

# Organic versus Inorganic Trace Minerals in Poultry: The Zinc Experience

T. K. Cheng, T. M. Fakler, C. J. Rapp, T. L. Ward  
Zinpro Corporation, Eden Prairie, MN

Trace minerals are required for the normal functioning of all biochemical processes in animal body. However, the trace mineral requirements of poultry are not well defined. Commercial diets typically supplement inorganic trace minerals at a rate much higher than those recommended by National Research Council (Lesson, 2005). The ever-increasing poultry genetic potential and environmental concerns have caused the industry to reconsider how to efficiently maximize productivity while minimizing waste disposal. Research studies have shown that one way to attain these industry goals for trace mineral usage is through the use of organic trace minerals.

According to the definitions provided by the Association of American Feed Control Officials, there are currently six classes of commercially available organic trace minerals (Table 1; AAFCO, 2005).

**Table 1. Definitions of organic trace minerals (AAFCO, 2005)**

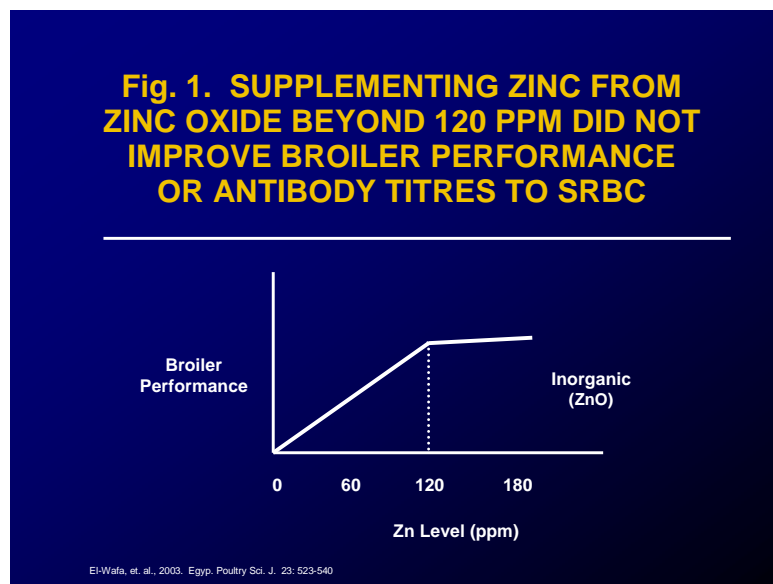
1	<b>Metal (specific amino acid) Complex</b> Product resulting from complexing a soluble metal salt with a specific amino acid. Minimum metal content must be declared. When use as a commercial feed ingredient, it must be declared as a specific metal, specific amino acid complex.
2	<b>Metal Amino Acid Complex</b> Product resulting from complexing a soluble metal salt with an amino acid(s). Minimum metal content must be declared. When use as a commercial feed ingredient, it must be declared as a specific metal amino acid complex.
3	<b>Metal Amino Acid Chelate</b> Product resulting from the reaction of a metal ion from a soluble metal salt with amino acids with a molar ratio of one mole of metal to one to three (preferably two) moles of amino acids to form coordinate covalent bonds. The average weight of the hydrolyzed amino acids must be approximately 150 and the resulting molecular weight of the chelate must not exceed 800. Minimum metal content must be declared. When used as a commercial feed ingredient, it must be declared as a specific metal amino acid chelate.
4	<b>Metal Proteinate</b> Product resulting from the chelation of a soluble salt with amino acids and/or partially hydrolyzed protein. It must be declared as an ingredient as the specific metal proteinate.
5	<b>Metal Polysaccharide Complex</b> Product resulting from complexing a soluble salt with a polysaccharide solution declared as an ingredient as the specific metal complex
6	<b>Metal Propionate</b> Product resulting from the reaction of a metal salt with propionic acid. The metal propionates are prepared with an excess of propionic acid, at an appropriate stoichiometric ratio. It must be declared as an ingredient of the specific metal propionate

However, not all organic trace minerals are created equal. Gou *et al.* (2001) showed that the solubility of various commercially available organic copper sources, including those from the same class of organic copper, was different. The authors reported that for a few

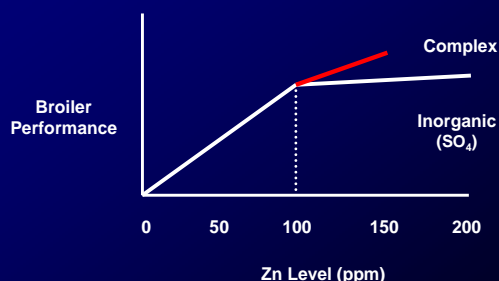
organic copper sources with high copper solubility, a large percentage of their ligands (the nitrogen portion) were not present in the solution with the copper ions. Therefore a high percentage of the soluble copper actually existed in an unbound state. This was also shown using a copper specific ion electrode. The data clearly showed that copper proteinate from source A may not be the same as copper proteinate from source B.

It is generally accepted that bioavailability of trace minerals from organic trace mineral sources was higher than that of the inorganic sources. Since organic trace mineral sources are different (via AAFCO definitions), not all organic trace minerals are the same. However, the impact of the presence of dietary antagonists on the bioavailability of trace minerals was not well documented. Wedekind *et al.* (1992) compared the bioavailability of ZINPRO<sup>®</sup> zinc-methionine to feed grade zinc sulfate using purified (crystalline amino acid), semi-purified (soy isolate), and complex (corn-soybean meal) diets. ZINPRO zinc methionine was reported to show higher bioavailability in all three diet types. The relative bioavailability of Zinpro zinc methionine compared to zinc sulfate increased (117, 177 and 206%, respectively) as complexity of the diet increased. Similarly, Wedekind *et al.* (1994) reported that when the calcium level in the test diet increased from 0.60 to 0.74%, the bioavailability of zinc from ZINPRO zinc-methionine relative to zinc sulfate increased from 166 to 292%.

Organic trace minerals were good vehicles to supply broilers with more trace minerals without increasing the dietary trace mineral levels. Adding more than 120 ppm of Zn from zinc oxide to the broiler diets did not further improve market-age broiler weight, feed conversion, and antibody titers to SRBC (El-Wafa *et al.*, 2003; Figure 1). If one assumed the bioavailability of zinc oxide was 65% relative to zinc sulfate, then, the “saturation point” for inorganic zinc for this study was equivalent to 78 ppm of Zn from zinc sulfate. Pooled data from two large scale broiler studies (Zinpro, unpublished data; Figure 2) showed that supplementing broiler diets with zinc from zinc sulfate beyond 100 ppm did not further enhance market-age broiler weight, feed conversion or livability. However, adding ZINPRO zinc-methionine beyond the 100 ppm Zn “saturation point” continued to improve broiler performance.



**Fig. 2. EFFECT OF COMPLEXED ZINC  
ADDED ON TOP OF ZINC SULFATE  
ON BROILER PERFORMANCE**



Zinpro, unpublished data

It was important to note that supplementing organic zinc to the broiler diets with inorganic zinc well below these “saturation points” was still highly beneficial. Two separate broiler trials were conducted (Zinpro, unpublished data) with a basal diet containing 60 ppm added zinc from zinc sulfate. Treatments involved (1) basal + 40 ppm zinc from zinc sulfate, and (2) basal + 40 ppm zinc from zinc amino acid complex. Broilers were reared to a final body weight of 8.3 to 8.5 lb. Pooled data showed that broilers fed diets supplemented with zinc from zinc amino acid complex outperformed those fed zinc sulfate in body weight, feed conversion, livability and breast meat yield.

**Fig. 3. EFFECT OF COMPLEXED ZINC  
ADDED ON TOP OF ZINC SULFATE  
ON BROILER PERFORMANCE**



Zinpro, unpublished data

Leeson (2005) reported a caged broiler study where the diets were formulated with mineral sulfates to furnish 100, 90, 30 and 5 ppm of zinc, manganese, iron and copper, respectively. These sulfates were assumed to be 70% bioavailable (“bioavailable” zinc, manganese, iron and copper were assumed to be 70, 63, 21, and 3.5 ppm, respectively). Five additional treatments involved feeding diets with a proteinate as sole mineral source that furnished 100, 80, 60, 40 and 20% of the “bioavailable” level of the mineral sulfates. There were no statistical differences among treatments for 42-day body weight and feed conversion. In a follow-up floor pen study, that involved the same inorganic control and the same proteinate used as sole mineral source to furnish either 14 or 7% of the “bioavailable” minerals (Leeson, 2005), no statistical differences were detected among treatments for 20 - 41 day weight gain, 0 - 20 as well as 20 - 41 day feed conversion. The author stated that when the proteinate was used as the sole mineral source to furnish 14% of the “bioavailable” minerals in the broiler diets, the cost was comparable to the inorganic premix used in the control treatment. Due to the ultra low mineral levels, it would be risky to feed such diets to the broilers in the field. Nonetheless, the author calculated that the zinc, iron, and copper output in the manure would be significantly reduced if any of these proteinate diets were fed to the broilers (Leeson, 2005). However, in general output will always decrease as supplementation level decreases. Feeding zinc amino acid complex had been reported to decrease broiler zinc excretion (Burrell, *et al.*, 2004).

In a series of broiler studies, broilers fed diets supplemented with 40 ppm of Zn from zinc amino acid complex on top of the inorganic control (range of added inorganic zinc: 80 - 110 ppm) were reported to improve body weight, feed conversion, livability and breast meat yield (Zinpro, unpublished data).

The macrophage tumoricidal activity of 5 week-old tom turkeys fed an organic trace mineral diet (40 ppm Zn from ZINPRO zinc methionine, 40 ppm Mn from MANPRO<sup>®</sup> manganese methionine, 80 ppm Zn from zinc sulfate and 120 ppm Mn from manganese sulfate), was reported to be significantly higher ( $P < 0.05$ ) than that of tom turkeys fed a sulfate control diet containing 120 ppm Zn and 160 ppm Mn (Ferket, 1992).

Broilers fed an organic trace mineral diet containing 40 ppm Zn from ZINPRO zinc methionine and 40 ppm Mn from MANPRO manganese methionine showed significantly ( $P < 0.05$ ) less skin tears and scratches than those fed an iso-zinc, iso-manganese and iso-methionine diet (100 ppm Zn and 105 ppm Mn from sulfates; Zinpro, unpublished data).

Rapp *et al.* (2001) gave broilers a very mild coccidial challenge using mixed field isolates. When anticoccidial was removed from the diet at 35 days of age, birds fed 40 ppm Zn from zinc amino acid complex were reported to significantly ( $P < 0.05$ ) reduce the intestinal lesion scores at day 42 when compared to those fed the iso-zinc sulfate control (115 ppm Zn).

Recently, broilers fed a diet supplemented with 40 ppm Zn from zinc amino acid complex on top of 100 ppm of Zn from zinc sulfate control were reported to significantly ( $P < 0.05$ ) increase the intestine elasticity (Zinpro, unpublished data).

Hudson *et al.* (2004) fed broiler breeders either a sulfate control diet containing 160 ppm Zn, or an iso-zinc diet where 80 ppm added Zn was furnished by zinc amino acid complex. These authors reported that broiler breeders fed zinc amino acid complex

produced 2.3 extra chicks per hen housed when compared to those fed the sulfate control. The livability of chicks produced from broiler breeders fed zinc amino acid complex was significantly ( $P < 0.05$ ) higher than those fed only the sulfates (Virden *et al.*, 2002). Chicks from broiler breeders fed a diet supplemented with 40 ppm of Zn from ZINPRO zinc methionine showed significantly heavier dry bone weight as well as enhanced cellular immune response ( $P < 0.05$ ; Kidd *et al.*, 1992, 1993). Broiler breeders fed similar diet supplemented with 40 ppm of Zn from an oxide source did not show similar responses. In fact, the responses of the oxide supplemented group were no different than the non-supplemented basal control ( $P > 0.05$ ; Kidd *et al.*, 1992, 1993).

## SUMMARY

There are currently six classes of organic trace minerals as defined by Association of American Feed Control Officials. Cross-classes or intra-class comparison of data is difficult due to differences in ligands and manufacturing processes. The best criteria to judge an organic trace mineral source is to look at the repeatability in animal efficacy data. Repeatability seen across many animal species is the best. Broiler data clearly shown that supplementing inorganic zinc beyond 80-100 ppm will not further improve broiler performance. However, supplementing selected organic trace minerals either above or below this “saturation point” has been reported to improve performance. Besides improving weight gain, feed conversion, livability and breast meat yield, supplementing selected organic trace minerals (alone or together with inorganic sources) has been reported to decrease minerals in the manure, enhance immune status, maintain skin integrity, decrease intestinal lesions due to mild coccidial challenge, increase intestine elasticity, improve breeder-progeny performance, etc.

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