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# **Progress and Prospect of** Nanominerals in Livestock and Poultry Nutrition

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### Abstract

inerals constitute a major role in production, reproduction and health of animals. Their deficiency or imbalances in diet lead to reduced growth and production. Nano minerals are mineral particles that exist in nano size (1-100 nm). Their action is attributed to their small size and increased surface area, thus leading to greater bioavailability. They are synthesized by physical, chemical or biological methods. Biological synthesis of Se nano-particle is gaining popularity due to its easily available source and less toxicity. Nano Zn particles could possibly reduce microbes generating methane in anaerobic fermentation. Thus, they reduced methane release and increased microbial biomass production. Sodium selenite nanoparticles were encapsulated by nano-precipitation for controlled release of Se nanoparticles. The release of selenium from nanoparticles was higher in acid (pH < 4), that caused better availability of the mineral in the small intestine.

## Introduction

inerals are most important nutrients necessary for different chemical reactions, physiological functions, growth, production and reproduction in animals. Many minerals which are present in feed have poor bioavailability and these minerals are required in large amount than actual requirement in the body of animals, thus increases in the production cost and due to less bioavailability in the body there is increase excretion of minerals in the environment causes environmental pollution. Antagonism properties of different minerals also reduce the bioavailability of minerals in animal body. Organic minerals are more bio available than inorganic minerals and have higher activity, higher digestibility but these are very costly. So new technology has emerged to minimize the antagonism properties among different minerals and increases the bioavailability, to improve the growth and production parameters, called as nanotechnology. Different nanominerals are prepared by nanotechnology and these nanominerals have different properties due to its altered structure like antimicrobial, antioxidant etc. Nanominerals are used as feed additives, supplements and help to improves feed efficiency, decreasing feed cost, increasing yield and value of animal products.

# Nanoparticles

anoparticles are microscopic particle with size ranges from 1 to 100 nm. Other names of nanoparticles are given as nano-powder or nano-cluster or nanocrystal.

#### **Properties of Nanoparticles**

hese nanoparticles are very appealing as they take very little space and have relatively leaguer surface area. When a bulky material is brought down to its nano

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size, the surface chemistry becomes more influential and the physical and chemical properties of the material alter. So, these are the altered properties of nanoparticles from its bigger counterparts.

• Nano-particles are less stable due to more active sites than larger structures.

• Nano particles have large surface area for chemical reactions to take place.

• Nanoparticles are mechanically strong and optically active particles.

• The reactivity of nanominerals increases about 1,000 times.

### Mode of Action

Nanoparticles have small size, greater surface area and altered properties. These are absorbed through blood vessels, distribute and retain in different body tissues and organs. Nanominerals enter into the cells by transcytosis process. Nanoparticles taken up by the villus epithelium may directly enter the blood stream and scavenged by liver and spleen. These are engulfed by kuffer cells of sizes 50-100 nm resulting in smaller particles (2 nm) being filtered out of the liver via the kidney whereas bigger particles (40 nm) are retained in kuffer cells. Small size of nanominerals increase uptake from GIT and hence make them more effective than the bulk mineral at lower doses. Because of increase uptake there is reduce excretion and increase bioavailability so requirement is less at cellular level.

# **Applications of Nanoparticles**

• *Therapeutics, Biocides (antimicrobial feed additives):* Nanosilver is used as an alternative to antibiotics to overcome the increasing incidences of antibiotics resistance.

• **Reproduction:** Nanoparticles of some metals fertility and protect spermatozoa has been found to enhance. Sperm purification through removal of damaged one via surface marker recognised by nanoparticle bound antibodies or lectins.

• **Diagnostics:** Iron oxide nanoparticles are used in magnetic resonance imaging to found exact causes of problems.

• *Food Safety Testing:* Nanoparticles used for identification of contaminant and pathogens for testing food safety.

• *Egg, Milk and Meat Quality:* Nano-particles have been tasted for treatment of mastitis for quality milk production. Copper nanoparticles used to improve meat quality.

• **Nutrient Delivery:** Naturally occurring nanoparticles in milk like casein micelle have been found for delivery of vitamin D. Encapsulated vitamin D in casein micelle was released at intestinal level for better absorption.

#### Some Studied Nanominerals in Livestock and Poultry are:

- Zinc
- Selenium

- Copper
- Calcium
- Silver

# Nano ZnO

n concentration in feed and fodders in most part of India is critically deficient. Nano Zn is the 3<sup>rd</sup> most widely produced nanomineral. Nano Zn has more bioavailability than organic and inorganic forms of ZnO.

#### Role of Nano ZnO in Methane Mitigation

Methane is major culprit of global warming released during fermentation of feed in rumen. To decrease the methane production from rumen, without affecting digestibility, animal health, and productivity is one of the main aims in animal nutrition. Microbes which are generating methane in rumen by anaerobic fermentation of feedstuffs are killed by ZnO nanominerals at the dose rate of 500 and 1000 ug/g. The enzymes acetate kinase and coenzyme F420 is for the energy production in bacterial cell, could be destroyed by supplementation nano ZnO. Methane producing bacteria present on the outer surface of protozoa as symbiotic association, supplementation of nano ZnO limit the available attachment sites on the bacterial cell.

#### Role of Nano-ZnO in Microbial Biomass Production

Nano-ZnO supplemented diet causes better adhesion of ruminal microbes to the feed, because both feed and microbes have negative charge on their surfaces which increases the microbial colony formation and also increases activity of microbial populations. Better synchrony between energy and nitrogen sources because of lower energy loss as methane could also improve microbial biomass production.

#### Antioxidant Property of Nano-ZnO

Nano-ZnO has smaller size, large surface area and more active sites to destroy the free radicles from the body thus it increases the antioxidant property. In poultry, nZnO improves antioxidant property and enhance the activity of some enzymes like superoxide dismutase, catalase, alaaminopeptidase activity, thereby these also decrease the free radicle from body and improve immunity, improves growth and carcass characteristics.

#### Antimicrobial Properties of Nano-ZnO

Annon like glycan sites present on the surface of microbes and their receptors for attachment present on intestinal wall. Nanominerals which have antimicrobial properties, bind to glycan site of microbes, so microbes not bind to intestinal receptors and wash off from intestine. Nano minerals have positive charge and microbes have negative chargethus they interact with each other and removed from intestine without affecting animal body. Nano-ZnO has bactericidal effect on spores, gram positive and negative microbes.



## **Selenium Nanoparticles**

G lutathione peroxidase contains selenium, have potent antioxidant property, which destroy the free radical from body by reducing peroxides and hydro peroxides in the animal body. Retention of selenium in the body and liver is higher in nano selenium supplemented diet than sodium selenite. There is variability in effect of nano selenium on growth performance but nano selenium has noticeable effects in tissue retention and antioxidant properties. Encapsulation of sodium selenite nanoparticles causes slow release of selenium and release of selenium is higher in acidic medium.

# **Copper Nanoparticles**

Copper nanomineral have good absorption which decrease copper dose and also decrease excretion in environment than organic and inorganic copper sources. Copper from copper nanoparticles sources shows better growth performance and immunity than conventional source of copper having large particle size. Copper nanoparticles have antibacterial, antifungal and antiviral properties.

# **Calcium Nanoparticles**

DCP used in diet of livestock but high concentration of limestone powder in diet can decrease the calcium, phosphorus and amino acid digestibility because of elevation of alkalinity in the intestine. Phosphorus is present in cereal crops but not much available to animal because it present as phytate.

#### Nano-Ca: Reduction of Heat Stress in Layers

Under heat stress there is heavy panting and development of respiratory alkalosis and increase urine excretion causing loss of calcium leading to formation of soft shell eggs but supplementation of nCaCO<sub>3</sub> in diet or drinking water of layers, reduced blood pH without affecting rectal temperature and egg production rate, there was stronger egg shell and water intake also increased, indicating amelioration of heat stress.

# **Silver Nanoparticles**

N ano-Ag is used in animal nutrition to reduce nitrogen oxides and ammonia emission. Silver nanoparticles have shown potent antibacterial activity against salmonella and campylobacter isolated from poultry. Best FCR was observed at 4 ppm Nano-Ag supplemented diet.

# **Toxicity of Nanominerals**

A part from positive effects of nanominerals some researchers have studies negative effect also. Naturally occurring nanominerals, which act as environmental pollutants, causes toxic effects on grazing animals near the industrial area. Free radicals form by nZnO causes oxidative injury and cell death because nZnO is much active and transformed into ions in gastric juice, so produced metal ions cause damage to hepatic and renal tissues.

# **Nanominerals: Future Prospects**

oxicity and safety margins of the mineral NP should be evaluated in animals and tested for long time before they can be recommended. Establishment safe and cost-effective nano minerals for inclusion in livestock feed. Environmental and biological fate, recyclability and overall sustainability assessment should be done. Microbial studies for nano Zn to establish their mode of action in rumen fermentation.

# Conclusion

t is concluded that nanoparticles are most recent form of minerals which fulfill the requirement of animal and having several useful properties. Nanoparticles having positive impact on livestock and poultry health, it improves feed conversion ratio, increase feed intake, increase nitrogen retention, antioxidant property, reduce the heat stress in poultry and enhances the microbial biomass. But the nano particles are not widely used because it is costly.

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