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Abstract

A total of 224 pigs (PIC 327 × 1050, initially 241.1 lb) were used in a 20-d trial to determine the optimum dietary CP concentration for growth performance and carcass characteristics of finishing pigs. Pens of 7 pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments with 7 or 8 replications per treatment. Dietary treatments included 4 levels of CP (10, 11, 12, and 13%) that were formed by reducing the amount of crystalline Lys in a corn-soybean meal diet. At d 20, pigs were transported to a packing plant for processing and carcass data collection. For overall growth performance (d 0 to 20), increasing CP increased (linear, $P < 0.05$ and quadratic, $P < 0.10$) ADG, ADFI, and HCW ADG with the greatest response for pigs fed the diet with 12% CP. Increasing diet CP also improved (linear, $P < 0.05$) F/G, NE caloric efficiency, final BW, HCW, and HCW F/G. In conclusion, poorer performance of pigs fed diets under 12% CP was predominantly explained by feed intake but the mechanisms underlying regulation of feed consumption when feeding lower CP remains unclear.

Keywords

amino acid, crude protein, finishing pigs

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Determination of the Optimum Levels of Dietary Crude Protein for Growth Performance and Carcass Characteristics of Finishing Pigs from 240 to 280 lb

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Summary

A total of 224 pigs (PIC 327 × 1050, initially 241.1 lb) were used in a 20-d trial to determine the optimum dietary CP concentration for growth performance and carcass characteristics of finishing pigs. Pens of 7 pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments with 7 or 8 replications per treatment. Dietary treatments included 4 levels of CP (10, 11, 12, and 13%) that were formed by reducing the amount of crystalline Lys in a corn-soybean meal diet. At d 20, pigs were transported to a packing plant for processing and carcass data collection. For overall growth performance (d 0 to 20), increasing CP increased (linear, $P < 0.05$ and quadratic, $P < 0.10$) ADG, ADFI, and HCW ADG with the greatest response for pigs fed the diet with 12% CP. Increasing diet CP also improved (linear, $P < 0.05$) F/G, NE caloric efficiency, final BW, HCW, and HCW F/G. In conclusion, poorer performance of pigs fed diets under 12% CP was predominantly explained by feed intake but the mechanisms underlying regulation of feed consumption when feeding lower CP remains unclear.

Key words: amino acid, crude protein, finishing pigs

Introduction

Multiple finishing pig studies have shown that a high-protein diet results in greater weight gain and higher carcass lean meat content (Adeola and Young, 1989²; Chiba et al., 2002³) of pigs fed a low-protein, amino acid fortified diet. Decreasing dietary protein may compromise pig growth and decrease carcass leanness (Tous et al., 2014⁴). One

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² Adeola, O., L.G. Young. 1989. Dietary protein-induced changes in porcine muscle respiration, protein synthesis and adipose tissue metabolism. *J. Anim. Sci.* 67:664-673.

³ Chiba, L., D.L. Kuhlbers, L.T. Frobish, S.B. Jungst, E.J. Huff-Lonergan, S.M. Lonergan and K.A. Cummins. 2002. Effect of dietary restrictions on growth performance and carcass quality of pigs selected for lean growth efficiency. *Livest. Prod. Sci.* 74:93-102.

⁴ 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.

possible explanation for these effects is that the low protein content restricted muscle growth, resulting in a surplus of energy being converted into intramuscular lipids (Tous et al., 2014). However, excessive CP intake has been shown to increase energy expenditure due to increased N excretion, as well as to impact organ size (Kerr et al., 2003⁵). Lenis and Jongbloed (1989)⁶ reported that a 1% reduction in dietary CP content resulted in an 8.5% reduction in N excretion. Previous research has reported no performance effects of lowering CP in late finishing pigs when correct amino acid ratios are met; however, the reduction in CP was limited to 12% CP (Kerr et al., 2003), or different genetics and body weight range have been used (Tous et al., 2014). Recently, Soto et al. (2016)⁷ studied the effects of feeding a 10 or 13% CP diet to finishing pigs and found significant performance reduction in pigs fed the diet with 10% CP. Overall, 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 levels of dietary crude protein for 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 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. A robotic feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) was used to deliver and record daily feed additions to each individual pen.

A total of 224 pigs (PIC 327 × 1050, initially 241.1 lb) were used in a 20 d trial. There were 7 pigs per pen (4 barrows and 3 gilts) at a floor space of 8.95 ft² 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. Pigs were allotted by BW and randomly assigned to 1 of 4 dietary treatments in a completely randomized block design. The dietary treatments included 4 CP concentrations (10, 11, 12, and 13%), with 7 replications for the treatment with 10% CP and 8 replications for the treatments with 11, 12, and 13% CP. Pigs were provided ad libitum access to water and feed in meal form. Prior to the trial, from 200 to 240 lb, these pigs were fed a corn-soybean meal-based diet with 14.2% CP, 0.72 standardized ileal digestible (SID) Lys and NE 1,150 Kcal/lb.

⁵ 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.

⁶ Lenis, N. and A. Jongbloed. 1999. New technologies in low pollution swine diets: Diet manipulation and use of synthetic amino acids, phytase and phase feeding for reduction of nitrogen and phosphorus excretion and ammonia emission. *Asian-Aust. J. Anim. Sci.* 12(2):305-327.

⁷ Soto, J.A., M.D. Tokach, S.S. Dritz, J.C. Woodworth, J.M. DeRouchey, and R.D. Goodband. 2016. Effects of dietary electrolyte balance and crude protein level on growth performance, carcass characteristics, and blood analytes of finishing pigs. Kansas State University Swine Industry Day, 2016. Kansas Agricultural Experiment Station Reports. 17-118-S. Vol: 2 Iss. 8.

To formulate the experimental diets, a 13% CP corn-soybean meal diet with 0.23% L-Lys HCl was formulated. Then L-lysine HCl was included at 0.52, 0.43, and 0.33% of the diet at the expense of soybean meal to reach the desired levels of 10, 11, and 12% CP, respectively (Table 1). Diets were isocaloric (NE kcal/lb 1,194) with all amino acids at or above minimum ratios relative to Lys.

Pigs were weighed on d 0, 7, 14, and 20 of the trial to determine ADG, ADFI, and F/G. At d 20, pigs were individually tattooed with a unique ID number to allow carcass measurements to be recorded on a pig basis. On d 20, final pen weights and individual weights were taken, and pigs were transported to a commercial packing plant (Farmland Crete, NE) for processing and determination of HCW.

Diet samples were taken from 6 feeders per dietary treatment 3 d after the beginning and 3 d before the end of the experiment and stored at -4°F until they were homogenized, subsampled, and submitted for analysis of DM, CP, Ca, P, ether extract, and ash (Cumberland Valley Analytical Services, Hagerstown, MD; Table 2).

Data were analyzed using the PROC GLIMMIX procedure in SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit and initial BW as a blocking factor. Dietary treatments were the fixed effect and block served as the random effect in the analysis. Statistical significance was determined at $P < 0.05$ and tendencies at $P < 0.10$.

Results and Discussion

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

For overall growth performance (d 0 to 20), increasing CP increased (linear, $P < 0.05$ and quadratic, $P < 0.10$) ADG and ADFI with the greatest response for pigs fed the diet with 12% CP with little improvement thereafter. In addition, increasing CP also improved (linear, $P < 0.05$) F/G, caloric efficiency, and final BW.

For carcass characteristics, increasing CP increased (linear, $P = 0.001$ and quadratic, $P = 0.07$) HCW ADG with the greatest response for pigs fed the diet with 12% CP. Furthermore, HCW increased (linear, $P = 0.040$) with increasing dietary CP without any influence on carcass yield. Also, HCW F/G, and HCW NE caloric efficiency improved (linear, $P < 0.050$) with increasing CP.

In conclusion, the optimum dietary CP for ADG, ADFI, and HCW ADG were reached by pigs fed diets with 12% CP. Further improvement in HCW, F/G, caloric efficiency and HCW caloric efficiency were observed in pigs fed the diet with 13% CP. The F/G improvement in pigs fed the 13% CP diet may be due to underestimation of the concentration of NE in soybean meal by NRC (2012), as suggested by Sotak-Peper et al. (2015).⁸ The poorer performance of pigs fed diets with less than 12% CP was predominantly explained by reduced feed intake, yet mechanisms underlying regulation of feed consumption when feeding lower CP remains unclear. In addition, it would

⁸ 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.

possible to hypothesize that by reducing CP to low levels it may result in a deficiency of non-essential amino acids (Ball et al., 2013⁹), or other nutrients not provided by low CP diets. However, other research has suggested that late finishing pigs fed low CP diets supplemented with non-essential amino acids were not able to overcome the negative impacts on growth performance and carcass characteristics of the low CP (Rojo, 2011¹⁰). 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.

⁹ 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.

¹⁰ 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. Ph.D. diss., University of Illinois. Urbana-Champaign, IL.

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

Ingredient, %	Crude protein, %			
	10	11	12	13
Corn	93.09	89.87	86.63	83.38
Soybean meal (46.5% CP)	2.96	6.03	9.17	12.32
Choice white grease	0.55	1.00	1.45	1.90
Monocalcium P (21% P)	0.71	0.68	0.65	0.63
Limestone	0.97	0.98	0.96	0.92
Salt	0.35	0.35	0.35	0.35
L-Lys-HCl	0.52	0.43	0.33	0.23
DL-Met	0.10	0.07	0.04	0.02
L-Thr	0.19	0.15	0.11	0.06
L-Trp	0.06	0.05	0.03	0.01
L-Val	0.16	0.11	0.05	0.00
L-Ile	0.16	0.11	0.06	0.00
Trace mineral premix	0.10	0.10	0.10	0.10
Vitamin premix	0.08	0.08	0.08	0.08
Phytase ²	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	0.66	0.66	0.66	0.66
Ile:Lys	65	65	65	65
Leu:Lys	132	143	154	165
Met:Lys	38	36	34	32
Met and Cys:Lys	62	62	62	62
Thr:Lys	66	66	66	66
Trp:Lys	19	19	19	19
Val:Lys	76	76	75	76
His:Lys	33	38	42	47
SID Lys: NE, g/Mcal	2.51	2.51	2.51	2.51
NE NRC, kcal/lb	1,194	1,194	1,194	1,194
CP, %	10.0	11.0	12.0	13.0
Ca, %	0.51	0.52	0.51	0.51
P, %	0.41	0.42	0.43	0.44
Available P, %	0.29	0.29	0.29	0.29
Standardized digestible P, %	0.31	0.32	0.32	0.32

¹Diets were fed from d 0 to 20.

²Ronozyme Hiphos (GT) 2700 (DSM Nutritional Products, Inc, Parsippany, NJ). Provided 181.8 phytase units (FTU) per lb of diet with a release of 0.10% available P.

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

Item, %	Crude protein, %			
	10	11	12	13
DM	85.3	85.4	85.4	85.7
CP	9.0	10.9	11.9	13.1
Ca	0.72	0.62	0.60	0.61
P	0.46	0.56	0.48	0.50
Ether extract	3.7	5.4	5.1	5.3
Ash	4.0	4.2	4.0	4.1

¹Multiple diet samples were collected from each diet throughout the study, homogenized, and then subsampled for analysis (Cumberland Valley Analytical Service, Hagerstown, MD).

Table 3. Effects of increasing dietary crude protein concentration on growth performance and carcass characteristics of finishing pigs from 240 to 280 lb^{1,2,3}

Item	Crude protein, %				SEM	Probability, <i>P</i> <	
	10	11	12	13		Linear	Quadratic
BW, lb							
d 20	276.8	278.9	281.4	280.9	1.40	0.022	0.341
BW CV, %							
d 0	9.2	8.3	8.4	8.5	1.03	0.650	0.600
d 20	7.8	6.8	8.4	7.8	0.84	0.670	0.770
d 0 to 20							
ADG, lb	1.69	1.89	2.01	1.99	0.068	0.001	0.080
ADFI, lb	5.69	5.99	6.26	6.09	0.127	0.014	0.060
F/G	3.35	3.18	3.11	3.06	0.086	0.020	0.452
NE Caloric efficiency ⁴	4,033	3,804	3,736	3,662	102.8	0.010	0.430
Carcass characteristics							
HCW, lb	207.2	207.2	210.5	209.5	1.09	0.040	0.640
Carcass yield, %	74.8	74.3	74.8	74.6	0.24	0.780	0.510
Carcass CV, %	9.0	7.5	8.6	8.6	0.82	1.000	0.320
Carcass performance							
HCW ADG, lb	1.32	1.43	1.52	1.50	0.038	0.001	0.070
HCW F/G	4.31	4.20	4.15	4.07	0.087	0.050	0.880
NE Caloric efficiency	5,145	5,013	4,952	4,859	104.7	0.050	0.850

¹A total of 224 pigs (PIC 1050 × 327; initially 241.1 lb) were used in a 20-d experiment with 7 pigs per pen.

²Allotment weight used as a covariate for growth performance, carcass characteristics, and carcass performance variables.

³Treatment with 10% CP had 7 replications and 8 replications for the treatments with 11, 12, and 13% CP.

⁴Caloric efficiency is expressed as kcal/lb of gain.