Effect of tribasic copper chloride on performance of animals facing health challenges

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Introduction
Monogastric animals, including pigs and chickens, often come closer to achieving optimal health and growth with contributions from minerals. The three research trials reviewed here shed light on the performance improvements achieved in pigs and chickens through the use of tribasic copper chloride. Research studies in chickens and pigs are particularly illuminating because of their ability to measure responses in thousands of animals in essentially identical conditions fed diets differing in a single nutrient.

Trial 1 - materials and methods
This swine trial compared the effectiveness of 150 ppm Cu from Micronutrients TBCC® (TBCC), 1,000 and 1,500 ppm Zn from Tetrabasic Zinc Chloride (TBZC), and combinations of both metals for improving growth and preventing scours in weanling piglets. The 21 day trial used PIC 337 × C22 pigs with an average initial weight of 6.8 kg each, divided into 6 treatments, with 5 reps each using 5 pigs per pen. Measurements tracked were average daily gain and scours, scored as + or – for each pen, scour score representing the number of days that scours were observed in a given pen. Dietary treatments consisted of 0, 1000 or 1500 ppm zinc using TBZC, with or without 150 ppm copper using TBCC.

Results
Compared to either the basal or zinc-supplemented diets, the addition of 150 pm copper in the form of TBCC significantly reduced the incidence of scours (Figure 1) and increased average daily gain (Figure 2) during the 21 day period post-weaning.

Trial 2 - materials and methods
This 21-day floor pen study conducted with 300 Cobb chicks divided into five groups (five replicates each of 10 chicks) inoculated with *Candida albicans* and Coccidia to induce crop mycosis at 3 days of age. Chicks were fed a commercial-type, corn-soybean meal crumbled feed (starter feed after pelleting) supplemented with 0, 125 or 250 ppm Cu from either feed-grade copper sulfate or tribasic copper chloride (Micronutrients TBCC®). Chicks were not replaced during the course of the trial. The birds were observed daily for signs of unusual growth patterns or health problems. Body weight, food consumption and mortality were evaluated over the 21 days, as well as disease scores and intestinal lesions.

Results
As measured by disease scores for spread of infection in crop membranes and for number of observed intestinal lesions, both copper sources at both treatment levels gave a significant improvement over untreated, infected birds, with 250 ppm Cu being statistically better than 125 ppm. Only TBCC at 250 ppm gave crop mycosis scores equal to the negative control (Table 1). Body weight gain and feed conversion were significantly improved versus the positive control at both 125 and 250 ppm added Cu, regardless of source. A linear regression of the data showed TBCC to be 112% as bioavailable as copper sulfate.

Trial 3 - Materials and methods
Ninety-six 1-day-old *Ross* broiler chicks of both sexes were individually weighed and divided at random into four groups, each of 24 chicks. There were three replicates of 8 broiler chicks for each of four dietary treatment groups. The chicks were housed in electrically heated batteries under fluorescent lighting and fed a starter diet from 1 to 21 day of age, followed by commercial grower diet for the period of 22 to 42 days. Aflatoxins were produced by fermentation in converted rice under constant stirring and controlled temperature. The NRLL 2999 strain of *Aspergillus parasiticus* (USDA, Agricultural Research Service, Peoria, Illinois, USA) was used for production of the AFs according to the method described by Shotwell et al. (1966) and improved by West et al. (1973). After autoclaving, the rice was dried with hot air and ground in a coffee grinder. The total concentration of AFs in rice powder was analyzed by fluorescence spectrophotometry and measured using thin-layer chromatography (TLC)-densitometry.
**Figure 1:** 21-Day scours

![Figure 1: 21-Day scours](chart1.png)

**Figure 2:** 21-Day growth

![Figure 2: 21-Day growth](chart2.png)
American Association of Swine Veterinarians

Table 1: Lesion scores

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Lesion score</th>
</tr>
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<tbody>
<tr>
<td>- Control</td>
<td>0.084a</td>
</tr>
<tr>
<td>+ Control</td>
<td>1.182d</td>
</tr>
<tr>
<td>TBCC 125 ppm</td>
<td>0.796a</td>
</tr>
<tr>
<td>TBCC 250 ppm</td>
<td>0.309ab</td>
</tr>
<tr>
<td>CuSO4 125 ppm</td>
<td>0.976cd</td>
</tr>
<tr>
<td>CuSO4 250 ppm</td>
<td>0.507b</td>
</tr>
</tbody>
</table>

Table 2: Broiler performance data at 42 days

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Weight gain (grams)</th>
<th>Feed/gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>2201ac</td>
<td>1.74a</td>
</tr>
<tr>
<td>TBCC</td>
<td>2281c</td>
<td>1.69a</td>
</tr>
<tr>
<td>Aflatoxin</td>
<td>2003b</td>
<td>1.9b</td>
</tr>
<tr>
<td>Aflatoxin + TBCC</td>
<td>2128ab</td>
<td>1.78a</td>
</tr>
</tbody>
</table>

Results
The Aflatoxin-induced changes in the levels of albumin, total protein and total cholesterol, and in the activities of serum ALT, LDH and ALP were detrimentally altered by Aflatoxin, and significantly improved by adding TBCC to the Aflatoxin-containing diet. While supplementation of TBCC to the Aflatoxin containing diet did not improve the BWG, adverse effects of AFs on FCR were reversed by TBCC supplementation. The 200 mg added copper/kg of diet from tribasic copper chloride restored 125 of 197 g body weight loss and 15 points of 19 points worse feed conversion ratio due to 1 mg aflatoxin/kg of diet at 42 days of age (Table 2).

Discussion
Copper is the third most abundant essential trace mineral in the body, after iron and zinc. It has been recognized as an essential nutrient since the 1920’s. In the past eighty years, much has been learned about the important biological roles of copper and the copper-dependent enzymes. Unbound, free copper is not found in large quantities in the body. Instead, almost all copper is bound to transport proteins (ceruloplasmin and copper-albumin), storage proteins (metallothionein), and copper containing enzymes. A substantial number of copper metalloenzymes have been studied. Copper is essential for the proper functioning of these copper-dependent enzymes, including cytochrome C oxidase (energy production), superoxide dismutase (antioxidant protection), tyrosinase (pigmentation), dopamine hydroxylase (catecholamine production), lysyl oxidase (collagen and elastin formation), clotting factor V (blood clotting), and ceruloplasmin (antioxidant protection, iron metabolism, and copper transport).

The responses to health challenges in animals are characterized by a dual system of immune response, the innate and acquired immune systems. The innate response, or first line of defense, consists of an animal’s recognition of danger and the resultant activation of inflammatory cell activity. This includes mobilization of cytokines such as interleukin-1 (IL-1), tumor necrosis factor α (TNFα) and interleukin-6 (IL-6), and performance parameters were statistically analyzed by one-way analysis of variance (ANOVA) followed by Duncan’s multiple range test (SPSS 9.05 for Windows). Numerical results are given as mean ± standard errors of means (SEM). For performance, n = 3, for biochemical analysis, n = 12 (3 replicates of 4 broiler chicks each). All statements of significance are based on the 0.05 level of probability.
which have among other effects decreased food intake, increased synthesis of fatty acids and acute phase proteins, increased energy expenditure and alteration of the distribution of iron, zinc and copper. The acquired immune system consists of lymphocytes, dendritic cells and macrophages, which are responsible for antibodies, anti-viral responses and the animal’s memory of previous exposures. The innate immune response is an inflammatory response and simply stated, results in activities that reduce the energy available to the animal for performance, or growth. In the extreme, amino acids are used for hepatic protein synthesis instead of growth and can result in skeletal muscle catabolism as the animal finds alternative ways to acquire amino acids for normal body functions.

Preventing exposure to pathogens is the most obvious way to avoid the costly expenditure of energy on immune response but in a practical sense is impossible to accomplish consistently in animal production systems. However, it has been learned over time that nutrition’s effects on the immune response can be manipulated to allow for the best response to a challenge while minimizing the negative impact on growth performance. All three of the research trials reviewed demonstrate the role of copper in ameliorating the negative impact of disease challenges. What is not clear is the mechanism by which this occurs. The two most common theories are that copper either directly interacts with gut micro flora to prevent any bacteria from proliferating and causing an upset or that copper acts on lymphocytes or their associated cytokines to down-regulate the response of the innate immune system.

References