Differences in efficacy of various oral and injectable vitamin E products in newly-weaned pigs

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Introduction

Vitamin E deficiency is a critical problem in rapidly growing weaned pigs. Newborn pigs are born with low vitamin E status and depend upon colostrum and milk to provide adequate vitamin E while nursing.[1] At weaning, typical serum α-tocopherol values are 3-5 μg/mL in pigs nursing sows consuming adequate vitamin E in lactation diets. After weaning, vitamin E status diminishes very quickly in pigs consuming a typical starter diet.[2] Within one week, serum α-tocopherol values rapidly decline to below 2 μg/mL which is considered inadequate. It has been reported that cell-mediated immunity in pigs is maximized when serum alpha-tocopherol levels are above 3 μg/mL.[3] Attempts to prevent this decline in serum-tocopherol status through feed supplementation have been unsuccessful. Feed has been supplemented with vitamin E acetate at levels up to 200 I.U. per kg (182,000 I.U. per ton) with little improvement in vitamin E status of the newly weaned pig.[4] The only methods to prevent the dramatic decline in serum is to either inject with vitamin E and/or administer supplemental vitamin E through drinking water.

Prior to absorption, feed-grade supplemental vitamin E esters have to be de-esterified (removal of acetate ester) and micellized (made water-soluble). Those two steps appear to be the main reasons pigs are unable to efficiently utilize feed-grade supplemental vitamin E after weaning. The form of supplemental vitamin E in feed is different from that in milk. The form in milk is alpha-tocopherol, while the form in feed is alpha-tocopheryl acetate, the stabilized acetate ester. The acetate ester has to be removed by an intestinal esterase enzyme, which appears to be lacking in the newly weaned pig.[5] Secondly, since vitamin E is a fat-soluble vitamin, the de-esterified vitamin has to also be micellized by the action of bile salts before the vitamin can be absorbed.

There are several oral and injectable vitamin E products on the market. The problem is that many of the products offer no efficacy data for the use in weaned pigs. Another major concern is that some liquid supplements formulated to be added to drinking water contain selenium in addition to vitamin E. The Food and Drug Administration (FDA) does not allow selenium to be administered in drinking water, therefore the use of selenium-containing products in drinking water is not legally allowable.[6] The only FDA approved methods to administer selenium are either via injection or in complete feeds not to exceed 0.3 ppm.

Injecting vitamin E can dramatically increase vitamin E status in weaned pigs provided the injectable product has high vitamin E levels and is bioavailable. Injectable selenium/vitamin E products contain only 68 I.U. per mL as d-alpha-tocopheryl acetate (BoSe and MuSe, Intervet/Schering Plough). A 20 lb- pig injected with 0.5 mL BO-SE or 0.1 mL MU-SE would receive 34 and 6.8 I.U. vitamin E, respectively. Injectable vitamin E products contain either 300 or 500 I.U. vitamin E (d-alpha-tocopherol). One injectable vitamin E product (VITAL E-500, Stuart Products, Inc.) has published bioavailability and safety data,[7] while private-labeled injectables have none. If using a product which contains vitamin E and selenium caution should be taken not to overdose on selenium.

The purpose of this paper is to compare the ability of two different liquid vitamin E products to improve vitamin E and/or selenium status when administered in drinking water and compare the bioavailability of injectable vitamin E products in weaned pigs.

Materials and methods

Oral vitamin E study. Thirty-six newly-weaned pigs (17-19 days of age) were randomly allotted to one of three drinking water treatments with two replicates of six pigs per replicate. Pigs were bled initially and at day 7 and 14 with plasma saved for vitamin E and selenium analysis. The three water treatments tested were control (water only); 362 I.U. vitamin E per gallon water (EMCELLE TOCOPHEROL, Stuart Products, Inc); and 79 I.U. vitamin E plus 0.39 g selenium per gallon water (E-Lyte, Ralco Nutrition, Inc). Each treatment followed label dosage recommendations. All pigs received the same diets that

contained 40 I.U. vitamin E per kg diet and 0.30 ppm selenium throughout the 14-day study. Disappearance of water from each pen was recorded daily and body weights and feed intake was measured weekly.

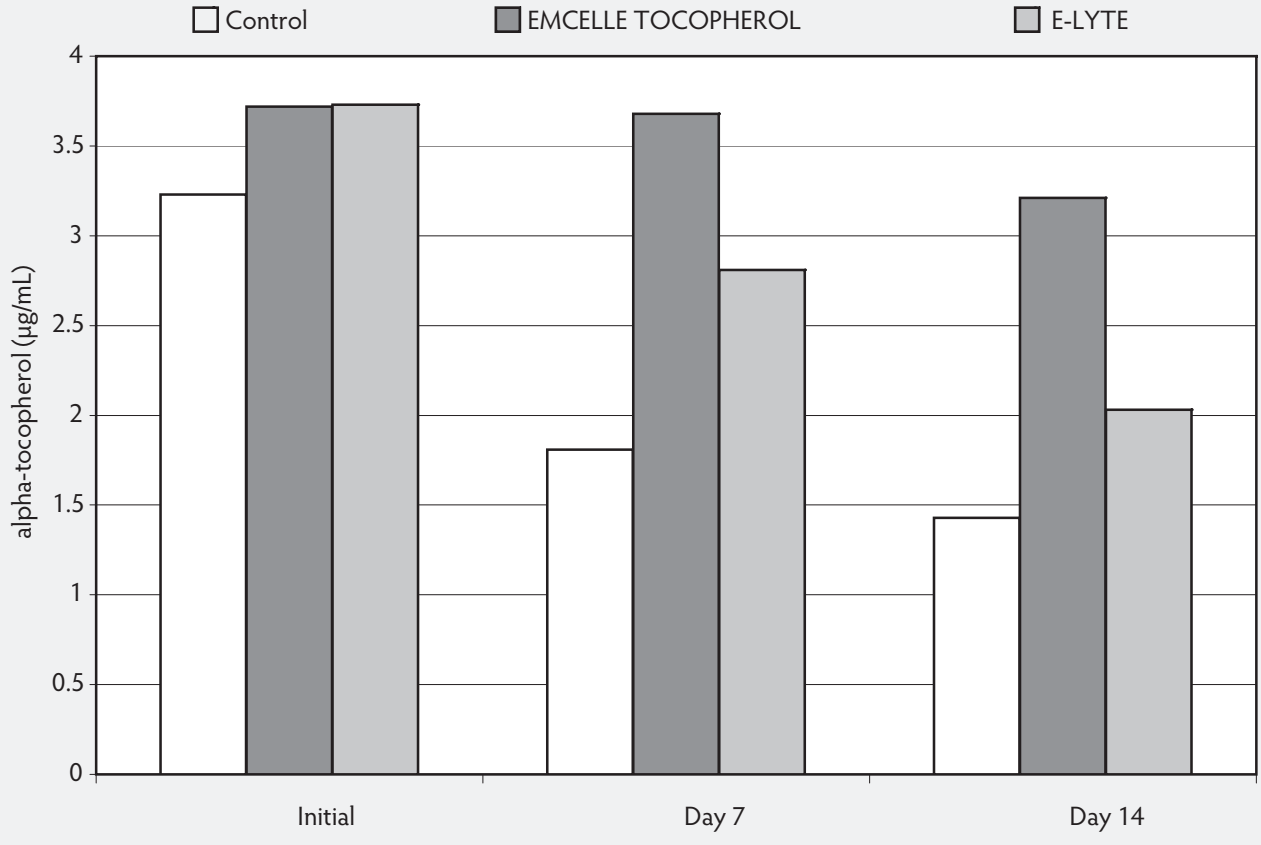
Injectable vitamin E study. Six 20 day-old pigs were bled and serum collected for alpha-tocopherol analysis. After bleeding, pigs were injected with 900 I.U. vitamin E from two injectable products. Three pigs were injected with 3 mL Vitamin E-300 (AgriLabs, Inc) and three pigs were injected with 1.7 mL VITAL E-500 (Stuart Products, Inc). Pigs were bled again twenty-two hours post-injection for serum alpha-tocopherol levels to determine if there were differences in bioavailability between the two products. Determination of serum alpha-tocopherol was done by HPLC with UV detection. Selenium in serum was determined on Varian 820-ICPMS instrument.

Results and discussion

Figure 1 shows the serum alpha-tocopherol levels in pigs administered either control, EMCELLE TOCOPHEROL (d-alpha-tocopherol) or E-LYTE (d-*alpha*-tocopheryl acetate and selenium). The average initial plasma tocopherol level across all pigs was 3.56 µg/mL. The control pigs' plasma alpha-tocopherol declined to 1.81 by day 7 and to 1.43 µg/mL by day 14. On day 7, the pigs receiving EMCELLE TOCOPHEROL did not decline in vitamin E status from the initial plasma levels and on day 14, the average plasma tocopherol level was 3.21 µg/mL which was 124.5% higher than control pigs ($P < 0.05$). On day 14, pigs receiving E-LYTE had plasma tocopherol levels of 2.03 µg/mL which was 58.1% less than pigs supplemented with EMCELLE TOCOPHEROL ($P < .05$). Since the supplemental form of vitamin E in E-LYTE is the same as in feed, one would expect that this form would not be utilized as efficiently as the micellized and non-ester form of vitamin E in EMCELLE TOCOPHEROL. Previous research in pigs has shown similar results.[2] Since vitamin E status is so critical for newly-weaned pigs, the most biologically available source of vitamin E should be supplemented. EMCELLE TOCOPHEROL contains the same form of vitamin E (*alpha*-tocopherol) that is found in sow's milk.

Figure 2 shows the serum selenium levels in all three treatment groups. The control and EMCELLE-supplemented pigs did not receive any additional selenium other than what was contained in the feed while E-LYTE

Figure 1: Plasma alpha-tocopherol (µg/mL) in pigs administered either EMCELLE TOCOPHEROL or E-LYTE in drinking water for 14 days



did. The average initial selenium level was 0.086 ppm. On day 7, the selenium levels for control, EMCELLE, and E-LYTE were 0.092, 0.099, and 0.118 ppm, respectively. On day 14 the selenium levels were 0.097, 0.093, and 0.109 ppm, for the three treatments respectively. E-LYTE supplementation improved selenium status in pigs by approximately 14.7%. According to Iowa State Veterinary Diagnostic Laboratory, serum selenium levels below 0.060 ppm are considered deficient.

Even though selenium should not be added to drinking water due to the potential of over-supplementation, several vitamin E and selenium products continue to be sold with directions for adding to drinking water.

Figure 3 shows the results from the injection study. Serum tocopherol levels at weaning averaged 5.05 μg/mL. Three pigs were injected with 900 I.U. vitamin E (1.8 mL VITAL E-500, Stuart Products, Inc), and three pigs were injected with 900 I.U. vitamin E (3 mL VITAMIN E-300, Agri-Labs, Inc). At 22 hours post-injection, pigs injected with VITAL E-500 had 64.7% higher serum tocopherol status than those injected with VITAMIN E-300 (261.7 vs. 158.9 μg/mL). In a farm that had been experiencing up to 3% death losses within 14 days post-weaning, a new group of pigs were injected with 1.7 mL VITAL E-500 and administered EMCELLE TOCOPHEROL in drinking water from days 5 through 10. Death loss was reduced from 10-12 in previous groups down to 1 pig that died 11 days post-weaning in the group injected with VITAL E-500 and administered EMCELLE TOCOPHEROL in drinking water for 10 days.

Conclusions

Vitamin E is a critically important nutrient for newly-weaned pigs. The use of oral and injectable vitamin E products that are bioavailable is critically important. Just because an oral product has vitamin E on the label, does not mean that it will be bioavailable to the young pig, especially those products that contain the acetate-ester. EMCELLE TOCOPHEROL is the only oral product that contains micellized, d-*alpha*-tocopherol, the same form that is in sow's milk. All other products provide the acetate-ester.

Many veterinarians are unaware that the addition of selenium to drinking water is unapproved. Because of potential toxicity and environmental concerns, FDA does not allow selenium to be administered to drinking water for any animal.

Figure 2: Plasma selenium (ppm) in pigs administered either EMCELLE TOCOPHEROL or E-LYTE in drinking water for 14 days

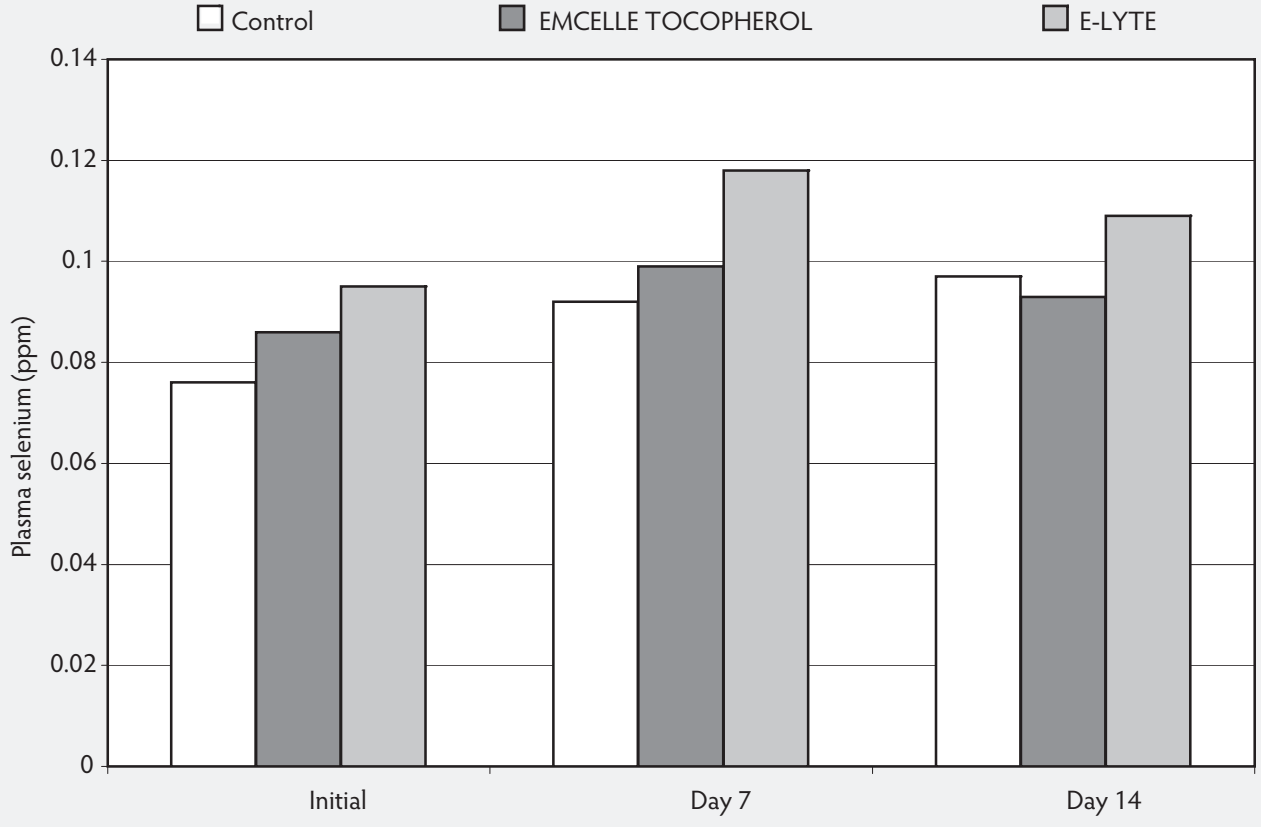
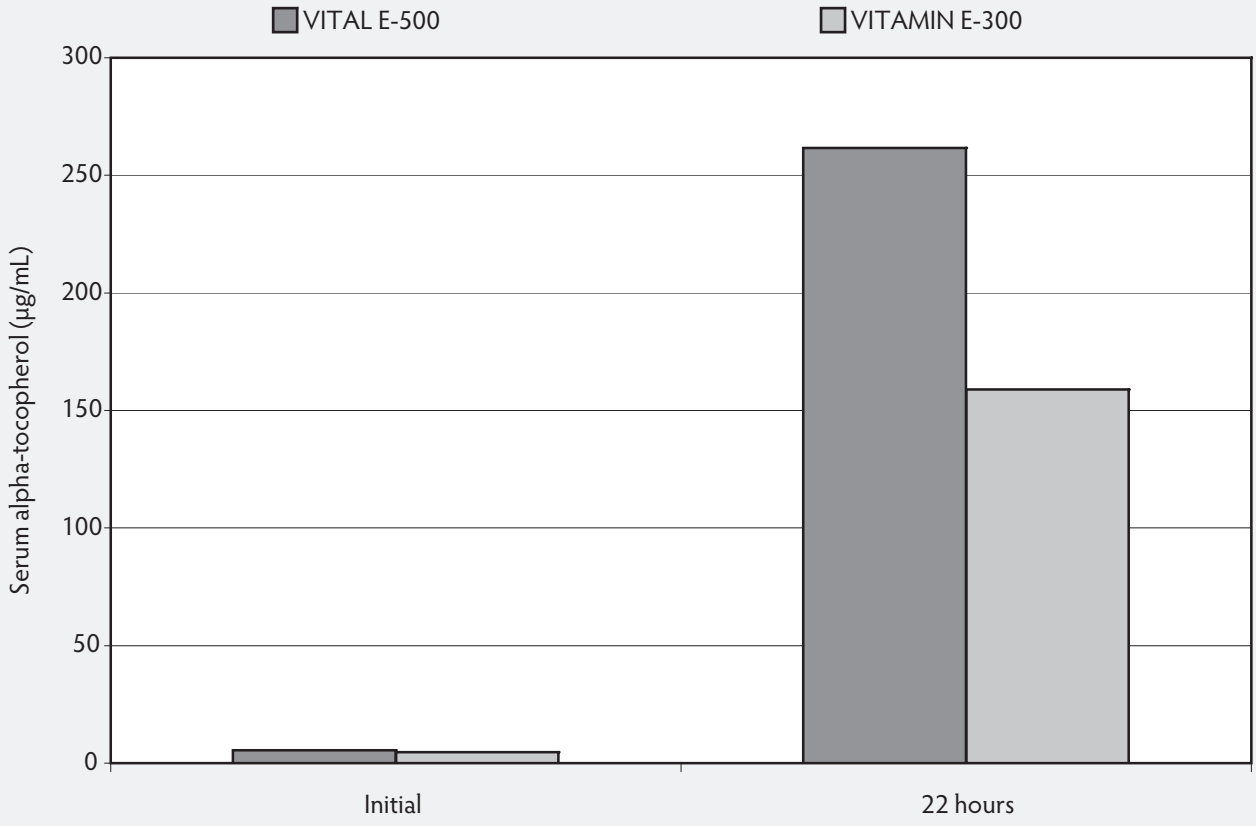


Figure 3: Serum alpha-tocopherol (µg/mL) in newly-weaned pigs injected with 900 I.U. vitamin E from either VITAL E-500 or VITAMIN E-300



VITAL E-500 was the first injectable product to provide d-*alpha*-tocopherol as a supplemental source of vitamin E. In the mid-1990's, VITAL E was knocked-off by a product line that has no bioavailability studies. The knock-off product is now sold with 7 different labels all using the original knock-off formulation and all have no bioavailability data. Just because the labels of injectable vitamins are identical to the pioneer product does not mean that bioavailability is equal.

The distressing point is that when a veterinarian uses either an oral or injectable vitamin E product that is not bioavailable, vitamin E is considered to be of no benefit. When in fact, product formulations are to blame for the lack of efficacy, not vitamin E.

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