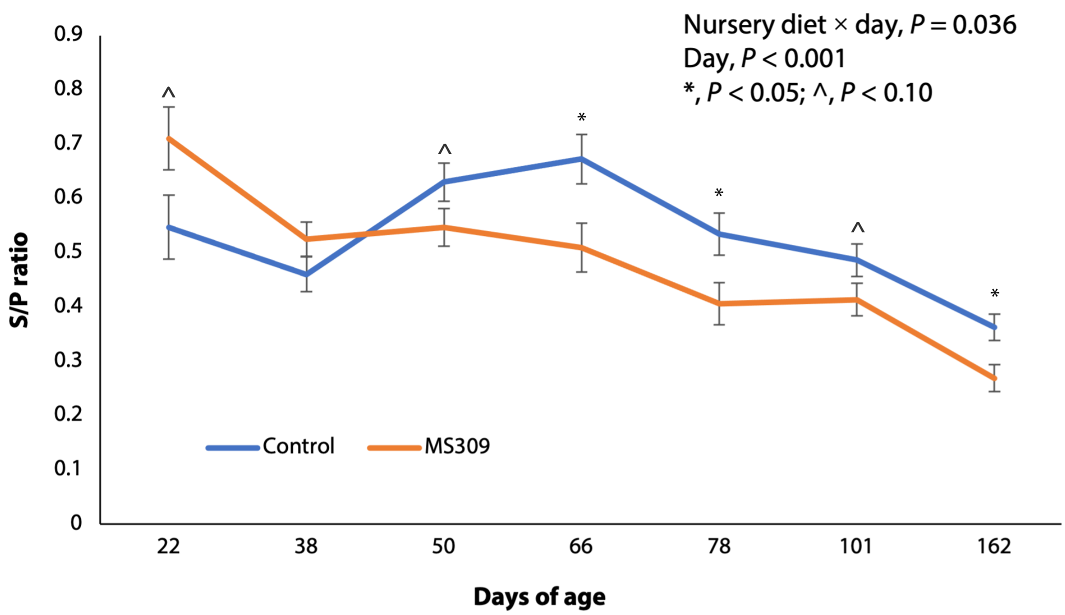

Figure 3. Effect of nursery diet on porcine circovirus type 2 S/P ratio.

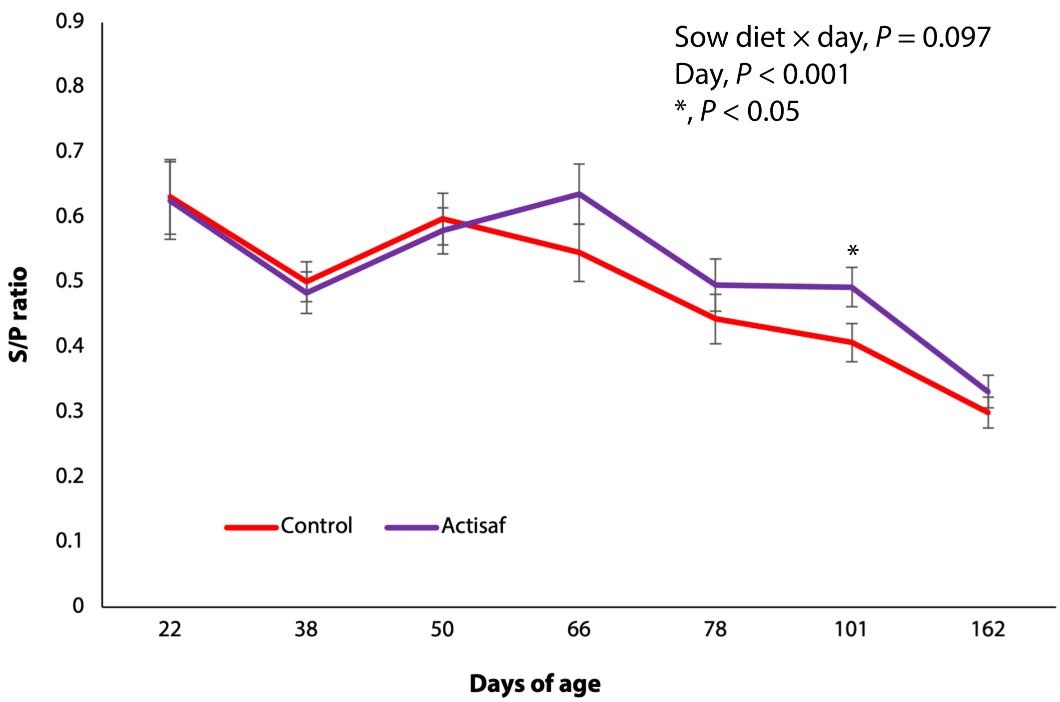

Figure 4. Effect of sow diet on porcine circovirus type 2 S/P ratio.

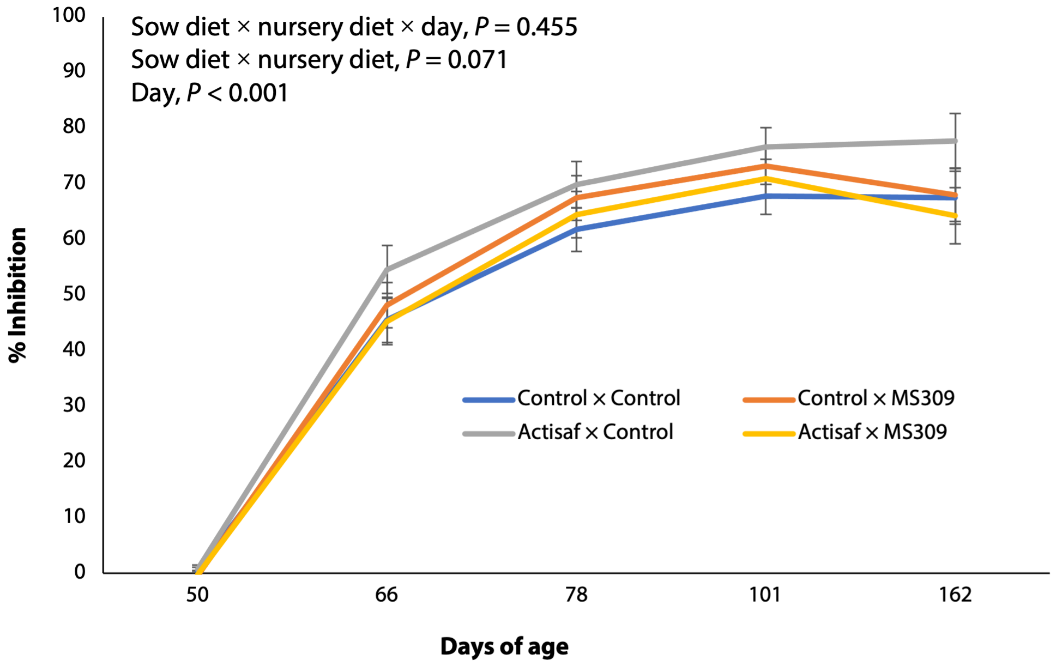

Figure 5. Effect of sow and nursery diet on *Lawsonia intracellularis* inhibition.