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SELENIUM SUPPLEMENTATION AND CONCENTRATIONS OF SELENIUM IN CATTLE TISSUES AND FLUIDS[1]

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ABSTRACT

An experiment was conducted for 22 months to determine Se status of grazing Brahman cows and their calves as affected by Se supplementation and season of the year. The three treatments administered to grazing cows for 120 days (November to March), either orally in a concentrate mixture or yearly injection intramusculary, were: 1) control (no Se), 2) control + .25 ppm Se + Intramuscular injection of 5 mg Se plus 1,500 mg vitamin E, and 3) control + .25 ppm Se. Soils, forages and animal tissues were collected six times during the 22-month experiment. Two collections were in the winter season, and four were in the grazing (spring-fall) season. Animal tissues collected were liver, hair, serum colostrum and milk from 36 cows and serum from their calves. The most consistent finding was low Se concentration of soils and pastures which were reflected in low Se concentrations in serum, liver, hair and feces. Both supplemental dietary Se and dietary plus injectable Se-vitamin-E resulted in higher Se tissue levels. Cows fed supplemental dietary and dietary plus injected Se and vitamin E had more Se in both colostrum and milk than that from cows fed no supplemental Se. Likewise, blood Se concentration of calves from Se supplemented cows was higher than controls. Low tissue and dietary Se concentrations found in this study plus the persistent reports of white-muscle disease in the state of Florida, emphasize the need for increasing intake of Se.

Key Words: Selenium, Status, Supplementation, Cattle, Milk, Serum

INTRODUCTION

In ruminants, nutritional muscular dystrophy and other related diseases are reported in many countries of the world where forages contain less than .05 ppm Se. According to Cary et al. (1) and Ammerman et al. (2), soil Se

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concentrations apparently have little relationship to Se content of plants. Tissue concentration of Se increased as intake of Se increased, regardless of the tissue sampled (3, 4). Segerson and Johnson (5) concluded that injections of supplemental Se increased both serum and tissue concentrations of this element. Serum and liver Se concentrations provide good indicators of dietary Se status in cattle (6).

The objectives of the present study were to investigate Se status of soil, forage and tissues of Brahman beef cattle and to determine the effect of supplemental selenium on cow/calf status.

MATERIALS AND METHODS

The experiment was conducted at the University of Florida Pine Acres Beef Research Unit located in central Florida. In general, the soils (Entisol) are coarse-textured, acid (pH 6.0) and low in natural fertility. Thirty-six registered Brahman cows (4 to 10 years old) in early pregnancy were studied. During the experiment, cows were confined to four fenced pastures (three *Cynodon dactylon* and one *Paspalum notatum*) and grazed rotationally to minimize pasture effect on treatments. Annual fertilization of pastures consisted of 304 lb of 15% (N), 5% (P_2O_5), and 10% (K_2O) per acre. Cattle were allotted randomly to three lots of 12 cows each. Each lot was offered from November, 1980 to March, 1982, *Paspalum notatum* hay *ad libitum* (6.8 kg average consumption; .02 ppm Se) and one of the three supplements. The three treatments were 1) control, 1.8 kg of shelled corn-urea concentrate (97% corn meal and 2.57% urea; .08 ppm Se), free choice white salt block (NaCl only) and a complete commercial mineral mixture not containing Se (Footnote b, Table 1); 2) control plus .25 ppm dietary Se (.6% sodium selenite as part of the concentrate mixture) and intramuscular injection (November) of 5 mg Se plus 1500 mg vitain E; and 3) control plus concentrate mixture with 8.2% fortified mineral mixture that provided .25 ppm Se (Table 1). During the 120 day supplementation period, control (Treatment 1) animals received an estimated daily dietary Se intake of 280 μg; treatment 2, 730 μg and treatment 3, 718 μg. In addition treatment 2 received 5 mg Se via intramuscular injection.

The experiment was divided into six collection periods for soil, forage, and animal tissues, i.e., May 1980; June 1980; June, 1981; and October, 1981 (1,2,4,5, spring and fall grazing) and February, 1981; and March, 1982 (3 and 6, winter nongrazing). Liver, hair, and serum samples were collected at the beginning of each of the six periods, whereas feces was taken four times (Periods 3, 4, 5 and 6), milk (oxytocin administered) four times (Periods 1, 3, 4 and 6) and colostrum twice (Periods 3 and 6). Serum was collected from calves three times each (at birth, 3 days and 3 months) in 1981 and 1982. Composite duplicate forage and soil samples were collected six times from the four pastures where cattle were grazing. Procedure for collection and sample preparation of liver, serum, forage, and soil samples have been described (7). Hair samples were clipped from both sides of the animals. Feces samples were collected directly from the rectum and were frozen until analyzed. Soil samples were collected with a stainless steel tube at a depth of 10 to 20 cm.

Forage, serum, feces, hair, liver, milk, colostrum and soil samples were analyzed for Se by a fluorometric procedure (8). Data were analyzed by the method of least squares ANOVA utilizing GLM procedures of the SAS (9). The experimental design was that of a split-plot (10). Group means were tested by the procedure of Kramer (11), with tests done at the 5% level.

TABLE 1
Ingredient and Element Composition of Fortified Mineral Supplement Treatment 3[a,b]

Ingredient	% of total mixture
BioFos[b]	27.453
Dyna-Mate[d]	32.976
Sodium chloride	20.610
Potassium chloride	12.861
Selenium premix (.02% Se)	5.153
Cobalt carbonate	.00089
Cupric sulfate	.1649
Manganous oxide	.0861
Zinc oxide	.2865
Ferrous carbonate	.1472
Additional trace mineral premix[e]	.2618
Total	100.00

[a]The fortified mineral mixture was 8.2% of a concentrate mixture provided from November to March (120 d) for Treatment 3.
[b]Treatments 1 and 2 received free-choice consumption of common white salt, trace mineral salt (Cu, .035%; Co, .007%; Fe, .175%; I, .007%; Mn, .28% and Zn, .35%) and a complete commercial mineral mixture (20% Ca, 6% P, 26% NaCl, 1% Fe, .15% Cu, .03% Co, .02% Mn, .5% Mg, and .04% Zn). In 1980-1981 daily concumption of total minerals was 18.2 grams with 20% common salt, 44% trace mineral salt and 36% complete mineral mixture. For 1981-1982 the daily consumption was 16.2 grams with 13, 31, and 56% consumption of the mixture, respectively.
[c]Contains 18% Ca and 21% P.
[d]Contains 18% K, 22% S, and 11% Mg.
[e]Calculated to provide 2 ppm Ni, 2 ppm Sn, .1 ppm Cr, .1 ppm V and .1 ppm I.

RESULTS AND DISCUSSION

Production Response. The 36 experimental animals calved twice, with no production response (calving percentage and growth rates) related to treatment. There were no signs (i.e., white muscle disease) related to Se-vitamin E deficiency.

Soil and Forage Selenium. Mean Se concentrations of soil and forage by period is presented in Table 2 with differences ($P<.05$) in forage Se found among periods of collection. Season affected forage Se, with values lower ($P<.05$) in winter vs spring-fall (.026 vs .037 ppm) with no detectable difference ($P>.05$) in soil Se concentrations between seasons (Table 3). Cary et al. (1) indicated that soil Se concentrations of less than .5 ppm are found in areas where Se deficiency occurs. Based on this critical level, all samples were deficient in Se. Also, McDowell et al. (12) reported similar low levels of soil Se in Florida with values ranging from .020 to .038 ppm.

TABLE 2
Sampling Periods (DM Basis)[a,b]

Item	P1 5/80	P2 10/80	P3 2/81	P4 6/81	P5 10/81	P6 3/82	Overall mean	% deficient[c]	SE range
	Sampling Periods								
	Mean								
Soil	.035	.042	.047	.040	.052	.045	.043	100	.012-.017
Forage	.036[e]	.031[ef]	.032[ef]	.049[d]	.032[ef]	.020[f]	.033	100	.002-.005

[a]Least squares estimates for sample numbers are based on 28 soil and 52 forage samples.
[b]Samples were collected four times during the springsummer and twice during the winter between June 1980 to March 1982.
[c]Percentage deficient is based on the critical level of .5 ppm for soil (1) and .1 ppm for forage (6).
[d,e,f]Means in the same row with different letters in their superscripts differ (P<.05).

TABLE 3
Selenium Concentrations of Forage, Soil and Animal Tissues in the Spring-Fall vs Winter

Item	Season[a] Spring-Fall	Winter
	ppm	
Forage	.037[b]	.026[c]
Soil	.042	.046
Liver	.338	.335
Serum	.021[b]	.084[c]
Feces	.049[b]	.080[c]
Hair	.125[b]	.403[c]

[a]Spring-Fall (periods 1, 2, 4 and 5) and Winter (periods 3 and 6).
[b,c]Means in the same row with different letters in their superscripts differ (P<.05).

Forage Se was higher (P<.05) during the grazing months than in winter, .037 vs .026 ppm, respectively. All forage samples analyzed were deficient in relation to the beef cattle requirement of .1 ppm as recommended by the 1976 NRC (13) or the revised requirement of .2 ppm as found in the 1984 edition of NRC (14). Similar deficient forage Se concentrations for Florida have been reported (12, 15).

Animal Se Concentrations. Mean Se concentrations by season (Table 3), period (Table 4) and treatment (Table 5) are presented. Seasonal differences ($P<.05$) were found, with serum, fecal and hair Se higher in the winter season. Differences ($P<.05$) among treatments for Se concentrations were found for liver, feces, hair and serum. Hair, fecal and serum Se concentrations were higher ($P<.05$) during the winter season, while there were no seasonal differences ($P>.05$) in liver Se. Period differences ($P<.05$) were found with lower values in liver and serum during the initial period before supplemental Se was provided.

McDowell et al. (6) indicated that the critical Se level in the liver of cattle usually is between .25 to .50 ppm DM. Thus, mean liver Se levels reported in the present study were low during both seasons, especially period I (initial period) where all samples were deficient. From Florida beef cattle ranches, McDowell et al. (12), reported liver Se concentrations below the critical level (<.25 ppm) in 32% and 39% of the samples in the summer and winter seasons, respectively.

Mean serum Se contents were higher ($P>.05$) during the winter vs spring-fall periods (Table 3), .021 and .084 ppm, respectively. Based on the critical level of .03 ppm (6), 73% and 20% of the serums analyzed for Se were deficient during the spring-fall and winter seasons, respectively.

Mean hair Se concentrations were .125 and .403 ppm in the spring-fall and winter seasons, respectively. Hidiroglou et al. (16) found that cows with hair Se values ranging from .06 to .25 ppm produced calves with white-muscle disease, while cows with hair Se higher than .25 ppm had normal calves. Hair Se therefore was considered deficient (<.25 ppm) in the spring-fall season but adequate in the winter season. Mean fecal Se was higher ($P<.05$) in the winter than spring-fall (.080 vs .049, respectively), likely reflecting supplemental Se provided during the winter.

Liver, serum, feces and hair Se were higher for oral and oral plus injectable Se treatments than controls (Table 5). Perry et al. (17) reported that tissue concentration of Se increased as daily intake of Se increased, regardless of tissue sampled. Cows receiving supplemental Se likewise increased ($P<.05$) concentration of the element in both colostrum and (Table 6) milk, but statistically only at the $P<.10$ level for non-colostrum milk. Treatment 2 containing both injectable and dietary Se was likewise higher ($P<.05$) than the oral Se treatment (treatment 3) alone. On the contrary, Perry et al. (18) reported that milk Se concentrations in dairy cows were not a good indicator of dietary Se. Higher milk Se resulting from supplementation of the element increased ($P<.05$) calf serum Se over the control group (Table 6). deToledo and Perry (19) reported that both dietary and injectable Se increased the element in serum of cows, but serum of calves at birth was greater only for those whose dams received Se by injection.

The two principal conclusions from this study were: 1) the Se status of Brahman cattle was low based on Se concentrations in soil, forage, serum, liver, hair and milk and 2) Se supplementation increased the Se status based on tissue analysis, including milk which was reflected in the serum of calves of supplemented cows.

TABLE 4
Concentrations as Affected by Sampling Period[a]

Item	Sampling Period P1 5/80	P2 10/80	P3 2/81	P4 6/81	P5 10/81	P6 3/82	Overall mean	% deficient[c]	SE range
	Mean								
Liver	.14[f]	.24[ef]	.27[ef]	.58[d]	.39[de]	.40[de]	.47	40	.06 -.08
Serum	.007[g]	.018[f]	.056[e]	.034[f]	.025[f]	.112[d]	.038	55	.005-.008
Hair	.094[g]	.076[g]	.599[d]	.186[ef]	.143[f]	.206[e]	.217		.014-.016
Feces			.087[d]	.062[e]	.036[f]	.072[e]	.064		.004

[a]Least squares estimates for liver, serum and hair are 34, 25, 21, 22, 26 and 18 samples for periods 1 through 6, respectively. Fecal sample numbers are 34, 32, 33 and 31 for periods 3 through 6, respectively.
[b]Samples were collected four times during grazing months [periods 1, 2, 4 and 5 and twice (periods 3 and 6) during non-grazing months (winter)].
[c]Percentage deficiency is based on the critical level of .25 ppm for liver and .03 ppm serum (6).
[d,e,f,g]Means in the same row with different letters in their superscripts differ (P<.05).

TABLE 5
Liver, Serum, Hair and Feces Selenium Concentrations (ppm, DM basis) as Affected by Treatment[a]

Item	Critical level[c]	Mineral supplementation[b] T1 Mean	T1 % deficiency	T2 Mean	T2 % deficiency	T3 Mean	T3 % deficiency	SE range
Liver	.25	.25[e]	69	.63[d]	27	.54[d]	34	.04
Serum	.03	.024[e]	81	.055[d]	52	.045[d]	62	.005-.006
Hair		.115[f]		.282[d]		.245[e]		.010-.011
Feces		.041[e]		.077[d]		.068[d]		.004-.005

[a]T1, T2 and T3 stand for control, injectable and dietary Se, and dietary selenium, respectively.
[b]LS means for liver, serum and hair are based on the following number of samples: 66, 69 and 66 for treatments 1, 2 and 3, respectively. LS means for feces represent 44, 45 and 41 for treatments 1, 2 and 3, respectively.
[c]McDowell et al. (6).
[d,e,f]Means in the same row with different letters in their superscripts differ (P<.05).

TABLE 6
Effect of Treatments on Selenium Concentrations (μg/ml) in Milk and Calf Serum[a]

Treatment	Colostrum	Milk	Calf serum
1	.015[d]	.0046[c]	.030[c]
2	.049[b]	.0097[b]	.053[b]
3	.031[c]	.0062[c]	.049[b]
SER	.004	.0008	.0009

[a]Least square means for treatments 1, 2, and 3, respectively, are based on 72 colostrum, 132 milk, and 175 calf serum samples. Treatments 1, 2 and 3 are control, injectable and dietary Se-vitamin E and dietary selenium, respectively.

[b,c,d]Means in the same column with different letters in their superscripts differ ($P<.05$). Treatment 1 for milk was different at the $P<.10$ significance level.

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