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NUTRITION AND OTHER TOPICS OF INTEREST TO THE HORSE INDUSTRY.

Antioxidants in Equine Nutrition

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“Antioxidant-rich.” “High in antioxidants.” These and similar phrases can be found on many equine feed bags and nutritional supplement labels, but what are antioxidants? Why are they important? What can they do for the horse?

An antioxidant is a substance capable of preventing the oxidation of other molecules. Oxidation is the chemical reaction whereby a molecule or atom gains positive charges (protons) or loses negative charges (electrons). Biologically, oxidation is the main process by which food is converted to usable energy within the body. The same process can also produce free radicals, which are highly reactive because they are missing an electron. They circulate throughout the body and ‘steal’ electrons from cells and tissues. When this occurs, the function of the cell may be impaired. Antioxidants defend against free radical attack by donating electrons to free radicals, thus protecting cells and tissues from damage.

The role of free radicals

Free radicals are essential for proper immune function, as they can destroy foreign organisms, such as bacteria and viruses, and aid in immune response. Circulating free radicals, however, can also attack and destroy healthy tissues and cells in the body. Under normal circumstances, the body has checks and balances to help keep free radicals from damaging healthy tissues and cells.

The rate of oxidation, and therefore free radical production, depends on the level of activity. At rest, oxidation is relatively low; therefore free radical production is low. During exercise or other activities (e.g., growth, pregnancy, lactation), energy demands increase. As a result, oxygen consumption also increases, more nutrients are broken down (increased oxidation), and an increase in free radical production may occur. In these circumstances, free radical production may overwhelm the body’s natural defenses. Consequently, healthy cells and tissues can be damaged.

The role of antioxidants

Unsaturated fatty acids are a major component of cell walls, and these fatty acids are particularly susceptible to oxidative damage by free radicals. During intense exercise, for instance, free radical production will likely be increased. Free radicals can damage any cell in the body as well as DNA, proteins, and lipids (fatty acids). If the free radicals attack the lipids in muscle cell walls, they can damage or destroy cells and cause muscle damage. Outwardly, the result may be muscle soreness, inflammation, and/or tying up. Antioxidants help slow or inhibit oxidation and the chain reactions that free radicals may trigger, thereby protecting cells and tissues from damage.

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Several nutrients in the equine diet have antioxidant properties or are components of enzymes with antioxidant properties. These include selenium (as a component of the enzyme glutathione peroxidase), beta carotene, ascorbic acid (vitamin C), and vitamins A and E. While each of these alone has antioxidant properties, many of these compounds work together to provide protection to cells and tissues.

Major antioxidants in the equine diet

Selenium

While selenium itself does not act as an antioxidant, it is an essential component in glutathione peroxidase. Glutathione peroxidase is an enzyme required to catalyze (promote) the reaction in which glutathione acts an intracellular antioxidant which helps to protect cell membranes. If selenium concentrations are insufficient, then glutathione peroxidase activity will be decreased; thus reducing glutathione's ability to serve as an antioxidant.

While selenium is found in most grains and forages, it is deficient in many areas. As a result, most horse feeds and supplements are fortified with selenium. A maintenance horse's selenium requirement is 0.1 mg per kg of dry matter diet (~1 mg/day for an 1100 pound horse).

Care must be taken to not over-supplement with selenium, as it can easily be toxic to horses. Acute overfeeding selenium may result in blind staggers (blindness, head pressing, sweating, colic, diarrhea, increased heart rate and respiration rate and lethargy). Chronic selenium toxicity is characterized by hair loss and cracking hooves, especially around the coronary band. According to the sixth edition of the National Research Council Nutrient Requirements for Horses, the maximum tolerable level of selenium is 2 mg per kg of dry matter diet (~20 mg/day for an 1100 pound horse).

Vitamin E

Perhaps the most well-known and most used antioxidant in the equine diet is vitamin E. Several molecules have vitamin E activity, but the most potent is alpha-tocopherol. Vitamin E is a fat soluble vitamin and is incorporated in the cell membrane lipids, where it serves to strengthen the cell and protect against oxidative damage. Within the cell, vitamin E also serves to protect the organelles (e.g., mitochondria) from lipid peroxidation (damage).

Research has shown that horses performing intense exercise can benefit from increased vitamin E intake. Exercise can increase lipid oxidation, although whether this leads to increased cellular damage is unclear. Additionally, research has shown plasma vitamin E concentrations declined in unsupplemented, exercised horses. As a result, the vitamin E requirement increases with increasing exercise.

Vitamin E is found in many common equine feedstuffs, with the highest concentrations being in fresh forages and forages harvested at an immature stage. Vitamin E is sensitive to heat and light, and vitamin E activity will decline with prolonged storage. A maintenance horse's requirement for vitamin E is 50 IU per kg of dry matter diet (~500 IU per day for an 1100 pound horse). At intense exercise, the requirement would be increased to 1000 IU per day. Vitamin E toxicity has not been reported in horses. Nevertheless, the upper safe level is set at 1000 IU per kg of dry matter diet (~10,000 IU/day for an 1100 pound horse). This is considered a conservative limit and is based on observations in other species.

Beta carotene/Vitamin A

Beta-carotene is a precursor for vitamin A. Like vitamin E, vitamin A is a fat soluble vitamin and works as an antioxidant within the cell wall lipids.

Good quality, fresh pasture provides the greatest source of beta-carotene and vitamin A. Horses consuming primarily good quality, fresh pasture will consume adequate beta-carotene. Stage of maturity at harvest, storage conditions, and duration of storage can affect beta-carotene concentrations in hay. Levels of beta-carotene in grains are variable and considerably less than that found in forages. Prolonged storage or exposure to heat and light can destroy beta-carotene activity in forages and grains. As a result, vitamin A is often supplemented in commercial feeds and supplements.

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A maintenance horse's requirement of vitamin A is 1200 IU per kg of dry matter diet (~15,000 IU/day for an 1100 pound horse). An exercising horse's requirement increases to 1800 IU per kg of dry matter diet (~22,500 IU/day for an 1100 pound horse).

The horse has a mechanism to control the conversion of beta-carotene to vitamin A; therefore, excess beta-carotene consumption is not thought to be harmful. The horse will simply store or excrete any excess beta-carotene. On the other hand, over-consumption of vitamin A has been shown to cause bone fragility, rough haircoat, congenital defects in the fetus and has been implicated in orthopedic disorders in growing horses. Additional research in humans has found that over-supplementation of vitamin A may have adverse effects on immune response; however, such research has not been studied in horses. The presumed upper safe limit is 16,000 IU of vitamin A per kg of dry matter diet (~160,000 IU/day for an 1100 pound horse).

Vitamin C (ascorbic acid)

Vitamin C (ascorbic acid) is water soluble and donates electrons to break the chain of reactions of oxidative damage (lipid peroxidation). Vitamin C acts in the intracellular fluid to destroy free radicals before they can cause damage.

The concentrations of vitamin C in common equine feedstuffs are not well known. Research indicates that the horse can synthesize vitamin C from glucose. Under average circumstances, a healthy horse is able to synthesize adequate vitamin C and store it in the liver; therefore, a healthy horse has no dietary requirement. Classic vitamin C deficiency symptoms (i.e., scurvy) have not been observed in the horse. Nevertheless, horses under stress, geriatric horses, or horses with a compromised immune system may benefit from vitamin C supplementation. Insufficient information exists as to an upper safe limit for horses. Intakes of approximately 1.75 g of ascorbic acid per kg of dry matter diet (~22 grams/day for an 1100 pound horse) have been tolerated without adverse effects.

Cooperative functions of antioxidants

Mixtures of antioxidants can increase their activity against free radicals. Antioxidants provide protection against oxidative damage in different ways: quenching free radicals, scavenging for free radicals, interrupting the chain reactions that result in free radical production, and providing sparing effects for other antioxidants. Rather than working singularly, many antioxidants work cooperatively to protect the body from oxidative damage. For example, vitamin E and selenium work together to protect the body from peroxide damage, as each has a sparing effect on the other. Whereas vitamin E stops the chain reactions in which peroxides are formed, selenium (as a part of glutathione peroxidase) acts to remove peroxides. If vitamin E levels are high, less selenium (glutathione peroxidase) is needed to remove any lipid and hydrogen peroxides. Likewise, if selenium levels are elevated, less vitamin E is needed to prevent the formation of peroxides.

Vitamin C may also have a sparing effect on vitamin E. Research in other species suggests that vitamin C recycles tocopheroxyl radical (the result of alpha-tocopherol donating an electron to a peroxy radical) back to the active alpha-tocopherol. Other studies suggest that vitamin C quenches the free radicals that would typically use up alpha-tocopherol.

By acting together, groups of antioxidants can reduce damage caused by free radicals. If one or more of the antioxidants are low in the diet, this may increase the need for others to provide minimal protection against oxidative damage.

Summary

Antioxidants are essential in the equine diet. A typical equine diet contains naturally-occurring levels of many antioxidants, including selenium, vitamins A, C, and E, and the vitamins' precursors. Often, the horse's diet contains sufficient concentrations of these antioxidants to prevent oxidative damage that occurs while at rest or during normal activities. Exercise, stress, or other activities can increase free radical production. As a result, the horse's requirements for antioxidants will be higher in order to combat the potential damage caused by the increased production of free radicals. As with all components of the horse's diet, care should be taken to meet the horse's antioxidant requirements and maintain a proper balance of all nutrients to ensure optimal health.

What is an IU?

Many vitamins exist in different chemical forms, with each form having similar, but different biological effects. A standard unit, termed the international unit (IU), was developed based on an internationally agreed upon biological effect. For example, vitamin A has several chemical forms: beta carotene, retinol, vitamin A acetate, and vitamin A palmitate to name a few. One IU of vitamin A is equivalent to 2.5 µg beta carotene (for horses), 0.3 µg retinol, 0.344 µg vitamin A acetate, or 0.55 µg vitamin A palmitate.

Customer Focus: Darryl Leifheit and Janeene Jennings-Leifheit

KNIGHT SKYE FARM

Darryl was born and raised on the Leifheit Homestead (1856) family farm, a livestock, grain and dairy operation in northern Illinois. He had Saddlebreds as 4-H projects and has continued to breed, raise and show them in many disciplines: in-hand, western, gymkhana, saddle seat, fine harness and Combined Driving. While attending Illinois universities, Darryl groomed Saddlebred show horses for Huntoon Stables and trainer Jack Baker near Aurora, IL. He received his bachelor's degree in 1975 from Northern Illinois University in biological science, Pre-Vet/Pre-Med focus with independent research in reproductive physiology and genetics. Upon graduating, Darryl took an opportunity in sales and marketing with the IBM Corporation for 12 successful years. In 1987, he went to work in management for a start-up personal computer manufacturer in Austin, TX which became Dell Computer Corporation.

Darryl and his wife, Janeene, started a small Saddlebred and Friesian breeding operation, Knight Skye Farm, on their ranch near Fredericksburg, TX. They have since bred and produced registered Saddlebreds and Friesians as well as their crosses, Georgian Grandes.



In 1999, Darryl retired from the world of high tech and continued to show his Saddlebreds. He and Janeene moved their entire horse operation to Lexington, KY in 2002. Their American Saddlebred mare, A Touch Too Much (aka Goldie), was the 2002 winner of the Kentucky County Fair Five-Gaited Championship at the World Championship Horse Show in Louisville during the Kentucky State Fair. Darryl went on to show and win with her in the amateur gentlemen's five-gaited division. Goldie retired in 2006, and Darryl began showing his Saddlebred gelding, Singsation, in this same division.

In 2007, Darryl became interested in the international equine sport of Combined Driving, the driving variation of Three Day Eventing, and had Singsation (aka Clint) retrained at the Gayla Driving Center LLC near Georgetown, KY. Darryl realized success with Clint in that demanding discipline as well, receiving the American Saddlebred Horse Association's 2008 Combined Driving Sport Horse Reserve Championship and 2009 and 2010 Championship. Clint won the prestigious Iron Horse International CDE Intermediate Single Horse Division as well as the Indiana CDE Intermediate Single Horse Division in 2010.

Darryl is currently competing their American Saddlebred gelding and Clint's half-brother, A Savannah Day (aka Trooper), in this sport while Clint recovers from an injury. Trooper has also seen success and was ASHA's 2011 High Point Sport Horse Champion and won the Reserve Championship at Combined Driving.



Clint and Trooper compete on McCauley's Alam and M30. They also use McCauley's All-Natural Rice Bran Oil and Hydrolyte. For more information about Darryl and Janeene, visit www.knightskycelfarm.com. Visit www.gayladrivingcenter.com for information about combined driving.

Product Focus: McCauley's Trinergy

- ▶ Supplement especially designed for racing and performance horses. The stresses of training and competition (strenuous exercise, high exposure to air-borne irritants and pathogens, shipping, confinement, etc.) require unique nutritional support.
- ▶ Supplies high levels of specific vitamins and minerals whose normal functions include:
 - antioxidant activity,
 - maintaining the integrity of muscles and lung tissue,
 - production of connective tissue (maintains tendon strength and elasticity) and activation of the immune response.
- ▶ Provides all additional minerals and vitamins required by horses.
- ▶ Extremely palatable. The perfect solution for the "picky" eater.
- ▶ High fat content. Only vegetable oil added.
- ▶ Available in 5/32 inch diameter pellets.



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