Effects of Dietary Vitamin E Level and Source on Sow, Milk, and Piglet Concentrations of α-tocopherol[1]

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Summary

A total of 126 gilts and sows (PIC 1050) and their litters were used to determine the effect of dietary vitamin E level and source on sow plasma, milk, and piglet tissue concentrations of α-tocopherol. The 6 dietary treatments included 2 levels of dl-α-tocopherol acetate (Syn E) at 44 and 66 mg/kg (40,000 and 60,000 mg/ton) and 4 levels of d-α-tocopherol acetate (Nat E) at 11, 22, 33, and 44 mg/kg (10,000, 20,000, 30,000 and 40,000 mg/ton). From breeding through d 69 of gestation, sows were fed 4.5 lb/d of a diet containing 40% dried distillers grains with solubles (DDGS), 0.30 ppm added Se, and no added vitamin E. Vitamin E treatments were fed from d 70 of gestation through weaning (d 21). Plasma was collected from sows on d 69 and 100 of gestation, at farrowing, and at weaning. Colostrum (d 1) and milk samples (weaning) were also collected. Plasma from 3 pigs per litter and heart and liver samples from 1 pig per litter were collected at weaning. All plasma, milk, and tissue samples from 6 sows and litters per treatment were analyzed for α-tocopherol.

Although tissue, plasma, and milk concentrations of α-tocopherol were the primary response criteria of interest, sow and litter performance were also measured. As expected, treatment effects were not observed ($P > 0.10$) for lactation feed intake, sow BW, or backfat thickness measurements. A trend ($P < 0.09$) for decreased average weaning weight in litters of sows fed 44 mg/kg Syn E was observed, likely because of the difference ($P < 0.05$) in weaning age and the numerical differences in birth weight. No other differences in litter performance were observed ($P > 0.05$).

As dietary Nat E increased, sow plasma, colostrum, milk, piglet plasma, and piglet heart concentrations of α-tocopherol increased (linear; $P < 0.03$). Sows fed diets with 44 mg/kg Nat E had greater ($P < 0.02$) plasma, colostrum, and piglet plasma concentrations of α-tocopherol than sows fed the 44 mg/kg of Syn E. Sows fed 66 mg/kg Syn E also had greater ($P < 0.03$) plasma concentrations of α-tocopherol at weaning than sows fed 44 mg/kg Syn E. Regression analysis indicated that the bioavailability coefficients for Nat E relative to Syn E ranged from 2.1 to 4.2 for sow and piglet plasma α-tocopherol, 2.9 to 3.0 for colostrum α-tocopherol, 1.6 to 7.3 for milk α-tocopherol, and 1.8 to 7.5 for heart and liver α-tocopherol. Overall, this study indicates that the relative bioavailability of Nat E relative to Syn E varies depending on the response criteria, but that it is greater than the standard value of 1.36 in sows.

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Introduction

Vitamin E is a generic term for a group of tocopherols and tocotrienols that serve as antioxidants in the lipid components of animal and plant tissues. Of the 8 compounds (4 tocopherols and 4 tocotrienols), α-tocopherol is the most bioactive form for animals. Within the α-tocopherol isomer are eight stereoisomers that position three methyl groups at the 2>, 4>, and 8> positions of the phytyl tail (R or S configuration) differently. The biological activities of these 8 stereoisomers range from 21 to 100%, with the RRR-α-tocopherol form being the greatest.

Two sources of vitamin E are available for supplementing swine diets. Synthetic vitamin E (all rac-α-tocopherol, dl-α-tocopherol) is a combination of the 8 stereoisomers, whereas natural vitamin E (RRR-α-tocopherol, d-α-tocopherol) comprises only the RRR stereoisomer. Using an esterified form to either acetate or succinate is common to prevent oxidation until the acetate or succinate is removed. Harris and Ludwig (1949[5]) showed that the relative bioavailability of natural vitamin E was 1.36 times that of synthetic vitamin E in pregnant rats, and that value has been extrapolated for use in other species. Recent research by Mahan et al. (2000[6]) suggests the ratio of relative bioavailability for natural vitamin E to synthetic vitamin E is 1.54 or greater in sows based on α-tocopherol concentrations in milk.

Most of the work with vitamin E has been with corn-soybean meal diets without DDGS. Adding DDGS to sow diets can reduce cost and improve profitability but increases the potential for oxidative compounds in the diets. Testing increasing natural vitamin E and comparing it to standard synthetic vitamin E levels in diets with high levels of DDGS could yield an estimate for the relative bioavailability of the two different sources; therefore, the objectives of this study were to determine the level of α-tocopherol in plasma, milk, and piglet body tissues when supplied from synthetic or natural vitamin E and to estimate the bioavailability of natural vitamin E relative to synthetic vitamin E when included in diets with DDGS.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at the K-State Swine Teaching and Research Facility in Manhattan, KS.

A total of 126 gilts and sows (PIC 1050) and their litters were used to evaluate the effects of dietary vitamin E level and source on sow and piglet concentrations of α-tocopherol. The six dietary treatments were 2 levels of dl-α-tocopherol acetate (Syn E) at 44 and 66 mg/kg (40,000 and 60,000 mg/ton) and 4 levels of d-α-tocopherol acetate (Nat E) at 11, 22, 33, and 44 mg/kg (10,000, 20,000, 30,000, and 40,000 mg/ton). Treatments were allotted to sows in a generalized block design with farrowing group as

[5] Harris, P. L., and M. I. Ludwig. 1949. Relative vitamin E potency of natural and synthetic alpha-tocopherol. J. Biol. Chem. 179:1111–1115.

[6] Mahan, D. C., Y. Y. Kim, and R. L. Stuart. 2000. Effects of vitamin E sources (RRR- or all rac-alpha-tocopherol acetate) and levels on sow reproductive performance, serum, tissue, and milk alpha tocopherol contents over a five parity period, and effects on progeny. J. Anim. Sci. 78:110–119.

the blocking factor. Six farrowing groups (farrowed between November 2010 and May 2011) were used to obtain the 126 gilts and sows for the trial.

Before beginning the experiment, all gilts and sows were fed diets containing 66 mg/kg Syn E. From breeding through d 69 of gestation, gilts and sows were fed 4.5 lb of a gestation diet containing no added vitamin E. On d 70 of gestation, gilts and sows were allotted to their dietary treatment and remained on their assigned dietary vitamin level and source through the end of lactation. The gestation and lactation diets were formulated at 0.55% and 0.94% standardized ileal digestible lysine, respectively (Table 1). Gestation and lactation diets contained 40% and 20% DDGS, respectively. A sample of each DDGS batch was analyzed for sulfur content with calcium sulfate then added to maintain a constant sulfur level of 0.80 ppm in the DDGS. All diets were also formulated with 0.30 ppm added selenium from sodium selenite provided in the trace mineral premix. For the first 3 d after farrowing, sows were gradually provided increased feed according to appetite; after d 3, all sows were allowed ad libitum access to the lactation diet. Temperature in the farrowing facility was maintained at a minimum of 68°F, and supplemental heat was provided to the piglets with heat lamps.

Although not the primary response criteria for the experiment, sow BW and backfat thickness measurements were recorded at breeding, d 69 of gestation, postfarrowing, and at weaning. Individual piglet weight, piglet count, and total litter weight were recorded at birth, d 3 of lactation, d 17 of lactation, and at weaning. Lactation feed intake was also measured. The primary response criteria were sow plasma, piglet tissue, and milk α-tocopherol levels. Blood was collected via jugular venapuncture on d 69 and 100 of gestation, approximately 4 h after feeding. Blood was stored on ice for approximately 1 h, then centrifuged at 1,600 × g for 20 min. Milk and sow plasma samples were also collected at 8 to 12 h postfarrowing and at weaning. Milk samples were obtained by an intravenous injection of oxytocin and milk was collected from all functional glands. At weaning, plasma was taken from 3 pigs per litter, and 1 pig per litter was sacrificed to obtain heart and liver samples, which were immediately flash frozen in liquid nitrogen to limit oxidation.

From each farrowing group, samples from 1 sow and litter per dietary treatment were used to analyze α-tocopherol, and similar parties were selected for each dietary treatment within a farrowing group. Samples were analyzed for α-tocopherol by HPLC at Dr. Mahan's laboratory at The Ohio State University.

Experimental data were analyzed initially using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, NC). Overall treatment significance was first determined by the overall treatment F-test. Contrast statements were used to test for linear and quadratic effects associated with increasing Nat E and to compare the 44 mg/kg Syn E treatment separately with the 44 mg/kg Nat E and 66 mg/kg Syn E treatments. Farrowing group was used as a random effect and sow was used as the experimental unit for all data analysis. For sow performance, interactions between dietary treatments and farrowing group were non-significant and were pooled with error variance components for each response. For sow plasma, d 69 plasma α-tocopherol was used as a covariate. Statistics were considered significant at $P < 0.05$ and were considered tendencies at $0.05 < P < 0.10$.

Coefficients for the bioavailability of Nat E relative to Syn E were also calculated. Linear regression was first conducted utilizing the PROC REG procedure of SAS (SAS Institute, Inc., Cary, NC) to relate the analyzed plasma, milk, and tissue levels of α-tocopherol to the dietary level of Nat E. Based on the regression line, the Nat E dietary level needed to achieve the same tissue concentration of α-tocopherol as each of the Syn E treatments was calculated. The ratio of each dietary Syn E relative to the calculated Nat E was used to estimate the relative bioavailability.

Results and Discussion

The analyzed concentrations of α-tocopherol in each treatment's gestation and lactation diet are shown in Table 2. Although not measured, the amount of indigenous α-tocopherol is approximately 10 to 12 mg/kg above any added. The analyzed α-tocopherol values were similar to those expected with the exception of the lactation diet with 66 mg/kg Syn E, gestation diet with 44 mg/kg Nat E, and lactation diet with 44 mg/kg Nat E, which were at lower than expected values.

No differences were observed ($P > 0.10$) in sow BW or backfat thickness measurements at any of the time points (Table 3) or in total or daily lactation feed intake ($P > 0.10$). Total number, average weight, and total litter weight differences were not observed ($P > 0.10$) for total born, born alive, d 3 of lactation, or d 17 of lactation (Table 4). A trend was observed ($P = 0.09$) for a difference in average pig weight at weaning, primarily due to the numerically lower average piglet weight for sows on the 44 mg/kg Syn E diet compared with other levels and/or sources of vitamin E. This lower average weight may be due to the difference ($P = 0.05$) in weaning age and a numerically lower average piglet birth weight for sows on that particular treatment. Differences in sow performance were not expected in this trial. When comparing 2 levels and 2 sources of vitamin E over 5 parities, Mahan et al. (2000) observed no differences ($P > 0.05$) in lactation litter performance. Also, the main goal of the experiment was not to determine differences in litter performance, so insufficient numbers of sows were used per treatment to determine differences in litter performance.

Sow plasma α-tocopherol increased (linear; $P < 0.003$) with additional added Nat E on d 100 of gestation, postfarrowing, and at weaning (Table 5). Sow plasma α-tocopherol was greater ($P < 0.003$) for sows fed 44 mg/kg Nat E than for sows fed Syn E at each time point. Sow plasma α-tocopherol also increased ($P < 0.03$) at weaning with increasing dietary Syn E. Figure 1 shows plasma α-tocopherol concentrations on d 100 of gestation in relation to the dietary level and source of vitamin E. The figure also illustrates the calculated bioavailability estimates of 2.1 and 2.4 for the 44 and 66 mg/kg Syn E treatments, respectively. These results suggest that Nat E has approximately 2.1 to 2.4 times the activity of Syn E or that when formulated on a mg/kg basis, Nat E can be added at 41.6% to 47.6% the level of Syn E and obtain the same tissue levels of α-tocopherol (Table 6). Plasma α-tocopherol post farrowing yielded bioavailability estimates of 4.2 and 3.0 for the 44 and 66 mg/kg Syn E treatments, respectively. Estimates of bioavailability based on sow plasma α-tocopherol at weaning were 2.7 and 2.4 for the 44 and 66 mg/kg Syn E treatments, respectively.

Sow colostrum and milk α-tocopherol increased (linear; $P < 0.03$) with increasing dietary Nat E. Sows fed 44 mg/kg Nat E had greater ($P < 0.05$) colostrum α-tocopherol than sows fed 44 mg/kg Syn E. A numerical increase in colostrum α-tocopherol occurred as Syn E increased in the sow's diet, but the difference was not significant ($P > 0.05$) due to a large amount of variation in α-tocopherol levels in colostrum. The calculated bioavailability estimates based on colostrum α-tocopherol were 3.0 and 2.9 for the 44 and 66 mg/kg Syn E treatments, respectively. Also, the estimates for bioavailability based on milk α-tocopherol were 1.6 and 7.3 for the 44 and 66 mg/kg Syn E treatments, respectively. The dramatic difference in the two estimates is due to the numerical decrease in milk α-tocopherol concentration as Syn E increased in the diet, which suggests that the response to Syn E was no longer in the linear portion and may have plateaued. The estimate for milk α-tocopherol concentrations was similar to the 1.54 estimate by Mahan et al. (2000).

Heart and plasma α-tocopherol increased (linear: $P < 0.004$) in piglets as the Nat E increased in the sow's diet, and the levels tended to increase (linear; $P = 0.09$) in the piglet's liver. Pigs from sows fed 44 mg/kg Nat E had greater ($P < 0.05$) plasma α-tocopherol than pigs from sows fed 44 mg/kg Syn E. Similar to sow's milk, a numerical decrease in plasma, heart, and liver α-tocopherol was observed as Syn E increased in the sow's diet, but the differences were not significant ($P > 0.05$). Based on analyzed piglet α-tocopherol concentrations of 44 and 66 mg/kg Syn E levels, respectively, the estimates for bioavailability were 3.0 and 5.1 for plasma, 1.8 and 5.3 for heart, and 2.0 and 7.5 for liver. As with sow's milk, the 66 mg/kg Syn E Ac treatment appears to no longer be in the linear portion of the response.

Several additional studies have compared the bioavailability or potency of Nat E and Syn E in sows. Lauridsen et al. (2002[7]) utilized deuterated labeled forms of Nat E and Syn E to compare the bioavailability of the two sources by supplementing both simultaneously. They determined ratios of incorporation of 2:1 for Nat E compared to Syn E in sow's milk and plasma, which also related to a 2:1 ratio in suckling piglet plasma and tissues. One explanation for the difference as compared to the rat fetal absorption model is related to the presence of the α-tocopherol transport protein (TTP), which was first thought to be associated only with hepatic regulation of plasma α-tocopherol concentrations. The TTP preferentially binds and facilitates the transport of the 2-R-sterioisomers of α-tocopherol, which agrees with the 2:1 bioavailability observed by Lauridsen et al.. Some evidence, however, indicates that this transfer protein, which is expressed in uterine tissues of mice, will transport the 2-S-sterioisomers when concentrations of vitamin E are very low. The rat fetal absorption model used low levels of vitamin E, which may explain the lower estimate of bioavailability observed in this experiment and by other researchers.

A range of bioavailability estimates was calculated in this trial. The bioavailability coefficients for Nat E relative to Syn E ranged from 2.1 to 4.2 for sow and piglet plasma α-tocopherol, 2.9 to 3.0 for colostrum α-tocopherol, 1.6 to 7.3 for milk α-tocopherol, and 1.8 to 7.5 for heart and liver α-tocopherol. This study shows that the bioavailability for Nat E relative to Syn E varies depending on the response criteria but is greater than the standard value of 1.36 in sows.

[7] Lauridsen, C., H. Engel, S. K. Jensen, and A. M. Craig. 2002. Lactating sows and suckling piglets preferentially incorporate RRR- over all-rac-α-tocopherol into milk, plasma, and tissues. J. Nutr. 132:1258–1264.

Table 1. Composition of diets (as-fed basis)[1]

Item	Gestation	Lactation
Ingredient, %		
Corn	51.98	51.96
Soybean meal (46.5% CP)	4.15	24.24
DDGS[2,3]	40.00	20.00
Monocalcium P (21% P)	0.70	1.00
Limestone	1.75	1.45
Salt	0.50	0.50
Vitamin premix[4]	0.25	0.25
Trace mineral premix	0.15	0.15
L-lysine HCl	0.18	0.10
Phytase[5]	0.10	0.10
Vitamin E premix[6]	0.25	0.25
Total	100	100
Calculated analysis		
ME, kcal/lb	1,498	1,494
CP, %	17.4	21.2
Total lysine, %	0.71	1.10
SID[7] amino acids, %		
Lysine	0.55	0.94
Threonine	0.49	0.66
Methionine	0.28	0.32
Tryptophan	0.11	0.20
Isoleucine	0.51	0.74
Leucine	1.67	1.79
Ca, %	0.84	0.84
P, %	0.61	0.66
Available P, %[8]	0.50	0.49

[1] A total of 126 sows and litters were used over 6 farrowing groups to determine the effects of supplemental vitamin E level and source on sow, milk, and piglet levels of α-tocopherol.
[2] DDGS: dried distillers grains with solubles.
[3] Calcium sulfate was added at the expense DDGS to maintain 0.60% S within each batch of DDGS.
[4] The vitamin premix contained normal KSU levels of vitamins with the exception of no vitamin E.
[5] Phyzyme 600 (Danisco Animal Nutrition, St. Louis, MO) provided 272 FTU/lb of diet.
[6] Vitamin E premixes were generated for each treatment by combining appropriate amounts of synthetic or natural vitamin E and rice hulls. For the depletion diet used in gestation, the vitamin E premix was replaced with corn starch.
[7] SID: standardized ileal digestible.
[8] Phytase provided 0.11% available P to the gestation and lactation diets.

Table 2. Analyzed dietary concentration of α-tocopherol, mg/kg[1]

Source of vitamin E:	Synthetic		Natural			
Added vitamin E, mg/kg:	44	66	11	22	33	44
Gestation diet	54.4	85.7	23.0	33.4	46.0	45.7
Lactation diet	54.9	66.3	23.0	33.2	47.6	48.4

[1] A total of 126 sows and litters were used over 6 farrowing groups to determine the effects of supplemental vitamin E level and source on sow, milk, and piglet levels of α-tocopherol. Diets samples were taken from each batch of feed, then one composite sample from each treatment was used for analysis.

Table 3. Effects of vitamin E level and source on sow backfat, BW, and lactation feed intake[1]

								Significance level, $P<$		
Source of vitamin E:	Synthetic		Natural						Nat. vitamin E	
Added vitamin E, mg/kg:	44	66	11	22	33	44	SEM	Trt	Linear	Quadratic
n	21	21	21	21	21	21				
Backfat measurements, mm[2]										
Breeding[3]	15.7	16.0	16.0	16.0	15.6	15.9	0.70	0.99	0.84	0.80
Gestation d 69[4]	16.2	16.4	16.2	16.0	15.9	16.3	0.76	0.99	0.96	0.72
Postfarrowing	15.8	15.7	15.6	15.9	15.7	16	0.59	0.99	0.69	0.94
Weaning	12.5	12.3	12.4	12	11.9	13	0.57	0.78	0.47	0.20
Sow BW, lb										
Breeding[3]	413	399	423	417	417	424	16.9	0.86	0.96	0.7.0
Gestation d 69[4]	457	449	462	455	460	467	15.9	0.93	0.71	0.57
Postfarrowing	469	459	480	470	472	476	14.9	0.89	0.86	0.57
Weaning	454	446	463	451	449	461	15.0	0.93	0.87	0.36
Daily lactation feed intake, lb										
d 0 to 17	13.4	13.2	13.1	13.0	12.8	13.0	0.74	0.98	0.89	0.78
d 0 to weaning	13.7	13.5	13.3	13.3	13.0	13.5	0.74	0.98	0.93	0.62

[1] A total of 126 sows and litters were used over 6 farrowing groups to determine the effects of supplemental vitamin E level and source on sow, milk, and piglet levels of α-tocopherol.
[2] Backfat measurements were determined by averaging both sides at the last rib, approximately 4 in. off the midline.
[3] From breeding until d 70 of gestation, all sows were fed a deficient diet containing no supplemental vitamin E.
[4] On d 70, sows were allotted to treatment diets and sows remained on the same vitamin E level throughout the remainder of gestation and through lactation.

Table 4. Effects of vitamin E level and source on sow lactation performance[1]

Source of vitamin E:	Synthetic		Natural					Significance level, P<		
									Nat. vitamin E	
Added vitamin E, mg/kg:	44	66	11	22	33	44	SEM	Trt	Linear	Quadratic
n	21	21	21	21	21	21				
Litter size, n										
Total born	14.1	13.2	12.6	12.6	13.2	14.0	0.82	0.65	0.18	0.61
Born alive	13.7	13.0	12.0	12.0	12.8	13.2	0.81	0.66	0.24	0.80
d 3	11.7	11.8	11.4	11.4	12.0	11.9	0.35	0.49	0.09	0.75
d 17	11.5	11.3	11.0	10.9	11.3	11.1	0.34	0.75	0.57	0.79
Weaning	11.5	11.3	11.0	10.8	11.3	11.1	0.34	0.66	0.46	0.92
Total litter weight, lb										
Total born	41.0	43.1	37.6	38.7	39.4	42.0	2.14	0.47	0.16	0.73
Born alive	40.4	42.2	36.4	37.5	38.5	40.2	2.13	0.43	0.21	0.90
d 3	45.7	49.7	46.0	46.5	47.4	47.1	1.71	0.54	0.57	0.81
d 17	123.0	129.3	126.4	126.6	125.0	128.8	5.29	0.96	0.80	0.72
Weaning	132.5	145.9	138.1	138	143.0	144.5	5.78	0.53	0.33	0.89
Average piglet weight, lb										
Total born	2.93	3.36	3.11	3.20	3.06	3.09	0.116	0.17	0.69	0.79
Born alive	2.96	3.37	3.16	3.24	3.08	3.13	0.117	0.23	0.64	0.93
d 3	3.88	4.21	4.05	4.08	3.94	3.95	0.124	0.38	0.40	0.96
d 17	10.74	11.45	11.66	11.62	10.99	11.60	0.417	0.31	0.62	0.35
Weaning	11.56	12.93	12.68	12.82	12.61	12.98	0.459	0.09	0.68	0.76
Lactation length, d	19.1	20.0	19.2	19.5	20.0	20.2	0.31	0.05	0.01	0.82

[1] A total of 126 sows and litters were used over 6 farrowing groups to determine the effects of supplemental vitamin E level and source on sow, milk, and piglet levels of α-tocopherol.

Table 5. Effects of vitamin E level and source on sow plasma, milk and piglet tissue concentrations of α-tocopherol[1]

								Significance level, $P<$				
Source of vitamin E:	Synthetic		Natural						Nat. vitamin E		44 Syn E vs.	
Added vitamin E, mg/kg:	44	66	11	22	33	44	SEM	Trt	Linear	Quadratic	44 Nat	66 Syn.
n	6	6	6	6	6	6						
Tissue concentrations of α-tocopherol, µg/mL												
Sow plasma												
Gestation day 69[2]	1.00	0.85	0.89	0.89	0.95	0.98	0.082	0.73	0.39	0.85	0.83	0.18
Gestation day 100[3]	1.32	1.51	1.09	1.28	1.64	1.99	0.187	0.003	0.001	0.56	0.003	0.38
Farrowing[3]	0.72	0.87	0.75	0.86	1.01	1.19	0.12	0.02	0.003	0.72	0.002	0.29
Weaning[3]	1.41	1.88	1.15	1.75	2.02	2.53	0.139	0.001	0.001	0.74	0.001	0.03
Sow colostrum[4]	8.19	10.31	7.62	11.39	9.40	17.76	2.165	0.02	0.004	0.26	0.003	0.46
Sow milk[5]	3.25	2.51	2.36	3.22	3.75	3.63	0.458	0.15	0.03	0.26	0.53	0.24
Piglet levels[5]												
Plasma	2.47	2.38	2.11	3.03	3.51	3.78	0.376	0.03	0.004	0.40	0.02	0.69
Heart	4.84	3.93	3.60	4.75	5.93	6.00	0.619	0.02	0.002	0.31	0.13	0.23
Liver	4.18	3.39	2.99	4.88	4.96	5.12	1.063	0.34	0.09	0.31	0.43	0.50

[1] A total of 126 sows and litters were used over 6 farrowing groups to determine the effects of supplemental vitamin E level and source on sow, milk, and piglet levels of α-tocopherol.

[2] Prior to beginning dietary treatments.

[3] Adjusted with d 69 as a covariate.

[4] Collected 8 to 12 hours after the completion of farrowing.

[5] Collected at the time of weaning.

Table 6. Bioavailability estimates based on tissue concentrations of α-tocopherol[1]

	Calculated bioavailability of Nat E relative to Syn E[2]	
Synthetic vitamin E, mg/kg:	44	66
Sow plasma		
Gestation d 100	2.1	2.4
Farrowing	4.2	3.0
Weaning	2.7	2.4
Sow colostrum	3.0	2.9
Sow milk	1.6	7.3
Piglet levels		
Plasma	3.0	5.1
Heart	1.8	5.3
Liver	2.0	7.5

[1] A total of 126 sows and litters were used over 6 farrowing groups to determine the effects of supplemental vitamin E level and source on sow, milk, and piglet levels of α-tocopherol.
[2] The relative bioavailability of natural vitamin E was calculated for each level of synthetic vitamin E.

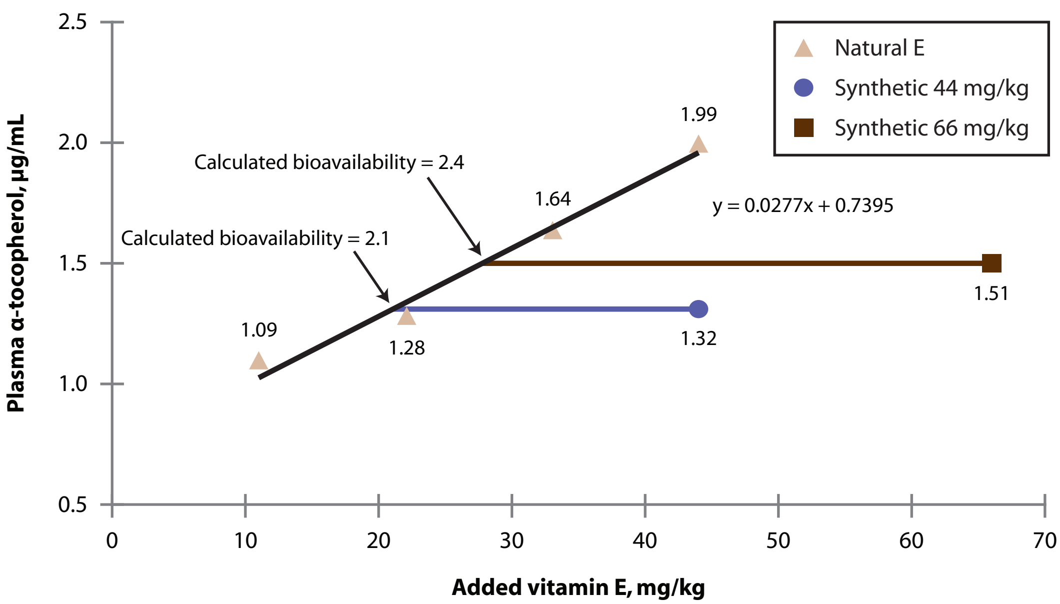

Figure 1. The graph depicts the response in sow plasma α-tocopherol from four levels of Nat E and 2 levels of Syn E on d 100 of gestation. Bioavailability of natural vitamin E relative to synthetic vitamin E was also calculated based on the α-tocopherol response from the regression line for natural E against each level of synthetic vitamin E. For example, the regression line predicts that 21 mg/kg of Nat E would need to add to achieve the same plasma α-tocopherol as 44 mg/kg Syn E, and the ratio of the two inclusion rates gives us the 2.1 estimate for bioavailability.