Zinpro Performance Minerals® Copper Beneficial Part of Dairy Cow Diets

Key Findings

- A field survey indicates that the average Minnesota dairy herd averages 495 parts per million (ppm) copper, dry matter (DM) basis of liver. Normal copper levels are 75 to 400 ppm.

- Zinpro Corporation recommends 10 to 15 ppm (supplemental) copper for dry and early lactation dairy cow diets, with 125 mg of the copper supplied by a Zinpro Performance Minerals® copper source.

Introduction

Dairy nutritionists have been increasing the level of copper supplemented to dairy cattle. It is quite common to find dairy rations containing greater than 20 ppm of supplemental copper and even some rations with greater than 30 ppm of supplemental copper. Coinciding with this increased level of copper supplementation is an increase in incidence of feed suppliers settling claims with dairy producers for copper toxicity.

Survey on Liver Copper Concentrations

At the 1999 American Dairy Science Assn. meetings in Memphis, TN, several papers were presented summarizing a study which surveyed concentrations of trace minerals in the livers of lactating dairy cows in Minnesota. Zinpro Corporation funded the research in conjunction with two major midwestern feed manufacturers.

The average concentration of copper in the liver of lactating cows in this Minnesota survey was 495 ppm, DM basis. A liver copper concentration of 75 to 400 ppm, DM basis, is considered normal. In four of the 30 herds surveyed, more than 25% of the cows had liver copper concentrations above 750 ppm, DM basis, a level considered high.

During the survey, a non-survey herd in Minnesota experienced a copper toxicity. This was a Jersey herd fed 37 ppm of copper for five years. Diagnosis confirmed that two cows died due to a copper toxicity.

Many of the surveyed herds were fed diets containing in excess of 20 ppm of copper. Several reasons why nutritionists are feeding elevated levels of copper include: recommendations from university and industry personnel; attempting to meet the copper requirements when cattle are consuming high levels of antagonists; and feeding high levels of copper as an insurance measure.

Strategies for Minimizing the Risk of Copper Toxicity

Two approaches can be taken to help minimize risk for copper toxicity:

- Remove all highly available sources of copper from the diet, including all organic sources of copper. End result: copper available to the animal is decreased.

- Formulate diets to contain a lower level of copper, but with a portion of the copper being supplied by a Zinpro Performance Minerals source of copper that minimize interaction with antagonists such as sulfur, molybdenum and iron.

Figure 1. Influence of copper source on copper metabolism in calves

- Collections for mineral balance and apparent absorption were made and calves (368 lb) bled on day 5 of period
- Prior to repletion, calves (368 lb) fed no mineral supplement for 3 days, followed by induced stress (feed restriction) for 3 days, followed by return to full feed for 3 days without mineral supplementation; Repletion phase was 4 days in length with samples being collected at the end of the period
- Treatment means differ (P < 0.05)
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The second approach is preferred for several reasons. Feedstuffs vary in levels of trace minerals and antagonists. This is especially true when forages and commodities are acquired from several sources. In a summary of more than 4,000 corn silage samples, zinc content ranged from 13 to 43 ppm, copper from 2 to 12 ppm and manganese from 14 to 57 ppm (Hinders, 1999). Similar variations in concentrations of zinc, copper and manganese were found in other forages (Hinders, 1999). Molybdenum, sulfur and iron content of feedstuffs and forages also can vary substantially from source to source. For instance, molybdenum content of forages varies significantly depending upon the agronomic practices of the grower.

Therefore, removing Zinpro Performance Minerals sources of copper that minimize interaction with antagonists to decrease the risk of copper toxicity can result in a copper deficiency in dietary situations where cows are consuming high levels of antagonists. Conversely, formulating diets to contain a lower level of copper, with a portion of the copper supplied by Zinpro Performance Minerals copper sources, helps increase the probability that the copper needs of the cow are met when consuming diets high in antagonists. This supplementation strategy also helps to minimize the risk of copper toxicity when cows are consuming diets low in antagonists.

**Bioavailability Versus Antagonists**

The difference in absorption of standard inorganic sources of trace minerals such as copper sulfate and a bioavailable Zinpro Performance Minerals source such as CuPLEX® copper lysine are minimal when the level of antagonists are low, but increase when the level of antagonists are high. This concept is illustrated in the study conducted by Wedekind et al. (1992). When chicks were fed diets formulated to contain only crystalline amino acids to minimize

<table>
<thead>
<tr>
<th>Item</th>
<th>Copper Sulfate</th>
<th>Copper Lysineb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake, mg/d</td>
<td>44.2</td>
<td>45.7</td>
</tr>
<tr>
<td>Fecal excretion, mg/d</td>
<td>36.9</td>
<td>37.0</td>
</tr>
<tr>
<td>Urinary excretion, mg/d</td>
<td>3.7c</td>
<td>2.2c</td>
</tr>
<tr>
<td>Apparent absorption, %</td>
<td>16.6</td>
<td>19.1</td>
</tr>
<tr>
<td>Retained, %</td>
<td>8.1</td>
<td>14.3</td>
</tr>
</tbody>
</table>

- a Collections for mineral balance and apparent absorption were made and calves (368 lb) bled on Day 5 of period
- b CuPLEX® copper lysine
- yz Treatment means differ (P < 0.05)

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<tr>
<th>Item</th>
<th>Copper Sulfate</th>
<th>Copper Lysineb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake, mg/d</td>
<td>44.1</td>
<td>45.8</td>
</tr>
<tr>
<td>Fecal excretion, mg/d</td>
<td>38.4</td>
<td>36.6</td>
</tr>
<tr>
<td>Urinary excretion, mg/d</td>
<td>4.2c</td>
<td>2.3c</td>
</tr>
<tr>
<td>Apparent absorption, %</td>
<td>13.1c</td>
<td>20.1c</td>
</tr>
<tr>
<td>Retained, %</td>
<td>3.3c</td>
<td>15.0c</td>
</tr>
</tbody>
</table>

- a Prior to repletion, calves (368 lb) fed no mineral supplement for 3 days, followed by induced stress (feed restriction) for 3 days, followed by return to full feed for 3 days without mineral supplementation; repletion phase was 4 days in length with samples being collected at the end of the period
- b CuPLEX copper lysine
- wx Within a row, means lacking a common superscript letter differ (P < 0.10)
- yz Means lacking a common superscript letter differ (P < 0.05)

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**Figure 1. Bioavailability of ZINPRO® zinc methionine relative to zinc sulfate within dieta**

- a Bioavailability estimated using multiple regression analyses of total tibia Zn in chicks; ZnSO₄ set to 100
- b ZINPRO zinc methionine
- wx Means lacking a common superscript letter differ (P < 0.05)
- yz Within diet type, means lacking a common superscript letter differ (P < 0.01)

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dietary fiber and phytate levels, the difference in availability of zinc from zinc sulfate and zinc from ZINPRO® zinc methionine was minimal (Figure 2, page 2). However, when chicks were fed diets formulated with soybean meal as the source of amino acids, and hence contained higher dietary levels of antagonists such as fiber and phytate, the difference in availability of zinc from zinc sulfate and ZINPRO increased (Figure 2). Therefore, formulating diets containing lower levels of trace minerals with a portion of the trace minerals supplied by a Zinpro Performance Minerals source increases the probability that trace mineral requirements of the animal will be met when dietary levels of antagonists are high, but minimizes the risk of toxicity when dietary levels of antagonists are low.

Not only do antagonists affect the ability of the animal to absorb copper, but stress affects this ability as well. In a study conducted at Colorado State University (Nockels et al., 1993), copper balance was examined prior to subjecting calves to copper restricted diets and induced stress. Calves then received a copper restricted diet for nine days with stress being induced by feed and water restriction for three of the nine days. Following the period of copper restriction and induced stress, copper balance was measured with calves receiving copper supplied by either copper sulfate or CuPLEX. Results of the study showed that prior to the period of copper restriction and induced stress, calves retained 8.1% of ingested copper from copper sulfate and 14.3% of ingested copper from CuPLEX (Table 1, page 2; Figure 1, page 1). Following the period of copper restriction and stress, calves retained 3.3% of copper from copper sulfate and 15.0% of copper from CuPLEX (Table 2, page 2). Hence, formulating diets to contain lower levels of trace minerals with a portion of the trace minerals being supplied by a Zinpro Performance Minerals source increases the probability that trace mineral requirements of the animal will be met when the animal is stressed.

The third advantage of formulating diets of lactating dairy cows to contain a lower level of copper with a portion of the copper being supplied by a Zinpro Performance Minerals source is a possible decrease in copper excretion. There is a growing concern over trace mineral content of animal waste. Research recently completed at Texas Tech University (Richardson and Bowen, 1999) indicates that inclusion of Availa®Cu in steer diets improved dietary copper utilization and decreased copper excretion (Table 3). In the study, replacing 50% or all of the copper sulfate with Availa-Cu resulted in decreased fecal copper excretion as a percent of intake and increased copper retention and absorption (Table 3). Results of this trial indicate copper content of animal waste can be decreased when copper from Availa-Cu is included in the diet. Furthermore, it indicates that diets of lactating dairy cows can be formulated to contain a lower level of copper when the Availa-Cu copper source supplies at least 50% of the supplemental copper and still meet the copper requirements of the animal.

### Summary of Copper Supplementation Strategies

Diets of high producing dairy cattle can be formulated to contain lower levels of copper. By supplying a portion of the copper from a Zinpro Performance Minerals source such as CuPLEX or 4-Plex® in a diet containing lower copper levels there is:

1. Increased probability of meeting the copper requirements of the cow when dietary levels of antagonists are high.
2. Increased probability of meeting the copper requirements of the cow when the animal is stressed.
3. Decreased copper levels in animal waste.
4. Decreased risk of copper toxicity.

### Table 3. Effect of copper source and level on copper balance

<table>
<thead>
<tr>
<th>Item</th>
<th>Sulfate</th>
<th>Availa-Cu High</th>
<th>Availa-Cu Low</th>
<th>Availa-Cu: Sulfate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper intake, mg/d</td>
<td>92.5</td>
<td>125.5</td>
<td>98.5</td>
<td>122.7</td>
</tr>
<tr>
<td>Fecal Cu excretion, mg/d</td>
<td>83.8&lt;sup&gt;y&lt;/sup&gt;</td>
<td>81.3&lt;sup&gt;y&lt;/sup&gt;</td>
<td>69.6&lt;sup&gt;y&lt;/sup&gt;</td>
<td>80.0&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fecal Cu excretion, % of intake</td>
<td>90.3&lt;sup&gt;y&lt;/sup&gt;</td>
<td>65.8&lt;sup&gt;y&lt;/sup&gt;</td>
<td>70.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>65.2&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cu retention, mg/d</td>
<td>6.9&lt;sup&gt;x&lt;/sup&gt;</td>
<td>40.4&lt;sup&gt;y&lt;/sup&gt;</td>
<td>27.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>42.2&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cu retention, % of intake</td>
<td>7.8&lt;sup&gt;y&lt;/sup&gt;</td>
<td>32.7&lt;sup&gt;c&lt;/sup&gt;</td>
<td>28.0&lt;sup&gt;c&lt;/sup&gt;</td>
<td>34.6&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cu absorption, %</td>
<td>9.8&lt;sup&gt;y&lt;/sup&gt;</td>
<td>34.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>29.3&lt;sup&gt;c&lt;/sup&gt;</td>
<td>34.8&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Sulfate: 125 mg Cu/day from copper sulfate
AAH: 125 mg Cu/day from Availa®Cu copper amino acid complex
AAL: 93.75 mg Cu/day from Availa-Cu copper amino acid complex
AA:S: 125 mg Cu/day, 50% from Availa-Cu copper amino acid complex and 50% from copper sulfate

XYZ Within a row, means lacking a common superscript letter differ (P < 0.05)

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**Zinpro Corporation**  
**Copper Recommendations**

To help ensure that the copper requirements of cows are met while minimizing the risk for copper toxicity, Zinpro Corporation recommends:

- 125 mg of supplemental copper from Zinpro Minerals;
- Dry and early lactation cows, 10 to 15 ppm supplemental copper;
- Mid to late lactation cows, 8 to 12 ppm supplemental copper;
- Supplementation levels for Jerseys should be lower than supplemental levels for Holsteins;
- Do not exceed these supplemental levels unless strongly suspect of a copper deficiency [faded hair coats, high levels of antagonists (ie. Cu:Mo < 5.1, etc.)], if feasible confirm with liver biopsy.

**Note:**

4-Plex fed at the recommended level of ½ ounce (14 grams)/head/day provides approximately 5 to 6 ppm of supplemental copper for diets typically fed to lactating dairy cows.