

MINTREX™ Zn and MINTREX™ Cu organic trace minerals improve intestinal strength and immune response to coccidiosis infection and/or vaccination in broilers.

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Abstract

Cobb 500 broilers were fed diets that were zinc deficient (35ppm), supplemented with 70ppm zinc sulfate, or 70ppm zinc sulfate + 35ppm organic zinc (MINTREX™ Zn or zinc-methionine). Half the birds were given a coccidiosis vaccine (ADVENT® coccidiosis control) at day of age, and challenged with all three species on day 24. MINTREX Zn and zinc-methionine both significantly increased intestinal breaking strength (IBS) in vaccinated + challenged birds. Only MINTREX Zn increased IBS in unvaccinated + unchallenged birds. Only birds fed MINTREX Zn exhibited significantly improved post-vaccination antibody responses. In another experiment, broilers were fed a low copper (9ppm) diet, or a diet supplemented with 25ppm copper from copper sulfate, a copper proteinate, copper lysine, or MINTREX Cu. All birds were vaccinated and challenged. Birds fed MINTREX Cu exhibited significantly greater IBS than all other treatments. Only MINTREX Cu gave a significant improvement in anti-coccidial (MIC2 antigen) antibody response.

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Introduction

Zinc and copper are both essential micronutrients, and are required for a variety of biochemical and cellular processes in all animals. Zinc is the most common metal constituent of cellular enzymes, and as such plays an essential role in cell proliferation and death, immune development and response, reproduction, gene regulation, and defense against oxidative stress and damage (Shankar and Prasad, 1998; Underwood and Suttle, 1999; Blanchard, et al., 2001; Ho, et al., 2003). Therefore, zinc deficiency can negatively impact these functions. Furthermore, zinc-deficiency results in the aberrant expression of a wide variety of genes, which in turn can lead to a number of health and performance problems (Underwood and Suttle, 1999; Blanchard, et al., 2001). For example, genes encoding uroguanylin and inducible nitric oxide synthase can both be upregulated during zinc-deficiency, which can lead to diarrhea and intestinal inflammation (Cui, et al., 2003). In contrast, collagen synthesis rates are decreased during zinc-deficiency, indicating a role for zinc in the synthesis of this protein (Starcher, et al., 1980). Furthermore, collagen turnover rates are also decreased, presumably because the collagenases are zinc-dependent enzymes (Starcher, et al., 1980; Pardo and Selman, 2005). Collagen is a major component of the extracellular matrix and connective tissues, and serves to provide tissue and bone strength. Thus, a zinc deficiency may negatively impact tissue and bone strength. Zinc is also required for the synthesis of keratin, which is a structural protein of feathers, skin, beaks and claws (Underwood and Suttle, 1999). Finally, zinc is required for the proper functioning of the immune system (Underwood and Suttle, 1999).

Like zinc, copper is essential for a wide variety of health and performance-related functions in poultry. For example, hens on a severely deficient diet display defective shell formation and reduced egg production and hatchability (Savage, 1968; Baumgartner, et al., 1978). Copper often works as a constituent of metalloenzymes, and often is required for proper enzymatic structure or function. Copper and zinc are both required constituents of the copper and zinc-dependent form of superoxide dismutase (Underwood and Suttle, 1999). Furthermore, the enzyme that crosslinks collagen and elastin, lysyl oxidase, is copper-dependent (Rucker, et al.,

1998). In copper-deficient animals, therefore, the elastin and collagen may be unable to withstand the mechanical stresses typical of the cardiovascular or skeletal systems, respectively. Because of its role in collagen crosslinking, copper also promotes strong skin, bone and intestinal strength (Underwood and Suttle, 1999). Finally, like zinc, copper-deficiency can negatively impact immune development and function (Underwood and Suttle, 1999).

In this paper, we have tested the ability of a variety of different inorganic and organic zinc and copper sources to improve intestinal breaking strength and the immune response to coccidiosis.

Materials and Methods

For the zinc experiment, Cobb 500 broilers were assigned to 4 dietary treatments, with six replicates of 10 birds per treatment. Treatment 1 was fed a zinc-deficient basal (milo-soy) diet analyzed to be 35ppm zinc. Treatments 2-4 were supplemented with zinc, as follows: treatment 2 contained 70ppm zinc from zinc sulfate; treatment 3 received 70ppm from zinc sulfate and 35ppm zinc from zinc methionine; and treatment 4 received 70ppm from zinc sulfate and 35ppm zinc from MINTREX™ Zn. Half of the birds were vaccinated with a 3 species (*Eimeria tenella*, *maxima*, and *acervulina*) coccidiosis vaccine (ADVENT® coccidiosis control) on day 0, and challenged with all 3 species (300,000 viable sporulated oocysts (VSO) *acervulina* per bird, 60,000 VSO *maxima*/bird, 20,000 VSO *tenella*/bird) on day 24. Antibody responses to the vaccination were measured by ELISA on day 20, assaying for antibodies against two *E. tenella* antigens (microneme protein MIC2, and sporozoite surface antigen). IBS was measured on day 28 (jejunum) and 29 (duodenum). Briefly, a 2.5 inch section of intestine was removed, and subjected to tensile strength analysis using an Imada MV-110 digital force tester. For the copper experiment, birds were fed a copper-deficient basal (corn-soy) diet, or the basal diet supplemented with 25ppm copper from either copper sulfate, a copper proteinate, copper lysine, or MINTREX Cu. All birds were vaccinated with ADVENT, and challenged with all 3 species as above. Anti-MIC2 antibody testing and IBS testing (in the ileum) were performed as above.

Results and Discussion

In the first experiment, broilers were fed diets that were zinc-deficient, or supplemented with zinc sulfate, zinc sulfate plus zinc methionine, or zinc sulfate plus MINTREX Zn. Naïve birds (unvaccinated and unchallenged with coccidiosis) were tested for IBS in duodenum and jejunum. The zinc sulfate and zinc methionine treatments numerically increased IBS in both tissues, but only the birds fed MINTREX Zn exhibited a significant increase in IBS in both duodenum and jejunum. IBS was also tested in the jejunum of birds that had been vaccinated with ADVENT and challenged with coccidiosis. The zinc sulfate birds did not exhibit a significant increase in IBS over the control. Both the birds fed zinc methionine and MINTREX Zn exhibited a significant increase in IBS, but the IBS in the birds supplemented with MINTREX Zn were numerically the highest. One likely explanation to understand these results is that the rates of collagen synthesis and turnover in the control birds may have been low due to the zinc deficiency. Addition of zinc, especially zinc from MINTREX Zn, may have improved these rates of synthesis and turnover, leading to greater epithelial strength. Because zinc is crucial for the immune response, we also tested the antibody response of all treatments to the coccidiosis vaccination. We measured antibodies against two *E. tenella* antigens—the microneme protein MIC2 and the sporozoite surface antigen. Only birds supplemented with MINTREX Zn exhibited a significantly improved antibody response to these antigens.

In the second experiment, broilers were fed a basal diet (9ppm copper), or a diet supplemented with 25ppm copper from copper sulfate, a copper proteinate, copper lysine, or MINTREX Cu. All birds were vaccinated with ADVENT, and challenged with all three species of coccidiosis. IBS was measured in the ileum. All forms of copper supplementation significantly increased IBS vs. the basal treatment. However, the birds supplemented with MINTREX Cu had IBS scores significantly higher than all other treatments. As with the results from MINTREX Zn, the increased IBS with MINTREX Cu may reflect a collagen benefit. Finally, we tested the antibody response to vaccination by measuring anti-coccidial MIC2 antibodies. Only the birds fed MINTREX Cu exhibited a significant improvement in antibody response to the vaccination.

These results demonstrate that MINTREX Zn and MINTREX Cu provide significant immune and intestinal health benefits to broilers.

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