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EFFECTS OF FEEDING HIGH MOLYBDENUM HAY TO MATURE BEEF STEERS

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ABSTRACT

A 3X3 latin square design experiment was used to study the effects of feeding high molybdenum (Mo) hay, from Highland Valley Copper, to three cannulated Hereford steers. Supplement treatments were; no supplement, copper oxide needles (CuO_n) and copper oxide bolus. Feed intakes, mineral content of feed, dry matter and nutrient digestibilities, supplement disappearance from the rumen and copper (Cu) concentrations in the blood were monitored. Hay from Highland Valley Copper was high Cu (19.09 ppm), high Mo (49.68 ppm) feed. Severe cases of molybdenosis were expected but did not develop in cattle. Feeding harvested sun-cured high Mo forage lessens the hazard of molybdenosis. The Cu supplements had little or no effect on dry matter or nutrient digestibilities nor on rumen metabolism. Cu concentrations in the blood were increased. Research grazing fresh forage is required before making conclusive recommendations for using mine waste dumps and tailings ponds for forage production.

INTRODUCTION

Reclamation of inactive tailings ponds and waste dumps at Highland Valley Copper has focused on testing plant species, planting criteria and fertilization. Tree farming, grazing, hay production, and public recreational areas are planned for the reclaimed land (Highland Valley Copper, Logan Lake, B.C.). Forage from these reclaimed sites was found to be high in molybdenum (Mo). High concentrations of Mo cause molybdenosis, characterized as a secondary Cu deficiency, by making copper Cu unavailable to ruminant species. Agriculture Canada's Kamloops Research Station and Highland Valley Copper studied the effects of feeding steers high Mo hay, with and without Cu supplements, to determine if the consumption of the forage would produce adverse effects in cattle..

The objectives of the investigation were:

1. To determine the organic matter, protein, fibre and mineral content of High Mo hay from the Bethlehem #1/ Main tailings pond.
2. To study the effects of feeding high Mo hay to cattle (with or without Cu supplementation) on ruminal pH and osmolarity, faecal dry matter, and faecal Cu and Mo content.
3. To study digestibility and rates of degradation of high Mo hay in the rumen of cattle, with and without copper supplementation.
4. To study the copper concentration of the blood of cattle consuming high Mo hay with or without the Cu supplements.

LITERATURE REVIEW

"Scouring disease", peat scours or "teartness", was first recognized in Britain 45 years ago. Pastures producing these symptoms in cattle were known as "teart" pastures. Thornton (1976) reported that the disease was caused by excess Mo in forages combining with Cu to form a Mo-Cu complex; whereby Mo made Cu in the feed unavailable to the animal.

Pastures with natural high levels of Mo have been identified in England, Scotland, Wales, Ireland, Europe, New Zealand, Australia (Thornton 1976), Northwest Manitoba (Boila et al. 1984), and British Columbia (Miltimore and Mason 1971). Pastures have also been contaminated with Mo from refining procedures, steel production, production of aluminum alloys (Hornick et al. 1976) and open pit mining where the run-off from tailings ponds contaminated local streams (Illanes 1991, Vlek and Lindsay 1976).

Factors causing high Mo forage and molybdenosis include soil type/ climate, age species and breed of animal and the individual animal (Hidiroglou 1981). Symptoms of a clinical Cu deficiency are: severe greyish yellow diarrhea, tender hind quarters and tail region, frequent defecation, thin bellies, loss of appetite, body odour, decreased milk production, rough or poor hair coat, achromatia or loss of colour in hair, stiff gait, swollen joints or fragile bones, reduced reproductive efficiency, male and female sterility and delayed puberty (Hornick et al. 1976).

Sudden heart attack, breathing difficulties, anemia and death may result if treatment is withheld (Hidiroglou 1981). Sub-clinical Cu deficiency results in unthrifty animals.

When the cause and etiology of molybdenosis were identified, tolerances of animals were not established. Research indicated that ruminants could tolerate higher levels of inorganic Mo in rations (200 parts per million (ppm)(Huber *et al.* 1971) than organic Mo obtained from grazing fresh forage. Mo levels in pasture forage greater than 2 to 4 ppm are generally of concern without copper supplement (Thornton 1976, Hornick *et al.* 1976, Leech and Thornton 1987).

The ratio of Cu to Mo may determine if molybdenosis occurs. Cu:Mo ratios above 2 were reported as being healthy for cattle, but lower ratios resulted in Cu deficiency (Illanes 1991, Fletcher and Brink 1969, Miltimore and Mason 1975).

Research on molybdenosis has concentrated on prevention by using various Cu supplementation techniques. Copper is included in most commercial mineral licks and salts. However, when forage Mo levels are higher than 10 ppm (Hornick et al. 1976) supplementation of the feed with Cu may be necessary. Cu levels have been increased by soil applications of Cu sulphate (Smart et al. 1992); by injections of a Cu salt (Smart et al. 1992); by oral dosing with several chemical forms of Cu complexed to sulphate, oxide, chelated, proteinated, or diamine peptides (Smart et al. 1992, Baker et al. 1991, Spears et al. 1991). Slow release boluses and Cu needles are best adapted to range grazing conditions. Oral doses of needles adjusted for age and weight of cattle have been effective in preventing Cu deficiency for up to 6 months (Smart et al. 1992).

MATERIALS AND METHODS

Three rumen cannulated Hereford steers were fed high Mo hay without (control) or with either copper oxide needles (CuO_N) or copper oxide bolus. The steers were group housed yet were individually fed free choice using Calan-Broadbent gate feeders. We weighed each animal at the beginning of each 28 day feeding trial.

Steers were maintained on chopped orchard-grass hay. Chopped high Mo hay was introduced one day before starting each 28 day feeding trial. Voluntary feed intake was measured for 5 days following a 14 day adjustment period. Fresh water and salt blocks were available at all times. Other mineral supplements were not provided.

We used a 3 X 3 Latin square design replicated twice in time to test the treatments. This minimized any residual effects from the treatments. In total there were six replicates of each treatment over six feeding trials. We used analysis of variance (SAS 1985) to analyze the data.

Feed samples were randomly collected from each batch of chopped hay, additional feed and faecal samples were collected both AM and PM from each steer for days 20-25 of each trial. Samples were dried at 60°C in a forced air oven, ground to pass a 1.0 mm screen and analyzed for dry matter, crude protein, neutral and acid detergent fibre and lignin, ash, Cu, Mo, calcium and acid insoluble ash. The difference in feed and faecal acid insoluble ash relative to the differences in nutrient content was used to calculate the digestibilities. A correction factor of 0.6 + 17.1 was applied. The sulphur content of water was obtained from the City of Kamloops.

Nylon bags, containing dried forage ground through a 2.0 mm screen, were inserted into the rumen for durations of 0.5, 3, 6, 9, 15, 24, 36 and 72 hour (h) beginning on day 24 of a feeding trial. Bags were washed immediately after removal from the rumen, dried to constant weight at 60°C in a forced draught oven and residues in the bags were analyzed for dry matter, crude protein, neutral detergent fibre and acid detergent fibre disappearance at each incubation time. Simultaneously with bag insertion, a rumen content sample from each of the steers was collected, strained through a double layer of cheese cloth and the pH of the rumen fluid was measured. The rumen fluid samples were then frozen for later determination of osmolarity.

Copper oxide supplements, inserted in the rumen in nylon bags at day 1 of each feeding trial, were removed and weighed on day 28 to determine the disappearance of Cu.

Blood samples were collected from each animal prior to the initiation of the feeding trials and on days 1, 14, 20, 24 and 29. The samples taken on day 29 were also day 1 samples for the subsequent trial. Cu analysis of blood involved dilution of 5 ml of plasma with 5 ml of distilled water, followed by quantification using the atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

The Highland Valley Copper hay would be classed as a high Cu high Mo (Table 1) hay with a Cu:Mo ratio 1:2.60 or 0.38. This ratio is below the recommended minimum of 2.0 for prevention of molybdenosis. In comparison, a standard alfalfa sample contained 9.85 ppm Cu and 10.36 ppm Mo. Fletcher and Brink (1969) and Miltimore and Mason (1971) reported that British Columbia forage species contained from 2.8 to 11.4 ppm Cu and from < 0.6 to 12 ppm Mo. Reported Cu: Mo ratios for forage crops ranged from 2.1 to 6.7 (Miltimore and Mason 1971).

Despite a low Cu:MO ratio and high Mo content in hay, molybdenosis did not occur in our experiment. Allaway (1976) reported that feeding livestock harvested sun-cured hay reduced the incidence of molybdenosis relative to that noted when green forages were grazed and that sun-cured hay with Mo concentrations up to 50 ppm did not produce molybdenosis in cattle. Apparently the drying process alters the availability of soluble Mo and the hazard of molybdenosis in cattle consuming the forage is therefore reduced.

Table 1. Chemical components *of* Hay from Highland Valley Copper, Bethlehem Nol/Main tailings pond. 1991

Items	Content
Dry matter (%)	91.33
Crude protein (% of dry matter)	6.77
Acid detergent fibre (% of dry matter)	46.42
Neutral detergent fibre (% of dry matter)	62.76
Acid detergent lignin (% of dry matter)	10.39
Ash (% of dry matter)	5.95
Calcium (% of dry matter)	0.95
Copper (ppm)	19.09
Molybdenum (ppm)	49.68
Copper:molybdenum ratio	1:2.6

The concentration of sulphur (S) in the diet determines if a Cu-Mo-S interaction occurs and the severity of a resultant Cu deficiency in ruminants. Copper metabolism in ruminants was affected when S concentrations in the diet exceeded 3000 ppm (Suttle 1991), but levels of 947 mg/L sulphate in water had no effect on animals containing copper oxide needles (Smart *et al.* 1992). Kamloops City Water had a sulphate content of 8 mg L^{-1} at the initiation of feeding trials in November and a content of 6 mg L^{-1} at the termination of trials in May. Highland Valley Copper hay had a S content of 0.100 % S (1000 ppm) (Pacific Soil Analysis Inc., Richmond, B.C.). The S content of hay and the sulphate content of the water in our trial were less than these reported values and were not a concern in producing molybdenosis.

There was no difference in feed intake of animals among treatments, (Table 2) although feed intakes of individual animals varied over the six trials. Intakes showed a trend of decreasing as the trial progressed. On average, control animals tended to consume more hay than the animals receiving the copper oxide treatments.

Feed digestibility values for dry matter and the various nutrients in animals fed high Mo hay with or without Cu oxide needles and bolus are given in Table 3. Significant differences due to diet or treatment were not observed. No unusual animal health effects were noticed from feeding high Mo hay.

Table 2. Changes in body weight (BW) and voluntary feed intake of steers fed high Mo, Highland Valley Copper hay. 1991

	Control	Needle	Bolus
Initial weight (kg)	893	893	893
Final weight (kg)	856	852	843
Weight loss (kg)	37	41	40
Feed Intake (kg/d)	13.0	12.2	12.8
Feed Intake (% BW)	1.5	1.4	1.5
Feed Intake (g/d/body weight$^{-0.75}$)	80.8	76.0	79.7

body weight ($kg^{-0.75}$) = metabolic body weight.

Table 3. Digestibility of feed dry matter and nutrient fractions by steers fed high Mo hay with or without Cu supplements.

	Copper oxide treatment			
	Control	Needle	Bolus	SEM
Nutrient	%			
Dry matter	70.7	70.1	70.4	0.5
Crude protein	43.6	42.9	42.8	2.6
Neutral detergent fibre	45.6	43.1	43.5	2.5
Acid detergent fibre	45.9	42.0	42.5	2.7

SEM = Standard error of the mean

The disappearance of dry matter and nutrients of the hay incubated in nylon bags in the rumen was in agreement with published values for various forages (Quinton and Ryder 1983).

Digestibilities and excretion of Cu and Mo in feces were not affected by the copper oxide treatments (Table 4). However, dry matter disappearance from nylon bags after 72 h of incubation in the rumen (Table 4) was lower than the in vivo dry matter digestibilities in the animals (Table 3) . The disappearance of the crude protein fraction from the bags after 72 h of incubation (Table 5) was greater than the total digestibilities noted for this fraction (Table 3) . Perhaps some extent of digestion by colonic microbes may have occurred resulting in higher in vivo dry matter digestibilities but lower crude protein digestibilities due to higher nitrogen content of feces (due to growth of microbes in the colon which would be excreted).

Table 4. Dry matter degraded in saco at various times of incubation in the rumen.

Incubation times (hours)	Treatment			
	Control	Copper oxide needle	Copper oxide bolus	
	------------------	%	------------------	SEM
0.5	27.1	27.1	27.3	0.73
3	29.2	28.5	28.7	0.87
6	34.3	34.6	34.7	1.06
9	39.6	39.0	38.8	0.89
15	46.1	46.1	46.6	0.88
24	53.3	51.6	52.1	0.99
36	58.0	57.0	57.0	0.68
72	63.0	62.2	62.3	0.63

SEM = Standard error of the mean

The in vivo digestibilities (Table 3) of neutral and acid detergent fibre fractions were comparable to the digestibilities noted after 72 h of incubation in nylon bags in the rumen (Tables 6 & 7) .

Rumen pH or osmolarity was not affected by the treatments. The average rumen pH for the copper oxide treated animals (6.53) was non-significantly more acidic than that noted for control animals (6.57).

The mean Cu concentration in blood plasma varied from 0.73 ppm Cu at the initiation of the feeding trials to 0.75 ppm of Cu by the end of the trial (Fig. 1). Normal plasma Cu concentrations for mature animals are 0.75-1.50 ppm (Suttle 1991).

Hornick et al. (1976) reported Cu deficiency symptoms in mature animals when the plasma Cu concentrations ranged from 0.28-0.38 ppm. Since plasma Cu concentrations did not decrease below the critical range, deficiency symptoms were not observed in our study. Perhaps our steers had adequate liver stores of Cu at the outset of the study and the time span of feeding without Cu supplement was not long enough to deplete the liver stores.

Table 5. Crude protein degraded in saco at various times of incubation in the rumen.

Incubation times (hours)	Treatment			
	Control	Copper oxide needles	Copper oxide bolus	
	------------------ % ------------------			SEM
0.5	47.9	49.6	47.9	1.71
3	51.1	52.5	51.4	1.97
6	58.5	59.5	57.7	1.67
9	64.3	63.9	63.3	1.91
15	69.7	69.7	71.6	1.57
24	73.6	73.5	73.6	1.24
36	75.7	75.1	74.3	1.39
72	80.0	78.9	79.1	0.86

SEM = Standard error of the mean

Table 6. Neutral detergent fibre degraded in saco at various times of incubation in the rumen.

Incubation times hours)	Treatment			
	Control	Copper oxide needle	Copper oxide bolus	
	------------------ % ------------------			SEM
0.5	2.1	3.2	2.4	1.18
3	4.8	3.5	3.6	1.26
6	9.5	10.1	9.9	0.77
9	15.7	15.2	14.5	1.49
15	23.5	25.1	24.2	1.53
24	34.0	31.1	31.9	1.99
36	40.2	38.9	38.9	1.32
72	48.1	46.3	46.6	1.45

SEM - Standard error of the mean

Figure 1

Plasma copper (Cu) in steers fed forage from Highland Valley Copper, Bethlehem No.1/Main tailings pond with and without supplemental copper

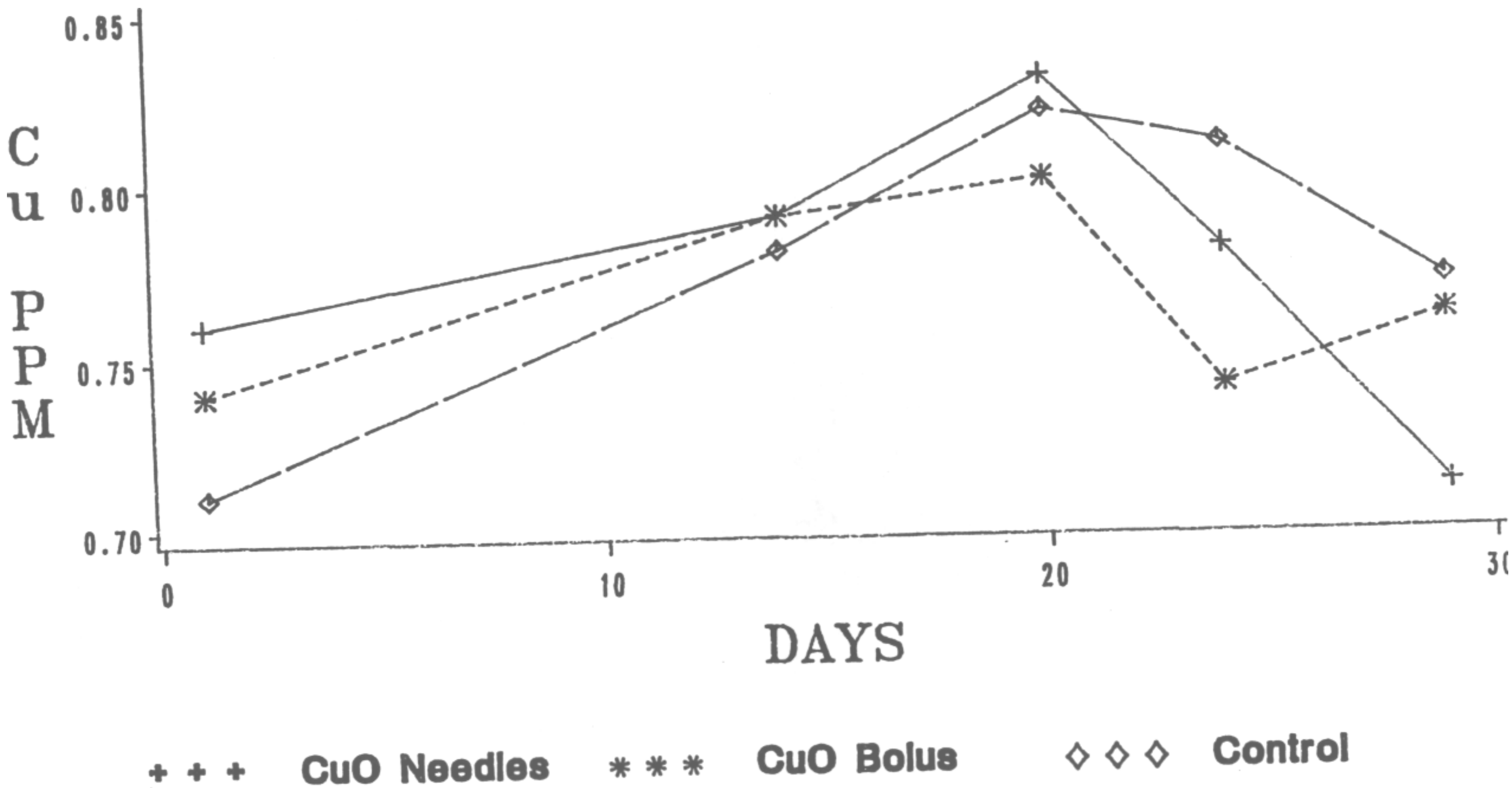

Table 7. Acid detergent fibre degraded at various incubation times in the rumen.

Incubation times (hours)	Treatment: Control	Copper oxide needle	Copper oxide bolus	SEM
	----	%	----	
0.5	0.6	3.0	3.8	1.91
3	2.9	3.7	4.0	1.95
6	6.8	8.6	11.0	1.50
9	12.3	13.9	13.1	1.34
15	20.3	23.2	22.8	2.18
24	30.6	29.1	29.7	1.37
36	37.5	37.3	36.4	1.04
72	45.4	43.6	43.1	1.20

SEM - Standard error of the mean.

SUMMARY

In this preliminary trial, we found that cured forage from the Highland Valley Copper No. I/Main tailings pond pasture did not cause clinical molybdenosis when fed to mature Hereford steers, nor were feed intakes, digestibilities, or the metabolism of the steers noticeably affected. From the data, it is difficult to determine if the Cu treatments helped the Cu status of the animals significantly or if their liver Cu stores were large enough to prevent Cu deficiency. A pasture grazing study using fresh forage is required before conclusions can be reached on the use of the tailings ponds as pasture sites.

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