The Effects of Selenium Supplementation on Equine Health and Immune Response

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Abstract

In the Equine industry a nutritional advantage can mean the difference between top animal performance and serious diseases and deficiencies. The objective of this paper was to look at some of the top studies looking at Selenium supplementation as it relates to prenatal mineral passage, increased antioxidant production, and increased immune response to vaccination in the horse's body. A study done supplementing pregnant mares with increasing doses of Se resulted in positive responses showing the active passage of Se prenatally and through colostrum to foal blood and muscle. In another study, the effect of Se source and dosage was examined on mature horses as it related to antioxidant production. Se supplementation was found to cause improvements in the antioxidant systems in the horses of this study. In a final study, Se supplementation was found to be a beneficial factor in antibody immune response levels in vaccination. Collectively, these studies indicate a strong correlation between Se supplementation and an increase in Equine health and performance.

Introduction

In today's competitive Equine field, having a nutritional advantage can take a horse from good to exceptional. Top care and feeding are priorities in every horse.With top level performance horses, reaching peak performance levels and achieving the fastest recovery time after competition are crucial components in every training program. One nutritional problem that equine breeders and trainers are encountering is a Selenium (Se) deficiency. Soils and forages vary widely in Se concentration and a diet that is deficient in Se can lead to both clinical and sub-clinical deficiency (Fiack et al., 2009). Geographically, the Midwest has soil that is Se deficient. Soil that is Se deficient leads to Equine forages such as hay and pastures that are nutritionally deficient. Signs of Severe Se deficiency are characterized by cardiomyopathy while moderate deficiency results in less severe, myodegenerative syndromes such as muscular weakness and pain as well as a variety of other selenium-associated diseases (Exon and Koller, 1986).

Se is a required nutrient and antioxidant in the Equine diet. The US Food and Drug Administration have recently recommended that 0.3 mg of Se can be safely supplemented in the diets of all livestock species [FDA 2004, Code of Federal Regulations, Title 21, Part 573.920(h)]. A Selenium deficiency in animals may lead to problems such as, white muscle disease or nutritional muscular dystrophy and suppression of the immune system. Se is an antioxidant and when supplemented, has been shown to increase serum Se levels and to enhance humoral immune function (Cavender et al., 2009).

Selenium has also been shown to produce anti-inflammatory roles in horses (Abenti et al., 2009). Physical exercise has been shown to induce cellular tissue damage by the oxidation of cellular components due to the increase in the body's oxygen consumption. The anti-inflammatory effects of Se rely on its ability to influence the redox state of the cell and the

ability of Se compounds to remove reactive oxygen species (McKenzie et al., 2002). This exercise-induced oxidative stress contributes to muscle fatigue, muscle fiber damage, and decreased immune defenses which can also lead to poor animal performance (Art et al., 2006).

Se supplementation can be done in two forms, an inorganic form such as Na selenite (Na2Se03) or an organic such as selenomethionine (SeMet), a form of Se within seleno yeasts that is fed as a top-dressing to daily feed rations (Abenti et al., 2009). Selenomethionine is actively transported by methionine transporter mechanisms across intestinal membranes during absorption and can be then incorporated into body proteins (Schrauzer, 2003). By supplementing Se into the diets of performance and breeding horses, we will be eliminating the fear of deficiency and Se deficiency-related diseases. Horses supplemented with Se have higher Se levels in blood, muscle, and cholostrum, have higher anti-oxidant levels, and immune responses are heightened. These animals are healthier and exhibit a generalized increase in health performance.

Discussion

In a study by Cavinder et Al. (2009) the effects of Selenium supplementation on pregnant mares and their foals were evaluated. The study evaluated the role of Se on muscle, blood plasma, and colostrums levels in the mare and foal. The objective of this study was to investigate the effects of maternal plane of nutrition and Se supplementation on mare and foal plasma, muscle, and cholostrum Se concentrations.

This study used twenty-eight pregnant Quarter Horse mares between the ages of 6 and 19 years of age. The mares were blocked by expected foaling dates and randomly assigned dietary treatments within the blocks. There were four treatments used: pasture (PA), pasture and grain

mix (PG), pasture and grain mix plus a Se supplementation (PGS), and pasture plus a Se supplementation (PS). The mares fed diets of PA and PS received 100% of their Digestible energy requirements, where as mares fed the diets containing PG and PGS received 120% of their daily DE requirement, assuming a 2% total dietary intake. Se supplementation began 110 days before expected foaling dates and were ended upon parturition. After parturition, all mares returned to pasture. Blood and muscle biopsy samples were collected on days 0, 14, and 28. Body weight and BCS were recorded every 14 days as determined by a digital scale. Rump fat was also measures every 14 days using ultrasound imaging. At parturition, colostrum, foal plasma and muscle samples were collected and sampling continued every 14 days for plasma and every 28 days for muscle until day 56.

Table 1: Calculated Se and dietary energy for treatments fed to mares in the last one-third of gestation[1]

	Treatment[2]			
Item	PA (n=7)	PS (n=8)	PG (n=5)	PGS (n=8)
Se,[3] mg/kg of DM	0.19	0.49	0.35	0.65
DE,[4] Mcal/kg of DM	2.17	2.17	2.53	2.53

[1]Calculated total intake assuming intake at 2% of mare BW/d on a DM basis.

[2]Mare dietary treatments: pasture (PA), pasture + Se (PS), pasture + grain mix (PG), and pasture + grain mix + Se (PGS).

[3]Includes pasture, grain mix, and Se supplement (Selenosource, Diamond V Mills Inc., Cedar Rapids, IA) sources.

[4]Calculated according to NRC (2007).

Mare body weight, body condition score, and rump fat, as well as changes in BW, BCS, and RF (final minus initial values) were all affected by dietary treatment. Dietary energy intake affected mare BW, BCS, and RF, with mares in the PG treatment and PGS treatment having greater values than the PA and PS treatment. There was determined to be no affect between Se supplementation on mare BW, BCS, RF, ADG or the changes in those values. Mare plasma Se concentrations were greater in mares fed PG and PGS. Therefore, Se supplementation was determined to affect plasma Se concentrations, with mares in the PS and PGS treatments having greater ($P< 0.01$) values than mares in the PA or PG treatment. Mare muscle and colostrums Se concentrations were greater ($P< 0.01$) in mares fed PGS and PS. Foal plasma and muscle Se concentrations differed with maternal dietary treatment, the foals of mares fed PG and PGS having greater plasma and muscle Se concentrations ($P< 0.01$) than the foals of mares fed PA and PS.

Results concluded that Se supplementation does affect plasma muscle, and colostrum Se concentrations. It was determined that maternal Se supplementation and DE manipulation can affect the Se status of mares and their foals. The Se status of foals is directly correlated with the maternal Se status during gestation, as determined by foal Se concentrations in plasma. It is possible that colostrum Se concentrations affected these values, as the plasma samples were collected at 12 hours after birth.

As shown by this study, the ability to improve tissue Se status prenatally is of great importance. It is doubtful that foals receive a sufficient enough supply of Se through milk alone due to the relatively low amount of Se concentration in mares not supplemented. Foals born to the mares supplemented with PS and PGS had increased Se concentrations at birth. It is therefore likely that these foals will be able to utilize body stores to meet Se needs in the first few months

of life. In conclusion of this study, Se supplementation seems to be effective in increasing the Se status of mares during the last one-third of pregnancy and in their foals. The maternal plane of nutrition and Se supplementation affect mare and foal plasma, muscle, and cholostrum Se concentrations.

In another study conducted by Abenti et al., (2009) the effects of dietary Se source and dose on the oxidative status in horses was analyzed. This study compared the anti-inflammatory properties of supplemented Se into the diets of mature horses. The aim of this study was to evaluate the effect of Se supplementation on hematological profile, enzyme activity, and plasma oxidative status, together with the markers of inflammatory status.

In this study 25 mature horses in good health were blocked according to body weight and randomly assigned to 1 of 5 different treatments with 5 horses in each group. One group consisted of a negative control group not supplemented, one positive control group supplemented with Na2Se03, and three groups were supplemented with Se yeast concentrations from 0.2, 0.3, and 0.4 mg of total Se/kg DM for a total of 112 days. All Se supplements were offered daily to each horse by top-dressing the concentrate fed each morning using Ca carbonate as a carrier. Horses were housed individually in a box stall and exercised on a consistent level.

Blood samples were taken before morning feeding on day 0, 28, 56, 84, 56, and 112. Blood plasma metabolites were tested in response to Se supplementation and a statistical analysis was run to determine the effect of Se sources and doses on plasma concentration. Inflammatory status appeared to be not affected by Se source and dosage, as indicated by ceruloplasmin and haptoglobin plasma concentrations. Total white blood cell concentrations were also not affected by Se supplementation. However, the number of lymphocytes increased slightly as Se yeast

supplementation increased. A linear decrease in plasma total antioxidants relating to increasing Se yeast supplementation levels were also seen.

The data from this study showed that with increasing Se yeast supplementation, a mild effect on the population of blood lymphocytes and neutrophils was seen. This is an indication of imunomodulatory action, as indicated by the increase in white blood cell numbers. Se yeast supplementation and reduced TA values in horses fed the Se supplement could be interpreted as an improvement in the antioxidant systems of these horses.

Table 2: Effect of Se sources and doses on positive acute phase proteins and oxidative status markers in plasma of mature horses[1]

Item	Dietary treatment[2]					SED	P-value		
	CTRL	SY02	SY03	SY04	SS03		Tr[3]	Tr × T[4]	Linear dose effect[5]
Ceruloplasmin, µmol/L	3.50	3.28	3.42	3.35	3.24	0.25	NS	NS	NS
Haptoglobin, g/L	0.55	0.58	0.58	0.55	0.66	0.06	NS	NS	NS
Globulin, g/L	29.51	28.18	28.74	28.06	26.86	1.35	NS	NS	NS
Thiol groups, µmol/L	286.9	277.2	291.2	269.6	287.0	14.8	NS	NS	NS
ROM, mg of H_2O_2/dL	13.61	13.54	13.56	13.22	13.02	1.20	NS	NS	NS
Total antioxidant, µmol of HClO[6]/mL	246.8^{b}	234.5^{ab}	220.9^{a}	218.1^{a}	244.1^{b}	11.4	0.029	NS	0.009

^{a,b}Within a row, means without common superscripts differ ($P < 0.05$).

[1]CTRL is control diet; SY02, SY03, and SY04 are Se yeast diets (Sel-Plex Se yeast; Alltech, Nicholasville, KY); and SS03 is Na selenite diet. Least squares means, n = 5 horses. NS: not significant ($P > 0.15$). ROM: reactive oxygen metabolites.

[2]Diet provided a total of 0.085 mg of Se/kg of DM by natural feedstuffs without Se supplementation. Se yeast provided 0.18, 0.29, and 0.39 mg of total Se/kg of DM for SY02, SY03, and SY04, respectively. Na selenite (SS03) provided 0.29 mg of total Se/kg of DM.

[3]Tr: treatment effect.

[4]Tr × T: treatment × time interaction.

[5]Linear dose effect including CTRL, SY02, SY03, and SY04 treatments.

[6]HClO = hypochlorous acid.

In a final study done by Adams et al., (2011) the effect of Se status on immune response was examined. Immune response at both a molecular and functional level were studied. The aim of this study was to examine the effect of low Se status on the ability of the immune system to respond to vaccination.

This study used 28 horses between the ages of 6 and 24 years of age. It included a 28 week adaptation of diet and a 7 week vaccination challenge. Horse in this study were blocked by age and gender and assigned to either a low (LS) or adequate (AS) Se group. Horses were kept on pasture containing 0.06 ppm Se DM. When pasture availability declined, horses were supplemented with hay containing 0.05 ppm Se DM and cracked corn containing 0.04 ppm Se Dm. Horses were individually fed a mineral supplement with adequate Se (AS) or without (LS) sodium selenate, so that total Se intake for AS and LS horses were 140% and 70% of the daily recommendation of dietary Se. The LS group contained 21 horses and the AS group contained 7 horses.

Blood samples were taken prior to and every 4 weeks for 28 weeks. The samples were collected and analyzed for whole blood Se concentration, and glutathione peroxidase (GPx) levels. To insure the observed immune response was primary and not due to a prior exposure, keyhole limpet hemocyanin (KLH), a novel antigen, was used. Horses received 10 mg KLM IM at the end of the 28 week feeding period and serum KLH antibody levels were measured using an ELISA assay. Blood samples were also drawn to isolate peripheral blood mononuclear cells (PBMC), to examine the impact of Se status on cell-mediated immunity to KLH.

After 28 weeks on treatment, blood Se concentrations were found to be lower in LS than AS ($P< 0.05$). In response to the first vaccination, KLH-specific IgG levels increased in both groups. The AS group responded faster, (time x treatment; $P< 0.05$), and with higher antibody levels at a 3 week period than the LS group ($p< 0.05$). After the second vaccination, KLH antibody levels of the LS horses were comparable to the AS horses. The AS horses responded faster to the first vaccination by producing larger amounts of KLH-specific antibodies and by more effectively priming a cellular immune response. The initial vaccination in the LS horses stimulated a poor immune response, as shown by a delayed response and the failure to up-regulate expression in the PBMC cultures. This response in LS horses may have been due to an Se deficiency which affected the ability of the immune system to recognize the antigen and limiting the response of the KLH-specific memory cells. These conditions led to a lag in antibody production and diminished cell responses.

The conclusions of this study determined that low Se nutritional status results in delayed and diminished response to vaccination. There was sufficient evidence indicating that the horses with AS had faster and stronger immune response than the LS horses. This study determined that horses kept in geographical areas with Se deficient soil, could have implications resulting in lower immune response to vaccinations.

Conclusions

Selenium is a required nutrient in the Equine diet. As shown by the study from Cavinder et al., (2009) Se has the capability to be passed prenatally into the blood, muscle, and colostrum in foals whose dams were supplemented with Se. These foals were then able to utilize the Se stores within the first few months of life, where as they may have been Se deficient due to the

low amount of Se passed through the mare's milk. As shown by the Abenti et al., (2009) study, Se plays an important role in the body as an antioxidant, possessing anti-inflammatory properties that have been shown to eliminate some of the damage that comes from the body's oxidation of tissue during physical exercise. In the final study by Adams et al., (2011) the effect of Se status on immune response was examined. Supplemented Se proved to increase the body's immune response to vaccination. All three studies showed Se as it improved aspects of Equine health and production performance. Further research on the effects of Se supplementation on actual performance and tissue structure could be beneficial. After reviewing these three studies, Selenium supplementation appears to be beneficial and justifiable to daily health and increased immune response in the horse.

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