Role for Vitashure® C in Equine Nutrition

Dana E. Putnam, Ph.D.
Balchem Encapsulates

Overview
Ascorbic acid (vitamin C) is a nutrient that is well understood and is widely used across species and physiological states. Although only primates and guinea pigs have an absolute requirement for ascorbic acid, many other species including poultry, swine, equine, aquaculture, ovine and bovine have been documented to respond favorably to supplementation under certain conditions. Responses noted include favorable shifts in immune cells and overall immune function, improved disease resistance, improved growth and efficiency of growth, increases in blood iron and hemoglobin concentrations, improved recovery from exercise and better overall performance. Practical supplementation of animals with ascorbic has been limited by its high instability under normal feed processing and storage conditions (Marchetti et al., 1999). High quality, encapsulated ascorbic acid can overcome these stability issues, allowing for easy, feed delivered supplementation to most animal species.

Equine traditionally have not been supplemented with ascorbic acid supplementation, due to their ability to synthesis ascorbic acid via glucose resulting in no apparent deficiency of ascorbic acid in these animals. However, like many species, there may be situations where ascorbic acid is conditionally limiting or, when supply is increased, stimulatory for the areas of immunity, health and performance. These responses in particular may fit certain areas of equine life cycles/usage patterns, leading to recommendations for targeted supplementation of vitamin C to horses.

Biology of ascorbic acid
Ascorbic acid has many important functions including collagen formation, antioxidant activity, iron absorption and immune system function. These functions are consistent across species and have been extensively documented.

Collagen formation: Ascorbic acid is essential for hydroxylating two key amino acids in the collagen protein. This process is critical for the strength and integrity of the collagen. Collagen is essential for its role in bone structure, wound healing and maintaining blood vessel structure.

Antioxidant activity: Ascorbic acid can act as an antioxidant, contributing to the total antioxidant capacity of an animal’s antioxidant defense system. Also, ascorbic acid is responsible for regenerating alpha-tocopherol (restoring its radical scavenging activity) in an animal’s system, allowing for alpha-tocopherol to maintain its antioxidant function.

Iron absorption: Absorption of non-heme iron, the form of iron found mainly in non-animal products, is greatly enhanced by ascorbic acid. This occurs for two reasons.
First, ascorbic acid can largely reverse the negative effect of compounds like phytic acid on reducing iron absorption by blocking the formation of insoluble and unabsorbable iron compounds (Hallberg et al., 1989). Secondly, ascorbic acid reduces ferric to ferrous iron in the intestine, which may be a prerequisite for intestinal absorption (Hallberg et al., 1989).

**Immune system function**: Ascorbic acid can stimulate the overall immune system based upon its role in maintaining immune cell function. In particular, ascorbic acid can improve lymphocyte function, phagocytosis and killing of bacteria by polymorphonuclear leukocytes (Goldschmidt, 1991) and has been shown to have positive effects on neutrophil function. In particular, ascorbic acid has been shown to reverse the suppressive effects of glucocorticoids, which are elevated during stress, on immune cell function (Roth and Kaeberle, 1985).

**Role/Responses to Vitamin C in Horses**

Vitamin C, through its above mentioned biological responses, can play an important role in horse health and performance. Normal ingredients offer variable and little overall supply of vitamin C to the animal, however deficiencies do not occur as horses can make ascorbic acid from glucose in their liver. Despite this ability to make glucose, augmented supply of ascorbic acid to horses has been considered. In particular, supplementing vitamin C to horse diets is appropriate under certain physiological and usage conditions, and may make senses as a standard ingredient across age, use and management conditions.

**Performance horses**

Logically, as ascorbic acid plays a critical role in immune function and oxidative stress, vitamin C supplementation to exercised equine is warranted. Under stress, performance or otherwise, the demand for ascorbic acid increases and concentrations of ascorbic acid in blood decrease (Hoffman, 2000; Hargreaves et al., 2002; Marlin et al., 2002). These decreases in ascorbic acid concentrations in blood (Figure 1) correspond with decreases in overall antioxidant status of the animal. Additionally, there is a significant correlation between decreases in concentrations of ascorbic acid in blood and increases muscle leakage (damage) (Hargreaves et al., 2002). Oxidative stress has been shown to contribute towards orthopedic and joint disease and cell membrane damage in horses, leading to exertional rhabdomyolysis (“tying up”) (Hoffman, 2000) and exercised induced pulmonary hemorrhaging. These responses to oxidative stress are consistent with limitations in ascorbic acid supply given ascorbic acid’s role in collagen formation which is critical for blood vessel integrity among other functions.

Vitamin C supplementation reduces exercise induced oxidative stress (Alessio et al., 1997; White et al., 2001). Ascorbic acid supplementation as a component of an antioxidant supplement improved airway inflammation in heaves affected horses (Kirschvink et al., 2002). Also, supplementation of 10g per day of vitamin C aided in maintaining serum alpha tocopherol concentrations in exercised horses compared to alpha-tocopherol supplementation only (Hoffman, 2000).
Transported horses

Horses are often transported long distances and are required to acclimate to new surroundings. Collectively this places stress on the horses, increasing risk for disease, particularly respiratory ailments. Research has indicated (Ralston, 2001) that supplementation with vitamin C improves post-transportation health in horses, likely due to its role in preserving immune cell function in the presence of high levels of stress hormones such as glucocorticoids (Roth and Kaeberle, 1985).

Geriatric horses

Geriatric horses, typically meaning 20 years old or more, are becoming a significant part of the horse population, approximately 15% of overall numbers (Gordon and Ralston, 2003). Older horses face the problems typical of aging in any specie. Reduced immunity, increased fragility, poor joint and tissue health all are typical in older equine and all are impacted by the vitamin C status of the animal.

Older horses have lower concentrations of ascorbic acid in blood than their younger counterparts (Gordon and Ralston, 2003; Crandell and Huntington, 2000). These lower levels of vitamin C may be the result of poor absorption of vitamin C in these animals, or more likely, decreased production of the liver enzyme required for ascorbic acid synthesis from glucose (Crandell and Huntington, 2000).

Due to vitamin C’s role in immunity, geriatrics may benefit from supplementation to ease chronic infections or to improve overall immune status. Supplementing vitamin C at the rate of 20g per horse per day has been shown to improve antibody response to vaccine injections in geriatric horses (Crandell and Huntington, 2000). Additionally, as ascorbic acid is involved with collagen structural integrity, supplementation may improve bone and tissue strength and wound healing, which are often compromised in older animals.

Other

There has been some consideration for supplementing vitamin C across the board in horses, however, little research has been done to this point. Growing horse in particular may merit consideration. Data from other species have shown that the ability to synthesize ascorbic acid may be gradually acquired over the first 1 to 2 months of life (Cummins and Brunner, 1991). Additionally, supplementation of ascorbic acid to growing ruminants (Chirase et al., 2003) and swine (Mahan et al., 1994; de Rodas et al., 1998) has been shown to improve growth efficiency, immunity and health. As vitamin C is important for collagen formation, it may play an important role in normal skeletal development in young equine although this has not been researched at this time.

Vitamin C may also be important to horses prone to anemia. Vitamin C is well documented to improve iron absorption across animal species. Data with Vitashure C in growing sheep showed significant increases in blood hemoglobin versus control or vitamin E supplemented animals (Chirase et al., 2003). Additionally, this study
showed significant improvements in growth and immune cell parameters with vitamin C supplementation versus control and vitamin E.

Role for Vitashure C
Vitashure C’s role in equine nutrition is simple; provide a safe, proven, stable and available source of vitamin C to high quality equine nutrition programs. Why are all of these features important? Because vitamin C is an extremely labile nutrient. It oxidizes readily, suffering losses due to light, heat and moisture. As a result, typical feed processing conditions will destroy much of the vitamin C in or added to feeds during the manufacturing of the feed (Marchetti et al., 1999). Additionally, prolonged storage of feeds with standard vitamin C added to them, will lead to extensive losses of the vitamin C (Figure 2). This places in doubt whether horses fed these feeds will be effectively and consistently be supplied with vitamin C in this form.

Vitashure C using generally recognized as safe (GRAS) approved, natural coating materials to protect vitamin C from light, temperature and moisture conditions. As a result, feeds manufactured with Vitashure C will retain the vitamin C through feed manufactured conditions and through months of post-manufacturing storage (Figure 2). Additionally, testing in animals and fish (Figures 3 and 4) have confirmed a high bioavailability of Vitashure C to the animal. The bottomline is that using Vitashure C allows for equine feeds and supplements to be designed, manufactured and utilized, that will safely and predictably delivered absorbed ascorbic acid to the animal.

Feeding recommendations
Daily supplementation of ascorbic acid is required to effectively supplement horses (Hoffman, 2000). Admittedly, exact dosages for horses across physiological states, ages and uses are not known at this time. However, enough is known to derive practical feeding recommendations. It appears a minimum of 4.5 g per day is required to elicit increases in plasma ascorbic acid in horses, but that little difference occurs between 4.5 and 20g/d (Hoffman, 2000). However, for eliciting optimum immune responses, particularly in older equine, somewhat higher levels may be warranted. Dosage recommendations for both vitamin C and Vitashure C (adjusted for the amount of vitamin C in the product) are shown in the table below.

<table>
<thead>
<tr>
<th>Use</th>
<th>Vitamin C need, g/d</th>
<th>Vitashure C dose, g/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>4.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Transported (pre/post)</td>
<td>6</td>
<td>8.5</td>
</tr>
<tr>
<td>Geriatric</td>
<td>6</td>
<td>8.5</td>
</tr>
<tr>
<td>Other</td>
<td>4.5</td>
<td>6.5</td>
</tr>
</tbody>
</table>

References
Figure 1. Decreases in plasma ascorbic acid concentrations in horses after 0, 40 and 80-km and during recovery during an endurance race.

Hargreaves et al., 2002.

Figure 2. Comparison of crystalline and Vitashure C stability through steam pelleting and subsequent storage.
Figure 3. Changes in plasma ascorbic acid concentrations in response to supplementation with Vitashure C.

![Figure 3](image1)

Figure 4. Bioavailability of Vitashure C as tested in shrimp.

![Figure 4](image2)