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Effects of Crude Protein and Amino Acid to Lysine Ratio on Finishing Pig Growth Performance and Carcass Characteristics^{1,2}

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Summary

The increased availability of synthetic amino acids has reduced the amount of intact protein sources used in swine diets. The objective of this study was to determine the effects of different CP levels and AA to Lys ratios on growth performance and carcass characteristics in late finishing pigs. A total of 1,682 pigs (327 × 1050, PIC, Hendersonville, TN; initially 252.7 lb BW) were used in a 25-d growth trial arranged in an unbalanced randomized complete block design with 25 pigs per pen and initially 8 or 16 pens per treatment. Dietary treatments were arranged in a 2 × 2 + 1 factorial consisting of combinations of 10.3 or 13.5% CP and 2 AA to Lys ratios plus a control diet (13.5% CP from soybean meal). The standardized ileal digestible (SID) ratios to Lys were 55% Met+Cys, 68% Thr, 17% Trp, 65% Val, 56% Ile, and 32% His for PIC (2013)⁵ and 60% Met+Cys, 68% Thr, 20% Trp, 72% Val, 55% Ile, and 37% His for the Modified ratio.

Overall, from d 0 to 25, pigs fed the control diet had increased ADG ($P < 0.001$) compared with pigs fed diets formulated with the PIC or Modified AA:Lys ratios. There were no statistical differences in ADFI observed between the treatments. For F/G, there was a 2-way marginally significant interaction ($P = 0.066$) where F/G was improved for pigs fed the PIC AA:Lys ratios with 13.5% CP compared to those fed diets with 10.3% CP; however, there were no statistical differences in F/G between CP levels in pigs fed Modified AA:Lys ratios. Final BW was increased in pigs fed the control compared to pigs fed diets formulated with the PIC ($P = 0.017$) or Modified ($P < 0.001$) AA:Lys ratios. Pigs fed 10.5% CP provided by glutamic acid and glycine, regardless of AA:Lys ratio, had increased ($P = 0.031$) carcass yield; however, there was

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⁴ Ajinomoto Heartland Inc., Chicago, IL.

⁵ PIC. 2013. Nutrient specifications manual. p. 56. accessed on December 8th, 2015 at <http://na.picgenus.com/resources.aspx>

no statistical differences between the dietary treatments regarding HCW, backfat, loin depth, and percentage lean.

In conclusion, reducing intact protein (soybean meal) decreased growth performance and the inclusion of a nitrogen source (glycine and glutamic acid) was not able to recover growth performance in this commercial study. The 2 amino acid ratios in the low crude protein diets evaluated in this study did not improve growth performance or carcass characteristics.

Key words: amino acid ratio, crude protein level, growth, finishing pig

Introduction

The increased availability of synthetic amino acids has reduced the levels of intact protein sources used in swine diets. Thus, the amount of nitrogen available for synthesis of non-essential AA has decreased. It has been observed that AA supplied by intact protein sources can be replaced by synthetic AA to meet the requirement of the first 5 limiting AA; however, including synthetic AA beyond the first 5 limiting has been shown to have inconsistent results, especially with pigs in the late finishing phase.^{6,7}

The objective of this study was to determine the effects of CP level and AA to Lys ratios on growth performance and carcass characteristics of late finishing pigs. The hypotheses were: 1) reducing intact protein would impair growth performance but the inclusion of a nitrogen source would recover performance, and 2) increased AA ratios would improve growth performance.

Procedures

The Kansas State University Institutional Animal Care and Use Committee (IACUC) approved the protocol used in this experiment. The experiment was conducted at a commercial research facility in Minnesota. The barn was naturally ventilated and double-curtain-sided and pens had completely slatted flooring and deep pits for manure storage. Each pen was equipped with a 3-hole stainless steel dry self-feeder (Thorp Equipment, Thorp, WI) and a cup waterer for ad libitum intake for feed and water. The facility was equipped with a computerized feeding system (FeedPro; Feedlogic Corp., Willmar, MN) that delivered and recorded daily feed additions.

Five representative samples of corn, soybean meal, and dried distillers grains with solubles (DDGS) were collected each week for 5 wk and analyzed in duplicate for total amino acids and CP (Ajinomoto Heartland, Inc., Chicago, IL). These values were then used in diet formulation. Other nutrients and SID AA digestibility coefficients used for diet formulation were obtained from NRC (2012).

⁶ Gloaguen, M., L. Floc'h, E. Corrent, Y. Primot, and J. van Milgen. 2014. The use of free amino acids allows formulating very low crude protein diets for piglets. *J. Anim. Sci.* 92:637-644.

⁷ Apple, J. K., C. V. Maxwell, T. C. Tsai, H. J. Kim, D. G. Cook, K. J. Touchette, J. E. Thomson, J. Less, J. J. Chewing. Effect of feed-grade amino acid supplementation in reduced crude protein (RCP) diets formulated on a NE basis on performance and carcass characteristic of growing-finishing pigs. *J. Anim. Sci.* 93:19 (Abstr.).

A total of 1,682 pigs (327×1050 , PIC, Hendersonville, TN; initially 252.7 lb BW) were used in a 25-d growth trial arranged in an unbalanced randomized complete block design with 25 pigs per pen and initially 8 or 16 pens per treatment.

Dietary treatments consisted of combinations CP (10.3 or 13.5%) and 2 AA to Lys ratios ("PIC" or "Modified") in a $2 \times 2 + 1$ factorial arrangement where the control diet was formulated at 13.5% CP using soybean meal as the major protein source. Crude protein was increased from 10.3 to 13.5% by inclusion of glutamic acid and glycine at a 2:1 ratio with the exception of the positive control diet where soybean meal was increased to achieve the desired CP level. The SID ratios to Lys were 55% Met+Cys, 68% Thr, 17% Trp, 65% Val, 56% Ile, and 32% His for PIC (2013)⁵ and 60% Met+Cys, 68% Thr, 20% Trp, 72% Val, 55% Ile, and 37% His for the Modified treatments. Diets were fed in meal form and were corn-soybean meal-based with 10% DDGS (Table 1).

Pens of pigs were weighed and feed disappearance measured at the beginning, d 13, 21, and 25 to determine ADG, ADFI, and F/G. Prior to marketing, the pigs were individually tattooed with a pen ID number to allow for carcass measurements to be recorded on a pen basis. Carcass measurements taken at the plant (JBS Swift and Company, Worthington, MN) included HCW, loin depth, backfat, and percentage lean. Percentage carcass yield was calculated by dividing the individual HCW at the plant by the pig's pen average final live weight at the farm. A total of 4 pens, one from each treatment (except treatment 13.5% CP and PIC ratio) was removed due to feeder flow ability issues.

Responses measured at the pen level were analyzed using a general linear mixed model and contrasts were used to evaluate the effect of the different factors on ADG, ADFI, F/G, and BW. Heterogeneous residual variances as a function of the response variables were fitted as needed. Model assumptions were checked and considered to be appropriately met. The experimental data were analyzed using the GLIMMIX procedure of SAS (SAS Institute Inc., Cary, NC). Hot carcass weight served as a covariate for the analysis of backfat, loin depth, and lean percentage. Results were considered significant at $P \leq 0.05$ and a tendency at $P \leq 0.10$.

Results and Discussion

From d 0 to 25, ADG was increased in pigs fed the control diet compared to PIC ($P < 0.001$) and Modified ($P < 0.001$) AA:Lys ratios. There were no statistical differences in ADFI between the treatments. For F/G, there was a 2-way marginally significant interaction ($P = 0.066$) where F/G was improved in the PIC AA:Lys ratio with 13.5% compared to 10.3%; however, no statistical differences in F/G between CP levels in pigs fed Modified AA:Lys ratio were observed. Final BW was increased in pigs fed the control diet compared to PIC ($P = 0.017$) and Modified ($P < 0.001$) AA:Lys ratios. Pigs fed 10.5% CP provided by glutamic acid and glycine, regardless of AA:Lys ratio, had increased ($P = 0.031$) carcass yield (Table 3); however, there were no statistical differences between the dietary treatments regarding HCW, backfat, loin depth, and percentage lean.

In conclusion, reducing intact protein impaired growth performance, and the inclusion of a nitrogen source was not able to recover growth performance in this commercial

study. This could be related to dietary electrolyte balance, other amino acids, or growth factors provided by soybean meal that were not available in the diets with 13.5% CP with added L-Glu or Gly. Increasing AA ratios relative to Lys did not improve growth performance or carcass characteristics.

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

	Control diet	PIC ratios, CP,%		Modified ratios, CP, %	
Item		13.5	10.3	13.5	10.3
Ingredient					
Corn	77.46	81.32	85.96	81.19	85.82
Soybean meal (46% CP)	10.32	1.44	1.15	1.44	1.16
DDGS ¹	10.00	10.00	10.00	10.00	10.00
Choice white grease	0.50	0.50	0.50	0.50	0.50
Calcium carbonate	0.85	0.85	0.85	0.85	0.85
Dicalcium phosphate (18.5% P)	0.10	0.15	0.15	0.15	0.15
Salt	0.35	0.35	0.35	0.35	0.35
L-Lys-HCl	0.215	0.513	0.513	0.513	0.513
DL-Met	---	0.025	0.025	0.055	0.055
L-Thr	0.040	0.180	0.180	0.180	0.180
L-Trp	0.014	0.045	0.045	0.065	0.065
L-Val	---	0.055	0.055	0.100	0.100
L-Ile	---	0.075	0.075	0.070	0.070
L-Glu	---	2.900	---	2.900	---
Gly	---	1.450	---	1.450	---
L-His	---	---	---	0.035	0.035
Vitamin-mineral premix	0.100	0.100	0.100	0.100	0.100
Phytase ²	0.050	0.050	0.050	0.050	0.050
Total	100.0	100.0	100.0	100.0	100.0

continued

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

	Control diet	PIC ratios, CP,%		Modified ratios, CP, %	
Item		13.5	10.3	13.5	10.3
Calculated analysis					
Standardized ileal digestible (SID) amino acids, %					
Lys	0.63	0.63	0.63	0.63	0.63
Ile:Lys	70	56	57	55	56
Leu:Lys	189	148	152	148	152
Met:Lys	32	28	29	33	34
Met and Cys:Lys	66	55	56	60	61
Thr:Lys	68	68	69	68	69
Trp:Lys	20.0	17.0	17.0	20.1	20.2
Val:Lys	81	65	66	72	73
His:Lys	47	32	32	37	38
ME, kcal/lb	1,525	1,528	1,532	1,529	1,532
NE NRC, kcal/lb	1,163	1,185	1,190	1,185	1,190
SID Lys:NE, g/Mcal	2.46	2.41	2.40	2.41	2.40
SID Lys:ME, g/Mcal	1.87	1.87	1.87	1.87	1.86
CP, %	13.5	13.5	10.28	13.53	10.36
Ca, %	0.41	0.39	0.39	0.39	0.39
P, %	0.35	0.31	0.32	0.31	0.32
Available P, %	0.19	0.19	0.19	0.19	0.19
Stand. Dig. P, %	0.23	0.21	0.21	0.21	0.21
Ca:P	1.15	1.26	1.22	1.26	1.22
dEB ³ , mEQ/kg ³	122	59	61	59	61

¹Diets were fed from 252.8 to 301.7 lb BW. Corn, dried distillers grains with solubles (DDGS), and soybean meal were analyzed for CP to use in formulation and total amino acid content and NRC (2012) SID digestibility values were used in the diet formulation.

²Axtra PHY (DuPont, Wilmington, DE) provided 150 phytase units (FTU) per lb of diet.

³Dietary electrolyte balance ($435 \times \text{Na} + 256 \times \text{K} - 282 \times \text{Cl}$).¹

¹ Austic, R. E., and C. C. Calvert. 1981. Nutritional interrelationships of electrolytes and amino acids. Fed. Proc. 40:63–67.

Table 2. Effects of different AA:Lys ratios and CP on finishing pig growth performance and carcass characteristics¹

	Control diet ²	AA:Lys ratio approach					Probability, <i>P</i> <		
		PIC		Modified				Control vs. PIC ³	Control vs. modified ³
CP, %:	13.5	13.5	10.3	13.5	10.3	SEM	Ratio × CP		
n	15	8	15	7	15	---	---	---	---
d 0 to 25									
ADG, lb	2.16	2.04	1.99	1.97	1.98	0.040	0.348	0.001	0.001
ADFI, lb	7.29	7.04	7.20	7.16	7.16	0.089	0.363	0.068	0.183
F/G	3.39	3.46	3.63	3.64	3.64	0.063	0.066	0.002	0.001
BW, lb									
d 0	252.6	252.7	252.8	253.1	252.7	2.45	0.780	0.868	0.761
d 25	304.6	302.2	301.0	300.4	300.3	1.35	0.627	0.017	0.001
Carcass characteristics									
HCW, lb	224.3	222.5	222.7	221.5	223.3	1.21	0.568	0.231	0.187
Yield, %	73.7	73.6	74.1	73.5	74.4	0.41	0.488	0.520	0.313
Backfat, in. ^{.4}	0.65	0.63	0.65	0.64	0.65	0.024	0.650	0.469	0.760
Loin depth, in. ^{.4}	2.94	2.91	2.93	2.94	2.94	0.024	0.506	0.223	0.784
Lean, % ⁴	56.7	56.7	56.7	56.7	56.7	0.20	0.793	0.588	0.937

¹ A total of 1,682 pigs (PIC 327 × 1050, initially 252.7 lb BW) were used in a 25-d growth trial arranged in an unbalanced randomized complete block design with 25 pigs; however, a total of four pens (one from each treatment except treatment 13.5% CP and PIC ratio) were removed due to feeder flow ability issues.

² Diets were corn-soybean meal-based with 10% DDGS and 0.63% SID Lys. Treatments included 2 CP levels (10.3 vs. 13.5% using glycine and glutamic acid as nitrogen sources in a 2:1 ratio to increase CP) and 2 AA to Lys ratio approaches (PIC vs Modified) and a control with 13.5% CP using mainly soybean meal as the nitrogen source. The PIC and Modified ratio to Lys approaches were set at 55, 68, 17, 56, 65, 32 and 60, 68, 20, 55, 72, and 37% of Lys for Met+Cys, Thr, Trp, Ile, Val, and His, respectively.

³ Contrast of control vs. PIC or Modified ratios independent of CP level.

⁴ HCW was used as a covariate.

Table 3. Main effects of different AA:Lys ratio approaches and CP on finishing pig growth performance and carcass characteristics¹

	AA:Lys ratio approach		SEM	Probability, <i>P</i> <	CP, %		SEM	Probability, <i>P</i> <
	PIC	Modified			13.5	10.3		
n	23	22	---	---	15	30	---	---
d 0 to 25								
ADG, lb	2.01	1.97	0.04	0.252	2.01	1.98	0.03	0.469
ADFI, lb	7.12	7.16	0.08	0.609	7.10	7.18	0.07	0.367
F/G	3.54	3.64	0.06	0.053	3.55	3.64	0.06	0.065
BW, lb								
d 0	252.8	252.9	2.4	0.877	252.9	252.8	2.4	0.872
d 25	301.6	300.3	1.3	0.275	301.3	300.6	1.2	0.554
Carcass characteristics								
HCW, lb	222.6	222.4	1.19	0.865	222.0	223.0	1.28	0.476
Yield, %	73.8	74.0	0.30	0.683	73.6	74.2	0.32	0.031
Backfat, in. ³	0.64	0.64	0.230	0.677	0.64	0.65	0.237	0.377
Loin depth, in. ³	2.92	2.94	0.024	0.338	2.92	2.93	0.024	0.608
Lean, % ³	56.7	56.7	0.20	0.638	56.7	56.7	0.20	0.708

¹ A total of 1,682 pigs (PIC 327 × 1050, initially 252.7 lb BW) were used in a 25-d growth trial arranged in an unbalanced randomized complete block design with 25 pigs per pen; however, a total of five pens (one from each treatment except treatment 13.5% CP and PIC ratio) were removed due to feeder flow ability issues.

² Diets were corn-soybean meal based with 10% DDGS and 0.63% SID Lys. Treatments included 2 CP levels (10.3 vs. 13.5% using glycine and glutamic acid as nitrogen sources in a 2:1 ratio to increase CP) and 2 AA to Lys ratio approaches (PIC vs Modified) and a control with 13.5% CP using mainly soybean meal as the nitrogen source. The PIC and Modified ratio to Lys approaches were set at 55, 68, 17, 56, 65, 32 and 60, 68, 20, 55, 72, and 37% of Lys for Met+Cys, Thr, Trp, Ile, Val, and His, respectively.

³ HCW was used as a covariate.