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1-1-2008

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Miller, Phillip S.; Moreno, Roman; Burkey, Thomas E.; and Johnson, Rodger K., "Estimation of the Lysine Requirements for High-Lean Growth Pigs" (2008). *Nebraska Swine Reports*. Paper 39.
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Estimation of the Lysine Requirements for High-Lean Growth Pigs

The lysine requirements (total basis) for high-lean growth potential barrows and gilts raised to maximize growth performance was 1.14, 1.04, 0.94, and 0.86% lysine, for Grower-1, 44 to 79 lb; Grower-2, 79 to 132 lb; Finisher-1, 132 to 189 lb; and Finisher-2, 189 to 260 lb, respectively.

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Summary

An experiment was conducted to determine the lysine regime required to maximize growth performance for high-lean-growth potential barrows and gilts beginning at 45 lb and concluding at approximately 260 lb. There were four growing-finishing phases and four lys treatments within phase (Grower-1, 44 lb to 79 lb; Grower-2, 79 lb to 132 lb; Finisher-1, 132 lb to 189 lb; and Finisher-2, 189lb to 260 lb). Dietary treatments were corn-soybean meal based supplemented with 0.15% crystalline lysine. The formulation of 2 dietary treatments was aimed to provide lysine below the requirement, while the other 2 dietary treatments provided lys above the requirement. The lysine regimen (requirement) to maximize growth performance of barrows and gilts appears to be approximated by 1.14%, 1.04%, 0.94%, and 0.86% total lysine, respectively, but greater dietary lysine concentrations (similar to the greatest lysine regimen) may be warranted to maximize carcass leanness. However, it should be noted that the highest lysine regimen (1.30, 1.20, 1.10, and 1.00%, respectively) may reduce feed intake and daily gain.

Introduction

Many studies have been conducted to investigate the amino acids requirements for growing-finishing pigs. Typically, these studies have focused on one specific phase of the growing-finishing period (i.e., 45 to 90 lb, 90 to 120 lb, etc). Often, information from a variety of these studies is collectively summarized to provide amino acid requirements for pigs throughout the growing-finishing period. An array of environmental and genetic factors have been documented to affect amino acid requirements for growing-finishing pigs and necessitate the periodic review and reassessment of amino acids requirements as management systems change and genetic selection for increased lean growth occurs. Therefore, the objective of this study was to define the lysine (lys) regimen (for the entire growing-finishing period) required for high lean-growth barrows and gilts.

Materials and Methods

Location and facilities

The experiment was conducted from December to April at the

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Table 1. Ingredients and calculated composition of the experimental diets, as-fed basis

	Phase 1				Phase2				Phase 3				Phase 4			
Ingredient (%)	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Corn	77.17	70.77	63.99	57.71	81.60	74.85	68.07	61.80	85.87	79.12	72.59	66.07	89.80	84.80	75.80	70.26
SBM, 47.5 % CP	17.35	23.75	30.50	36.75	13.45	20.00	26.75	33.00	9.25	16.00	22.50	29.00	5.50	10.50	19.50	25.00
Tallow	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Dicalcium phosphate	1.30	1.30	1.30	1.30	1.05	1.05	1.05	1.05	0.90	0.90	0.90	0.90	0.75	0.75	0.75	0.75
Limestone	0.88	0.88	0.88	0.88	0.80	0.80	0.80	0.80	0.78	0.78	0.78	0.78	0.75	0.75	0.75	0.75
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL-Methionine	0.00	0.00	0.03	0.06	0.00	0.00	0.03	0.05	0.00	0.00	0.03	0.05	0.00	0.00	0.00	0.04
L-Lysine · HCL	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix[a]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Trace mineral mix[b]	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Calculated composition																
lysine, %	0.80	0.97	1.14	1.30	0.70	0.87	1.04	1.20	0.60	0.77	0.94	1.10	0.50	0.63	0.86	1.00
CP, %	14.80	17.30	19.90	22.00	13.20	15.90	18.50	20.90	11.70	14.30	16.90	19.40	10.20	12.20	15.70	17.90
ME,[c] Mcal/lb	1.55	1.55	1.55	1.55	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
Calcium, %	0.70	0.72	0.74	0.76	0.60	0.63	0.65	0.67	0.55	0.57	0.59	0.61	0.50	0.51	0.54	0.56
Phosphorus, %	0.58	0.60	0.63	0.66	0.51	0.54	0.55	0.60	0.50	0.50	0.53	0.55	0.43	0.45	0.49	0.51
Lys:ME, g/Mcal	2.34	2.84	3.34	3.81	2.04	2.53	3.03	3.50	1.74	2.24	2.73	3.20	1.45	1.82	2.49	2.91
Met + Cys, %	0.52	0.59	0.66	0.79	0.48	0.55	0.65	0.74	0.44	0.51	0.60	0.70	0.40	0.45	0.55	0.64
Threonine, %	0.54	0.64	0.75	0.85	0.48	0.59	0.69	0.79	0.42	0.53	0.63	0.73	0.36	0.44	0.58	0.67
Tryptophan, %	0.16	0.20	0.24	0.27	0.14	0.17	0.21	0.25	0.11	0.15	0.19	0.23	0.09	0.12	0.17	0.20
Met+Cys:lys	0.65	0.60	0.60	0.60	0.68	0.63	0.62	0.61	0.73	0.66	0.63	0.63	0.80	0.71	0.64	0.64
Thr:lys	0.68	0.66	0.65	0.65	0.68	0.67	0.66	0.65	0.70	0.68	0.67	0.66	0.72	0.69	0.67	0.67
Trp:lys	0.20	0.20	0.21	0.20	0.20	0.19	0.20	0.20	0.18	0.19	0.20	0.20	0.18	0.19	0.19	0.20

[a]Supplied per kilogram of diet at 0.2% inclusion: 4,400 IU vitamin A as retinyl acetate; 440 IU vitamin D_3 as cholecalciferol; 24 IU vitamin E as α-tocopherol acetate; menadione sodium bisulfite, 3.5 mg; riboflavin, 8.8 mg; d-pantothenic acid, 17.6 mg; niacin, 26.4 mg; vitamin B_{12}, 26.4 mg.
[b]Supplied per kilogram of diet at 0.15% inclusion: Zn (as ZnS_4O), 128 mg; Fe (as $FeSO_4 \cdot H_2O$),128 mg; Mn (as MnO), 30 mg; Cu (as $CuSO_4 \cdot 5\ H_2O$), 11 mg; I (as $Ca(IO_3) \cdot H_2O$), 0.26 mg; Se (as Na_2SeO_3), 0.3 mg.
[c]ME = Metabolizable energy.

University of Nebraska Swine Research Unit located in Mead, NE. Pigs were housed in a 24-pen modified-open-front building equipped with automated environmental controls. Pens were 4 × 15 ft and flooring was half concrete half slotted. Each pen was equipped with one automatic feeder and one nipple waterer.

Animals

One hundred twenty barrows and gilts (NE index × Landrace) × Pietran were used in a 16-wk experiment. The average initial body weight (BW) was 44.5 lb and final BW was 260.8 lb. Three barrows and three gilts were placed in each of 20 pens, and there were five replicates for each of the four dietary treatments. All management and experimental procedures were approved by the Institutional Animal Care and Use Committee of the University of Nebraska–Lincoln.

Experimental diets

Pens were randomly assigned to one of four dietary treatments designed as follows: Four experimental diets were formulated to contain a complete lysine regimen fed during the entire growing-finishing period. There were four growing-finishing phases and four lys treatments within phase [Grower-1 (G1), 44 to 79 lb; Grower-2 (G2), 79 to 132; Finisher-1 (F1), 132 to 189 lb; and Finisher-2 (F2), 189 to 260 lb)]. Dietary treatments were corn-soybean meal based supplemented with 0.15% crystalline lysine. The formulation of 2 dietary treatments was aimed to provide lys below the estimated requirement, while the other two dietary treatments provided lys above the requirement. Other nutrient concentrations were formulated to meet or exceed allowances identified in the Nebraska-South Dakota Swine Nutrition Guide. The composition of dietary treatments is described in Table 1.

Data and sample collection

Pigs and feeders were weighed at the beginning of the experiment and biweekly thereafter. Pigs and feeders were also weighed at dietary phase changes. Feed disappearance was estimated by the difference between feed offered and feed remaining in the feeder. Average daily gain (ADG), average daily feed intake (ADFI) and ADG:ADFI (G:F) were estimated based on the individual biweekly BW and feed disappearance. Additionally, ultrasound measurements of 10th -rib backfat (BF), and longissimus muscle area (LMA) were conducted every 28 days.

Statistical analysis

Each pen was considered an experimental unit. The model was a completely randomized design and data were analyzed using a single-factor analysis of variance using the MIXED procedure (SAS Inst. Inc., Cary, N.C.). Pen effect was considered

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Table 2. Effect of lysine concentration on average daily gain (ADG), average daily feed intake (ADFI) and feed efficiency (G:F) of (NE index × Landrace) × Pietran pigs.

		Treatment					*P*-value		
Item		1	2	3	4	SEM[a]	Treatment	Linear	Quadratic
No. of pigs		30	30	30	30				
No. of pens		5	5	5	5				
Initial BW, lb		43.84	44.70	44.56	44.98	0.441	0.33	0.11	0.62
Final BW, lb		235.62	272.32	270.86	264.34	3.528	< 0.0001	< 0.0001	< 0.0001
Grower 1, week 0 to 3									
	ADG, lb	1.504	1.738	1.813	1.801	0.035	< 0.0001	< 0.0001	0.0032
	ADFI, lb	3.724	3.804	3.753	3.715	0.053	0.6344	0.7357	0.2794
	G:F, lb/lb	0.891	1.008	1.065	1.069	0.020	< 0.0001	< 0.0001	0.0098
Grower 2, week 4 to 6									
	ADG, lb	1.715	1.790	1.993	1.766	0.093	0.2076	0.4091	0.1252
	ADFI, lb	4.606	4.481	4.767	4.271	0.123	0.0682	0.2089	0.1544
	G:F, lb/lb	0.820	0.880	0.924	0.911	0.035	0.1833	0.0539	0.3151
Finisher 1, week 7 to 11									
	ADG, lb	1.599	1.956	2.185	1.956	0.115	0.0194	0.0228	0.0219
	ADFI, lb	5.852	6.125	6.258	5.513	0.161	0.0229	0.2353	0.0060
	G:F, lb/lb	0.602	0.708	0.770	0.781	0.044	0.0436	0.0083	0.3010
Finisher 2, week 12 to 16									
	ADG, lb	1.786	2.245	1.998	2.143	0.154	0.2141	0.2482	0.3248
	ADFI, lb	5.945	6.886	6.774	6.668	0.172	0.0056	0.0165	0.0076
	G:F, lb/lb	0.662	0.719	0.650	0.703	0.042	0.6142	0.7392	0.9721
Overall									
	ADG, lb	1.658	1.965	2.020	1.945	0.040	< 0.0001	< 0.0001	0.0002
	ADFI, lb	5.173	5.548	5.669	5.285	0.064	0.0001	0.1258	< 0.0001
	G:F, lb/lb	0.706	0.781	0.785	0.811	0.011	< 0.0001	< 0.0001	0.0533

[a]Standard error of the mean.

Table 3. Effect of lysine concentration on back fat (BF) and longissimus muscle area (LMA) of (NE index × Landrace) × Pietran pigs.

		Treatment					*P*-value		
Item		1	2	3	4	SEM[a]	Treatment	Linear	Quadratic
No. of pigs		30	30	30	30				
No. of pens		5	5	5	5				
Initial wt, lb		43.835	44.695	44.563	44.982	0.441	0.33	0.11	0.62
Final weight, lb		235.626	272.318	270.862	264.335	3.528	<0.0001	<0.0001	<0.0001
Initial, day 0									
	BF, in	0.260	0.252	0.248	0.260	0.004	0.6719	0.8268	0.4194
	LMA, in^2	1.113	1.170	1.096	1.149	0.026	0.2298	0.7856	0.9591
Final, day 112									
	BF, in	0.925	1.004	0.929	0.760	0.012	0.0038	0.0058	0.0061
	LMA, in^2	5.270	6.459	6.479	6.369	0.121	< 0.0001	< 0.0001	< 0.0001
Week 0 to 8									
	BF change, in	0.236	0.232	0.220	0.142	0.012	0.0004	0.0002	0.0157
	LMA change, in^2	2.113	2.641	2.843	2.571	0.099	0.0007	0.0026	0.0010
Week 9 to 16									
	BF change, in	0.425	0.508	0.457	0.354	0.031	0.0355	0.1078	0.0133
	LMA change, in^2	2.043	2.646	2.540	2.647	0.155	0.0417	0.0257	0.1303
Overall									
	BF change, in	0.661	0.744	0.681	0.496	0.035	0.0023	0.0047	0.0033
	LMA change, in^2	4.156	5.289	5.383	5.219	0.119	< 0.0001	<0.0001	< 0.0001

[a]Standard error of the mean.

random, and treatment was considered a fixed effect. In addition, orthogonal contrasts examining the linear and quadratic effect of lysine-feeding regime were evaluated.

Results and Discussion

The responses of ADG, ADFI, and G:F to lys regimen is shown in Table 2. Significance of treatment as well as linear and quadratic effects are also shown in Table 2. The response of BF and LMA change to lys regimens and the significance of treatment, linear and quadratic effect are shown in Table 3.

No treatment, linear, or quadratic effects were observed for initial BW (IBW; $P = 0.33$, $P = 0.11$, $P = 0.62$ respectively); however, lys regimen affected final weight (FW). The lightest FW was recorded for T1 while the

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greatest weight corresponded to pigs receiving T2. There was a slight reduction in the FW of T4 (264.3 lb) compared to T2 and T3 (272.3 and 270.9 lb, respectively).

Average daily gain was affected by lys regimen during G1 ($P < 0.0001$), and F1 phases ($P = 0.0194$); however, no differences among treatments were detected for phases G2 ($P = 0.2076$) and F2 ($P = 0.2141$). For the overall period, ADG was affected by lys regimen ($P < 0.0001$). Average daily gain responded linearly ($P < 0.0001$), and quadratically ($P = 0.0002$) to lysine regimen. For the overall period, the quadratic effect indicated that increased lys concentration resulted in an increase in ADG; however, ADG was maximized at dietary lys concentrations corresponding to T3 (2.02 lb) and a further increase in lys concentration resulted in a reduction in ADG for T4 (1.95 lb).

No treatment effect was recorded for ADFI during G1 ($P = 0.6344$) or G2 ($P = 0.0682$); however, there was an effect of lys regimen on ADFI during F1 ($P = 0.0229$) and F2 ($P = 0.0056$). The linear effect of lys regimen on ADFI was not significant for any of the feeding phases except for F2 ($P = 0.0165$). A quadratic effect of lysine regimen on ADFI for F1 and F2 ($P = 0.0060$, $P = 0.0076$ respectively) was observed. With respect to the overall experimental period lys regimen affected ADFI ($P = 0.0001$). A quadratic effect was detected ($P < 0.0001$) which was consistent with the reduction in ADFI resulting from feeding pigs diets with a lys concentration above those used in the T3 regimen.

Lysine regimen affected G:F. A quadratic effect of lys concentration on G:F for G1 ($P < 0.0001$) was observed; however, G:F was not affected by increasing concentrations of lys during feeding phases G2 and F2 ($P = 0.1833$, $P = 0.6142$ respectively). During F1, the increase in lys concentration resulted in a linear increase in G:F ($P = 0.0083$). For the overall period, G:F was linearly affected by increased lys concentration ($P < 0.0001$).

At the beginning of the experimental period, no difference among treatments was recorded for BF ($P = 0.8268$) or LMA ($P = 0.2298$; Table 3). Feeding different lys regimens affected both final BF ($P = 0.0038$) and LMA ($P < 0.0001$). For BF, the results were consistent with previous lysine-titration studies which showed that the lowest BF changes for the T4 treatment occurred during the first, and second halves of the experimental period and overall (0.14, 0.35, and 0.50 in, respectively). The same treatment (T4) also recorded the lowest final BF (0.76 in). The increments in BF change for T1 were the second lowest for the weeks 9 to 16 and for the overall experimental period (0.43 and 0.66 in respectively); however, during the first half of the experimental period, T1 showed the greatest increase in BF among all treatments (0.24 in) which was likely the result of deficient amounts of lys consumed by pigs receiving this treatment (Table 1). Backfat change during the second half of the experimental period ($P = 0.2076$) and during the overall period ($P = 0.0033$), responded quadratically to dietary lysine regimen. For the overall experimental period, the lowest BF change was for T4 and the greatest change was for T2 (0.50 and 0.74 in respectively). The response of BF to lys regimen suggests that the lys concentration required for minimum BF deposition is between T3 and T4 lys regimens. It appears that when the lys requirements are met for growth performance, further increase in dietary lysine result in decreased BF deposition. This agrees with the results from previous lysine-titration studies.

There was no difference in LMA among treatments at the beginning of the experiment ($P = 0.2298$). A significant effect of lys regimen on LMA change was recorded during both periods of the experiment and overall, ($P = 0.0007$, $P = 0.0417$, and $P < 0.0001$ respectively). The lowest change in LMA was observed for T1 during the 0 to 8 and 9 to 16 week periods as well as overall period (2.11, 2.04, and 4.16 in^2 respectively). The greatest change in LMA during the first half of the experiment corresponded to T3 (2.84 in^2); however, during the second half of the experimental period, the maximum increase in LMA was associated with the T4 treatment (2.65 in^2). The lowest LMA was observed for the T1 treatment at the end of the experimental period (5.27 in^2), while the greatest LMA was recorded for T3 (6.48 in^2). During the first half of the experimental period, as well as the overall period, lys concentration fed to growing finishing pigs had a quadratic effect on LMA change ($P = 0.0010$, and $P < 0.0001$ respectively). Again, in the latter part of the finishing period, dietary lysine concentrations needed to maximize muscle (protein) deposition may be greater than concentrations needed to maximize overall growth.

Conclusions

The lys regimen (requirement) to maximize growth performance of barrows and gilts (NE index × Landrace) × Pietran] appear to be approximated by T3 (1.14, 1.04, 0.94, and 0.86% total lysine, respectively for grower 1, 2, Finisher 1, and 2), but greater dietary lysine concentrations (similar to the greatest lysine regimen (T4)) may be warranted to maximize carcass leanness. However, it should be noted that the T4 regimen may reduce ADFI and ADG.

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[1] Phillip S. Miller is a professor, Roman Moreno is a graduate student and research technologist; Thomas E. Burkey is an assistant professor, and Rodger K. Johnson is a professor in the Animal Science Department. The authors would like to acknowledge the financial support of Monsanto Co.

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