

Comparison of the Effects of Zinc-Methionine and Nano-Zinc Oxide Supplementation in Dairy Cows

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ABSTRACT

Zinc is one of the most abundant trace minerals, which are required by the body to maintain good health due to its role in multiple processes. There is a comparison between Nanoparticle ZnO(NP-ZnO) and Zinc-Methionine (Zn-Met), which are two different forms of zinc supplementation. There is a discussion on the effects of these zinc forms on the haematological parameters such as superoxide dismutase (SOD) and malondialdehyde (MDA), oxidative stress management, gastrointestinal tract (GIT) health, and milk production. Furthermore, the future aspects of zinc supplements in the udder health and reproductive health by improving the hormonal imbalance are discussed.

Keywords: Zinc supplementation, nano-particle zinc oxide, zinc methionine, dairy cow

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Introduction

Zinc is an essential trace mineral that plays important roles in regulating the normal physiology of the body. It is responsible for the regulation and functioning of more than 300 enzymes as a cofactor in the body [1]. Zinc not only acts as an activator of enzymes but also plays an important role in the regulation of oxidative stress in lactating animals, in neutralizing various oxidative species, such as superoxide anion(O_2^-) and hydrogen peroxide(H_2O_2). Furthermore, it is used to prevent the incidence of diarrhea in newborn calves [1].

With the advancement in science and quantum mechanics, there are modifications in trace mineral supplementation. In this article, a comparison of two such bioavailable forms of zinc supplementation is made: 1) NP-ZnO and 2) Zn-Met. NP-ZnO is an inorganic source of zinc, and Zn-Met is an organic source of zinc. NP-ZnO, having a particle size of 1-100 nm, has a significant value and a high surface area to quantity ratio. So, in this way, its bioavailability is greater than normal Zn in the body. NP-ZnO is often observed to have a higher absorption rate than any other source. It also helps in improving the function of microbiota in ruminants [2].

Zn-Met is one of the most bioavailable, organic sources of zinc; Methionine, being an amino acid, is not limited to protein synthesis only. It also improves milk yield and the overall health of the dairy cattle. It has a role in preventing fat accumulation in the liver and also promotes the absorption of zinc into the body [3]. Zn-Met is proven to have a significant role in improving udder health. This indicates that Zn-Met has a role in preventing diseases associated with the mammary gland. It is observed that Zn-Met leads to a reduction in the somatic cell count (SCC) in the milk [4].

Furthermore, this article includes a comparison of the effects of zinc-methionine and nano-particle zinc oxide with respect to haematological parameters, GIT health, oxidative stress management, and production health.

Effect on Haematological Parameters:

NP-ZnO supplement, being more bioavailable than any other source, indicates higher serum zinc levels, which are responsible for better hormonal balance from the hypothalamic-pituitary axis, which result into better reproductive health. This improved serum zinc concentration leads to a lower level of alanine aminotransferase (ALT), which catalyzes the synthesis of oxaloacetate in the liver, in the blood during the prepartum and postpartum period, which is increased otherwise, due to stress on the liver. Thus, NP-ZnO supplements are indicative of the hepato-protective role of zinc by managing ALT levels in the blood, if used in a recommended range of dosages to prevent toxicity. Furthermore, NP-ZnO at a dosage range of 40-60 ppm is beneficial for maintaining cholesterol levels for hormone production [5]. Supplementation with zinc-methionine has no impact on either blood triglyceride concentration parameters or on blood lipoprotein levels [3]. Zn-Met also evidently increased the albumin concentration in blood [3], whereas the NP-ZnO has no impact on albumin levels in the blood [12]. Zn-Met increased the calcium concentrations in the blood significantly due to its antagonistic effect. But there was a significant impact

on non-esterified fatty acid (NEFA) levels, which are indicative of the fact that Zn-Met mobilizes NEFA into the liver to help the liver manage the hepatocyte damage. The enzyme concentrations in blood have no significant impact due to Zn-Met supplementation [3].

Effect on GIT health:

NP-ZnO has very pronounced effects on reducing the incidence of diarrhea in young calves; this anti-diarrheal effect is due to enhanced immunity. This is because most of the diarrheal incidents were due to *Escherichia coli* (*E. coli*), and strong immunity lowers the burden of the pathogen. In cases of diarrhea, the rate of resolution of diarrhea was significantly shorter than that of the control group, as mentioned in the study. Furthermore, the faecal conditioning score (FCS) also improved as a result of NP-ZnO supplement [1]. Same results were observed in the cases of Zn-Met-supplemented calves; there were ~14% reduced incidences of diarrhea, and in the cases of diarrhea, there was relatively faster recovery than the control group in a study [5]. The incidence of diarrhea in young calves was also very low during the first month of life at a dosage of 80 mg/kg DM feed. And the average daily gain also improved significantly [8].

NP-ZnO in the feed reduces ammonia nitrogen (NH_3-N) content in the rumen. In a study, zinc improves the digestibility of the feed, leading to faster conversion of NH_3-N in bacterial protein. This improved digestibility causes higher dry matter intake (DMI). In another study, this effect is due to the action of zinc in inhibiting the proteolysis process [2].

Effect on Oxidative Stress Management (OSM):

Oxidative stress (OS) is the imbalance of the ratio of oxidative and antioxidant species [9]. NP-ZnO supplementation is responsible for managing OS, as zinc plays a cofactor role in various enzymatic activities, as a result of which, the superoxide dismutase levels in blood rise, indicating high antioxidant activity. Furthermore, there was a reduction in the blood malondialdehyde (MDA) levels; these two molecules are indicators of good antioxidant activity of zinc supplementation. Thus, there was an overall better OSM in animals supplemented with NP-ZnO instead of those that were given either no supplement or simple ZnO as a supplement [1]. The antioxidant activity of Zn-Met is similar in effect to NP-ZnO in reducing the blood concentration of oxidative species by metabolizing them with the help of enzymes such as SOD. These effects are products of zinc concentrations in blood, irrespective of their supplementation form [4]. This antioxidant role of zinc is associated with the fact that zinc promotes the expression of genes with antioxidant response element (ARE) components, which are responsible for the synthesis of antioxidant proteins such as SOD. These effects were observed at the dosage of 32 ppm of NP-ZnO[8].

These effects are limited to the involvement of zinc, but the methionine component of Zn-Met also plays a role during long-term environmental heat stress (LEHS), when the heat stress (HS) reduces the metabolism of amino acids (AA) in the body, alternatively, to promote nitrogen excretion into the blood. Thus, the supplement of AA, such as methionine in feed, helps in

maintaining the blood AA concentration, which ultimately leads to lowering the inflammation and oxidative stress [9].

Effect On Milk Production:

NP-ZnO is reported to have increased milk production compared to control groups at a dosage of 90 ppm, as mentioned in the study [2]. NP-ZnO is associated with improved milk yield with reduced somatic cell count and more resistance to the subclinical cases of mastitis [11]. It is observed that Zn-Met produces an average of 1.25 kg more milk than the control group, as mentioned in the study. This increment is a product of improved under health and reduced SCC, resulting in sustained milk output [4]. But this increment was observed after 70 days of constant organic zinc supply.

But there was no consistent increase in the fat content of milk; this fat increase was limited to a short period of time. The total protein content also improved. Thus, Zn-Met not only results in higher milk yield but also better milk quality than inorganic zinc.

Furthermore, the lactose concentration reduced while the solid-not-fat (SNF) levels remained unchanged [9]. It is observed that ZnO has an antagonistic effect on the calcium concentration in serum, which leads to hypocalcemia. This effect is more pronounced in lactating cows as compared to dry cows [10]. But Zn-Met increased the calcium concentrations in the blood significantly, which is opposite to the function of NP-ZnO[3]. The effects of zinc supplements are illustrated in the figure as:

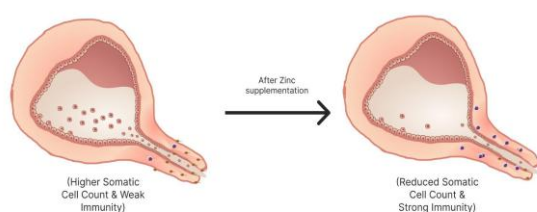


Fig. 1: Before and aftereffects of zinc Supplementation

Future Prospect:

Zinc supplements can be used in a wide range of treatments for improving the health and production of dairy cattle. Zinc can be used for balancing hormones in animals with hormonal imbalance due to mineral deficiencies. Thus, it should be used as a treatment for subclinical cases of mastitis and under-related disorders, as zinc reduces the somatic cell count in the milk. Zinc should be used in the treatment of diarrhea in dairy cattle, especially in young calves. In immunocompromised individuals, zinc can be used as an immunity booster as it plays a role in the synthesis of immune proteins.

Conclusion:

To conclude the discussion, there are two most bio-available forms of zinc supplements, i.e., NP-ZnO & Zn-Met. Both of these forms of zinc are excellent, as they both give good serum levels of zinc, NP-ZnO being more bioavailable due to its size, which results in better penetration into the cellular membranes, so NP-ZnO is better if solely Zn supplementation is required. But Zn-Met has other benefits, which are due to its Met group attached to it. These benefits include improved protein intake, better HS management, and a protective role. Some common benefits of both of these supplements are associated with zinc concentration in serum. Thus, Zn-Met should be used in cases where methionine, in addition to zinc, is meant for supplementation in feed, for the benefits mentioned above.

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