January 2000

Copper Levels and Sources in Pre- and Post-calving Diets of First-Calf Cows

Dennis R. Brink
University of Nebraska-Lincoln, dbrink1@unl.edu

Gene H. Deutscher
University of Nebraska-Lincoln, gdeutscher@inebraska.com

Erick Muehlenbein
University of Nebraska-Lincoln

Copper Levels and Sources in Pre- and Post-calving Diets of First-Calf Cows

Dennis Brink
Gene Deutscher
Erick Muehlenbein[1,2]

Calf health and cow pregnancy rates were not affected by Cu additions to diets fed pre- and post-calving to cows with liver Cu concentrations of about 50 ppm 60 days prior to calving.

Summary

A study replicated over two years involving 197 first-calf cows compared reproductive performance, growth and health of calves and concentration of Cu in liver, colostrum, and milk. Three treatments were evaluated: control (no Cu but Mo and Fe added to hay diet); 200 mg Cu from $CuSO_4$; and 100 mg Cu from AvailaCu® added daily. In 1998 a fourth treatment, 400 mg AvailaZn® was included with 100 mg AvailaCu®. Supplementation of Cu and/or Zn did not improve total pregnancy rate, or growth and health of calves. In 1998 cows fed only AvailaCu® conceived 10 days earlier compared to controls; however, in 1997 no differences in date of conception were found. Cu in colostrum and milk, and IgG levels in colostrum and calf serum were not improved by Cu supplementation.

Introduction

Research studies and practical observations have resulted in major differences in recommendations regarding Cu supplements in beef cow diets to improve reproductive performance and calf health. The objectives of this study were to determine if supplementation of Cu in the organic or inorganic form, fed to 2-year-old cows pre-and post-calving, alters reproduction rate, calf health and performance, incidence of calf scours, passive transfer of immunoglobulin or liver and serum Cu concentrations.

Procedure

The study was conducted at the West Central Research and Extension Center (WCREC), North Platte for a period of two years using a total of 197 first-calf cows. In 1997, 77 crossbred MARC II (1/4 Angus × 1/4 Hereford × 1/4 Simmental × 1/4 Gelbvieh) cows were used, and in 1998, 120 (51 MARC II, and 69 1/2 Red Angus × 1/4 Gelbvieh × 1/4 Hereford) cows were used. As bred heifers, cows grazed native range during summer and fall. In winter, grass hay (Table 1) was fed ad libitum plus salt and dicalcium phosphate free choice. In November, 1997, bred heifers grazed cornstalks for 30 days.

The following three treatments were studied each year: 1) Control (CON), 2) Inorganic, CUSO ($CuSO_4$), 3) Organic (ORG), AvailaCu® Zinpro Corp., Eden Prairie, MN. CUSO supplied 200 mg Cu while ORG supplied 100 mg Cu to investigate if less dietary Cu is needed with an organic source of Cu which is

Table 1. **Nutrient composition of grass hay by year (DM).**

Nutrient	1997[a]	1998[b]
Crude protein, %	10.6	8.9
TDN, %	52.2	48.8
Calcium, %	.52	.60
Phosphorus, %	.25	.23
Copper, ppm	4.8	4.0
Zinc, ppm	17.1	23.0
Iron, ppm	219.0	82.0
Molybdenum, ppm	3.5	1.1

[a]Brome grass hay was harvested from meadows near North Platte, NE.
[b]Mixed grass hay harvested from meadows near Paxton, NE

suggested to have higher bioavailability. A fourth treatment was added in 1998, 4) ORG + Zn, (AvailaCu, 100 mg, Cu, and AvailaZn, 400 mg, Zn). Supplements were fed individually to the cows for at least 45 days prior to calving and on the average 60 days after calving. The pre-calving CON supplement in 1997 consisted of limestone and rolled corn plus iron sulfate and sodium molybdate to provide 600 mg Fe and 5 mg Mo/day. In 1998, the supplement consisted of rolled corn and dehydrated alfalfa plus the additional Fe and Mo. The CUSO supplement consisted of the CON supplement plus copper sulfate. The ORG supplement consisted of the CON supplement plus the organic Cu source. Supplements were formulated to meet recommended requirements for all ingredients except the supplemental trace elements. Additional corn was fed to provide supplemental energy (NRC, 1996).

Liver biopsies were performed in both cows and calves to obtain samples used to determine their trace element status. In each year, liver biopsies were collected from 15 cows/treatment. Liver tissue was collected on the cows prior to the initiation of the individual feeding (approximately Jan. 1 each year) to estimate the herd mineral status. Samples were also collected from cows and calves 10 + 3 days and at 30 + 3 days post-calving. Animals were restrained in a squeeze chute and hair between the 10th and 13th ribs was clipped. Local anesthesia was given in the form of a 5 ml lidocaine injection between the 12th and 13th ribs. A scalpel was used to make a small incision at the same point, and biopsies were collected using a Tru-Cut® (Baxter Healthcare Corporation, Valencia, CA) biopsy needle (14 × 6"). About six successful biopsies were needed to obtain enough liver tissue for analysis. Biopsy samples were placed in plastic tubes and stored at -20° C until mineral analyses were conducted.

Blood samples were collected from cows and calves, via jugular veinapuncture, at the time of calving as well as in conjunction with the liver biopsies at 10 + 3 and 30 + 3 days after calving. A blood sample also was collected from the calves at 24 to 36 hours of age for determination of passive transfer of immunity. Cows were bled in early May and again 10 days later to determine cyclicity. Serum progesterone was analyzed using a validated radioimmunoassay. Cows having a concentration greater than 2 ng/ml in 1997 and 1.5 ng/ml in 1998 for one of the sampling dates were considered to be cycling. Estrual activity was verified by rectal palpation of the ovaries.

Colostrum was collected at the time of calving and analyzed for both trace mineral content and immunoglobulin G titer. Milk samples were collected from the cows in conjunction with the post-calving liver biopsies and stored at -20°C until mineral analysis. Analyses of trace mineral concentrations in liver biopsies, serum, colostrum and feeds were performed (after samples were ashed), using a sequential inductively coupled argon plasma atomic emission spectrophotometer (ICP-AES) interfaced with an ultrasonic nebulizer.

Milk production of the cows was determined using the weigh-suckle-weigh method when calves were 30 to 45 days of age. In mid May 1997, cows and calves were moved to the Gudmundsen Sandhills Laboratory (GSL) near Whitman for summer pasture and breeding. In 1998, cows and calves remained at the WCREC, North Platte.

Passive transfer of immunity was determined via single radial immunodiffusion (SRID; VMRD, Pullman, WA).

Results

Cu Status

The Cu concentrations in the liver at initiation of the project were not different between treatments (P > .10); however, a significant year effect (P < .05) was present. Liver Cu levels for 1998 were lower (58 ppm, 1997; 39 ppm, 1998).

By 30 days after calving, the Cu level for CON fell to about 14 ppm both years, a level considered deficient (Puls, 1994), while liver Cu concentrations for the supplemented treatments tended to increase throughout the trial (Figure 1). Cows fed ORG tended to increase at a slower rate compared to the cows fed CUSO. It should be noted that 100 mg Cu was fed for ORG and 200 mg Cu was fed for CUSO. Changes of liver Cu concentrations indicate the combination of low (4 ppm) Cu in hay plus the presence of Fe and Mo, considered to

(Continued on next page)

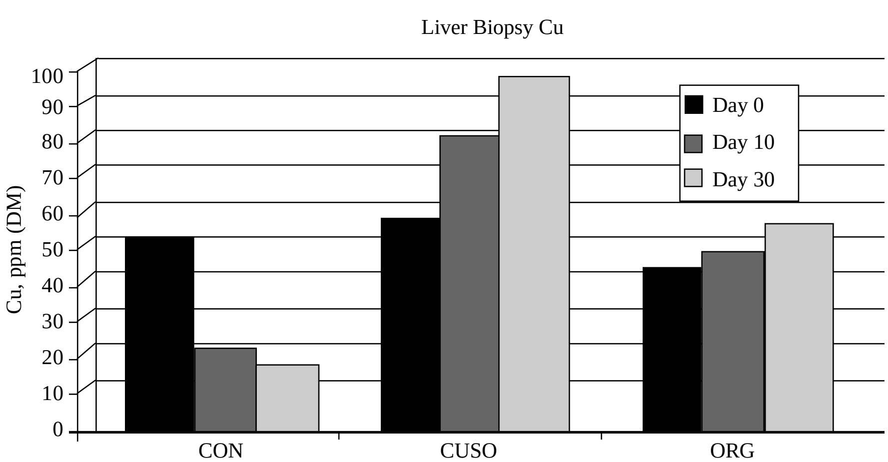

Figure 1. Liver Cu concentrations (dry matter basis) by day within treatments pooled over years [$CuSO_4$) = 200 mg Cu and ORG (AvailaCu) = 100 mg Cu]. Day 0=60 days before calving; Day 10 = 10 days post-calving and Day 30 = 30 days post-calving. All treatments are different at day 10 and 30 (P<.05).

Table 2. Liver Cu and Zn concentrations of calves pooled over years.

	10 days	SE	30 days	SE
CON				
No.	22		23	
Liver Cu, ppm (DM)	198	13.1	99[a]	9.3
Liver Zn, ppm (DM)	148	12.8	87[a]	6.8
CUSO				
No.	23		26	
Liver Cu, ppm (DM)	183	12.3	142[b]	15.9
Liver Zn, ppm (DM)	175	18.5	111[ab]	11.0
ORG				
No.	21		22	
Liver Cu, ppm (DM)	211	23.4	155[b]	13.4
Liver Zn, ppm (DM)	177	21.4	105[ab]	7.7
ORG + Zn				
No.	5		13	
Liver Cu, ppm (DM)	187	26.7	111[ab]	13.1
Liver Zn, ppm (DM)	146	24.2	128[b]	8.1

[a,b]Means with unlike superscripts within a column and mineral differ (P < .05).
CON = Control; CUSO = $CuSO_4$ providing 200 mg Cu; ORG = AvailaCu providing 100 mg Cu and ORG + Zn = AvailaCu providing 100 mg Cu and AvailaZn providing 400 mg Zn.

Table 3. Trace elements in colostrum and milk of cows in 1997[a].

	Colostrum[b]			Milk[c]		
Element/Treatment	No. of cows	Samples detected[d]	Mean + SE	No. of cows	Samples detected[d]	Mean + SE
Cu, ppm						
CON	25	15	.30 + .07	5	1	.12 + .12
CUSO	25	14	.30 + .06	8	1	.01 + .01
ORG	25	14	.22 + .06	8	3	.24 + .18
Zn, ppm						
CON	25	25	27.3 + 1.7	5	5	5.5 + .58
CUSO	25	25	29.8 + 1.5	8	8	4.8 + .53
ORG	25	25	32.0 + 1.8	8	8	4.6 + .19

[a]Only 1997 data reported as Cu levels in 1998 samples were below detectable level.
[b]Colostrum was sampled immediately after calving before calf nursed.
[c]Milk was sampled at 10 days + 3 after calving.
[d]Samples with detectable Cu levels of .12 ppm or higher. Many milk samples that had below detectable levels of Cu were recorded as zero and included in the means.
CON = Control; CUSO = $CuSO_4$ providing 200 mg Cu; ORG = AvailaCu providing 100 mg Cu.

be antagonistic to Cu absorption, resulted in depletion of Cu from the liver in late pregnancy. Results of supplementation on cow liver biopsy concentration (Figure 1) suggest storage of Cu in the liver, even in the presence of antagonists, is similar for $CuSO_4$ and organic Cu. The $CuSO_4$ was fed at twice the level of AvailaCu, and liver biopsy Cu concentrations were almost double for CuSO compared to organic Cu.

Calf liver Cu concentrations were similar 10 days after birth (Table 2). No supplemental mineral was provided to the calves, so milk and consumed forage accounted for their mineral source. All groups of calves showed a decrease (P < .10) in liver Cu concentration from day 10 to day 30 post-calving, but by day 30 post-calving, the liver Cu concentration for calves in CON had decreased to a level significantly lower (P < .05) than in other treatment groups.

Differences in liver Cu concentrations in calves at 30 days post-calving are difficult to explain when Cu concentrations in liver were not different 10 days post-calving. If 10-day values for calves in CON would have been lower, it would suggest transfer of Cu from the dam to the fetal calf was lower in the absence of supplemental Cu. Two possible explanations exist for the significant difference. First, the liver Cu status of CON occurred by chance or possibly the rate of depletion of Cu stores was greater for CON. Additional observations are necessary to determine an explanation.

Calf serum was collected at calving prior to the calf nursing. No differences (P > .10) were found between Cu treatments with all values near .30 ppm. These levels were sufficient to classify the Cu status of the neonatal calves as adequate (Puls, 1994). By 30 days after birth, the Cu levels of the calf serum had elevated (with no differences between treatments) to .69 ppm or higher, which is also considered adequate (Puls, 1994).

In 1998, Cu levels in the colostrum samples were all below the detection limit (.12 ppm). Data for 1997 colostrum and milk samples are presented (Table 3). Because no treatment differences were found, these data indicate that Cu supplementation to the cow before calving did not increase Cu levels in colostrum or early milk.

Passive Transfer of Immunity

A significant year effect (P < .05) was detected in the immunoglobulin G (IgG) response of the colostrum (Table 4). This was due to the evaluated levels of immunoglobulin detected in 1998 compared with 1997. A treatment difference (P < .05) was observed in the colostrum in 1997. Cows in the CON had lower IgG in the colostrum compared to CUSO. The IgG in the calf serum for that year was also lowest in the CON group. A year by treatment interaction (P < .05) was observed in the calf serum IgG response. This was due to the CON calf serum IgG titer for 1998 being significantly greater than that of ORG, but in 1997 the CON group was significantly lower than ORG. All levels of IgG in calf serum were in the range considered normal.

No significant differences were found (P > .10) between treatments in the incidence of sickness in calves. Sickness was defined as any time a calf was expelling loose, runny feces (scours), or appeared bloated. The greatest percentage (44%) of the calves treated for sickness was found in CON; however, this was not significantly greater than the percentage of calves treated in the other treatments (38%). Based on the year by treatment interactions and the lack of significant differences in calf health, it is difficult to conclude that supplementation of Cu to the dam will reduce the incidence of sickness in calves.

Animal Performance

No differences (P > .10) were found between treatments in cow weights at various times throughout the entire study.

Table 4. Passive transfer of immunoglobulin G (IgG) in colostrum and calf serum by year.[a]

	Year			
	1997		1998	
Item/Treatment	n	Mean + SE	n	Mean + SE
	(mg/dL)			
Colostrum				
CON	25	$6118 + 354^{b}$	15	7487 + 239
CUSO	25	$6914 + 334^{c}$	17	7611 + 189
ORG	25	$6696 + 234^{bc}$	19	7236 + 305
Calf serum				
CON	25	$2073 + 232^{b}$	16	$3011 + 272^{b}$
CUSO	23	$2433 + 149^{bc}$	17	$2448 + 230^{bc}$
ORG	24	$2924 + 260^{c}$	19	$2395 + 150^{c}$

[a]Colostrum was sampled immediately after calving before calf nursed. Calf serum samples were collected between 24 and 36 h after birth. A year × treatment interaction was found (P<.05) in calf serum data.
[b,c]Means with different superscripts within column and category differ (P<.05).
CON = Control; CUSO = $CuSO_4$ providing 200 mg Cu; ORG = AvailaCu providing 100 mg Cu.

Table 5. Reproductive performance of 2-year-old cows supplemented with organic or inorganic Cu.

	Treatment			
Trait	CON	CUSO	ORG	ORG + Zn
1997				
No. cows exposed	22	23	24	NA
Estrus prior to May 15[a], %	5	9	13	NA
Pregnant first 30 days breeding[bd], %	86^{e}	57^{f}	75^{ef}	NA
Pregnant in 60 days, %	100	91	88	NA
No. nonpregnant cows	0	2	3	NA
Day of conception[cd]	170	178	174	NA
Second calving date[d]	3/31	4/7	4/2	NA
1998				
No. cows exposed	23	30	27	26
Estrus prior to May 15[a], %	9	23	30	19
Pregnant first 30 days breeding[bd], %	61^{e}	80^{ef}	85^{f}	77^{ef}
Pregnant in 60 days breeding, %	87	87	93	89
No. nonpregnant cows	3	4	2	3
Day of conception[cd]	178^{e}	170^{ef}	168^{f}	173^{ef}
Second calving date[d]	$4/2^{e}$	$3/26^{ef}$	$3/22^{f}$	$3/28^{ef}$
Two-year-data				
No. of cows	45	53	51	—
Estrus prior to May 15[a], %	7^{e}	17^{ef}	22^{f}	—
Pregnant in 60 days breeding, %	93	89	90	—

[a]Estrus based on serum progesterone values.
[b]Determined by day of conception.
[c]Determined by breeding date, ultrasound, palpations and confirmed by calving date.
[d]Treatment × year interaction (P<.05).
[ef]Means with different superscripts within a row differ (P<.05).
CON = Control; CUSO = $CuSO_4$ providing 200 mg Cu; ORG = AvailaCu providing 100 mg Cu and ORG + Zn = AvailaCu providing 100 mg Cu and AvailaZn providing 400 mg Zn.

The same also was true for condition scores (P > .10). Cow weight changes during the mineral feeding period were also not different. Calf birth weights and May 12 weights (after supplementation period) were not different (P > .10) between treatments. Milk-production estimates of cows were not different between treatment groups. At weaning, a treatment by year interaction was detected (P < .05) for calf weights. The CON calves in 1997 were lighter (388 lb vs 416 lb) than CUSO calves, but in 1998, the reverse occurred with the CON calves being heavier than CUSO calves (393 lb vs 370 lb). The ORG calves were intermediate in weight each year.

Reproductive performance of the cows in the study is shown by year in Table 5. No significant treatment differences were observed within year for estrus cycling before the breeding season or cows pregnant in 60 days. However, when data were pooled over years, a higher percentage (P<.05) of cows in ORG cycled prior to the breeding season compared to CON cows. No differences were found (P>.1[redacted]) in cows pregnant in 60 days when p[redacted]led over both years.

Year by treatment interactions existed (P<.05) for cows pregnant in first 30 days of breeding, day of conception and consequently, second calving date. In 1997 no significant differences occurred in day of conception. However, in 1998 cows in the group supplemented with AvailaCu® conceived earlier (10 days) than cows in the control group.

The year by treatment interactions may be due to differences in the Cu status of the herd at the initiation of the treatment period. In 1998 liver Cu concentrations were lower (39 ppm) than in 1997 (58 ppm). Therefore, in 1998 Cu status of the cows may have reached a point where additional Cu was beneficial relative to early conception. Also, cows in 1997 were taken to GSL for summer pasture and breeding, while in 1998 cows were left at North Platte. Therefore, another explanation for the interaction may be related to mineral content of forage consumed at different locations during the breeding season. Cu content of the grazed forage was not measured.

Results of the ORG + Zn treatment in 1998 did not differ from the other treatments for cow reproduction or calf health and growth. In general, results were similar to the CUSO treatment.

In conclusion, responses in calf performance and cow reproductive performance to additional Cu depend on Cu status of the cows. A hay-based diet containing 4 to 5 ppm Cu and Cu antagonists will cause liver Cu stores to deplete. If liver Cu is about 50 ppm 60 days prior to calving, cows in average body condition provided recommended protein and energy nutrition will not respond with improved calf health or number pregnant in 60-day breeding season when provided additional Cu, regardless of source (inorganic or organic). Further studies are needed to clarify relationships of Cu status, Cu source and Cu content of forage in breeding pastures on day of conception.

---

[1]Dennis Brink, professor, Animal Science, Lincoln; Gene Deutscher, professor, and Erick Muehlenbein, graduate student; West Central Research and Extension Center, North Platte.

[2]Appreciation is expressed to Zinpro Corp., Eden Prairie, MN (A. B. Johnson) for products used and partial funding of research.