SELENIUM CONTENT OF NORTH DAKOTA BEEF
(1998 Field Day Presentation)

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RESEARCH SUMMARY

The overall goal of this study is to determine the correlation between high selenium range and selenium content of beef. To achieve this objective, rangeland in North Dakota will be surveyed for forage and soil selenium concentrations. Cull cows will be obtained from surveyed areas and slaughtered at a commercial abattoir. Skeletal muscle, liver, blood, and hair will be analyzed for selenium content. A correlation will then be made between environmental selenium and selenium content of skeletal muscle. Secondary endpoints, such as skeletal muscle and environmental selenium compared to liver, blood, and hair selenium content will be also examined; the goal being to determine if simpler tests are feasible to ascertain skeletal muscle and environmental selenium status.

Recent studies have shown that increased selenium intake in the human diet may decrease incidences of certain carcinomas. Beef provides a significant portion of human dietary selenium (approximately 17%). Selenium content in beef is highly variable, the biggest factor being the geographical origin of the cattle from which the beef was derived. Rangeland in some areas of western North Dakota tends to be seleniferous and may produce high selenium beef. Wheat growers in seleniferous areas have started to market portions of their crop as a high selenium product. This same marketing strategy may be possible for beef producers when the correlation between seleniferous range and beef selenium content is determined.

GOALS AND OBJECTIVES

The long-term goal of this project is to compare selenium levels in forage and soil to levels in skeletal muscle of cattle grazing seleniferous and non-seleniferous range in North Dakota. To complete this goal, five different areas within North Dakota will be surveyed for forage and soil selenium. The areas being surveyed are western Bowman and Slope Counties, Sioux County, eastern Williams County, northern

Morton County, and the sandhills region of the southeastern portion of the state. The sandhills area may be lower in selenium than other areas of the state due to the sandy nature of the soils in that area. Cull cows from the surveyed areas will be obtained and slaughtered. Skeletal muscle, blood, hair, and liver tissue will then be examined for selenium content. The specific objectives of this project are: 1) to determine the correlation between soil and forage selenium levels and beef selenium content; 2) to determine the correlations between liver, blood, and hair selenium concentrations to soil, forage, and skeletal muscle tissue selenium content; and 3) to complete a comprehensive survey of soil and forage selenium content of the aforementioned regions.

INTRODUCTION

Selenium is widely distributed in the earth's crust, having an average occurrence of about 0.09 ppm in the earth's soil (Lakin, 1972). Many areas within the United States have been surveyed to determine environmental selenium. Extensive studies have been done in this regard in South Dakota and Wyoming. Seleniferous soils are primarily alkaline soils derived from cretaceous aged shales (Rosenfeld and Beath, 1964). Pierre shale, a cretaceous age shale found extensively in central South Dakota and in areas of North Dakota, has been found to contain 2 to 10 ppm selenium (Lakin and Davidson, 1967). Pierre shale can be found in many areas of North Dakota, but the greatest concentration of it exists in western Bowman County. Sioux County is dominated by the Hell Creek formation, also a Cretaceous age shale.

Some forage and soil selenium surveying has been done in North Dakota. In 1940, an extensive selenium survey was completed in northwest North Dakota. The results were variable, mainly because the surveyed area was associated with glacial drift. In areas where the glacial drift is shallow, such as river valleys, selenium levels tend to be high. This is due, in part, because underlying the glacial drift the geologic layers tend to be shales and from the Cretaceous period. Eastern Williams County tended to have uniformly high selenium levels, up to 8.0 ppm in the soil and 3,990 ppm in selenium accumulator plants (Lakin and Byers, 1948). The 1940 study never surveyed areas in the state where Cretaceous shales derive the parent soil. To date, there have been no comprehensive studies examining these areas of the state for forage and soil selenium. There is interest in these regions to quantify selenium concentrations in forages.

Although selenium toxicity has not been a problem, some producers believe local cattle may be showing sub-clinical signs of selenosis. This study will provide useful data for producers in these areas.

Selenium in Cattle Grazing Native Range

Cattle consuming high levels of organic selenium will accumulate selenium in skeletal muscle. Selenium is stored in muscle primarily as selenomethionine, a selenium containing amino acid. Muscle serves as an important storage area for selenium. In a study conducted in Canada, skeletal muscle selenium content was examined in cattle from different geographic locations. Selenium deficient areas produced beef with much lower selenium content than cattle produced on seleniferous areas in Manitoba and Saskatchewan (Table 1). A similar study tested skeletal muscle selenium concentrations in ewes grazing forages with known selenium content (Table 2). These studies indicate that much of the variation of selenium content of skeletal muscle can be attributed to selenium levels in feed influenced by geographic location. The aforementioned studies correlate to a generalized map of the United States and Canada showing selenium distribution in crops (Figure 1).

Current Status of Research

Several studies have investigated inorganic selenium (selenate and selenite) supplementation for cattle and subsequent tissue deposition. There have been limited studies examining skeletal muscle tissue deposition of selenium ingested from native range in seleniferous areas. Studies that have analyzed selenium content of beef from differing geographic regions give an accurate picture of general areas where high selenium beef is produced, but provide no information on selenium intake and correlations to deposition.

Impact on Human Nutrition and Health

Recent studies have shown that increased selenium intake in the human diet may decrease incidences of certain carcinomas. Beef provides a significant portion of dietary selenium, approximately 17% (Shi and Spallholz, 1994). In an eight-year study, patients with a prior history of basal or squamous cell carcinomas were supplemented with 200 µg of organic selenium or a placebo. The study showed significant decreases in lung, prostate, and colorectal cancers of patients supplemented with selenium (Clark et al., 1996). Other studies have shown that an inverse correlation exists between areas high in forage selenium and cancer rates (Clark et al., 1991; Shamberger and Frost, 1969). Selenium compounds have also been shown to inhibit tumor development in a variety of animal models (Combs and Clark, 1985).

Sources of Selenium in the Human Diet

The amount of selenium in human foods varies largely with its protein content and the area of the country it was produced. Selenium tends to accumulate in proteinaceous foods because it is primarily stored in plant and animal tissue as selenomethionine, a seleno-amino acid. Foods low in protein, such as fruits and vegetables, tend to have low selenium concentrations, normally less than 0.01 µg/g. Whereas cereal products and beef tend to have concentrations greater than 0.3 µg/g. (Morris and Levander, 1970), a study that examined selenium concentration in lamb muscle, found that selenium content varied greatly geographically. Lambs raised in Laramie, Wyoming, a known seleniferous area, had an average of 1.56 ppm selenium in muscle tissue. Lambs from Corvallis, Washington, a selenium deficient area, had average concentrations of 0.04 ppm. This same study examined muscle selenium levels in calves raised in different locations in Canada. Calves from Brandon, Manitoba, had muscle tissue levels of 1.24 ppm compared to 0.04 ppm found in calves from Nova Scotia (Hoffman et al., 1972). In 1985-87, ranchers from seleniferous areas in western South Dakota and eastern Wyoming were screened for selenium status. The subjects average selenium intake was 200 µg/d. The American average is 76 µg/d. Ninety-seven percent of the subjects reported eating beef raised from their ranches, which was the one common dietary ingredient that seemed to account for elevated selenium status (Longnecker et al., 1991).

MATERIALS AND METHODS

The study will examine the correlation between soil and forage selenium levels to selenium levels in skeletal muscle, blood, hair, and liver samples in cull cows from five different areas in the state. Western Bowman County, Sioux County, and eastern Williams County will serve as the high selenium areas. The sandhills region of southeast North Dakota and an area near New Salem that has a history of white muscle disease will serve as the low selenium control area. Six ranches were selected from each area. During the summer of 1998, 30 forage and soil samples were taken from each ranch. Pastures were divided into six blocks, five forage and soil samples were taken from each block. A standard 1-meter clipping square was used to collect forage samples and a soil probe was used to collect soil samples. Grasses and broadleaf plants were clipped and analyzed for selenium. Multiple soil samples were taken and composited as an average for each soil sample taken. Selenium accumulator plants were also clipped when encountered, namely *Astragalus bisulcatus* and *A. racem*osus which can accumulate selenium in excess of 10,000 ppm.

In the fall of 1998, 5 cull cows will be obtained from each ranch, at which point blood and hair samples will be collected. Blood will be collected by jugular venipuncture and hair samples will be taken from the switch of the tail. Cull cows will be slaughtered at a commercial abattoir. Skeletal muscle and liver samples will be harvested and analyzed for selenium content.

RESULTS EXPECTED

It is reasonable to believe that there will be a significant correlation between biological levels of selenium and soil and forage levels. Several studies have shown that as selenium intake increases, selenium content of skeletal muscle, liver, hair and blood increases as well (Kincaid et al., 1977; Hoffman et al., 1972; Perry et al., 1976; Ammerman et al., 1980). The primary question that remains to be seen is the extent of the correlation between the parameters.

CONCLUSION

Selenium content in beef is highly variable, the biggest factor being the geographical origin of the cattle from which the beef was derived. Rangeland in western North Dakota tends to be seleniferous and may produce high selenium beef. Wheat growers in seleniferous areas have started to market portions of their crop as a high selenium product. This same marketing strategy may be possible for western North Dakota beef producers when the correlation between seleniferous range and beef selenium content is determined.

Table 1. Skeletal muscle selenium content of beef from Canada

Muscle Se (ppm)	Geographic Origin				
	St. Johns, Newfoundland	Nappan, Nova Scotia	Kapuskasing, Ontario	Brandon, Manitoba	Swift Current, Saskatchewan
	0.37 ± 0.06	0.21 ± 0.07	0.07 ± 0.02	1.24 ± 0.04	1.33 ± 0.13

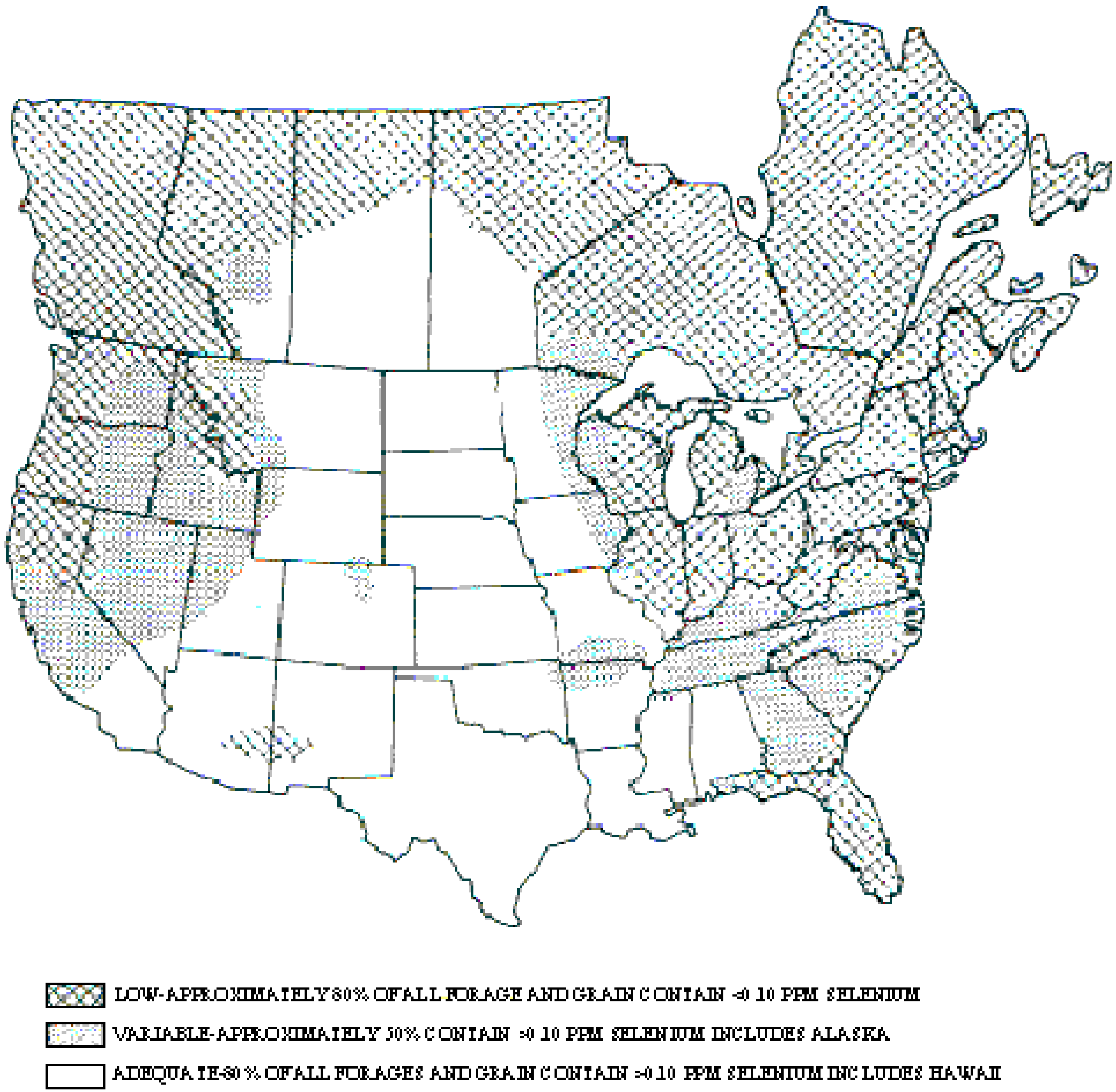
(Hoffman et al., 1972)

Table 2. Skeletal muscle selenium concentrations in ewes grazing forages with known selenium content

Geographic Origin	Selenium Concentration in Ewe Diet (ppm)	Muscle Selenium (ppm)
Arlington, Wisconsin	0.02	0.10 ± 0.01
Urbana, Illinois	0.16	0.36 ± 0.02
Laramie, Wyoming	0.23	1.56 ±0.30
Fort Collins, Colorado	0.26	0.62 ± 0.06
Brookings, South Dakota	0.46	0.97 ± 0.04
Minneapolis, Minnesota	0.52	0.62 ± 0.10

(Paulson, et al., 1968)

Figure 1. Selenium distribution in crops in the United States and Canada *(Kubota et al., 1967)*



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