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Dietary Supplementation of Choline or Potassium in Low Crude Protein Diets on Growth and Carcass Performance of Finishing Pigs from 245 to 295 lb

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Summary

A total of 284 pigs (DNA 600 × 241, initially 247.4 lb) were used in a 26-d trial to determine the effect of added choline or potassium on growth and carcass performance of finishing pigs fed low CP diets. Pens of 7 or 8 pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments with 9 replications per treatment. Experimental treatments included a 12% CP, positive control diet with 10.6% SBM; a 10% CP, negative control diet with 4.0% SBM; the negative control with added choline; or potassium such that the added choline or potassium matched the amount that was provided in the 12% CP diet. At d 26, pigs were transported to a packing plant for processing and carcass data collection. For overall growth performance, there was no evidence for differences in ADG or ADFI; however, there was a marginal improvement ($P < 0.10$) in F/G for pigs fed the positive control diet with 12% CP compared with the mean of pigs fed the diets with 10% CP. Adding choline or potassium to the diet did not influence performance. For carcass characteristics, there was no evidence for differences in HCW, yield, backfat, loin depth, or lean percentage. In summary, marginally poorer F/G observed in pigs fed the 10% CP diet with 4.0% SBM was not influenced by supplementation with choline or potassium.

Introduction

Studies with finishing pigs have shown that decreasing dietary protein may compromise pig growth and decrease carcass leanness.[2,3] The current body of literature has suggested that there are several possible explanations for these effects. These include the possible

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

[2] Tous, N., R. Lizardo, B. Vila, M. Gispert, M. Font-i-Furnols and E. Estevez-Garcia. 2014. Effects of reducing dietary protein and lysine on growth performance, carcass characteristics, intramuscular fat, and fatty-acid profile of finishing barrows. J. Anim. Sci. 92:129-140.

[3] J. A. Soto, M. D. Tokach, S. S. Dritz, J. C. Woodworth, J. M. DeRouchey and R. D. Goodband. 2017. Effects of dietary electrolyte balance and crude protein on growth performance and carcass characteristics of finishing pigs from 110 to 130 kilograms. J. Anim. Sci. 2017 95: supplement 2: 133-134. doi:10.2527/asasmw.2017.277.

underestimation of the concentration of NE in soybean meal (SBM) by the NRC[4] or a deficiency of non-essential amino acids or other nutrients not provided in low CP diets.[5,6,7] Furthermore, to determine whether the reduced performance with the low CP diets was due to the lower CP itself or lower concentration of SBM, Soto[8] et al. conducted a trial with varying SBM concentrations and CP fixed at 12% and showed that performance worsened as SBM concentration was reduced. This suggests that SBM concentration could represent one of the reasons for the lower performance in finishing swine fed low CP diets, also suggesting that the reduced performance is due to something other than CP concentration. By reducing the amount of SBM in the diet, there is an important reduction of dietary choline and potassium, among other nutrients.

Choline is involved in phospholipid synthesis, acetyl choline formation, and plays a role as a methyl donor. According to the NRC,[4] the requirements for choline is 137 mg/lb for finishing pigs. Potassium is involved in electrolyte balance and neuromuscular function, and plays a role in the Na-K pump, which impacts the absorption of many nutrients. According to the NRC,[4] the requirement for potassium is 0.17% for finishing pigs. Although the concentration of choline and potassium are well above the NRC[4] requirement estimates in a diet with low amounts of SBM, there is a 17 and 25% reduction in dietary choline and potassium, respectively, when SBM is reduced from 10.6 to 4.0%. Therefore, the objective of the present study is to determine the effect of added choline or potassium in low CP diets on growth performance and carcass characteristics of finishing pigs from 245 to 295 lb.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. This study was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. The facility was totally enclosed and environmentally regulated, containing 36 pens. Each pen was equipped with a dry, single-sided feeder (Farmweld, Teutopolis, IL) and a 1-cup waterer. Pens were located over a completely slatted concrete floor with a 4-ft pit underneath for manure storage. Pigs were stocked at a floor space of 7.83 ft^2 per pig. Pens were equipped with adjustable gates to allow space allowances per pig to be maintained if a pig died or was removed from a pen during the experiment. A robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) was used to deliver and record daily feed additions to each individual pen.

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[4] NRC. 2012. Nutrient Requirements of Swine. 11th ed. Natl. Acad. Press, Washington, DC.

[5] Rojo, A. 2011. Evaluation of the effects of branched chain amino acids and corn-distillers dried grains by-products on the growth performance, carcass, and meat quality characteristics of pigs. PhD diss., University of Illinois. Urbana-Champaign, IL.

[6] Ball M., E. Magowan, K. McCracken, V. Beattie, R. Bradford, F. Gordon, M. Robinson, S. Smyth and W. Henry. 2013. The effect of level of crude protein and available lysine on finishing pig performance, nitrogen balance and nutrient digestibility. Asian-Aust. J. Anim. Sci. 26(4):564-572.

[7] Sotak-Peper, K.M., J.C. Gonzalez-Vega and H.H. Stein. 2015. Concentrations of digestible, metabolizable, and net energy in soybean meal produced in different areas of the United States and fed to pigs. J. Anim. Sci. 93:5694-5701.

[8] J. A. Soto, M. D. Tokach, S. S. Dritz, J. C. Woodworth, J. M. DeRouchey and R. D. Goodband. 2017. Effects of dietary soybean meal concentration with dietary crude protein fixed at 12% on growth performance of finishing pigs from 250 to 300 lb. *Kansas Agricultural Experiment Station Research Reports*: Vol. 3: Iss. 7.

A total of 284 pigs (DNA 600 × 241, initially 247.4 lb) were used in a 26-d trial. There were 7 or 8 mixed-gender pigs that were allotted by BW to pens. Pens were randomly assigned within weight blocks in a completely randomized block design with 9 replications per treatment. Experimental treatments included a 12% CP positive control diet with 10.6% SBM; a 10% CP, negative control diet with 4.0% SBM; the negative control with added choline; or potassium to equal their amounts provided by the 12% CP diet.

To create the experimental diets, a 12% CP corn-soybean meal diet with an inclusion of 10.6% SBM with 0.13% L-Lys HCl was formulated. Then, a negative control, 10% CP corn-soybean meal diet with 4.0% inclusion of SBM with 0.33% L-Lys HCl was formulated. Lastly, the negative control diet was supplemented with 0.03% choline chloride or 0.24% potassium chloride so the level of choline or potassium matched that in the 12% CP diet. In all these diets, ratios of other AA to Lys were maintained well above minimum levels to ensure that other AA were not limiting (Table 1). All diets contained 1,206 kcal NE by adjusting fat level as the amounts of corn and SBM changed in the diet.

Pigs were weighed on d 0, 14, 21, and 26 to determine ADG, ADFI, and F/G. At d 26, pigs were individually ear tagged with a unique radio frequency identification (RFID) number to allow for carcass measurements to be recorded on a pig basis. On d 26, final pen weights and individual weights were taken, and pigs were transported to a commercial packing plant (Triumph St. Joseph, MO) for processing and determination of carcass characteristics. Due to numerous RFID tags dislodged and lost during the dehairer process, the recovery of carcass data from the processing plant was 65, 59, 49, and 65% for positive control, negative control, choline supplement, and potassium supplementation diets, respectively.

Diet samples from each dietary phase were taken from 6 feeders per dietary treatment 3 d after the beginning and 3 d before the end of each dietary phase and stored at -20°C until they were homogenized, subsampled, and submitted to Cumberland Valley Analytical Service (Hagerstown, MD) for analysis of DM, CP, Ca, P, K, ether extract, and ash. In addition, samples of the diets were submitted to Barrow-Agee (Memphis, TN) for choline analysis.

Data were analyzed using the GLIMMIX procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC) in a randomized complete block design with pen serving as the experimental unit and initial BW serving as the blocking factor. Dietary treatments were the fixed effect and block served as the random effect in the analysis. Random effects of block and treatment × block was included in the model for growth performance and carcass characteristics response variables, respectively. 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 $P < 0.05$ and a marginally significant between $P > 0.05$ and $P \leq 0.10$.

Results

The analyzed total DM, CP, Ca, P, ether extract, ash, and K contents of experimental diets were reasonably consistent with formulated estimates (Table 2). The analyzed levels for choline were lower than formulated values, suggesting that either the corn

or soybean meal contained less choline than NRC[4] suggested levels. However, choline increased in the choline supplement diet and was similar to the analyzed value in the positive control diet.

For overall growth performance (d 0 to 26), there was no evidence for differences in ADG or ADFI for pigs fed the positive control diet with 12% CP and 10.6% SBM compared with pigs fed the diets containing 10% CP and 4% SBM. However, there was a marginal improvement ($P < 0.10$) in F/G for pigs fed the positive control diet with 12% CP and 10.6% SBM compared with the mean of pigs fed the diets with 10% CP and 4.0% SBM. Adding choline or potassium to the negative control diet did not influence pig performance. For carcass characteristics, there was no evidence for differences in HCW, yield, backfat, loin depth, or lean percentage.

In conclusion, marginally poorer F/G observed in pigs fed the 10% CP and 4.0% SBM diets was not influenced by choline or potassium supplemented to meet the amounts contained in the 12% CP diet. These results are consistent with the finding of Soto et al.,[8] where, pigs fed a diet with 12% CP and 10.6% SBM had improved F/G, compared with pigs fed 10% CP and 4.0% SBM. These results suggest that the reduced concentration of potassium and choline in late finishing diets with low SBM and CP concentrations do not appear to be the reason for the poorer F/G.

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

	CP, %			
	12	10		
Ingredient, %	PC	NC	Choline[2]	Potassium[3]
Corn	84.89	91.76	91.73	91.40
Soybean meal (46.5% CP)	10.63	4.00	4.01	4.03
Choice white grease	2.25	1.35	1.35	1.45
Monocalcium P (21% P)	0.52	0.56	0.56	0.56
Limestone	0.98	1.05	1.05	1.05
Salt	0.35	0.35	0.35	0.35
L-Lys-HCl	0.13	0.33	0.33	0.33
DL-Met	0.06	0.11	0.11	0.11
L-Thr	0.01	0.10	0.10	0.10
L-Trp	0.01	0.04	0.04	0.04
L-Val	---	0.06	0.06	0.06
L-Ile	---	0.11	0.11	0.11
Choline chloride	---	---	0.03	---
Potassium chloride	---	---	---	0.24
Vitamin and trace mineral premix	0.18	0.18	0.18	0.18
Phytase[4]	0.02	0.02	0.02	0.02
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Standardized ileal digestible (SID) AA, %				
Lys	0.55	0.55	0.55	0.55
Ile:Lys	75	75	75	75
Leu:Lys	191	164	164	164
Met:Lys	47	51	51	51
Met and Cys:Lys	86	86	86	86
Thr:Lys	67	67	67	67
Trp:Lys	21	21	21	21
Val:Lys	88	80	80	80
SID Lys: NE, g/Mcal	2.07	2.07	2.07	2.07
NE NRC, kcal/lb	1,206	1,206	1,206	1,206
CP, %	12.0	10.0	10.0	10.0
Ca, %	0.53	0.53	0.53	0.53
P, %	0.43	0.41	0.41	0.41
Available P, %	0.26	0.26	0.26	0.26
Standardized digestible P, %	0.30	0.29	0.29	0.29

[1] Diets were fed from 245 to 295 lb.

[2] Choline: choline supplemented diet (0.03% choline chloride).

[3] Potassium: potassium supplemented diet (0.24% potassium chloride).

[4] Ronozyme Hiphos (GT) 2700 (DSM Nutritional Products, Inc, Parsippany, NJ). Provided 181.8 phytase units (FYT) per lb of diet, with a release of 0.10% available P.

Table 2. Chemical analysis of experimental diets (as-fed basis)[1]

	CP, %			
	12	10		
Item	PC	NC	Choline[2]	Potassium[3]
DM, %	87.5	86.8	86.4	88.3
CP, %	12.7	10.3	10.3	10.5
Ca, %	0.67	0.75	0.68	0.66
P, %	0.38	0.38	0.35	0.38
Ether extract, %	4.7	4.7	4.1	4.0
Ash, %	3.3	2.8	4.2	4.4
K, %	0.55 (0.51)[4]	0.42 (0.39)	0.42 (0.39)	0.54 (0.51)
Choline, mg/lb	235 (370)	206 (307)	232 (370)	209 (307)

[1] Diet samples were taken from 6 feeders per dietary treatment 3 d after the beginning of the trial and 3 d prior to the end of the trial and stored at -20°C until analysis. Samples of the diets were submitted to Cumberland Valley Analytical Service (Hagerstown, MD) for analysis of DM, CP, Ca, P, ether extract, ash, and K. Samples of the diets were submitted to Barrow-Agee (Memphis, TN) for analysis of choline.

[2] Choline: choline supplemented diet (0.03% choline chloride).

[3] Potassium: potassium supplemented diet (0.24% potassium chloride).

[4] Values in parentheses indicate those calculated from diet formulation and are based on values from NRC, 2012 (Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington DC).

Table 3. Evaluation of dietary supplementation of choline or potassium chloride in low crude protein diets on growth performance and carcass characteristics of finishing pigs from 245 to 295 lb[1]

	CP, %					
	12	10				Probability, *P*<
	PC	NC	Choline[2]	Potassium[3]	SEM	12 vs. 10% CP[4]
BW, lb						
d 0	247.4	247.4	247.4	247.4	1.97	0.921
d 26	296.8	294.2	294.3	294.4	2.05	0.600
d 0 to 26						
ADG, lb	1.86	1.80	1.80	1.81	0.056	0.735
ADFI, lb	6.25	6.45	6.55	6.46	0.141	0.314
F/G	3.36	3.59	3.65	3.58	0.067	0.085
Carcass characteristics[5]						
HCW, lb	222.6	222.0	219.0	220.2	1.76	0.101
Carcass yield, %	74.4	74.9	74.1	74.3	0.31	0.289
Backfat, in.[6]	0.73	0.68	0.68	0.69	0.029	0.840
Loin depth, in.[6]	2.21	2.21	2.24	2.28	0.068	0.929
Lean, %[6]	52.0	52.3	52.7	52.4	0.52	0.896

[1] A total of 284 pigs (DNA 600 × 241; initially 246.4 lb) were used in a 26-d experiment with 7 or 8 pigs per pen and 9 replications per treatment.

[2] Choline: choline supplemented diet (0.03% choline chloride).

[3] Potassium: potassium supplemented diet (0.24% potassium chloride).

[4] Contrast to compare the positive control diet with 12% CP to the three diets with 10% CP. No evidence for differences were found due to choline or potassium supplementation.

[5] Recovery of carcass data from the processing plant was 65, 59, 49, and 65% for positive control, negative control, choline supplementation, and potassium supplementation treatment, respectively.

[6] Adjusted using HCW as a covariate.