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Technical Bulletin

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Deploying Trace Minerals effectively to enhance Productivity and Profits

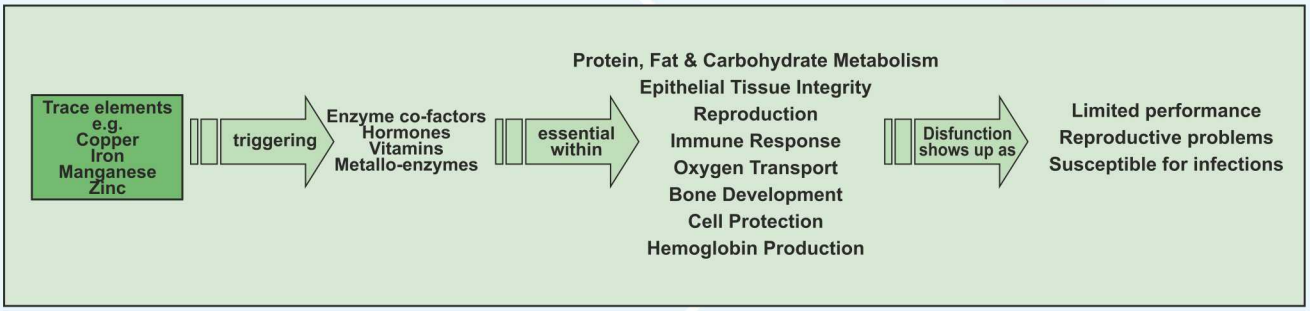
Trace minerals are the minerals that are required in small quantities. Some minerals are not required but may be associated with the minerals required for animals. The essential and non-essential trace minerals may be toxic especially if present in large quantity. The classification of essential minerals is given in Table 1.

The complexity of trace mineral nutrition requires a thorough review of functions, interactions and availability of sources from time to time by the poultry producer/ nutritionist. The trace minerals of primary concern in poultry diets and recommended by the NRC (1994) include Zinc (Zn), Manganese (Mn), Copper (Cu), Iron (Fe),

Table 1. Classification of Essential Mineral

Essential Macro Mineral (>100 ppm)	Essential Micro Mineral (< 100 ppm)	Essential	Highly Toxic (ppm or ppb)
Ca	Cr	Al	Cd
Cl	Co	As	Pb
Mg	Cu	B	Hg
P	I	Br	
K	Fe	F	
Na	Mn	Li	
S	Mo	Ni	
	Se	Rb	
	Zn	Si	
		Sn	
		V	

Role of Trace Elements for Growth, Health and Reproduction



Selenium (Se) and Iodine (I). Mineral Nutrition, though being a small part of complete nutrition is critical for well being and performance of bird.In the past 25 years, trace minerals role in immune function and related physiological roles have gained importance. New organic sources of trace minerals have been patented and marketed providing a more available form of trace minerals for the chicken.

Even though the daily requirement of trace elements is expressed in milligrams and micrograms, they play a vital role in various body functions like synthesis of Metallo-enzymes, Enzyme co-factors, Hormone production etc.

Trace minerals have a wide range of functions. It is important to understand these functions in order to better understand how these minerals affect animal growth and performance.

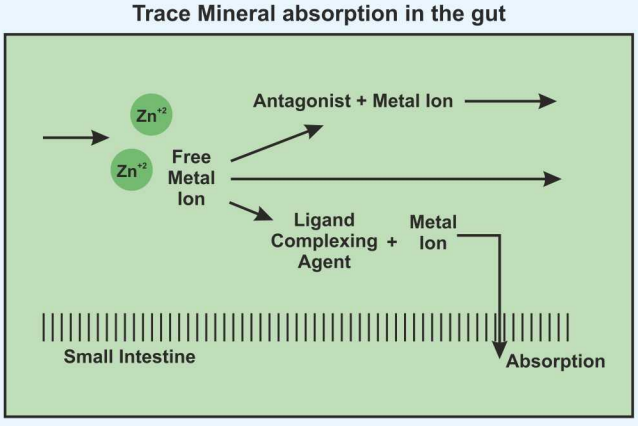
As described by Underwood and Suttle (1999), the functions of trace minerals can be broadly classified into four categories – structural, physiological, catalytic and regulatory functions.

1. **Structural Functions** – Trace minerals can form structural components of organs and tissues, such as Zinc, which is a structural part of membranes and molecules.
2. **Physiological Functions** – Minerals are involved in maintaining osmotic balance, acid-base balance, membrane permeability and tissue irritability.
3. **Catalytic Functions** – Of all the functions, these are the largest. Trace minerals act as catalysts in enzyme & hormone systems and also serve as integral structural components of numerous metallo-enzymes. These metallo-enzymes are required for a broad variety of metabolic activities such as energy production, protein digestion, cell replication, antioxidant activity and wound healing.
4. **Regulatory Functions** – These are illustrated by the role of trace minerals in regulating cell replication and differentiation. While Zinc influences transcription, Iodine as a constituent of thyroxine is associated with thyroid function and energy metabolism.

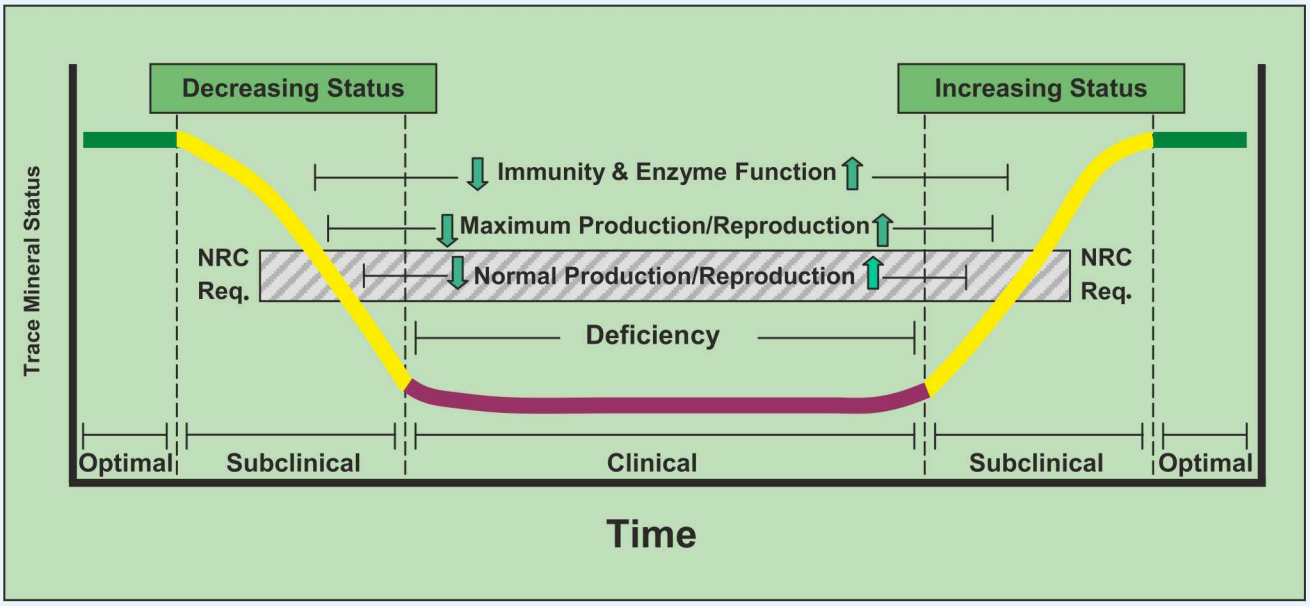
Need of Trace Minerals

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 within the animal body. Deficiency or imbalance of any of these vital micronutrients results in deficiency symptoms, metabolic disorders, poor growth rate, low egg production, low hatchability and low feed efficiency.

Trace Mineral absorption in the gut



Impact of Trace Mineral Status on Biological Function



Absorption of trace minerals in the intestine

Trace Minerals are absorbed in the intestine in ionic form. They are usually supplemented as 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 the balance is excreted.

Supplementation through inorganic minerals

Selection of Trace Mineral Salts/ Forms

Minerals find their use in various industries and also vary in the forms in which they are available. Hence, from a nutritional standpoint, proper selection of the mineral salts is important. The following criteria play an important role in trace mineral salt selection-

- Bio-availability
- Potency
- Availability
- Stability
- Purity
- Economics

Of these, bio-availability is an essential criterion, as highly bio-available forms are able to meet the birds' need, without much wastage. Purity of trace minerals is also important as these trace mineral salts are by-products of the chemical industry and normally do not undergo rigorous quality testing for purity. One of the most important factors to ascertain prior to formulation is the state of hydration of a mineral. Many minerals forms contain bound water which obviously dilutes effective mineral concentration. The main threat in one of the minerals is heavy metals contamination. These heavy metals and other impurities, which may be toxic, pose a threat to efficient poultry production/ performance.

Example: Iodine is the most reactive element. Potassium Iodide, stabilized Potassium Iodide, Potassium Iodate, Calcium Iodate and EDDI are the sources widely used for supplementing iodine in the feed (Table 2).

The practice of feeding trace elements in amounts exceeding animal requirements is widespread, probably because it is inexpensive, unlikely to harm animal and may be beneficial. It is desirable to identify maximum bio-available elements necessary to support peak performances.

Table 2: Iodine variants

Salt	Potency, %	Purity, %	Water Solubility	Stability	Bio-availability
Potassium Iodide	75.0-76.5	99.0	High	Least	High
Potassium Iodate	58.5-60.0	99.0	Moderate	Fair	Moderate
Calcium Iodate	64.0-65.0	97.5	Poor	High	Moderate
Potassium Iodide (Stab.)	68.0-70.0	90.0	Moderate	High	High
EDDI	79.5-80.0	99.0	Poor	Moderate	Very High

Trace mineral sourcing

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.

For example: **"State of hydration of a mineral"** i.e. mineral forms contain "bound" water that effectively dilutes mineral concentration, like hydrated cupric sulphate contains about 25% copper. Relative bio-availability of CuO and $CuSO_4$ is 76% and 100% respectively.

Supplementation of minerals to animals above requirements/needs is also a common practice as a safety margin to prevent any likelihood of deficiencies. If any mineral is supplemented or present in feed ingredients of levels higher than the need of animal it may negatively affect the availability and absorption of other minerals.

The general guidelines for analytical parameters for selected mineral salts are as follows:

Physical Properties:

- Color
- Density
- Particle size, distribution
- Hygroscopicity
- Uniformity
- Foreign matter and molds
- Odor
- Texture
- Flow ability
- Lumpiness
- Compressibility

Certain parameters like size, shape and density of each raw material should preferably be uniform or conforming within a range to enable homogenous premix production.

Chemical properties:

While analyzing the trace minerals, international standard analytical methods like AOAC (Association of Analytical Chemists) AOCS (Association of Oil Chemical Society), BP (British Pharmacopoeia) and USP (United States Pharmacopoeia) are utilized. Some of the parameters being analyzed and studied are:

- Bio-availability
- Stability
- Inherent characteristics of the salt
- pH
- Electrostatic charge
- Purity
- Potency
- Heavy Metal Content

Feed manufacturers are often concerned about space in the diet whilst designing during formulations. There is trend towards making very concentrated mineral and vitamin premixes to try and optimize on the space availability. In considering concentration of mineral source, oxide appears attractive, since they invariably contain the highest mineral concentration. Oxides however are potent oxidizing agents and if stored with premixed vitamins for any length of time, can cause destruction/ deterioration of vitamins that are susceptible to oxidation.

Different class of poultry require different levels of trace minerals

In the Indian scenario, it is observed that the trace minerals do not get due respect whilst formulating the feed. Many of the trace minerals manufacturers tend to formulate trace minerals in

Table 3. Requirement for each segment of poultry is different

Mineral (ppm)	NRC (Broilers)	Leeson	Cobb 400	NRC (Layers)	BV 300
Zinc	40	80	100	40	85
Manganese	60	70	120	30	96
Copper	8	10	20	4	15
Iron	80	80	40	60	96
Selenium	0.15	0.30	0.30	0.10	0.50
Iodine	0.35	0.40	1.00	0.35	1.45

general and do not consider the different requirements of broilers and layers. The requirement of each type of poultry is different as they represent distinct categories with entirely different needs.

For example: Requirement of iron in layers is higher than that of broilers, whereas requirement of copper is lower in layers as compared to broilers (Table 3).

Need for organic minerals

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. 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. Organic minerals have shown specific target tissue response, so they are bound to pronounce better result/ response. As organic minerals are absorbed more effectively with an advantage of better results at lower usage level. Providing supplemental trace mineral sources that are readily bio-available to the animal will, further, allow for a lower inclusion rate in the diet and thus minimize mineral losses in animal excreta.

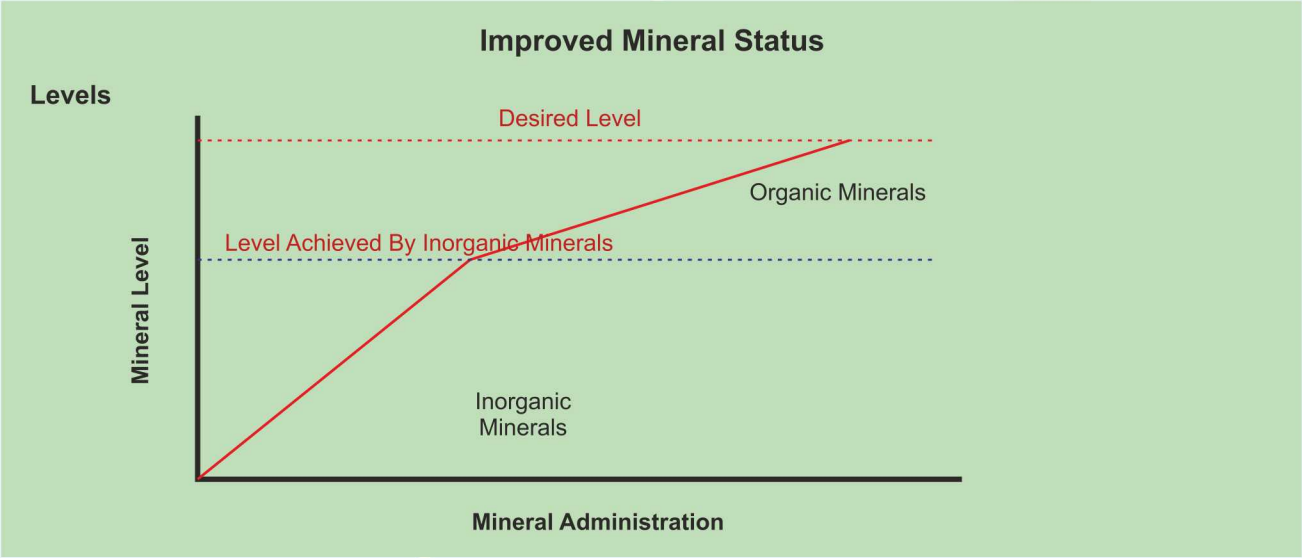
Bio-availability differences also exist between trace minerals sources. Complexed trace minerals have increased bio-availability when compared to inorganic trace minerals. Complexed TM has shown to exhibit superior metabolic activity and to enhance animal performance.

There are six types of organic trace minerals available in the market. They are as follows:

1) **Metal amino acid complex:** Metal amino acid complex result from complexing a specific soluble metal salt of Zinc, Copper and Manganese with an amino acid. These metal amino acid complexes are manufactured using a new patented “amino acid extraction process” that breaks down a pure source of protein into an intermediate product containing only free amino acids without dipeptides, tripeptides or larger protein fragments. The free amino acids are complexed in one-to-one ratio, i.e. amino acid molecule bonded to one amino acid molecule.

2) **Metal specific amino acid complex:** These complexes result from complexing a soluble

Strategies to achieve optimum trace mineral



metal salt of mineral with specific amino acid. The end product is a new molecule containing one ion of the metal and one molecule of the amino acid, say methionine.

3) **Metal amino acid chelate:** Chelates are formed from the reaction of a metal ion from a soluble metal salt with amino acids having a mole ratio of one mole of a metal to one, two or three (preferably two) moles of amino acids to form co-ordinate – covalent bonds. The process is deficient because of its inability to specify which amino acids – and how many are being chelated.

4) **Metal proteinate:** Metal proteinates result from the chelation of salts with amino acids and/ or partially hydrolysed proteins. The final product may contain single amino acids, dipeptides, tripeptides or other protein derivatives. Often the resulting mixture is bound too weakly to withstand the environment of the digestive tract. Metal proteinates are not a defined chemical entity. These types of products tend to vary from one batch to the other.

5) **Metal polysaccharide complex:** It results from complexing a soluble salt with a polysaccharide solution declared as an ingredient of the specific metal complex. The product is more of an organic mineral matrix without any chemical bonding between the mineral and the polysaccharide.

6) **Metal propionate:** It is the result of combining soluble metals with soluble organic acids. Resulting products are highly soluble and generally dissociate in solution.

In order to achieve optimum and desired performance, supplementation of trace mineral in right and sufficient quantities is crucial.

How do we achieve improved mineral status?

1. To supplement the entire requirement through inorganic forms of trace minerals at high levels.

To meet the increasing need for trace minerals to cater the growing production needs of poultry, the industry has steadily been increasing the quantities of inorganic trace minerals in the diet. Whether these high levels will fulfill the required optimum trace mineral status is a question mark. Various researchers have described the negative impact of feeding high level of inorganic minerals, due to their interactions and competition for absorption sites. Apart from this, higher level of minerals in the diet will have a serious impact on

Trace Mineral	Minerals interfering with absorption
Zinc	Copper, Cadium, Calcium, Iron
Manganese	Calcium, Potassium, Iron, Mangnesium, Phosphorous and Cobalt
Cobalt	Manganese, Zinc, Iron, Iodine
Copper	Zinc, Iron, Molybdenum, Phosphorous and Zinc
Iodine	High dietary Nitrities
Selenium	Cadmium, Copper, Mercury, Lead, Zinc and Sulphur

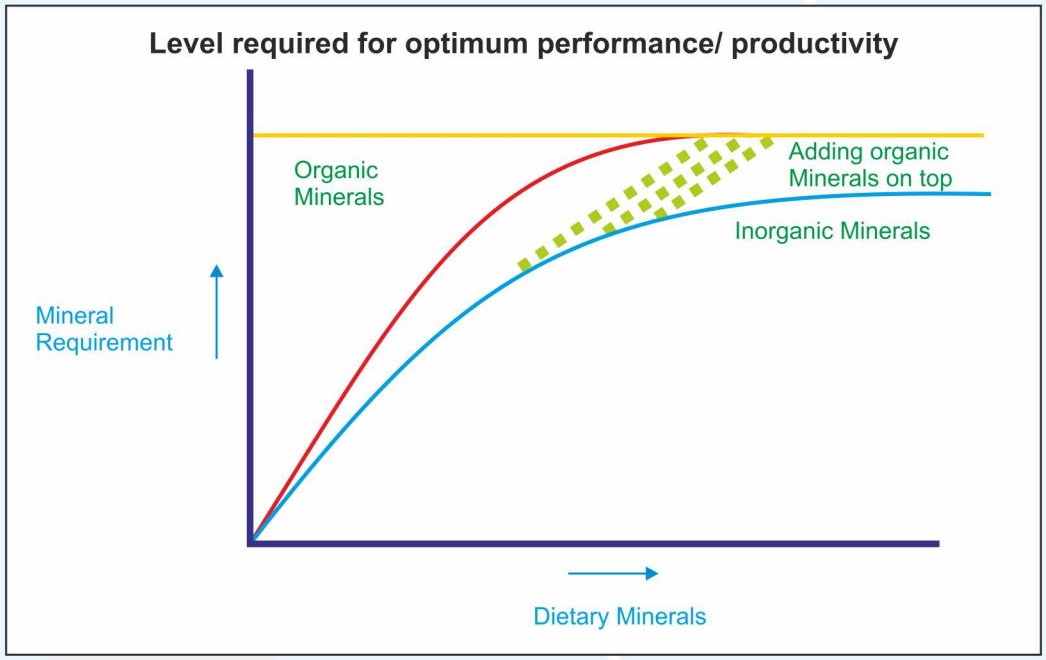
environment in terms of variable excretion of trace minerals in the excreta.

Mineral Interaction

The most common antagonism occurs between Zinc and Copper, as both compete for the same binding site during absorption. High levels of dietary Zinc will inhibit Copper absorption, hepatic accumulation and deposition in the egg. Ratios greater than 4:1 of Zinc : Copper can be considered antagonistic. High levels of Calcium, Copper and Iron can interfere with Zinc. Excess dietary Phosphorus will interfere with Manganese availability in poultry. High Manganese increases Iodine excretion and reduces Iron absorption. Excess Calcium and Phosphorus inhibit Manganese absorption. Iron and Cobalt slightly reduce Manganese availability. These interactions can be reduced by supplementing a portion of the mineral requirement through chelated minerals, which are protected from interactions and have better bio-availability.

2. To supplement the total requirement of trace minerals in organic form.

Whereas organic minerals may be absorbed more readily, the option of providing the entire requirement of trace minerals in an organic form is an option that is very expensive. To counter the pricing challenge, several producers of organic trace minerals



recommend their products at very low levels which, often, depress production specially in the long run.

This matter is further aggravated by the availability of sufficient forms of organic trace minerals with varying bio-availability.

For example: Leeson (2005) did not observe any significant difference between two groups fed with sulphate salts and with proteinates. The proteinates were fed as the sole mineral source that furnished 100%, 80%, 60%, 40% and 20% of the bio-available level of the mineral sulphates. He also commented, "Due to the ultra low mineral levels, it would be risky to feed such diets to the broilers in the field. In general: output will always decrease as supplementation level decreases."

3. **To supplement trace minerals in a combination of both organic as well as inorganic forms.**

It is observed that inorganic trace minerals exhibit an equally good or better bio-availability than organic minerals especially at lower levels of supplementation; hence the majority of the required optimal levels can be achieved by adding bio-available forms of inorganic minerals procured from a reliable source. To achieve a still higher mineral status in the bird, which may not be possible by inorganic minerals for reasons explained above the same can be fulfilled by adding appropriate forms of organic/ complexed minerals.

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 to provide a viable solution to trace mineral nutrition in modern day poultry.

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