Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 10 *Swine Day (1968-2014)*

Article 958

2009

Effects of porcine circovirus type 2 vaccine and increasing standardized ileal digestible lysine:calorie ratio on growth performance and carcass composition of growing and finishing pigs

N W. Shelton

J L. Usry

Michael D. Tokach

See next page for additional authors

Effects of porcine circovirus type 2 vaccine and increasing standardized ileal digestible lysine:calorie ratio on growth performance and carcass composition of growing and finishing pigs

Authors

N W. Shelton, J L. Usry, Michael D. Tokach, Robert D. Goodband, Jim L. Nelssen, Joel M. DeRouchey, and Steven S. Dritz

Effects of Porcine Circovirus Type 2 Vaccine and Increasing Standardized Ileal Digestible Lysine:Calorie Ratio on Growth Performance and Carcass Composition of Growing and Finishing Pigs[1,2]

N. W. Shelton, M. D. Tokach, S. S. Dritz[3], R. D. Goodband, J. L. Nelssen, J. M. DeRouchey, and J. L. Usry[4]

Summary

A series of 4 experiments was conducted to determine the effect of porcine circovirus type 2 (PCV2) vaccination on the lysine requirement of growing and finishing pigs. Experiments 1 and 2 evaluated the requirement for 85- to 140-lb gilts and barrows, respectively. Experiments 3 and 4 evaluated the requirement for 225- to 275-lb gilts and 215- to 260-lb barrows, respectively. Data from each trial were analyzed as 2 × 4 factorial designs with 2 PCV2 vaccination treatments (vaccinates and non-vaccinates) and 4 levels of increasing standardized ileal digestible (SID) lysine:ME ratio (2.24, 2.61, 2.99, and 3.36 g/Mcal in Exp. 1 and 2 and 1.49, 1.86, 2.23, and 2.61 g/Mcal in Exp. 3 and 4).

No PCV2 vaccination × SID lysine:ME ratio interactions were observed ($P > 0.14$) in any of the 4 studies. In Exp. 1 and 2, PCV2 vaccinates had increased ($P < 0.04$) ADG, ADFI, final weight, and daily SID lysine intake and tended to have improved ($P < 0.09$) F/G compared with non-vaccinates. In Exp. 1, ADG and F/G improved (quadratic; $P < 0.03$) as the SID lysine:ME ratio increased, with increases through 2.99 g/Mcal. In Exp. 2, increasing the SID lysine:ME ratio improved (linear; $P < 0.001$) F/G and increased (linear; $P < 0.001$) daily SID lysine intake and SID lysine intake per pound of gain. Thus, 3.36 g SID lysine/Mcal ME appears to maximize efficiency for 85- to 140-lb barrows.

In Exp. 3, PCV2 vaccinates had improved ($P < 0.02$) F/G and increased ($P < 0.03$) final weight, SID lysine intake per pound of gain, and backfat thickness compared with non-vaccinates. Both ADG and F/G improved (quadratic; $P < 0.05$) as the SID lysine:ME ratio increased, with ADG improving through 1.86 g/Mcal and F/G improving through 2.23 g/Mcal, indicating the requirement may be between those levels. In Exp. 4, both ADG and ADFI were decreased ($P < 0.04$) in vaccinates compared with non-vaccinates. In this study, ADG, F/G, daily SID lysine intake, and SID lysine intake per pound of gain increased (linear; $P < 0.001$) and F/G improved (linear; $P < 0.001$) through the highest level of 2.61 g lysine/Mcal, with the greatest magnitude of change when lysine was increased from 2.23 to 2.61 g/Mcal. Because of the lack of any interactions between dietary SID lysine level and PCV2 vaccination, it appears that PCV2

[1] Appreciation is expressed to New Horizon Farms for the use of pigs and facilities and to Richard Brobjorg, Scott Heidebrink, and Marty Heintz for technical assistance.
[2] The authors thank Ajinimoto Heartland Inc. for partial funding of this project.
[3] Food Animal Health and Management Center, College of Veterinary Medicine, Kansas State University.
[4] Ajinimoto Heartland Inc., Chicago, IL.

vaccination did not increase the lysine requirement for growing and finishing barrows and gilts. On the basis of these studies, which used corn-soybean meal-based diets with 3% added fat, the requirement was 1.04% SID lysine or 1.17% total lysine for 85- to 135-lb gilts, 1.17% SID lysine or 1.31% total lysine for 85- to 140-lb barrows, 0.78% SID lysine or 0.88% total lysine for 225- to 275-lb gilts, and 0.91% SID lysine or 1.02% total lysine for 215- to 260-lb barrows.

Key words: amino acid requirements, lysine, porcine circovirus type 2 (PCV2) vaccine

Introduction

Evaluating amino acid requirements of the current high-lean pig genotypes is essential for generating cost-effective diets for growing and finishing pigs. Recent research by Shelton et al. (2008a[5], 2008b[6]) has shown an increase in the lysine requirement from requirements estimated 6 yr ago (Main et al., 2002[7]) in the same facilities with the same genetic lines. Also, recent research (Jacela et al., 2007a[8], 2007b[9]; Potter et al., 2008[10]) has shown an increase in growth rates and final weights of growing and finishing pigs administered porcine circovirus type 2 (PCV2) vaccine. Combined with the advancement within genetic lines, the increase in growth rate as a function of PCV2 vaccine may be one of the main factors driving the increase in the lysine requirement. Therefore, the main objective of these experiments was to evaluate the effects of increasing dietary lysine level in PCV2-vaccinated and non-vaccinated growing and finishing pigs.

Procedures

Procedures in this experiment were approved by the Kansas State University Institutional Animal Care and Use Committee. The experiment was conducted at a commercial research finishing facility in southwestern Minnesota. The facility was double curtain sided with completely slatted flooring. Pens were 10 × 18 ft and were equipped with a 5-hole conventional dry feeder and a cup waterer.

A total of 2,571 barrows and gilts (PIC 337 × 1050) were weaned into a wean-to-finish facility. Pens were double stocked with 56 pigs per pen, and gilts and barrows were penned separately. Two vaccination treatments for PCV2 were then allotted by pen at placement: no vaccine or vaccination with 2 doses of commercial PCV2 vaccine (Circumvent PCV; Intervet Inc., Millsboro, DE) given at placement into the wean-to-finish barn and again 21 d after the initial vaccination. All pigs were also inoculated with serum containing PRRS virus as part of this production system's protocol. When the barn average pig weight reached approximately 55 lb, the barn was split out by moving gilt pens to an adjacent barn to be used in Exp. 1 and 3 and splitting barrows pens in half in the original barn for use in Exp. 2 and 4. Additional details regarding the effect of vaccination on nursery performance are presented in another article in this report of progress (Shelton et al., 2009[11]).

[5] Shelton et al., Swine Day 2008, Report of Progress 1001, pp. 82-92.
[6] Shelton et al., Swine Day 2008, Report of Progress 1001, pp. 93-97.
[7] Main et al., Swine Day 2002, Report of Progress 897, pp. 135-150.
[8] Jacela et al., Swine Day 2007, Report of Progress 985, pp. 5-9.
[9] Jacela et al., Swine Day 2007, Report of Progress 985, pp. 10-16.
[10] Potter et al., Swine Day 2008, Report of Progress 1001, pp. 5-13.
[11] Shelton et al., Swine Day 2009, Report of Progress 1020, pp. 28-32.

A total of 1,008 gilts (initially 84.5 lb) and 1,002 barrows (initially 85.7 lb) were then selected and used in Exp. 1 and 2, respectively, for 28 d. Four experimental diets were used in Exp. 1 and 2 with standardized ileal digestible (SID) lysine:ME ratios of 2.24, 2.61, 2.99, and 3.36 g/Mcal, which correspond to SID levels of 0.78%, 0.91%, 1.04%, and 1.17% or total lysine levels of 0.88%, 1.02%, 1.17%, and 1.31% (Table 1). After the conclusion of Exp. 1 and 2, all pigs were placed on diets that were above the determined lysine requirement. Also, before beginning Exp. 3 and 4, initial marketing occurred in which pigs were removed from each pen, with more pigs removed from vaccinated pens to attempt to minimize the difference in pig density and initial weight between the PCV2 vaccinates and non-vaccinates.

A total of 930 gilts (initially 224.3 lb) and 825 barrows (initially 215.4 lb) were then selected and used in Exp. 3 and 4 for 28 and 21 d, respectively. Four experimental diets were again used with SID lysine:ME ratios of 1.49, 1.86, 2.23, and 2.61 g/Mcal, which correspond to dietary SID lysine levels of 0.52%, 0.65%, 0.78%, and 0.91% or total lysine levels of 0.59%, 0.74%, 0.88%, and 1.02% (Table 2). At the conclusion of Exp. 3 and 4, all pigs were marketed to a USDA-inspected packing plant.

For each experiment, dietary treatments were allotted to both PCV2-vaccinated and non-vaccinated pens in a completely randomized design. Each experiment had 5 replications for each diet and vaccine treatment combination. All treatment diets were corn-soybean meal based with 0.15% added L-lysine HCl. Corn and soybean meal levels were altered to achieve the desired SID lysine:ME ratio in the diet. In addition, all diets contained 3% added fat from choice white grease. Diets were formulated to meet all other requirements recommended by NRC (1998[12]). Diet samples were collected from each diet in each experiment and analyzed for amino acid concentrations.

Pig weights (by pen) and feed disappearance were measured throughout the experiments. On the basis of these measurements, ADG, ADFI, F/G, daily SID lysine intake, and SID lysine intake per pound of gain were calculated for each pen. At the conclusion of the growth portion of Exp. 3 and 4, the pigs were marketed to a USDA-inspected packing plant and carcass data were collected. Pen data for yield, backfat depth, loin depth, percentage lean, fat-free lean index, and live value were determined by the packing plant. Yield reflects the percentage of HCW relative to live weight (obtained at the packing plant). Live value was determined by taking a base carcass price of $55.90, adding lean premiums, subtracting discounts, and converting to a live weight basis. Feed cost per pound of gain and income over feed cost (IOFC) were also calculated. For Exp. 1 and 2, IOFC was determined on a per-head basis by valuing each pig's weight gain at $0.50/lb and subtracting feed costs associated with the trial period. In Exp. 3 and 4, IOFC was determined on a per-head basis by subtracting the feed costs incurred during the trial from the full value for each pig.

Data were then analyzed as a completely randomized design with treatments arranged as 2 × 4 factorial designs for each experiment (2 PCV2 vaccine treatments and 4 dietary lysine levels). Growth and carcass data were analyzed using the MIXED procedure in SAS (SAS Institute Inc., Cary, NC), and pen counts were analyzed using the GENMOD procedure in SAS. Dietary lysine values were used as dose levels to test for

[12] NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

linear and quadratic responses to dietary treatments. Pen was used as the experimental unit in all analyses.

Results and Discussion

Analyzed amino acid levels for diets from Exp. 1, 2, 3 and 4 are shown in Tables 3, 4, 5, and 6, respectively. Formulated diet values are included in parenthesis. For each experiment, the analyzed concentrations of amino acids for the feed samples collected were similar to the calculated total values (within the acceptable limits for analytical variation). Also for each experiment, no PCV2 vaccine ×lysine interactions were detected ($P > 0.14$) for any of the growth or carcass data (Tables 7, 8, 9, and 10).

In Exp. 1 (85- to 135-lb gilts), PCV2-vaccinated pigs tended ($P < 0.08$) to be heavier (3.5 lb) at initiation of the trial and had an increased ($P < 0.001$) number of pigs per pen (3.6 pigs per pen) compared with non-vaccinates (Table 7). This initial difference is due to the increase in removals and decrease in pretrial performance of non-vaccinated pens that resulted from the inoculation of PRRS. Vaccinates had increased ($P < 0.001$) ADG, ADFI, final weight, daily SID lysine intake, and IOFC and tended to have improved ($P < 0.09$) F/G compared with non-vaccinates. In addition, at the conclusion of the experiment, pens vaccinated with PCV2 vaccine maintained a greater ($P < 0.001$) pen head count (5.0 more pigs per pen) than non-vaccinates. Average daily gain, F/G, and IOFC improved (quadratic; $P < 0.03$) as the SID lysine:ME ratio increased, with increases through 2.99 g/Mcal. Increasing the lysine level of the diet also increased (linear; $P < 0.02$) daily lysine intake and SID lysine per pound of gain. These results indicate that 2.99 g SID lysine/Mcal ME, or approximately 9.76 g of SID lysine per pound of gain, was sufficient to meet the needs of 85- to 135-lb gilts.

In Exp. 2 (85- to 140-lb barrows), similar to the gilts, PCV2 vaccinates tended to be heavier ($P < 0.06$) at the start of the experiment and had increased ($P < 0.001$) initial pen head counts (4.4 more pigs per pen) compared with non-vaccinates (Table 8). Vaccination for PCV2 also increased ($P < 0.04$) ADG, ADFI, final weight, daily lysine intake, and IOFC and tended to improve ($P < 0.08$) F/G. At the conclusion of Exp. 2, pen counts were greater ($P < 0.001$) for PCV2-vaccinated pens than for non-vaccinated pens by 7 pigs. Increasing the SID lysine:ME ratio of the diet improved F/G ($P < 0.001$) and increased (linear; $P < 0.001$) daily SID lysine intake and SID lysine intake per pound of gain. As evidenced by the improvements in F/G, these results suggest that 3.36 g SID lysine/Mcal ME, or 11.34 g of SID lysine per pound of gain, maximized the efficiency of 85- to 140-lb barrows.

In Exp. 3 (225- to 275-lb gilts), the increased ($P < 0.002$) starting weight and pen head count was maintained for PCV2-vaccinated pens, but the difference was reduced to only 2 more pigs per pen, which is less than the earlier difference of 5 pigs per pen that was a result of removing more pigs from vaccinated pens at initial barn marketing, which began just prior to the start of Exp. 3 and 4 (Table 9). No difference in ADG or ADFI was detected ($P > 0.23$) between PCV2 vaccinates and non-vaccinates. However, PCV2 vaccinates had improved ($P < 0.02$) F/G and increased ($P < 0.03$) final weight, final head count, SID lysine intake per pound of gain, and backfat. As seen from the improvements in feed efficiency, PCV2 vaccinates had a small improvement ($P < 0.02$) in feed cost per pound of gain, and the increase in final weight drove

the increase ($P < 0.001$) in IOFC for vaccinates compared with non-vaccinates. Both ADG and F/G improved (quadratic; $P < 0.05$) as the SID lysine:ME ratio increased, with ADG improving to 1.86 g/Mcal and F/G improving through 2.23 g/Mcal. Feed intake tended to decrease (linear; $P < 0.09$) as dietary lysine increased. But despite the decreases in feed intake, daily SID lysine intake and SID lysine intake per pound of gain increased (linear; $P < 0.001$) with increases in dietary lysine. No lysine level effects were observed ($P > 0.23$) for any of the carcass criteria. Feed cost per pound of gain improved (quadratic; $P < 0.001$) and IOFC tended to increase (quadratic; $P < 0.10$) as lysine increased in the diet, with the greatest values obtained at 2.23 g/Mcal for non-vaccinates and 1.86 g/Mcal for vaccinates. Results from this experiment indicate that approximately 1.86 g SID lysine/Mcal ME was required to maximize growth and 2.23 g SID lysine/Mcal ME was required to maximize efficiency and generate the most economic value.

In Exp. 4 (215- to 260-lb barrows), there was a difference ($P < 0.001$) in the initial average pen head count, with vaccinated pens having almost 3 more pigs per pen than non-vaccinated pens. However, there was no difference ($P > 0.85$) in starting weight between vaccination treatments (Table 10). Both ADG and ADFI were decreased ($P < 0.04$) in vaccinated pens compared with non-vaccinated pens, and the average pen head count was increased ($P < 0.001$) at the conclusion of the trial for vaccinated pens. In this study, ADG, F/G, daily SID lysine intake, and SID lysine intake per pound of gain increased (linear; $P < 0.01$) through the highest level of 2.61 g/Mcal, with the greatest change occurring when lysine level increased from 2.23 to 2.61 g/Mcal. Similar to Exp. 3, no differences in any of the carcass characteristics were observed ($P > 0.15$) as the SID lysine:ME ratio increased. Results from this trial indicate that feeding up to 2.61 g SID lysine/Mcal ME, or 12.39 g SID lysine per pound of gain, improved performance for 215- to 260-lb barrows.

Results from the first 2 experiments indicate that 85- to 135-lb BW gilts required 2.99 g SID lysine/Mcal ME and 85- to 140-lb BW barrows required 3.36 g SID lysine/Mcal ME to maximize performance. These requirements reflect a SID lysine level of 1.04% (1.17% total) for gilts and 1.17% (1.31% total) for barrows in a corn-soybean meal-based diet with 3% added fat. These results are similar to the requirement reported by Shelton et al. (2008a) that PCV2-vaccinated gilts from 85 to 140 lb required 3.16 g SID lysine/Mcal ME. One item that could be a confounding factor in the present studies is the different number of pigs per pen. This was a result of the effectiveness of the PCV2 vaccine and changes in death loss and reduced number of cull pigs. However, research published by Gonyou et al. (2006[13]) indicates that pig space should not have been an issue in Exp. 1 and 2 between vaccinated and non-vaccinated pens because pens had not reached the critical k-value (0.0336) at which space becomes a liming factor for growth rate.

Shelton et al. (2008a) reported linear increases in growth and feed efficiency through 2.55 g SID lysine/Mcal ME for 185- to 245-lb gilts. Results from Exp. 3 and 4 showed that the optimal SID lysine:ME ratio for 225- to 275-lb gilts appears to be approxi-

[13] Gonyou, H. W., M. C. Brum, E. Bush, J. Deen, S. A. Edwards, T. Fangman, J. J. McGlone, M. Meunier-Salaun, R. B. Morrison, H. Spoolder, P. L. Sundberg, and A. K. Johnson. 2006. Application of broken-line analysis to assess floor space requirements of nursery and grower-finisher pigs expressed on an allometric basis. J. Anim. Sci. 84:229-235.

mately 2.23 g/Mcal and that the optimal level for 215- to 260-lb barrows is 2.61 g/Mcal. The gilt requirement of 2.23 g SID lysine/Mcal ME corresponds to a corn-soybean meal-based diet with 3% fat containing 0.78% SID lysine, or 0.88% total lysine, and the barrow requirement of 2.61 g/Mcal reflects a diet with 0.91% SID lysine, or 1.02% total lysine. Despite the barrows being heavier, the high requirement in Exp. 4 is similar to the requirement observed by Shelton et al. (2008a), indicating there may be advantages to feeding increased SID lysine:ME ratios in the early stages of finishing. In Exp. 3 and 4, pig space would have been a limiting factor based on the critical k-value as described by Gonyou et al. (2006). The PCV2 vaccinates would be at a disadvantage for growth and efficiency compared with non-vaccinates because of limited pig space.

Because no interactions between dietary SID lysine level and PCV2 were observed, it appears that the overall increase in performance with PCV2 vaccination did not increase the lysine requirement for growing and finishing barrows and gilts. With only minor differences, the SID lysine:ME ratio that optimized growth and economic return was similar between PCV2 vaccinates and non-vaccinates.

Table 1. Composition of diets, Exp. 1[1] and 2[2] (as-fed basis)

	SID[3] lysine:ME, g/Mcal			
	2.24	2.61	2.99	3.36
	SID lysine, %			
Ingredient, %	0.78	0.91	1.04	1.17
Corn	75.52	70.16	64.81	59.44
Soybean meal (45% CP)	19.38	24.74	30.09	35.45
Choice white grease	3.00	3.00	3.00	3.00
Monocalcium P (21% P)	0.54	0.51	0.48	0.45
Limestone	0.90	0.90	0.90	0.90
Salt	0.35	0.35	0.35	0.35
L-threonine	0.005	0.015	0.020	0.030
Methionine hydroxy analog	---	0.015	0.045	0.070
Vitamin and trace mineral premix	0.10	0.10	0.10	0.10
Phytase[4]	0.013	0.013	0.013	0.013
Liquid lysine (60% lysine)	0.195	0.195	0.195	0.195
Total	100.00	100.00	100.00	100.00
Calculated analysis				
SID amino acids, %				
Lysine	0.78	0.91	1.04	1.17
Isoleucine:lysine	70	69	69	69
Leucine:lysine	167	156	148	142
Methionine:lysine	29	29	30	31
Met & Cys:lysine	61	59	58	58
Threonine:lysine	62	62	62	62
Tryptophan:lysine	19	19	20	20
Valine:lysine	81	79	77	76
ME, kcal/lb	1,580	1,580	1,579	1,579
Total lysine, %	0.88	1.02	1.17	1.31
CP, %	15.4	17.5	19.5	21.6
Ca, %	0.53	0.54	0.56	0.57
P, %	0.46	0.47	0.49	0.51
Available P, %[5]	0.27	0.27	0.27	0.27
Diet cost, $/ton[6]	185.47	194.45	203.51	212.67

[1] A total of 1,008 gilts (PIC 337 × 1050) were used in this 28-d trial with 5 replications per PCV2 vaccination and diet combination.
[2] A total of 1,002 barrows (PIC 337 × 1050) were used in this 28-d trial with 5 replications per PCV2 vaccination and diet combination.
[3] Standardized ileal digestible.
[4] OptiPhos 2000 (Enzyvia LLC, Sheridan, IN) provided 227 phytase units per pound of diet.
[5] Phytase provided 0.10% available P to the diet.
[6] Diets costs were based on corn at $4.00/bu and soybean meal at $300/ton.

Table 2. Composition of diets, Exp. 3[1] and 4[2] (as-fed basis)

	SID[3] lysine:ME, g/Mcal			
	1.49	1.86	2.23	2.61
	SID lysine, %			
Ingredient, %	0.52	0.65	0.78	0.91
Corn	86.46	81.12	75.77	70.41
Soybean meal (45% CP)	8.66	14.01	19.36	24.72
Choice white grease	3.00	3.00	3.00	3.00
Monocalcium P (21% P)	0.4	0.375	0.35	0.32
Limestone	0.85	0.85	0.85	0.85
Salt	0.35	0.35	0.35	0.35
L-threonine	---	0.01	0.02	0.035
Methionine hydroxy analog	---	---	0.005	0.025
Vitamin and trace mineral premix	0.08	0.08	0.08	0.08
Phytase[4]	0.013	0.013	0.013	0.013
Liquid lysine (60% Lys)	0.195	0.195	0.195	0.195
Total	100.00	100.00	100.00	100.00
Calculated analysis				
SID amino acids, %				
Lysine	0.52	0.65	0.78	0.91
Isoleucine:lysine	71	70	70	69
Leucine:lysine	204	182	167	156
Methionine:lysine	35	32	30	30
Met & Cys:lysine	73	66	61	60
Threonine:lysine	65	65	64	65
Tryptophan:lysine	18	18	19	19
Valine:lysine	89	84	81	79
ME, kcal/lb	1,585	1,585	1,584	1,584
Total lysine, %	0.59	0.74	0.88	1.02
CP, %	11.4	13.4	15.5	17.5
Ca, %	0.45	0.46	0.48	0.49
P, %	0.39	0.40	0.42	0.43
Available P, %[5]	0.23	0.23	0.23	0.23
Diet cost, $/ton[6]	169.62	178.31	187.10	196.33

[1] A total of 930 gilts (PIC 337 × 1050) were used in this 28-d trial with 5 replications per PCV2 vaccination and diet combination.
[2] A total of 825 barrows (PIC 337 × 1050) were used in this 21-d trial with 5 replications per PCV2 vaccination and diet combination.
[3] Standardized ileal digestible.
[4] OptiPhos 2000 (Enzyvia LLC, Sheridan, IN) provided 227 phytase units per pound of diet.
[5] Phytase provided 0.10% available P to the diet.
[6] Diets costs were based on corn at $4.00/bu and soybean meal at $300/ton.

Table 3. Chemical composition of diets (Exp. 1)[1]

	SID[2] lysine:ME, g/Mcal			
	2.24	2.61	2.99	3.36
	SID lysine, %			
Item, %	0.78	0.91	1.04	1.17
CP	13.8 (15.4)[3]	15.4 (17.5)	17.4 (19.5)	19.3 (21.6)
Essential amino acids				
Arginine	0.88	1.03	1.17	1.34
Histidine	0.38	0.42	0.47	0.53
Isoleucine	0.60 (0.62)	0.69 (0.71)	0.78 (0.81)	0.88 (0.91)
Leucine	1.28 (1.43)	1.43 (1.57)	1.58 (1.71)	1.72 (1.84)
Lysine	0.86 (0.88)	0.99 (1.02)	1.11 (1.17)	1.27 (1.31)
Methionine	0.25 (0.25)	0.28 (0.29)	0.30 (0.34)	0.33 (0.39)
Met + Cys	0.48 (0.54)	0.53 (0.60)	0.58 (0.68)	0.64 (0.76)
Phenylalanine	0.75	0.85	0.95	1.06
Threonine	0.57 (0.57)	0.63 (0.66)	0.71 (0.75)	0.81 (0.84)
Tryptophan	0.16 (0.17)	0.18 (0.20)	0.22 (0.23)	0.24 (0.26)
Valine	0.65 (0.72)	0.74 (0.82)	0.83 (0.91)	0.94 (1.01)
Nonessential amino acids				
Alanine	0.76	0.83	0.91	0.99
Aspartic acid	1.39	1.63	1.85	2.14
Cysteine	0.23	0.25	0.28	0.31
Glutamic acid	2.47	2.81	3.15	3.54
Glycine	0.57	0.65	0.73	0.84
Proline	0.83	0.88	0.93	1.00
Serine	0.70	0.79	0.89	1.00
Tyrosine	0.41	0.48	0.52	0.61

[1] A total of 1,008 gilts (PIC 337 × 1050) were used in this 28-d trial with 5 replications per PCV2 vaccination and diet combination.
[2] Standardized ileal digestible.
[3] Values in parentheses indicate formulated values.

Table 4. Chemical composition of diets (Exp. 2)[1]

	SID[2] lysine:ME, g/Mcal			
	2.24	2.61	2.99	3.36
	SID lysine, %			
Item, %	0.78	0.91	1.04	1.17
CP	13.6 (15.4)[3]	15.1 (17.5)	17.3 (19.5)	19.1 (21.6)
Essential amino acids				
Arginine	0.86	0.99	1.17	1.29
Histidine	0.38	0.42	0.48	0.52
Isoleucine	0.57 (0.62)	0.66 (0.71)	0.75 (0.81)	0.81 (0.91)
Leucine	1.28 (1.43)	1.38 (1.57)	1.54 (1.71)	1.65 (1.84)
Lysine	0.85 (0.88)	0.96 (1.02)	1.12 (1.17)	1.23 (1.31)
Methionine	0.25 (0.25)	0.27 0.29)	0.30 (0.34)	0.33 (0.39)
Met + Cys	0.48 (0.54)	0.52 (0.60)	0.58 (0.68)	0.63 (0.76)
Phenylalanine	0.76	0.83	0.94	1.04
Threonine	0.56 (0.57)	0.62 (0.66)	0.71 (0.75)	0.78 (0.84)
Tryptophan	0.15 (0.17)	0.17 (0.20)	0.21 (0.23)	0.20 (0.26)
Valine	0.65 (0.72)	0.72 (0.82)	0.83 (0.91)	0.91 (1.01)
Nonessential amino acids				
Alanine	0.78	0.82	0.90	0.99
Aspartic acid	1.39	1.58	1.85	2.04
Cysteine	0.23	0.25	0.28	0.30
Glutamic acid	2.48	2.74	3.13	3.43
Glycine	0.58	0.64	0.73	0.82
Proline	0.97	1.01	1.04	1.19
Serine	0.70	0.77	0.89	0.97
Tyrosine	0.42	0.47	0.51	0.56

[1] A total of 1,002 barrows (PIC 337 × 1050) were used in this 28-d trial with 5 replications per PCV2 vaccination and diet combination.
[2] Standardized ileal digestible.
[3] Values in parentheses indicate formulated values.

Table 5. Chemical composition of diets (Exp. 3)[1]

	SID[2] lysine:ME, g/Mcal			
	1.49	1.86	2.23	2.61
	SID lysine, %			
Item, %	0.52	0.65	0.78	0.91
CP	9.8 (11.4)[3]	10.8 (13.4)	13.7 (15.5)	15.2 (17.5)
Essential amino acids				
Arginine	0.61	0.69	0.89	1.02
Histidine	0.28	0.31	0.38	0.44
Isoleucine	0.43 (0.42)	0.48 (0.52)	0.61 (0.62)	0.70 (0.71)
Leucine	1.05 (1.16)	1.08 (1.30)	1.29 (1.44)	1.47 (1.57)
Lysine	0.57 (0.59)	0.68 (0.74)	0.87 (0.88)	0.96 (1.02)
Methionine	0.17 (0.20)	0.21 (0.23)	0.25 (0.26)	0.28 (0.30)
Met + Cys	0.35 (0.43)	0.40 (0.48)	0.48 (0.54)	0.53 (0.61)
Phenylalanine	0.58	0.61	0.76	0.84
Threonine	0.39 (0.41)	0.45 (0.50)	0.57 (0.59)	0.64 (0.68)
Tryptophan	0.10 (0.11)	0.12 (0.14)	0.16 (0.17)	0.18 (0.20)
Valine	0.49 (0.53)	0.52 (0.62)	0.66 (0.72)	0.74 (0.82)
Nonessential amino acids				
Alanine	0.65	0.67	0.78	0.87
Aspartic acid	0.93	1.07	1.41	1.62
Cysteine	0.18	0.19	0.23	0.25
Glutamic acid	1.81	1.97	2.49	2.83
Glycine	0.41	0.46	0.58	0.65
Proline	0.75	0.29	1.11	1.27
Serine	0.50	0.56	0.70	0.79
Tyrosine	0.33	0.34	0.42	0.47

[1] A total of 930 gilts (PIC 337 × 1050) were used in this 28-d trial with 5 replications per PCV2 vaccination and diet combination.
[2] Standardized ileal digestible.
[3] Values in parentheses indicate formulated values.

Table 6. Chemical composition of diets (Exp. 4)[1]

	SID[2] lysine:ME, g/Mcal			
	1.49	1.86	2.23	2.61
	SID lysine, %			
Item, %	0.52	0.65	0.78	0.91
CP	9.7 (11.4)[3]	10.9 (13.4)	13.6 (15.5)	15.1 (17.5)
Essential amino acids				
Arginine	0.60	0.71	0.92	0.98
Histidine	0.28	0.32	0.38	0.41
Isoleucine	0.43 (0.42)	0.49 (0.52)	0.62 (0.62)	0.66 (0.71)
Leucine	1.05 (1.16)	1.11 (1.30)	1.31 (1.44)	1.40 (1.57)
Lysine	0.56 (0.59)	0.68 (0.74)	0.87 (0.88)	0.93 (1.02)
Methionine	0.20 (0.20)	0.19 (0.23)	0.25 (0.26)	0.26 (0.30)
Met + Cys	0.38 (0.43)	0.38 (0.48)	0.48 (0.54)	0.51 (0.61)
Phenylalanine	0.58	0.64	0.76	0.83
Threonine	0.42 (0.41)	0.45 (0.50)	0.58 (0.59)	0.64 (0.68)
Tryptophan	0.10 (0.11)	0.12 (0.14)	0.16 (0.17)	0.17 (0.20)
Valine	0.48 (0.53)	0.53 (0.62)	0.67 (0.72)	0.72 (0.82)
Nonessential amino acids				
Alanine	0.64	0.67	0.78	0.84
Aspartic acid	0.93	1.10	1.44	1.56
Cysteine	0.18	0.19	0.23	0.25
Glutamic acid	1.81	2.03	2.54	2.73
Glycine	0.41	0.47	0.58	0.63
Proline	0.59	0.67	0.71	1.18
Serine	0.50	0.57	0.71	0.77
Tyrosine	0.32	0.36	0.43	0.45

[1] A total of 825 barrows (PIC 337 × 1050) were used in this 21-d trial with 5 replications per PCV2 vaccination and diet combination.
[2] Standardized ileal digestible.
[3] Values in parentheses indicate formulated values.

Table 7. Effects of SID lysine:ME ratio and PCV2 vaccination on 85- to 135-lb gilts (Exp. 1)[1]

	PCV2 vaccine[2]									Probability, $P <$				
	No				Yes					Vaccine			Lysine	
SID lysine:ME, g/Mcal:	2.24	2.61	2.99	3.36	2.24	2.61	2.99	3.36	SEM	× Lysine	Vaccine	Lysine	Linear	Quadratic
Initial wt, lb	82.7	82.7	82.7	82.8	86.3	86.2	86.3	86.2	2.75	0.99	0.08	0.99	0.99	0.99
Initial pen head count	23.0	23.8	23.0	23.8	26.8	27.2	27.0	27.0	0.86	0.97	0.001	0.88	0.72	0.88
ADG, lb	1.52	1.60	1.72	1.64	1.78	1.92	1.90	1.84	0.04	0.33	0.001	0.002	0.02	0.002
ADFI, lb	3.58	3.61	3.56	3.50	4.05	4.06	3.94	3.85	0.08	0.88	0.001	0.22	0.06	0.45
F/G	2.36	2.26	2.07	2.15	2.28	2.12	2.07	2.09	0.06	0.71	0.09	0.001	0.001	0.03
Final wt, lb	128.0	130.9	133.1	130.3	136.0	140.0	139.8	137.8	2.98	0.99	0.001	0.48	0.46	0.18
Final pen head count	21.2	22.0	21.6	22.8	26.8	27.2	26.8	27.0	0.80	0.68	0.001	0.84	0.37	0.93
Daily SID lysine intake, g	12.68	14.92	16.78	18.58	14.33	16.77	18.56	20.43	0.39	0.99	0.001	0.001	0.001	0.37
SID lysine intake/lb gain, g	8.36	9.32	9.78	11.39	8.07	8.76	9.74	11.11	0.26	0.80	0.13	0.001	0.001	0.09
Feed cost/lb gain, $[3]	0.22	0.22	0.21	0.23	0.21	0.21	0.21	0.22	0.006	0.75	0.10	0.07	0.14	0.04
IOFC, $/pig[3,4]	9.81	10.36	11.48	10.22	11.87	13.16	12.78	11.73	0.463	0.39	0.001	0.03	0.60	0.004

[1] A total of 1,008 gilts (PIC 337 × 1050) were used in this 28-d trial with 5 replications per PCV2 vaccination and diet combination.

[2] Vaccination for PCV2 was administered at placement into the wean-to-finish facility and again 3 wk later.

[3] Diets costs were based on corn at $4.00/bu and soybean meal at $300/ton.

[4] Income over feed cost = (Weight gain per pig × $0.50/lb) - feed cost per pig.

Table 8. Effects of SID lysine:ME ratio and PCV2 vaccination on 85- to 140-lb barrows (Exp. 2)[1]

	PCV2 vaccine[2]									Probability, $P <$				
	No				Yes					Vaccine			Lysine	
SID lysine:ME, g/Mcal:	2.24	2.61	2.99	3.36	2.24	2.61	2.99	3.36	SEM	× Lysine	Vaccine	Lysine	Linear	Quadratic
Initial wt, lb	83.4	83.4	83.4	83.5	87.9	88.0	87.8	88.0	3.24	0.99	0.06	0.99	0.97	0.99
Initial pen head count	23.0	22.4	22.6	23.4	27.4	27.0	27.4	27.2	0.80	0.94	0.001	0.89	0.82	0.49
ADG, lb	1.77	1.72	1.91	1.91	2.06	2.08	2.05	2.11	0.07	0.44	0.001	0.39	0.13	0.66
ADFI, lb	4.37	4.13	4.20	4.05	4.74	4.74	4.52	4.51	0.15	0.77	0.001	0.31	0.07	0.86
F/G	2.48	2.41	2.20	2.12	2.31	2.29	2.21	2.15	0.05	0.15	0.08	0.001	0.001	0.77
Final wt, lb	136.3	139.1	141.7	143.0	145.7	146.5	145.1	147.4	3.94	0.87	0.04	0.77	0.30	0.99
Final pen head count	21.4	18.8	19.8	20.4	27.2	26.6	27.4	27.0	1.01	0.74	0.001	0.48	0.78	0.25
Daily SID lysine intake, g	15.45	17.03	19.80	21.47	16.77	19.58	21.32	23.95	0.65	0.71	0.001	0.001	0.001	0.96
SID lysine intake/lb gain, g	8.79	9.95	10.37	11.27	8.16	9.43	10.42	11.40	0.22	0.22	0.13	0.001	0.001	0.37
Feed cost/lb gain, $[3]	0.23	0.23	0.22	0.23	0.21	0.22	0.23	0.23	0.005	0.17	0.09	0.61	0.50	0.64
IOFC, $/pig[3,4]	11.00	10.42	12.10	11.97	13.58	13.23	12.89	13.08	0.592	0.24	0.001	0.63	0.47	0.56

[1] A total of 1,002 barrows (PIC 337 × 1050) were used in this 28-d trial with 5 replications per PCV2 vaccination and diet combination.
[2] Vaccination for PCV2 was administered at placement into the wean-to-finish facility and again 3 wk later.
[3] Diets costs were based on corn at $4.00/bu and soybean meal at $300/ton.
[4] Income over feed cost = (Weight gain per pig × $0.50/lb) - feed cost per pig.

Table 9. Effects of SID lysine:ME ratio and PCV2 vaccination on 225- to 275-lb gilts (Exp. 3)[1]

	PCV2 vaccine[2]									Probability, $P <$				
	No				Yes								Lysine	
SID lysine:ME, g/Mcal:	1.49	1.86	2.23	2.61	1.49	1.86	2.23	2.61	SEM	Vaccine × Lysine	Vaccine	Lysine	Linear	Quadratic
Initial wt, lb	220.7	220.5	220.6	220.7	227.8	228.0	227.8	228.0	3.02	0.99	0.002	0.99	0.98	0.98
Initial pen head count	20.4	20.2	20.4	20.6	22.6	22.2	22.4	22.4	0.77	0.99	0.001	0.98	0.94	0.72
ADG, lb	1.62	1.83	1.84	1.80	1.68	1.84	1.85	1.92	0.06	0.79	0.24	0.005	0.003	0.05
ADFI, lb	5.99	5.98	5.78	5.71	5.90	5.90	5.64	5.82	0.14	0.79	0.60	0.21	0.09	0.75
F/G	3.72	3.28	3.14	3.18	3.52	3.20	3.05	3.04	0.07	0.77	0.02	0.001	0.001	0.001
Final wt, lb	266.0	271.7	272.2	271.5	275.5	279.6	279.7	281.7	3.22	0.97	0.001	0.27	0.10	0.36
Final pen head count	20.4	20.2	20.4	20.4	22.2	22.2	22.4	22.4	0.78	0.99	0.001	0.99	0.85	0.93
Daily SID lysine intake, g	14.14	17.64	20.44	23.56	13.91	17.39	19.94	24.0	0.44	0.72	0.70	0.001	0.001	0.86
SID lysine intake/lb gain, g	8.79	9.67	11.10	13.12	8.29	9.44	10.78	12.6	0.21	0.85	0.02	0.001	0.001	0.007
Carcass measurements														
Backfat, in.	0.63	0.61	0.59	0.62	0.65	0.65	0.64	0.65	0.026	0.84	0.03	0.67	0.62	0.32
Lean, %	56.4	55.9	56.5	56.0	56.3	56.5	56.4	56.4	0.70	0.91	0.71	0.97	0.89	0.91
Loin depth, in.	2.41	2.45	2.47	2.44	2.47	2.53	2.45	2.47	0.07	0.86	0.35	0.87	0.95	0.51
Yield, %	75.6	75.7	75.9	75.5	76.4	75.6	75.5	75.4	0.50	0.54	0.87	0.67	0.25	0.94
FFLI, %[3]	50.9	51.1	51.4	51.0	50.8	50.9	50.9	50.9	0.28	0.86	0.18	0.67	0.54	0.35
Economics														
Live value, $/cwt	48.08	48.83	49.17	48.09	49.03	49.01	48.87	48.93	0.53	0.48	0.21	0.58	0.97	0.18
Feed cost/lb gain, $[4]	0.32	0.29	0.29	0.31	0.30	0.29	0.29	0.30	0.006	0.81	0.02	0.005	0.80	0.001
IOFC, $/pig[4,5]	113.66	116.90	118.11	114.80	120.73	122.24	121.99	121.86	1.99	0.75	0.001	0.34	0.47	0.10

[1] A total of 930 gilts (PIC 337 × 1050) were used in this 28-d trial with 5 replications per PCV2 vaccination and diet combination.
[2] Vaccination for PCV2 was administered at placement into the wean-to-finish facility and again 3 wk later.
[3] Fat-free lean index.
[4] Diets costs were based on corn at $4.00/bu and soybean meal at $300/ton.
[5] Income over feed cost = value per pig - feed costs during trial period.

Table 10. Effects of SID lysine:ME ratio and PCV2 vaccination on 215- to 260-lb barrows (Exp. 4)[1]

	PCV2 vaccine[2]									Probability, $P <$				
	No				Yes					Vaccine			Lysine	
SID lysine:ME, g/Mcal:	1.49	1.86	2.23	2.61	1.49	1.86	2.23	2.61	SEM	× Lysine	Vaccine	Lysine	Linear	Quadratic
Initial wt, lb	215.1	215.2	214.8	215.1	215.5	215.6	215.7	215.7	4.34	0.99	0.86	0.99	0.99	0.99
Initial day pen head count	18.2	19.0	19.2	18.2	22.8	22.6	22.6	22.4	0.99	0.93	0.001	0.93	0.88	0.53
ADG, lb	2.02	2.14	2.15	2.25	1.90	2.01	2.09	2.25	0.04	0.36	0.02	0.001	0.001	0.81
ADFI, lb	6.70	7.15	7.12	6.80	6.48	6.57	6.85	6.70	0.18	0.62	0.04	0.19	0.31	0.06
F/G	3.32	3.34	3.32	3.03	3.42	3.27	3.29	2.97	0.09	0.76	0.80	0.001	0.001	0.07
Final wt, lb	259.0	260.2	259.9	262.2	255.9	257.9	259.8	263.0	3.99	0.96	0.68	0.63	0.21	0.84
Final pen head count	18.0	19.0	19.0	18.2	22.4	22.6	22.4	22.4	1.01	0.92	0.001	0.96	0.96	0.49
Daily SID lysine intake, g	15.80	21.07	25.20	28.07	15.29	19.38	24.25	27.65	0.58	0.69	0.04	0.001	0.001	0.07
SID lysine intake/lb gain, g	7.84	9.85	11.74	12.51	8.07	9.64	11.64	12.27	0.26	0.79	0.65	0.001	0.001	0.005
Carcass measurements														
Backfat, in.	0.77	0.75	0.76	0.77	0.81	0.79	0.77	0.76	0.024	0.74	0.24	0.70	0.29	0.63
Lean, %	54.0	54.1	54.0	53.8	53.0	53.4	53.9	54.0	0.48	0.59	0.29	0.79	0.37	0.66
Loin depth, in.	2.30	2.26	2.25	2.22	2.14	2.21	2.28	2.27	0.07	0.38	0.52	0.92	0.63	0.72
Yield, %	74.3	74.6	74.6	74.1	74.8	74.8	74.8	74.8	0.51	0.95	0.25	0.96	0.93	0.60
FFLI, %[3]	48.8	49.1	49.0	48.9	48.2	48.5	48.8	49.0	0.28	0.55	0.11	0.47	0.16	0.48
Economics														
Live value, $/cwt	40.71	41.42	41.10	40.52	40.83	41.37	41.73	42.31	0.65	0.50	0.19	0.70	0.35	0.51
Feed cost/lb gain, $[4]	0.28	0.30	0.31	0.30	0.29	0.29	0.31	0.29	0.008	0.77	0.86	0.04	0.11	0.04
IOFC, $/pig[4,5]	93.49	94.52	92.93	92.36	92.90	94.44	94.98	97.47	2.96	0.77	0.45	0.95	0.63	0.94

[1] A total of 825 barrows (PIC 337 × 1050) were used in this 21-d trial with 5 replications per PCV2 vaccination and diet combination.
[2] Vaccination for PCV2 was administered at placement into the wean-to-finish facility and again 3 wk later.
[3] Fat-free lean index.
[4] Diets costs were based on corn at $4.00/bu and soybean meal at $300/ton.
[5] Income over feed cost = value per pig - feed costs during trial period.