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Clinical Trials with Copper Supplementation of Cattle

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CLINICAL TRIALS WITH COPPER SUPPLEMENTATION OF CATTLE

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Copper deficiency has been diagnosed in beef cattle herds in many areas of the intermountain west. Copper supplements are not widely used, even though several products are available. It is difficult to correct a deficiency because too much copper can result in copper toxicity or poisoning. Toxicity is less a hazard with cattle than with sheep, but it is still a problem to guard against. Periodic monitoring of the herd’s copper status is essential for proper supplementation.

When dealing with a copper deficiency consider whether it will be economically worthwhile to provide supplemental copper. If the animals are only marginally deficient, supplementation will not bring enough additional income to offset expenses. The deficiency may occur for a relatively short period, or on specific pastures or feeds. This type of deficiency corrects itself when the cattle are moved to another site. Yet, in some herds copper deficiency causes significant production losses each year.

The clinical signs of copper deficiency include ill thrift and poor growth, rough haircoat, diarrhea, lameness, rickets-like condition, depraved appetite and infertility. Affected cattle may also show faded hair color. The specific signs depend on the cause of the deficiency, and this contributes to confusion in diagnosis.

Copper deficiency may be caused by a diet that is low in copper content or by interference with copper from an excess of elements such as molybdenum, sulfate and iron. Livestock water that is high in sulfates can trigger copper deficiency. Growing plants, especially tall fescue and quackgrass, tend to tie up copper more than harvested feeds. Some breeds are more susceptible than others. Old lake-bottom soil (which applies to much of the mountain west) and alkaline areas are prone to copper deficiency. It has been stated that if you have 25 acres of swampland you will have copper deficient cattle, even though you have 250 acres of other good ground. There seems to be considerable truth in that statement.

Diagnosis of copper deficiency should be based on clinical signs, history, blood serum copper levels, and liver copper levels. Forage analysis for copper, molybdenum, iron and sulfate and water analysis for sulfate are also important aids for diagnosis and in planning for supplementation. The liver is the best measure of current copper status, except in the fetus or newborn. The fetus stores copper in its liver at the expense of the dam. In late pregnancy, it is normal for the cow's serum and liver copper levels to decline drastically. Blood serum is a more reliable and consistent measure of copper status than is whole blood. But serum does not reflect dietary intake unless the liver is severely depleted of its copper stores. Low serum copper indicates that almost all of the liver copper storage has been used. When the serum copper reaches normal levels, the only way to determine copper reserve status is by liver biopsy. Supplementing ruminants which have a normal serum copper level could lead to toxicity. The serum copper level may also be increased by infection, trauma and hemolysis of red blood cells. Supplementation with selenium reduces the serum copper level, but actually increases the amount of copper available to the animal.(2) Guides for interpretation of laboratory results are included in Tables 1 and 2.

Table 1. Tissue Copper Concentrations (1)

	Serum Copper (ppm)	Liver Copper (wet weight, ppm)
Clinical Signs	< 0.2	NA
Deficient	0.2–0.4	0.5–10.0
Marginal	0.4–0.7	5–25
Normal	0.7–1.1	25–550
Toxic	> 1.2	250–800

Table 2. Element Levels in Forages and Water (1,2,3)

	ppm Cu	ppm Mo	Cu:Mo Ratio	(S) Sulfate %	ppm Iron	ppm S in Water
Clinical Signs	< 2		< 2			
Deficient	< 3-5		< 2			
Marginal	< 10		< 3			
Adequate	10	> 3	6–10			
High	—			> 0.2%	> 300	> 500
Toxic	—	>10	> 12			

Methods to supplement copper include feeding salt which contains 0.5-2.0% additional copper, injecting a commercial preparation of copper, dosing with gelatin capsules containing copper wires, adding copper tablets to water, and fertilizing pastures with copper. Salt supplementation is not always successful because some grazing areas are high in salt, and cattle may not ingest enough free-choice salt to obtain adequate copper.

Several trials (partially funded by the Utah Department of Agriculture) have been conducted on commercial cattle herds in Utah to correct copper deficiency without toxicity. In each herd, the copper status was monitored with serum analysis of 5–10 animals per herd or group. These trials are summarized below:

Injectable Copper Trial

The herd used for this trial was located in Emery County, Utah, where the soils are alkaline. The cattle showed some signs of copper deficiency, confirmed by blood serum analysis.

Half of the cows were used as a treatment group and the others left as untreated controls. Blood samples were used to monitor for a variety of elements on a monthly basis for a full year. All cows and calves were maintained together. The treated group was injected with a copper solution (Molycu, by Schering Corp.) in April and June. Each milliliter of the injectable product contained 200 mg cupric glyconate, equivalent to 60 mg copper. One injection was supposed to last for 3–6 months. But blood serum levels increased very little during the first few months, so the injections were given once per month from August through March. Injectable copper did not increase the serum copper level significantly in this trial, even when used monthly.

INJECTION COMPARED TO BOLUS (CAPSULE) TRIAL

This herd was also located in Emery County. The owner recognized a herd health problem for several years and, in 1990, the problem was diagnosed as copper deficiency. The majority were of Angus breeding but several breeds and breed crosses were present. They were grazed on fescue pastures from mid April to mid November and then fed protein block or alfalfa hay. All cows and calves were injected that spring with a copper supplement (Molycu). The owner observed some improvement, but not complete correction of the problem. In the spring of 1991 the herd was supplemented with salt containing 2% copper sulfate. The cows ate the salt well initially, but soon their intake almost stopped. On initial evaluation in June 1991 blood serum samples were collected from five animals and the mean copper content was 0.30 ppm (parts per million). Liver samples were collected from two feedlot animals sent to slaughter. They had been taken off of pasture and fed alfalfa and grains for several months. The liver copper values were 171 and 157 ppm, which was within the normal range. This helped confirm that the deficiency was related to grazing.

The clinical signs observed were faded hair color and persistent diarrhea. The owner complained that in 1990, 10 of 50 cows were open and in 1991, 3 were open and 3 more aborted. He also described a gait problem with some calves. One typical calf was present and appeared to be slightly stiff in the rear legs and ran with a “hoppy” gait. In the owner’s experience, these calves gradually worsened but usually survived and could be salvaged for slaughter.

Two forage samples were collected from the pasture and analyzed. The copper content was marginal (7.7 and 9.0 ppm), molybdenum elevated (3.3–3.5 ppm), sulfate was high (0.3%) and iron was high (510–1067 ppm). One water source was also high in sulfate (709 ppm). The fescue was very low in endophyte.

Because of the cows low salt intake, a trial was designed to compare supplementation with a long lasting copper bolus and a fall and spring injection of copper. On September 28, 1991, all cows were weighed, pregnancy tested and scored for body condition. All cows (100%) were pregnant. The cows were divided into two treatment groups based on estimated length of pregnancy and age. Group 1 was treated with two copper boluses (CUPRAX by Cooper Animal Health), Group 2 was injected with a copper supplement (MOLYCU). Blood serum samples were collected from six cows in each group. All cows were maintained together throughout the year.

The calves born in 1991 were not involved in the trial but they were present and were observed. The color of many was faded, they appeared less thrifty than expected, and a number showed enlarged epiphyses at the fetlock joints on front and rear legs.

On May 2, 1992, the cows and calves were weighed and scored again. Group 2 cows were again injected with the copper supplement. Group 1 cows (bolus) were not given any additional copper supplement since the product directions prohibited dosing more than once per year. The calves of both groups were treated according to the grouping of their dams. Those of Group 1 were given one copper bolus; those of Group 2 were given a 1 ml injection of copper glyconate. Blood samples were collected from the same cows from each group as in September and from the calves of those same cows. All cows and calves were pastured together during the summer.

On September 19, 1992, the cows and calves were weighed and evaluated again and blood samples were collected from those previously sampled. Only one cow was open from those included in this study. The mean days pregnant were similar (Group 1-125, Group 2-121). The data on blood serum levels are summarized in Table 3.

The data suggest that both forms of supplementation were of some value, but were not adequate to compensate for the interference present. Interference was greatest during the spring to fall grazing period. The bolus caused a greater increase in blood serum copper levels from September until May than did the injection, and there was a significant difference in the serum copper values of the two groups. But the liver copper stores from the bolus were apparently almost gone by May. By September of 1992, the serum levels were the same for both groups of cows. The 7 grams of copper in the bolus was apparently not enough to counteract the interference for a full year. Even the additional injection of copper in May to those on that treatment, did not prevent a severe deficiency during summer grazing.

The calves from the bolus treated cows had a higher serum copper level in May 1992, but that difference was not significant. By September 1992, the calves from bolus treated cows, which calves had also been given a bolus in May 1992, had a significantly higher serum copper level than did the calves from the injection group. The bolus appeared to be a much more effective form of treatment for the calves than the injection.

Since neither the bolus nor the injection supplied sufficient copper to this herd, the owner resumed the feeding of copper supplemented salt. Cottonseed meal was added to increase salt intake during times when they wouldn't eat the salt free choice. Later blood tests indicated the cattle were still below normal in copper, but above the level where deficiency should cause economic losses (see Table 3).

TRIAL FOR COMPARISON OF SALT AND PROTEIN BLOCK SUPPLEMENTED WITH COPPER

A Cache Valley herd of copper deficient cows and calves was used to compare copper supplemented salt with protein block. Copper sulfate was added to the salt at 1.5% and 0.19% to the 14% protein block. The supplementation rate was calculated to provide at least 454 mg of copper sulfate per head per day. Both the salt and protein block were supplied once per week, so as to be limit fed at the calculated rate. The cows readily adapted to the block and ate all that was offered, so intake was easily controlled. The salt intake varied slightly from week to week, but the cows ate more than was needed to meet the minimum copper supplement goal. Intake levels are compared with the goals in Table 4. The advantage of using salt or protein block is the ease of limiting copper intake to a calculated amount for the herd. The intake by individual animals could vary greatly depending on individual preferences.

There were differences in the quantity of forage available in the pastures and this was reflected in the cow weight gains. One group lost weight during the last half of the summer grazing, and another gained very slowly. The weight and gain data from the study cannot be used to compare the supplement groups. Data from the blood serum copper levels can be compared, and it is listed in Table 5.

Table 3. Blood Serum Copper Values (ppm)

Treatment Group	Sep 1991	May 1992	Sep 1992	30 Jan 1993	15 Mar 1993	9 Jan 1993	30 Sep 1993	29 Mar 1994
Cows:								
1. Bolus (Std Dev) # Samples	.113 (.016) 6	.502 (.247) 5	.110 (.062) 6	.575 (.086) 4	.548 (.094) 5	.352 (.176) 5	.332 (.123) 5	.562 5
2. Inject (Std Dev) # Samples	.113 (.016 6	.253 (0.59) 6	.150 (.077) 6	.550 (.083) 6				
P Value	1.000	.039	.347	.800				
Calves:								
1. Bolus	—	.636 (.210) 5	.490 (.135) 5	—	—	.568 (.141) 5	.518 (.148) 6	—
2. Inject	—	.466 (.199 5	.142 (.016) 5	—				
P Value	—	.226	.000	—				

Table 4. Minimum Goal and Intake Levels for Protein Block and Salt with Copper Sulfate Added

	Pounds of Blocks/Hd/Day	CuSO4/Hd/Day (Mg)	Pounds of Salt/Hd/Day	CuSO4/Hd/Day (Mg)
Minimum	1.00	454	0.0667	454
Target	1.03	467.6	0.0996	677.9
Actual Intake (Percentage of Target)	(103%)		(149%)	

Both the block and salt supplements increased the cows serum copper levels above the controls (highly significant difference). More importantly, the level of serum copper in the calves increased in both supplemented groups. Milk does not contain a high level of copper, but this trial helps confirm that if the cows are supplemented adequately, they will supply enough copper to their calves. Although blood copper levels did not reach normal, they did rise to a point where there was little hazard of economic loss due to copper deficiency.

The protein block supplement cost 11 times as much as salt, but was no more effective in raising serum copper levels (see Table 6). Salt supplementation is an economical way to provide additional copper. Salt should be considered even if other products have to be added occasionally to increase intake. Cows in this study were not eating enough block to make up for any feed limitations or energy deficiency. If lack of feed is a problem, it would be better to wean the calves early.

Table 5. Blood Serum Copper Levels (ppm) Comparing Supplementation by Block or Salt vs. Control.

	May 25	Aug 17	Sep 28	Nov 8
Groups—Cows				
1&2 Block—Mean	0.548	0.622	0.595	
(Std Dev)	(0.176)	(0.105)	(0.143)	
# Samples	10	9	17	
3&4 Salt—Mean	0.524	0.585	0.597	
(Std Dev)	(0.091)	(0.073)	(0.131)	
# Samples	10	8	19	
5 Control—Mean	0.434	0.300	0.325	
(Std Dev)	(0.192)	(0.137)	(0.081)	
# Samples	5	5	10	
P Value	0.391	0.000	0.000	
Groups—Calves				
1&2 Block—Mean	0.471	0.553	0.462	0.866
(Std Dev)	(0.136)	(0.081)	(0.146)	(0.230)
# Samples	11	11	20	8
3&4 Salt—Mean	0.403	0.440	0.483	1.042
(Std Dev)	(0.176)	(0.137)	(0.136)	(0.037)
# Samples	7	10	20	4
5 Control—Mean	0.404	0.198	0.208	0.780
(Std Dev)	(0.149)	(0.040)	(0.056)	(0.161)
# Samples	5	5	11	6
P Value	0.574	0.000	0.000	0.119

Table 6. Comparative Cost of Block and Salt for Copper Supplementation

	Cost Per Ton	Cost Per Pound	Cost Head Per Day
Block	$143.20	$0.072	$0.0741
Salt	$132.54	$0.0663	$0.0066

AFTER WEANING—HARVESTED FEEDS

Copper deficiency occurs primarily in grazing animals. Cattle on harvested feeds are usually normal or only marginally deficient. Data were collected from four different herds to show the relatively rapid change in serum copper from grazing (at weaning) to the feedlot (see Table 7).

Table 7. Comparison of Serum Cu Levels When Moved from Grazing Cond. (at Weaning) to Feedlot

Herd Location (Year)	Time Between Blood Samples (Months)	Serum Copper @ Weaning (ppm)	Serum Copper in Feedlot
Sevier County	2	0.52	0.72
Rich County	2 ¼	0.50	0.78
Cache County (1992)	2	0.29	0.79
Cache County (1993)	1 ¼	0.21	0.78

Conclusions on Copper Monitoring and Supplementation

1. Blood serum analysis is a valuable tool for monitoring the copper status of cattle herds. Sampling 5–10 animals per herd or group provides a useful measure of the herd or age group status. It should be used to monitor copper supplementation.

2. The injectable copper did not seem to be of great value in correcting deficiencies.

3. The bolus brought a better response than injectable copper, but does not contain enough copper to correct a severe deficiency. It could be administered to calves in the spring to help carry them through the grazing period. Once given, it cannot be removed, so the producer has less dosage control than with a continuing supplement.

4. Salt is a very good, economical means of providing supplemental copper. The rate of supplementation can be carefully controlled. If cattle are eating more salt than expected, copper-free salt can be fed for a time. Low salt intake can be corrected by adding cottonseed meal, ground barley, etc., to achieve the desired level of salt consumption. Salt management takes a little planning and work, but gives very good control of copper supplementation.

5. Copper-supplemented protein block also gives very good control but is more expensive than salt. The cost per head is still very reasonable when compared to the losses which may be caused by copper deficiency.

Copper supplementation is NOT a simple task, but it is manageable and can be applied to the individual ranch situation. Using serum sample monitoring and copper-supplemented salt and/or block, copper deficiency can be prevented and controlled.

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