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M.S. Carlson
South Dakota State University

G.W. Libal
South Dakota State University

C.R. Hamilton
South Dakota State University

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Effect of added lysine to starter diets containing primarily zein protein and formulated to provide .14% tryptophan

M.S. Carlson, G.W. Libal, and C.R. Hamilton
Department of Animal and Range Sciences

SDSU

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Corn gluten meal (CGM) is a by-product of the wet milling of corn. It is the residue that remains after the bran, germ and starch have been removed and may contain either 41 or 60% crude protein. There is a temptation to use CGM as an alternative to soybean meal (SBM) when the cost of SBM is high. The 60% protein CGM contains a greater quantity of protein and more threonine, sulfur amino acids, and other neutral amino acids than 44% protein SBM. However, SBM contains greater amounts of lysine and tryptophan. Previous studies with growing and finishing swine indicated that tryptophan is limiting in diets containing CGM, even though the diets were formulated to meet the requirements for tryptophan established by the NRC (1988). The objective of this study was to determine if feed intake is maintained for 10- to 20 kg pigs fed low protein diets containing CGM if crystalline L-lysine-HCL (L-LYS) is added to meet the lysine requirement.

(Key Words: Nursery pigs, Lysine, Tryptophan, Corn gluten meal.)

Experimental Procedure

Seventy-two crossbred nursery pigs weaned at approximately 28 days of age were fed a 20% edible whey pretreatment diet (Table 1) containing corn and soybean meal (SBM) to an average weight of 10.82 kg. Pigs were stratified by weight, sex, and ancestry and allotted to dietary treatments for the 21-day study. Pigs were housed four per pen with raised plastic flooring in an environment-modified nursery. The experiment was a complete block design with six dietary treatments with three replications (weight blocks). A corn-CGM-SBM diet formulated to provide .14% TRP and .50% LYS was used as a basal diet (Table 1) to which 0, .15, .30, or .45% lysine was added as crystalline L-LYS to produce four dietary treatments. In addition, two corn-SBM diets not containing CGM were used as reference diets (Table 1). Both reference diets were formulated to provide the same levels of TRP (.14%) and LYS (.50%) from corn and SBM as the basal diet containing CGM. Crystalline LYS was added to the positive reference diet (+REF; .95% total LYS) while no L-LYS was added to the negative reference diet (-REF; .50% total LYS). Crystalline amino acids, sources of vitamins and trace minerals, and ground corn were mixed together and added to the diet as a premix. All experimental diets (Table 2) were formulated to contain .14% TRP and with the exception of LYS met or exceeded all nutrient requirements established for 10- to 20 kg pigs (NRC, 1988).

The dietary treatments were as follows:

- Corn-CGM-SBM diet formulated for .14% TRP and .50% LYS with 0% added L-LYS
- As 1 with .15% added L-LYS
- As 1 with .30% added L-LYS
- As 1 with .45% added L-LYS
- Corn-SBM diet formulated for .14% TRP and .50% LYS with 0% added L-LYS (-REF)
- As 5 with .45% added L-LYS (+REF).

Feed samples were collected, pooled by treatment, and ground using a Wiley mill fitted with a 1-mm screen. Crude protein was determined using a mercury catalyst and semi-automatic Kjeldahl procedures. Lysine concentrations were determined after acid hydrolysis of diet samples and quantified using HPLC methods.

On day 14, nursery pigs were restrained in a V-trough and bled via anterior vena cava puncture. Plasma urea nitrogen concentrations were determined colorimetrically and the concentration of total (bound + free) amino acids was determined in deproteinated plasma by HPLC methodology.

Data were analyzed as a complete block design. Pens and individual pigs were used as the experimental units for performance data and blood analyses, respectively. Orthogonal contrasts were used to test for linear, quadratic, and cubic effects of L-LYS additions within the CGM diets as well as between -REF and the CGM diet containing 0% L-LYS addition and between +REF and the CGM

diet with .45% L-LYS addition. Probability level accepted as significant was P<.10.

Results and Discussion

Adding increasing concentrations of L-LYS to the CGM basal diet had a quadratic effect (P=.01) on ADG each individual week and for the overall 21-day period (Table 3). Gains increased as added lysine increased to .15% and declined as greater amounts of L-LYS were added to the CGM diets. For week 3 and the overall 21-day period, increasing additions of L-LYS had a quadratic effect (P=.02) on ADFI. A cubic effect (P=.01) during week 1 and a linear effect (P=.02) during week 2 were observed. As with ADG, the greatest overall ADFI was observed for pigs fed the CGM diet containing .15% added L-LYS with an intake of 801 g/day. Increasing dietary lysine concentrations resulted in a linear decrease in feed wastage (P=.08) during week 1 and tended (P=.16) to have the same effect for the overall 21-day period. During week 1 and for the overall 21-day period, gain/feed increased as added L-LYS increased to .15% and declined quadratically as greater amounts of lysine were added to the CGM diets (P=.01).

Performance results for pigs fed the corn-SBM diets and CGM diets containing similar lysine concentrations are shown in Table 4. Pigs fed the corn-SBM diets exhibited 26% (P=.10) and 47% (P=.05) greater overall ADG than pigs fed the CGM diets when the diets were formulated at .50% LYS and .95% LYS, respectively.

For the overall 21-day period, pigs fed either diet containing SBM had greater ADFI than those fed the CGM diet with similar concentrations of added L-LYS. Pigs fed the corn-SBM diet with 0% added L-LYS had a 16% increase in feed intake compared to pigs fed the 0% added L-LYS CGM diet (P=.08). Pigs fed the corn-SBM diet with .45% added L-LYS had an increase in feed intake of 23% over pigs fed the CGM diet containing a similar amount of added L-LYS (P=.06). Pigs fed the corn-SBM diet with 0% added L-LYS had less feed wastage (P=.02) than those fed the CGM diet with 0% added L-LYS during week 1 and through the overall 21-day period. Feed wastage was similar for pigs fed the CGM diet and the corn-SBM diet containing .45% added L-LYS (P>.1) for each period measured.

When pigs were fed either the corn-SBM diet or CGM diet containing 0% added L-LYS, efficiency of gain did not differ (P>.1) for any period. However, pigs fed the corn-SBM diet containing .45% added L-LYS had greater gain/feed than pigs fed the corresponding CGM diet during week 1 (P=.04) and overall (P=.05).

Selected amino acid and plasma urea nitrogen (PUN) concentrations of pigs fed the CGM diets are shown in Table 5. The PUN concentrations decreased quadratically (P=.08) as added L-LYS increased. The lowest concentrations of PUN were obtained for pigs fed .30% or more added L-LYS. There was a linear increase in plasma lysine concentrations with increasing additions of L-LYS to the diet (P=.0002). The large neutral amino acid (LNAA) pool (P=.0002) and specifically threonine (P=.004) decreased with increasing additions of L-LYS. Among pigs fed CGM diets, plasma TRP concentrations decreased quadratically as concentration of added L-LYS increased (P=.08).

Comparisons between corn-SBM diets and CGM diets with similar lysine levels are shown in Table 6. Pigs fed the CGM diets had higher PUN concentrations than pigs fed the corn-SBM diets at both levels of added L-LYS (P=.0001). Plasma concentrations of TRP and threonine for pigs fed the reference diets were similar (P>.1) to those for pigs fed CGM diets with similar concentrations of added L-LYS. However, the plasma LNAA pool was higher for pigs fed CGM diets than for those fed corn-SBM diets at 0% (P=.05) or .45% (P=.07) added L-LYS. Pigs fed the CGM diets with .45% L-LYS added had a lower (P=.0002) plasma LYS concentration (3.5 mg/dL) than pigs fed the corn-SBM diet with .45% L-LYS added (5.9 mg/dL). Plasma LYS concentrations of pigs fed the two diets with 0% added L-LYS were similar (P=.71).Increased gain and feed intake, reduced feed wastage, and improved feed efficiency suggest that .15% added L-LYS or a dietary lysine concentration of .65% is adequate for 10- to 20 kg pigs fed high-zein diets containing .14% tryptophan. Additional lysine supplied as L-LYS depressed ADFI, resulting in concomitant decreases in ADG and gain efficiency. However, a decrease in plasma urea nitrogen, tryptophan, threonine, and the LNAA pool with .30% added L-LYS suggests a total dietary lysine concentration of .80% to be the requirement for 10- to 20 kg pigs fed .14% tryptophan. Previous experiments involving linear additions of limiting amino acids have resulted in quadratic responses for gain and feed intake. Corn gluten meal is high in neutral amino acids, especially leucine. Neutral amino

acids compete with tryptophan for absorption, especially when tryptophan is limiting. The results of this experiment suggest that tryptophan may be limiting in CGM diets when greater than .15% L-LYS is added. The relative availability of TRP from CGM and SBM was not evaluated in this study. Pigs fed diets marginal in tryptophan are likely to waste feed. However, feed wastage has not been previously reported for diets in which lysine was limiting or in excess. Performance was numerically similar for pigs fed -REF and pigs fed CGM with .15% added L-LYS. This would suggest a lower availability of LYS from CGM than from SBM. However, this observation was not statistically tested within the pre-established orthogonal comparisons made in this study.

Summary

Seventy-two crossbred nursery pigs weaned at approximately 28 days of age were fed a 20% edible whey pretreatment diet containing corn and soybean meal to an average weight of 10.82 kg. They were then allotted to three replications of six dietary treatments (complete block design). A corn-CGM-SBM diet formulated to provide .14% TRP and .50% LYS was used as a basal diet to which 0, .15, .30, or .45% lysine was added as crystalline L-LYS to produce four dietary treatments. In addition, two corn-SBM diets not containing CGM were formulated to provide the same levels of TRP (.14%) and LYS (.50%) from corn and SBM as the basal diet containing CGM. Crystalline LYS was added to +REF (.95% total LYS) while no L-LYS was added to -REF (.50% total LYS).

Adding increasing concentrations of L-LYS to the CGM basal diet had a quadratic effect on ADG, ADFI, and gain/feed for the overall 21-day period. Gains increased as added lysine increased to .15% and declined as greater amounts of L-LYS were added to the CGM diets. The greatest overall ADFI was observed with .15% added L-LYS. Increasing dietary lysine concentrations resulted in a linear decrease in feed wastage during week 1 and tended to have the same effect for the overall 21-day period. Gain/feed increased as added L-LYS increased to .15% and declined as greater amounts of lysine were added to the CGM diets.

Pigs fed the corn-SBM diets exhibited greater overall ADG and ADFI than pigs fed the CGM diets when the diets were formulated at either .50% LYS or .95% LYS. Pigs fed the corn-SBM diet with 0% added L-LYS had less feed wastage than those fed the CGM diet with 0% added L-LYS. Feed wastage was similar for pigs fed the CGM diet and the corn-SBM diet containing .45% added L-LYS. When pigs were fed the corn-SBM diet and CGM diet containing 0% added L-LYS, efficiency of gain did not differ. However, pigs fed the corn-SBM diet containing .45% added L-LYS had greater gain/feed than pigs fed the corresponding CGM diet.

In the plasma, PUN concentrations decreased quadratically, the large neutral amino acid (LNAA) pool and threonine concentrations decreased linearly, and plasma TRP concentrations decreased quadratically for pigs fed CGM diets with increasing additions of L-LYS.

Pigs fed the CGM diets had higher PUN concentrations and a higher LNAA pool than pigs fed the corn-SBM diets at both levels of added L-LYS. Plasma concentrations of TRP and threonine for pigs fed the reference diets were similar to those for pigs fed CGM diets with the same levels of added L-LYS. Pigs fed the CGM diet with .45% added L-LYS had lower plasma LYS concentrations than pigs fed the corn-SBM diet with .45% added L-LYS. Plasma LYS concentrations of pigs fed the two diets with 0% added L-LYS were similar.

Implications

Young weaned pigs fed diets containing primarily zein protein formulated to a TRP content of .14% exhibited a LYS requirement between .65% and .80%. Higher levels of L-LYS added to the CGM diet resulted in decreased performance suggesting that another amino acid had become first limiting. It is logical to assume that TRP was the amino acid that was limiting. It is unclear from this experiment if the TRP and LYS in CGM were as available as that found in SBM.

TABLE 1. PERCENTAGE COMPOSITION OF EXPERIMENTAL DIETS (AS FED)

Main ingredients	Pretreatment	Basal	Reference
Ground corn	56.01	81.99	86.45
Soybean meal, 44%	21.22	7.63	9.69
Edible dried whey	20.00	–	–
Corn gluten meal	–	6.20	–
Dicalcium phosphate, 21%	1.37	1.59	1.58
Limestone	.65	.79	.78
White salt	.25	.25	.25
Dynamate[a]	–	.30	–
Premix[b]	.50	1.25	1.25
Total	100	100	100

		CGM diets				Reference	
		% added lysine				% added lysine	
Item	Pretreatment	0	.15	.30	.45	0	.45
L-lysine-HCl	1.50	0	1.92	3.84	5.77	0	5.77
L-threonine	0	0	0	0	0	.60	.60
DL-methionine	0	0	0	0	0	.15	.15

[a]Added as a source of potassium: Dynamate, feed grade double sulfate of magnesium and potassium manufactured by Pitman-Moore, Inc., contains .06% Ca, 18.0% K, 11.0% Mg, 22.0% S, and .76% Na.

[b]Provided per kg of complete diet: 100 mg Zn, 75 mg Fe, 7.5 mg Cu, 25 mg Mn, 175 :g I, 300 :g Se, 16.5 IU vitamin E, 3.3 mg riboflavin, 17.6 mg niacin, 13.2:g vitamin B_{12}, 2.2 mg vitamin K_3, 13.2 mg pantothenic acid, 3960 IU vitamin A, and 396 IU vitamin D_3.

TABLE 2. CALCULATED AND CHEMICALLY DETERMINED NUTRIENT COMPOSITION OF EXPERIMENTAL DIETS, %

Nutrient	Pretreatment	Basal	Reference
Calculated nutrient levels, as fed			
Protein	16.80	14.20	11.70
Calcium	.80	.70	.70
Phosphorus	.70	.60	.60
Potassium	.63	.49	.49
Lysine	1.10	.50	.50
Threonine	.74	.57	.56
Tryptophan	.22	.14	.14

Chemically determined nutrient levels, 90% DM	Crude protein	Lysine	Tryptophan
1. Corn-CGM-SBM basal	14.9	.50	.14
2. As diet 1 + .15% added L-LYS	15.2	.68	.14
3. As diet 1 + .30% added L-LYS	14.9	.74	.14
4. As diet 1 + .45% added L-LYS	15.3	.95	.14
5. Corn-SBM (-REF)	12.8	.53	.14
6. As diet 5 + .45% added L-LYS (+REF)	12.9	.91	.14

TABLE 3. EFFECT OF ADDED L-LYSINE TO CGM DIETS ON NURSERY PIG GROWTH PERFORMANCE

	Added L-lysine				
Criteria	0	.15	.30	.45	SE[a]
Daily gain, g/day					
Day 0 to 7[b]	173	228	165	93	31
Day 8 to 14[b]	202	283	251	168	32
Day 15 to 21[b]	252	386	248	228	37
Day 0 to 21[b]	209	299	221	163	28
Daily feed intake, g/day					
Day 0 to 7[c]	676	750	556	523	32
Day 8 to 14[e]	785	747	541	454	47
Day 15 to 21[b]	642	905	794	558	52
Day 0 to 21[b]	701	801	631	512	40
Feed wastage, g/day					
Day 0 to 7[d]	557	150	155	19	144
Day 8 to 14	170	25	138	193	80
Day 15 to 21	296	33	166	115	132
Day 0 to 21	341	70	153	109	81
Gain/feed					
Day 0 to 7[b]	.26	.31	.30	.18	.03
Day 8 to 14	.26	.38	.45	.37	.16
Day 15 to 21	.43	.44	.35	.42	.07
Day 0 to 21[b]	.30	.37	.35	.32	.01

[a]Standard error of the treatment mean for three observations per treatment.
[b]Quadratic response to added L-LYS (P=.02).
[c]Cubic response to added L-LYS (P=.01).
[d]Linear response to added L-LYS (P=.08).
[e]Linear response to added L-LYS (P=.02).

TABLE 4. EFFECT OF ADDED L-LYSINE TO CGM DIETS ON NURSERY PIG GROWTH PERFORMANCE COMPARISON WITH REFERENCE DIETS

	Added L-lysine						
	0%			.45%			
Criteria	REF[a]	CGM[b]	P=[c]	REF	CGM	P=	SE[d]
Daily gain, g/day							
Day 0 to 7	211	173	.39	171	93	.08	31
Day 8 to 14	293	202	.05	268	168	.03	32
Day 15 to 21	285	252	.52	279	228	.33	37
Day 0 to 21	263	209	.10	239	163	.05	28
Daily feed intake, g/day							
Day 0 to 7	739	676	.19	561	523	.42	32
Day 8 to 14	1067	785	.13	682	454	.21	121
Day 15 to 21	624	642	.94	650	558	.70	169
Day 0 to 21	810	701	.08	631	512	.06	40
Feed wastage, g/day							
Day 0 to 7	48	557	.03	22	19	.98	144
Day 8 to 14	40	170	.27	107	193	.46	80
Day 15 to 21	35	296	.19	256	115	.47	132
Day 0 to 21	41	341	.02	128	109	.87	81
Gain/feed							
Day 0 to 7	.29	.26	.58	.29	.18	.04	.03
Day 8 to 14	.29	.26	.93	.40	.37	.95	.30
Day 15 to 21	.62	.43	.35	.43	.42	.94	.13
Day 0 to 21	.32	.30	.37	.37	.32	.05	.01

[a]Reference (corn-soybean meal) diet.
[b]Corn gluten meal diet.
[c]Probability (P) value for contrasts comparing the reference and CGM treatments having similar amounts of L-LYS added.
[d]Standard error of the treatment mean for three observations per treatment.

TABLE 5. EFFECT OF ADDED L-LYSINE TO CGM DIETS ON PLASMA UREA NITROGEN AND AMINO ACID CONCENTRATIONS, MG/DL

	Added L-lysine, %				
Item	0	.15	.30	.45	SE[a]
Urea nitrogen[b]	20.70	18.00	15.50	15.70	.96
Large neutral amino acids[c]	14.70	14.50	12.00	11.40	.93
Tryptophan[b]	.68	.50	.17	.23	.07
Lysine[c]	1.00	1.70	2.80	3.50	.44
Threonine[d]	15.00	13.70	12.60	12.20	.89

[a]Standard error of the treatment mean for 12 observations per treatment.
[b]Quadratic response to added L-LYS (P=.08).
[c]Linear response to added L-LYS (P=.0002).
[d]Linear response to added L-LYS (P=.004).

TABLE 6. EFFECT OF ADDED L-LYSINE TO CGM DIETS ON PLASMA UREA NITROGEN AND AMINO ACID CONCENTRATION COMPARISONS WITH REFERENCE DIETS, MG/DL

	Added L-lysine						
	0%			.45%			
Period	REF[a]	CGM[b]	P=[c]	REF	CGM	P=	SE[d]
Urea nitrogen	13.60	20.70	.0001	10.20	15.70	.0001	.96
Large neutral AA	12.30	14.70	.05	9.10	11.40	.07	.93
Tryptophan	.80	.68	.28	.12	.23	.34	.07
Lysine	1.20	1.00	.71	5.90	3.50	.0002	.44
Threonine	16.50	15.00	.24	11.40	12.20	.54	.89

[a]Reference (corn-soybean meal) diet.
[b]Corn gluten meal diet.
[c]Probability (P) value for contrasts comparing the reference to CGM treatments having similar amounts of L-LYS added.
[d]Standard error of the treatment mean for 12 observations per treatment.