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Utilization of crystalline or protein-bound lysine for growth and carcass traits of barrows and gilts fed individually or in groups[1]

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ABSTRACT: An experiment consisting of two 4-wk trials was conducted to determine Lys use for growth and carcass traits in barrows and gilts fed individually or in groups. One hundred twelve growing pigs (56 barrows and 56 gilts; average initial BW of 18.6 kg) were used in each trial. Pigs were fed individually or in groups of 3. There were 28 pigs individually penned, and 84 pigs in 28 pens (3 pigs/pen). There were 2 replications per treatment in each trial for a total of 4 replications. Dietary treatments consisted of a corn–soybean meal (SBM) basal diet (0.48% Lys) and diets containing 0.56%, 0.65%, and 0.74% standardized ileal digestible (SID) Lys that were achieved by adding Lys to the basal diet from either SBM or crystalline source as L-Lys HCL (CLys). At the end of each trial, all pigs were scanned using real-time ultrasound to determine 10th-rib back fat depth and LM area, and fat-free lean gain (FFLG) was calculated. Blood samples were taken from all pigs weekly to determine plasma urea N (PUN). Pigs fed CLys and Lys from SBM were not different in final BW, ADG, ADFI, or G:F. The ADG and G:F increased linearly ($P < 0.01$) as dietary Lys concentration increased. The SID Lys intake increased linearly ($P < 0.01$) as dietary Lys concentration increased and was not different when comparing pigs fed diets with CLys or SBM. The amount of SID Lys required per unit of growth or BW gain increased linearly (about 13 to 15.50 g/kg) in pigs fed either CLys or SBM Lys. Pigs fed individually had a greater ($P < 0.05$) ADG (0.59 vs. 0.57 kg) and ADFI (1.36 vs. 1.29 kg) than pigs fed in groups. The SID Lys intake was greater ($P < 0.05$) in pigs fed individually in comparison with pigs fed in a group (8.51 vs. 8.06 g/d). Fat-free lean gain and LM area increased ($P < 0.01$) as dietary Lys concentration increased regardless of Lys source. Pigs fed CLys diets had a greater ($P < 0.05$) LM area than pigs fed SBM at 0.74% SID Lys. Gilts had a greater ($P < 0.01$) LM area (14.28 vs. 13.58 cm^2) and FFLG (264 vs. 245 g/d) than barrows. Pigs fed individually with CLys had less ($P < 0.01$) PUN than pigs fed Lys from SBM. Barrows fed individually had less (sex × feeding method, $P < 0.01$) PUN than gilts (26.75 vs. 29.32 g/100 mL). The results indicate that Lys from SBM-bound and CLys source were utilized similarly for growth and carcass traits regardless of sex or feeding method.

Key words: carcass traits, crude protein, growth performance, lysine, pigs, plasma urea nitrogen

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INTRODUCTION

Some factors such as the level of feed intake (restricted or ad libitum), individual or group feeding, and sex differences may affect the efficiency of Lys use in growing pigs. Previous studies have evaluated the effect of stocking density on the responses of growing pigs to dietary Lys (Brumm and Miller, 1996; Hyun et al., 1997; Ferguson et al., 2001). It has been reported that there were no interactions between dietary Lys concentration and housing (individual vs. group feeding) on growth traits (Ferguson et al., 2001). However,

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individually penned pigs had greater feed intakes and growth rate than group-penned pigs (Gómez et al., 2000; O'Doherty and McKeon, 2000).

Gilts and barrows have a different pattern of lean and fat deposition (Henry, 1993; Cline and Richert, 2001), and results of several studies indicated that gilts require greater dietary AA concentrations than barrows (Cromwell et al., 1993; Chen et al., 1999; Cline and Richert, 2001). However, others (Batterham et al., 1985; Giles et al., 1986) have reported that barrows require greater AA concentrations than gilts. Although previous studies with nursery pigs demonstrated that there are no differences of Lys needs between barrows and gilts (Hill et al., 2007) and growth is similar between pigs fed soybean meal (**SBM**)–bound Lys and Lys from L-Lys HCL (Colina et al., 2010), there is evidence that gilts require greater concentrations of dietary AA to maximize lean growth rate compared with barrows (Cromwell et al., 1993). On the basis of these observations and considering the differences in the growth response observed in pigs fed individually or in groups, this study was designed to determine the use of crystalline Lys (**CLys**) from L-Lys HCL relative to the Lys in SBM for growth and carcass traits in barrows and gilts fed individually or in groups.

MATERIALS AND METHODS

The University of Nebraska Institutional Animal Care and Use Committee approved all procedures and guidelines involving animals.

Experimental Design and Facilities

This research consisted of an experiment replicated in time (2 trials). One hundred twelve Landrace × Yorkshire × Duroc × Hampshire growing pigs (56 barrows and 56 gilts) with initial BW of 18.6 kg were used in each trial and randomly allotted in 2 rooms with 28 pens/room. All pens (1 × 1.5 m) contained a nipple waterer and 1-hole feeder and had a concrete slatted floor. In each trial, barrows or gilts were fed individually or in groups of 3 (feeding method, **FM**). There were 56 gilts (14 individually penned and 42 in 14 pens with 3 pigs/pen) and 56 barrows (14 individually penned and 42 in 14 pens with 3 pigs/pen) used in each feeding trial. There were 2 replications per dietary treatment in each trial for a total of 4 replications.

Experimental Diets

Pigs had ad libitum access to 1 of 7 experimental diets and water throughout the 28-d trials. The 7 diets used (Tables 1 and 2) consisted of a corn-SBM basal diet (0.48% Lys) and diets containing 0.56%, 0.65%, and 0.74% standardized ileal digestible (**SID**) Lys that were achieved by adding Lys to the basal diet from either SBM or crystalline source as L-Lys HCL (CLys) in place of cornstarch. Diets were formulated to be limited only in SID Lys, and the other AA were calculated to meet requirements (NRC, 1998). Crystalline Trp, Met, and Thr were added to the experimental diets to meet the requirements for those AA.

Response Criteria

Pigs and feeders were weighed at the beginning of each 4-wk trial and weekly thereafter to determine ADG, ADFI, and G:F. The SID Lys intake was estimated on the basis of ADFI and analyzed Lys concentration of the diets. The amount of Lys per kilogram of BW gain was also calculated. At the end of the trials, all pigs were scanned at the 10th rib using real-time ultrasound to measure back fat thickness and LM area. These measurements were used to calculate the fat-free lean gain (**FFLG**) using the National Pork Producers Council's (2000) equation.

In each experiment, blood samples were taken from each pig weekly (wk 1, 2, 3, and 4). Blood samples were collected from a jugular vein by venipuncture into 10-mL heparinized tubes and placed in ice. Plasma was separated on the day of collection by centrifugation (2,000 × *g* for 20 min at 4°C) and frozen at -20°C until analysis for plasma urea N (**PUN**).

Chemical Analysis

Diet samples were ground through a 1-mm screen and analyzed in duplicate for CP and AA concentrations (regular and sulfur content) according to the procedures of AOAC (1990). The CP content (N × 6.25) was determined with a Kjeltec apparatus (method 990.03; AOAC, 1990). To determine AA composition (method 994.12; AOAC, 1990), with the exception of sulfur AA, diets were hydrolyzed for 20 h (6 *N* HCl) at 110°C (Moore and Stein, 1963). Amino acids were separated using ion exchange chromatography. The AA analyzer contained a cation exchange column, and AA were eluted by a gradient of Li buffers. After elution from the column, the AA were quantified fluorometrically using *o*-phthalaldehyde as the derivatization reagent. Sulfur- containing AA (Met and Cys) were determined by ion exchange chromatography of acid hydrolyzate samples that had been preoxidized with performic acid (method 985.28; AOAC, 1990). Plasma samples were analyzed for PUN using the diacetylmonoxime method of Marsh et al. (1965).

Table 1. Composition of experimental diets (as-fed basis)

	Diets[1]						
	Basal,	CLys			SBM		
Item	0.48%	0.56%	0.65%	0.74%	0.56%	0.65%	0.74%
Ingredient, %							
Corn	52.44	52.44	52.44	52.44	52.44	52.44	52.44
Cornstarch	13.00	12.61	12.24	11.86	9.64	6.33	2.98
Soybean meal, 46.5% CP	7.50	7.50	7.50	7.50	10.80	14.10	17.40
Sunflower meal, dehulled	21.50	21.50	21.50	21.50	21.50	21.50	21.50
Tallow	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Dicalcium phosphate	2.20	2.20	2.20	2.20	2.10	1.95	1.85
Limestone	0.47	0.47	0.47	0.47	0.50	0.55	0.57
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin mix[2]	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Trace mineral mix[3]	0.15	0.15	0.15	0.15	0.15	0.15	0.15
L-Lys HCL	—	0.13	0.26	0.39	—	—	—
L-Trp	0.06	0.08	0.12	0.14	0.06	0.07	0.08
L-Thr	0.11	0.23	0.33	0.46	0.17	0.21	0.28
DL-Met	0.07	0.19	0.29	0.39	0.14	0.20	0.25
Energy and nutrient composition							
CP,[4] %	14.51	14.83	15.61	15.73	16.20	18.15	19.49
Total Lys,[4] %	0.56	0.64	0.75	0.84	0.64	0.75	0.84
SID Lys,[5,6] %	0.48	0.56	0.65	0.74	0.56	0.65	0.74
Ca,[5] %	0.70	0.70	0.70	0.70	0.70	0.70	0.70
P,[5] %	0.60	0.60	0.60	0.60	0.60	0.60	0.60
ME,[5] kcal/kg	3030	3014	2999	2983	3008	2987	2964

[1]Basal: Lys concentration provided by corn, soybean meal, and dehulled sunflower meal; CLys: basal diet supplemented with additional Lys from L-Lys HCL (78% Lys); SBM: basal diet supplemented with additional Lys from soybean meal. The percentages given for each diet indicate the amount of Lys.

[2]Supplied per kilogram of complete diet: vitamin A as retinyl acetate, 5,500 IU; vitamin D_3 as cholecalciferol, 550 IU; vitamin E as dl-α-tocopheryl acetate, 30 IU; vitamin K as menadione sodium bisulfate, 4.4 mg; riboflavin, 11 mg; d-pantothenic acid as d-calcium pantothenate, 22.05 mg; niacin, 30 mg; choline as choline chloride, 77 mg; cyanocobalamin (vitamin B12), 33.0 µg.

[3]Supplied per kilogram of complete diet: Cu (as $CuSO_4\cdot 5H_2O$), 10.5 mg; I [as $Ca(IO_3)\cdot H_2O$], 0.26 mg; Zn (as ZnO), 125 mg; Fe (as $FeSO_4\cdot H_2O$), 125 mg; Mn (as MnO), 30 mg; Se (as Na_2SeO_3), 0.3 mg.

[4]Analyzed composition.

[5]Calculated composition.

[6]SID: standardized ileal digestible.

Statistical Analysis

Data for growth variables (ADFI, ADG, and G:F) and PUN were analyzed as a split-plot experiment in a randomized complete block design (Kuehl, 2000) with repeated measurements in time on the same experimental unit using the MIXED procedure (SAS Inst. Inc., Cary, NC; Littell et al., 1996). The whole plot consisted of the combination of diet, sex, and FM, with week as the subplot. Data for carcass traits were analyzed as a randomized complete block design without repeated measurements. The block for both analyses was considered as the combination between the 2 trials and the 2 rooms. The pen was considered as the experimental unit. Orthogonal contrasts were used to compare diets. The contrasts were basal diet vs. the other diets and comparisons between the 2 sources of Lys (CLys vs. SBM) at 3 SID Lys concentrations of 0.56%, 0.65%, and 0.74%, respectively. Linear and quadratic effects of Lys concentration were tested using the slope ratio approach (Littell et al., 1997). The quadratic effects were not significant ($P > 0.10$) and were not included in the final model.

RESULTS

The main effect of diet on growth performance, carcass traits, Lys intake, and PUN of pigs for each diet is presented in Table 3. Final BW was affected by dietary Lys concentration ($P < 0.01$). Pigs fed the basal diet had the lowest final BW ($P < 0.01$). However, pigs fed CLys and pigs fed Lys from SBM were not different in final BW, ADG, ADFI, and G:F at the same dietary Lys concentration. This response was independent of FM and sex. The ADG and G:F increased linearly as dietary SID Lys concentration increased ($P < 0.01$). The SID Lys intake increased linearly ($P < 0.01$) with dietary Lys concentration and was not different when comparing pigs fed diets with CLys and those fed SBM (7.13 vs. 7.09, 8.87 vs. 9.11, 9.91 vs. 9.62 g/d at 0.56%, 0.65%, and 0.74% SID

Table 2. Calculated standardized ileal digestible (SID, %) AA composition of experimental diets (as-fed basis)

Item	Basal, 0.48%	CLys 0.56%	CLys 0.65%	CLys 0.74%	SBM 0.56%	SBM 0.65%	SBM 0.74%
	Diet[1]						
AA, %							
Arg	0.80	0.81	0.85	0.82	0.89	1.02	1.04
His	0.28	0.29	0.30	0.30	0.31	0.36	0.37
Ile	0.40	0.43	0.44	0.43	0.47	0.55	0.57
Leu	1.01	1.02	1.04	1.01	1.07	1.23	1.32
Lys	0.48	0.56	0.65	0.74	0.56	0.65	0.74
Met + Cys	0.55	0.67	0.74	0.83	0.64	0.72	0.81
Phe + Tyr	0.84	0.86	0.87	0.85	0.94	1.07	1.15
Thr	0.54	0.64	0.73	0.85	0.65	0.71	0.78
Trp	0.17	0.20	0.23	0.26	0.20	0.23	0.26
Val	0.49	0.53	0.54	0.52	0.56	0.64	0.67
Calculated AA ratios (Lys = 100)							
Arg	163	145	131	112	168	165	155
His	57	52	46	41	58	58	55
Ile	82	77	68	59	89	89	85
Leu	206	182	160	138	202	198	197
Met + Cys	112	120	114	114	121	116	121
Phe + Tyr	171	154	134	116	177	173	172
Thr	110	114	112	116	123	115	116
Trp	35	36	35	36	38	37	39
Val	100	95	83	71	106	103	100

[1]Basal: Lys concentration provided by corn, soybean meal, and dehulled sunflower meal; CLys: basal diet supplemented with additional Lys from L-Lys HCL (78% Lys); SBM: basal diet supplemented with additional Lys from soybean meal. The percentages given for each diet indicate the amount of Lys.

Lys, respectively). The amount of SID Lys required per unit of growth or BW gain increased linearly (about 13 to 15.5 g/kg) in pigs fed either CLys or SBM Lys; however, there were no differences between Lys sources. Overall, pigs fed diets supplemented with CLys were not different in growth performance with respect to pigs fed diets supplemented with Lys from SBM. Back fat thickness was not different among pigs offered dietary treatments regardless of FM and sex. A linear increase ($P < 0.01$) in LM area as the Lys concentration increased was observed in pigs fed CLys or SBM Lys. There were no differences in LM area in pigs fed CLys or SBM Lys at the 0.56% and 0.65% SID Lys concentrations. However, pigs fed the diet supplemented with 0.39% CLys (0.74% SID Lys) had 1.03 cm^2 greater ($P < 0.05$) LM area than pigs fed the same percentage of Lys from SBM. In addition, FFLG increased linearly ($P < 0.01$) as the dietary Lys concentrations increased (CLys or SBM supplemented diets). Pigs fed diets supplemented with CLys had less ($P < 0.001$) PUN than pigs fed diets supplemented with Lys from SBM (Table 3).

The main effect of FM on growth performance, carcass traits, Lys intake, and PUN of pigs fed individually or in a group is presented in Table 4. Pigs fed individually had a greater ADG and ADFI ($P < 0.05$) than pigs fed in groups; however, FM did not affect G:F. The intake of SID Lys was greater ($P < 0.05$) in pigs fed individually vs. pigs fed in groups. There was no effect of FM on carcass traits. The PUN was not affected by FM either; however, a diet × FM interaction ($P < 0.01$) was a reflection that pigs fed individually with CLys had decreased PUN compared with pigs fed individually with Lys from SBM (Table 5). In addition, a sex × FM interaction (data not shown) indicated that barrows that were fed individually had less ($P < 0.01$) PUN than gilts (26.75 vs. 29.32 g/100 mL) regardless of dietary Lys source or dietary Lys concentration.

Table 3. Effect of diet on growth performance, standardized ileal digestible (SID) Lys intake, carcass traits, and plasma urea N (PUN) of pigs fed crystalline (CLys) or soybean meal (SBM) Lys

Item	Basal, 0.48%	CLys 0.56%	CLys 0.65%	CLys 0.74%	SBM 0.56%	SBM 0.65%	SBM 0.74%	SE	P-value Diet	Contrasts[2] 1	Contrasts[2] 2	Contrasts[2] 3	Linear[3]
	Diet[1]												
Initial BW, kg	18.71	18.50	18.72	18.37	18.36	19.00	18.45	0.35	0.84	0.77	0.57	0.87	0.97
Final BW, kg	32.43	33.46	35.89	36.51	32.69	36.63	36.18	1.00	<0.01	0.45	0.47	0.74	<0.01
ADG, kg	0.48	0.52	0.60	0.64	0.52	0.62	0.62	0.02	<0.01	0.75	0.62	0.66	<0.01
ADFI, kg	1.29	1.28	1.36	1.36	1.29	1.39	1.32	0.04	0.38	0.87	0.56	0.51	0.98
G:F, kg/kg	0.38	0.41	0.45	0.49	0.40	0.44	0.49	0.01	<0.01	0.36	0.65	0.84	<0.01
SID Lys intake, g/d	6.30	7.13	8.87	9.91	7.09	9.11	9.62	0.26	<0.01	0.91	0.51	0.43	<0.01
SID Lys/BW gain, g/kg	13.13	13.70	14.78	15.48	13.63	14.69	15.52	0.50	0.52	0.67	0.57	0.54	<0.01
Back fat, cm	1.03	1.03	1.00	0.97	0.99	1.02	0.94	0.04	0.30	0.47	0.82	0.42	0.11
LM area, cm^2	12.14	13.45	14.40	15.72	12.81	14.28	14.69	0.31	<0.01	0.14	0.80	<0.05	<0.01
FFLG,[4] g/d	200	233	269	302	221	270	287	6.36	<0.01	0.20	0.87	0.10	<0.01
PUN, g/100 mL	32.11	25.71	20.94	14.98	30.58	35.38	36.63	0.82	<0.01	<0.01	<0.01	<0.01	<0.01

[1]Basal: Lys concentration provided by corn, soybean meal, and dehulled sunflower meal; CLys: basal diet supplemented with additional Lys from of L-Lys HCL (78% Lys); SBM: basal diet supplemented with additional Lys from soybean meal. The percentages given for each diet indicate the amount of Lys.

[2]Contrast: 1 = CLys vs. SBM at 0.56%; 2 = CLys vs. SBM at 0.65% Lys; 3 = CLys vs. SBM at 0.74% Lys.

[3]Linear effect of Lys concentration.

[4]FFLG = fat-free lean gain calculated using the National Pork Producers Council's (2000) equation.

There was no sex effect on growth performance characteristics (Table 6). However, gilts had a greater ($P < 0.01$) LM area and FFLG than barrows. There was trend for a diet × sex interaction ($P = 0.07$) because gilts had greater FFLG than barrows when fed CLys (data not shown).

DISCUSSION

Results indicated no differences in growth performance and carcass traits of pigs fed Lys-deficient diets supplemented with CLys or SBM in growing pigs between 18.6 and 34.8 kg BW. As expected, pigs fed the basal diet had the lowest final BW, ADG, and G:F. These similar responses in ADG, G:F, and SID Lys intake to supplemental Lys from CLys and SBM indicated that diets were limiting in Lys according to SID values calculated for the experimental diets and the NRC (1998) estimate of SID Lys requirement for 20- to 50-kg pigs of 0.83% (15.3 g/d). The linear effect of dietary Lys concentration on ADG and G:F is in agreement with the increasing intake of SID Lys from CLys or SBM diets and allows the estimation of the amount of SID Lys required per unit of BW gain for each source of Lys. The intakes of SID Lys are close to those reported by Libao-Mercado et al. (2006) with values of 4.8 to 7.7 g/d in growing pigs fed diets limiting in Lys. In addition, in the present study estimates of SID Lys/kg BW gain had values that were very close in range for both sources of Lys (13.70 vs. 13.63, 14.78 vs. 14.69, and 15.48 vs. 15.52 g/kg at 0.56%, 0.65%, and 0.74% SID Lys, respectively). These values agree with the report of Schneider et al. (2010), who indicated that at least 13.0 and 14.20 g of SID Lys per kilogram of BW gain appear to be required to maximize growth and G:F. However, in our study, a maximum amount of SID Lys/kg BW cannot be established. Dietary treatments did not affect ADFI, indicating that Lys source or concentration did not affect feed intake. This is in agreement with the results of Roux et al. (2011), who reported that ADFI was not affected by supplemental Lys addition from a crystalline source in diets fed to 20- to 45-kg pigs. Lopez et al. (1994) evaluated a group of gilts from 71 to 102 kg in a thermoneutral environment and fed control and ideal diets, in which Lys concentration was limiting (0.65%), and reported that ADFI was not different for gilts fed the intact diet compared with gilts fed the ideal protein diet. Fuller et al. (1986) reported that the amount of feed required per kilogram of carcass weight gain, or per kilogram of lean tissue gain, was not affected by the source of Lys (SBM vs. L-Lys HCL).

Table 4. Effect of feeding method (FM) on growth performance, carcass traits, standardized ileal digestible (SID) Lys intake, and plasma urea N (PUN)

Item	Individual[1]	Group[2]	SE	*P*-value FM	*P*-value Diet × FM
Initial BW, kg	18.59	18.58	0.19	0.97	0.80
Final BW, kg	35.18	34.47	0.38	0.19	0.67
ADG, kg	0.59	0.57	0.01	<0.05	0.84
ADFI, kg	1.36	1.29	0.22	<0.05	0.97
G:F, kg/kg	0.43	0.44	0.01	0.28	0.80
SID Lys intake, g/d	8.51	8.06	0.14	<0.05	0.96
SID Lys/BW gain, g/kg	14.42	14.65	0.11	0.28	0.56
Back fat, cm	1.00	0.98	0.16	0.29	0.24
LM area, cm^2	14.04	13.82	0.16	0.34	0.72
FFLG,[3] g/d	259	251	3.41	0.11	0.88
PUN, mg/100 mL	28.04	28.06	0.45	0.97	0.01

[1]Mean of 14 pigs individually penned used in each feeding trial.

[2]Mean of 42 pigs in 14 pens with 3 pigs/pen used in each feeding trial.

[3]FFLG = fat-free lean gain calculated using the National Pork Producers Council's (2000) equation.

Feed intake was not different between barrows and gilts, which agrees with previous studies (Cromwell et al., 1993; Fuller et al., 1995), indicating that differences in feed intake between barrows and gilts are of practical importance when pigs reach a weight of 35 kg or greater. Under the ad libitum feeding conditions used in the present study, it appears that CLys is utilized as efficiently as SBM-bound Lys for growth traits, as demonstrated previously in nursery pigs (Colina et al., 2010). Also, Gahl et al. (1995) evaluated BW gain in barrows fed supplemental Lys from SBM, SBM + l-Lys, or SBM + corn gluten meal and showed no differences among sources over a wider range of dietary Lys concentrations than those used in the current experiment. It is likely that

Table 5. Effect of diet and feeding method (FM) interaction on plasma urea N (PUN) of pigs individually fed or fed in groups with crystalline (CLys) or soybean meal (SBM) Lys

Item	Diet[1] Basal, 0.48%	CLys 0.56%	CLys 0.65%	CLys 0.74%	SBM 0.56%	SBM 0.65%	SBM 0.74%	SE	*P*-value Diet	*P*-value FM	*P*-value Diet × FM
PUN, g/100 mL								1.19	0.01	0.97	0.01
Individual[2]	31.26	27.87	20.94	13.50	28.75	36.38	37.60				
Group[3]	32.96	23.56	20.94	16.50	32.40	34.38	35.70				

[1]Basal: Lys concentration provided by corn, soybean meal, and dehulled sunflower meal; CLys: basal diet supplemented with additional Lys from l-Lys HCL (78% Lys); SBM: basal diet supplemented with additional Lys from soybean meal. The percentages given for each diet indicate the amount of Lys.

[2]Mean of 14 pigs individually penned used in each feeding trial.

[3]Mean of 42 pigs in 14 pens with 3 pigs/pen used in each feeding trial.

Table 6. Effect of sex on growth performance, standardized ileal digestible (SID) intake, carcass traits, and PUN

Item	Barows[1]	Gilts[2]	SE	*P*-value Sex	Diet × sex
Initial BW, kg	18.67	18.51	0.19	0.57	0.88
Final BW, kg	34.95	34.70	0.38	0.64	0.60
ADG, kg	0.57	0.57	0.01	0.85	0.61
ADFI, kg	1.32	1.33	0.22	0.74	0.65
G:F, kg/kg	0.44	0.44	0.01	0.82	0.49
SID Lys intake, g/d	8.26	8.31	0.14	0.77	0.71
SID Lys/BW gain, g/kg	14.49	14.58	0.12	0.59	0.63
Back fat, cm	1.01	0.98	0.02	0.15	0.35
LM area, cm^2	13.58	14.28	0.16	<0.01	0.61
FFLG,[3] g/d	245	264	3.42	<0.01	0.07
PUN, mg/100 mL	27.40	28.70	0.44	<0.05	0.16

[1]Mean of 56 barrows used in each trial.

[2]Mean of 56 gilts used in each trial.

[3]FFLG = fat-free lean gain calculated using the National Pork Producers Council's (2000) equation.

a balanced supply of AA is absorbed with frequent feeding, leading to similar rates of oxidation of excess of AA from diets containing either CLys or protein-bound Lys (Batterham and Bayley, 1989). Fuller et al. (1986) and Shelton et al. (2001) compared the response of growing pigs to dietary Lys supplied from SBM or Lys HCl. Results of those experiments indicated that pigs fed SBM had greater ADG and improved G:F. However, these differences between the 2 sources of Lys may be attributable to differences in gut fill because the differences were not detected on the basis of carcass weight (Fuller et al., 1986).

The similar growth response to supplemental Lys from CLys or SBM between barrows and gilts indicates that when Lys is limiting in the diet, barrows and gilts utilize it similarly for growth regardless of the source of dietary Lys. This is in agreement with the review of Susenbeth (1995), who concluded that when Lys is first limiting, Lys utilization is not different between barrows and gilts. Other researchers (Easter and Baker, 1980; Dourmad et al., 1996) have shown that the relationships between dietary Lys and ADG or G:F are similar for both sexes. Hyun et al. (1997) reported that although barrows had a greater number of meals per day with increasing dietary Lys concentrations, feed intake was similar to that of gilts. Also, Yi et al. (2006) and Hill et al. (2007) reported similar G:F in young barrows and gilts (11 to 26 kg and 6 to 19 kg, respectively).

The greater ADFI in pigs fed individually has been reported in other studies (Gómez et al., 2000; O'Doherty and McKeon, 2000; Ferguson et al., 2001). The decreased ADFI in pigs penned in groups resulted in a concomitant decrease in ADG when compared with pigs housed individually. The reduced feed intake also implies a reduction in Lys intake in pigs fed in groups. Brumm and Miller (1996) showed no space × diet interaction, indicating that the reduction in ADG associated with the reduction in ADFI for pigs given less space is independent of dietary Lys concentrations. The explanation for less feed intake in group-penned pigs used in the present experiment may be related to feeder design and the number of pigs/pen, which reduced the space/pig in the pens with 3 pigs and the same 1-hole feeder that was used for pigs fed individually. Young and Lawrence (1994) indicated that an increase in nonfeeding visits to the feeder may result from pigs being physically displaced from the feeder because of the social hierarchy. Also, when pigs are fed in groups, they may show willingness to wait and avoid competition for the feeder, which has been associated with a reduction in ADG (Gómez et al., 2000).

Some studies have reported similar response in carcass traits of pigs fed L-Lys HCL or SBM-supplemented diets (Stahly et al., 1979; Lopez et al., 1994; Myer et al., 1996; De la Llata et al., 2002). Back fat thickness was not different among pigs fed the dietary treatments, indicating that fat deposition did not change in response to Lys source, Lys concentration, sex, and FM. Results of other experiments have indicated that there were no effects of dietary Lys concentration and source of Lys on back fat thickness (Stahly et al., 1979) or no differences in back fat thickness with increasing Lys concentration or excess of protein in barrows and gilts (Chen et al., 1999).

Differences in LM area between pigs fed CLys and pigs fed SBM-supplemented diets at the greatest dietary Lys concentration may be attributed to the observed greater FFLG of pigs fed CLys (0.74% SID Lys) as Lys approached the requirement of 0.83% (NRC, 1998). The improved FFLG and LM area in gilts, compared with barrows, may be related to a greater potential for lean tissue growth in gilts regardless of the dietary source of Lys. Although barrows and gilts had similar growth rates when fed the CLys or SBM-supplemented diets, gilts had greater FFLG than barrows. Thus, the results of FFLG in the present study indicate that barrows and gilts respond differently to increased concentrations of dietary Lys. Cromwell et al. (1993), Henry (1993), and Thompson et al. (1996) showed that gilts are leaner and require a greater dietary Lys concentration than barrows.

In the present study, it was observed that increasing dietary Lys concentration affected LM area and FFLG regardless of dietary Lys source. This observation is supported by the research of Lopez et al. (1994), who reported a large effect of dietary Lys on LM area, which increased in gilts fed 1.0% dietary Lys compared with those fed 0.6% Lys and was independent of the source of dietary Lys used (CLys or protein bound).

A reduction in PUN has been previously documented in pigs fed CLys (Lopez et al., 1994; Gómez et al., 2002; Colina et al., 2010; Roux et al., 2011). The decrease in PUN for pigs fed diets with increasing additions of L-Lys HCL indicated that Lys was deficient throughout the range of diets fed. A reduction in PUN has been previously associated with feeding graded levels of CLys (Roux et al., 2011). The increased PUN in pigs fed the SBM-supplemented diets reflected the greater CP content in these diets that occurred as the dietary Lys concentrations increased. The excess absorbed AA are catabolized, and the resulting N is excreted as urea. It seems that the increased urea synthesis and plasma urea concentrations caused by high-protein diets are a function of both liver weight and urea cycle enzyme activity (Chen et al., 1999). Pigs fed low-protein AA-supplemented diets have reduced PUN (Cai et al., 1996; 1996; Gómez et al., 2002; Roux et al., 2011). Lopez et al. (1994) reported less PUN in pigs fed ideal protein diets vs. diets formulated exclusively using corn and SBM. Roux et al. (2011) showed that PUN decreased as the Lys concentration in the diet increased (approaching the requirement) in growing pigs fed diets supplemented with graded amount of CLys.

The diet × FM interaction for PUN indicated that pigs fed individually with dietary Lys from the CLys source had reduced PUN compared with pigs fed individually with Lys from SBM. The greater feed intake in pigs fed individually compared with pigs fed in groups indicates that the concomitant increase in CP intake was responsible for the increased PUN of individually fed pigs consuming the CLys vs. SBM-supplemented diets.

Gómez et al. (2000) did not report any differences in PUN between gilts penned individually or in groups; however, these authors did not consider sex effect, and pigs were evaluated between 46 and 118 kg BW. Others (Chen et al., 1999) have reported greater PUN in barrows than in gilts that were also heavier (63 to 105 kg BW) and were fed diets with excess protein. These factors probably explain the differences with this research, in which pigs were 18 to 36 kg BW in both sexes, two different FM, and diets were limiting in Lys. The sex × FM interaction for PUN showed that barrows fed individually had less PUN than gilts, which indicates that barrows had improved N retention compared with gilts when they were fed individually; however, ADFI and SID Lys intake were not different between sexes. Also, in the present study, the FM effect on ADFI indicated that pigs fed individually consumed more feed independent of sex, which indicates differences in PUN between barrows and gilts cannot be attributed to sex alone. Therefore, decreased PUN in barrows may be related to an improved efficiency of dietary N use (Cai et al., 1996) when they are fed individually in comparison with gilts.

This experiment demonstrated that when pigs are given ad libitum access to feed, there were no differences in growth performance and carcass traits between pigs fed diets supplemented with CLys and Lys from SBM. This result is supported by the amount of SID Lys required per unit of growth or BW gain, which increased linearly (about 13 to 15.50 g/kg) in pigs fed either CLys or SBM Lys. On the other hand, barrows and gilts had similar increases in growth as Lys concentration increased regardless of dietary Lys source, although gilts had a greater FFLG than barrows. Apparently, the greater ADFI and ADG of pigs fed individually, compared with group-fed pigs, are independent of dietary Lys and sex. Accordingly, the response in growth and carcass traits reported in this study indicated that CLys and Lys from SBM are used similarly regardless of sex or FM.

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