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IMPORTANCE OF MANGANESE IN CATTLE AND POULTRY

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INTRODUCTION

The importance of manganese in poultry nutrition became evident in the 1930s when it was discovered that a crippling leg disorder called “perosis” was due to a deficiency of manganese (Wilgus et al., 1936). The incidence of perosis in chicks had been increasing prior to this time as production of chickens was moving more from barnyards to chicken houses. Manganese deficiency was later found to impair reproduction in cows (Bentley and Phillips, 1951) and result in calves born with severe leg abnormalities (Rojas et al., 1965).

It is now accepted that manganese is required by animals for normal skeletal development and reproduction. Manganese requirements can range from 4 to over 60 mg Mn/kg of diet. Requirements for manganese are greatly affected by animal species and dietary factors that reduce manganese absorption. Only a small percentage (less than 1% to 5%) of manganese present in the diet is normally absorbed. In the body manganese is widely distributed at low concentrations. Manganese is among the least toxic of all of the trace minerals required by animals.

Manganese functions in the body by regulating the activity of certain enzymes. Many of the deficiency signs observed in manganese deficiency appear to relate to reduced activity of glycosyltransferases, a group of enzymes that require manganese to function. Glycosyltransferases are involved in the synthesis of mucopolysaccharides (also referred to as proteoglycans). Mucopolysaccharides are critical for the development of the bone matrix and play an important role in cartilage integrity. Manganese deficiency reduces mucopolysaccharides in cartilage, resulting in impaired skeletal development. This paper will describe manganese deficiency in cattle and poultry, and discuss factors that affect manganese requirements.

CATTLE

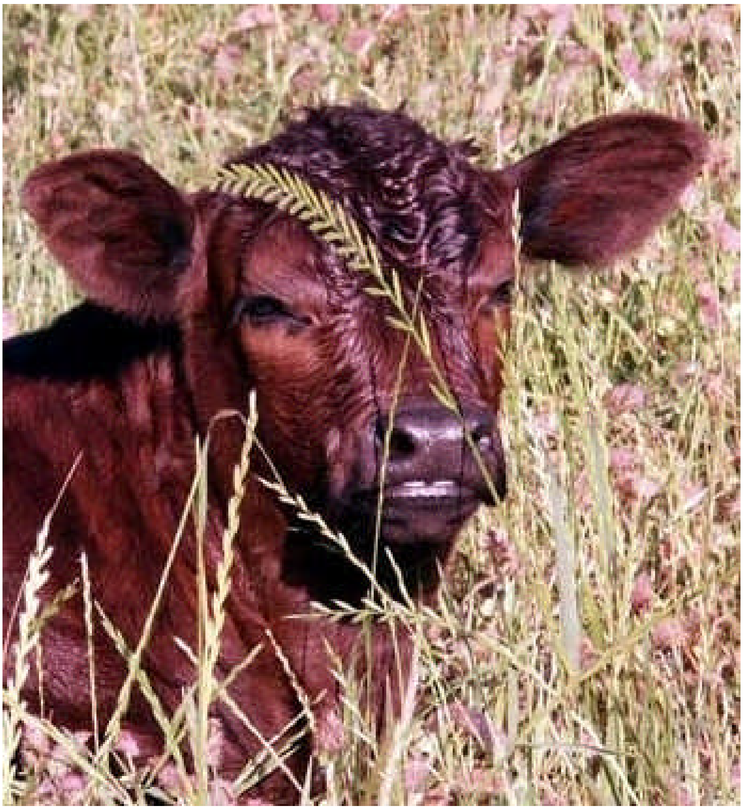
The manganese requirement of growing cattle is approximately 20 mg/kg of diet (NRC, 1996). Based on recent studies this level would appear to be adequate for growing and finishing cattle. Legleiter et al. (2005) found that manganese supplementation to a corn silage-based diet did not affect performance of steers during an 84-day growing phase. The corn silage diet used in this study contained 29 mg Mn/kg of diet (before any manganese was supplemented). At the end of the growing phase steers were switched to a corn-based finishing diet that analyzed 8 mg Mn/kg diet, for 112 days. During the finishing phase manganese supplementation at various concentrations (0, 10, 20, 30, 120, or 240 mg Mn/kg diet) to the diet did not affect growth, feed efficiency or carcass quality measurements. This would suggest that manganese concentrations as low as 8 mg/kg diet are adequate for growth in finishing cattle fed corn-based diets.

Another recent study (Hansen et al., 2006a) examined manganese requirements for growth and reproduction in heifers. Angus and Simmental heifers with an average initial body weight of approximately 550 pounds were fed diets supplemented with 0, 10, 30 or 50 mg Mn/kg of diet for 196 days. This study indicated that the control diet, which contained 16 mg Mn/kg, was adequate for growth, onset of estrus, and conception.

The developing fetus is quite susceptible to manganese deficiency and the Nutrient Requirements of Beef Cattle (NRC, 1996) recommends 40 mg Mn/kg of diet for beef cows. Early studies (Rajas et al., 1965) at Washington State University showed that calves born to cows fed diets containing 15.8 mg Mn/kg exhibited enlarged joints, twisted legs, stiffness, and a general weakness. The humerus bone in the leg of manganese -deficient calves was shorter, and had a reduced breaking strength compared to bones from calves adequate in manganese.

Manganese deficient calf with enlarged joints and weakness

Reports published over the last 20 years suggest that manganese deficiency in newborn calves may be a problem in many areas around the world. In addition to the U.S., suspected manganese deficiency in newborn calves under practical conditions has been reported in Australia (McLaren et al., 2007; Cave et al., 1994), New Zealand (Valero et al., 1990), Ireland (Mee, 1995), South Africa (Staley et al., 1994), and Canada (Ribble et al., 1989). Calf deformities observed in these reports include superior brachygnathism, disproportionate dwarfism (shorter than normal statue), and joint problems that interfered with the ability of the calves to stand and walk. Superior bachygnathism is a shortening of the nasomaxillary bones, causing the lower jaw to appear extended. Visually this results in the bottom row of teeth being exposed. A picture of a manganese deficient calf with superior brachygnathism is shown below. Dwarfism in manganese deficient calves results from the long bones in the legs being shorter than normal.



Manganese deficient calf with superior brachygnathism

Recently, in a controlled study Hansen et al. (2006b) reported that calves born to dams fed a low manganese diet showed similar abnormalities to those observed under practical conditions. In this study heifers were fed a control diet containing 15 to 16 mg Mn/kg of diet or the control diet supplemented with 50 mg Mn/kg of diet from approximately 10 months of age until after calving. Growth and breeding performance of heifers were not affected by manganese level. However, a high percentage of calves born to dams fed the low manganese diet showed signs of dwarfism (43%), unsteadiness or weakness at birth (43%), and superior brachygnathism (71%). None of these abnormalities were observed in calves born to heifers supplemented with 50 mg Mn/kg of diet. Whole blood manganese concentrations at birth were lower in calves from heifers fed the low manganese diet.

Manganese deficiency in cows has also been associated with suppressed or irregular estrus and low conception rate (Bentley and Phillips, 1951; Rojas et al., 1965). In a Minnesota study manganese supplementation from calving until week 19 post calving reduced days to conception in both first-calf Angus heifers and older cows (DiCostanzo et al., 1986). In this study cows were fed a corn silage-based diet that contained 32 mg Mn/kg of diet.

POULTRY

Broilers and turkeys have a much higher requirement for manganese than other animals. To prevent bone abnormalities broilers and turkeys require 60 mg Mn/kg of diet. In contrast manganese requirements of swine range from 4 to 20 mg /kg of diet. It was discovered in the 1930s that a condition known as perosis or slipped tendon in chicks was due to a deficiency of manganese. Perosis is characterized by enlarged and malformed leg joints, thickening and shortening of the long bones, and twisting and bending of the tibia (Suttle, 2010). As the condition becomes more severe chicks are reluctant to move and walk on their hocks. Recent research showed that manganese supplementation to diet low in manganese reduced the percentage of abdominal fat in broilers (Lu et al., 2007).

Manganese deficiency in breeder hens results in decreased hatchability and shortening and thickening of the legs and wings in the embryo, and a high mortality (Suttle, 2010). Hatched chicks may also have what is referred to as “parrot beak”, resulting from a shortened lower mandible bone. With severe manganese deficiency young chicks may exhibit a nervous disorder or ataxia, and may assume a “stargazing posture” with their head bent backwards. This condition is caused by abnormal bone development in the inner ear of the bird. In laying hens manganese deficiency results in reduced egg production and poor egg shell formation (McDowell, 2003).

FACTORS AFFECTING MANGANESE REQUIREMENTS

High levels of calcium and phosphorus are known to increase manganese requirements in poultry. Phosphorus appears to be more important than calcium in reducing manganese absorption (Wedekind et al., 1991). Phytate found in grains and oilseed meals also reduces manganese absorption. Manganese and iron are absorbed from the small intestine using a common transporter, and high dietary iron has been shown to reduce manganese absorption (Hansen et al., 2009).

Factors that affect manganese requirements in cattle are not well defined. Research in Canada indicates that manganese in grass or clover silage is less bioavailable than manganese present in hay. Hidiroglou et al. (1990) fed pregnant cows either red clover silage, grass silage (primarily timothy) or timothy hay. The red clover silage, grass silage, and hay analyzed 64, 63, and 51 mg Mn/kg of dry feed, respectively. The manganese requirement for beef cows is considered to be 40 mg Mn/kg diet (NRC, 1996). Although all three feedstuffs exceeded NRC requirements for manganese, 38% of calves born to cows fed red clover silage and 28% of calves born to cows fed grass silage exhibited signs (joint problems and dwarfism) consistent with manganese deficiency. All calves born to cows fed hay were considered normal at birth. Cows fed hay also had higher serum manganese concentrations during gestation than those fed silage (Hidiroglou et al., 1990).

High dietary iron may be an important factor that increases manganese requirements in cattle under certain conditions. Feedstuffs consumed by cattle are frequently high in iron; however, it is unclear how available the iron is to interact with manganese. Soil contamination of feedstuffs during harvesting will result in high iron levels in feeds. Iron from soil would be expected to be of very low bioavailability to the animal. However, recent research suggests that acid conditions that occur during silage fermentation greatly increases the bioavailability of iron from soil (Hansen and Spears, 2009).

PREVENTION OF MANGANESE DEFICIENCY

In poultry manganese is supplemented to the diet to prevent deficiency. Poultry diets require manganese supplementation because cereal grains, especially corn, are low in manganese. Corn contains approximately 5 mg Mn/kg while other grain sources generally contain 15 to 30 mg Mn/kg. Sources of manganese supplemented to diets include manganese sulfate, manganese oxide, and various organic or chelated forms of manganese. Manganese from manganese oxide is considered to be 70 to 80 % as available for absorption as manganese sulfate. Research has indicated that some organic forms of manganese are 10 to 40 % more bioavailable than manganese sulfate for broilers (Henry, 1995).

Manganese is usually provided in a free choice mineral supplement for cattle grazing pasture. Forages vary in their manganese content but generally are considerably higher in manganese than cereal grains. However, as discussed earlier the manganese naturally present in forages does not appear to be utilized very well by cattle in some situations. Free choice mineral supplements that provided manganese include trace mineral salt and mineral supplements that supply calcium, phosphorus, and magnesium in addition to salt and trace minerals. With dairy cattle and feedlot cattle, manganese would usually be supplied in a mineral mix that would be added in the complete diet. The same forms of manganese used in poultry diets are also used in cattle mineral supplements.

SUMMARY

Manganese is a trace mineral required for normal skeletal development and reproduction. Calves born to cows fed diets deficient in manganese exhibit enlarged joints, dwarfism, and shortening of the nasomaxillary bones in their jaw. Manganese deficiency in cows can also reduce conception rate. In poultry manganese deficiency results in enlarged and malformed leg joints, and thickening and shortening of the long bones. High levels of calcium, phosphorus, and iron in the diet increase manganese requirements. Manganese deficiency can be prevented in cattle by providing a free choice mineral that supplies adequate manganese. In poultry it is critical that a bioavailable source of manganese be supplemented to their diet.

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