

Vitamin E: why it is needed by the performance horse



What is Vitamin E?

Vitamin E is a fat soluble vitamin. It was first discovered in 1922 by Evans and Bishop who found that feeding rancid lard to pregnant rats resulted in foetal reabsorption. A “factor” within wheat germ oil was found to prevent this occurring and was named vitamin E. It was identified chemically as α -tocopherol and, following the determination of its chemical structure, it was synthesised in 1938 (1). Vitamin E research continued and a group of 8 compounds, 4 tocopherols and 4 tocotrienols, were shown to possess vitamin E activity. These compounds have a 6-chromanol ring structure and an isoprenoid side chain; the extent of “vitamin E” activity depending on the placement of the methyl groups on the ring. The terms α , β , γ and δ are used to describe this methyl group placement and the α -tocopherol form has the greatest biological activity.

Sources of Vitamin E

Vitamin E is produced naturally within plants as RRR- α -tocopherol or, d- α -tocopherol. The amount of d- α -tocopherol in feeds varies greatly (2) (3) (4) (Table 1) and, the content can decline rapidly due to processing or prolonged storage. This is because it is naturally present in the alcohol form which is highly susceptible to oxidative destruction and is thus unstable.

Feed	d- α -tocopherol
Leafy grass	29-170
Mature grass	16-63
Hay	1-85
Lucerne Meal	30
Straw	3-10
Oats	9
Barley	7



Vitamin E crystal under a high power microscope.

Vitamin E intakes

The intake by horses will be affected by the feed types available and will vary from season to season. A horse eating 6kg of leafy grass dry matter (DM) per day will consume up to 1020 mg d-a-tocopherol per day, whereas a horse consuming the equivalent quantity of hay DM would only consume 510mg.

Vitamin E supplementation

It should be obvious from Table 1 that supplementation is necessary for horses that have restricted access to pasture and for those fed low forage, high cereal diets.

The commonest form of vitamin E that is used as a supplement is all-racemic dl-a-tocopheryl acetate; this form is used because of its superior stability and proven efficacy and 1mg is equivalent to 1IU of vitamin E.

Functions of Vitamin E

The most important function of vitamin E is its action as a cellular antioxidant, preventing

the oxidation of unsaturated lipids to peroxides (5) within cell membranes by free radicals. The latter are the normal by-products of metabolic processes occurring within the body whose production increases during exercise (12) and may disturb redox reactions in muscle cells, leading to muscle fatigue. Vitamin E deficiency has been shown to reduce endurance in the rat (13). Exercise has been shown to increase lipid hydroperoxide levels in showjumpers and to a lesser extent in dressage horses (14). Oxidative stress in exercising horses is represented by an association between increased lipid peroxidation and increased leakage of the lipoprotein membranes of the muscle cells (15). Interest in the role of vitamin E for human athletes is also increasing as it has been shown to have a protective effect against free-radical-induced muscle damage (16). Vitamin E molecules act as scavengers of free radicals through the action of single, highly reactive electrons in their outer shells (1); once the electron is donated, an α -tocopherol radical is produced that requires another antioxidant to reactivate the α -tocopherol.

Good heart and lung function is essential for the performance horse (6) and vitamin E removes free radicals formed in respiratory and cardiac muscles as well as maintaining red blood cell stability (7). It is essential for maintenance of the nervous system, preventing oxidation of the lipid of nerve membranes and it promotes immune system function. Frequent disease outbreaks or poor disease resistance may be related to inadequate vitamin E status. Vitamin E supplementation has been shown to improve immune response to novel antigens, such as tetanus toxoid and equine influenza virus (25).

Interactions with other nutrients

There is a close relationship between vitamin E, selenium and vitamin C (ascorbic acid).

Vitamin C, an important antioxidant in its own right, recycles the α -tocopherol radical back to the active form of α -tocopherol (8). Selenium forms part of the cellular enzyme glutathione peroxidase and is located inside the aqueous cell cytosol and mitochondrial matrix. It destroys any peroxides formed before they can cause damage to cell membranes (1). To some extent selenium and vitamin E are interchangeable but they each have unique functions and, below a critical point no amount of one can prevent deficiency symptoms of the other appearing. It has been reported that vitamin E and selenium supplementation

Requirements for Vitamin E

The absolute requirement of a nutrient by an animal is affected by its age, reproductive state and activity level. The NRC (1998) suggests that diets for working horses should contain between 80-100mg vitamin E per kg of DM intake (10), which equates to a daily requirement of 800-1000 mg vitamin E per day assuming 10kg of DM is eaten by a 500kg horse. If this data is used, the horse should receive 1.6-2mg of vitamin E per kilo of bodyweight (BW). A study using idle adult standardbred horses suggested that the daily requirement was between 600-1800mg of all-rac- α -tocopheryl acetate per day, equivalent to 1.5-4.4mg/kg BW (11) in order to maintain vitamin E levels in the tissues.

Feeding 240mg vitamin E/kg feed together with 10g/day ascorbic acid to polo ponies maintained high blood levels of vitamin E and ascorbic acid late in the polo season. Supplementation is also suggested for animals undergoing conditioning training to help maintain blood and skeletal muscle vitamin E concentrations (18) and may improve performance of racehorses (6).

A negative correlation between vitamin E intake and blood creatine kinase and aspartate aminotransferase levels, indicators of muscle damage and cell leakage during exercise, was found to exist in endurance horses following an 80km ride (19). Increased vitamin E intake was therefore associated with less muscle leakage. Intake ranged between 1150 to 4700mg of vitamin E per day. On average the horses consumed 5mg vitamin E/kg BW. A 500kg horse would therefore need to consume 2500mg vitamin E/day. 3-5mg/kg BW per day is recommended by *Saastamoinen (2000)* for horses in training and racing (20). Frapce however suggests that 8-9mg vitamin E/kg BW could be required by the performance horse (3).

The use of fat-enriched diets, particularly for endurance horses, has increased considerably over the last few years. Corn and soyabean oil are commonly used (21)



Production of Vitamin E at TRM's collaborative raw material synthesiser.

and both contain high levels of poly-unsaturated fatty acids (PUFA). High PUFA intakes have been shown to increase free radical production in horses (22). When fat is added to the diet of a horse it is recommended that an additional 3mg of vitamin E per g of PUFA (23) is added to the feed. Thus, feeding 500ml soya oil per day containing ~62% PUFA would contribute about 310g PUFA, which would require feeding an additional 1000mg vitamin E. Rancid fats should never be fed as they contain peroxidising fats which rapidly increase the requirement for vitamin E.

Stress leads to the production of stress hormones such as gluco-corticoids and adrenaline. Free radical production increases and as a result, depletes the body's

vitamin E stores (1). The stressor may be high intensity exercise or, poor general management, poor grazing, transportation, weaning or breaking-in.

The hygienic quality of feed used by performance horses is paramount because moulds produce mycotoxins that disturb vitamin E absorption (1) and thus would increase dietary requirements.

Deficiency

Vitamin E deficiency has been identified as a factor involved with two neurological disorders of horses, equine motor neurone disease (EMND) and equine degenerative myeloencephalopathy (EDM). EMND has been reported with the highest frequency in 4-9 year old horses but in a group of horses fed similar diets, not all horses will go on to develop the condition. It seems that an individual's susceptibility to a disturbed antioxidant/pro-oxidant balance can lead to progression of the disease; EMND tends to develop after a prolonged vitamin E deficiency. Vitamin E appears to have a protective effect against oxidative damage within the spinal cord of horses, the actual neuro-anatomical site depending on the age of the horse (24). EDM usually develops in younger, growing animals, with some genotypes having a greater tendency to develop the disease than others; the spinal cord and caudal medulla oblongata degenerate.(3). Horses suffering from EDM require between 2000-6000mg vitamin E per day.

Summary

A performance horse must consume enough vitamin E to support optimal muscular and neurological activity. Vitamin E is an essential antioxidant and, together with selenium and vitamin C, it helps to maintain good health and performance. Variable feed levels of vitamin E necessitate supplementation, the precise amount depending on the level of activity but, can be as high as 8 to 9mg/kg BW for the horse in hard work. ■

References

- (1) McDowell, L.R., 2000, In Vitamins in Animal and Human Nutrition, 2nd Edition, Chapter 4, p. 155-223, Iowa State University Press
- (2) Williams, P.E.V., Ballet, N. and Robert J.C., 1998, The provision of vitamins for ruminants, In. Proc. 1998, Cornell Nutrition Conference for Feed Manufacturers
- (3) Frape, D., 2004, Equine Nutrition and Feeding, p96-100, Blackwell Publishing Ltd.
- (4) Cuddeford, D., 2006, Personal Communication
- (5) Leeson, S., and Summers, J.D., Scotts Nutrition of the Chicken, 4th Edition, Guelph (Ontario) University Press
- (6) Putnam, M.E., 1986, The effect of vitamins in nutrition of performance horses. Mod. Vet. Pract. 67:121-124
- (7) Avellini, L., Chiaradia, E., and Gaiti, A., 1999, Effect of exercise training, selenium and vitamin E on some free radical scavengers in horses (Equus caballus), Comp. Bioch. And Phys, Part B 123, p.147-154
- (8) Evans, P. and Halliwell, B., 2001, Micronutrients: oxidant/antioxidant status, Brit. J. Nut, 85, Suppl. 2, S67-S74
- (9) Dewes, H.F., 1981, A possible vitamin e-responsive condition in adult horses, N.Z Vet J, 29, 68
- (10) National Research Council, 1989, Nutrient Requirements of Horses, 5th Revised Edition. National Academy of Sciences, Washington DC.
- (11) Roneus, B. O., R. V. J. Hakkarianen, C. A. Lindholm, and J. I. Tyopponen, 1986, Vitamin E requirements of adult Standardbred horses evaluated by tissue depletion and repletion. Eq. Vet. J. 18:50.
- (12) Powers, S. K.P. and Lennon, S.I., 1999, Analysis of cellular responses to free radicals: focus on exercise and skeletal muscle, Proceedings of the Nutrition Society, 58, 1025-1033
- (13) Gohil, K., Packer, L., de Lumen B., Brooks, G.G., and Terblanche, S.E., 1986, Vitamin E deficiency and vitamin C supplements: exercise and mitochondrial oxidation. J. App. Phys. Vol 60, Issue 6, p 8750 – 7587
- (14) Munoz-Escassi, B. Maranon, G. Manley, W. Sanchez de la Muela, M., Riber, C., Cayado, P., Leon, R., Garcia, C., Suarez, M., and Vara E., 2006, Exercise-induced changes on lipid peroxides and antioxidant enzymes levels changes in plasma of show jumping and dressage horses, Intern. J. Appl. Res. Vet. Med, Vol 4, No 3 p247-281
- (15) Williams, C.A., Kronfeld D.S., Hess, T.M., Saker, K.E., Waldron, J.N., Crandell, K.M., Hoffman, R.M., and Harris, P.A., 2004, Antioxidant supplementation and subsequent oxidative stress of horses during an 80km endurance race. J. Anim. Sci. 82:588-594
- (16) Itoh, H., Ohkuwa, T., Yamazaki, Y., Shimoda, T., Wakayama, A., Tamura, S., Yamamoto, T., Sato, Y., and Miyamura, A., 2000, Vitamin E supplementation attenuates leakage of enzymes following 6 successive day of running training. Int. J. Sports Med. 21: 369-374
- (17) Hoffman RM, Morgan KL, Phillips A, Dinger, J.E., Zinn, S.A., and Faustman, C., 2001, Dietary vitamin E and ascorbic acid influence nutritional status of exercising polo ponies, in Proceedings. Equine Nutr Physiol Soc;129-130
- (18) Siciliano, P.D., Parker, A.L., and Lawrence, L.M., 1997, Effect of dietary vitamin E supplementation on the integrity of skeletal muscle in exercised horses. J. Anim. Sci. 75:1553-1560.
- (19) Williams, C.A., D.S. Kronfeld, T.M. Hess, J.E. Waldron, K.E. Saker, R.M. Hoffman, and P.A. Harris, 2003, Vitamin E intake and oxidative stress in endurance horses. Equine Nutr. Phys. Soc. Proc. 18:134-135.
- (20) Saastamoinen, M.T., 2002, Vitamin requirements and supplementation in athletic horses. P527, reprint Courtesy of Kentucky Equine Research, Inc
- (21) Bergero, D., 2004, New insights related to the nutritional management of endurance horses, Third European Equine Health and Nutrition Congress Proceedings, 2004
- (22) Bergero, D, Miraglia, N., Schiavone, A., Poldori, M. and Prola, L., 2004, Effect of dietary