Dietary B Vitamin Needs of Pigs Experiencing a Moderate or High Level of Antigen Exposure

T. S. Stahly, professor, and
Doug Cook, assistant research scientist,
Department of Animal Science

ASL-R1373

Summary and Implications

Pigs were reared via two management schemes to create a moderate and high level of antigen exposure in the pigs. In each antigen exposure group, pigs were self-fed one of five dietary concentrations of a group of five B vitamins (niacin, pantothenic acid, riboflavin, B_{12}, and folacin) from 22 to 61 pounds body weight. Bioavailable concentrations of the vitamins equivalent to 70, 170, 270, 370, and 470% of the current estimated need (NRC, 1988) for 11 to 22 pound pigs were provided. Pigs experiencing a moderate versus high level of antigen exposure consumed more feed (+.54 lb/day) and gained more body weight (.32 lb/day) but required similar amounts of feed per unit of gain (-.03).

Dietary B vitamin additions at concentrations above current estimated requirements (NRC, 1988) resulted in up to 21 and 19% faster body growth rates and 10 and 6% less feed required per unit of gain in pigs experiencing a moderate and high level of antigen exposure, respectively. Based on these data, dietary concentrations of one or more of the test B vitamin equivalent to 370% of the current estimated needs (NRC, 1988) are required to optimize rate and efficiency of growth in 20 to 60 pound pigs experiencing a moderate or high level of antigen exposure.

Introduction

Vitamins are essential nutritional inputs which are required to fuel normal tissue growth and maintenance processes. Because of their role in energy and protein metabolism, vitamins, particularly the B vitamins, are key elements in proteinaceous tissue accretion. Furthermore, factors which increase body protein accretion rates potentially result in greater dietary vitamin needs.

Current estimates of dietary vitamin requirements for pigs are based on studies conducted 20 to 40 years ago. Because of recent changes in industry practices, vitamin requirements for pigs now are potentially much greater. These changes include the development of leaner genetic strains of pigs, adaptation of management technologies that improve the health status of pigs, and the feeding of more nutrient (i.e., protein, energy) dense diets.

Modern genetic strains of pigs have up to an 80% greater capacity for proteinaceous (lean) tissue accretion and have been shown to require up to 500% more B vitamins (Stahly et al., 1995) than pigs evaluated 20 to 40 years ago. Management schemes that minimize the pig's chronic exposure to antigens also have been shown in work at our station to improve the pig's capacity for proteinaceous tissue growth. Assuming the vitamin needs per unit of body protein accretion are relatively constant, pigs which experience low or moderate levels of antigen exposure would be hypothesized to require more dietary B vitamins than animals experiencing high levels of antigen exposure.

The objective of this study was to determine the impact of the dietary concentration of a group of five B vitamins on the rate and efficiency of growth of pigs experiencing a moderate or high level of chronic antigen exposure.

Materials and Methods

Experimental Treatments

The experimental treatments consisted of two levels of chronic antigen exposure and five dietary concentrations of a group of five B vitamins. Two rearing schemes were used to create a moderate and a high level of chronic antigen exposure (AE) in the pigs. Pigs in both rearing schemes were derived from a single genetic strain and source and were weaned at 12±2 days of age. The moderate pigs were administered ceftiofur (Naxcel) once daily (4.5 mg/lb body weight) for three days postweaning and placed in a sanitized facility physically isolated from other pigs. The high AE group was not administered ceftiofur at weaning and were placed in a nonsanitized facility concurrently occupied with older pigs derived from the pigs' herd of origin. The herd of origin possessed serological titers for mycoplasma hyopneumonia (MP), actinobacillus pleuropneumoniae (APP), porcine reproductive and respiratory syndrome (PRRS), swine influenza virus (SIV), and transmissible gastroenteritis (TGE). Based on previous studies, the daily lean tissue growth capacities of the genetic source of pigs used are estimated to be .75 to .80 pounds for pigs fed from 40 to 245 pounds body weight.

The dietary regimens consisted of a basal diet supplemented with five levels of specific B vitamins. The basal diet consisted of a corn-soybean meal, 15% lactose, 5% casein, 5% choice white grease mixture (Table 1).

The diet was formulated to meet or exceed the pigs' requirements for all nutrients except the five test vitamins. The five test vitamins (niacin, pantothenic acid, riboflavin, B_{12}, and folacin) were chosen because they are closely involved in fueling proteinaceous tissue accretion. Based on the estimated vitamin content and the bioavailability of these vitamins in the ingredients used, the basal diet was calculated to contain 70% of the NRC (1988) estimated requirements for these five vitamins. In the experimental diets, synthetic sources of each of the five test vitamins were added to provide 70, 170, 270, 370, and 470% of NRC (1988) estimated requirements for 11 to 22 pound pigs for this group of B vitamins. All other vitamins were supplemented to provide 600% of the NRC (1988) estimated requirements.

Table 1. Basal diet composition.

Ingredient	Amount, %
Corn	30.73
Lactose	15.00
Choice white grease	5.00
Casein	5.00
Soybean meal, dehulled	38.16
L-Lysine - HCl	.30
DL-Methionine	.30
L-Threonine	.18
Dicalcium phosphate	3.53
Calcium carbonate	.51
Salt, iodized	.40
Trace mineral mix[a]	.20
Basal vitamin mix[b]	.10
Choline chloride, 50%	.21
Antimicrobial agent[c]	.18
Suppl. B vitamin carrier[d]	.20
Total	100.0

[a]Provided in diet (ppm): 140 Fe; 120 Zn; 48 Mn; 14 Cu; .8 I; .3 Se.
[b]Provided per pound of diet: 6,050 IU Vit. A; 600 IU Vit. D_3; 44 IU Vit. E; 1.4 mg Vit. K; 2.4 mg niacin; .18 mg pantothenic acid; .45 mg riboflavin; .005 mg Vit. B_{12}; 0 mg folacin; 0 mg choline; .14 mg biotin; 4 mg pyridoxine; 2.7 mg thiamin; .14 mg ascorbic acid.
[c]Provided per pound of diet: 100 mg chlortetracycline, 50 mg penicillin and 100 mg sulfathiolzole.
[d]Corn starch.

Table 2. B vitamin content of diets (mg/lb of diet).[a]

	Dietary B vitamins %NRC for 11 to 22 lb pigs				
Item	70	170	270	370	470
Total vitamin content, analyzed[b]					
Niacin	8.4	15.9	23.4	30.8	38.2
Pantothenic acid	4.4	8.7	12.9	17.1	21.3
Riboflavin	1.4	3.0	4.6	6.1	7.7
B_{12}	.006	.013	.021	.028	.036
Folacin	.75	.85	.95	1.06	1.16
Available vitamin content, analyzed[b] x calc. availability					
Niacin	4.3	11.1	17.9	24.7	31.5
Pantothenic acid	4.0	8.3	12.5	16.7	21.0
Riboflavin	1.1	2.4	3.9	5.4	7.0
B_{12}	.006	.013	.020	.027	.036
Folacin	.45	.55	.69	.78	.88

[a]NRC requirements assumed to be based on 100% bioavailable sources of nutrients. The bioavailable content of the five test vitamins in the basal diet ingredients were estimated by multiplying the ingredients' estimated vitamin content (NRC, 1988) by estimates of the bioavailability of these vitamins reported in the literature.
[b]Analyzed vitamin contents are derived from the analysis of the basal diet and the supplemental B vitamin premix.

The analysis of the five test vitamins in the experimental diets and vitamin mixture are reported in Table 2. These values represent total analyzed B vitamin contents and the estimated bioavailable vitamin contents.

Experimental Procedure

Within each AE group, 10 sets of five littermate pigs were utilized. Pigs were penned individually in 1.3 x 1.4 ft pens in environmentally-regulated buildings maintained at 80 to 85ºF. For the initial four days postweaning, pigs were offered a dried milk diet containing no supplemental vitamins. From day 16 to 20 pounds body weight, pigs were fed the basal diet (70% NRC) to minimize the amount of vitamin stored in the pigs' body. Pigs were allowed to consume feed and water ad libitum.

At 22±2 pounds body weight, pigs within each litter were randomly allotted to one of the five dietary vitamin regimens. Pig weights and feed consumption were measured at four-day intervals until each animal reached a body weight of 61±4 pounds. Serum concentration of the acute phase protein alpha-1 acylglycoprotein was monitored at body weights of 22 (initial), 42, and 61 (final) pounds as an indicator of the level of antigen exposure the pigs experienced. The presence or absence of serological titers for common antigens in the pigs also were determined at the initiation and completion of the study.

Data were analyzed as a split-plot design with antigen exposure level representing the whole-plot and dietary B vitamin concentrations representing the subplot. Least square means are reported. Responses of pigs to dietary vitamin concentrations at different stages of the pig's development were analyzed as a repeated measure.

Results and Discussion

Diet Composition

The analyzed vitamin content of the experimental diets corrected for estimated bioavailability of the vitamins in the feed ingredients approximated the calculated bioavailable values for niacin, pantothenic acid, riboflavin, and B_{12}, but not folacin (Table 2). The analyzed values expressed as a percentage of the calculated values ranged from 90 to 98 for niacin, 98 to 137 for pantothenic acid, 90 to 99 for riboflavin, and 92 to 107 for Vitamin B_{12}, whereas the folacin value ranged from 137 to 470% of the expected values for folacin. The analyzed folacin content was unexpectedly high in the basal diet but was as expected in the vitamin premix.

Immune Status of Experimental Animals

The initial experimental objective was to create animals that experienced a low and high level of antigen exposure. Based on the analyses of the pigs' serological titers for common antigens, the serum concentrations of alpha-1 acid glycoprotein (AGP) and the growth performance of the pigs, a moderate and high level of the pigs' AE was achieved rather than the initial goal of a low and high level of AE (Table 3). Consequently, the magnitude of the difference in animal performance between the two AE groups was less than that previously obtained in pigs reared using the management techniques employed in this study.

Table 3. Immune status of the pigs.

Item	AE Level	Pig weight, lb 20	40	60
Serological titers (% of pigs with titers)[a]				
PRRS	Mod			10
	High			35
SIV	Mod			14
	High			19
TGE	Mod			66
	High			90
Serum AGP, µg/ml[b]				
	Mod	629	495	502
	High	804	628	848

[a]All pigs were free of titers for MP and APP.
[b]Antigen exposure effect, P<.05.

Antigen Exposure (AE) Effect

As expected, the moderate AE pigs consumed more feed and gained weight faster than the high AE group throughout the duration of the study (Figure 1). The quantity of feed required per unit of weight gain was less in the moderate AE group during the initial two-thirds of the study but not during the last 10 pounds of growth. Consequently, differences in feed/gain ratios between AE groups over the duration of the study were small. This response likely is due to the fact that the difference in the magnitude of antigen exposure among the AE groups was smaller than that previously achieved when using the two pig rearing schemes.

Dietary B Vitamin and AE x B Vitamin Effects

Voluntary feed intake, daily body weight gain, and feed/gain ratios responded quadratically as dietary concentrations of the five test B vitamins increased (Table 4). These responses occurred in both the moderate and high AE groups. Over the duration of the study, daily body weight gain and the quantity of feed required per unit of weight gain was optimized in pigs fed diets containing a minimum of 370% of the NRC (1988) B vitamin requirements for 11 to 22 pound pigs. No antigen exposure by dietary B vitamin interaction was detected. The smaller than intended difference in antigen exposure between the two AE groups may have limited differences in the vitamin needs between the two AE groups.

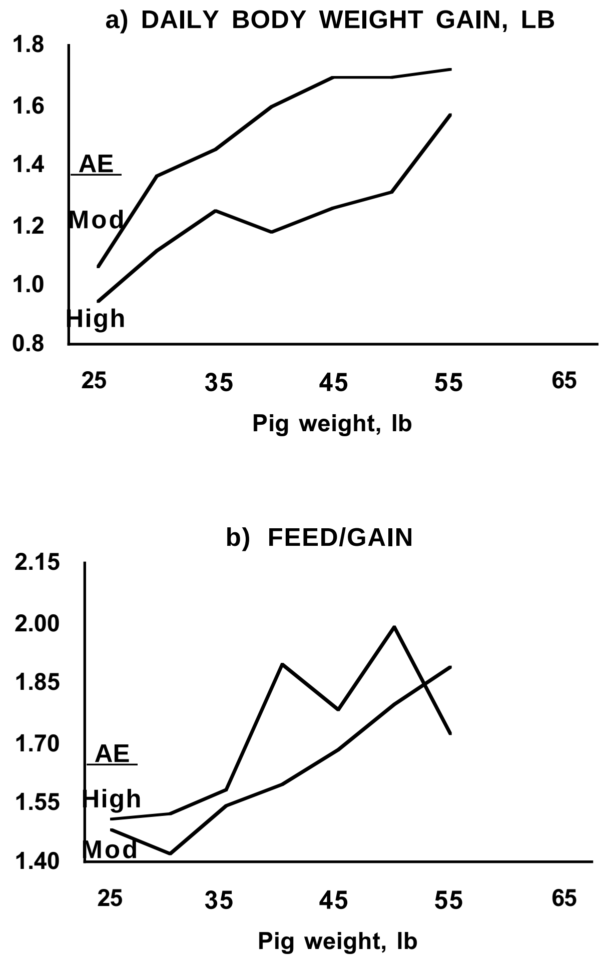

Figure 1. Daily body weight gain (a) and feed/gain ratios (b) of pigs (pooled across dietary B vitamins) during four-day periods when the pigs weighed (±2.7) 25, 31, 36, 42, 47, 53, and 58 pounds. Pigs experienced a moderate (mod) or high level of antigen exposure (AE).

AE x B Vitamins x Pig Weight Effects

The daily weight gains and feed/gain ratio of each pig during four-day periods when the pig weighed (±2.7 pounds) 25, 31, 36, 42, 47, 53, and 58 pounds were analyzed. Daily feed intake and daily body weight gains increased as pigs grew from 22 to 61 pounds body weight (Figure 1). Efficiency of feed utilization was reduced as pigs matured. Based on daily gains and efficiency of feed utilization, the moderate AE pigs weighing 22 to 33, 33 to 44, and 44 to 61 pounds required dietary B vitamin concentrations equivalent to a minimum of 370%, 370%, and 370 to 470% of the NRC (1988) requirements for 11 to 22 pound pigs (Table 5). In high AE pigs, pigs weighing 22 to 33, 33 to 44, and 44 to 61 pounds required dietary B vitamin concentrations equivalent to 270%, 370%, and 270 to 370% of the NRC (1988) requirements for 11 to 22 pound pigs, respectively.

Table 4. Responses of pigs to dietary B vitamin concentrations.

Item	Antigen Exposure	Dietary B vitamins, % NRC for 11 to 22 lb pigs				
		70	170	270	370	470
Pig weight, lb						
Initial[a]	Mod	22.2	22.6	22.3	22.4	22.8
	High	20.7	19.6	20.8	21.5	20.7
Final[a]	Mod	61.0	61.5	61.1	62.0	60.9
	High	60.5	60.4	59.5	60.9	58.9
Days on test[bc]	Mod	30.0	26.0	26.1	25.1	24.8
	High	38.9	36.2	32.2	32.2	31.7
Daily feed, lb[bc]	Mod	2.21	2.40	2.40	2.41	2.40
	High	1.66	1.82	1.90	1.86	1.86
Daily gain, lb[bd]	Mod	1.31	1.50	1.49	1.58	1.55
	High	1.04	1.15	1.21	1.24	1.22
Feed/gain[d]	Mod	1.69	1.60	1.61	1.52	1.55
	High	1.60	1.59	1.58	1.51	1.55

[a]Antigen exposure effect, $P<.10$.
[b]Antigen exposure effect, $P<.01$.
[c]Dietary B vitamin effect, $P<.01$.
[d]Dietary B vitamin effect, $P<.05$.

In summary, pigs (22 to 61 pounds) with a moderate genetic capacity for lean tissue growth exhibit up to 19 to 21% greater body weight gains and require 6 to 10% less feed per pound of body weight gain when dietary additions of a group of five B vitamins were increased about four times that of the current estimated requirements for young pigs. The optimum dietary concentrations of the five B vitamins did not differ between pigs experiencing a moderate or high level of chronic antigen exposure.

Table 5. Dietary B vitamins expressed as a percentage of the NRC (1988) estimated requirement for 11 to 22 pound pigs needed to optimize daily gain and feed/gain in pigs at various stages of growth.

Criteria	Pig Weight, lb	AE level	
		Mod	High
Daily gain	22-33	370	270
	33-44	370	370
	44-61	470	370
Feed/gain	22-33	370	270
	33-44	370	370
	44-61	370	270

References

Stahly et al. 1995. ISU Swine Research Report, ASL-R1263.

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