Dietary Vitamin A, E, and C Needs of Pigs Experiencing a Low or High Level of Antigen Exposure

T. S. Stahly, professor,
D. R. Cook, assistant research scientist,
and R. C. Ewan, professor
Department of Animal Science

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Summary and Implications

The impact of dietary vitamin A, E, and C concentration on rate and efficiency of body weight gain and serum vitamin E (α-tocopherol) concentration was determined in pigs experiencing a low or high level of antigen exposure (AE). Pigs were reared via two management schemes that resulted in either a low or high level of AE. Dams of the pigs received a corn and soybean meal diet devoid of supplemental vitamins A, E, and C from day 60 of pregnancy through lactation. Post-weaning, pigs were individually penned and self-fed a basal diet containing 25% of the estimated requirement (1) for 11–22 lb pigs for vitamins A and E, and 3.64 mg of vitamin C per pound of diet. At 21±2.6 lb body weight, pigs within a litter were randomly allotted to the basal diet supplemented with vitamins A, E, and C equivalent to 0, 100, 200, 300, and 400% of NRC (2 mg of C added per 1 IU of E).

Low AE pigs had lower serum alpha-1 acid glycoprotein concentrations (466 vs 726 μg/mL) indicating they experienced a lower level of AE. Low AE pigs also gained body weight faster (1.39 vs 1.27 lb/day) and required less feed per unit of gain (1.37 vs 1.45) than high AE pigs fed from 21 to 55 lb body weight. As dietary concentrations of A, E, and C increased, daily gains increased quadratically, but the magnitude of response was greater for the high AE pigs. Serum vitamin E concentrations increased with increasing dietary concentrations of vitamins A, E, and C in low AE pigs but remained constant in high AE pigs.

Based on these data, dietary needs for one or more of vitamins A, E, and C are greater in pigs experiencing a high versus low level of chronic antigen exposure. Furthermore, the needs of high-antigen-exposed pigs are greater than current estimated requirements (1).

Introduction

Antigen exposure in pigs results in immune system activation. Cells of the activated immune system secrete hormone-like molecules called cytokines that stimulate immune cell proliferation and antibody production. Although cytokines are necessary for proper immune system function and disease resistance, their effect on animal performance is negative because they increase core body temperature, decrease feed intake, decrease protein synthesis, and increase protein degradation in skeletal muscle. Therefore, overproduction of cytokines is undesirable for optimal animal performance.

In addition to cytokines, the immune system produces toxic free radicals to aid in killing foreign organisms. Cytokines and free radicals have the capacity to enhance the production of each other. Because of the potential detrimental effect of these compounds on animal performance, control of the actions or production of these molecules may be beneficial for optimal growth during immune system activation resulting from antigen exposure.

The stimulatory effect of free radicals on cytokine production can be limited by the action of antioxidants (e.g., vitamin E). The dietary addition of antioxidant vitamins for antigen-exposed pigs could potentially minimize negative effects of free radical-induced cytokine production.

This study was conducted to determine the influence of dietary vitamin A, E, and C regimen on the growth response of pigs experiencing a low or high level of chronic antigen exposure.

Materials and Methods

Experimental treatments consisted of two levels of antigen exposure (low or high) and five dietary concentrations of the antioxidant vitamins A, E, and C. Pigs with a low level of AE were created by administering ceftifor and ampicillin to pigs at 1, 3, 5, 8, and 11 days of age and at weaning, weaning the pigs at 12–14 days of age, and then placing them into a sanitized facility physically isolated from the site of origin. High AE pigs did not receive antimicrobial agents and were weaned into an unsanitized nursery at the site of origin that was co-occupied by older pigs.

To minimize body stores of the test vitamins in the experimental animals, dams of the pigs were fed a corn-soybean meal diet devoid of supplemental vitamins A, E, and C from day 60 of gestation through lactation. At weaning, pigs were fed a milk product-based diet devoid of supplemental vitamins A, E, and C for seven days. Pigs were then placed on the basal diet that supplied 25% of NRC (1988) (1) estimated requirements of vitamins A and E for 11 to 22 lb pigs (Table 1). At 21±3 lb, pigs were randomly allotted within a litter to one of the five concentrations of the test vitamins. The five diets consisted of the basal diet supplemented with 0, 100, 200, 300, and 400% of NRC (1988) (1) for vitamins A and E and 2 mg of vitamin C per IU of vitamin E. All other vitamins were included at 600% of the requirement (1). A single

Table 1. Composition of basal diet.

Ingredient	%
Corn	25.00
Soybean meal, 48.5%	40.00
Skim milk, dried	5.00
Whey, dried	20.00
Choice white grease	4.00
Dicalcium phosphate	3.19
Limestone	.03
Salt	.20
Tryptosine	.20
L-Threonine	.30
Lysine	.10
D,L-Methionine	.35
TM-vit premix[a]	.33
Choline Cl, 60%	.30
Starch[b]	.50
Antimicrobial agent[c]	.50

[a] Provided the following per pound of diet: Cu, 8.0 mg; Fe, 79.5 mg; Mn, 27.3 mg; Se, .11 mg; Zn, 68.2 mg; biotin, .06 mg; folacin, .52 mg; riboflavin, 7.8 mg; pyridoxine, 2.1 mg; pantothenic acid, 21.2 mg; vit D, 60 IU; vit K, 1.1 mg; vit B_{12}, 40μg.
[b] Vitamin A, E, and C premix substituted for starch.
[c] Provided the following per pound of diet: 50 mg chlortetracycline, 50 mg sulfathiozole, and 25 mg penicillin in low AE diet.

source of each ingredient was used to minimize variation in vitamin content.

Pigs were penned individually in 1.5 x 4 ft pens and allowed to consume feed and water *ad libitum*. Ambient temperatures were maintained at 82 to 85°F. Pig weights and feed consumption were measured at 4-day intervals from 21 to 55 lb body weight. Blood samples were collected at 11-lb body weight intervals beginning at 21 lb body weight for serum vitamin E (α-tocopherol) and alpha-1-acid glycoprotein (AGP) determination.

Data were analyzed as a split-plot design with AE serving as the whole plot and dietary vitamin A, E, and C concentration serving as the subplot. Least square means are reported.

Results and Discussion

Antigen exposure effect. Consistent with previous results at our station, low AE pigs gained body weight faster and more efficiently (Table 2) than high AE pigs. In addition, the concentration of AGP, an acute phase protein synthesized in the liver and released into the bloodstream during immune system activation, was greater in high AE pigs at each of the four stages of growth monitored (Figure 1). These data indicate that the rearing schemes used were successful in creating two different levels of antigen exposure and, thus, immune system activation.

Table 2. Growth and feed utilization of low and high antigen exposed (AE) pigs fed from 21 to 55 lb.

	Antigen exposure	
Criteria	Low	High
Body weight, lb		
Initial	20.3	22.1
Final	55.1	55.6
Daily feed, lb	1.94	1.86
Daily gain, lb[a]	1.39	1.27
Gain/feed[b]	.72	.69

[a] AE effect, $P<.01$.
[b] AE effect, $P<.05$.

Dietary vitamin A, E, and C effect. Feed intake in pigs fed from 21 to 55 lb was maximal in animals consuming 225% of NRC (1) levels of vitamins A, E, and C (Figure 2). Daily body weight gain increased as vitamin A, E, and C concentrations increased up to 225% of NRC (1988); however, the magnitude of response was greater in high compared with low AE pigs (Figure 2). Feed/gain ratios were not altered by dietary vitamin A, E, C concentrations (Figure 3).

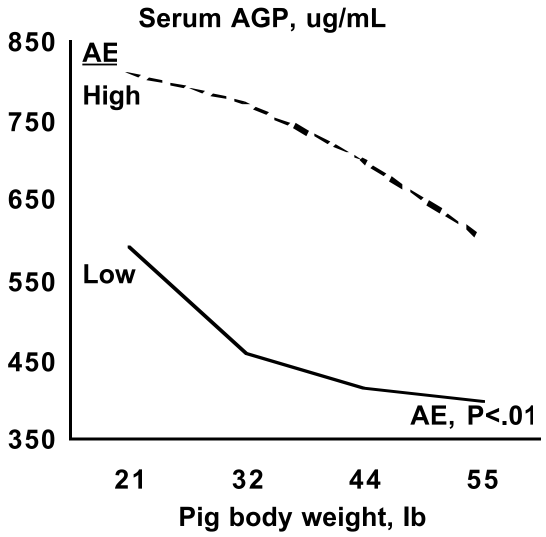


Figure 1. Serum alpha-1-glycoprotein (AGP) concentrations in low and high antigen exposed (AE) pigs at four stages of growth.

Serum α-tocopherol concentrations were measured at each of four stages of growth when the pigs' body weight averaged 21, 32, 44, and 55 lb. The change in serum α-tocopherol from 21 lb to 55 lb body weight is shown in Figure 4. Serum α-tocopherol increased as dietary vitamin A, E, and C concentrations increased, and the magnitude of increase was greater in low compared with high AE pigs.

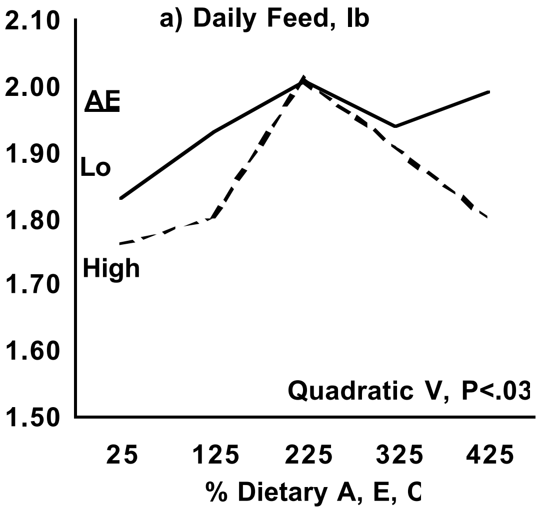
The increase in daily feed intake and body weight gain up to 225% of NRC (1) vitamin levels may reflect the antioxidant action of the test vitamins against free radicals and, thus, cytokines. The minimization of feed intake and body weight gain response in the high AE pigs as the test vitamins were elevated further was unexpected. One possible explanation is the pro-oxidant effect of vitamin C at high concentrations. Vitamin C does have antioxidant activity but is known to become a pro-oxidant when included at high concentrations. High AE pigs likely had elevated free radical production. Pro-oxidant activity of vitamin C (at high concentrations) may have negated some antioxidant capacity and, thus, minimized the growth response of high AE pigs to dietary vitamin concentrations above 225% of NRC (1). However, the highest dietary concentration of vitamin C in the current study (136 ppm) is substantially below concentrations normally associated with pro-oxidant activity and likely did not contribute to the response.

A greater demand and, thus, use of the antioxidant vitamins seemed to occur in the high AE pigs resulting in low concentrations of vitamin E in the serum of these pigs. In contrast, the lower demand for antioxidants in the low AE pigs was associated with a linear increase in serum vitamin E as dietary vitamin concentrations increased.

These data provide evidence that current needs for one or more of the test antioxidant vitamins by 20- to 55-lb pigs experiencing a high level of antigen exposure are greater than current NRC (1988) estimates.

References

1. National Research Council (NRC). 1988. Swine Nutrient Requirements. National Academy of Sciences, Washington, D.C.



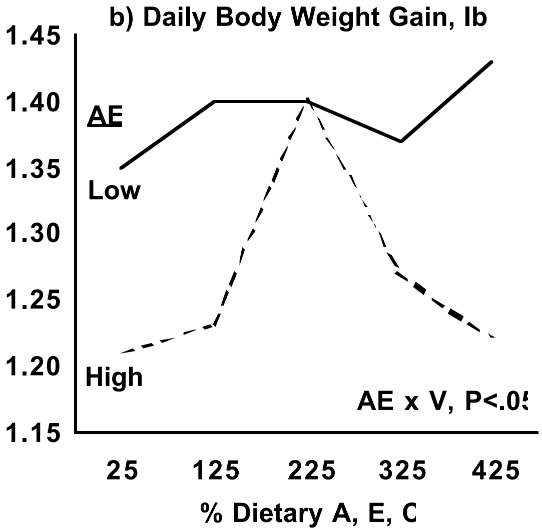


Figure 2. Daily feed intake (a) and body weight gain (b) of low and high antigen exposed (AE) pigs fed one of five dietary concentrations of vitamins A, E, and C from 21 to 55 lb body weight. (Percent based on NRC [1].)

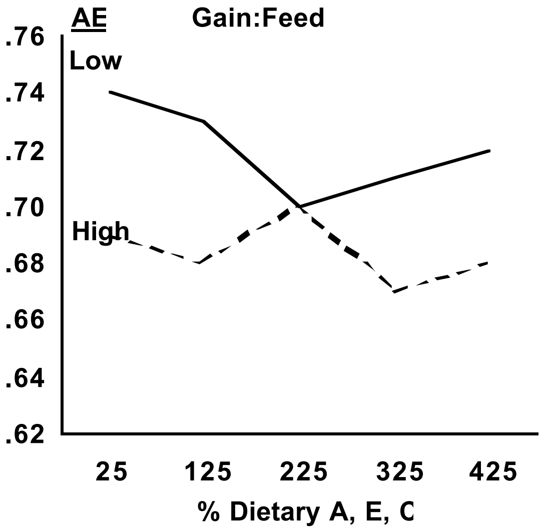


Figure 3. Feed/gain ratios of low and high antigen exposed (AE) pigs fed one of five dietary concentrations of vitamins A, E, and C from 21 to 55 lb body weight. (Percent based on NRC [1].)

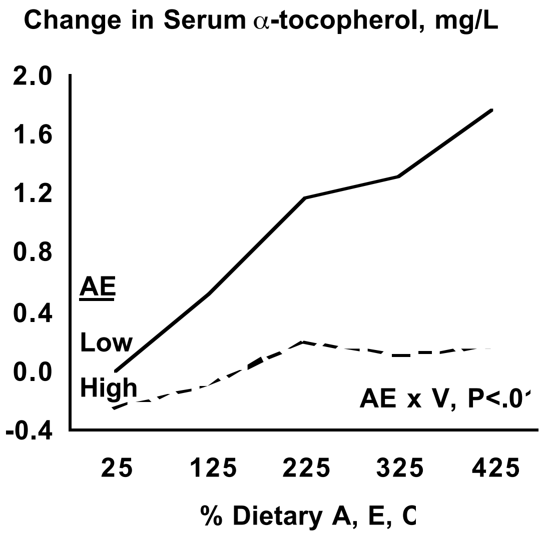


Figure 4. Change in serum α-tocopherol concentration in low and high antigen exposed (AE) pigs fed one of five dietary concentrations of vitamins A, E, and C from 21 to 55 lb body weight. (Percent based on NRC [1].)