Methods of Selenium Supplementation to Beef Cows on Blood, Liver and Milk Selenium Concentrations

Paul Davis[1]
Lee McDowell
Claus Buergelt
Nancy Wilkinson
Rachel Van Alstyne
Tim Marshall
Richard Weldon

Organic selenium was superior to other forms of supplementation in maintaining blood and milk selenium adequate for nursing calves.

Summary

In a 365-d study, the effects of form and method of selenium (Se) supplementation on blood, milk, and tissue Se in grazing beef cows were evaluated. Forty-three Angus cows (115-130 d gestation) were randomly assigned to 1 of 5 treatments and received either no Se supplementation (control), one 9-mL barium selenate injection at the initiation of the study, one 5-mL sodium selenite injection + 68 IU vitamin E at the initiation of the study and every 4 mo thereafter, or free-choice minerals containing 26 mg/kg Se as sodium selenite or Se yeast (Sel-Plex). Cows receiving Se in free-choice minerals were heavier and had a greater increase ($P < 0.05$) in bodyweight at d 365 than cows receiving all other treatments. Liver Se at d 365 was adequate (> 1,200 µg/kg) and greater ($P < 0.05$) in Se yeast-treated cows than in all other treatments. Cows receiving injectable selenate also had adequate liver Se concentrations that were greater ($P < 0.05$) than the inadequate concentrations from control, free-choice selenite or injectable selenite. At 205 d postpartum, cows receiving injectable selenate and both free-choice treatments were inadequate whole blood Se concentrations. Cows receiving Se yeast produced colostrums with greater ($P < 0.05$) Se concentration than all others. At weaning (205 d postpartum), cows receiving Se yeast had at least 2-fold greater ($P < 0.05$) milk Se than cows on other treatments. Selenium supplementation with organic or inorganic Se via free-choice minerals or injectable selenate maintained adequate Se concentrations in whole blood, plasma, and liver. Inorganic Se was limited in its ability to increase milk Se, whereas Se yeast increased milk Se at parturition and at weaning.

Introduction

Many areas of the United States have soils that are deficient in selenium (Se) (McDowell, 2003) and may produce forages and grains that do not provide adequate Se to livestock. Almost all regions of Florida are severely deficient in Se (McDowell and Arthington, 2003). Selenium deficient brood cows may give birth to calves which are stillborn, premature, weak, or afflicted with nutritional muscular degeneration (Corah and Ives, 1991). Likewise, even with adequate blood Se at birth, calves suckling Se deficient dams are susceptible to becoming Se deficient (Pehrson et al., 1999; Gunter et al., 2003). The objective of this experiment was to evaluate and compare effects of form and method of Se supplementation on blood, liver, and milk Se concentrations in beef cows.

Procedure

Animals were housed at the University of Florida Boston Farm-Santa Fe Beef Unit located in Northern Alachua County, Florida. On August 6, 2002, 43 Angus cows, aged two to three yr, (mean age = 2.67 yr) were palpated to diagnose pregnancy and estimate days in gestation. All cows were determined pregnant and gestation estimates ranged from 115 to 130 d. Cows were weighed (average initial body weitht (BW) = 919 ± 101 lb), stratified by age and assigned to one of five treatment groups for a 365-d study. The 5 treatments were 1) no Se supplementation (control), 2) one subcutaneous injection of 9 mL (50 mg Se/mL) of barium selenate (Deposel Multidose®; Novartis New Zealand, Ltd., Auckland, NZ) at the initiation of the experiment, 3) three subcutaneous injections of 5 mL (5 mg Se/mL) of sodium selenite with 68 IU vitamin E/mL as DL-alpha tocopheryl acetate (Mu-Se®; Schering-Plough Animal Health, Union, NJ), one at the initiation of the experiment and one every four mo thereafter, 4) free-choice access to a mineral mixture containing 26 mg/kg Se as sodium selenite (Southeastern Minerals, Inc., Bainbridge, GA), or 5) free-choice access to a mineral mixture containing 26 mg/kg Se as Se yeast (Sel-Plex®; Alltech, Inc, Nicholasville, KY). All cows grazed bahiagrass (*Paspalum notatum*) pastures and were supplemented with bahiagrass hay, ad libitum molasses-based liquid supplement, and whole cottonseed and pelleted citrus pulp at rates of 1.5 and 4.0 lb/d per cow, respectively, from November 2002 through March 2003. During the experiment pasture, blood, liver, colostrum and later produced milk were analyzed for Se by a fluorometric procedure.

Effects of treatment on change in BW were analyzed using PROC MIXED in SAS (SAS for Windows 8e; SAS Inst., Inc., Cary, NC) in a completely randomized design with a diagonal covariance structure. The PROC MIXED of SAS was also used to analyze effects of treatment, day, and the interaction of treatment × day on BW, whole blood Se, milk Se, plasma Se, and liver Se as repeated measures.

Results

Selenium concentration of pasture and hay for all groups averaged 0.071 ± 0.014 and 0.045 mg/kg (DM basis), respectively. Mineral consumptions, total amount of Se administered, and total vitamin E supplemented are summarized in Table 1. Both free-choice treatment groups were similar and had a greater increase in BW ($P < 0.05$) than did control and the injectable Se treated groups.

Cow whole blood Se concentrations at intervals postpartum are summarized in Table 2. Significant effects of treatment ($P < 0.001$), day ($P < 0.001$), and treatment × day ($P = 0.013$) were observed. At parturition, whole blood Se concentrations from cows receiving Deposel or Sel-Plex were greater ($P < 0.05$) than whole blood Se from controls and cows receiving Mu-Se or free-choice selenite.

At calving, cows receiving Se via Deposel or Sel-Plex had greater whole (P<0.05) blood Se than did cows receiving no Se, Mu-Se, or selenite in free-choice minerals. Whole blood Se measured at 30 and 90 d postpartum followed a similar pattern, with respect to treatment, to whole blood Se at calving. Deposel and Sel-Plex produced similar and consistently greater whole blood Se than sodium selenite or no Se supplementation. From d 90 to d 205 postpartum, whole blood Se decreased in controls and cows receiving Mu-Se, and both were below the adequate whole blood Se level (> 100µg/L). Cows receiving Se from Deposel or either free-choice mineral mix maintained blood Se above the adequate level from parturition to 205 d postpartum. At d 205 postpartum, 100% of controls and 89% of cows receiving Mu-Se had whole blood Se below the adequate level.

Effects of treatment and d ($P < 0.001$) were observed in Se concentration of milk collected at the same postpartum intervals as whole blood (Table 3). Cows receiving Sel-Plex had greater ($P < 0.05$) Se concentrations in postsuckled colostrum than did cows receiving all other treatments. Colostrum Se was similar ($P > 0.54$) from control, Deposel, Mu-Se and free-choice selenite treated cows. At 90 d postpartum, no differences or tendencies were observed in milk Se among treatment groups ($P > 0.28$). Selenium in milk collected at 205 d postpartum, was similar ($P > 0.50$) among control, Mu-Se, Deposel, and free-choice selenite treatments. Cows receiving Sel-Plex produced greater ($P < 0.01$) milk Se than cows receiving any other form of Se supplementation. Milk Se from all treatment groups decreased quadratically ($P < 0.001$) from parturition to 205 d postpartum.

Plasma Se concentrations were evaluated at d 0 and at d 365. Plasma Se concentrations in Sel-Plex treated cows were greater ($P < 0.005$) than from cows receiving any other treatment. After 1 yr, only cows receiving Sel-Plex had increased ($P < 0.001$) plasma Se, data not shown.

Liver from biopsies at d 0 and d 365 was evaluated for Se concentration (Table 4). Liver Se (946 to 1136 µg/kg) did not differ among treatment groups at d 0 ($P > 0.31$). However, at d 365, liver Se from Sel-Plex treated animals was greater ($P < 0.02$) than from animals on all other treatments. Liver Se concentrations from cows receiving Se from Deposel or free-choice selenite were similar, ($P = 0.21$) and both were greater ($P < 0.05$) than those from controls and cows receiving Mu-Se. At the end of this study, liver Se had increased ($P < 0.001$) in cows receiving Sel-Plex. Cows receiving Mu-Se had decreased ($P <0.01$) liver Se, which tended to decrease ($P = 0.07$) in controls. Liver Se remained unchanged ($P = 0.48$; 0.73) in cows receiving Deposel and free-choice mineral with sodium selenite, respectively. Liver and plasma Se concentrations were highly correlated ($P < 0.001$; $r = 0.71$). In spite of the high degree of correlation, the authors suggest that liver Se continue to be used where possible to help validate plasma, whole blood Se concentrations, or both.

Sel-Plex supplemented cows had greater Se concentration in liver at the end of our study than did cows receiving any other treatment. Sel-Plex produced liver Se concentrations up to 3-fold greater than Mu-Se. At the termination of the experiment, 100% of cows supplemented with selenite, free-choice or injectable, and cows receiving no supplemental Se had plasma Se concentrations below the critical level of > 70 µg/L.

Literature Cited

Corah and Ives. 1991. Vet Clin. North Am. Food Anim. Pract. 7:41.
Gunter et al. 2003. J. Anim. Sci. 81:856.
McDowell. 2003. Minerals in Animal and Human Nutrition, Elsevier Science, Amsterdam.
McDowell and Arthington. 2005. Minerals for Grazing Ruminants in Tropical Regions, Dept. Animal Sci., Gainesville.
Pehrson et al. 1999. J. Anim. Sci. 77:3371.

Acknowledgments

Special thanks go to Southeastern Minerals Inc., Flint River Mills, U.S. Sugar Corp., and Alltech Inc. for donation of products or services to aid in this research, to E.Y. Matsuda-Fugisaki for assistance in analyses of blood and tissues, and to Steve Chandler and Bert Faircloth for animal care and feeding.

[1]Paul Davis, Former Graduate Student; Lee McDowell, Professor; Nancy Wilkinson, Chemist; Tim Marshall, Professor; Rachel Van Alstyne, Former Graduate Student; UF/IFAS, Department of Animal Sciences, Gainesville, FL; Claus Buergelt, Professor, College of Veterinary Medicine, Gainesville, FL; Richard Weldon, Professor, Food and Resource Economics, Gainesville, FL.

Table 1. Frequency, daily amount, and total of amount of supplemental Se administered to cows

Source of supplemental Se	Selenium supplementation interval, d	Avg Se supplementation, mg Se/cow per d	Total Se supplementation, mg	Total Vitamin E supplementation, IU
No Se supplementation	—[1]	—[1]	—[1]	235
Barium selenate[2] (Deposel)	365	1.23	450	235
Sodium selenite[3] (Mu-Se)	125	0.21	75	1255
Free-choice mineral mix[4] (sodium selenite)	1[6]	1.08	393	158
Free-choice mineral mix[5] (Sel-Plex)	1[6]	2.22	811	326

[1]Cows received no Se supplementation or injectable Se had free-choice access to and consumed the basal free-choice mineral mix (no Se) at an average of 62.2 g/d per cow.

[2]Cows received a s.c injection of 9 mL Deposel at d 0.

[3]Cows received a s.c. injection of 5 mL Mu-Se every four mo beginning at d 0.

[4]Cows had continuous access to free-choice mineral mix containing 26 mg Se/kg as sodium selenite and consumed mineral mix at an average of 41.5 g/d per cow.

[5]Cows had continuous access to free-choice mineral mix containing 26 mg Se/kg as Se yeast and consumed mineral mix at an average of 85.5 g/d/ per cow.

[6] Access to free-choice minerals containing Se was continuous throughout the study.

Table 2. Whole blood Se concentrations of cows receiving different sources and forms of Se supplementation at various days postpartum[1]

	Days postpartum			
	0	30	90	205
Source of Se supplementation	Whole blood Se, µg/L			
Control (No Se)	143[a] ± 15	162[a] ± 15	121[a] ± 15	74[a] ± 15
Barium Selenate[2] (Deposel)	235[b] ± 12	207[bc] ± 12	166[bc] ± 12	156[b] ± 12
Sodium Selenite[3] (Mu-Se)	173[a] ± 13	178[ac] ± 12	127[ad] ± 12	89[a] ± 12
Free Choice Mineral Mix[4] (Sodium selenite)	159[a] ± 12	184[ac] ± 13	140[cd] ± 13	155[b] ± 13
Free Choice Mineral Mix[5] (Sel-Plex)	216[b] ± 12	241[b] ± 12	185[b] ± 12	198[c] ± 12

[a-d]Means within columns lacking a common superscript differ ($P < 0.05$).

[1]Data represent least squares means ± SE; n = 41/d; adequate Se level in whole blood is > 100 µg/L.

[2]Cows received a s.c. injection of 9 mL Deposel at d 0.

[3]Cows received a s.c. injection of 5 mL Mu-Se every four mo beginning at d 0.

[4]Cows consumed free-choice mineral mix containing 26 mg/kg Se as sodium selenite at an average of 41.5 g/d per cow beginning at d 0.

[5]Cows consumed free-choice mineral mix containing 26 mg/kg Se as Se yeast at an average of 85.5 g/d per cow beginning at d 0.

Table 3. Milk Se concentrations of cows receiving different sources and forms of Se supplementation at various days postpartum[1]

	Days postpartum			
	0	30	90	205
Source of Se supplementation	Milk Se, µg/L			
Control (No Se)	39[a] ± 7	14 ± 7	6 ± 7	15[a] ± 7
Barium Selenate[2] (Deposel)	34[a] ± 6	15 ± 6	15 ± 6	21[a] ± 6
Sodium Selenite[3] (Mu-Se)	35[a] ± 6	13 ± 6	6 ± 6	16[a] ± 6
Free Choice Mineral Mix[4] (Sodium selenite)	39[a] ± 7	26 ± 6	16 ± 6	15[a] ± 7
Free Choice Mineral Mix[5] (Sel-Plex)	71[b] ± 6	27 ± 6	15 ± 6	42[b] ± 6

[a.b]Means within columns with different superscripts differ ($P < 0.05$).

[1]Data represent least squares means ± SE; n = 41 for each sample day.

[2]Cows received a s.c. injection of 9 mL Deposel at d 0.

[3]Cows received a s.c. injection of 5 mL Mu-Se every four mo beginning at d 0.

[4]Cows consumed free-choice mineral mix containing 26 mg/kg Se as sodium selenite at an average of 41.5 g/d per cow beginning at d 0.

[5]Cows consumed free-choice mineral mix containing 26 mg/kg Se as Se yeast at an average of 85.5 g/d per cow beginning at d 0.

Table 4. Liver Se concentration (DM basis) at d 0 and d 365 of beef cows that received different sources and forms of Se supplementation[1]

Source of Se Supplementation	d 0 Liver Se, µg/kg	d 365 Liver Se, µg/kg
Control (No Se)	973 ± 129	642 ± 129[a]
Barium Selenate[2] (Deposel)	1136 ± 105	1240 ± 105[b]
Sodium Selenite[3] (Mu-Se)	946 ± 105	537 ± 105[a]
Free Choice Mineral Mix[4] (Sodium selenite)	1089 ± 105	1046 ± 105[b]
Free Choice Mineral Mix[5] (Sel-Plex)	1011 ± 105	1604 ± 105[c]

[a-c]Means within columns lacking a common superscript differ ($P < 0.05$).

[1]Data represent least squares means ± SE; n = 42 and 41 for d 0 and d 365, respectively; adequate Se concentration in liver is > 1,200 µg/kg.

[2]Cows received a s.c. injection of 9 mL Deposel at d 0.

[3]Cows received a s.c. injection of 5 mL Mu-Se every four mo beginning at d 0.

[4]Cows consumed free-choice mineral mix containing 26 mg Se/kg as sodium selenite at an average of 41.5 g/d per cow beginning at d 0.

[5]Cows consumed free-choice mineral mix containing 26 mg Se/kg as Se yeast at an average of 85.5 g/d per cow beginning at d 0.