A Review of Zinc Nutrition on Extensive Rangeland

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Abstract

Zinc sufficiency in animal body system have been discovered to contribute to immunity and form part of essential enzymes used for maintaining animals health and promotion of fertility. Nutritional value of zinc cannot be overlook as it affect apparent digestibility and absorption of other nutrients. In depletion-repletion trials, zinc have been established to play critical roles as proteolytic enzyme associated with muscle protein turnover. Zinc in animals is important for energy production through carbohydrate metabolism, protein synthesis, stabilization of animal cellular membrane against pathogenic microorganisms, function as antioxidant agent, maintenance of blood cells altogether resulting into improved immunity and better performance of animals. For animals on extensive grazing, primary source of zinc is forage however the zinc in forage is limited in absorption by animals because the mineral is found in plant cell wall which hardly hydrolyzed easily by the enzymes of the small intestine. This need assessment of extensive rangeland for biological examination of zinc for purpose of promoting animals improved performance on range. Therefore, this paper present a review of zinc nutrition on extensive rangeland. The objectives of the review is to give an overview account of importance of zinc to grazing animals, procedures for evaluation of zinc in range pasture, need for exogenous zinc supplementation for animals on range and sources of external zinc supplements.

Keywords: Zinc, rangeland, zinc proteinate, zinc sulfate, animal performance.
Introduction

Mineral nutrition in animal is essential to their well-being and production performance. Some of these minerals are required in large quantity while some of them are required in little quantity by animals. The minerals required on large quantity by animals are regarded to as macro minerals while those require in small quantity are termed as micro minerals. Whether in small or large quantity, mineral that are essential to life of living organisms are 22. The macro minerals among the essential minerals are 7 while micro minerals among the essential minerals are 15. The macro essential minerals are calcium, phosphorus, potassium, sodium, chlorine, magnesium and sulfur; essential micro minerals includes iron, iodine, zinc, copper, manganese, cobalt, molybdenum, selenium, chromium, tin, vanadium, fluorine, silicon, nickel and arsenic (Underwood, 1981).

These minerals either macro or macro, they are require for various biochemical activities within the body systems. These functions are broadly categorized into structural, physiological, catalytical and regulatory roles in the body systems. Some minerals forms parts of some important structural components of the body organs and tissues; these minerals include calcium, phosphorous and magnesium that form reasonable components of the bone. Minerals are also components of body protein and contribute to structural frame of body. An example of this is zinc that contribute to structural stability of the body molecules and membranes.

Deficiency in zinc by grazing animals cannot be overlook because such deficiency can lead to gross economic loss since it affect growth, health and general well-being of the animals. Zinc is important in vital body activities such as cell-division. Adequate zinc is also required as part of metalloenzymes that promote DNA metabolism at cellular levels. Zinc supplementation prevent a disease condition reffered to as paraketosis in swine and ruminant animals (a condition whereby animal skin becomes thicken and dry-up). In poultry chicks, zinc deficiency cause poor feathering and skin lesion.

Minerals also act as catalyst in enzymes and endocrine system; they also form specific components of metalloenzymes and hormone as well as co-enzymes. An example of this mineral is zinc; this established zinc as a vital mineral. Zinc perform multiple roles in organism system ranging from anabatic to catabolic role and antioxidant. Zinc and some other minerals are found as main or major components of metalloenzymes that are presented in the table 1 below:

<table>
<thead>
<tr>
<th>Metal</th>
<th>Metalloenzyme or metalloprotein</th>
<th>Functions</th>
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<tbody>
<tr>
<td>Fe</td>
<td>Hepcidin</td>
<td>Iron regulating hormone</td>
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<tr>
<td></td>
<td>Succinate dehydrogenase</td>
<td>Oxidation of carbohydrates</td>
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<td></td>
<td>Hemoglobin</td>
<td>Oxygen transport in blood</td>
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<td></td>
<td>Catalase</td>
<td>Protection against hydrogen peroxide, H₂O₂</td>
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<tr>
<td>Cu</td>
<td>Cytochrome oxidase</td>
<td>Terminal oxidase</td>
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<td></td>
<td>Lysyl oxidase</td>
<td>Lysine oxidation</td>
</tr>
<tr>
<td></td>
<td>Hephaestin</td>
<td>Iron absorption</td>
</tr>
<tr>
<td></td>
<td>Caeruloplasmin</td>
<td>Copper transport</td>
</tr>
<tr>
<td></td>
<td>Superoxide dismutase</td>
<td>Dismutation of superoxide radical, O₂²</td>
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<tr>
<td>Mn</td>
<td>Pyruvate carboxylase</td>
<td>Pyruvate metabolism</td>
</tr>
<tr>
<td></td>
<td>Superoxide dismutase</td>
<td>Antioxidant by removing O₂</td>
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<tr>
<td></td>
<td>Glycosyl aminotransferases</td>
<td>Proteoglycan synthesis</td>
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<td>Se</td>
<td>Glutathione peroxidases (four)</td>
<td>Selenium transport and synthesis of selenoenzymes</td>
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<td>Removal of H₂O₂ and hydrogenperoxides</td>
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<td>Type 1 and 2 deiodinases</td>
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<td>Conversion of tetraiodothyronine to triiodothyronine</td>
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<td></td>
<td>Selenocysteine</td>
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<tr>
<td>Zn</td>
<td>Carbonic anhydrase</td>
<td>Formation of carbon dioxide</td>
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<tr>
<td></td>
<td>Alkaline phosphatase</td>
<td>Hydrolysis of phosphate esters</td>
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<td></td>
<td>Phospholipase A2</td>
<td>Hydrolysis of phosphatidylcholine</td>
</tr>
</tbody>
</table>
However, the functions performed by minerals can only be fulfilled if sufficient amounts of the ingested mineral are absorbed and retained to keep pace with growth, development and reproduction to replace minerals that are lost either as products, such as in meat, milk or eggs, or insidiously during the process of living (Suttle, 2010). This is the reason why zinc sufficiency is very important for animals especially ones that are grazing extensively this is because zinc is found associated with cell walls of forages and cell walls composed of materials that are not easily hydrolyzed by the enzymes present in the intestine of animals.

**Evaluation of Minerals Status on a Rangeland**

Although, an understanding of mineral status of a rangeland can be done through soil mapping and analysis, this can give account of particular mineral deficient or available in a particular rangeland but this may not be suitable or may not support livestock production because a mineral available in the soil may not be biologically available for livestock nutrition (Suttle, 2008). Because of many impeding factors that can militate against transmission of minerals from soil to livestock that are grazing, it is more accurate to evaluate mineral status of a land by grazing animals on such rangeland, animals on such soil will give true account of the target mineral and a result that would have remain empirically as figure can be biologically meaningful and support animal production as well as assist in making decision on production of animals.

Even collection of forage from rangeland for laboratory analysis to measure the level of minerals may not provide adequate biological viable result of mineral status of a rangeland because animal often do selective grazing on field. Animals show preferences for different types and parts of plants which can vary widely in mineral concentration. For example, selective grazing by animals on range greatly influences the assessment of dietary minerals status and could equally influence mineral intakes where livestock have access to a mixture of pasture and browse material (Fordyce et al., 1996). Although, plant material selected during grazing can be sampled via oesophageal fistulae, but the contamination of masticated food with saliva can complicate interpretation of such findings. Therefore mineral supplementation trial of animals on range can give a more accurate findings of mineral nutrition status of a rangeland.

**Nutritional Functions of Zinc**

The findings of (Todd et al., 1934) set the first undisputable evidence for the nutritional need of zinc by animals for promotion of growth and health of animals but this was established with laboratory animals. The evidence in domestic food producing animal species did not came up until more than 20 years later where experiment showed that zinc deprivation in chick, lamb, calf and piglets led to a disorder characterized by loss of appetite, growth depression, abnormalities of the skin and its appendages as well as reproductive failures. When zinc was supplemented to feeding of animals with aforelisted disorder, it was observed that animals regain well-being and grow better (Suttle, 2010). This means zinc is a mineral whose requirement is central to animals feeding improvement, good growth and bodily well-being.

Zinc function in several metalloenzymes and also act as catalyst in many body biochemical reactions. Zinc is required in formation of structural and functional integrity of more than 2000 transcription factors and almost every signaling and metabolic pathway is dependent on one or more zinc-requiring proteins (Beattie and Kwun, 2004; Cousins et al., 2006). Zinc-finger is an important enzyme that is used up in DNA metabolism for transcription and cell division processes; tetrahedral coordination of zinc to cysteine and histidine residues creates zinc-finger domains in DNA-binding proteins (Berg, 1990). Zinc is majorly require in livestock for gene-expression, fat-absorption, appetite control and antioxidant. In fat absorption, zinc is a factor affecting production of phospholipase A2, this enzyme (phospholipase A2) hydrolyses phosphatidylcholine, facilitating its absorption and the formation of chylomicrons, which are crucial for the absorption of fat micelles. This mechanism ensure utilization and derivation of energy from fat sources of feed available to livestock. It also promote utilization of vitamins A, D, E and K since they are all fat-soluble vitamins.
A REVIEW OF ZINC NUTRITION ON...

This function also hold a potential for exploration of zinc nutrition status as it affect fatty-acid content of animal products such as meat and milk. Zinc when deficiency in all animal cause inappetence, retardation or cessation of growth and lesions of the integument and its outgrowths – hair, hoof, horn, wool or feathers (Suttle, 2010).

**Sources of Zinc in Animal Nutrition**

There are two main sources of zinc for animals on range, this include natural and synthetic sources; zinc sources are also classified as organic and inorganic sources, most often than none, natural sources are organic sources of zinc for animals consumption but there are some synthetic sources that are also categorized as organic sources, this include complex zinc compounds such as chelates and proteinates. Inadequate supply of zinc from either of the sources is more or less a process of slow killing for the animals because the main problem associated with zinc deficiency is anorexia (animal’s inability to feed); this give room for poor overall performance of the animals (Suttle, 2010). Forages on rangeland are good source of organic zinc for animal consumption. Zinc is found in forages at levels between 25mg to 50mg per kilogram dry matter. Although some studies put the record at 7mg to 100mg per kilogram dry matter of forages across the world. But irrespective of the level and quantity of zinc in the forage consumed by animals, zinc bioavailability to animals is limited and is under factors including soil zinc status and sward maturity, climatic factor, part of the forage consume by animals, age of the animals consuming the forage and above all the type of digestive tract of the animal. Some animals because of their stomach type, can derive very limited amount of zinc from forage due to lack of fermentation in stomach complex, an example of this is pig, horse which cannot ferment forage consumed. Even ruminant animals with capacity to ferment in the rumen may not utilize zinc to the fullest from forage because zinc are abundantly associated with cell walls of plant as such the zinc is lignified and then prevented from being absorbed in the intestine.

Techniques for improving bioavailability of zinc from forage include application of zinc based fertilizers, harvesting of forage when young before they become lignified, improved pasture management, cultivation of grass and legumes with higher zinc level and production of silage for animal consumption (Masters and Somers, 1980; Underwood and Suttle, 1999; Grace, 1972 and Minson, 1990). Supplementation of zinc from inorganic sources for animals on rangeland has not proven as better alternative to all these management techniques for improvement because, zinc from inorganic sources are volatile and are absorbed across the rumen before getting to the small intestine where absorption by villi take place to enhance animals utilization and performance.

**Zinc Requirement Level on a Rangeland**

For accurate assessment of zinc nutrition status on a rangeland, there is need to understand metabolism underlying zinc within the body system. Zinc when consumed by animal is absorbed in the small intestine especially in monogastric animal, but in ruminant animal because of the rumen fermentation zinc is absorbed and lost in the rumen especially in sheep (Gregory, 2006). Zinc absorption is through mucosal of the intestine across enterocytes brush boarder then into the circulatory system and it is a metabolic process that is being regulated by metallothioneine. Absorption of zinc depend on body zinc need and saturation level in the diet of the animals. In calves apparent decrease in absorption of zinc decrease from 0.47 to 0.22 of zinc as zinc concentration in milk replacer increased from 40mg to 1000mg per kilogram dry matter (Jenkins and Hidiroglolu, 1991). Relative Biological Value of zinc is under influence of phytase and some minerals such as calcium. In a study by (House et al., 1989), a small increase from 6.0 to 7.4g of calcium per kilogram dry matter reduced the relative biological value of zinc for chicks by 3.8 folds higher.

Zinc requirement of grazing animals is high and vary per kilogram dry matter; growing bulls housed and fed 30mg to 50mg zinc per kilogram dry matter developed foot lesion, also growing bulls on rangeland with forages containing 18mg to 88mg zinc per kilogram dry matter developed skin lesion; these show that zinc nutritional require for animals on range is high and varied greatly (Suttle, 2010). In a study by (Maryland et al., 1980), range pasture...
with zinc concentration between 12-25mg per kilogram dry matter showed growth retardation but such animals graze well and remain physically healthy.

In sheep, zinc is require for live weight gain, wool growth and fertility especially in male where zinc for part of major enzymes involved in the processes of spermatogenesis because this processes require huge cell formation and divisions. In goats, the requirement for zinc is lower compare with that of sheep and cattle but for lactating goats, zinc requirement is the same as that of sheep and cattle. Horses under intensive management require higher zinc compare with horses on rangeland because cereals forming major components of housed horse feed contain phytase which limit availability of zinc for the animals. Hence, such animals need to consume more to overcome the challenge of the phytase. But horses on rangeland just like ruminant animals, they thrive well on pastures with zinc level between 30mg to 50mg per kilogram dry matter feed.

**Genetics and Zinc Deficiency on Rangeland**

Animals respond to an inadequate zinc supply by up-regulating several intestinal zinc transporters, detectable by mRNA abundance assays (Suttle, 2010). Zinc deficiency result to cause of genetic disorders in animals. In laboratory animals such as mice, zinc deficiency lead to a disorder reffered to as lethal milk syndrome. It is an inherited trait from parent whereby offspring from such parent when fed with lethal milk, the offspring died after nursing. When this was observed in laboratory animals; the animals were fed zinc supplemented glycine. Zinc deficiency in food producing animal can cause a genetic disorder refered to lethal trait A46 otherwise reffered to as Adema. It is a genetic disorder originated from Scotland in the mid-fifties. Animals with this genetic disorder are normal at birth but began to produce excessive saliva at 2-4 weeks of age. This follow by hair loss around the mouth, eyes, and anus, erosions within the mouth and skin lesions on the legs, abdomen and thorax (Gregory, 2006). Zinc supplementation has been shown to control problems associated with adema disorder in animals. The doses of zinc needed to treat the animals with the trait were 200 times higher than those needed by normal animals, simply because the lethal trait animals are unable to absorb zinc efficiently. This strongly suggested the loss of a transport mechanism for zinc in the intestinal mucosa.

**Assessment of Zinc Status of a Rangeland**

The rangeland can be describe as a large proportion of grassland producing native forage for animal consumption under natural condition (i.e. the rangeland is not intensively managed). To assess zinc status of a given rangeland; experimental animals such as growing lamb or goats can be allowed to graze extensively on the rangeland. Then in addition to the zinc naturally derived from the pasture forage, animals can be divided into treatment groups and fed with supplemented graded levels of zinc from both organic and inorganic sources. The animals unsupplemented will give condition of zinc in the natural rangeland while the supplemented animals can give what source and levels of zinc will be require in case the zinc level of the range is not sufficient for the grazing animals.

Inorganic zinc sulfate can be used as zinc supplements while zinc proteinate can be used as organic synthetic source of zinc for animals supplementation. There are many laboratory and experimental procedures described for the production of the zinc proteinate and other zinc complex Lee et al., (2006). Zinc supplementation can be done through formulation of concentrate diets with zinc sulfate and zinc proteinate for consumption of the experimental animals daily throughout the experimental period.

Animals in the experiment must be animals of known weight which will be the initial weights of the animals; for possible estimation of animals weight gain per given area of range, an evaluation of the rangeland area becomes necessary. This procedure will give room for evaluation of effects of zinc supplementation on animals weight gain. Common forages on the rangeland will also be necessary for harvesting and the analysis in the laboratory for their zinc composition. This will give room for comparative analysis of chemical composition and biological value of zinc in range pasture plants.
A REVIEW OF ZINC NUTRITION ON ...

Conclusion

Zinc is one of the most limiting minerals in rangeland forage; because of its nutritional importance it evaluation on extensive range becomes necessary so as to take decision on what type and levels of zinc supplementation in require to ensure optimum livestock performance on extensive rangeland.

References


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