Research Note

PLASMA SELENIUM AND COPPER IN DAIRY CATTLE FROM DAIRIES THROUGHOUT PUERTO RICO[1]

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One of the major concerns of dairy producers in Puerto Rico is maintaining adequate reproductive efficiency in their herds. It has been proposed that the status of selenium (Se) and copper (Cu) levels in dairy cattle can influence reproductive performance (Underwood and Suttle, 1999). The specific roles of these minerals in reproductive tissues are not well defined in cattle, but their requirements for optimal reproductive efficiency deserve careful re-evaluation. A relationship between the reproductive functions and these two minerals has long been recognized (Aréchiga et al., 1994; Hurley and Doane, 1989; N.R.C., 2001). Both selenium and copper are required micronutrients because of their roles in cellular metabolism, maintenance and growth (Arthur and Boyne, 1985; NRC, 2001).

Borderline nutrient deficiencies in dairy cattle may manifest as impaired fertility before other clinical symptoms are apparent (Hurley and Doane, 1989; Hidiroglou, 1979). Harsh tropical climates with high temperatures, high humidity and decreased forage intake can accentuate these deficiencies (Hunter, 1977). Specific mineral requirements for optimal reproduction in modern dairy cattle have not been fully defined during critical periods of the reproductive cycle. Nor are nutrient requirements of reproductive tissues and endocrine systems that account for the constantly changing physiological states fully understood. Advancement of knowledge in this area must be based upon a fundamental understanding of general nutrient metabolism and of the specific roles of each nutrient in reproductive tissues. This study was undertaken to ascertain the current status of blood levels of selenium and copper in dairies throughout the island.

To accomplish this objective, a local pharmaceutical company (Schering-Plough, Inc.), in coordination with ten local veterinarians, collected blood samples from cows selected at random throughout the island. Twenty-nine dairy herds were selected for the determination of selenium (n = 232) and 37 herds for copper (n = 305). Five to 10 cows were selected from each herd, depending on its size. The herds were selected from the geographical zones established by the Regulation Board of the Dairy Industry (O.R.I.L., 2000). Sampled herds were from Region 1 (Camuy, Isabela, Mayagüez, Quebradillas and San Sebastián); Region 2 (Arecibo, Hatillo and Utuado); Region 3 (Barceloneta, Corozal, Dorado and Manatí); and Region 4 (Caguas, Cayey, Gurabo, Las Piedras and Naguabo).

Blood samples were collected by venipuncture of the coccygeal vein. Blood for selenium analysis was sampled in 6-ml glass vacutainers containing the anticoagulant Potassium EDTA whereas blood collected for the copper assay was placed in 10-ml glass vacutainer tubes without additive. Plasma samples for copper analysis were prepared by

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centrifuge at 12,000 RPM for 120 seconds. Both plasma and blood samples were sent to the Schering-Plough Animal Health Technical Services Laboratory in Elk Horn, Nebraska. Selenium and copper analysis were conducted by using a Varian Spectra AA-20 Atomic Absorption Spectrophotometer.[6]

Results of the study are presented in Table 1. The main concentration of selenium in blood was 0.11 mg/L with a standard deviation of 0.04 mg/L. Selenium levels in bovine blood are considered normal in the range of 0.08 to 0.30 mg/L, whereas concentrations from 0.03 to 0.07 mg/L are marginal (Blood et al., 1986). However, if incidences of mastitis and retained fetal membranes are considered, the optimal blood levels may be somewhat higher than previously stated (Maus et al., 1980). A selenium level higher than 0.18 mg/L was suggested as optimal by Jukola et al. (1996). Individual cows in this study showed a range from 0.07 to 0.15 mg/L, thus with selenium levels in their blood from marginal to adequate.

Selenium deficiencies have been related to abnormal reproductive function in female cattle and to an increase in the incidence of retained placentas (Hurley and Doane, 1989; Julien et al., 1976). Cows given selenium for 21 days prepartum have shown a lower incidence of uterine infections and faster involution than non-supplemented cows (NRC, 2001). Selenium is a component of gluthatione peroxidase, an enzyme with antioxidant properties that help maintain cell membrane integrity. Deficiency of selenium may suppress defense against infectious diseases, producing a decrease in microbicidal activity, all of which may contribute to a higher incidence of metritis at parturition (Acevedo, 1996). It has been suggested that supplementation with selenium, with or without vitamin E, also tends to reduce the incidence of retained placenta (Hurley and Doane, 1989). Other researchers have found supplementation of selenium and vitamin E more effective than selenium alone, but others have concluded that the effect of selenium is independent of vitamin E supplementation. This prophylactic effect has stimulated

TABLE 1.—*Plasma selenium and copper (mg/L) from dairy cows in selected herds throughout Puerto Rico.*

Region[1]	Number of Cows	Selenium[2] Mean	Selenium[2] SD	Copper Mean	Copper SD
		mg/L			
1	55	0.11[a3]	0.04	0.45[a]	0.18
2	183	0.12[a]	0.04	0.60[b]	0.18
3	175	0.11[a]	0.04	0.54[bc]	0.13
4	124	0.11[a]	0.04	0.53[c]	0.13
Total	537	0.11	0.04	0.52	0.18

[1]Region: 1 = Camuy, Isabela, Mayagüez, Quebradillas, San Sebastián; 2 = Arecibo, Hatillo, Utuado; 3 = Barceloneta, Corozal, Dorado, Manatí; and 4 = Caguas, Cayey, Gurabo, Las Piedras, and Naguabo.

[2]Number of cows (N) = 232 for selenium determination; N = 305 for copper.

[3]Values with different letters are significantly different ($P < 0.05$).

[6]Atomic Absorption Spectrophotometer. Varian Techtron, Melbourne, Australia. Trade names in this publication are used only to provide specific information. Mention of this name does not constitute a warranty or statement of preference by the University of Puerto Rico nor is this mention a statement of preference over equipment or materials.

interest in selenium and vitamin E as enhancers of reproductive efficiency, and subsequent studies have followed a protocol in which selenium and vitamin E are administered prepartum (Acevedo, 1996; Moyá et al., 2000).

The mean copper blood level observed in this survey was 0.52 mg/L with a 0.18 standard deviation (Table 1). Blood et al. (1986) reported that normal levels of blood copper are in the range of 0.95 to 1.57 mg/L, with levels lower than 0.50 mg/L considered deficient. The NRC (2001) considers normal concentrations of copper those in the range of 0.5 to 1.5 mg/L with 0.9 mg/L and average value. These guidelines would place the cows of this study in a range of copper concentrations from 0.343 to 0.697 mg/L, as varying from deficient to marginal.

Blood selenium levels were similar among the different regions of the island ($P > 0.05$, Table 2). Mean values range from 0.11 to 0.12 mg/L across regions and all had standard deviations of 0.04 mg/L. Mean plasma copper in the same geographical regions varied somewhat, with levels in the eastern part of the island (region 1) being lowest (0.45 mg/L) and those in region 2 (0.60 mg/L) highest ($P < 0.05$), whereas regions 3 and 4 gave values of 0.54 and 0.53 mg/L, respectively. Copper deficiency in grazing cattle has been recognized as a major problem in many parts of the world, resulting from either too little dietary copper available or from influences of other interfering substances, such as high levels of molybdenum, iron and sulfur. Dairy nutritionist may need to adjust copper requirements for grazing animals because soil contamination of the forages can reduce copper absorption by as much as 50% (NRC, 2001). Dairies in regions 1, 3, and 4 use predominantly grazing-type management systems, which could partially explain these results. By contrast, dairies in region 2 are predominantly confinement or semi confinement-type operations using mostly hay and haylage instead of pastures. In grass hays and silage the inhibitory effect on copper absorbability previously mentioned is present by to a lesser degree. In these cases, however, a high sulfur content of the diet can be a determining factor on copper absorption (Underwood and Suttle, 1999) and this finding should be considered.

Plasma copper concentrations may change during the periparturient period, when stress associated with fetal development and the process of calving may increase copper requirements (Waterman et al., 1991). The fetal liver may take up this mineral more rapidly than that of the mother (Hemken et al., 1993). These reports suggest that copper requirements previously recommended by the NRC (2001) may not be adequate for the transition cow during late gestation. Other effects associated with copper deficiency include early embryonic death, abnormal ovarian activity, delayed or depressed estrus, reduced conception rates, increased incidence of retained placenta and loss of hair color (Hidiroglou, 1979). Supplemental copper has increased conception rate in cows with marginally low blood copper (Hunter, 1977). Dairy cows under tropical grazing management conditions, supplemented with Cu-containing boluses immediately after parturition, had fewer days open (196.9 vs. 253.6 d) than non-supplemented animals (Moyá et al., 2000). Infertility associated with delayed or depressed estrus has been observed in cows grazing Cu-deficient pastures, whereas conception rate was increased from 53 to 67% upon injection of supplemental copper, and the increase was greater (93%) after injection of copper and cobalt (Alderman, 1963). Supplementation of cows with both copper and magnesium has also resulted in improved fertility (Ingraham et al., 1987).

Both selenium and copper are involved in oxidative reactions within the cell, providing a diversity of antioxidant mechanisms. Therefore, a significant deficiency of these micronutrients may compromise, to a certain extent, cellular function affecting the tissues involved in the reproductive processes. Inconsistent responses to selenium and copper supplementation are not surprising, considering the number of factors and complexity of their interactions involved in reproductive processes. Optimal function of reproductive tissues may be limited by nutritional deficiencies at critical periods, including puberty, parturition, and peak lactation; the latter is a particularly critical period in the dairy cow as it overlaps the optimal period for rebreeding. Nutrient availability for reproduction is of particular concern in the primiparous cow, which also has a nutrient requirement for growth (NRC, 2001).

These findings show a tendency for dairy cows in Puerto Rico to have blood selenium levels from marginal (borderline) to adequate and copper values from marginal to deficient. These micronutrients are important components of biochemical reactions at the cellular level. In addition, research has shown the need for supplementation of selenium and copper to improve reproductive performance in dairy cattle. However, it should be mentioned that response to supplementation of these nutrients in humid tropical areas such as Puerto Rico could well be inconsistent because of the multiple factors that affect reproduction. Special attention should be given to the status of selenium and copper in cattle because supplementation of these micronutrients could prevent nutritional deficiencies during critical periods such as parturition, peak lactation, and first lactation combined with growth. Supplementation of these micronutrients under tropical conditions merits further study, especially when most of the dairy cattle on the island are managed under intensive grazing conditions. More supplementation of these micronutrients may be needed because forage quality, availability, and intake can be influenced by tropical temperatures and humidity.

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