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TRACE MINERALS IN POULTRY NUTRITION

Need Of Trace Minerals

Micronutrients as trace minerals play a vital role in various metabolic, enzymatic and biochemical reactions ultimately leading to better growth rate, egg production and feed efficiency. Trace minerals have a very important role to play in the mechanism of nutrient circulation in the animal organism. Deficiency or imbalance of any of these vital micronutrients results in deficiency disease, metabolic disorders, poor growth rate, low egg production, low hatchability and low feed efficiency.

Role Of Trace Minerals

Trace elements function as part of larger organic molecules. Iron is a part of hemoglobin and cytochrome, and iodine is a part of thyroxin. Copper, manganese, selenium, and zinc function as essential accessory factors to enzymes. If any of these minerals is deficient, the functional activity of the organic moiety requiring the presence of the mineral will be decreased. The physiological activity and its deficiency symptoms are tabulated in Table 1.

Absorption of trace minerals in the intestine

Trace Minerals are absorbed in the intestine in ionic forms. They are usually supplemented in inorganic salts, which get dissociated after entering the system. The free metal ion first gets attached to an organic molecule or "escort". Due to multiple antagonistic reactions of ingredients in the animal digestive system and limited ligand /escort availability whatever minerals are able to find an escort are absorbed and balance is excreted.

The absorption process of mineral is well expressed in the fig.1

Trace Mineral Sourcing

The requirements for trace minerals are often fulfilled by concentrations present in conventional feed ingredients. Soils vary, however, in their content of trace minerals, and plants vary in their uptake of minerals. Consequently, feedstuffs grown in certain geographic areas may be marginal or deficient in specific elements. Thus, poultry diets may require supplementation to ensure adequate intake of trace minerals.

Minerals come from rocks and often are thought of as inert, inorganic substances. Naturally occurring minerals are usually

Fig 1 : Trace Mineral absorption in the gut

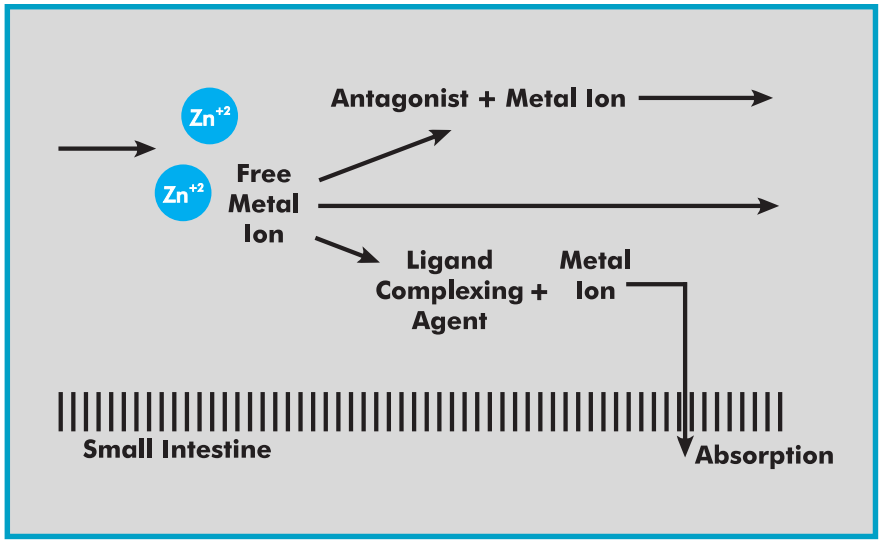

Table 1 : Role of Trace Minerals

Trace Minerals	Role Of Trace Mineral	Deficiency Symptoms
Zinc	• Essential component of 200 Enzyme systems. • Major role in Immune system and certain reproductive hormones. • Essential for proper sexual maturity and reproductive capacity.	• Result in poor semen quality. • Retardation in growth, leg abnormality with long bones becoming shorter, thickened and crooked. • Hatched chicks are weak with skeletal deformities. • Delayed feathering.
Manganese	• Activator of enzyme system in the metabolism of carbohydrates, fats, proteins and nucleic acid. • Plays role in collagen formation, bone growth, urea formation, eggshell formation and the function of the immune system. • Involved in enzymes related with oxidative phosphorylation in mitochondria.	• Retarded growth • Characteristic crippling leg deformity called perosis. • Reduction in eggshell strength. • Reduction in hatchability.
Cobalt	• Required for Vitamin B12 Synthesis. • Activation of enzymes • Erythropoiesis. • Synthesis of pyrimidine.	• Loss of appetite • High embryo mortality • Low hatchability
Copper	• It is a necessary component of number of enzymes which function in increased structural strength, elasticity of connective tissues and blood vessels. • Helps in the maturation of erythrocytes.	• Anaemia, Enlarged heart and fragile bones, leg weakness.
Iron	• Constituent of haemoglobin and myoglobin for oxygen transport and cellular use. • Component of many enzymes containing protein such as cytochrome C, peroxidase, catalase etc.	• Depigmentation of feathers • Stunted growth • Hypochromic microcytic anaemia • Heart hypertrophy
Magnesium	• Essential constituent of bones • Activator of various enzyme systems those concerned with the transfer of phosphate from ATP to ADP and metal –enzyme complexes.	• Rapid decrease in egg production, reduced mobilization of magnesium from skeletal systems.
Selenium	• Functions as Antioxidant. • Protection of unsaturated tissue lipids against peroxidation.	• Stunted growth, poor feather development and degeneration of pancreas • Exudative diathesis.
Iodine	• It is required for synthesis of thyroid hormone, thyroxin, which regulates the rate of metabolism. • Regulates rate of cellular oxidation. • Regulates neuromuscular functions.	• Increase in the size of thyroid gland called goitre. • Retention of yolk in the hatched chicks. • Lower hatchability
Molybdenum	• Constituent of enzyme Xanthine oxidase involved in the metabolism of purines. • Synthesis of haemoglobin.	• Retarded growth. • Copper Poisoning.

mined in their most stable states. Compounds such as Zinc oxide and cupric- cuprous oxide, require more extensive process to remove unwanted compounds or to concentrate the major elements. Manganese dioxide (MnO_2) to Manganese Oxide (MnO) implying conversion to different valence state, which allows for improved bioavailability, is achieved by firing in a furnace under a reducing atmosphere.

Trace minerals are available in a variety of forms and periodically problems arise due to lack of knowledge of the composition and/or stability of salts. Example "state of hydration of a mineral" i.e. mineral forms contain "bound" water that effectively dilutes mineral concentration, like hydrated cupric Sulphate (white crystal) contains about 40% copper and common pentahydrate (blue) contains 26% copper. Various processing conditions used in manufacturing will likely reduce the biological availability. A combination of these 2 factors can mean a substantially lower potency of trace minerals sources relative to chemical standard values.

Purity of trace minerals is a critical criterion whilst selecting the salt for a trace mineral. Eventually by-products of the Chemical Industry, trace mineral salts do not undergo rigorous quality testing for purity. The main threat to these salts is contamination with heavy metals. These heavy metals and other impurities, which may be toxic, pose a threat to efficient production/performances.

Table 2 : Different salts available for minerals

Mineral	Salt	Mineral	Salt
Iron	Ferrous chloride 4H2O	**Manganese**	Manganese carbonate
	Ferrous Sulphate7 H2O		Manganese chloride 2 H2O
	Ferric citrate		Manganous oxide
	Iron carbonate		Manganese sulphate 4 H2O
	Iron sulphate	**Iodine**	Calcium Iodate
Copper	Copperous chloride		Potassium Iodate
	Copper oxide		Potassium Iodide
	Copper sulphate		Sodium Iodide
	Copper sulpahte5 H2O	**Cobalt**	Cobalt carbonate
Zinc	Zinc carbonate		Cobalt chloride 6 H2O
	Zinc chloride		Cobalt sulphate 7 H2O
	Zinc oxide		Cobalt oxide
	Zinc sulpahte 1 H2O	**Selenium**	Sodium selenite
	Zinc sulphate 7 H2O		Selenium phosphate

Table 3 : Trace Minerals interactions

Trace Mineral	Minerals interfering with absorption
Zinc	Copper, cadmium, calcium and Iron
Manganese	Calcium, potassium, Iron, magnesium, phosphorus and cobalt.
Cobalt	Manganese, Zinc, Iron and Iodine
Copper	Zinc, Iron, Molybdenum and sulfur.
Iron	Cadmium, cobalt, manganese, phosphorus and Zinc.
Iodine	High dietary nitrites,
Selenium	Cadmium, Copper, Mercury, lead, Zinc and sulfur

Trace Mineral Interactions during absorption

Numerous interactions occur between various minerals such as copper and molybdenum, selenium and mercury, calcium and zinc, calcium and manganese; excessive concentrations of one element may result in a deficiency in the amount available to the bird of some other element (see table 3). Formulators of poultry diets should be aware of these possible mineral interactions and of the potential effects that the chemical form (cation-anion combination) of mineral sources may have on their utilization by poultry .The balance between dietary minerals is referred to bioavailable concentrations relative to animal requirements is an important factor effecting mineral utilization and thus animal requirements.

Supplementation of minerals to animals above the requirements/ needs is also a common practice as a safety margin to prevent any likelihood of deficiencies. Providing a certain level of safety is a sound practice. What

represents safety? If one mineral is supplemented or present in feed ingredients at levels higher than the need of animal it may negatively affect the availability of other minerals.

Different class of poultry require different levels of Trace Minerals

Broilers and Layers are the two distinct categories in poultry. The requirement of micronutrients differs according to their activities. Broilers are expected to grow fast in a very short duration, whereas layers are slow growing birds with a productive lifespan of 72 weeks. Broilers are expected to put on weight rapidly whereas Layers are expected to remain lean to produce eggs.

There is no definite ratio between different trace mineral requirements for these two categories. If we assume the example of Iron and Copper, it is found that requirement of iron in layers is high than that of broilers, whereas requirement of copper is just opposite, i.e requirement of copper is low in layers as compared to broilers.

The above considerations are of significance whilst formulating Trace Mineral formulations. In the Indian scenario it is observed that, the trace minerals do not get due respect whilst formulating the feed. Many of the trace mineral manufacturers formulate trace minerals in general and do not consider the different requirements of broilers and layers. Moreover in a study conducted by ***Prasad et al*** observed that certain mineral supplements available in the Indian market do not conform to quality standards. Many manufacturers, in an attempt to bring the cost lower, use cheaper and locally available ingredients; hence the supplies show enough of compositional variability. ***Lall and Prasad*** analyzed samples of mineral mixtures marketed by 10 different firms and found that none of them matched the BIS specifications. All the samples were either deficient or in excess for one or more essential trace minerals.

Table 4 : Requirements of Trace Minerals for Broilers

Minerals	NRC 1994	Leeson Std.	Techna France
All values are in mg/Kg of feed			
Iron (mg)	80.0	80.0	28.8
Iodine (mg)	0.35	0.4	2.7
Copper (mg)	8.0	10.0	22.5
Manganese (mg)	60.0	70.0	81.0
Zinc (mg)	40.0	80.0	81.0
Selenium (mg)	0.15	0.3	0.4

The Need for Organic Trace Minerals

Modern high producing poultry has evolved a lot. Modern poultry is akin to a sophisticated machine, capable of high performance. These extremely efficient performances require a

Table 5:Recommended Trace Mineral requirements by different Breeders for broilers

	Avian	Cobb 100	Ross	Hybro	Hubbard	Average Values
All values are in mg/Kg of feed						
Iron (mg)	30.0	80.0	80.0	60.0	50	60.0
Iodine (mg)	0.75	2.0	-	1.2	1.0	1.24
Copper (mg)	3.0	15.0	8.0	14.0	10.0	10.0
Manganese (mg)	100.0	100.0	100.0	120.0	60.0	96.0
Zinc (mg)	80.0	60.0	80.0	100.0	70.0	78.0
Selenium (mg)	0.3	0.225	0.15	0.25	0.2	0.225

Table 6 : Requirements of Trace Minerals for Layers

Minerals	NRC 1994	Leeson Std.	Techna France
All values are in mg/Kg of feed			
Iron (mg)	60.0	80.0	48.3
Iodine (mg)	0.35	0.4	0.8
Copper (mg)	4.0	8.0	5.0
Manganese (mg)	30.0	70.0	65.0
Zinc (mg)	35.0	60.0	55.0
Selenium (mg)	0.10	0.3	0.25

Table 7: Recommended Trace Mineral requirements by different Breeders for Layers

Minerals	Babcock	Bovans	Hyline	Average Values
All values are in mg/Kg of feed				
Iron (mg)	20.0	35.0	50.0	35.0
Iodine (mg)	0.3	1.0	0.5	0.60
Copper (mg)	5.0	10.0	8.0	7.66
Manganese (mg)	35.0	70.0	65.0	56.66
Zinc (mg)	35.0	70.0	65.0	56.66
Selenium (mg)	0.3	0.25	0.15	0.23

Table 8: Effect of Independent supplementation of Micro Nutrients on Broiler breeder Performance (47-67 Weeks of age)

Parameters	Control with inorganic Trace minerals	Control + Organic Trace minerals*	Control + 20% extra inorganic Trace Minerals
Depletion %	6.66 ^{c}	2.22^{a}	4.44^{b}
Hen Housed Total Eggs	78.07	81.3	77.3
Hen Housed H.E	76.61	79.63	75.86
H.E. A grade %	73.53	74.42	72.33
H.E. B grade %	18.34^{a}	17.32^{a}	19.67^{b}
H.E C grade %	6.26	6.21	6.12
Broken Eggs %	1.63	1.91	1.74
Hen Day Prod%	57.82^{bc}	58.86^{ab}	56.71^{bc}
% Hatch Salable chicks	81.69	82.27	81.41
Fertility %	88.59	89	88.49
% Embryonic Mortality	4.95	4.99	5.12
% Cull Chicks	1.63	1.62	1.72
Chicks per Breeder	62.58	65.51	61.75

** Availa Z/M - Zinpro,USA.*

close examination of the nutritional profile of diets. Of particular interest is the enhanced need of minerals in high producing animals.

Inorganic sources of trace minerals are efficiently absorbed and utilized up to a point. Beyond a certain level inorganic supplementation of trace minerals does not evoke a positive response and may infact hamper performance. Hence beyond a certain level of supplementation, organic forms of the essential trace minerals should be incorporated in a ration in order to maximize animal performance.

A study in India conducted by Ganpule and Koshy, 2002 illustrates the beneficial effect of Organic Trace minerals and the inability of inorganic extra supplementation to achieve the same results.(Table 8)

Providing supplemental trace mineral sources that are readily bioavailable to the animal will, further, allow for a lower inclusion rate in the diet and thus minimize mineral losses in animal excreta. Use of organic trace minerals has been limited because of their high cost relative to inorganic sources. However in the future, if regulations are placed on the amount of certain trace minerals that can appear in animal excreta, organic trace minerals may become more widely used.

There are many chemical and structural differences between various types of organic trace minerals used in livestock diets. Bioavailability differences also exist between trace mineral sources. Complexed trace

minerals have increased bioavailability when compared to inorganic trace minerals. Complexed trace minerals have been shown to exhibit superior metabolic activity and to enhance animal performance.

Presently there are five categories of organic trace minerals as defined by the Association of American Feed Control Officials.

1. Metal (Specific Amino Acid) Complex
2. Metal Amino Acid Complex.
3. Metal Amino Acid Chelate
4. Metal Proteinate
5. Metal Polysaccharide
6. Metal Organic Acid (Proposed)

The most noted and researched category of these is the metal (specific amino acid) complexes. This is a very consistent and defined molecule with a specific chemical structure. Examples of this type of organic trace mineral would be zinc methionine, manganese methionine, copper lysine and iron methionine. These products are very well defined, specific in nature and consistent in production, batch after batch.

Metal amino acid complexes are very similar to the metal (specific amino acid) complexes. The only difference between these two categories is that the amino acid is not specified in this group. It is important to note that the metal is still complexed to individual amino acids, but that the amino acids are not specified. Individual amino acids will have the ability to donate electrons from both the nitrogen and oxygen atoms. By utilizing only individual amino acids, the total molecular weight of the complex is kept low.

By definition, metal chelates are the same as proteinates except that there is a maximum molecular weight that is given to chelates. The maximum molecular weight of a chelate is 800 daltons. By definition, the metal to amino acid ration is 1: 1 up to 1: 3 thus accounting for the increased molecular weight of chelates compared to complexes. Increasing ligand size decreases bond strength and may reduce absorption.

Metal proteinates are less consistent by definition and vary in production and research results. The first step in the manufacturing process is an incomplete digestion of a protein source. This incomplete digestion process yields varying lengths of peptide chains that are then exposed to either a single metal or several metal atoms at once.

Metal polysaccharides are the products resulting from mixing a soluble metal salt with a polysaccharide solution. The polysaccharide matrix envelops the trace mineral and may provide some physical protection from gut degradation.

Metal organic acid salts are highly soluble forms of organic acids. They dissolve and rapidly dissociate in the digestive tract of the animal and offer no improvement over inorganic sources.

Conclusion

Trace minerals play a vital role in poultry nutrition. The requirements of different classes of poultry, selection of the salt, and the quality of the trace mineral used are areas that warrant attention. Further, the bio-availability of inorganic minerals to the bird is limited due to natural factors; hence the role of organic trace minerals to improve mineral availability in high producing poultry may be examined.

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