IMPORTANCE OF SOURCE AND FORM OF VITAMIN E FOR YOUNG POULTRY

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INTRODUCTION

Vitamin E (*alpha*-tocopherol) is a critically important nutrient. It is a primary dietary antioxidant, and helps in maintaining cell membrane integrity. It also affects humoral and cell-mediated immunity, although these effects are at considerably higher dietary levels than are normally fed (Nockels, 1979; Tengerdy et al., 1981). Cardiomyopathy in broilers and turkeys may be reflective of vitamin E deficiencies (Bottje and Wideman, 1995).

The yolk sac is an important source of vital nutrients to the newly hatched bird. One critically important fat-soluble nutrient contained in the yolk sac is vitamin E (*alpha*-tocopherol). Those vitamin E levels are dependent upon the amount fortified in the hen's diet (Surai, 1999). Typically breeder hens are supplemented at a higher level than layers in order to increase quantity of vitamin E to hatchlings (NRC, 1994).

After the yolk sac has been absorbed, young birds depend on their diet for vitamin E that is typically provided as a stabilized vitamin E ester (*alpha*-tocopheryl acetate). The efficiency of absorption of the vitamin E ester in young birds is very low (Abawi et al., 1985). The reasons may be two fold:

- Lack of esterase to cleave the acetate moiety in the intestinal tract
- Lack of bile salts to micellize vitamin E (fat-soluble) prior to absorption making it water-soluble

ROLE OF VITAMIN E IN IMMUNOCOMPENTENCY

Vitamin E supplementation improves immune response to antigens by stimulating production of antibody-producing lymphocytes (NRC, 1994; Tengerdy and Nockels, 1975; Nockels, 1979; Colnago et al, 1984; Tengerdy et al, 1984; Boren and Bond, 1996). Vitamin E supplementation also enhances antibody production, thus offering improved resistance to disease and protection against various infections in poultry (Gore and Qureshi, 1997). Vitamin E at levels up to 300 IU of dl-alpha-tocopheryl acetate per kg (273,000 IU per ton) was shown to effectively improve resistance to disease in chicks and poults challenged with E. coli (Heinzerling et al, 1974; Tengerdy and Nockels, 1975).

Since vitamin E is critically important for optimum function of the immune system, it is necessary to provide the vitamin in a form and/or source to enhance absorption.

DIFFERENCES IN SOURCES OF VITAMIN E

In nature, most plants and oils naturally contain a mixture of tocopherols (***alpha***-, ***beta***-, ***gamma***- and ***delta***-) that show variable vitamin E activity. Of the four tocopherols, *alpha*-tocopherol has the highest biological potency. The two commercial sources of vitamin E are natural-source and synthetic-source vitamin E (Figure 1). Since natural and synthetic tocopherols are unstable, the acetate-ester form is included in premixes due to its enhanced stability. The International Unit (I.U.) converts various sources of vitamin E to biological activity (National Formulary, 1965). The I.U. per mg values for the various sources are as follows: Natural Alcohol (1.49 I.U./mg), Synthetic Alcohol (1.10 I.U./mg), Natural Acetate (1.36 I.U./mg) and Synthetic Acetate (1.00 I.U./mg). The natural sources have been shown to have 100% more biological activity than synthetic (Traber et al, 1992), not 36%; however due to lower cost; the synthetic source is typically used in vitamin premixes instead of the natural sources. Several liquid vitamin E products are commercially available. Most contain synthetic acetate in a water dispersible carrier, while one product contains micellized alpha-tocopherol (EMCELLE® TOCOPHEROL, Stuart Products, Inc.).

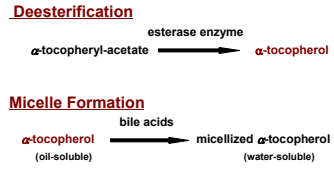
Figure 1.
Commercial Vitamin E Products

- **Powders (acetate esters)**
  - Water-dispersible (spray-dried)
    - 500 to 600 IU/g (Natural or synthetic)
  - Adsorbed (silicon dioxide)
    - 400-600 IU/g (Natural or synthetic)
- **Liquids (acetate ester and non-esterified)**
  - Water-dispersible (d and dl-α–tocopheryl acetate)
    - 400-500 IU/ml
  - Micellized (d-α–tocopherol)
    - 500 IU/ml

IMPORTANCE OF FORM OF VITAMIN E

In order for supplemental vitamin E-ester to be utilized, two steps are necessary (Figure 2). The acetate moiety has to be removed and the fat-soluble vitamin has to be made water-soluble by the action of bile salts (Gallo-Torres, 1980). Research has shown that micellized, un-esterifed *alpha* tocopherol is better utilized than the oily acetate-ester (Data on File, Stuart Products, Inc., 2002). However, due to lack of stability in feed, the only viable means to provide micellized *alpha*-tocopherol to poultry is via the water. Even though tocopherol is more available than its ester, water products generally contain synthetic tocopheryl acetate. The only product commercially available that contains un-esterified *alpha*-tocopherol is **EMCELLE® TOCOPHEROL.**

Figure 2. Steps for absorption of supplemental vitamin E esters



EMCELLE® TOCOPHEROL is a water-dispersible micellized source of d-*alpha*-tocopherol. Each ml contains 500 I.U. vitamin E activity. The product readily mixes into drinking water and does not affect water consumption. It should not be mixed into complete feeds and stored for extended time due to its unstable form. The micellization process creates tiny microscopic water-soluble droplets (optimally 0.1 to 0.4 microns) of oily vitamin E liquid. The micellization process dramatically enhances the ability of birds to absorb vitamin E (Soto-Salanova, 1995). The micelle is completely water soluble, which greatly enhances absorption from the small intestine and rapidly increases blood and tissue tocopherol levels. Essentially two steps prior to absorption are eliminated, allowing for quick and efficient uptake of the vitamin. The micellized, non-esterified form of vitamin E, does not require the acetate ester to be hydrolyzed prior to absorption and there is no need for micellization by bile salts.

EMCELLE® TOCOPHEROL EFFICACY STUDIES

Turkey Poults

Figures 3-5 show the responses of newly-hatched poults to synthetic vitamin E supplemented in the feed compared to EMCELLE in the water (Soto-Salanova 1995). One-day old turkeys were fed either 12, 46, 81, 115 I.U. synthetic acetate per kg diet from day one or 12 I.U. synthetic acetate plus 150 I.U. micellized natural tocopherol (Emcelle) per liter drinking water from days 3 through 10. Plasma, liver and lung a-tocopherol levels were significantly higher for the poults receiving EMCELLE compared to all levels of synthetic vitamin E-acetate in the feed. Tocopherol levels in bursa of Fabricius at 10 days of age were 12.5 µg/g and 52.5 µg/g for 115 I.U. synthetic acetate per kg and 150 I.U. per liter drinking water, respectively. Weight gains were not affected.

Figure 3.
Poult Plasma Tocopherol (µg/ml)

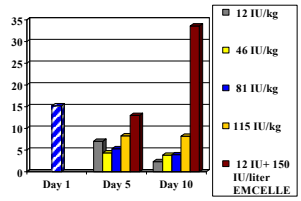


Figure 4.
Poult Liver α-tocopherol (µg/g)

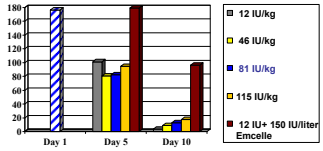
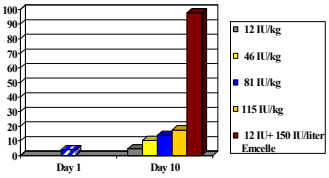


Figure 5.
Poult Lung α-tocopherol (µg/g)



Waibel et al, 1994 fed one-day old turkeys 25 I.U. vitamin E either synthetic acetate or EMCELLE added per kg diet or 25 I.U. synthetic acetate added to the diet plus 60 I.U. EMCELLE per liter drinking water. The later treatment would mimic what a commercial operation would utilize under field conditions. Plasma tocopherol was significantly higher for turkeys fed EMCELLE in the drinking water compared to the other treatments (Figure 6). EMCELLE added in the feed increased serum tocopherol levels 50% above synthetic acetate (2.1 vs.1.4 µg/ml) on day 26 of the study. EMCELLE added in the drinking water increased serum vitamin E levels 457% and 271% when compared to synthetic acetate and EMCELLE in the feed, respectively (Figure 6). Liver vitamin E levels showed a similar response to EMCELLE supplementation (Figure 7).

Figure 6. Plasma Response of Young Turkeys to EMCELLE in feed and water

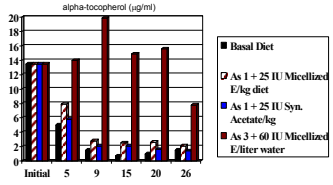
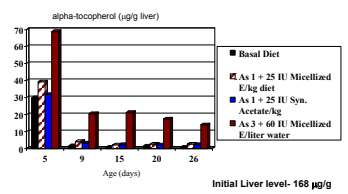


Figure 7. Liver a-tocopherol in Turkeys fed EMCELLE or Synthetic vitamin E



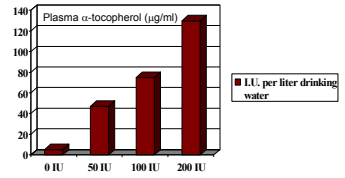
Broiler Chicks

Maurice and Lightsey 2002 provided EMCELLE at 0, 50, 100 and 200 IU vitamin E per liter drinking water to broiler chicks from days 3 thru 17. EMCELLE at all levels showed significantly higher plasma alpha-tocopherol compared to non-supplemented chicks (Figure 8). Efficiency of absorption decreased as EMCELLE level increased.

EMCELLE RECOMMENDATION

Due to the vitamin E content of the yolk sac, vitamin E supplementation is not needed prior to day 3 after hatch. For optimum blood and tissue levels, it is recommended that EMCELLE be included in drinking water at 50 to 100 I.U. per liter drinking water from days 3 to 10. After day 10, the bird is more able to utilize dietary sources of vitamin E ester.

Figure 8. Chick Plasma a-tocopherol levels after EMCELLE Supplementation



Chicks were 17 days of age

SUMMARY

All sources and forms of supplemental vitamin E are not utilized similarly. Young poultry utilize water-dispersible forms of vitamin E (*alpha*-tocopherol) more effectively than feed sources. Alpha-tocopherol is absorbed better than its acetate-ester. EMCELLE® TOCOPHEROL (d-*alpha*-tocopherol) administered in the drinking water is an excellent method to maintain and/or increase vitamin E status of young poultry. This provides them the necessary vitamin E once the yolk sac is exhausted. This is especially critical to boost their immune status when often young poultry are affected with bacterial or protozoal challenges and are building innate immunity. Elevated vitamin E status may protect against inherent diseases such as ascites or round heart. EMCELLE® TOCOPHEROL is the most effective means to enhance and maintain tissue *alpha*-tocopherol levels during the most critically important time in the bird's life.

LITERATURE CITED

Abawi F.G., T.W. Sullivan and S.E. Scheideler. 1985. Interaction of dietary fat with levels of vitamins A and E in broiler chicks. Poult Sci. 64:1192.

Boren, B. and P. Bond. 1996. Vitamin E and immunocompetence. Broiler Industry. November: 26.

Bottje, W. and R.F. Wideman Jr. 1995. Potential role of free radicals in the pathogenesis of pulmonary hypertension syndrome. Poultry & Avian Biology Reviews 6 (3):211.

Colnago, G.L., L.S. Jensen, and P.L. Long. 1984. Effect of selenium and vitamin E on the development of immunity to coccidiosis in chickens. Poultry Sci. 63:1136.

Gallo-Torres, H.E. 1980. Absorption. In "Vitamin E- A Comprehensive Treatise". L.J. Machlin, ed. p. 170.

Gore A.B. and M.A. Qureshi. 1997. Enhancement of humoral and cellular immunity by vitamin E after embryonic exposure. Poult Sci. 76:984.

Heinzerling, R.H. et al, 1974. Protection of chicks against E. coli infection by dietary supplementation with vitamin E. Proc. Soc. Exp. Biol. Med. 146:279.

Maurice and Lightsey, 2002. Comparative efficacy of liguid vitamin E products. Unpublished.

National Formulary. 1965. 12th ed., Mack Printing Co, Easton, PA.

National Research Council. 1994. Nutrient Requirements of Poulty. 9th Edition. Natl. Acad. Press, Washington, D.C.

Nockels, C.F. 1979. Protective effects of supplemental vitamin E against infection. Fed. Proc. 38: 2134.

Soto-Salanova, M. 1995. Utilization of sources and levels of vitamin E activity by young turkeys. Ph.D. Dissertation, Iowa State University, Ames, Iowa.

Surai P.F., R.C. Noble and B.K. Speake. 1999. Relationship between vitamin E content and susceptibility to lipid peroxidation in tissues of the newly hatched chick. Br Poult Sci. 40:406-10.

Tengerdy, R.P. et al. 1981. Vitamin E, immunity and disease resistance. Adv. Exp. Med. Biol. 135: 27.

Tengerdy, R.P. et al, 1984. Effect of vitamin E on immunity and disease resistance. In: Vitamins, Nutrition, and Cancer. K. Prasad, ed. Karger. Basel. p. 123-133.

Tengerdy, R.P. and C.F. Nockels. 1975. The effect of vitamin E and A on disease protection in chickens against E.coli. Poultry Sci. 54:1292.

Traber, M.G, Burton, G.W., Hughes, L., Ingold, K.U., Hidaka, H. Malloy, M, Kane, J., Hyams, J. and H.J. Kayden. 1992. Discrimination between forms of vitamin E by humans with and without genetic abnormalities of lipoprotein metabolism. J.Lipid Res. 33: 1171.

Waibel, P.E., Felice, L.J. Brannon, J.A., Chen, F. and Chen, M. 1994. Vitamin E forms for turkeys. J. Appl. Poult. Res. 3:261