Organic Trace Minerals for Broilers and Breeders

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Organic Trace Minerals

The term “organic mineral” refers to a variety of compounds including metal-amino acid complexes, metal amino chelates, metal proteinates, metal-polysaccharide complexes, metal-yeast complexes, and metal-organic acid complexes. (Patton, 1990)

An organic mineral is simply a combination of a metal ion with an organic ligand such as amino acids, proteins, polysaccharides, yeast, or organic acids. Specifically, the metal ion is bound to the organic ligand through multiple attachments (either ionic or covalent) with the metal ion occupying a central position in the structure (Kincaid, 1989, Nelson, 1988). During organic mineral formation, the metal ion and organic ligand act as mutual electron donors (ligand) and electron acceptors (metal cations) forming a heterocyclic ring structure (Nelson, 1988). Generally, the metal ion is attached to electronegative areas (two or more) on a ligand.

Organic minerals can be classified into two categories: natural and synthetic. Natural mineral complexes are formed during normal digestion, absorption, and metabolism in a living system. Synthetic mineral complexes (usually by dietary supplementation) conversely, are used to enhance mineral utilization efficiency. During digestion, a variety of natural mineral complexes are formed which either enhance or diminish the usefulness of the ingested minerals.

Herrick (1993) categorized natural organic minerals into three types based on their function in biological systems. These include complexes which: (1) transport and store metal ions, (2) are essential to physiological activity, and (3) interfere with metal ion utilization. Amino acids, EDTA, and other synthetic ligands are important as metal binding and transporting agents in the
gastrointestinal tract, which enhance uptake of metal ions from the intestinal lumen into the mucosal cells. For instance, transferrin is essential for gut absorption, transport, and storage of iron. Additionally, metal complexes may form in biological systems to allow physiological activity of certain compounds. Hemoglobin contains iron and vitamin B$_{12}$ contains a central cobalt atom.

Synthetic organic minerals are produced in an attempt to increase the utilization of dietary minerals. By complexing metal ions with a variety of organic ligands, an effort is made to enhance mineral absorption across the intestinal mucosa. When thinking of the effectiveness of synthetic mineral complexes for increasing mineral availability, the concepts of stability constant and ligand molecular weight must be considered. The stability constant is a measure of the affinity between a metal ion and a ligand (Nelson, 1988). Herrick (1993) underscored the importance of stability constant and ligand molecular weight when evaluating a synthetic metal complex. The stability constant must be high enough to allow intact absorption of the metal-ligand complex and low enough to allow metal ion removal at the metabolic point of use. In addition, the ligand molecular weight must be low enough to permit intact absorption of the metal complex.

**Bioavailability of Organic Minerals**

Reports of organic mineral bioavailability in livestock and poultry are inconsistent. Mahan and Parrett (1996) reported retention of Se was increased when a Se-yeast complex was fed to grower-finisher pigs. Likewise, Rojas et al. (1995) showed increased bioavailability of Zn-lysine and Zn-methionine, over inorganic Zn sources, when supplemented to sheep. A Mn-
methionine complex, when fed to chicks, was 74.4% more available than an inorganic source (MnO) (Fly, et al., 1989).

Conversely, some reports have shown no influences of complexing with an organic ligand (protein, methionine, or lysine) on mineral (Zn and Mn) bioavailability (Aoyagi, et al., 1993; Pimental, et. al., 1991b; Baker and Halpin, 1987). A review on comparative intestinal absorption of metal-amino acid complexes, however, shows improved jejunal uptake of copper, magnesium, iron, and Zn-amino acid complexes versus inorganic forms (SO₄, O₂, CO₃) of the same metal ions (Ashmead, 1993). Moreover, ⁶⁵Zn studies showed increased (78%) transfer of Zn from the mucosa to the serosa with a Zn amino acid complex compared with ZnCl₂ (Ashmead, 1993).

Intrinsic, extrinsic, and luminal factors can affect mineral bioavailability (Nelson, 1988; Ashmead, 1993). The variable reports of organic mineral bioavailability in animal systems are likely due to interactions among these factors. Although reports of organic mineral availability have varied across research trials, an effective increase in mineral absorption and tissue retention is weighted toward organic mineral complexes for poultry.

**Organic Trace Minerals in Broiler Production**

Organic trace minerals have been used in broiler feeds for some time, showing promise in improving live performance, bird health, processing yield and meat quality characteristics. The most commonly used organically-complexed minerals include zinc, manganese, selenium, copper and iron. Zinc sources have been the most studied of these compounds and a number of researchers have reported improvements in broiler growth rate and/or feed conversion with organic zinc sources (Sanford and Kawchumpong, 1972; Sandford, 1976; Hess et al., 2001). In
addition to improvements in body weight and feed conversion, foot pad quality has been enhanced with organic zinc (Hess et al., 2001). This use of organic zinc has gained increased importance as measurement of foot pad lesion incidence has become a common tool to assess broiler welfare.

Interest is also building in using organic trace minerals in place of a portion of the feed inorganic mineral supplement in order to get maximum growth and health with lower levels of mineral intake, thus lowering the amount of minerals excreted from the birds (Bao et al., 2006). Reducing mineral levels in litter placed on the land is an issue in many areas of the U.S. and lower levels of complexed trace minerals may aid in reducing litter mineral excess.

**Bird Health**

A number of minerals have been shown to play crucial roles in broiler health and organic trace minerals have been shown to have a role in boosting cellular and humoral immunity in broilers. Organic zinc compounds have shown benefits in improving immunity in birds (Pimental et al., 1991a; Kidd et al., 1994). In addition, chicks hatched from breeder hens fed organic trace minerals have shown improved cellular and humoral immunity as well (Kidd et al., 1992; Kidd et al., 1993). Research at Auburn has shown improvements in the amount of cellulitis (IP) associated with the feeding of organic zinc products (Downs et al., 2000; Downs et al., 2003). These reductions may come from an improvement in skin quality and healing often seen with organic zinc sources, or may be due to improvements in immune function.

**Processing Performance**
Meat yield and product quality have become driving forces in broiler production and nutritional products that improve processing yield have become important tools for broiler companies interested in increasing broiler product output. Organic trace minerals, in this case a combination of complexed zinc and manganese, have been shown to affect meat quality through reduced cooking loss (Saenmahayak et al., 2007). In addition, fillet color measurements indicated that broilers fed organic trace minerals showed darker fillets, which may be correlated with a lower incidence of pale, soft and exudative meat. Recent research from our lab recorded improvements in fillet yield and fillet darkness in 6 lb birds fed complexed zinc and/or manganese. Organic selenium products may also affect product quality through improvements in tissue integrity (Downs et al., 2000).

**Broiler Breeders**

Although organic trace minerals have been shown through field trials to improve breeder performance directly, a good deal of research work has also been completed on the influence of these products on the health and growth response of breeder progeny (Kidd et al., 1992; Kidd et al., 1993). Although final body weight, FCR and carcass characteristics of broilers from breeder hens fed organic trace minerals showed no changes, immunity and livability have shown responses to these added minerals. Research trials with broilers hatched from eggs laid by breeders fed zinc methionine showed improvements in cellular (Kidd et al., 1992; Kidd et al., 1993) and humoral immunity (Kidd et al., 1992). Work by Virden et al. (2003) reported improved livability (1.5 to 2%) in chicks from hens fed both organic zinc and manganese. In breeder males, there is some limited information that feeding complexed zinc during the pullet phase may lead to increased gonadal maturation at placement (Suchy et al., 1998).
Conclusion

Organic trace minerals, particularly zinc, manganese and selenium, show improved bioavailability over inorganic sources for commercial poultry and are being used to improve health and processing performance in broilers and breeders.

REFERENCES


