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Zinc as an element of therapeutic importance: A review

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Abstract
Zinc enjoys vital role by being cofactor of large number of mettaloenzymes enzymes like carbonic anhydrase, superoxide dismutase, phospholipase A_2, alkaline phosphate, a-mannosidase, alcohol dehydrogenase, carboxypeptidase A and B, D-glyceraldahyde-3-phosphate dehydrogenase, glutamic dehydrogenase, lactic dehydrogense. Zinc deficiency may be caused due to primary deficiency of zinc in diet or secondary influences like increased phytate and calcium in diet. Zinc deficiency signs are more common in non ruminants; in ruminants the rumen environment overcomes the effect of phytate present in diet. Zinc deficiency causes skin lesions probably by interfering in protein synthesis, impaired immunity by affecting both cell mediated as well as humoral immunity, growth by depressing the appetite and decreasing feed conversion efficiency, infertility by causing retarded testicular development and interference in spermatogenesis.

Keywords: Trace minerals, Benefits, Zinc, Immunomodulation

1. Introduction

Preamble

Zinc was discovered in 15^{th} century and its role in life processes was first realized many centuries afterwards in 1869 [1]. It was found that zinc is imperative for growth of mould *Aspergillus niger* [2] experiments on laboratory animals found with conclusive evidence role of zinc in growth and health of animals [2]. Zinc is associated with more than 300 enzymes either as component, activator or cofactor for RNA and DNA polymerases [3-5]. Some of the important zinc dependent metalloenzymes include alkaline phosphate, a-mannosidase, alcohol dehydrogenase, carboxypeptidase A and B, carbonic anhydrase, D-glyceraldahyde-3-phosphate dehydrogenase, glutamic dehydrogenase, and lactic dehydrogenase [6-10]

2. Sources and bioavailability

The element is fairly widely distributed in nature. Natural sources of zinc for farm animals are primarily bran, grains and fodder yeasts [11].Yeast is a rich source of zinc, and this trace element is concentrated in the bran and germ of cereal grains. Animal protein by-products, such as fishmeal, are usually richer sources of the element than are plant protein supplements [12]. The common forms of zinc used to supplement animal rations are the oxide (ZnO) and feed grade sulfate (ZnSO4.7H2O). Dietary Zinc requirements for different species are comprehensively outlined by [13].

Absorption of Zinc occurs actively as well as passively. Zinc is absorbed actively according to needs of body [14-16] by carrier mediated transport [17] in proximal part of small intestine particularly duodenum [18]. Passive transport operates on a diffusion mechanism, and its effectiveness is proportional to the concentration of Zn in the intestinal lumen [19, 20]. There is a inverse relationship between dietary zinc levels and percentage zinc absorption from the diet, with increased zinc being absorbed when diet is zinc deficient [21] and vice versa [22, 23]. Zinc absorption is also influenced by the zinc status of the animal, zinc deficient animal absorb zinc more efficiently than animal having adequate zinc levels in their body [21, 23]

3. Interaction

In monogastric animals several nutritional factors including Cd, Ca, Mg, P, Cu, chelating agents such as EDTA, vitamin D, and phytic acid have much influence on zinc absorption and metabolism [24]. Phytic acid and calcium reduce zinc absorption in pig, poultry and rats.

Excess dietary calcium (0.5-1%) in pigs predisposes them to parakeratosis, and the addition of zinc to such diets at levels much higher (0.02% zinc carbonate or 100 ng/kg zinc) than those normally required by growing swine prevents the occurrence of the disease [25] while as increasing dietary copper level can decrease the requirement of dietary zinc. Plant proteins such as soya been meal or seasame meal reduce zinc absorption in poultry and pigs due to high phytic acid content [26-28]. In normally fed ruminants, phytic acid or other factors in plant proteins don't decrease zinc absorption presumably because phytic acid is broken in the rumen environment [29, 30]

Predominant route of zinc excretion is through pancreatic secretion and ultimately out of body through feces, urine plays only a minor if any role in maintain zinc homeostasis of the body [31] In milk Zn is bound primarily to colloidal calcium phosphate of the casein micelle [32]. In the blood zinc is 75 % bound in plasma (primarily to proteins), 22% in erythrocytes 3 % in leukocytes [33]. Glucocorticoids and cytokines reduce plasma zinc and increase hepatic zinc by inducing MT (metallothionein) synthesis [34]

Multifaceted role of zinc in animals

1. growth and digestibility

Zinc deficiency has been documented to reduce growth rate of animals. Growth retardation seen in the case of Zn deficiency may be attributed to loss of appetite, imperfect use of nutrients from feedstuffs, and in disorders of the protein and energy metabolism [35]. Zinc deficiency in calves decrease the dry matter intake, feed conversion efficiency and growth [22]. Reduction in feed conversion efficiency was found not due to impaired digestibility but apparently due to less efficient utilization of digested nutrients [36-38] However found no effect of zinc intake on the growth rate of calves fed with three different levels of zinc.

2. Reproduction

Zinc deficiency was seen to cause retarded testicular development in bull calves [39] and ram lambs [25] with complete cessation of spermatogenesis, pointing towards impaired protein synthesis. However early mitigation of zinc deficiency in bull calves restored normal histological appearance of testis and semen production [15], which is in contrast to findings on rats in which severe zinc deficiency produced permanent and irreversible damage to testicles [40].

3. Immunomodulator

Zinc plays a important role in immune system [41], cell-mediated immunity [42] as well as humoral immunity [43-45] Reported the immunosuppression in trychophytosis was associated with zinc deficiency. Zinc along with copper, acts as a essential cofactor of enzyme super oxide dismutase (SOD), which is an anti-oxidant [46, 47] and thereby protects the cell membrane and organelles from the harmful effects of superoxide anions [48, 49] produced in course of normal cellular metabolism.

4. Skin Health

Zinc deficiency causes parakeratosis due to failure of proper keratinzation [25]; a disorder involving epidermal layers of skin is a late sign of zinc deficiency in all species characterized by thickening, hardening and fissuring of skin [13, 50] Attributed these signs to impaired protein synthesis in zinc deficiency. Predilection sites vary between species as follows: feet and feathers in the chick [51] the extremities in young pigs [52]; the muzzle, neck, ears, scrotum and back of the hind limbs in calves [22]; the hind limbs and teats in the dairy cow [53]; and around the eyes, above the hoof and on the scrotum in lambs [30]. In calves and other ruminants it manifests itself as shedding of the coat around the eyes ("glasses"), on the head, neck and limbs [54-56, 25] reported that zinc deficient cattle showed cattle reduced growth and feed intake, excessive salivation, swollen feet with open, scaly lesions and impaired reproduction and loss of hair and skin lesions which are most severe on legs, neck, head, around the nostrils.

5. fat absorption

Phosphor-lipase A_2 secreted by pancreas is a zinc dependent enzyme [57]. Phosphatidayl choline is hydrolyzed by zinc-dependent phospholipase A2, thus facilitating fat absorption and formation of chylomicrons, which are crucial for the absorption of fat micelles [58].

6. Role of zinc in Skelton disorders

Zinc plays a role in bone formation by affecting biological processes at several levels, encompassing DNA synthesis, cell division and gene expression [42] and as a component of alkaline phosphatase (ALP) [59, 60], which plays a role in ossification of bone.

7. Conclusions

Zinc is a important trace element which plays a vital role in normal health, growth and productivity of all farm animals and humans. Probably economic losses are more due to subclinical deficiency which causes impaired immunity predisposing the animal to infectious diseases, ill thrift, loss of productivity and reproductive inefficiency. Dietary zinc estimation can provide valuable information in ruminants; however in monogastric animals the method is not always useful. Preventive strategies include fertilization of pastures in endemic zinc deficient soils or supplementation of deficient animals with dietary zinc.

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