Amino acid chelated minerals in animal nutrition

Metal ions are readily absorbed if they are formed neutral complexes with organic molecules. Only uncharged molecules containing the metal ion can move through the cell membrane. The neutral complexes with cations are formed more preferably than charged complexes because metal ion is deprotonated at physiological pH. Such complexes have been use not only as food supplements, but also for treatment of some diseases. For example, copper complexes of S-(methylthio)-DL-homocycteine have been used for cancer treatment[1], zinc complexes of carnosine (carnosine is dipeptide of alanine and histidine) have been approved as anti-ulcer drugs[2]. Antibacterial properties of metal complexes of ionophores have been approved for livestock production[3]. The whole process of their action leads to changes in Na+/K+ gradient and to an increase in the osmotic pressure inside the cell, causing swelling and vacuolization, and finally death of the cell.

The benefits of using amino acid chelated minerals (or dipeptides chelated with minerals) that after their dechelation in the cell leftover amino acids or dipeptided are using by animals as a building blocks of protein. Ionophorous, e.g. monensin that have been approved and widely use in for veterinary practice, could lead for intoxication and death of cattle and other species[4], as well as environmental pollution[5]. There is no antidote or specific treatment for toxicoses induced by ionophores[6].

All applications of amino acids chelated minerals (Fig. 1a) (not metal amino acid complexes (Fig.1 b) are closely related to ability of amino acids to form non-depolarizing (electroneutral) complexes with metal cations (host-guest complexes) and transport these complexes across cell membranes. Typically, the complexation of the cation is connected with formation of five-member rings structure which is stabilized by coordinate covalent bonds.

Multidentate chelates, chelates in which there are more than two donor atoms in the ligand (Fig. a), are more stable because the ligands are able to occupy a large number of positions in the coordination shell of the cation.

Increased interest in amino acid chelated minerals has been observed in recent years. The global organic trace minerals market was valued at USD 375 million in 2012 and is expected to grow at a CAGR of 6.7% from 2013 to 2020.[7]

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[7] Animal Feed Organic Trace Minerals Market Analysis By Product (Zinc, Iron, Manganese, Copper) And Segment Forecasts To 2020, Published: January 2014 | ISBN Code: 978-1-68038-065-1

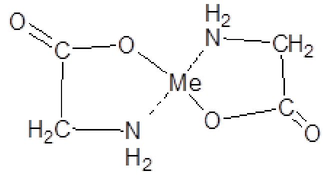
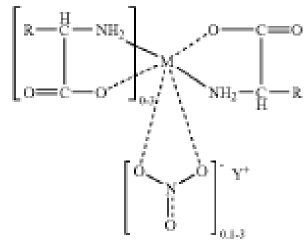
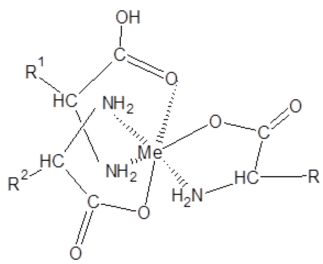
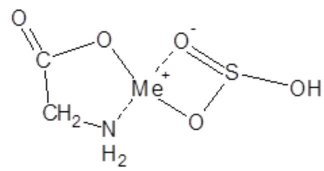
(a) electroneutral complexes	(b) charged complex
 Albion Laboratories (US Pat. 4,599,152); Biochem Lohne Germany; Royal DSM	 Albion Laboratories (US Pat. 20090182044)
 Mirochembiotech Ltd. (Can. Pat. 2,623,964)	 e.g. Zinpro; Aliphos; Global Animal Product; Tanke Biosciences Corp.

Fig. 1. Structure of (a) amino acid chelated mineral; (b) metal amino acid complex.

The effect of replacing inorganic minerals with organic minerals in pigs

Studies have shown using chelated minerals has numerous benefits comparing to using inorganic salts in meat production industry. For example, in one study, piglet growth was consistently better with Copper chelates at 50 to 100 ppm, in comparison with inorganic Cu at 250 ppm. In addition, organic Cu increased Cu absorption and retention, and decreased Cu excretion, at 77% and 61% respectively, compared with 250 ppm inorganic Cu[8].

In weaned piglets evaluated various supplementation rates of organic Zn in the form of a chelate or as a polysaccharide complex and compared these with ZnO, zinc oxide, at 2,000 ppm. Feeding lower concentrations of organic Zn greatly decreased the amount of Zn excreted in comparison with inorganic Zn, without loss of growth performance[9].

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Cu and Zn are widely used at high levels as growth promoters in the industry. In pigs, dietary concentrations of 150÷250 mg copper sulphate/kg and 2500÷3000 mg Zn sulphate/kg (more than 25 times the minimum requirements). It was found that pigs excrete contained approximately 80–95% of given Cu and Zn dietary supplements[10] .

In weaned piglet nutrition zinc-oxide used as antibacterial compound against gastrointestinal diseases at high dose (2000 mg kg-1 feed as zinc)[11] but it resulted high rate of zinc excretion through feces, while zinc-methionine at the dose of 200 mg kg-1 feed as zinc reduce the occurrence of diarrhea at the same rate[12].

The effect of replacing inorganic minerals with organic minerals in broiler chickens

One group of chickens received inorganic sulfates of Cu (12 ppm), Fe (45 ppm), Mn (70 ppm) and Zn (37 ppm) and their performance was compared to a similar group supplemented with chelates of Cu (2.5 ppm), Fe, Mn, and Zn (all at 10 ppm). There were no differences in performance between the birds fed the high inorganic minerals and the birds fed the low organic chelates. Faecal concentrations of Cu, Fe, Mn and Zn were 55%, 73%, 46% and 63%, respectively, of control birds fed inorganic minerals[13].

A Zn chelate supplement was compared with Zn sulfate in broiler chickens. Weight gain and feed intake increased quadratically ($p<0.05$) with increasing Zn concentrations from the chelate and linearly with Zn sulfate. The relative bioavailability of the Zn chelate was 183% and 157% of Zn sulfate for weight gain and tibia Zn, respectively. The authors concluded that the supplemental concentration of Zn required in corn-soy diets for broilers from 1–21 days of age would be 9.8 mg/kg diet as Zn chelate and 20.1 mg/kg diet as Zn sulfate, respectively[14].

A broiler study reported also compared inorganic and organic mineral supplementation in broiler chickens. Control birds were fed Cu, Fe, Mn Se and Zn in inorganic forms (15 ppm Cu 15 from sulfate; 60 ppm Fe from sulfate etc.), and compared with three treatment groups supplemented with organic forms. Apart from improved feathering, most likely associated with the presence of organic Se, there were no significant performance differences between birds fed inorganic and organic minerals. The authors concluded that the use of organic trace minerals permits a

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reduction of at least 33% in supplement rates in comparison with inorganic minerals, without compromising performance[15].

Relative bioavailability of different copper compounds in poultry as compared to $CuSO_4$ in poultry was Cu-Lys: 114%; Cu-Met: 92%; Cu-proteinate: 108%, in piglets $CuCl_2$: 118%; Cu-Met: 85% and Cu-Lys: 105% and in ruminants (sheep and cattle) Cu-Lys: 104%. Relative bioavailability of different zinc compounds in poultry as compared to ZnSO4 and based on the tibia Zn content was ZnO: 85 %; Zn-Met: 133 %; Zn-proteinate: 120 % and Zn-propionate: 126 %, in piglets ZnO: 55÷87%; Zn-Lys: 83%; Zn-Met: 99% and Zn-proteinate: 100% and in ruminants (sheep and cattle) Zn-Lys:102 %; Zn-Met: 109% and Zn-proteinate: 112%. Relative bioavailabilities of different iron compounds in piglets, as compared to ZnSO4, are as follows: Fe-fumarate: 95÷100%; Fe-proteinate: 110÷-122 % and Fe-Met: 177÷184%. Bioavailability of Mn from Mn-proteinate seems to affect by, among other factor, some adverse situations, such as; it was found that the bioavailability of Mn-proteinate showed much higher values (125÷140%) as compared to $MnSO_4$ in heat-stressed broiler chickens[16].

[more…] http://en.wikipedia.org/wiki/Chelates_in_animal_nutrition

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