Threonine Requirement of Pigs Weighing 5 to 15 Kgs.

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THREONINE REQUIREMENT OF PIGS WEIGHING 5 TO 15 KG[1,2]

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ABSTRACT

Weanling crossbred pigs (avg initial wt 6.4 kg) were fed diets containing six levels of threonine to determine the threonine requirement of young pigs fed diets somewhat similar to those used in commercial swine production. The diets (16% crude protein) were composed primarily of grain sorghum, oat groats and soybean meal supplemented with minerals, vitamins, lysine, tryptophan, methionine and isoleucine, and were calculated to be adequate in all nutrients except threonine and crude protein. Threonine levels were .53, .57, .62, .68, .75 and .83% of the diet. There were two trials, each with 96 pigs. The pigs were fed the experimental diets for 28 d. The addition of threonine increased weight gain (P<.02) and feed efficiency (P<.001), with most of the response occurring between .53 and .68% threonine. There was little further response when threonine was increased above .68%. Plasma threonine concentrations increased as dietary threonine increased, with a sharp rise when dietary threonine exceeded .68%. Concentrations of most other essential amino acids in the plasma declined in response to increasing dietary threonine, and reached minimum values at either .68 or .75% threonine. Plasma urea concentrations decreased as threonine was increased in the diet, reaching a plateau at .68% dietary threonine. The data indicate the young pigs weaned at 3 to 4 wk of age require approximately .70% threonine.
(Key Words: Piglets, Threonine, Requirements.)

Introduction

Threonine is an important nutrient in swine diets. It is the second limiting amino acid in grain sorghum (Eckert and Allee, 1974; Cohen and Tanksley, 1976), barley (Fuller et al., 1979) and wheat (Allee and Hines, 1971), and the third limiting amino acid in corn (Grosbach et al., 1985). Notwithstanding this importance, there have been few experiments to determine the threonine requirements of swine.

Current estimates of the threonine requirement of young pigs differ greatly. The NRC (1979) lists the requirement of 5- to 10-kg pigs as .56%. This is lower than earlier estimates, which were .62% (NRC, 1973) and .70% (NRC, 1968). The current estimate of the British Agricultural Research Council (ARC, 1981) is that the threonine requirement of 3- to 8-wk-old pigs (approximately 5 to 15 kg) is .85%. Because threonine is such an important nutrient, and is likely to become even more important as the use of crystalline amino acids increases, better estimates of the threonine requirements of young pigs are needed.

The objective of the current research was to evaluate the threonine requirement of pigs weaned between 3 and 4 wk of age and fed a diet somewhat similar to those used in commercial swine production.

Materials and Methods

Crossbred pigs, weaned between 3 and 4 wk of age, were used in two trials to determine the threonine requirement of young pigs fed a semipractical diet. In each trial, 96 pigs (avg initial wt was 6.4 kg in each trial) were housed in groups of four in an environmentally regulated room. Allotment of pigs to dietary treatments was at random within sex and weight blocks. Each pen contained two barrows and two gilts. There were six diets containing various levels of threonine, and pigs were allowed ad libitum access to feed and water. Other aspects of the experimental design were

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TABLE 1. COMPOSITION OF BASAL DIET[a]

Ingredient	%
Ground grain sorghum (IFN 4–20–893)	63.69
Oat groats (IFN 4–03–331)	15.00
Soybean meal, solvent extracted (IFN 5–04–604)	12.50
Dried fish solubles (IFN 5–01–971)	2.50
Brewers dried yeast (IFN 7–05–527)	1.00
Dicalcium phosphate (IFN 6–01–080)	2.00
Limestone, ground (IFN 6–02–632)	.84
Iodized salt (IFN 6–04–151)	.50
Vitamin premix[b]	1.00
Trace mineral premix[c]	.10
Selenium premix[d]	.05
L-lysine·HCl	.67
L-tryptophan	.03
L-methionine	.05
L-isoleucine	.07

[a]Six threonine levels were formulated by adding 0, .04, .09, .15, .22 or .30% L-threonine at the expense of grain sorghum.

[b]Provided the following per kg of complete diet: vitamin A, 5,511 IU; vitamin D_3, 551 IU; vitamin E, 22 IU; menadione sodium bisulfite, 2.2 mg; riboflavin, 5.5 mg; d-pantothenic acid, 19.8 mg; niacin, 33 mg; choline chloride, 551 mg; vitamin B_{12}, .017 mg; ethoxyquin, 4.4 mg; chlortetracycline, 110 mg; sulfathiazole, 110 mg; penicillin, 55 mg.

[c]Provided the following in mg per kg of complete diet: Fe, 175; Zn, 150; Mn, 60; Cu, 17.5; I, 2.

[d]Provided the following in mg per kg of complete diet: Se, .1.

similar to those described for a previous experiment (Lewis et al., 1980).

The composition and analysis of the basal diet are presented in tables 1 and 2, respectively. The diet was designed to meet the NRC (1979) requirements for all nutrients except threonine and crude protein. Threonine levels from .53 to .83% were formulated by adding various amounts of crystalline threonine at the expense of grain sorghum. Analyses for dry matter,

TABLE 2. ANALYSIS OF BASAL DIET[a]

Component	%
Dry matter	89.32
Protein (N × 6.25)	15.90
Threonine	.53
Isoleucine	.76
Lysine	1.28
Methionine + cystine (calculated)	.56
Tryptophan	.18
Calcium	.91
Phosphorus	.74

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

protein, Ca and P were by standard (AOAC, 1980) procedures. Samples of the diet were hydrolyzed with 6 M HCl at 110 C under N for 6, 12, 18, 24, 36, 48 and 72 h, and analyzed for amino acids by high-performance liquid chromatography. The purpose of the serial hydrolyses was to correct for any destruction of amino acids that occurred during acid hydrolysis (Kohler and Palter, 1967; Rudemo et al., 1980). Tryptophan was analyzed after alkaline hydrolysis of the diet samples.

Blood samples were collected from the pigs on d 14 and 28 of the trials. The samples were obtained by puncture of the anterior vena cava, and the blood was collected in evacuated heparinized tubes. Plasma was separated by centrifugation, and an aliquot was stored at −20 C until analyzed for urea by the automated method of Marsh et al. (1965). One milliliter of plasma from each pig within a pen was combined to form a pooled sample. The pooled samples were deproteinized with sulfosalicylic acid by the method of Perry and Hansen (1969) and stored at −20 C. Deproteinized plasma was analyzed for essential amino acids (except tryptophan) using high-performance liquid chromatography with an

ion-exchange column and a fluorometric detection system (Benson and Hare, 1975). Plasma tryptophan was determined by the method of Lewis et al. (1976).

Data were analyzed by procedures appropriate for factorial experiments (SAS, 1979). The model included trial (n=2), weight blocks within trial (n=6), treatment (n=6) and treatment × trial interaction. The five degrees of freedom for treatment (threonine level) were divided into single degree of freedom orthogonal regression comparisons. The technique used to calculate the orthogonal comparisons allowed for the unequal spacing between the threonine levels.

Results and Discussion

Pigs in trial 2 ate more feed (525 vs 483 g/d; P=.02) and gained weight faster (296 vs 274 g/d; P=.04) than those in trial 1. There was also a significant trial × treatment interaction for these two traits. The interaction was caused by the fact that there was little treatment effect on feed intake or weight gain in trial 1, whereas in trial 2 both intake and gain increased as dietary threonine increased up to .68%. For all other response criteria there were no (P>.05) trial or trial × treatment effects. The results were therefore re-analyzed as one experiment, and will be discussed in that manner.

Feed intake of pigs was not affected by the dietary threonine concentrations tested in this experiment (table 3). Weight gains and feed efficiencies, however, were both improved by the addition of threonine to the basal diet. The increase in weight gain was linear (P=.02) in response to threonine addition, but most of the increase occurred between .53 and .68% dietary threonine. Pigs fed the highest threonine level (.83%) had the highest weight gain (resulting in the linear effect), but the increase from .68 to .83% was variable. The improvement in feed efficiency was both linear (P<.001) and quadratic (P=.023). There was a progressive improvement in feed efficiency from .53 to .68% threonine, with little or no further improvement at higher threonine levels.

Plasma amino acid and urea concentrations at 2 and 4 wk of the experiment are presented in tables 4 and 5, respectively. Plasma threonine concentrations increased (linear and quadratic P<.001) with dietary threonine content at both 2 and 4 wk of the experiment. The first two increments of dietary threonine produced

TABLE 3. PERFORMANCE OF WEANLING PIGS FED DIETS WITH VARIOUS LEVELS OF THREONINE[a]

Criterion	Dietary threonine, %						P values[b]		CV, %
	.53	.57	.62	.68	.75	.83	Linear	Quadratic	
Feed intake, g/d	511	489	522	502	480	522	.918	.566	13.39
Weight gain, g/d	268	262	287	298	283	312	.020	.881	14.38
Gain/feed, g/kg	524	537	554	594	591	596	.001	.023	4.89

[a]Each value represents the mean of eight pens with four pigs/pen. The average initial weight was 6.4 kg and the average final weight was 14.4 kg. The length of the experiment was 28 d.

[b]Probability values for the linear and quadratic effects of threonine level.

TABLE 4. CONCENTRATIONS (MG/100 ML) OF ESSENTIAL AMINO ACIDS AND UREA IN PLASMA OF WEANLING PIGS FED DIETS WITH VARIOUS LEVELS OF THREONINE FOR 2 WK[a]

Item	Dietary threonine, %						P values[b]		CV, %
	.53	.57	.62	.68	.75	.83	Linear	Quadratic	
Threonine	.88	1.02	1.51	3.01	5.33	8.78	.001	.001	28.11
Arginine	3.25	2.78	2.49	2.29	2.35	2.34	.001	.014	19.95
Histidine	1.46	1.54	1.37	1.34	1.42	1.33	.234	.742	20.98
Isoleucine	2.34	2.29	2.14	2.09	2.05	2.10	.023	.161	12.25
Leucine	3.06	3.25	2.92	2.91	2.77	3.03	.183	.128	12.10
Lysine	6.68	5.94	5.66	5.16	5.21	5.02	.001	.085	16.03
Methionine	.69	.67	.60	.58	.59	.67	.448	.026	18.62
Phenylalanine	1.75	1.62	1.49	1.38	1.50	1.53	.020	.003	12.28
Tryptophan	1.44	1.29	1.27	1.16	1.13	1.19	.002	.035	14.19
Valine	3.20	3.00	2.34	2.04	2.15	2.16	.001	.001	16.56
Urea	22.30	18.68	13.88	10.66	13.69	9.59	.001	.023	31.52

[a]Each value represents the mean of duplicate analyses of eight samples, each sample being a composite of plasma from the four pigs in each pen, except for plasma urea in which individual samples from all pigs were analyzed.

[b]Probability values for the linear and quadratic effects of threonine level.

TABLE 5. CONCENTRATIONS (MG/100 ML) OF ESSENTIAL AMINO ACIDS AND UREA IN PLASMA OF WEANLING PIGS FED DIETS WITH VARIOUS LEVELS OF THREONINE FOR 4 WK[a]

	Dietary threonine, %						P values[b]		
Item	.53	.57	.62	.68	.75	.83	Linear	Quadratic	CV, %
Threonine	.80	1.04	1.51	3.42	5.24	7.84	.001	.001	26.04
Arginine	3.78	3.87	3.14	3.09	2.66	2.78	.001	.071	15.40
Histidine	1.48	1.46	1.04	1.00	1.07	1.01	.001	.001	15.52
Isoleucine	2.24	2.41	2.10	2.29	2.09	2.04	.008	.638	9.85
Leucine	3.48	3.75	3.53	3.70	3.33	3.42	.135	.373	9.53
Lysine	6.50	6.43	5.56	5.71	5.01	5.12	.001	.280	16.25
Methionine	.64	.70	.64	.68	.59	.63	.175	.719	13.13
Phenylalanine	1.93	1.75	1.66	1.61	1.55	1.53	.001	.049	10.71
Tryptophan	1.60	1.59	1.53	1.69	1.33	1.47	.033	.823	13.00
Valine	3.49	3.36	2.78	2.73	2.42	2.57	.001	.001	11.10
Urea	21.64	17.56	14.04	11.13	12.37	11.16	.001	.001	23.38

[a]Each value represents the mean of duplicate analyses of eight samples, each sample being a composite of plasma from the four pigs in each pen, except for plasma urea in which individual samples from all pigs were analyzed.

[b]Probability values for the linear and quadratic effects of threonine level.

relatively small increases in plasma threonine, whereas the higher dietary levels resulted in much larger effects. The increase in plasma threonine concentration was particularly great when dietary threonine was greater than .68%.

The plasma concentrations of most other essential amino acids decreased as dietary threonine increased, reaching a minimum value at either .68 or .75% dietary threonine. Similar results have been reported in other experiments to determine the amino acid requirements of swine (Lewis and Speer, 1973, 1975). The response is, presumably, caused by an accumulation of excess essential amino acids in the plasma (and other tissues) when one essential amino acid is limiting. As the dietary amino acid balance is improved by the addition of the limiting amino acid, there is an increase in the utilization of the other essential amino acids and a commensurate decline in plasma levels.

Plasma urea concentrations also responded to threonine supplementation in the same manner as was observed for essential amino acids at both 2 and 4 wk of the experiment. At both times there were significant linear and quadratic effects (tables 4 and 5). Plasma urea concentrations declined as dietary threonine increased from .53 to .68%, but there was little further change at higher threonine levels. The results are similar to those reported previously in other research on the amino acid requirements of young pigs (Lewis et al., 1980). That is, the point at which plasma urea is minimized corresponds with the point at which the requirement for an amino acid is met.

The consistent effects of dietary threonine on plasma metabolites at both 2 and 4 wk of the experiment suggest that the threonine requirement did not change appreciably during this period. This conclusion is in contrast to a previous experiment with lysine (Lewis et al., 1980), in which the plasma lysine data indicated that the lysine requirement decreased between 2 and 4 wk.

Performance and plasma metabolite data from this experiment both indicate a threonine requirement of approximately .68%. This is 21% higher than the current NRC (1979) requirement of .56%. It is, in fact, more similar to earlier estimates (NRC, 1968) of the threonine requirement.

Although there has been little previous research to determine directly the threonine requirement of young pigs, other data are consistent with the results of this experiment.

Kroening et al. (1965), in an experiment using six individually fed pigs/treatment (4.4 kg initially), found that weight gain, feed efficiency and apparent N retention were improved when dietary threonine was increased from .56 to .63%. In a second experiment, also using six individually fed pigs/treatment (6.4 kg initially), there was no improvement in weight gain or feed efficiency when dietary threonine was increased from .89 to .96%.

Mitchell et al. (1968) using two pigs/treatment measured the N balance of 8.8-kg pigs fed diets based on casein and containing .38, .53, .68 or .83% threonine. There appeared to be a definite increase in N retention between .38 and .53%, a small increase from .53 to .68%, and essentially no change from .68 to .83% dietary threonine.

More recently, Rosell and Zimmerman (1985) used 70 individually fed pigs (5 kg initially) in an experiment with five threonine levels (.55 to .75% of the diet). On the basis of changes in feed efficiency and plasma metabolites, they estimated that the threonine requirement was .70% of the diet.

We conclude that the current NRC (1979) recommendation for the threonine requirement of 5 to 10 kg pigs is too low. Our estimate of the threonine requirement of pigs of this weight range that are fed practical diets containing grain and soybean meal is approximately .70% of the diet.

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