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Effects of standardized ileal digestible lysine level in diets containing tribasic copper chloride on finishing pig growth performance, carcass characteristics, and fat quality

Abstract

A total of 1,248 pigs (PIC 337 Ã— 1050; initially 63.8 lb) were used in a 120-d experiment to study the effects of increasing standardized ileal digestible lysine (SID Lys) in diets with or without 150 ppm added Cu from tri-basic copper chloride (TBCC) on growth performance, carcass characteristics, and fat quality. Pens of pigs were allotted to 1 of 6 dietary treatments in a randomized complete block design with 26 pigs (similar number of barrows and gilts) per pen and 8 replications per treatment. Treatments were arranged in a 2 Ã— 3 factorial with main effects of added TBCC (0 or 150 ppm of Cu) and SID Lys (85, 92.5, and 100% of the pigâ€™s estimated requirement). Diets were corn-soybean mealâ€“based with 30% dried distillers grains with solubles and 15% bakery meal. Overall (d 0 to 120), no TBCC Ã— Lys interactions (P > 0.10) were observed for growth performance. Adding dietary TBCC tended (P < 0.10) to increase ADG and improve F/G. As SID Lys increased, ADG increased and F/G improved (linear; P < 0.05). Final BW increased (linear; P < 0.05) as SID Lys increased, and if pigs were fed diets containing TBCC (P < 0.05); however, only HCW increased with increasing SID Lys (linear; P < 0.05). Backfat iodine value (IV) was not affected by treatment; however, increasing the SID Lys level tended to increase jowl fat IV only in pigs fed TBCC (TBCC Ã— Lys linear; P < 0.10). Feeding TBCC decreased (P < 0.02) liver a* values, resulting in decreased redness of the liver and increased (P < 0.01) liver Cu concentrations. Feed cost per pig, cost per pound of gain, and gain value all increased (linear; P < 0.05) as SID Lys increased when calculated on a constant days basis. As a result, IOFC was $2.19 lower (linear; P < 0.02) when pigs were fed only 85% of their estimated SID Lys requirement compared with those fed 100% of their requirement. The value of the weight gained during the experiment tended to increase (P < 0.10) for pigs fed diets containing TBCC. When calculating cost on a constant weight basis, adjusted F/G was improved (P < 0.05), and facility costs tended to be lower (P < 0.10) for pigs fed TBCC. Facility cost decreased (linear; P < 0.01) as SID Lys increased. In conclusion, feeding 150 ppm Cu from TBCC tended to increase ADG and F/G. More importantly, these results suggest that 100% of the estimated SID Lys requirement should be fed to achieve the highest net return when pigs are fed for a constant number of days and that TBCC cannot compensate for deficient SID Lys concentrations in finishing pig diets.; Swine Day, Manhattan, KS, November 20, 2014

Keywords

Swine Day, 2014; Kansas Agricultural Experiment Station contribution; no. 15-155-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 1110; Copper; Finishing pig; Lysine; Tribasic copper chloride

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Effects of Standardized Ileal Digestible Lysine Level in Diets Containing Tribasic Copper Chloride on Finishing Pig Growth Performance, Carcass Characteristics, and Fat Quality[1,2]

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Summary

A total of 1,248 pigs (PIC 337 × 1050; initially 63.8 lb) were used in a 120-d experiment to study the effects of increasing standardized ileal digestible lysine (SID Lys) in diets with or without 150 ppm added Cu from tri-basic copper chloride (TBCC) on growth performance, carcass characteristics, and fat quality. Pens of pigs were allotted to 1 of 6 dietary treatments in a randomized complete block design with 26 pigs (similar number of barrows and gilts) per pen and 8 replications per treatment. Treatments were arranged in a 2 × 3 factorial with main effects of added TBCC (0 or 150 ppm of Cu) and SID Lys (85, 92.5, and 100% of the pig's estimated requirement). Diets were corn-soybean meal–based with 30% dried distillers grains with solubles and 15% bakery meal. Overall (d 0 to 120), no TBCC × Lys interactions ($P > 0.10$) were observed for growth performance. Adding dietary TBCC tended ($P < 0.10$) to increase ADG and improve F/G. As SID Lys increased, ADG increased and F/G improved (linear; $P < 0.05$). Final BW increased (linear; $P < 0.05$) as SID Lys increased, and if pigs were fed diets containing TBCC ($P < 0.05$); however, only HCW increased with increasing SID Lys (linear; $P < 0.05$).

Backfat iodine value (IV) was not affected by treatment; however, increasing the SID Lys level tended to increase jowl fat IV only in pigs fed TBCC (TBCC × Lys linear; $P < 0.10$). Feeding TBCC decreased ($P < 0.02$) liver a* values, resulting in decreased redness of the liver and increased ($P < 0.01$) liver Cu concentrations.

Feed cost per pig, cost per pound of gain, and gain value all increased (linear; $P < 0.05$) as SID Lys increased when calculated on a constant days basis. As a result, IOFC was $2.19 lower (linear; $P < 0.02$) when pigs were fed only 85% of their estimated SID Lys requirement compared with those fed 100% of their requirement. The value of the weight gained during the experiment tended to increase ($P < 0.10$) for pigs fed diets containing TBCC. When calculating cost on a constant weight basis, adjusted F/G was improved ($P < 0.05$), and facility costs tended to be lower ($P < 0.10$) for pigs fed TBCC. Facility cost decreased (linear; $P < 0.01$) as SID Lys increased.

[1] Appreciation is expressed to New Horizon Farms for use of pigs and facilities, to Richard Brobjorg and Marty Heintz for their technical assistance, and to Micronutrients (Indianapolis, IN) for partial funding.
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In conclusion, feeding 150 ppm Cu from TBCC tended to increase ADG and F/G. More importantly, these results suggest that 100% of the estimated SID Lys requirement should be fed to achieve the highest net return when pigs are fed for a constant number of days and that TBCC cannot compensate for deficient SID Lys concentrations in finishing pig diets.

Key words: copper, finishing pig, lysine, tribasic copper chloride

Introduction

Copper (Cu) is an essential trace mineral that is included in all swine diets through trace mineral premix and endogenously by feed ingredients. In addition to the dietary Cu needed to meet the pig's basal requirements (approximately 3 to 6 ppm[5]), it is sometimes added up to 250 ppm in the nursery and early finishing periods to enhance growth performance. A recent experiment by Coble et al. (2013[6]) suggested that high levels of Cu may provide benefits for a longer duration in the finishing period than previously thought. In that experiment, adding 150 ppm of Cu from tribasic copper chloride (TBCC) in finishing diets formulated 0.05% below the pig's standardized ileal digestible lysine (SID Lys) estimated requirement resulted in a linear increase ($P < 0.01$) in overall ADG and ADFI. This improvement in ADG resulted in an 8.3-lb heavier carcass.

Formulating diets 0.05% below the pig's estimated SID Lys requirement was done because previous work in poultry suggested that when TBCC was added to diets containing marginal levels of Lys, growth performance of broilers was similar to those fed diets adequate in Lys with no additional Cu. Although many experiments have been completed to better understand the SID Lys requirement of growing pigs, previous research has not investigated the effects of SID Lys level in diets supplemented with Cu. Our study sought to replicate the poultry data and investigate whether SID Lys levels could be decreased below the pig's estimated requirement in diets containing Cu from TBCC. Therefore, this study was designed to investigate the effects of limiting SID Lys in diets with or without 150 ppm added Cu from TBCC on growth performance, carcass characteristics, and fat quality. In addition, liver Cu concentrations and color, carcass fat IV, and the economics of added Cu were addressed.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted in a commercial research-finishing barn in southwest Minnesota. The barn was naturally ventilated and double-curtain-sided. Pens had completely slatted flooring and deep pits. Each pen was equipped with a 4-hole stainless steel feeder and cup waterer for ad libitum access to feed and water. Feed additions were made by a robotic feeding system (FeedPro; Feedlogic Corp., Willmar, MN) that measured feed amounts for each individual pen.

A total of 1,248 pigs (PIC 337 × 1050; initially 63.8 lb) were used in a 120-d study. Before initiating the trial, pigs were fed a common diet containing 205 ppm Cu from TBCC (Intellibond C; Micronutrients, Inc., Indianapolis, IN). Pens of pigs were allot-

[5] NRC. 2012. Nutrient Requirements of Swine. 11th ed. Natl. Acad. Press, Washington, DC.
[6] Coble et al. Swine Day 2013. Report of Progress 1092, pp. 168-180.

ted to 1 of 6 dietary treatments in a randomized complete block design with 26 pigs (similar number of barrows and gilts) per pen and 8 replications per treatment. Treatments were arranged in a 2 × 3 factorial with main effects of added Cu from TBCC (0 or 150 ppm) and SID Lys (85, 92.5, and 100% of the estimated requirement based on previous studies; Main et al., 2008[7]). All diets were corn-soybean meal–based with 30% dried distiller's grains and 15% bakery meal and contained 17 ppm of Cu from copper sulfate ($CuSO_4$) provided by the trace mineral premix. Treatment diets were fed in 5 phases (Tables 1 through 3). During the last phase, all diets contained 9 g/ton of ractopamine HCl (Paylean; Elanco Animal Health, Greenfield, IN). Each treatment diet was sampled at the start and before the last day of each phase change to form a composite sample and analyzed for Cu (Table 4).

Pens of pigs were weighed and feed disappearance was recorded at d 23, 38, 70, 97, and 120 to determine ADG, ADFI, and F/G. Caloric efficiency on both an ME and NE basis were calculated for each treatment by dividing the sum of total feed intake and dietary energy (kcal) by total gain. On d 97, the 3 heaviest pigs in each pen were weighed and sold according to standard farm procedures. Prior to marketing, the remaining pigs were individually tattooed with a pen ID number to allow for carcass measurements to be recorded on a pen basis. On d 120, final pen weights were taken and 3 individual pigs were visually identified as representatives of the mean individual pig weight of the pen and transported to a small commercial packing plant in northwestern Iowa (Natural Foods Holdings Inc.; Sioux City, IA) for measuring liver mineral concentrations and color, and collecting backfat and jowl fat samples. All other pigs were transported to a commercial packing plant in southwestern Minnesota (JBS Swift and Company, Worthington, MN) for processing and carcass data collection. Carcass measurements there included HCW, loin depth, backfat, and percentage lean. Percentage carcass yield was calculated by dividing the average pen HCW by the average final live weight at the farm. Hot carcass weight ADG was calculated by subtracting the assumed initial HCW (d 0 wt × an estimated 75% yield) from HCW, then dividing the value by 120 d. Carcass F/G was calculated by dividing ADFI by HCW ADG. Carcass data between the two plants was combined for the analysis

Pigs transported to the packing plant in northwestern Iowa were used to collect liver and carcass fat samples. Individual livers were collected on the production line to determine an objective liver color score. Using a MiniScan EZ (Model 4500L; Hunter Associates Laboratory, Reston, VA) L*, a*, and b* color values were obtained that indicate lightness, redness, and yellowness, respectively, by taking three scans from each liver and obtaining an average for each color value. From these values, the hue angle and chroma were calculated. Hue angle describes the blemish or taint of the color, and chroma describes the color saturation. Approximately 1-lb samples of each liver were taken from the ascending right lobe and sent to Michigan State University for analysis of total Cu, Fe, and Zn. Fat samples were taken from both the jowl and 10th-rib backfat (all 3 layers) and sent to the University of Georgia for complete fatty acid profile analysis.

At the conclusion of the study, an economic analysis was calculated on both a constant days on feed or constant market weight basis to determine the value of feeding TBCC

[7] Main, R.G, S.S. Dritz, M.D. Tokach, R.D. Goodband, J.L. Nelssen, and J.M. DeRouchey. 2008. Effects of feeding growing pig's less or more than their estimated lysine requirement in early and late finishing on overall performance. PAS 24:76–87.

and varying levels of SID Lys in two scenarios. For calculating on a constant days on feed basis, economics were determined using the treatment means from the trial. To determine the economics on a constant weight basis, feed efficiency was adjusted to a common final BW by a factor of 0.005 per pound of final weight. The actual ADG and adjusted F/G were then used to determine the difference in total number of days and total amount of feed needed to reach a common weight of 275 lb. For the constant days on feed and constant weight economic evaluation, total feed cost per pig, cost per pound of gain, gain value, and income over feed cost (IOFC) were calculated. Feed cost was calculated by multiplying ADFI by the feed cost per pound and the number of days in each respective period, then taking the sum of those values for each period calculated the total feed cost per pig. Cost per pound of gain was calculated by dividing the total feed cost per pig by the total pounds gained overall. The value of the weight gained during the experiment (gain value) was calculated by subtracting the product of initial pig weight times the assumed live price of $68.83 per cwt from final pig weight times $68.83 per cwt. Income over feed cost was calculated by subtracting total feed cost from gain value. Income over feed and facilities cost (IOFFC) was calculated for the constant market weight evaluation because pigs with faster growth rates will reach 275 lb sooner, thus decreasing the cost of housing the pigs. Facility cost was calculated by multiplying the number of overall days the pigs need to reach 275 lb based on their respective growth rate by $0.10 per-day facility cost.

The experimental data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) as a randomized complete block design with pen serving as the experimental unit and initial weight as the blocking factor. Linear and quadratic contrasts were tested to determine if SID Lys affected the response to TBCC. If the interaction was significant, pairwise comparisons for TBCC within SID Lys were determined to describe the interaction. The main effect of TBCC and linear and quadratic effects of SID Lys were also tested. Hot carcass weight served as a covariate for the analysis of backfat, loin depth, and lean percentage. Results from the experiment were considered significant at $P \leq 0.05$ and considered a tendency between $P > 0.05$ and ≤ 0.10.

Results and Discussion

All diets from each phase were analyzed for Cu (Table 4). Considering the Cu originating from both the trace mineral premix and the ingredients used in formulation, these results are similar to expected values.

During the early finishing period from d 0 to 70, SID Lys affected the response to TBCC (TBCC × Lys linear interaction; $P < 0.05$; Table 5). This was due to the significant increase ($P < 0.05$) in ADG with added Cu from TBCC when pigs were fed 100% of the estimated SID Lys requirement and the lack of Cu response within the 85 or 92.5% SID Lys treatments. As a result, pigs fed added Cu from TBCC and 100% SID Lys tended to have a 5-lb increase in BW by d 70 (TBCC × Lys linear interaction; $P < 0.10$). Similar to ADG, SID Lys tended to affect the ADFI response to TBCC (TBCC × Lys quadratic interaction; $P < 0.10$) because pigs fed added Cu from TBCC and 100% SID Lys had increased ($P < 0.05$) ADFI, whereas pigs in other treatments did not. As expected, F/G improved as SID Lys increased (Lys linear; $P < 0.05$), but added Cu from TBCC had no effect. During the late finishing period from d 70 to 120, neither TBCC nor SID Lys level affected ADG, ADFI, or F/G.

Overall, (d 0 to 120), no TBCC × Lys interactions were detected for growth performance. Adding 150 ppm Cu from TBCC to the diet tended ($P < 0.10$) to increase ADG and improve F/G. This was due to the response in gain and efficiency to TBCC within the 100% SID Lys level. Average daily gain increased and F/G improved as SID Lys increased (linear; $P < 0.01$). These differences also led to an increase in final BW with added Cu from TBCC ($P < 0.05$) and as SID Lys increased (linear; $P < 0.01$). Caloric efficiency on both an ME and NE basis tended to improve when Cu from TBCC was added to the diet ($P < 0.10$) and significantly improved as SID Lys increased ($P < 0.01$).

For carcass characteristics, increasing SID Lys increased ($P < 0.01$) HCW by over 5 lb, or almost 3%, in pigs fed 100% of their estimated SID Lys requirement compared with those fed only 85% (Table 6). The TBCC response for increasing loin depth tended to be influenced by SID Lys (TBCC × Lys linear; $P < 0.10$) because pigs fed 100% SID Lys with added Cu from TBCC tended to have increased ($P < 0.10$) loin depth, whereas pigs not fed supplemental TBCC did not. Standardized ileal digestible Lys also tended to affect percentage lean only when TBCC was included in the diet (TBCC × Lys quadratic; $P < 0.10$), specifically within the 92.5% SID Lys treatment ($P < 0.10$). Evaluating performance on a HCW basis showed that HCW ADG increased and HCW F/G improved ($P < 0.05$) as the SID Lys level increased. Added Cu from TBCC did not affect HCW ADG or F/G.

No interactions were detected between SID Lys and TBCC for any of the calculated economic criteria (Table 7). When values were calculated on a constant days basis, feed cost per pig, cost per pound of gain, and gain value all increased (linear; $P < 0.05$) as SID Lys increased. This resulted in increased (linear; $P < 0.05$) IOFC by $2.19 when pigs were fed 100% of their estimated SID Lys requirement compared with those fed only 85% of the requirement. Value of the weight gained during the experiment (gain value) tended to increase ($P < 0.10$) for those fed diets containing 150 ppm TBCC. When the economics were calculated on a constant weight basis, the adjusted F/G was improved ($P < 0.05$) for pigs fed 150 ppm TBCC because they were heavier at the end of the experiment. Also, similar to the treatment means, adjusted F/G improved (linear; $P < 0.05$) as SID Lys increased. Facility cost tended to be reduced ($P < 0.10$) when pigs were fed diets with TBCC because they would achieve 275 lb quicker. Facility cost decreased (linear; $P < 0.05$) as SID Lys increased. Although statistically not significant, pigs fed added TBCC with 100% SID Lys had an increase in IOFC of $2.54 per pig on a constant days basis and $1.89 per pig on a constant weight basis compared with those fed 100% SID Lys without added Cu.

No interactions were found between TBCC and SID Lys on liver color (Table 8); however, the main effect of TBCC led to a decrease ($P < 0.05$) in a*, suggesting that TBCC decreased the redness of the liver. The a* value also tended ($P < 0.10$) to decrease as SID Lys increased. Furthermore, TBCC tended to decrease ($P < 0.10$) chroma, or the intensity of the liver color. Although these slight differences were statistically significant, these color changes would not be visibly discernable.

Analysis of liver Cu, Fe, and Zn did not result in any TBCC × Lys interactions (Table 9). The main effect of 150 ppm added Cu from TBCC increased ($P < 0.05$) liver Cu concentrations by only 19 ppm. This is consistent with previous research that demonstrated liver Cu concentration increased only when dietary Cu supplementation was greater than 150 ppm (Cromwell et al., 1989[8]). However, liver Zn concentrations tended ($P < 0.10$) to decrease when pigs were fed diets with added Cu from TBCC compared with those not fed TBCC. Liver Cu concentrations tended (quadratic; $P < 0.10$) to increase then decrease, whereas Zn tended to increase as SID Lys increased.

For backfat fatty acid profile, SID Lys × TBCC interactions were observed for gadoleic acid (C20:1) and eicosatrienoic acid (C20:3n-3); however, both these fatty acids represent less than 1% of the fatty acid composition (Table 10). Increasing SID Lys levels influenced ($P < 0.10$) the percentage of heptadecanoic acid (C17:0), α-linoleic acid (C18:3n-3), eicosadienoic acid (C20:2), and other fatty acids, although when the percentages for these fatty acids are combined, they equate to less than 3% of the total fatty acid composition. These small but significant differences did not influence the iodine value (IV) for backfat.

In the jowl, as SID Lys increased in diets containing TBCC, the percentage of steric acid (C18:0) and palmitoleic acid (C16:1) increased (Table 11). These changes caused the percentage of total SFA to decrease and UFA:SFA to increase (TBCC × Lys interaction; linear $P < 0.05$), but PUFA:SFA and jowl IV only tended to increase (TBCC × Lys interaction; linear $P < 0.10$) with increasing SID Lys in diets containing TBCC.

In conclusion, results from this study differed from our initial hypothesis. Based on previous work by Coble et al. (2013), it was expected that TBCC would increase feed intake and allow the pigs fed the lower SID Lys diets to compensate for the deficiency in Lys. This did not occur, even though TBCC tended to increase ADG and improve F/G. Results from this study confirmed that 100% of the estimated SID Lys requirement should be fed to achieve the highest net return when pigs are fed for a constant number of days. Although not statistically significant, pigs fed added TBCC within 100% SID Lys had a numeric increase in IOFC of $2.54 per pig on a constant days basis and $1.89 per pig on a constant weight basis compared with those not fed added Cu from TBCC.

[8] Cromwell, G.L., T.S. Stahly, and H.J. Monegue. 1989. Effects of source and level of copper on performance and liver copper stores in weanling pigs. J. Anim. Sci. 67:2996–3002.

Table 1. Diet composition for Phases 1 and 2 (as-fed basis)[1]

	Phase 1			Phase 2		
SID Lys,[2] %:	85.0	92.5	100.0	85.0	92.5	100.0
Ingredient, %						
Corn	39.42	36.82	34.23	43.31	41.07	38.82
Soybean meal, 46.5% CP	13.02	15.59	18.15	9.42	11.64	13.86
Bakery meal	15.00	15.00	15.00	15.00	15.00	15.00
DDGS[3]	30.00	30.00	30.00	30.00	30.00	30.00
Dicalcium P, 18.5%	---	---	---	0.13	0.13	0.13
Monocalcium P, 21.5%	0.25	0.25	0.25	---	---	---
Limestone	1.25	1.25	1.25	1.15	1.15	1.15
Salt	0.35	0.35	0.35	0.35	0.35	0.35
L-threonine	0.03	0.03	0.03	0.00	0.00	0.00
Lysine sulfate[4]	0.51	0.54	0.57	0.46	0.49	0.52
Phytase[5]	0.01	0.01	0.01	0.01	0.01	0.01
Vitamin premix	0.08	0.08	0.08	0.08	0.08	0.08
Trace mineral premix[6]	0.10	0.10	0.10	0.10	0.10	0.10
Added Cu[7]	---	---	---	---	---	---
Total	100.0	100.0	100.0	100.0	100.0	100.0
Calculated SID Lys requirement[2], %	1.04	1.04	1.04	0.91	0.91	0.91
Calculated analysis						
SID amino acids, %						
Lysine	0.88	0.96	1.04	0.77	0.84	0.91
Isoleucine:lysine	74	72	71	77	75	73
Leucine:lysine	191	181	174	207	197	188
Methionine:lysine	34	33	31	37	35	34
Met & Cys:lysine	63	61	58	69	65	63
Threonine:lysine	65	63	62	64	63	61
Tryptophan:lysine	18.2	18.2	18.2	18.2	18.2	18.2
Valine:lysine	87	84	82	91	88	86
Total lysine, %	1.07	1.16	1.24	0.95	1.03	1.10
ME, kcal, lb	1,536	1,535	1,534	1,541	1,540	1,539
SID lysine:ME, g/Mcal	2.61	2.84	3.08	2.28	2.48	2.68
CP, %	19.9	20.9	22.0	18.5	19.4	20.3
Ca, %	0.59	0.59	0.60	0.53	0.53	0.54
P, %	0.47	0.48	0.49	0.42	0.43	0.44
Available P, %	0.32	0.32	0.33	0.28	0.28	0.29

[1] Phase 1 diets were fed from d 0 to 23 (63.8 to 102.8 lb); Phase 2 diets were fed from d 23 to 38 (102.8 to 132.8 lb).

[2] Standardized ileal digestible lysine values were based on 100% of the estimated SID Lys requirement for these pigs in this environment and production stage.

[3] Dried distillers grains with solubles (Valero, Aurora, SD).

[4] Biolys (Evonik, Inc., Kennesaw, GA).

[5] Optiphos 2000 (Huvepharma, Inc., Peachtree City, GA) provided 1,816,000 phytase units (FTU)/lb, with a release of 0.10% available P.

[6] Trace mineral premix provided 17 ppm Cu in the form of $CuSO_4$ to each diet.

[7] Supplemental copper provided in the form of tri-basic copper chloride (TBCC; Intellibond C; Micronutrients, Inc., Indianapolis, IN) at 150 ppm at the expense of corn.

Table 2. Diet composition for Phases 3 and 4 (as-fed basis)[1]

	Phase 3			Phase 4		
SID Lys,[2] %:	85.0	92.5	100.0	85.0	92.5	100.0
Ingredient, %						
Corn	46.59	44.58	42.57	48.80	46.98	45.17
Soybean meal, 46.5 CP	6.31	8.30	10.28	4.15	5.95	7.74
Bakery meal	15.00	15.00	15.00	15.00	15.00	15.00
DDGS[3]	30.00	30.00	30.00	30.00	30.00	30.00
Limestone	1.15	1.15	1.15	1.13	1.13	1.13
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Lysine sulfate[4]	0.43	0.45	0.47	0.40	0.42	0.44
Phytase[5]	0.01	0.01	0.01	0.01	0.01	0.01
Vitamin premix	0.08	0.08	0.08	0.08	0.08	0.08
Trace mineral premix[6]	0.10	0.10	0.10	0.10	0.10	0.10
Added Cu[7]	---	---	---	---	---	---
Total	100.0	100.0	100.0	100.0	100.0	100.0
Calculated SID Lys requirement[2], %	0.80	0.80	0.80	0.72	0.72	0.72
Calculated analysis						
SID amino acids, %						
Lysine	0.68	0.74	0.80	0.68	0.74	0.80
Isoleucine:lysine	80	78	76	83	81	79
Leucine:lysine	225	213	203	242	229	217
Methionine:lysine	40	38	36	43	41	39
Met & Cys:lysine	74	70	67	79	75	72
Threonine:lysine	67	65	64	70	68	66
Tryptophan:lysine	18.2	18.2	18.2	18.3	18.3	18.3
Valine:lysine	97	93	90	102	98	95
Total lysine, %	0.85	0.92	0.98	0.85	0.92	0.98
ME, kcal, lb	1,544	1,544	1,543	1,546	1,545	1,544
SID lysine:ME, g/Mcal	2.00	2.17	2.35	1.80	1.96	2.12
CP, %	17.2	18.0	18.8	16.4	17.1	17.8
Ca, %	0.49	0.49	0.50	0.47	0.48	0.48
P, %	0.38	0.39	0.40	0.37	0.38	0.39
Available P, %	0.25	0.26	0.26	0.25	0.25	0.26

[1] Phase 3 diets were fed from d 38 to 70 (132.8 lb to 189.9 lb); Phase 4 diets were fed from d 70 to 97 (189.9 to 239.1 lb).
[2] Standardized ileal digestible lysine values were based on 100% of the estimated SID Lys requirement for these pigs in this environment and production stage.
[3] Dried distillers grains with solubles (Valero, Aurora, SD).
[4] Biolys (Evonik, Inc., Kennesaw, GA).
[5] Optiphos 2000 (Huvepharma, Inc, Peachtree City, GA) provided 1,816,000 phytase units (FTU)/lb, with a release of 0.10% available P.
[6] Trace mineral premix provided 17 ppm Cu in the form of $CuSO_4$ to each diet.
[7] Supplemental copper provided in the form of tri-basic copper chloride (TBCC; Intellibond C; Micronutrients, Inc., Indianapolis, IN) at 150 ppm at the expense of corn.

Table 3. Diet composition for Phases 5 (as-fed basis)[1]

	Phase 5		
SID Lys,[2] %:	85.0	92.5	100.0
Ingredient, %			
Corn	41.81	39.39	36.97
Soybean meal, 46.5 CP	11.04	13.40	15.79
Bakery meal	15.00	15.00	15.00
DDGS[3]	30.00	30.00	30.00
Limestone	1.15	1.15	1.15
Salt	0.35	0.35	0.35
L-threonine	0.03	0.03	0.03
Lysine sulfate[4]	0.45	0.48	0.50
Ractopamine HCl,[5] 9 g/ton	0.03	0.03	0.03
Phytase[6]	0.10	0.10	0.10
Vitamin premix	0.08	0.08	0.08
Trace mineral premix[7]	0.10	0.10	0.10
Added Cu[8]	---	---	---
Total	100.0	100.0	100.0

continued

Table 3. Diet composition for Phases 5 (as-fed basis)[1]

	Phase 5		
SID Lys,[2] %:	85.0	92.5	100.0
Calculated SID Lys requirement[2], %	0.65	0.65	0.65
Calculated analysis			
SID amino acids, %			
Lysine	0.81	0.88	0.95
Isoleucine:lysine	77	75	74
Leucine:lysine	203	193	185
Methionine:lysine	36	35	33
Met & Cys:lysine	67	64	62
Threonine:lysine	68	66	65
Tryptophan:lysine	18.6	18.6	18.6
Valine:lysine	91	88	85
Total lysine, %	0.99	1.07	1.14
ME, kcal, lb	1,542	1,541	1,540
SID lysine:ME, g/Mcal	2.38	2.59	2.80
CP, %	19.1	20.1	21.0
Ca, %	0.50	0.51	0.52
P, %	0.41	0.42	0.43
Available P, %	0.26	0.27	0.28

[1] Phase 5 diets were fed from d 97 to 120 (239.1 to 276.6 lb).
[2] Standardized ileal digestible lysine values were based on 100% of the estimated SID Lys requirement for these pigs in this environment and production stage.
[3] Dried distillers grains with solubles (Valero, Aurora, SD).
[4] Biolys (Evonik, Inc., Kennesaw, GA).
[5] Ractopamine HCl (Elanco Animal Health, Inc., Greenfield, IN).
[6] Optiphos 2000 (Huvepharma, Inc, Peachtree City, GA) provided 1,816,000 phytase units (FTU)/lb, with a release of 0.10% available P.
[7] Trace mineral premix provided 17 ppm Cu in the form of $CuSO_4$ to each diet.
[8] Supplemental copper provided in the form of tri-basic copper chloride (TBCC; Intellibond C; Micronutrients, Inc., Indianapolis, IN) at 150 ppm at the expense of corn.

Table 4. Copper analysis of complete diets (ppm, as-fed)[1]

	TBCC,[2] ppm:					
	0			150		
SID Lys,[3] %:	85.0	92.5	100.0	85.0	92.5	100.0
Total Cu, ppm						
Phase 1	45	38	28	217	218	218
Phase 2	34	25	29	188	178	215
Phase 3	30	29	41	182	219	196
Phase 4	42	39	56	222	246	232
Phase 5	34	39	33	187	225	221

[1] Values represent means from one composite sample, analyzed in duplicate.
[2] Tri-basic copper chloride (Intellibond C; Micronutrients, Indianapolis, IN).
[3] Standardized ileal digestible lysine values were based on 100% of the estimated SID Lys requirement for these pigs in this environment and production stage.

Table 5. Effects of standardized ileal digestible lysine (SID Lys) and added copper on growth performance of finishing pigs[1]

	TBCC,[2] ppm							Probability, $P <$				
	0			150				TBCC × Lys			SID Lys	
SID Lys,[3] %:	85.0	92.5	100.0	85.0	92.5	100.0	SEM	Linear	Quadratic	TBCC	Linear	Quadratic
BW, lb												
d 0	63.8	63.8	63.9	63.9	63.8	63.9	2.06	0.896	0.940	0.915	0.930	0.840
d 70	185.6	190.8	190.8	186.3	190.4	195.6	3.31	0.089[7]	0.124	0.089	0.001	0.325
d 120	270.6	276.5	278.1	272.6	277.4	284.4	3.05	0.110	0.169	0.006	0.001	0.636
d 0 to 70[4]												
ADG, lb	1.74	1.80	1.80	1.74	1.81	1.88	0.022	0.034[8]	0.222	0.057	0.001	0.236
ADFI, lb	4.32	4.41	4.35	4.35	4.37	4.49	0.087	0.172	0.095[9]	0.184	0.053	0.765
F/G	2.49	2.44	2.41	2.50	2.42	2.39	0.029	0.398	0.537	0.516	0.001	0.266
d 70 to 120[5]												
ADG, lb	1.79	1.78	1.81	1.80	1.80	1.83	0.027	0.772	0.956	0.514	0.339	0.519
ADFI, lb	5.55	5.54	5.56	5.54	5.51	5.53	0.069	0.897	0.997	0.599	0.979	0.752
F/G	3.11	3.11	3.08	3.09	3.07	3.02	0.040	0.562	0.915	0.121	0.156	0.596
d 0 to 120												
ADG, lb	1.76	1.80	1.80	1.76	1.80	1.86	0.016	0.109	0.414	0.095	0.001	0.740
ADFI, lb	4.82	4.86	4.83	4.82	4.83	4.91	0.070	0.414	0.333	0.654	0.227	0.949
F/G	2.74	2.71	2.68	2.74	2.68	2.64	0.028	0.279	0.838	0.097	0.001	0.542
Caloric efficiency[6]												
ME	4,228	4,170	4,130	4,223	4,127	4,068	42.9	0.278	0.837	0.087	0.001	0.541
NE	3,144	3,087	3,044	3,139	3,055	2,998	31.7	0.276	0.831	0.085	0.001	0.535

[1] A total of 1,248 (PIC 337 × 1050; initial BW 63.8 lb) pigs were used in a 120 d study with 6 treatments and 8 replications per treatment.
[2] Tri-basic copper chloride (Intellibond C; Micronutrients, Indianapolis, IN).
[3] SID Lys values were based on 100% of the estimated SID Lys requirement for these pigs in this environment and production stage.
[4] Phase 1, 2, and 3 diets were fed from d 0 to 70.
[5] Phase 4 and 5 diets were fed from d 70 to 120.
[6] Caloric efficiency is expressed as kcal per pound of live weight gain.
[7] Main effect of TBCC within 100 % SID Lys: $P < 0.007$.
[8] Main effect of TBCC within 100% SID Lys: $P < 0.003$.
[9] Main effect of TBCC within 100% SID Lys: $P < 0.019$.

Table 6. Effects of standardized ileal digestible lysine (SID Lys) and added copper on carcass characteristics of finishing pigs[1]

	TBCC,[2] ppm							Probability, *P* <				
	0			150				TBCC × Lys			SID Lys	
SID Lys,[3] %:	85.0	92.5	100.0	85.0	92.5	100.0	SEM	Linear	Quadratic	TBCC	Linear	Quadratic
Carcass characteristics[4]												
HCW, lb	204.2	208.7	207.9	205.8	208.5	213.2	2.54	0.346	0.290	0.170	0.007	0.619
Farm yield, %	75.45	75.51	74.76	75.47	75.16	74.97	0.464	0.838	0.557	0.921	0.203	0.666
Backfat,[5] in.	0.64	0.66	0.62	0.63	0.64	0.63	0.017	0.745	0.509	0.765	0.553	0.215
Loin depth,[5] in.	2.74	2.71	2.71	2.71	2.74	2.78	0.026	0.068[6]	0.930	0.260	0.340	0.601
Lean,[5] %	57.42	57.31	58.12	57.59	58.04	57.87	0.222	0.342	0.057[7]	0.249	0.040	0.696
Carcass performance												
HCW ADG, lb	1.30	1.34	1.33	1.32	1.34	1.38	0.016	0.321	0.276	0.151	0.006	0.591
HCW F/G	3.70	3.63	3.63	3.67	3.61	3.56	0.051	0.599	0.593	0.141	0.012	0.428

[1] A total of 1,248 (PIC 337 × 1050; initial BW 63.8 lb) pigs were used in a 120-d study with 6 treatments and 8 replications per treatment.
[2] Tri-basic copper chloride (Intellibond C; Micronutrients, Indianapolis, IN).
[3] SID Lys values were based on 100% of the estimated SID Lys requirement for these pigs in this environment and production stage.
[4] 1,069 pigs (19 to 23 pigs/pen) were transported to a commercial packing plant for processing and data collection (Swift and Company, Worthington, MN) and 144 pigs (3 pigs/pen) visually assumed to represent the mean live weight of the pen were subsampled and shipped to a separate processing facility for further carcass measurements (Natural Foods Holdings, Inc., Sioux Center, IA). The weighted average of the two plants were used for HCW, farm yield, and backfat.
[5] HCW was used as a covariate.
[6] Main effect of TBCC within 100% SID Lys: *P* < 0.063.
[7] Main effect of TBCC within 92.5% SID Lys: *P* < 0.062.

Table 7. Effects of standardized ileal digestible lysine (SID Lys) and added copper on economics of finishing pigs[1]

	TBCC,[2] ppm							Probability, *P* <				
	0			150				TBCC × Lys			SID Lys	
SID Lys,[3] %:	85.0	92.5	100.0	85.0	92.5	100.0	SEM	Linear	Quadratic	TBCC	Linear	Quadratic
Constant days												
Feed cost, $/pig	79.20	81.65	83.10	80.00	81.79	84.90	1.180	0.502	0.372	0.136	0.001	0.900
$/lb gain	0.376	0.379	0.384	0.379	0.378	0.381	0.004	0.188	0.888	0.879	0.029	0.537
Gain value,[4] $/pig	142.34	146.38	147.43	143.68	147.06	151.77	1.412	0.296	0.383	0.074	0.001	0.740
IOFC,[5] $/pig	63.14	64.73	64.33	63.68	65.26	66.87	0.991	0.302	0.545	0.131	0.028	0.558
Constant weight[6]												
Adjusted F/G[7]	2.76	2.70	2.66	2.75	2.67	2.59	0.023	0.192	0.794	0.037	0.001	0.543
Feed cost, $/pig	79.65	79.47	80.26	79.86	79.15	78.73	0.678	0.187	0.764	0.309	0.686	0.578
Feed cost, $/lb gain	0.377	0.376	0.380	0.378	0.375	0.373	0.003	0.187	0.764	0.309	0.686	0.578
Gain value,[4] $/pig	145.37	145.37	145.37	145.37	145.37	145.37	---	---	---	---	---	---
IOFC,[5] $/pig	65.72	65.90	65.11	65.51	66.22	66.64	0.678	0.187	0.764	0.309	0.686	0.578
Facility cost,[8] $/pig	12.24	11.91	11.84	12.12	11.87	11.48	0.188	0.312	0.306	0.075	0.001	0.758
IOFFC,[9] $/pig	53.48	53.99	53.27	53.39	54.35	55.16	0.712	0.173	0.660	0.225	0.278	0.578

[1] A total of 1,248 (PIC 337 ×1050; initial BW 63.8 lb) pigs were used in a 120-d study with 6 treatments and 8 replications per treatment.
[2] Tri-basic copper chloride (Intellibond C; Micronutrients, Indianapolis, IN).
[3] SID Lys values were based on 100% of the estimated SID Lys requirement for these pigs in this environment and production stage.
[4] Gain value calculated using (final wt. x $68.83/cwt) – (initial wt. × $68.83/cwt).
[5] Income over feed cost = carcass gain value – feed cost.
[6] Adjusted to constant final weight of 275 lb.
[7] Adjusted using a factor of 0.005 for 1 lb change in live weight.
[8] Facility cost at $0.10/hd/day.
[9] Income over feed and facility cost = IOFC – facility cost.

Table 8. Effects of standardized ileal digestible lysine (SID Lys) and added copper on liver color of finishing pigs[1]

	TBCC,[2] ppm							Probability, *P* <				
	0			150				TBCC × Lys			SID Lys	
SID Lys,[3] %:	85.0	92.5	100.0	85.0	92.5	100.0	SEM	Linear	Quadratic	TBCC	Linear	Quadratic
Liver color												
L*[4]	32.55	31.18	32.24	31.48	31.05	32.08	0.594	0.431	0.888	0.160	0.800	0.191
a*[5]	14.86	15.01	14.71	14.77	14.09	13.71	0.359	0.206	0.537	0.027	0.097	0.912
b*[6]	6.42	5.59	6.19	6.75	5.61	5.68	0.461	0.357	0.271	0.303	0.163	0.695
Hue Angle,[7] °	0.399	0.409	0.389	0.424	0.370	0.379	0.199	0.376	0.186	0.647	0.170	0.639
Chroma[8]	16.24	16.43	16.02	16.28	15.23	14.98	0.488	0.266	0.404	0.071	0.125	0.908

[1] 144 pigs (PIC 337 ×1050) were used (3 pigs/pen) to determine liver color scores in a 120-d study with 6 treatments and 8 replications per treatment.
[2] Tri-basic copper chloride (Intellibond C; Micronutrients, Indianapolis, IN).
[3] SID Lys values were based on 100% of the estimated SID Lys requirement for these pigs in this environment and production stage.
[4] L*, 0 = black, 100 = white.
[5] a* – values = green; + values = red.
[6] b* – values = blue; + values = yellow.
[7] Hue angle = $\tan^{-1}(b^*/a^*)$.
[8] Chroma = $(\sqrt{a^*} + b^*) / L^*$.

Table 9. Effects of standardized ileal digestible lysine (SID Lys) and added copper on liver mineral concentrations (DM basis) of finishing pigs[1]

	TBCC,[2] ppm							Probability, *P* <				
	0			150				TBCC × Lys			SID Lys	
SID Lys,[3] %:	100.0	92.5	85.0	100.0	92.5	85.0	SEM	Linear	Quadratic	TBCC	Linear	Quadratic
Cu, ppm	12	13	13	26	39	33	3.27	0.393	0.105	0.001	0.182	0.092
Fe, ppm	211	221	196	205	203	200	11.43	0.654	0.368	0.437	0.344	0.322
Zn, ppm	59	59	62	55	57	59	2.29	0.566	0.806	0.095	0.099	0.841

[1] 144 pigs (PIC 337 ×1050) were used (3 pigs/pen) to determine liver mineral concentrations in a 120-d study with 6 treatments and 8 replications per treatment.
[2] Tri-basic copper chloride (Intellibond C; Micronutrients, Indianapolis, IN).
[3] SID Lys values were based on 100% of the estimated SID Lys requirement for these pigs in this environment and production stage.

Table 10. Effects of standardized ileal digestible lysine (SID Lys) and added copper on backfat fatty acid analysis (DM basis) of finishing pigs[1]

	TBCC,[2] ppm							Probability, $P <$				
	0			150				TBCC × Lys			SID Lys	
SID Lys,[3] %:	85.0	92.5	100.0	85.0	92.5	100.0	SEM	Linear	Quad.	TBCC	Linear	Quad.
Myristic acid (C14:0). %	1.11	1.14	1.13	1.12	1.14	1.09	0.027	0.419	0.664	0.597	0.909	0.277
Palmitic acid (C16:0), %	19.82	20.22	20.07	19.75	19.80	19.63	0.262	0.469	0.725	0.145	0.797	0.382
Palmitoleic acid (C16:1), %	1.88	1.91	1.87	1.83	1.95	1.87	0.071	0.731	0.597	0.880	0.842	0.280
Heptadecanoic acid (C17:0), %	0.41	0.41	0.47	0.40	0.40	0.47	0.021	0.786	0.953	0.486	0.004	0.089
Stearic acid (C18:0), %	9.97	10.37	10.17	10.38	10.05	10.17	0.266	0.455	0.272	0.896	0.975	0.859
Oleic acid (C18:1 *cis*-9), %	37.25	36.57	36.46	36.82	37.20	36.19	0.420	0.851	0.190	0.946	0.101	0.574
Linoleic acid (C18:2n-6), %	25.70	25.54	25.87	25.99	25.56	26.58	0.618	0.738	0.658	0.508	0.545	0.374
α-linoleic acid (C18:3n-3), %	0.92	0.93	0.94	0.93	0.95	0.98	0.021	0.402	0.688	0.235	0.098	0.945
γ-linoleic acid (C18:3n-6), %	0.10	0.10	0.10	0.10	0.11	0.10	0.007	0.630	0.593	0.617	0.448	0.822
Conjugated linoleic acid (*c*9, *t*11), %	0.14	0.14	0.12	0.15	0.16	0.14	0.009	0.539	0.870	0.064	0.224	0.113
Arachidic acid (C20:0), %	0.17	0.18	0.17	0.16	0.17	0.18	0.007	0.163	0.726	0.642	0.141	0.544
Gadoleic acid (C20:1), %	0.72	0.71	0.79	0.67	0.72	0.74	0.016	0.887	0.028[11]	0.018	0.001	0.302
Eicosadienoic acid (C20:2), %	0.94	0.95	1.01	0.93	0.96	1.01	0.026	0.803	0.647	0.845	0.005	0.487
Eicosatrienoic acid (C20:3n-3), %	0.12	0.12	0.11	0.11	0.12	0.12	0.005	0.054[10]	0.589	0.683	0.213	0.681
Dihomo-γ-linoleic acid (C20:3n-6), %	0.12	0.13	0.12	0.11	0.12	0.13	0.005	0.255	0.749	0.589	0.143	0.358
Arachidonic acid (C20:4n-6), %	0.34	0.31	0.30	0.33	0.32	0.33	0.015	0.100	0.837	0.510	0.100	0.711
Other fatty acids, %	0.28	0.27	0.29	0.26	0.27	0.29	0.010	0.303	0.224	0.309	0.081	0.309
Total SFA,[4] %	31.49	32.31	32.01	31.79	31.57	31.53	0.474	0.405	0.422	0.427	0.786	0.566
Total MUFA,[5] %	39.85	39.20	39.13	39.32	39.87	38.80	0.472	0.823	0.187	0.869	0.198	0.531
Total PUFA,[6] %	28.37	28.22	28.57	28.63	28.29	29.38	0.671	0.684	0.691	0.494	0.484	0.410
UFA:SFA ratio[7]	2.18	2.09	2.14	2.15	2.18	2.17	0.047	0.461	0.323	0.465	0.810	0.561
PUFA:SFA ratio[8]	0.91	0.88	0.91	0.91	0.90	0.94	0.032	0.592	0.829	0.494	0.651	0.394
Iodine value,[9] g/100 g	82.63	81.75	82.21	82.64	82.44	83.36	0.901	0.530	0.942	0.406	0.869	0.433

[1] 144 pigs (PIC 337 ×1050) were used (3 pigs/pen) to determine fatty acid concentrations in a 120-d study with 6 treatments and 8 replications per treatment.
[2] Tri-basic copper chloride (Intellibond C; Micronutrients, Indianapolis, IN).
[3] SID Lys values were based on 100% of the estimated SID Lys requirement for these pigs in this environment and production stage.
[4] Total SFA = ([C14:0] + [C16:0] + [C17:0] + [C18:0] + [C20:0]); brackets indicate concentration.
[5] Total MUFA = ([C16:1] + [C18:1*cis*-9] + [C20:1]); brackets indicate concentration.
[6] Total PUFA = ([C18:2n-6] + [C18:3n-3] + [C18:3n-6] + [*c*9,*t*11] + [C20:2] + [C20:3n-3] + [C20:3n-6] + [C20:4n-6]); brackets indicate concentration.
[7] UFA:SFA = (total MUFA+PUFA)/ total SFA.
[8] PUFA:SFA = total PUFA/ total SFA.
[9] Calculated as IV = [C16:1] × 0.950 + [C18:1] × 0.860 + [C18:2] × 1.732 + [C18:3] × 2.616 + [C20:1] × 0.785 + [C20:4] × 3.201 + [C22:1] × 0.723 + [C22:5] × 3.697 + [C22:6] × 4.463; brackets indicate concentration.
[10] Main effect of TBCC within 100% SID Lys: $P < 0.030$; within 85% SID Lys: $P < 0.012$.
[11] Main effect of TBCC within 100% SID Lys: $P < 0.070$.

Table 11. Effects of standardized ileal digestible (SID) lysine and added copper on jowl fatty acid analysis (DM Basis) of finishing pigs[1]

	TBCC,[2] ppm							Probability, P <				
	0			150				TBCC × Lys			SID Lys	
SID Lys, [3]%:	85.0	92.5	100.0	85.0	92.5	100.0	SEM	Linear	Quad.	TBCC	Linear	Quad.
Myristic acid (C14:0). %	1.10	1.16	1.19	1.12	1.16	1.14	0.032	0.305	0.803	0.687	0.092	0.446
Palmitic acid (C16:0), %	18.63	18.22	19.00	19.00	18.80	18.51	0.377	0.218	0.282	0.573	0.858	0.358
Palmitoleic acid (C16:1), %	2.52	2.35	2.64	2.39	2.66	2.59	0.116	0.678	0.032[10]	0.628	0.129	0.744
Heptadecanoic acid (C17:0), %	0.41	0.44	0.43	0.40	0.41	0.42	0.026	0.924	0.760	0.446	0.496	0.733
Stearic acid (C18:0), %	8.07	8.55	8.10	8.91	7.95	7.67	0.289	0.024[11]	0.092	0.781	0.030	0.795
Oleic acid (C18:1 *cis*-9), %	40.70	40.07	40.23	40.19	40.98	39.98	0.568	0.811	0.174	0.911	0.537	0.605
Linoleic acid (C18:2n-6), %	24.52	25.12	24.34	24.08	24.01	25.45	0.630	0.211	0.176	0.776	0.332	0.950
α-linoleic acid (C18:3n-3), %	0.89	0.94	0.90	0.87	0.89	0.96	0.025	0.123	0.086[12]	0.946	0.044	0.771
γ-linoleic acid (C18:3n-6), %	0.10	0.10	0.10	0.09	0.09	0.10	0.005	0.660	0.774	0.100	0.515	0.907
Conjugated linoleic acid (*c*9, *t*11), %	0.16	0.15	0.14	0.16	0.17	0.18	0.008	0.047[13]	0.701	0.013	0.952	0.580
Arachidic acid (C20:0), %	0.13	0.14	0.13	0.13	0.14	0.14	0.006	0.878	0.266	0.882	0.746	0.156
Gadoleic acid (C20:1), %	0.80	0.78	0.80	0.76	0.80	0.80	0.019	0.245	0.281	0.692	0.261	0.974
Eicosadienoic acid (C20:2), %	1.02	1.04	1.03	1.00	1.02	1.08	0.026	0.178	0.463	0.891	0.109	0.798
Eicosatrienoic acid (C20:3n-3), %	0.13	0.13	0.13	0.12	0.13	0.14	0.005	0.154	0.450	0.443	0.152	0.704
Dihomo-γ-linoleic acid (C20:3n-6), %	0.13	0.15	0.14	0.12	0.14	0.14	0.005	0.492	0.637	0.090	0.017	0.259
Arachidonic acid (C20:4n-6), %	0.36	0.35	0.35	0.34	0.34	0.37	0.012	0.196	0.505	0.492	0.409	0.247
Other fatty acids, %	0.34	0.34	0.36	0.30	0.32	0.34	0.014	0.451	0.789	0.043	0.049	0.846
Total SFA,[4] %	28.35	28.49	28.85	29.56	28.45	27.87	0.501	0.019[14]	0.837	0.854	0.191	0.635
Total MUFA,[5] %	44.02	43.20	43.67	43.34	44.44	43.38	0.644	0.752	0.109	0.864	0.803	0.687
Total PUFA,[6] %	27.30	27.97	27.13	26.79	26.78	28.41	0.687	0.188	0.175	0.800	0.285	0.951
UFA:SFA ratio[7]	2.54	2.54	2.47	2.40	2.52	2.59	0.066	0.032[15]	0.941	0.756	0.294	0.562
PUFA:SFA ratio[8]	0.97	1.00	0.95	0.91	0.95	1.03	0.037	0.073[16]	0.339	0.672	0.233	0.835
Iodine value,[9] g/100 g	84.20	84.62	83.61	82.73	83.61	85.48	0.861	0.052[17]	0.402	0.769	0.202	0.882

[1] 144 pigs (PIC 337 x 1050) were used (3 pigs/pen) to determine fatty acid concentrations in a 120-d study with 6 treatments and 8 replications per treatment.
[2] Tri-basic copper chloride (Intellibond C; Micronutrients, Indianapolis, IN).
[3] SID Lys values were based on 100% of the estimated SID Lys requirement for these pigs in this environment and production stage.
[4] Total SFA = ([C14:0] + [C16:0] + [C17:0] + [C18:0] + [C20:0]); brackets indicate concentration.
[5] Total MUFA = ([C16:1] + [C18:1*cis*-9] + [C20:1]); brackets indicate concentration.
[6] Total PUFA = ([C18:2n-6] + [C18:3n-3] + [C18:3n-6] + [*c*9, *t*11] + [C20:2] + [C20:3n-3] + [C20:3n-6] + [C20:4n-6]); brackets indicate concentration.
[7] UFA:SFA = (total MUFA+PUFA)/total SFA.
[8] PUFA:SFA = total PUFA/total SFA.
[9] Calculated as IV = [C16:1] × 0.950 + [C18:1] × 0.860 + [C18:2] × 1.732 + [C18:3] × 2.616 + [C20:1] × 0.785 + [C20:4] × 3.201 + [C22:1] × 0.723 + [C22:5] × 3.697 + [C22:6] × 4.463; brackets indicate concentration.
[10] Main effect of TBCC within 92.5% SID Lys: $P < 0.042$.
[11] Main effect of TBCC within 85% SID Lys: $P < 0.031$.
[12] Main effect of TBCC within 100% SID Lys: $P < 0.07$.
[13] Main effect of TBCC within 100% SID Lys: $P < 0.004$.
[14] Main effect of TBCC within 85% SID Lys: $P < 0.059$.
[15] Main effect of TBCC within 85% SID Lys: $P < 0.089$.
[16] Main effect of TBCC within 100% SID Lys: $P < 0.160$.
[17] Main effect of TBCC within 100% SID Lys: $P < 0.125$.