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Optimum Level of Dietary Crude Protein for Growth Performance and Carcass Characteristics of Finishing Pigs from 245 to 300 lb

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Abstract

A total of 238 pigs (DNA 600 × 241, initially 246.4 lb) were used in a 26-d trial to determine the optimum dietary CP concentration for growth performance and carcass characteristics of finishing pigs. Pens of 7 or 8 pigs were allotted by BW and randomly assigned to 1 of 5 dietary treatments with 6 replications per treatment. Dietary treatments included 5 levels of CP (9, 10, 11, 12, and 13%) that were formed by reducing the amount of feed-grade amino acids and increasing soybean meal in a corn-based diet. At d 26, pigs were transported to a packing plant for processing and carcass data collection. For overall growth performance, increasing CP improved (quadratic, $P < 0.05$) ADG, F/G, and caloric efficiency with the greatest improvement as CP was increased from 9 to 11% with smaller, continued improvements as CP was further increased to 13%. For carcass characteristics, increasing CP increased (quadratic, $P < 0.05$) carcass ADG and improved (quadratic, $P < 0.05$) carcass feed efficiency and carcass caloric efficiency, with the greatest response for pigs fed the diet with 13% CP. Furthermore, increasing CP marginally increased (quadratic, $P < 0.10$) HCW, with the greatest response for pigs fed the diet with 12% CP. In conclusion, ADG, F/G, caloric efficiency, carcass ADG, carcass feed efficiency, and carcass caloric efficiency were maximized in pigs fed diets with 13% CP. The greatest response for HCW was observed in pigs fed diets with 12% CP.

Keywords

amino acid, crude protein, finishing pigs

Authors

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J.A. Soto, M.D. Tokach, S.S. Dritz,[1] J.C. Woodworth, J.M. DeRouchey, and R.D. Goodband

Summary

A total of 238 pigs (DNA 600 × 241, initially 246.4 lb) were used in a 26-d trial to determine the optimum dietary CP concentration for growth performance and carcass characteristics of finishing pigs. Pens of 7 or 8 pigs were allotted by BW and randomly assigned to 1 of 5 dietary treatments with 6 replications per treatment. Dietary treatments included 5 levels of CP (9, 10, 11, 12, and 13%) that were formed by reducing the amount of feed-grade amino acids and increasing soybean meal in a corn-based diet. At d 26, pigs were transported to a packing plant for processing and carcass data collection. For overall growth performance, increasing CP improved (quadratic, $P < 0.05$) ADG, F/G, and caloric efficiency with the greatest improvement as CP was increased from 9 to 11% with smaller, continued improvements as CP was further increased to 13%. For carcass characteristics, increasing CP increased (quadratic, $P < 0.05$) carcass ADG and improved (quadratic, $P < 0.05$) carcass feed efficiency and carcass caloric efficiency, with the greatest response for pigs fed the diet with 13% CP. Furthermore, increasing CP marginally increased (quadratic, $P < 0.10$) HCW, with the greatest response for pigs fed the diet with 12% CP. In conclusion, ADG, F/G, caloric efficiency, carcass ADG, carcass feed efficiency, and carcass caloric efficiency were maximized in pigs fed diets with 13% CP. The greatest response for HCW was observed in pigs fed diets with 12% CP.

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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 underestimation of the concentration of NE in soybean meal by NRC[4] or deficiency of non-essential amino acids or other nutrients not provided in low CP diets.[5,6,7] Previous research has reported no performance effects of lowering CP in late finishing pigs when correct amino acid ratios are met; although, CP content of the diet was at least 12%.[8] Furthermore, continuous advancements in the genetics of modern pigs have resulted in superior growth performance and protein accretion, and potentially altering dietary nutrient requirements.[9] To our knowledge there is limited published research available to establish the optimal or minimum dietary CP level for late finishing pigs. Therefore, the objective of the present study is to determine the optimum level of dietary crude protein for growth performance and carcass characteristics of finishing pigs from 240 to 300 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 32 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) were used to deliver and record daily feed additions to each individual pen.

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[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.

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

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[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] Kerr, B. J. Yen, J. Nienaber and Easter. 2003. Influences of dietary protein level, amino acid supplementation and environmental temperature on performance, body composition, organ weights and total heat production in growing pigs. J. Anim. Sci. 81:1998-2007.

[9] O'Connell, M., Lynch, P., O'Doherty, J. 2005. Determination of the optimum dietary lysine concentration for growing pigs housed in pairs and in groups. Animal Science, v. 81, p. 249-255.

A total of 238 pigs (DNA 600 × 241, initially 246.4 lb) were used in a 26-d trial. There were 7 or 8 pigs per pen (3 and/or 4 barrows and gilts) and pigs were allotted by BW to pens. Pens were randomly assigned within weight blocks in a completely randomized block design with 6 replications per treatment. The dietary treatments included 5 levels of CP (9, 10, 11, 12, and 13%). Pigs were provided ad libitum access to water and to feed in meal form. Prior to the trial, from 200 to 245 lb, pigs were fed a corn-soybean meal-based diet with 14.2% CP, 0.72% SID Lys, and 1,150 kcal/lb of NE.

To create the experimental diets, a 13% CP corn-soybean meal diet with 0.04% L-Lys HCl was formulated. Then, a 9% CP diet was formulated including 0.43% L-lysine HCl and other commercially available feed-grade amino acids as necessary to maintain ratios relative to lysine. Ratios were maintained well above requirement estimates to ensure that other amino acids were not limiting. The 9 and 13% CP diets were blended to create the 10, 11, and 12% CP diets (Table 1). All diets contained the same NE content (1,198 kcal/lb) by adjusting the amount of added fat as corn and soybean meal amounts changed in the diet.

Pigs were weighed on d 0, 7, 14, and 26 of the trial to determine ADG, ADFI, and F/G. At d 26, pigs were individually tattooed with a unique ID number to allow 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 HCW.

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 they were homogenized, subsampled, and submitted for total AA analysis (method 994.12;[10]) by Ajinomoto Heartland, Inc. (Chicago, IL). Samples of the diets were also 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. Dietary treatments were the fixed effect and block served as the random effect in the analysis. Preplanned linear and quadratic orthogonal contrast were built using coefficients for equally spaced treatment, and used to determine the main effects of increasing SID Lys. Hot carcass weight served as a covariate for the analysis of backfat, loin depth, and lean percentage.

Results and Discussion

The analyzed total amino acids, DM, CP, Ca, P, ether extract, and ash contents of experimental diets (Table 2) agreed closely with formulated estimates.

For overall growth performance (d 0 to 26), increasing CP improved (quadratic, $P < 0.001$) ADG, F/G, and caloric efficiency on a NE basis with the greatest improvement as CP was increased from 9 to 11% with smaller improvements as CP was further increased to 13%. Similarly, increasing CP marginally improved (linear, $P = 0.073$)

[10] AOAC International. 2012. Official Methods of Analysis of AOAC Int. 19rd ed. Assoc. Off. Anal. Chem., Gaithersburg, MD.

ADFI with the greatest improvement as CP was increased from 9 to 10% with slight reduction as CP was further increased to 13%.

For carcass characteristics, increasing CP increased (quadratic, $P < 0.001$) carcass ADG and improved (quadratic, $P < 0.05$) carcass feed efficiency and carcass caloric efficiency, with the greatest response for pigs fed the diet with 13% CP. Furthermore, increasing CP marginally increased (quadratic, $P = 0.074$) HCW, with the greatest response for pigs fed the diet with 12% CP. There was no evidence for treatment differences in carcass yield, backfat, loin depth, or percentage lean.

In conclusion, ADG, F/G, caloric efficiency, carcass ADG, carcass feed efficiency, and carcass caloric efficiency were maximized in pigs fed diets with 13% CP. The greatest response for HCW was observed in pigs fed diets with 12% CP.

The results of this study are consistent with the findings of Soto[11] et al. (2016), where the optimum dietary CP for F/G, caloric efficiency, carcass ADG, carcass F/G, and carcass caloric efficiency were observed in pigs fed a diet with 13% CP. Reducing CP may result in a deficiency of non-essential amino acids or other nutrients not provided by low CP diets.[6,12] However, Rojo[5] observed that supplementing low CP diets with non-essential amino acids had no effect on finishing pig performance. Further research is needed to understand the reasons that pigs fed diets with seemingly adequate levels of amino acids, but with less than 12% CP, have reduced performance.

[11] Soto, J.A., M.D. Tokach, S.S. Dritz, J.C. Woodworth, J.M. DeRouchey, and R.D. Goodband. 2016. Determination of the optimum levels of dietary crude protein for growth performance and carcass characteristics of finishing pigs from 240 to 280 lb. Kansas *Agricultural Experiment Station Research Reports:* Vol. 2: Iss. 8. http://dx.doi.org/10.4148/2378-5977.1309.

[12] Powell, S., T.D. Bidner, R. L. Payne, and L. L. Southern. 2011. Growth performance of 20- to 50-kilograms pigs few low-crude-protein diets supplemented with histidine, cystine, glycine, glutamic acid, or arginine. J. Anim. Sci. 89:3643-3650.

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

	Crude protein, %				
Ingredient, %	9	10	11	12	13
Corn	96.01	92.33	88.92	85.62	82.30
Soybean meal (46.5% CP)	0.47	3.96	7.27	10.42	13.57
Choice white grease	0.35	0.90	1.35	1.80	2.20
Monocalcium P (21% P)	0.60	0.58	0.55	0.53	0.50
Limestone	0.98	0.95	0.93	0.88	0.85
Salt	0.35	0.35	0.35	0.35	0.35
L-Lys-HCl	0.43	0.33	0.23	0.13	0.04
DL-Met	0.11	0.08	0.05	0.03	---
L-Thr	0.16	0.11	0.07	0.03	---
L-Trp	0.07	0.05	0.03	0.02	---
L-Val	0.11	0.06	---		---
L-Ile	0.19	0.13	0.07	0.02	---
Trace mineral premix	0.10	0.10	0.10	0.10	0.10
Vitamin premix	0.08	0.08	0.08	0.08	0.08
Phytase[2]	0.02	0.02	0.02	0.02	0.02
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
SID amino acids, %					
Lys	0.55	0.55	0.55	0.55	0.55
Ile:Lys	78	78	78	78	84
Leu:Lys	150	165	178	191	204
Met:Lys	48	45	43	41	39
Met and Cys:Lys	80	80	80	80	80
Thr:Lys	70	70	70	70	73
Trp:Lys	22	22	23	22	23
Val:Lys	79	79	79	88	97
His:Lys	35	40	45	50	55
SID Lys:NE, g/Mcal	2.08	2.08	2.08	2.08	2.08
NE NRC, kcal/lb	1,198	1,198	1,198	1,198	1,198
CP, %	9.0	10.0	11.0	12.0	13.0
Ca, %	0.50	0.50	0.50	0.50	0.50
P, %	0.41	0.42	0.43	0.43	0.44
Available P, %	0.26	0.26	0.26	0.26	0.26
Standardized digestible P, %	0.29	0.29	0.30	0.30	0.30

[1] Diets were fed from 245 to 300 lb.

[2] 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]

	Crude protein, %				
Item	9	10	11	12	13
DM, %	86.0	86.1	86.2	86.5	86.5
CP, %	8.9	10.0	10.8	11.9	12.9
Ca, %	0.63	0.69	0.57	0.61	0.61
P, %	0.41	0.41	0.41	0.41	0.42
Extract ether, %	3.6	3.7	3.7	4.1	4.0
Ash, %	2.0	2.3	2.4	2.8	2.7
Total amino acids, %					
Lys	0.55	0.58	0.55	0.59	0.59
Ile	0.45	0.46	0.54	0.48	0.57
Leu	0.96	1.02	1.15	1.21	1.32
Met	0.27	0.26	0.24	0.24	0.23
Met and Cys	0.46	0.47	0.46	0.48	0.48
Thr	0.46	0.46	0.43	0.48	0.47
Trp	0.12	0.12	0.13	0.13	0.13
Val	0.51	0.55	0.60	0.61	0.66
His	0.22	0.25	0.26	0.31	0.33
Phe	0.47	0.52	0.57	0.65	0.69

[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. Amino acid analysis was conducted on composite samples by Ajinomoto Heartland, Inc. (Chicago, IL). Samples of the diets were also submitted to Cumberland Valley Analytical Service (Hagerstown, MD) for analysis of DM, CP, Ca, P, ether extract, and ash.

Table 3. Effects of increasing dietary crude protein concentration on growth performance and carcass characteristics of finishing pigs from 245 to 300 lb[1]

	Crude protein, %						Probability, *P* <	
Item	9	10	11	12	13	SEM	Linear	Quadratic
BW, lb								
d 0	246.4	246.4	246.4	246.4	246.4	1.64	0.948	0.961
d 26	292.8	295.2	297.7	298.7	299.4	1.76	0.463	0.001
d 0 to 26								
ADG, lb	1.79	1.88	1.97	2.01	2.05	0.050	0.508	<0.001
ADFI, lb	6.60	6.93	6.92	6.87	6.85	0.122	0.073	0.322
F/G	3.71	3.71	3.51	3.42	3.34	0.057	0.336	<0.001
NE efficiency, Kcal/lb gain[2]	4,439	4,440	4,206	4,094	4,009	67.9	0.362	<0.001
Carcass characteristics								
Carcass ADG, lb[3]	1.34	1.41	1.48	1.51	1.53	0.037	0.461	<0.001
Carcass G:F[4]	0.203	0.203	0.215	0.220	0.223	0.004	0.535	<0.001
NE efficiency, Kcal/lb gain	5,920	5,910	5,595	5,461	5,371	93.6	0.496	<0.001
HCW, lb	219.8	222.1	223.6	224.1	223.3	1.93	0.344	0.074
Carcass yield,[5] %	75.0	75.2	75.1	75.0	74.6	0.46	0.533	0.638
Backfat, in.[6]	0.72	0.73	0.71	0.71	0.70	0.019	0.922	0.424
Loin depth, in.[6]	2.50	2.48	2.51	2.51	2.52	0.032	0.538	0.544
Lean, %[6]	53.3	53.1	53.3	53.3	53.4	0.27	0.424	0.531

[1] A total of 238 pigs (DNA 600 × 241; initially 246.4 lb) were used in a 26-d experiment with 7-8 pigs per pen and 6 replications per treatment.

[2] Caloric efficiency = Kcal of NE per pound of gain ((ADFI × NE/lb) /ADG).

[3] Carcass average daily gain = overall ADG × carcass yield.

[4] Carcass G:F = overall average feed intake/carcass average daily gain.

[5] Carcass yield calculated by dividing HCW by live weight obtained at the farm before transportation to the packing plant.

[6] Adjusted using HCW as a covariate.