

## Effect of Supplementation of Choline in Moderate and Low Crude Protein Diets on Growth Performance of Finishing Pigs from 245 to 275 lb

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### Summary

A total of 254 pigs (DNA 600 × 241, initially 247.4 lb) was used in a 19-d trial to determine the effects of added choline on growth performance of finishing pigs fed moderate and low CP diets. Pens of 7 or 8 pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments with 8 replications per treatment. Experimental treatments were arranged in a 2 × 2 factorial with main effects of CP (12 or 10%) and choline (none or added) to reach a final diet concentration of chloride of 823 mg/lb of diet. For overall growth performance, there was no evidence for CP × choline interaction or choline effect. Pigs fed diets with 12% CP had marginally increased ( $P = 0.076$ ) ADG compared with pigs fed diets with 10% CP, which resulted in a heavier ( $P = 0.036$ ) final BW. Pigs fed the diets with 12% CP also had improved ( $P = 0.020$ ) F/G compared with pigs fed the 10% CP diets. In conclusion, supplementing diets with a high concentration of choline did not influence growth performance of pigs fed moderate or low CP diets.

### Introduction

Studies with finishing pigs have shown that decreasing dietary protein may compromise pig growth and decrease carcass leanness.<sup>2,3</sup> The current body of literature has suggested that there are several possible explanations for these effects. These include the possible underestimation of the concentration of NE in soybean meal (SBM) by the NRC<sup>4</sup> or deficiency of non-essential amino acids or other nutrients not provided in low CP

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<sup>2</sup> 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.

<sup>3</sup> 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.

<sup>4</sup> NRC. 2012. Nutrient Requirements of Swine. 11th ed. Natl. Acad. Press, Washington, DC.

diets.<sup>5,6,7</sup> In addition, Soto<sup>8</sup> et al. suggested that lower SBM concentration could represent one of the reasons for poorer growth performance in finishing swine fed low CP diets.

By reducing the amount of SBM in the diet, there is an important reduction of dietary choline, among other nutrients. Choline is involved in phospholipid synthesis, acetyl choline formation, and plays a role as a methyl donor. According to the NRC,<sup>4</sup> the requirements for choline is 137 mg/lb for finishing pigs. Although the concentration of choline is well above the NRC<sup>4</sup> in a diet with low amounts of SBM, there is a 17% reduction in dietary choline when SBM is reduced from 10.6 to 4.0%. Furthermore, Soto<sup>9</sup> et al. conducted a trial supplementing choline or potassium in low CP diets in finishing pigs, and showed that lower performance was not influenced by supplementation with choline or potassium. In this trial, diets were supplemented with only 0.03% choline chloride, matching the amount of choline provided in a 10.6% SBM diet. Taking into consideration the significance of the processes involving choline, the objective of the present study is to determine the effect of high choline chloride supplementation in moderate and low CP diets on growth performance and carcass characteristics of finishing pigs from 240 to 280 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 K-State 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<sup>2</sup> 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.

<sup>5</sup> 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.

<sup>6</sup> 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.

<sup>7</sup> 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.

<sup>8</sup> 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.*

<sup>9</sup> J. A. Soto, M. D. Tokach, S. S. Dritz, J. C. Woodworth, J. M. DeRouchey and R. D. Goodband. 2017. Dietary supplementation of choline or potassium in low crude protein diets on growth and carcass performance of finishing pigs from 245 to 295 lb. *Kansas Agricultural Experiment Station Research Reports: Vol. 3: Iss. 7.*

A total of 254 pigs (DNA 600 × 241, initially 247.4 lb) were used in a 19-d trial. There were 7 or 8 pigs per pen, with a similar number of barrows and gilts in each pen. Pens were randomly assigned within weight blocks in a completely randomized block design with 8 replications per treatment. Experimental treatments were arranged in a 2 × 2 factorial with main effects of CP (12% or 10%) and choline (none or added to reach a total of 823 mg/lb of diet).

To create the experimental diets, a 12% CP corn-soybean meal diet with an inclusion of 10.6% SBM and 0.13% L-Lys HCl was formulated. Then, a 10% CP corn-soybean meal diet with 4.0% inclusion of SBM and 0.33% L-Lys HCl was formulated. Then the high and low CP diets were supplemented with 0.20 or 0.23% choline chloride, respectively, to provide a total of 823 mg of choline per lb in the final diet. The 12% CP diet contained a basal level of choline that was approximately 2.7 times the NRC requirement. The supplemental choline increased the concentration to approximately 6.0 times the choline requirement estimate for finishing pigs suggested by NRC.<sup>4</sup> In all diets, ratios of AA to Lys were maintained well above minimum levels to ensure that AA were not limiting (Table 1). All diets contained 1,206 kcal NE by adjusting amount of fat as the ratios of corn and SBM changed in the diet.

Pigs were weighed on d 0, 8, 16, and 19 to determine ADG, ADFI, and F/G. 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, ether extract, and ash.

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. Main effects of CP and choline, as well as their interaction, were tested. Dietary treatments were the fixed effect and block served as the random effect in the analysis. Results from the experiment were considered significant at  $P < 0.05$  and a marginally significant  $P > 0.05$  and  $P \leq 0.10$ .

## Results and Discussion

The analyzed total DM, CP, Ca, P, ether extract, and ash contents of experimental diets were reasonably consistent with formulated estimates (Table 2).

For overall growth performance (d 0 to 19), there was no evidence for CP × choline interaction. Added choline did not influence pig performance. Pigs fed diets with 12% CP had marginally increased ( $P = 0.076$ ) ADG compared with pigs fed diets with 10% CP, which resulted in a heavier ( $P = 0.036$ ) final BW. Pigs fed the diets with 12% CP had improved ( $P = 0.020$ ) F/G compared with pigs fed the 10% CP diets.

In conclusion, supplementing diets with a high concentration of choline did not influence growth performance of pigs fed moderate or low CP diets. These results suggest that the reduced concentration of choline in late finishing diets with low SBM and CP concentrations does not appear to be the reason for the poorer ADG and F/G observed when feeding low CP diets.

**Table 1. Diet composition (as-fed basis)<sup>1</sup>**

Item	Crude protein, %			
	12		10	
	None	Choline <sup>2</sup>	None	Choline
Corn	84.89	84.51	91.76	91.41
Soybean meal (46.5% CP)	10.63	10.66	4.00	4.03
Choice white grease	2.25	2.40	1.35	1.45
Monocalcium P (21% P)	0.52	0.52	0.56	0.56
Limestone	0.98	0.98	1.05	1.05
Salt	0.35	0.35	0.35	0.35
L-Lys-HCl	0.13	0.13	0.33	0.33
DL-Met	0.06	0.06	0.11	0.11
L-Thr	0.01	0.01	0.10	0.10
L-Trp	0.00	0.00	0.04	0.04
L-Val	---	---	0.06	0.06
L-Ile	---	---	0.11	0.11
Trace mineral premix	0.10	0.10	0.10	0.10
Vitamin premix	0.08	0.08	0.08	0.08
Choline chloride	---	0.20	---	0.23
Phytase <sup>3</sup>	0.02	0.02	0.02	0.02
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Standardized ileal digestible amino acids, %				
Lys	0.55	0.55	0.55	0.55
Ile:Lys	75	75	75	75
Leu:Lys	191	191	164	164
Met:Lys	47	47	51	51
Met and Cys:Lys	86	85	85	85
Thr:Lys	67	67	67	67
Trp:Lys	20.5	20.5	20.5	20.5
Val:Lys	88	88	80	80
His:Lys	50	50	40	40
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
Ca, %	0.53	0.53	0.53	0.53
P, %	0.43	0.43	0.43	0.43
Available P, %	0.26	0.26	0.26	0.26
Standardized digestible P, %	0.30	0.30	0.30	0.30
Choline, mg/lb	370	823	308	823

<sup>1</sup> Diets were fed from 243 to 272 lb.

<sup>2</sup> Choline: supplementation with choline chloride to provide 823 mg of choline per lb of diet.

<sup>3</sup> 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)<sup>1</sup>**

Item, %	Crude protein, %			
	12		10	
	None	Choline <sup>2</sup>	None	Choline
DM	87.6	87.3	87.4	87.2
CP	11.7	11.6	9.3	9.7
Ca	0.67	0.64	0.74	0.68
P	0.39	0.41	0.38	0.39
Ether extract	5.2	5.1	4.8	5.1
Ash	3.1	3.5	3.0	3.0

<sup>1</sup> 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, and ash.

<sup>2</sup> Choline: supplementation with choline chloride to provide 823 mg of choline per lb of diet.

**Table 3. Evaluation of supplementation of choline chloride in low crude protein diets on growth performance of finishing pigs from 245 to 275 lb<sup>1</sup>**

Item	Crude protein, %				SEM	Probability, <i>P</i> <		
	12		10			CP	Choline	CP × choline
	None	Choline <sup>2</sup>	None	Choline				
BW, lb								
d 0	243.5	243.5	243.5	243.5	1.95	0.973	0.938	0.994
d 19	271.9	271.4	269.6	269.2	1.81	0.036	0.670	0.964
d 0 to 19								
ADG, lb	1.47	1.47	1.37	1.35	0.062	0.076	0.808	0.907
ADFI, lb	5.52	5.54	5.50	5.52	0.127	0.889	0.976	0.976
F/G	3.80	3.79	4.05	4.10	0.120	0.020	0.891	0.772

<sup>1</sup> A total of 254 pigs (DNA 600 × 241; initially 243.5 lb) were used in a 19-d experiment with 7 or 8 pigs per pen and 8 replications per treatment.

<sup>2</sup> Choline: supplementation with choline chloride to provide 823 mg of choline per lb of diet.