Lysine Requirement of Pigs Weighing 5 to 15 Kg Fed Practical With and Without Added Fat

A. J. Lewis
University of Nebraska-Lincoln, alewis2@unl.edu

E. R. Peo, Jr.
University of Nebraska-Lincoln

B. D. Moser
University of Nebraska-Lincoln

T. D. Crenshaw
University of Nebraska-Lincoln

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LYSINE REQUIREMENT OF PIGS WEIGHING 5 TO 15 KG FED PRACTICAL DIETS WITH AND WITHOUT ADDED FAT[1,2]

A. J. Lewis, E. R. Peo, Jr., B. D. Moser and T. D Crenshaw

University of Nebraska[3]*, Lincoln 68583*

Summary

Weanling crossbred pigs (average weight 5 kg) were fed diets containing two levels of fat and six levels of lysine in a 2 x 6 factorial design to determine the lysine requirement of young pigs fed practical diets with and without added fat. The diets were based on corn and soybean meal and contained either 5% sucrose or 5% lard. Lysine levels ranged from .95% (basal) to 1.45% in .10% increments. The growth trial was 28 days long and pigs were bled at 14 and 28 days. Feed intake (ADFI), weight gain (ADG), feed efficiency (G:F) and changes in plasma levels of urea and lysine were the response criteria. Dry matter, protein and energy digestibilities of the diets were measured at the end of the growth trial. As expected, the addition of fat caused a decrease in ADFI and an increase in G:F but did not influence ADG. The addition of lysine significantly improved ADG and G:F and tended to increase ADFI ($P<.065$). Plasma urea levels were not influenced by fat addition, and the response was the same at both bleeding periods. Urea levels decreased in response to added lysine, reaching a plateau at 1.25% dietary lysine, Plasma lysine levels increased with dietary lysine, but the shape of the response was different for the two bleeding periods. At 14 days, it was curvilinear, indicating a lysine requirement of 1.15 to 1.25%; at 28 days, it was linear, suggesting that at this time the requirement was less than .95%. Findings indicate that pigs weighing 5 to 15 kg and fed practical diets containing 19% crude protein require 1.15 to 1.25% lysine. In this experiment, there were no significant fat x lysine interactions and no indication that the addition of fat increased the lysine requirement.
(Key Words: Lysine, Fat, Baby Pigs, Requirements.)

Introduction

Several experiments have been conducted to determine the lysine needs of pigs weaned at 2 to 3 weeks of age and weighing approximately 5 kg (Hutchinson *et al.*, 1957; Mitchell *et al.*, 1965a; Anderson and Bowland, 1967; Campbell, 1978). However, there is still a lack of consensus about the lysine requirement of young swine. The NRC (1979) lists the lysine requirement of 5- to 10-kg swine as .95% of the diet. This value is essentially unchanged from the value of .96% listed in the seventh edition (NRC, 1973) but is substantially reduced from the value of 1.20% listed in the sixth edition (NRC, 1968). The reduction from 1.20 to .96% was based on extrapolation from the requirements of pigs weighing 20 to 35 kg, not on new experimental data. European estimates of nutrient requirements are much higher than the current NRC value: 1.23% in the United Kingdom (ARC, 1967), 1.40% in France (AEC, 1978) and 1.10 to 1.60% in Norway (Homb, 1976).

Many commercial starter feeds currently available in the United States have lysine contents that are more in line with European standards than with the NRC recommendation. Lysine is usually the first limiting amino acid in starter diets, and the establishment of reliable requirement data is economically important to the swine industry. Lysine requirements may be influenced by other dietary factors, such as energy density (Mitchell *et al.*, 1965b; Anderson and Bowland, 1967; Henry *et al.*, 1971) and protein level (McWard *et al.*, 1959; Klay, 1964; Baker *et al.*, 1975), and this may explain some of the differences in requirement estimates.

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[3] Dept. of Anim. Sci.

The first objective of the present research was to reevaluate the lysine requirement of 5-kg pigs fed a basal diet similar to that of currently available commercial feeds. The second objective was to determine the effect of added fat on the lysine requirement of young swine.

Materials and Methods

Experimental Design. Crossbred pigs, weaned at approximately 21 days of age, were used in two trials conducted to determine the lysine requirement of this class of swine fed diets with and without added fat. In each trial, 96 pigs (initial weight 5.5 kg) were housed in groups of four in 1.6 m × 1.8 m pens with one-third slotted floors and equipped with self feeders and waterers. The pens were situated in a room with environmental control and continuous fluorescent light. Room temperature was maintained at 30 C for the first 2 weeks of the experiment and lowered to 27 C during the second 2 weeks. The pigs were divided into 12 groups and fed two levels of fat and six levels of lysine in a 2 × 6 factorial design.

The composition and analyses of the diets are presented in tables 1 and 2. The basal diets were designed to meet the NRC (1979) requirements for all nutrients, including lysine.

Allotment of pigs to treatment was at random within sex and weight blocks. Each pen contained two barrows and two gilts. Individual weight gains and pen feed intakes were recorded weekly during a 4-week growth period.

Collection of Blood Samples. Blood was collected from the pigs twice during the experiment (on day 14 and day 28) for plasma urea and plasma lysine determinations. No attempt was made to regulate the feeding pattern before bleeding, as previous attempts to do this (Lewis *et al.*, 1977) resulted in less consistent data than when pigs were allowed *ad libitum* access to feed throughout. The blood was collected via anterior *vena cava* puncture with evacuated heparinized tubes. Plasma was separated by centrifugation and stored at −20 C until analyzed.

Digestibility Measurements. At the end of the 4-week growth period, six barrows (three from each basal diet) were selected for diet digestibility measurements. They were placed in metabolism cages, and three were assigned to the basal diet containing no added fat and three to the basal diet containing 5% added fat. The barrows were fed their respective diets at a rate equivalent to 5% of their (body weight)$^{.9}$ per day; daily portions were divided into two equal feedings. Complete fecal collections were made for 5 days following a 3-day acclimation period. Each barrow was then changed to the other basal diet, and feces were collected for a second 5-day period following 4 days of acclimation.

TABLE 1. COMPOSITION OF BASAL DIETS (%)[a]

Ingredient	Internat'l Ref. No.	Added fat, % 0	Added fat, % 5
Corn, ground	4-02-931	64.31	64.31
Soybean meal	5-04-604	23.12	23.12
Sucrose	4-04-701	5.00	0
Lard, stabilized	4-04-790	0	5.00
Dried fish solubles	5-01-971	2.50	2.50
Brewers dried yeast	7-05-527	1.00	1.00
Dicalcium phosphate	6-01-080	1.72	1.72
Limestone, ground	6-02-632	.75	.75
Salt, iodized	6-04-151	.50	.50
Trace mineral mix[b]		.10	.10
Vitamin mix[c]		1.00	1.00
		100.00	100.00

[a]Six different lysine levels were formulated for each basal diet by adding 0, .1, .2, .3, .4 or .5% lysine (as L-lysine·HCl) at the expense of corn.

[b]Provided the following in milligrams/kilogram of diet: Zn, 200; Fe, 100; Mn, 55; Cu, 10; Co, 1; I, 1.5.

[c]Provided the following per kilogram of diet: vitamin A, 5,511 IU; vitamin D, 441 IU; vitamin E, 22 IU; menadione sodium bisulfite, 2.2 mg; riboflavin, 2.9 mg; d-pantothenic acid, 22 mg; niacin, 22 mg; choline chloride, 220 mg; vitamin B_{12}, 22 μg; ethoxyquin, 4.4 mg; chlortetracycline, 110 mg; sulfamethazine, 110 mg; penicillin, 55 milligrams.

Analytical Methods. Plasma urea in individual samples was determined by the method of Marsh *et al.* (1965). For plasma lysine, a pooled sample from the four pigs in each pen was prepared, and the lysine content was measured by a semiautomated ion exchange procedure and a fluorometric detection system (Blackburn, 1978; Benson and Hare, 1975). Analyses of feed and feces samples for dry matter and protein and of feed samples for calcium and phosphorus were performed by standard procedures (AOAC, 1975). Gross energy contents of feed and feces were measured in an automatic adiabatic bomb calorimeter.

Statistical Methods. Data from the two trials were examined together in a combined analysis of variance by procedures appropriate for factorial designs (Barr *et al.*, 1976). In addition

TABLE 2. CHEMICAL ANALYSES OF BASAL DIETS[a]

Component	Added fat, %	
	0	5
Dry matter, %	90.20	90.11
Protein (N X 6.25), %	18.70	18.85
Digestible protein, %	15.23	15.54
Lysine, %	.95	.95
Determined gross energy, kcal/kg	3,887	4,088
Determined digestible energy, kcal/kg	3,299	3,552
Calcium, %	.79	.79
Phosphorus, %	.70	.69

[a]Analyzed values are expressed on an as-fed basis.

to the main effects and interactions of treatments, the model included trial (n = 2), period within trial (n = 2) and weight blocks within trial (n = 2). The five degrees of freedom for lysine level were divided into single degree of freedom orthogonal regression comparisons.

Results and Discussion

Analyses of the basal diets are presented in table 2. Dry matter digestibilities were 85.6 and 86.5% for the diets with 0 and 5% added fat, respectively. The crude protein contents of the two diets were slightly lower than the 20% level that the NRC (1979) recommends for pigs of this weight range, but the lysine level (.95%) just met the NRC requirement. Although diets were not analyzed for other essential amino acids, the calculated levels of these were well in excess of NRC requirements, except for methionine + cystine, which was calculated to be borderline. Energy digestion coefficients of the two diets were 84.9 and 86.2%. The determined digestible energy contents of the two diets were similar to calculated values. Replacement of 5% sucrose with 5% lard increased the digestible energy content of the diet by 6.8%.

As expected, pigs fed diets containing added fat compensated for the greater energy density by consuming less ($P<.001$) feed than those receiving no added fat (table 3). The digestible energy intakes for the two diets, 2,167 and 2,074 kcal/day, were similar. Although not significant ($P>.05$), there was a tendency for feed intake to increase as lysine level increased up to 1.25% of the diet (quadratic $P<.065$). There was no evidence of a fat x lysine interaction in the feed intake data.

Addition of fat did not affect ($P>.05$) weight gains of the pigs (table 4). This result is consistent with the findings of several other workers who have added fat to diets for young weanling pigs (Peo *et al.*, 1957; Leibbrandt *et al.*, 1975; Cline *et al.*, 1977) but differs from the situation observed for growing-finishing pigs, where added fat usually increases weight gain (Moser, 1977). Increasing the lysine level from .95% had a pronounced effect on weight gain (linear $P<.039$, quadratic $P<.005$). Weight gains increased as lysine level increased up to 1.15 to 1.25% of the diet; after that there was a slight decrease. The fat x lysine interaction was not significant.

Pigs fed diets with added fat had better ($P<.001$) feed efficiencies (gain to feed ratios) than those given diets without added fat (table

TABLE 3. FEED INTAKES (GRAMS/DAY) OF WEANLING PIGS FED DIETS WITH ADDED FAT AND LYSINE[a,b]

Added fat, %	Lysine, %						Avg for fat levels[c]
	.95	1.05	1.15	1.25	1.35	1.45	
0	608	644	679	710	651	646	657
5	566	596	590	620	566	593	589
Avg for lysine levels[d]	587	620	634	665	609	620	623

[a]Individual values represent the mean of four pens with four pigs per pen.

[b]Coefficient of variation, 5.78%.

[c]Fat effect ($P<.001$).

[d]Quadratic effect ($P<.065$).

TABLE 4. WEIGHT GAINS (GRAMS/DAY) OF WEANLING PIGS FED DIETS WITH ADDED FAT AND LYSINE[a,b]

	Lysine, %						Avg for
Added fat, %	.95	1.05	1.15	1.25	1.35	1.45	fat levels
0	320	349	369	397	359	359	359
5	320	342	374	370	348	353	351
Avg for lysine levels[c]	320	346	371	384	354	356	355

[a]Individual values represent the mean of four pens with four pigs per pen.

[b]Coefficient of variation, 8.95%.

[c]Linear effect (P<.039); quadratic effect (P<.005).

5). But when feed efficiencies were calculated on a digestible energy intake basis, the two diet series were essentially equal, 166 and 169 g weight gain/Mcal digestible energy intake. Feed efficiency (gain:feed) was significantly improved by lysine addition (linear P<.020, quadratic P<.001) and appeared to reach a maximum at the same lysine levels as weight gains, 1.15 to 1.25% lysine. Again, there was no evidence of a fat x lysine interaction.

A comparison of feed intakes (table 3) and weight gains (table 4) shows that, although the addition of 5% fat resulted in a consistent decrease in feed intake, there was no concomitant decrease in weight gain. This phenomenon was particularly evident at the first three lysine levels (.95, 1.05 and 1.15%), where lysine was the first limiting nutrient. These data seem to indicate an apparent improvement in efficiency of lysine utilization by pigs consuming diets with added fat.

Plasma urea data are illustrated in figure 1. Results from the two bleedings were similar (period effect P>.05) and they are combined in figure 1. Plasma urea concentrations decreased (linear P<.001, quadratic P<.004) as dietary lysine level increased up to 1.25%. There appeared to be a plateau after this point. The reduction in plasma urea presumably reflected more efficient nitrogen utilization and less urea synthesis by the pigs that received the higher lysine levels. Within each lysine level, the values for the two different fat levels were almost identical, and the fat effect and fat x lysine interaction were not significant (P>.05).

Plasma lysine concentrations were influenced by the time of bleeding (period effect P<.05) and, hence, the data from the two bleedings are presented separately in figures 2 and 3. The plasma lysine response curve obtained after 2 weeks of the experiment (figure 2) was quite typical of experiments designed to determine

TABLE 5. FEED EFFICIENCIES (GAIN:FEED) OF WEANLING PIGS FED DIETS WITH ADDED FAT AND LYSINE[a,b]

	Lysine, %						Avg for
Added fat, %	.95	1.05	1.15	1.25	1.35	1.45	fat levels[c]
0	.516	.537	.547	.564	.541	.553	.543
5	.560	.576	.640	.601	.596	.584	.593
Avg for lysine levels[d]	.538	.557	.593	.583	.569	.568	.568

[a]Individual values represent the mean of four pens with four pigs per pen.

[b]Coefficient of variation, 7.67%.

[c]Fat effect (P<.001).

[d]Linear effect (P<.020); quadratic effect (P<.001).

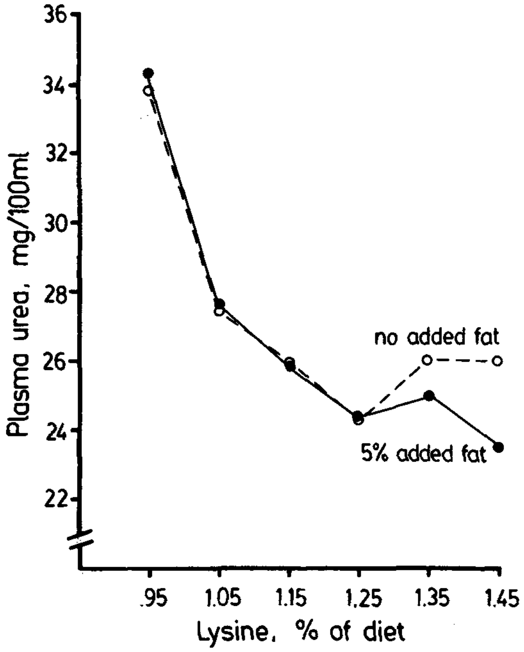

Figure 1. Plasma urea concentrations of weanling pigs fed diets with added fat and lysine. Each value represents the mean of 32 samples (16 pigs X two bleedings). Linear effect of lysine (P<.001), quadratic effect of lysine (P<.004). Coefficient of variation, 9.35%.

amino acid requirements (Lewis and Speer, 1975). Plasma lysine remained at a relatively low, constant level until 1.15% lysine was included in the diet, after which there was a dramatic increase (linear P<.001, quadratic P<.084, cubic P<.006). These data are consistent with the growth data and plasma urea data and indicate that pigs of this age and weight require 1.15 to 1.25% lysine.

Somewhat different results were obtained at 4 weeks (figure 3). The increase in plasma lysine (linear P<.001) followed dietary lysine without an initial plateau. The difference between the two bleeding periods may reflect a reduction in the lysine requirement of the pigs from week 2, when they weighed approximately 8 kg, to week 4, when they weighed approximately 15 kilograms. Average daily feed intake more than doubled from week 2 to week 4 (.47 kg/day *vs* 1.02 kg/day). Thus, at each dietary lysine concentration, the total intake of lysine was much higher at week 4, and this may have resulted in a reduction in the lysine requirement when expressed as a percentage of the diet.

In both bleedings, there was a tendency for the pigs fed diets with added fat to have lower plasma lysine concentrations at equal dietary lysine levels. This effect was significant (P <.024) for the second bleeding. The effect of fat on plasma lysine may also simply have been a reflection of feed intake differences, as pigs fed diets containing 5% fat ate less total feed at all lysine levels (table 3).

The results of this experiment indicate that pigs weighing 5 to 15 kg and fed practical diets containing 19% crude protein require 1.15 to 1.25% lysine. This estimate is about 25% higher than the current NRC (1979) recommendation. It is, however, similar to European recommendations and to the content of many commercial feeds in the United States.

Throughout this study, there was no evidence that the addition of fat altered the lysine requirement. We anticipated that because pigs fed diets with added fat consumed less feed, the lysine requirement as a percentage of the diet would be higher. Some possible explanations for the absence of an interaction between fat and lysine are that: (1) the parameters studied were not sensitive enough to detect a change in lysine requirement when the energy density increased by 7%; (2) there were changes in

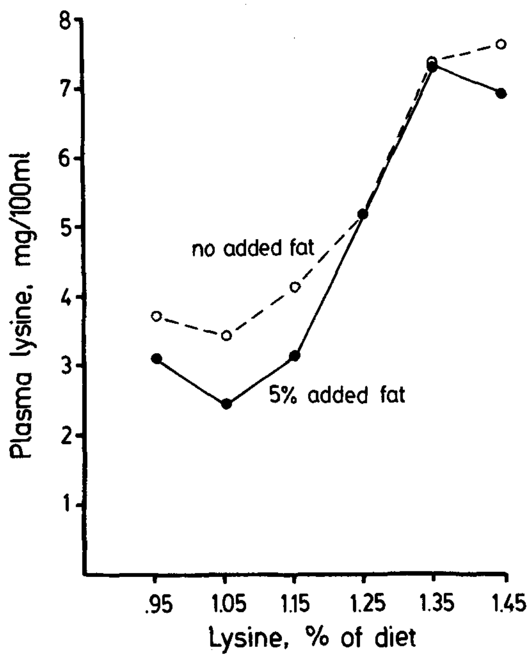

Figure 2. Plasma lysine concentrations of weanling pigs after 2 weeks of being fed diets with added fat and lysine. Each value represents the mean of four samples, each sample being composed of a pool of the plasma of four pigs. Linear effect of lysine (P<.001), quadratic effect of lysine (P<.084), cubic effect of lysine (P<.006). Coefficient of variation, 26.60%.

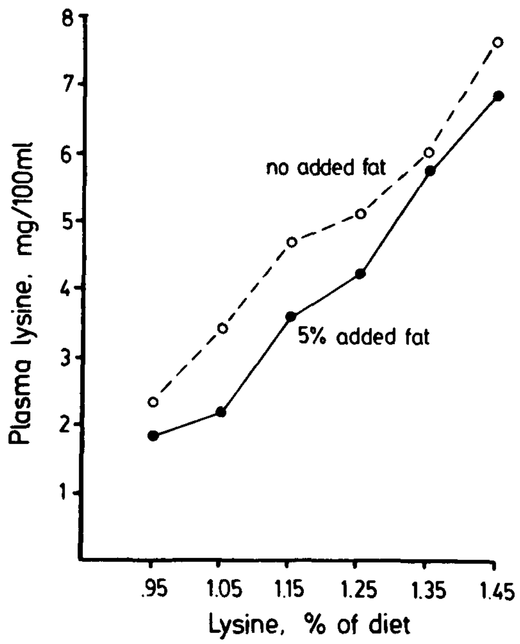

Figure 3. Plasma lysine concentrations of weanling pigs after 4 weeks of being fed diets with added fat and lysine. Each value represents the mean of four samples, each sample being composed of a pool of the plasma of four pigs. Fat effect ($P<.024$), linear effect of lysine ($P<.001$). Coefficient of variation, 25.79%.

carcass composition between groups of pigs that masked differences in lysine requirements, and (3) the addition of fat may have promoted more efficient utilization of lysine.

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