POTENTIAL FOR REDUCING NITROGEN EXCRETION IN SWINE[1]

Charles V. Maxwell[2]

Story in Brief

Two studies were conducted to determine the potential for reducing nitrogen excretion without impacting animal performance and carcass composition. In Trial 1, lysine levels which optimized lean tissue gain during the starting, growing and finishing periods were .92, .79 and .70%, respectively. In Trial 2, substituting increasing levels of crystalline amino acids based on an ideal protein composition tended to improve gain and tended to increase backfat at one of the higher levels of substitution. Crystalline animo acids may reduce energy needed to process extra nitrogen, increasing the net energy level of the diet. These data suggest that when diets include amino acids, energy adjustments may be necessary to avoid increasing carcass fat.

(Key Words: Protein Level, Ideal Protein, Swine, Growing-Finishing.)

Introduction

Environmental nitrogen contamination attributed to the livestock industry arises from the fact that animal efficiency for converting feed into animal protein is less than 100%. Though swine are among the most efficient, they convert only 35 to 45% of ingested dietary nitrogen to meat. Theoretically, waste nitrogen may be reduced by lowering the dietary crude protein level via utilization of dietary crystalline amino acids to maintain diet adequacy. Decreasing the excesses of dietary nitrogen offers the potential for not only decreasing nitrogen excretion, but should improve feed efficiency by reducing energy required to metabolize the excess amino acids. The ideal amino acid balance would be a feed that supplies 100% of the amino acid requirement for maximum protein synthesis with no excesses.

Most swine and poultry diets consist of grain-soybean meal based mixtures which contain excesses of all amino acids except the limiting amino acid, lysine. The crude protein for the growing pig could, for example, be reduced from 16% (.75% lysine) to 14% (.62% lysine) with no additional limitations other than lysine (Figure 1). A diet formulated to the theoretical

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[2] Professor

100% requirement, with little or no excesses, should dramatically reduce nitrogen excretion.

The limiting amino acids for swine fed corn-soybean meal diets are lysine, methionine, threonine and tryptophan. At present, diets are routinely formulated with a 2% crude protein reduction with added crystalline lysine. Further reductions in crude protein with the addition of the other commercially available amino acids (methionine, threonine and tryptophan) has not always produced equivalent gain and carcasses have tended to be fatter.

The protein and amino acid requirements of various genotypes of growing-finishing swine have been shown to vary greatly depending upon the lean growth rate of the line in question. The industry consensus is that protein and amino acid requirements for rapid growth line-lean gain genotypes, are higher than previously estimated. Therefore, the initial study was to establish the minimum dietary lysine and/or protein level required to optimize gain and carcass composition.

Materials and Methods

Trial 1. A small pen research facility located in northwestern Arkansas was used to conduct this trial which used gilts of two genotypes (N= 144 each). Six isocaloric corn-soybean meal diets differing in lysine level (Table 1) due to differences in percentage of soybean meal only (no synthetic lysine) were fed. Diets were initiated when pigs weighed approximately 51 lb. The starter, grower and finisher diets were formulated to contain 1553, 1673 and 1623 kcal M.E./lb, respectively. Transition from starter to grower and from grower to finisher occurred when the mean weight of all pigs was approximately 75 and 150 lb, respectively.

Line 1 was 1/2 Duroc, 1/2 lean growth-line Large White and Line 2 was 1/2 Line 1, 1/4 Landrace, 1/4 maternal-line Large White. Blocks (n=3) were formed to account for variation in initial weight and within-house location effects. Pigs were randomly assigned to diet within block separately for each genotype. Eight pigs were assigned to each pen (n=36) which served as the experimental unit. Weight gain and feed consumption were measured on a per pen basis for each of the three phases of feeding. When the mean weight of each block was 239 lb, pigs were slaughtered and carcass data collected on a per pen basis. Lysine intake per head per day was calculated (range 16 to 30 grams) and results used to predict the response to level of lysine for the two lines. These predictions produce a plot that shows expected performance at each level of lysine for each line.

Trial 2. This study was conducted to determine the potential for reducing total dietary nitrogen and supplementing amino acids as a means of reducing nitrogen excretion while maintaining swine performance and carcass composition. The control non-synthetic amino acid diet consisted of the protein and amino acid levels in the starter, grower and finisher phase of the study determined to optimize lean tissue gain in Trial 1. (Diet D; 1.10, .95 and .85% total lysine and .92, .79 and .70% available lysine in the starter, grower and finisher phase, respectively.)

A total of 288 Line 1 gilts (same line as Trial 1) were utilized in this study. Gilts were sorted into one of nine blocks based on initial weight (56 days of age) and were fed one of four isocaloric diets (Starter 1550, grower 1610, and finisher 1620 Kcal M.E /lb). The starter ration was fed when pigs weighed from 33 to 82 lb, the grower from 82 to 153 lb and finisher from 153 to 228 lb. Diets were formulated to reduce lysine by .09% increments in the starter and grower periods and by .08% increments in the finisher period (total reduction of up to .27% lysine in the starter and growing phase and .24% lysine in the finishing period). Table 2 contains the calculated available amino acid levels for the starter, grower and finisher diets. All supplemental amino acids were supplied with crystalline amino acids to meet the ideal available amino acid levels (Baker and Chung, 1992). Diets were randomly assigned to pens within block and eight pigs were placed per pen. Pigs were weighed individually and feed consumption recorded on a per pen basis at each diet change to calculate feed conversions. When a block averaged 230 lb, those pens were removed from the test and transported to Reeves Packing in Ada, OK for processing. Pen served as the experimental unit for all data analysis.

Results and Discussion

Trial 1. Since response to diets was similar between the two lines for treatment, data for both lines were combined in the analysis. Average daily gain during the starter period (Figure 2) increased as dietary lysine increased to 1.10% of the diet followed by a decline in daily gain at higher lysine intakes. Daily gain was not significantly affected by lysine level during the growing (Figure 3) or finishing periods (Figure 4). Feed efficiency during the starting period was reduced ($P<.1$) in pigs fed the highest protein intake when compared with those fed the 1.03 or 1.17% lysine diets while feed efficiency during the growing and finishing periods was not significantly affected by dietary treatment (Figure 5).

Backfat decreased with increasing lysine level fed during the finishing period (Figure 6). Percentage of ham in pigs fed the .85 and .90% lysine diets was greater than in pigs fed a .75% lysine diet during the finishing period (Figure 7). Similarly, loin eye area was greater in pigs fed the .85% lysine diet when compared with those fed the .70 or 75% lysine diets (Figure 8).

When the response to dietary protein level was based upon lysine intake per head per day, regression coefficients for lysine intake differed ($P<.16$) between lines for carcass weight, backfat and percentage of primal cuts.

Carcass weight at slaughter increased with increasing lysine intake in the lean line (Line 1), but tended to decline with increased lysine intake in Line 2 (Figure 9). Similarly, the decrease in backfat (Figure 10) and the increase in percentage of primal cuts (Figure 11) with increasing daily lysine intake was greater in Line 1 pigs than in Line 2 pigs. This suggests that when given access to a higher protein diet, the lean growth line responded whereas the response in Line 2 was minimal.

Trial 2. Pigs fed Diet 3 grew faster (Table 3; $P<.10$) during the growing period and for the overall study than pigs fed Diets 1 or 2, resulting in a heavier pig completing the study ($P<.10$). Pigs fed the highest level of amino acid substitution (Treatment 4) were intermediary. Pigs on Treatment 3 were less efficient ($P < .10$) during the starter period than pigs on Treatments 1 or 2; however, the magnitude of the decrease was small and during the growing, finishing and for the overall study, feed efficiency was similar among all treatments.

Tenth rib backfat was greater ($P<.10$) in pigs on Treatment 3 when compared with those on Treatments 1, 2 or 4 (Table 4). Carcass length was also reduced in pigs assigned to Treatment 3 when compared with those on Treatment 2 ($P<.1$). In addition, pigs on Treatments 1 and 3 had reduced loin weight (percent) when compared with pigs on Treatments 2 or 4 ($P<.05$). All other carcass measurements including loin eye area, % ham, % Boston butt, % picnic and % primal cuts as well as cut out value were not significantly affected by reducing dietary protein and substituting synthetic amino acids. With the exception of Treatment 3, decreasing protein and increasing synthetic amino acids had little effect on carcass composition. Rationale for the increase in fat deposition and decreasing carcass value in pigs fed the second highest level of substitution of amino acids for protein (Treatment 3), but not in pigs fed the highest level of substitution (Treatment 4) is unknown.

This study suggests that decreasing dietary crude protein by decreasing soybean meal and formulating diets on an available ideal amino acid basis by using synthetic amino acids has the potential to improve rate of gain and has little impact on feed efficiency or carcass composition. Diets formulated using these principles have the potential to substantially reduce nitrogen excretion.

Literature Cited

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NRC. 1988. National Academy Press, Washington, DC.

Table 1. Lysine and protein levels of the six diets in Trial 1.

Phase	Dietary treatment					
	A	B	C	D	E	F
Starter:						
% crude protein	16.86	17.86	18.86	19.87	20.87	21.87
% lysine	.89	.96	1.03	1.10	1.17	1.24
Grower:						
% crude protein	15.04	15.89	16.74	17.61	18.46	19.32
% lysine	.77	.83	.89	.95	1.01	1.07
Finisher:						
% crude protein	14.01	14.73	15.44	16.15	16.86	17.58
% lysine	.70	.75	.80	.85	.90	.95

Table 2. Amino acid content of rations using synthetic amino acids to partially substitute for soybean meal in Trial 2.

	Dietary treatments			
	1	2	3	4
Starter				
Available non-synthetic lys	.92	.83	.74	.65
Crystalline Lys	.00	.09	.18	.27
Crystalline Met + Cys	.00	.03	.07	.11
Crystalline Thr	.00	.03	.09	.14
Crystalline Trp	.00	.00	.02	.03
Grower				
Available non-synthetic lys	.79	.70	.61	.52
Crystalline Lys	.00	.09	.18	.27
Crystalline Met + Cys	.00	.01	.04	.08
Crystalline Thr	.00	.01	.07	.11
Crystalline Trp	.00	.00	.01	.03
Finisher				
Available non-synthetic lys	.70	.62	.54	.46
Crystalline Lys	.00	.08	.16	.24
Crystalline Met + Cys	.00	.00	.02	.04
Crystalline Thr	.00	.01	.06	.10
Crystalline Trp	.00	.00	.01	.03

Table 3. Least-squares means by diet for body weight, average daily gain and feed conversion using synthetic amino acids to partially substitute for soybean meal in Trial 2.

	Dietary treatments			
	1	2	3	4
Daily gain (lb/day)				
ADG starter	1.69	1.70	1.69	1.69
ADG grower	2.01[b]	1.98[b]	2.10[a]	2.07[ab]
ADG finisher	1.78	1.74	1.81	1.73
ADG overall	1.84[b]	1.81[b]	1.88[a]	1.84[ab]
LB feed/LB gain				
FCONV starter	1.92[b]	1.92[b]	1.98[a]	1.96[ab]
FCONV grower	2.44	2.40	2.40	2.35
FCONV finisher	3.00	2.85	2.92	3.03
FCONV overall	2.52	2.44	2.49	2.50
Body weight (lbs)				
Weight 1 initial	33.2	33.2	33.1	33.2
Weight 2 starter	82.2	82.6	82.3	82.3
Weight 3 finisher	152.8[ab]	152.1[b]	156.1[a]	155.0[ab]
Weight 4 overall	227.4[b]	225.1[b]	232.5[a]	228.0[ab]

[a,b] Means within the same row with different superscripts differ (P<.10).

Table 4. Least-squares means by diet for cut out data using synthetic amino acids to partially substitute for soybean meal; adjusted for differences in live weight in Trial 2.

	Dietary treatments			
	1	2	3	4
Carcass length, in	32.30[ab]	32.38[a]	32.07[b]	32.14[ab]
Backfat, (in)				
Tenth rib (3/4 mid-line)	1.17[a]	1.12[a]	1.25[b]	1.13[a]
Loin eye area, sq in	6.14	6.16	6.09	6.27
Ham, %	19.20	19.28	19.19	19.37
Loin, %	17.96[c]	18.39[d]	17.84[c]	18.37[d]
Boston butt %	6.39	6.46	6.32	6.42
Picnic, %	6.89	6.91	6.89	6.97
Total primals cuts %	50.44	51.04	50.24	51.13
Cut out value ($)	54.58	54.17	53.61	54.31
Belly	13.01	12.81	13.26	12.83

[a,b] Means within the same row with different superscripts differ ($P<.10$).

[c,d] Means within the same row with different superscripts differ ($P<.05$).

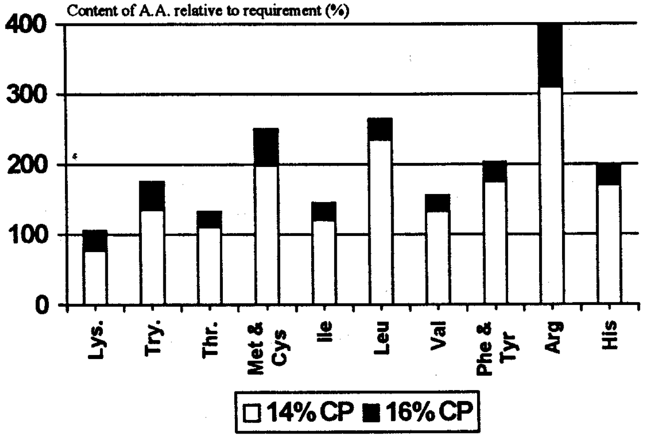

Figure 1. **Amino acid profiles of two corn/soybean meal based diets for growing pigs in relation to requirement. Requirement values are those currently recommended by NRC (1988) for growing swine.**

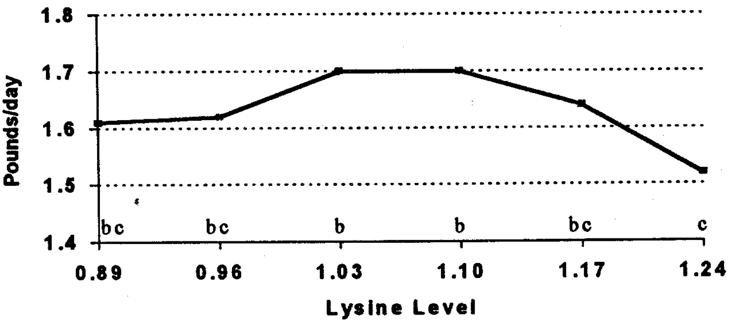

Figure 2. **Effect of dietary lysine level during the sarter phase on average daily gain in Trial 1 (lb/day). Least squares means. Means with different superscripts differ (P<.1).**

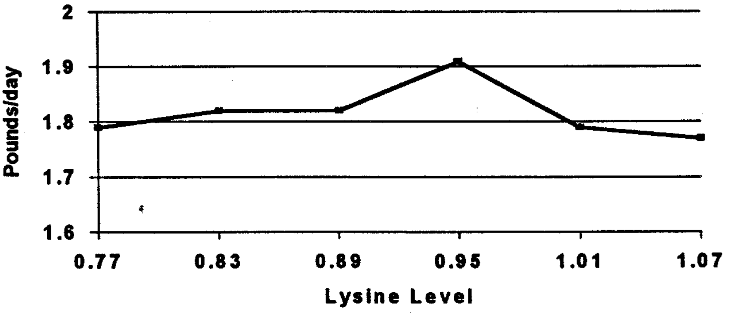

Figure 3. Effect of lysine level during the grower phase on average daily gain in Trial 1 (lb/day). Least squares means.

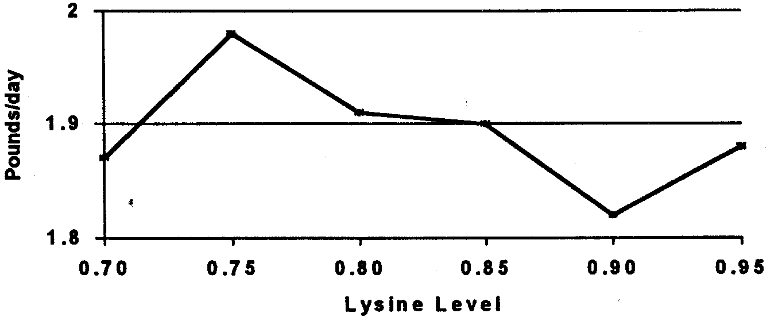

Figure 4. Effect of dietary lysine level during the finishing phase on average daily gain in Trial 1 (lb/day). Least squares means.

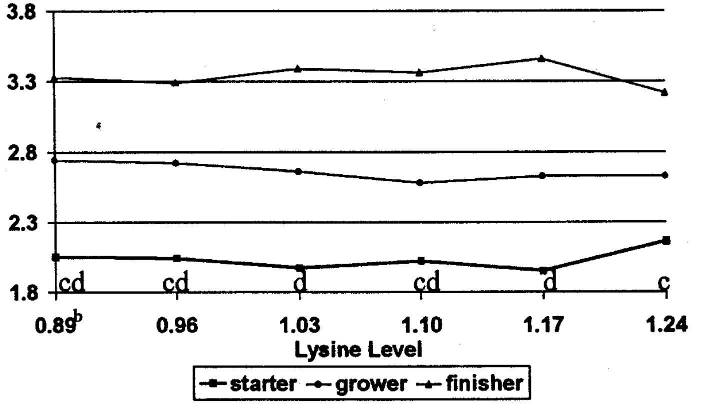

Figure 5. Effect of dietary lysine level on feed efficiency during the starter, growing and finishing periods in Trial 1 (feed/gain). Least squares means.[b]Lysine level was reduced by .12% during growing period and by .19% during finishing period.[c,d]Means in the starter period with different superscripts differ (P<.1).

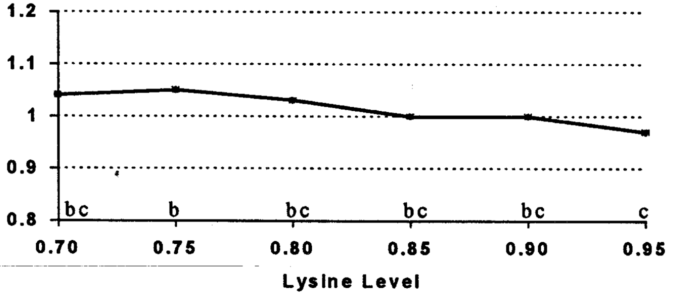

Figure 6. Effect of dietary lysine level on 10th rib backfat in Trial 1 (in). Least squares means.[b,c]Means with different superscripts differ (P<.1).

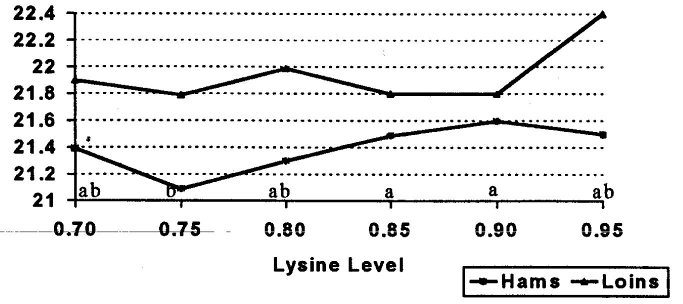

Figure 7. Effect of dietary lysine level on percent hams and loins in Trial 1. Least squares means.[b,c]Means with different superscripts differ (P<.1).

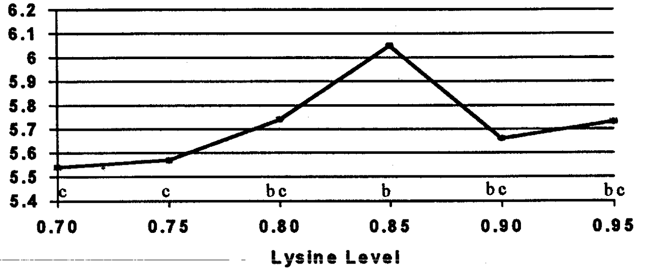

Figure 8. Effect of dietary lysine level on a loin eye area in Trial 1 (sq in). Least squares means.[b,c]Means with different superscripts differ (P<.1).

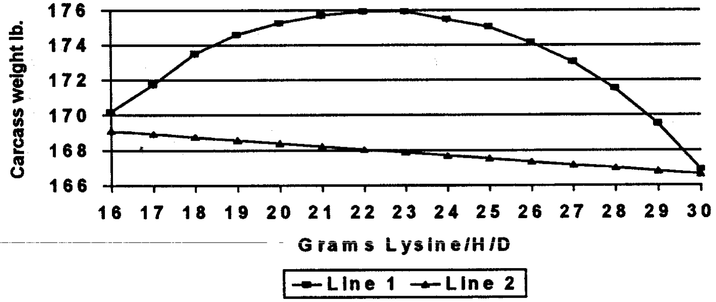

Figure 9. Effect of daily lysine intake on chilled carcass weight in Trial 1.

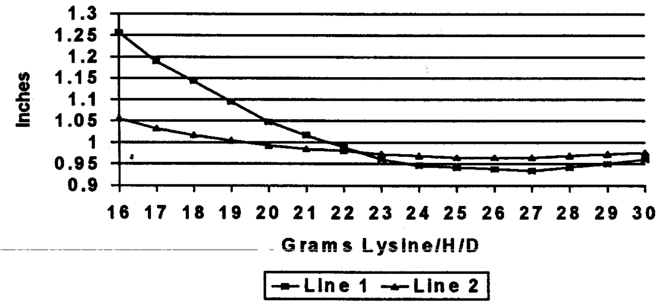

Figure 10. Effect of daily lysine intake on 10th rib backfat in Trial 1 (in).

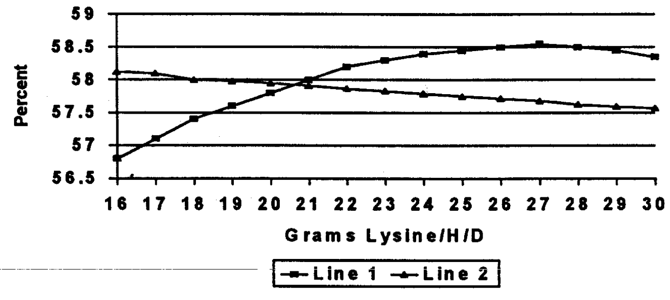

Figure 11. Effect of daily lysine intake on percent primal cuts in Trial 1.