ISSN: 2356-7767

Overview on the Impact of Trace Element Zinc on Farm Animals Health and Performance

Hamada, M. Yousif*; Ahmed, M. El-Mahdy*; Reda, A.A. Rezk*; Marwa, F. Hassan* and Asmaa, G. Abd El Monsef**

*Department of Biochemistry, Nutritional deficiency diseases and Toxicology Animal Health Research Institute (AHRI), Agricultural Research Center (ARC), Dokki, Giza, Egypt.

**Department of Biochemistry, Nutritional deficiency diseases and Toxicology, Animal Health Research Institute (AHRI), Agricultural Research Center (ARC), Zagazig Provincial Lab, Zagazig, Egypt.

Review Article

Corresponding author:
Hamada Mahmoud Yousif
E.mail; hamadayousif82@gmail.com

Received in 19/11/2024
Accepted in 24/12/2024

Abstract

Trace elements have a crucial role in farm animal's health and performance. In animal life, zinc is thought to be the most important trace element. Meanwhile, it is crucial for metabolic pathways, immunological response, oxidative balance, homeostatic processes, and the operation of several proteins and enzymes that are involved in numerous physiological and biochemical activities. As a result, zinc directly affects immunity, growth, production, reproduction, and health. Also, it is a trace element that is required by several key enzymes, including catalase, reduced glutathione, glutathione peroxidase, and superoxide dismutase. Additionally, zinc improves an animal's resilience to sickness, which benefits its general health. Farm animals needed zinc supplements in order to either improve their overall health or prevent the negative effects of a zinc deficit. Most of newly studies were provided the better contributions of using zinc nanoparticles in improving livestock performances. This review highlights the impact of trace element zinc on farm animals health and performance, and the adversely effects of its deficiency, furthermore, the better uses of zinc nanoparticles supplements.

Keywords: *Trace element, Zinc, Farm Animals, Antioxidants, Nano-zinc.*

Introduction

1. Trace Elements Importance:

Trace elements (microelements), which are present in living tissues in veritably small quantities, such as zinc, iodine, iron, chromium, molybdenum, cobalt, copper, and selenium. Obtained substantially from sources of food, microelements principally serve as enzyme co-factors and are thus critical for maintaining immune response and health as well as improving growth, reproduction, and production **Duffy *et al.* (2023)**. Trace elements serve as cofactors for superoxide dismutase (SOD), thioredoxin reducates, reduced glutathione (GSH), glutathione peroxidase (GSH-Px), ceruloplasmin, and catalase (CAT). These metabolic compounds have antioxidant properties, and suppress oxidative stress via neutralizing oxidants generated under stress. Furthermore, trace elements improve general animal health through increasing disease resistance. They are essential for the proper functioning of numer-

ous proteins and enzymes, which are included in most physiological, metabolic and biochemical processes that support growth and production. In generally, trace elements ameliorate immune response as well as productive efficiency **Yatoo *et al.* (2013)**. Although the small amounts required from these elements, they're necessary for numerous biological processes, involving; production of energy, DNA transcription, protect cell injury by antioxidant activation, and accelerate the immune response, while trace element supplementation is pivotal to immunity enhancement, especially in stressed animals **Palomares (2022)**. Many factors impact the trace element status of farm animals, inclusive of the feedstuffs, mineral content of soils, animal productivity, age, trace element needs, containing of feed antagonists, and supplement formula **Marques *et al.* (2016)**. This review focuses on zinc as one of the essential trace elements.

2. Zinc:-

Zinc considers a vital functional and structural component of numerous enzymes and proteins needed in distinct metabolic processes. It performs a crucial impact of tissue development and growth, likewise; mucous membrane, skin, lymphoid and testicular tissues. At the same time, zinc contributes to the strength of the digestive and respiratory systems mucosal lining. Furthermore, it's included in epithelial integrity and mucosal tissue repair. This related to its capability to impact epithelium proliferation through involvement in replication and transcription of nucleic acid, as well as protein synthesis **Maywald *et al.* (2017)**. Numerous of zinc crucial roles are involvement in more than 300 co-enzymes metabolic activity, with its necessity for DNA and protein synthesis, and the function of immune system **Naji (2017)**. While its pivotal involvement in antioxidant system, which capable of tissue injury protection. So, if zinc deficient occurred, lipid peroxidation rises, resulting in tissue oxidative damage **Yousef *et al.* (2002); Wen *et al.* (2018)**. Zinc interacts with vitamin A, while it implicates in vitamin A metabolism, absorption, hepatic release, conversion, and tissue utilization of vitamin **Naha *et al.* (2016)**. It has a vital role in clonal growth with lymphocytes differentiation and proliferation prior to the execution of effector activities **Puertollano *et al.* (2011)**. Additionally, it plays a crucial role in release of cytokine via lymphocytes and macrophage throughout both natural and acquired immunity **Wang *et al.* (2013)**. It considered a component element of superoxide dismutase, a mitochondrial and cytosolic inter-membrane enzymes included with transformation of the superoxide radicals to the hydrogen peroxide **Bonaventura *et al.* (2015)**. Additionally, it plays a critical part in nitric oxide (NO) synthesis via macrophages, which is a vital molecule for bacteria killing **Abbas and Lichtman (2018)**. Furthermore, zinc plays a part in perfecting growth of epidermal cells, cellular integrity, keratin production, differentiation and proliferation of keratinocytes in the skin **Ogawa *et al.* (2016)**. Zinc has a vital impact on reproductive functions besides its influence on gonadotropin hormone excretion **Yan *et al.* (2010)**. Figure (1) a diagram illustrating the role of zinc in farm animal life.

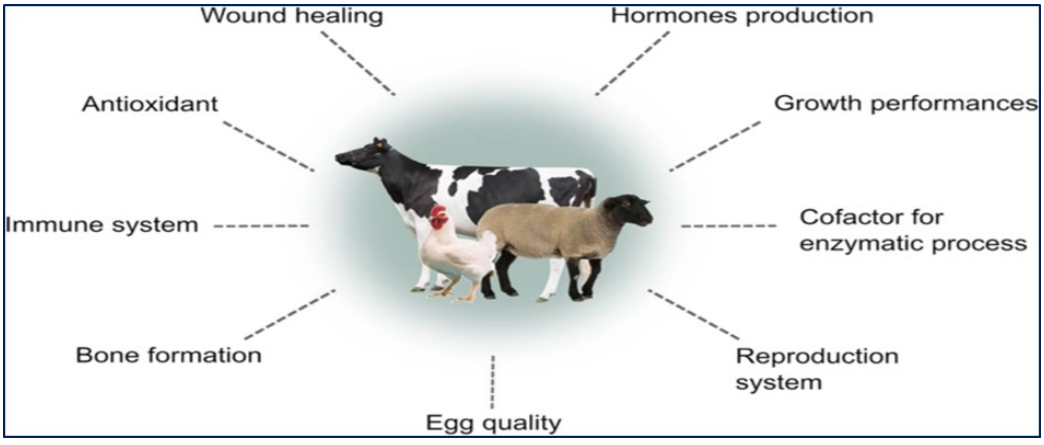

Figure (1). A diagram illustrating the role of zinc in farm animal life **Agrawal *et al.* (2023)**

2.1. Absorption and Maintenance of Zinc:
Zinc is mostly absorbed as divalent cations in digestive system, while excretion occurred in either labile or bounded with protein. Significant amounts of the labile-zinc are carried into the cytosol, where zinc-T proteins export the metal and carrier proteins like metallothionein sequester it **Bonaventura *et al.* (2015)**. The zinc conservation happens substantially in the gut. Absorption of zinc from diet occurred across the gut membranes. Also, the endogenous zinc released into the gut lumen, while part of it was reabsorbed and the other part excreted with feces. In cases of deficiency, intestinal absorption efficiency is increased, endogenous losses through bile and pancreatic secretions are reduced, and one part of which could be mobilized from skeleton **Windisch (2002)**. Whole-body zinc levels significantly influence the relative efficiency of absorption; however other elements like containing of food promoters or inhibitors with physiological conditions like age and disease can also have an impact **Maares and Haase (2016)**. As a result of zinc being involved as divalent cations, zinc absorption decreased via elevated the other divalent cations, like calcium, magnesium, copper, cadmium, iron, and nickel **Duffy *et al.* (2023)**.

2.2. Zinc Deficiency in Farm Animals:
Zinc deficiency in farm animals may be attributed to a ration composition of low levels of zinc with a higher level of calcium. While elevated calcium levels in rations reduce zinc absorption **Ibrahim *et al.* (2016); Yousif *et al.* (2022)**. Low levels of zinc may cause impaired hepatic synthesis of cellular retinol-pound protein, and vitamin A metabolism within the liver **Naha *et al.* (2016)**. Zinc insufficiency may result in an elevation of serum l-malondialdehyde, and a reduction of total antioxidant capacity (TAC), catalase, glutathione peroxidase, and superoxide dismutase activity. Meanwhile, zinc deficiency has adverse effects on antioxidant activities that affect growths, development, and immunity, with an extension to the animals exposed to various diseases **Song and Shen (2020); Yousif *et al.* (2022)**. Zinc and male reproductive hormones are strongly related; consequently, its deficiency in males causes hypogonadism. Furthermore, lack of zinc could influence testosterone levels, thyroid hormone production, and testicular dystrophy **Yan *et al.* (2010)**. Also, zinc insufficient impairs the two types of immunity. The first one innate immunity, while zinc insufficient adversely affects macrophage and neutrophils migration, phagocytosis, microorganism killing, skin integrity and mucous membranes development. The second one adaptive immunity, as soon as zinc deficiency adversely influences thymus function, furthermore proliferation, differentiation, activation, and cytokines production by lymphocyte **Rink and Gabriel (2000)**. Neonatal calves' diarrhea may be associated with the zinc status **Enjalbert *et al.* (2006)**.
In all farm animals, zinc insufficient has adversely effects on tissues integrity; skin, immune system, and digestive system, which clinically manifested by decreased feed intake, and reduced feed conversion, depressed growth, and parakeratosis of the integument **Bonaventura *et al.* (2015)**. Clinical signs of zinc-deficient lambs included poor wool growth with keratinization, scales, and crusts forming in the various body parts with rough wool, as well as an area of alopecia around the nose, eye, as well as tests **Yousif *et al.* (2022)**. Moreover, low appetite in growing animal may lead to skeleton deformity, immunopathology, including thymus atrophy and lymphoid depletion. Hypogonadism reduced androgen production and testicular development in bulls and rams. Additionally, infertility, reproductive impairment, abortions and retained placenta in females were associated with zinc deficiency **Duffy *et al.* (2023)**; many of these conditions can be prevented or even reversed with dietary zinc at recommended amounts.

2.3. Zinc Supplementation in Farm Animals:
Zinc dietary supplementation considered a routine practices for several farm animals **Underwood & Suttle (1999)**. This supplement is critically for inhibiting or overcome the clinical and biochemical changes related to zinc insufficiency. The current feeding program aimed to inhibit zinc deficiency while avoiding zinc toxicity, resulting in wide ranges of recommended dietary levels **Shurson *et al.* (2022)**. While, the common fed to farm animals constitutes several zinc concentrations that could participate in

nutrient requirement, diversity of zinc levels by the several sources, and components of plants that interrupt mineral utilization, such as phytic acids. The inorganic forms are the main extensively applied; however, the organic form appears to have a higher bioavailability. Zinc can be obtained as a zinc sulfates, zinc oxide, zinc-amino acid (zinc methionine, zinc glycine), zinc carbonate, zinc proteinate, zinc chelate, zinc propionates, zinc hydroxyl-chloride, and zinc nanoparticles **Duffy *et al.* (2023)**. Figure (2), a diagram showing the organic and inorganic sources of zinc in farm animals.

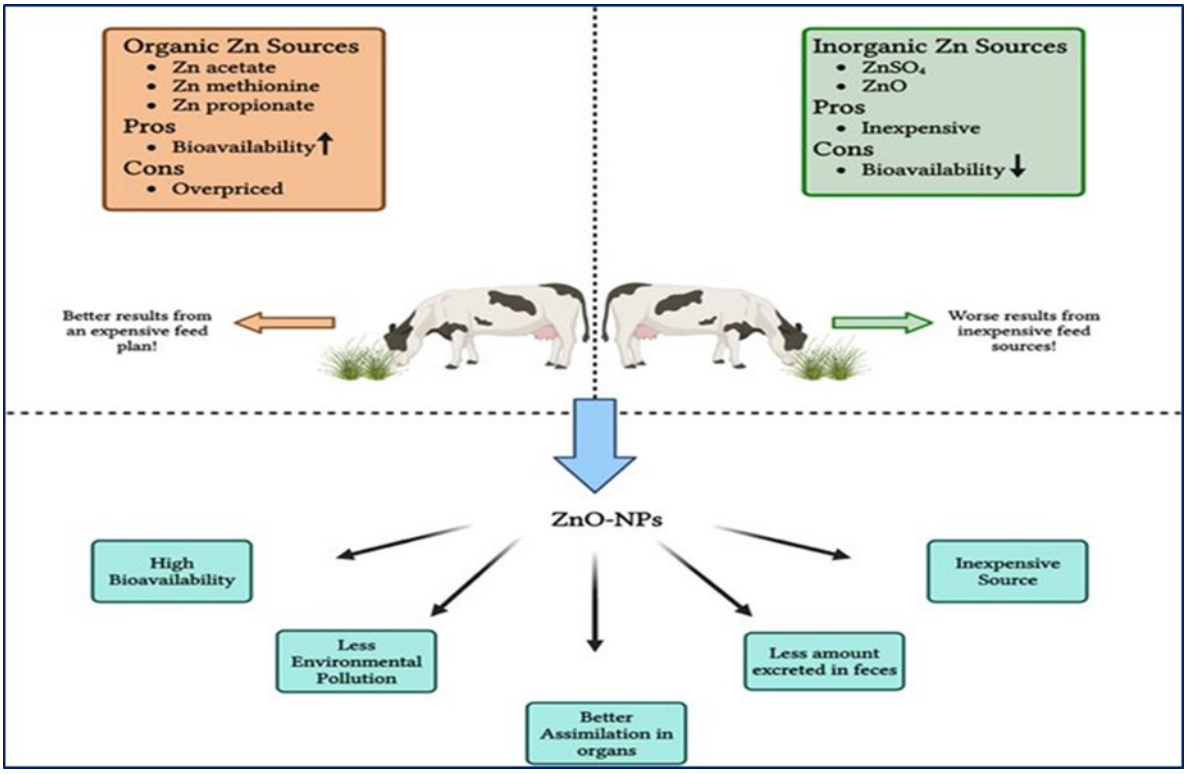

Figure (2). Both organic and in organic sources of zinc in farm animal feed **Fatima *et al.* (2024)**

Zinc Nanoparticle Supplementation:

Nano-mineral technology is widely applied of many sectors, like that agricultural field, food systems, and farm animals **Seven *et al.* (2018)**. Zinc oxide nanoparticles have better bioavailability, a high catalytic potency, greater surfaces area, stronger adsorbing ability, and higher surfaces activities **Raje *et al.* (2018)**, also because they are frequently easily carried up via the gastrointestinal tract and utilized within the animal system and reach deeper tissues more effectively than the larger or ordinary size particle **Liao *et al.* (2010)**. Nano zinc oxide is frequently willing by several methods, as the chemical precipitation, traditionally high-temperatures solid state method, hydrothermal methodology and sol gel synthesis **Wang *et al.* (2018)**. Zinc oxide nanoparticles have strong and rapid restraint once livestock fed in commensal diets, increasing growths, immune responses, reproductive performance, and fed efficiency **Mohamed *et al.* (2015)**. Nanoparticles of zinc oxide induced rapid recovery of tissue integrity, alopecia, and mange cases of sheep **Yousif *et al.* (2023)**. Furthermore, nano-zinc oxide has a stronger impact on both immune responses and antioxidants activities than zinc-oxide of normal size **Mansour *et al.* (2023)**.

Conclusion

Trace elements have an essential role in farm animals health and performance. Zinc considered one of the most critical trace elements, essential for main of body enzymes, metabolic processes, and the function of immune system. Insufficient zinc resulting in interruption of antioxidant activity and biochemical, that ad-

versely affects immune responses, as well as decreased appetite and feed conversion, depressed growth, and parakeratosis of the integument. Additionally, it could result in skeletal deformities in young animals, hypogonadism, decreased testosterone production, and in older animals, reproductive disorders, infertility, abortion, and placental retention. Nano-zinc supplement provide a rapid and efficient recoveries further than zinc-oxide in normal size, furthermore, nanoparticles of zinc-oxide has a greater impact on antioxidants and immunity.

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