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Effect of Dietary Zinc and Manganese on Performance, Skin Quality and Meat Quality of Broilers: A review

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Abstract

Trace minerals such as zinc, copper, and manganese are essential cofactors for hundreds of cellular enzymes and transcription factors in all animal species. Thus, trace minerals participate in several biochemical processes such as immune development and response, tissue and bone development and integrity, protection against oxidative stress, and cellular growth and division. Trace minerals are critical for a wide variety of physiological processes in all animals. Besides, Trace minerals act as cofactors of enzymes which are important to the immunity of animal. Superoxide dismutase, glutathione reductase, glutathione peroxidase, thioredoxin reductase, ceruloplasmin and catalase are important enzymes that have trace elements as cofactors. These enzymes act as antioxidants and prevent oxidative stress by neutralizing oxidants produced under different stresses. Zinc (Zn) and Manganese (Mn) are important trace minerals in animal nutrition involved in many metabolic processes, including growth, skin quality and wound healing. Bioavailability of these trace mineral can be improved through complexing them with available compounds that can enhance mineral absorption. Zn complexed with organic compounds showed better absorption in animals than inorganic Zn sources. Overall, trace minerals improve competence and productive performance and meat quality.

Key Words: Trace Mineral, Zinc and Manganese, Poultry, Response, Production

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Introduction

Many dietary nutrients are required in order to promote good health and normal growth of animals. Trace elements are required in small amounts, usually less than 100 mg/kg dry matter [1]. In commercial poultry diets, majority of trace minerals are commonly supplemented in the form of inorganic salts, such as sulfates, oxides and carbonates, to provide levels of minerals that prevent clinical deficiencies and allow the birds to reach their genetic growth potential [1]. Zinc (Zn) is an essential mineral that exerts its biochemical functions in association with proteins (2-4). Zinc is an important trace mineral in poultry nutrition for growth, bone development, feathering, enzyme structure and function [5].

Manganese (Mn) is an essential mineral that functions as an enzyme activator and is a constituent of multiple enzymes [3, 6]. A summary of enzymes that require manganese associated physiological functions as well as deficiency symptoms that occur when the manganese supply is inadequate. Manganese is absorbed rapidly in the small intestine via a carrier mediated mechanism [7].

Bioavailability of trace minerals

Zinc is an important trace mineral in poultry nutrition for the growth, bone development, feathering, enzyme structure and function [5]. Trace mineral supplements such as Zn and Mn are often added to broiler diets as sulfates, oxides, chelates, proteinates, or polysaccharides [8]. The two feed grade sources of Zn widely used in poultry industry are zinc oxide (72%) and zinc sulfate (36%). Zinc sulfates are highly water soluble, reactive metal ions that promote free radical formation. Free radicals decrease the nutritional value of the diet due to breakdown of vitamins, and fats [5]. Zinc oxide is less bio available than zinc sulfate. Zinc oxide has a bioavailability ranging from 61 to 77% relative to zinc sulfate, with tibia zinc being more responsive to dietary zinc source than weight gain (8). Manganese sulfate has been reported to have more bioavailability in broilers when compared with manganese oxide and manganese carbonate [9]. Manganese oxide had a relative bioavailability of 79%, 58%, and 64% for bone, kidney, and liver respectively compared with manganese sulfate with a relative bioavailability of 100% for all response variables [10]. Because of the high bioavailability of the sulfate forms of trace minerals, they are used to assess the bioavailability standards of organic trace minerals [11].

Organic mineral sources exist in the form of metal amino acid chelate, metal proteinate, and metal specific amino acid complexes. Metal amino acid chelate and metal proteinate are the chelation of a soluble salt with amino acids or hydrolysed protein. The molar ratio is 1 mole of a soluble salt with 2 or 3 moles of an amino acid. However, metal specific amino acid complexes and metal amino acid complexes consist of a specific amino acid or free amino acids compiled with a soluble metal salt in a molar ratio of 1:1. Organic sources of trace minerals have greater bioavailability because of the ability of organic compounds, such as amino acids, to bind strongly to zinc under physiological pH conditions [12].

Biochemistry of trace minerals

Zinc is an important element in the nutrition of human beings, animals, and plants. Its atomic number is 30, atomic weight 65.38, found as a soil constituent (ZnS). The average Zn content of the animal body is approximately 30 mg/kg of body weight; a major portion of this is present in bone and is unavailable to metabolism [13]. About 65% of the body Zn is found in the skeletal muscle. High concentrations are also present in liver, kidney, skin, hair and wool, and intestines [13]. The primary function of zinc is being a co-factor for enzyme activation. Zinc is known to be necessary for more than 100 enzymes associated with carbohydrate and energy metabolism, protein degradation and synthesis, nucleic acid synthesis, heme biosynthesis, carbon dioxide transport, and other reactions [13]. In enzymes systems, zinc acts as cross-link between enzyme proteins, thereby stabilizing enzyme structure. Because of its association with enzyme systems, Zn affected many physiological and metabolic activities [14,15]. In poultry, Zn maintains optimum growth rate and skin quality, bone strength, feather development, bone development and wound healing

Manganese is an essential element in the nutrition for humans and animals. Its atomic number is 25, atomic weight 54.94 and is, found as a soil constituent. Manganese can be found in bone, liver, kidney and pancreatic tissue, but manganese has low concentrations in animal tissues. Manganese is poorly absorbed from the intestinal tract; however, absorption occurs into mucosa cells throughout the small intestine. It is bound to α-2-macroglobulin when transported to the liver. Manganese is excreted through bile and pancreatic juices and ultimately via feces. Manganese is involved in numerous enzyme systems as both a cofactor and a structural component. The metabolic and physiological activities of Mn are attributable to its association with enzymes including oxidoreductases, transferases, hydrolases, lyases, and synthetases involved in carbohydrate, lipid, protein and nucleic acid metabolism. Manganese affects animals in three systems; bone, reproductive and brain [16].

In evaluate the influence of zinc oxide or zinc methionine on reproductive performance of broiler breeder hens [17] could not demonstrate any effect of Zn source on fertility, hatchability, mortality, egg and chick weight, feed conversion and body weight. In turkeys, zinc methionine improved body weight and feed conversion, and decreased mortality and leg abnormality [18,19]. Broiler chicks and turkeys fed low zinc diets reported high mortality rates [20].

In another study, three supplemental manganese sources (manganese sulfate, manganese oxide, and manganese proteinate) fed at three different levels (1,000, 2,000 and 3,000 ppm) and examined, but the study could not demonstrate significantly feed intake and feed conversion differences in broiler chickens [21]. They concluded that organic manganese may be more effective during heat stress periods when feed intake is reduced but availability is increased. In another study by Baker and Halpin [11], weight gain, feed intake and feed conversion were not different when chickens were fed manganese sulfate or manganese proteinate.

Effect of Dietary Zinc and Manganese on broiler performance

Appearance is the major criterion of evaluation of meat quality and purchase for consumers. However; other quality attributes, such as tenderness, drip loss, cook loss, water holding capacity and pH are equally important during the preparation of meat. Assessment of water holding capacity (WHC), drip loss and cooking loss of meat is very important for both fresh meat and further

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processed products, where high yield and low cooking losses are desired [22]. Raw meat used in further processed products should have excellent functional properties to ensure a final product of exceptional quality and profitability.

In recent years, the use of organic trace minerals in animal nutrition has received increasing attention. Zn and Mn are important trace minerals that are commonly added to poultry diets to maintain optimum growth rate, skin quality and wound healing. Bioavailability and absorption of inorganic mineral supplements can be improved through complexing them with more readily available compounds (amino acids, proteins, carbohydrates, organic acids). Therefore, an amino acid complexed Zn product may contribute to improved animal performance and meat quality attributes beyond that of an inorganic Zn source. In chickens, Zn has been associated with growth feathering and skin condition [23]. When Zn levels in the diet were below the requirement, mortality rates and leg abnormalities in broiler chicks and turkey poults were increased [20]. A previous study showed that ducks receiving feed with chelated trace elements improved the feed conversions [4]. Little information is available regarding the effects of complexed Zn and Mn sources on live performance and meat quality in broiler chickens.

Effect of Dietary Zinc and Manganese on skin quality of broilers

Skin associated downgrading problems (cuts and tears) continue to cause substantial economic losses to the United States broiler industry. Skin defects also result in lower productivity, loss of markets and decreases in product wholesomeness. Skin lesions, such as sores, scabs and scratches or underlying infections, mostly occur during the grow-out phase, and contribute to skin tearing during processing [24]. Skin lesions in broilers can be increased due to poor management conditions (overcrowding, poor feathering, inadequate water and feeder space and excessive bird activity) or improper handling during catching. Skin with a higher percentage of total protein, results in greater skin strength and lower skin tears during processing. Male broilers of slow feathering strains are more prone to scratches because their skin is exposed for longer periods of time. Also, high temperature and humidity can cause skin problems due to broilers trying to find cooler spots and crowding [25].

Zn and Mn are important trace minerals in animal nutrition involved in many metabolic processes, including growth, skin quality and wound healing. Bioavailability of these trace mineral supplements can be improved through complexing them with more readily available compounds that can enhance mineral absorption. Zn complexed with organic compounds showed better absorption in animals than inorganic Zn sources. Zn has been shown to be a cofactor for several enzymes that are involved in the synthesis of proteins as well as the synthetic and catabolic rates of RNA and DNA [26]. Zn plays a role in the cross-linking process of collagen which contributes to tensile strength and wound healing. Deficiencies of Zn and vitamin C have been shown to reduce collagen synthesis, leading to weaker skin [27]. Organic Zn and Mn compounds may enhance growth and skin quality in poultry.

Effect of Dietary Zinc supplement on skin and meat quality in broilers

The poultry industry has benefited from growing domestic and international markets. Appearance is the major criterion of evaluation of carcass and meat quality, and purchase for the consumers. Many production and processing factors contribute to carcass quality problems. Pododermatitis is a type of skin dermatitis in broiler chickens affecting the foot pads (also referred to paw burns or ammonia burns). Several factors contribute to the prevalence of pododermatitis in broilers, including nutrient deficiencies, litter type, moisture and high stocking density [23, 28]. Zn is a required micro mineral in many bodily processes including growth, skin quality and wound healing. Zn is also involved in the synthesis of RNA and DNA [27].

Conclusions

In this review paper, we conclude the following: 1) Trace elements are essential for growth and production. They are essential for functioning of a number of components of the production, 2) Body weights and feed conversions were improved with C-Zn supplementation of broiler diets and 3) Complexed Zn may improve redness color in meat fillet.

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