Lysine Requirement of the Gestating Sow Determined by Using Plasma Urea Nitrogen as a Rapid Response Criterion

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Summary and Implications

Lysine requirements at two stages of gestation were estimated in adult sows who had been fed either low (LL) or high lysine (HL) diets in the previous lactation period. Sows fed LL lost more weight during lactation that sows fed HL. Also, sows fed LL diet had more days of anestrus than sows fed HL. There were no differences, however, in litter weight gain of sows fed LL and HL.

Estimates of gestation lysine requirements for sows fed LL were 9.6 ± 1.5 and 12.2 ± 1.7 g/d for early gestation and late gestation, respectively. The plasma urea nitrigen (PUN) technique did not accurately or precisely estimate the lysine requirement of the sows fed the HL diet in lactation.

Introduction

Plasma urea nitrogen (PUN) response has been demonstrated as a viable technique for determining lysine requirement of the growing pig and the lactating sow. We were interested in determining the lysine requirement of the gestating sow under specific conditions using a small number of sows.

We used PUN concentrations as the response criterion. Previous research has demonstrated that PUN concentration is lowest when the limiting amino acid (lysine) requirement is met. When PUN concentration are at their lowest the protein from the diet is being utilized at top efficiency.

Materials and Methods

Twenty-one Yorkshire × Landrace crossbred sows from third to fifth parity were used. Sows were penned individually in farrowing crates (2.1 × 6 m) with woven-wire flooring that had a .6 × .6 m rubber mat centered under the sows' shoulders. Suckling pigs were provided a .3 × 1.3 m electric heating pad. Litter size was standardized to 10 pigs by fostering pigs within 2 d of parturition. Pigs that died after day 4 were not replaced. Within 2 d of birth, each pig was given 100 mg of iron as iron dextran, needle teeth were clipped, and tails docked. Pigs had continuous access to water but were not offered creep feed. Sows were provided ad libitum access to water, and feed was hand fed three times daily during lactation to ensure constant feed availability and freshness of feed. Feed intake was measured by weighing feed before feeding and weighing back stale and wasted feed before each morning feeding. Sows were weighed before entering the farrowing room at approximately day 112 of gestation, within 24 h post farrowing, and at weaning. Pigs were weighed at birth and weaning on day 21 of lactation. During anestrus, sows were fed a common gestation diet. After breeding, sows were fed a common gestation diet that contained 25% rice hulls for 1 day. This feeding was designed to acclimate sows to experimental diets. Sows were then fed experimental diets from day 2 to 21 and 51 to 70 of gestation, and sows were fed a common gestation diet during the rest of gestation. The common gestation diet was fed at 2 kg/d and was based on corn and soybean meal. It contained 11.6% crude protein, .51% lysine and 3.286 Mcal/kg of metabolizable energy (ME) by calculated analysis.

Dietary treatments. Lactation diets were based on corn and soybean meal and were calculated to furnish 40 g (LL) and 55 g (HL) of lysine, and 22.6 Mcal digestible energy (DE)/d at a feed intake of 6.7 kg/d. Calculated and analyzed nutrient composition of lactation diets are presented in Table 1. Experimental dietary treatments during gestation consisted of five lysine concentrations (.256, .325, .398, .470, and .540%). Analyzed lysine levels were .28, .34, .40, .52, and .54, respectively. Sows were fed 2.95 kg/d of feed in three equal portions to allow efficient utilization of crystalline amino acids. Therefore, daily lysine intakes were calculated to be 7.50, 9.63, 11.75, 13.88, and 16.00 g. Gestation treatment diets were based on corn and soybean meal, with rice hulls added for bulk. All diets were made isonitrogenous by replacing graded additions of crystalline L-lysine·HCl with crystalline L-glutamic acid. Crystalline DL-methionine, L-threonine, and L-tryptophan were supplemented to maintain ideal ratios to lysine in the diet with the greatest lysine concentration (.540%). The calculated ratios of digestible amino acid to digestible lysine in this diet were as follows: histidine .28, isoleucine .58, leucine .99, methionine + cystine .71, phenylalanine + tyrosine .99, threonine .75, tryptophan .19 and valine .75. Gestation treatment diets supplied 7.2 Mcal/d of ME. Therefore, the only differences among the experimental gestation diets were the lysine and glutamic acid concentrations. Calculated and analyzed nutrient composition of gestation diets are presented in Table 2.

Experimental design. A total of 21 sows were used, with 11 sows receiving LL and 10 sows receiving HL diets in lactation. Within each lactation treatment two 5×5 Latin squares were formed with five sows being fed the five gestation treatment diets during five 4-d periods. Treatments consisted of two concentrations of protein (lysine) that were fed for the 21-d lactation, and five dietary lysine intakes administered during two 20-d periods in gestation (7.50, 9.63, 11.75, 13.88, and 16.00 g/d). The extra sow was used as a replacement for a sow that became ill during gestation. Sows were randomly assigned to lactation diets from pairs based on similar parity and farrowing date. During the two experimental periods in gestation each animal received the five gestation treatments, and each treatment was fed for a 4-d period to each sow. Dietary treatments were randomly assigned so within each Latin square only one sow received each treatment during a given 4-d period. Within a given 4-d period, all dietary treatments were being fed. Gestation treatments were fed twice in the gestation period. Treatment periods started on days 2 and 51 of gestation and ended on days 21 and 70, respectively. When sows were not on treatment they were fed a common gestation diet.

Table 1. Composition of the experimental lactation diets.

	Lactation diet	
Ingredient, %	LL	HL
Corn	83.13	75.44
Soybean meal, 48%	13.15	20.88
Dicalcium phosphate	1.54	1.49
Limestone	1.33	1.33
Calculated analysis,		
CP, %	12.5	15.7
Lysine, %	.60	.82
Threonine, %	.60	.72
Methionine +	.43	.52
Tryptophan, %	.16	.20
ME, Mcal/kg	3.3	3.3
Calcium, %	.90	.90
Phosphorus, %	.61	.62
Nutrient Composition,		
CP, %	12.8	16.3
Lysine, %	.54	.77

Blood samples were obtained on days 3 and 4 of each gestation treatment period, before feeding the sows at 0700. Blood (3 to 5 ml) was collected via ear vein puncture with a 23-gauge butterfly needle and transferred to heparinized tubes. Plasma samples were separated by

centrifugation and stored at -20°C until they were analyzed. The PUN concentrations were determined colorimetrically.

Table 2. Gestation treatment diets.

	Gestation diets, lysine g/d				
Ingredient, %	7.5	9.6	11.7	13.8	16.0
Corn	68.3	68.3	68.3	68.3	68.6
Rice hulls	24.3	24.2	24.3	24.3	24.3
Soybean meal, 48%	3.21	3.21	3.21	3.21	3.21
Dicalcium phosphate	1.97	1.97	1.97	1.97	1.97
Limestone	.71	.71	.71	.71	.71
Salt	.40	.40	.40	.40	.40
Vitamin premix [a]	.20	.20	.20	.20	.20
Trace mineral premix	.03	.03	.03	.03	.03
Choline chloride	.08	.08	.08	.08	.08
Selenium premix[c]	.05	.05	.05	.05	.05
DL-Methionine	.15	.15	.15	.15	.15
L-Threonine	.07	.07	.07	.07	.07
L-Tryptophan	.03	.03	.03	.03	.03
L-Lysine. HCl	0	.09	.18	.27	.36
Glutamic acid	.58	.43	.28	.13	0
Calculated analysis,					
Crude protein, %	7.9	7.9	7.9	7.9	7.9
Lysine, %	.26	.33	.40	.47	.54
Threonine, %	.40	.40	.40	.40	.40
Sulfur A. A.,%	.39	.39	.39	.39	.39
Tryptophan, %	.10	.10	.10	.10	.10
ME, Mcal/kg	2.44	2.44	2.44	2.44	2.44
Calcium, %	.75	.75	.75	.75	.75
Phosphorus, %	.60	.60	.60	.60	.60
Nutrient composition,					
Crude protein, %	8.01	7.79	7.57	7.8	8.08
Lysine, %	.28	.34	.40	.52	.54

[a] Contributed the following per kilogram of diet: vitamin A, 4,400 IU; vitamin D_3, 1,100 IU; vitamin E, 22 IU; vitamin B_{12}, 0.022 mg; riboflavin, 6.6 mg; D-pantothenic acid, 18.0 mg; and niacin, 33.1 mg.
[b] Contributed the following in parts per million of diet: Fe, 87.5; Zn, 75; Cu, 8.8; Mn, 30; and I, 1.0;
[c] Contributed the following per kilogram of diet: Se 0.3 ppm.

Statistical analyses. Data from the lactation period were analyzed as a random complete block design

by using the appropriate GLM procedure. The PUN data from gestation periods were analyzed as a Latin square design with sows as columns and time period as rows by using the appropriate GLM procedure. The responses of PUN to dietary lysine in the gestation periods were fitted by a two-slope, broken-line regression model to estimate the optimum lysine intake (requirement) that minimized PUN concentrations.

Table 3. Lactation results.

Item	LL	HL	CV	P>
	Lactation Treatments			
Parity	3.4	3.6	8.8	.11
Post farrowing wt, kg	224	218	10.1	.80
Weaning wt, kg	203	214	11.2	.21
Weight loss, kg	21.8	3.6	131.5	.04
ADFI, kg/d	6.15	5.95	15.2	.79
Lysine intake, g/d	36.5	49.0	15.6	.01
Litter weight gain, kg	47.6	48.8	13.0	.63
Days of anestrus, d	5.65	4.65	19.2	.06
Number born (subsequent pregnancy)	9.6	11.4	23.3	.15

Results and Discussion

Lactation. All 21 sows were used in analysis of lactation treatment effects. The ADFI did not differ (P>.67) between treatments; therefore, sows fed the LL diet had a lower daily lysine intake compared with sows fed the HL diet, 35.4 and 50.1 g/d of lysine per day, respectively (P>.01). Sows fed LL lost more (P<.05) body weight from post farrowing to weaning than sows fed HL; 21.2 vs. 4.0 kg. In addition, sows fed the LL diet had an increase (P<.07) in days of anestrus compared with the sows fed the HL diet, 5.6 and 4.7 days. There were, however, no differences in litter weight gain (P>.63) between sows fed LL and HL diets, 47.6 and 48.9 kg, respectively. Sow milk production and lysine in milk were calculated by assuming 3.7 kg of milk production per 1 kg of litter weight gain, milk containing 5% protein and milk protein containing 7% lysine. There were no differences in lysine output from milk production between LL and HL, 45.1 and 46.4 g of lysine per day, respectively. Because sows fed LL had less lysine intake than the lysine in milk, maternal tissue was mobilized to make up the difference in lysine. Maintenance lysine requirement was calculated by determining an average metabolic body weight from post farrowing and weaning weights and multiplying 38 mg of lysine per day. There were no differences in maintenance lysine requirements between LL and HL, 2.12 and 2.14 g of lysine per day, respectively. Adding lysine for milk production and maintenance gives 47.3 and 48.6 g of lysine per day required by sows fed LL and HL, respectively.

Comparing the lysine intake to lysine requirement for production, the sows fed LL were under fed lysine by 10.8 g per day. Thus, the protein for milk production in the sows fed LL had to come from the body stores.

Although the suckling pigs did not benefit from the higher protein diet, the sows fed HL lost less body weight and had fewer days of anestrus than the sows fed LL. Decreases in days of anestrus and weight loss allow for a higher rate of reproduction and an increase in total production over the life of the sow. In addition, 3 of 11 sows fed LL did not conceive on the first estrus, whereas all 10 sows fed HL conceived on the first estrus (P<.09). Sow fed HL had numerically more pigs born alive than sows fed LL, 11.1 and 9.6, respectively. Three sows fed LL were not included in data of pigs born alive because they did not farrow, and one sow previously fed HL died during farrowing and was not included in the data of pigs born alive.

Gestation PUN concentrations decreased quadratically (P<.01) with increasing dietary lysine intake during both EG and LG in sows that had been fed LL. The PUN concentrations in sows fed HL, however, did not respond to graded lysine concentrations as expected in EG, but in LG, PUN concentrations decreased linearly (P<.01) as lysine levels increased. A two-slope, broken-line analysis indicated a total daily lysine requirements of 9.6 ± 1.5 and 12.2 ± 1.7 g/d in EG and LG_ respectively for sows previously fed LL diets. The PUN technique, however, did not adequately estimate the lysine requirement of sows that were fed HL diet in lactation.

Summary

Feeding a high protein diet during lactation has great benefits for the next reproductive cycle over a lower protein diet. A higher protein diet may decrease the time sows are in anestrus and increase the percentage of sows that conceive on the first mating. Therefore, feeding a higher protein diet can decrease the time spent on estrus detection and rebreeding. Further it has potential to increase the number of pigs per litter.

The PUN data from the sows fed low lysine (LL) during gestation indicate that 9.6 ± 1.5 and 12.2 ± 1.7 g of lysine per day are required during early gestation and late gestation, respectively, when 7.2 Mcal/d of ME is fed. These estimated lysine requirements are higher than factorially calculated estimates and, therefore, indicate that sows are capable of utilizing more lysine for protein accretion than previously thought. The failure, however, of PUN concentrations to give a clear estimate of lysine requirement for sows previously fed high lysine diets (HL) during lactation indicates that the PUN technique is not completely reliable in determining amino acid requirements for sows during gestation