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Iodine Nutrition and Toxicity in Cattle

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Iodine is an essential trace element in the nutrition of man and animals but can be harmful when fed at levels which greatly exceed requirements. Iodide is normally used by the thyroid gland to produce the thyroid hormones thyroxine and triiodothyronine. The amount of thyroid hormones released into the blood influences the metabolic rate of the body. The rate at which thyroid hormones are released is controlled by a thyroid stimulating hormone from the pituitary gland. Gross imbalances of iodide in the blood hamper normal thyroid function.

A deficiency of iodide in the diet (or consumption of substances that interferes with iodide metabolism) can result in enlarged thyroid glands (goiter) and low concentrations of thyroid hormones in the blood (hypothyroidism). Long-term deficiencies of iodine may result in decreased milk yields. Similarly, iodide toxicity can result from prolonged intake of excessive iodide.

Dietary Requirements for Iodide

To insure that iodine requirements of high-producing dairy cows are met under usual feeding conditions, 0.5 parts per million (ppm) iodide is recommended in the ration dry matter (14). This amounts to 10 to 12 milligrams (mg) iodide from all sources. Addition of iodized salt containing .005 to .01% iodide will provide 0.5 to 1.0 ppm in the grain mix when salt is added as 1% of the grain mix. Feeding one part grain to two parts forage will add .16 to .33 ppm supplemental iodide to the diet.

If iodized salt is fed separately, the iodide requirement for lactating cows can be met by feeding 3 to 3.5 ounces of salt containing .005 to .01% iodide. Dry cows require 1 to 2 ounces of salt daily. The estimated requirement for growing calves, heifers and bulls is 0.25 ppm dietary iodide (14).

Iodine Content of Feedstuffs

The iodide content of natural feedstuffs varies widely depending on the crop and the area of the country. Feedstuffs grown in states surrounding the Great Lakes are generally considered low in iodine in comparison to some other areas. For example, iodide content of alfalfa hay averaged .82 ppm (range .68 to 1.02) from farms in Northern Illinois compared to 1.87 ppm (range 1.31 to 2.54) from farms in Maryland (6). Corn silage contained less iodide than alfalfa from the same farms averaging .52 ppm in Illinois and 1.64 ppm in Maryland. Survey data on the iodine content of Michigan feedstuffs are not available.

Limited data suggest that the iodide requirement may increase slightly when feeding large amounts of soybean meal and corn silage as the only forage. Addition of 6.8 milligrams (mg) iodide daily to the diet was adequate for lactating cows fed a corn silage-soybean meal ration containing 0.9 ppm iodide. The iodide content of milk increased from 8 to 81 micrograms per liter (μg/l) (.008 to .081 ppm) when 6.8 mg iodide was fed and increased further to 694 μg/l (.694 ppm) when 68 mg iodide was fed. No increase in milk production or growth of young cattle resulted from feeding the larger amount of iodide (5). When herd milk contains less than 20 μg/l (.02 ppm), dietary iodide is considered to be too low and may indicate iodide deficiency in a herd. Milk from Michigan herds fed nutritional amounts of iodide averages about 200 to 400 μg/l (.2 to .4 ppm); or 10 to 20 times the deficiency level. Milk from herds fed prophylactic amounts of iodide to prevent footrot contained 700 to 4,400 μg/l (.7 to 4.4 ppm) iodide. Michigan data indicate that milk iodide should not exceed .5 ppm. Use of iodophor teat dip may increase milk iodide .1 to .2 ppm.

Calculation of Dietary Iodide Intake

Since iodide is often included in commercial protein, mineral and salt supplements, estimate daily iodide intake from these sources. Multiply the

quantity (weight) of each supplement fed by the iodide content of the supplement.

A. **Convert Feed or Supplement Pounds to Kilograms:** Since iodide is used in very small quantities, the calculation is simplified by converting all weights to the metric system. 1 kilogram (kg) is equivalent to 2.2 pounds = 1,000 grams (g) = 1,000,000 milligrams (mg). Thus, 1 mg/kg = 1 part per million (ppm). Then, feed or supplement weight (pounds) ÷ 2.2 = kilograms.

B. **Convert Percent Iodide to mg/kg or ppm:** The iodide content of supplements is usually listed on the feed registration tag or minimum guaranteed analysis as percent (iodine %). Percent concentration is converted to milligrams per kilogram by simply moving the decimal point four places to the right. For example, .01% converts to 0100. (100 mg/kg).

C. **Determine milligrams iodide provided from each source of feed or supplement.** Multiply: feed weight (kg) × mg iodide/kg = mg iodide. *Example:* Calculate the iodide intake from 20 lb of grain mix to which has been added 1% salt (20 lb/ton) containing .01% iodide. Daily feed (grain mix) 20 lb ÷ 2.2 = 9.09 kg. Salt intake = 9.09 × .01 (1%) = .0909 kg. Iodide content of salt (.01%) = 100 mg/kg. Iodide intake from salt = .0909 kg × 100 = 9.09 mg.
Calculate the iodide provided from all mineral and protein supplements and add to find the total intake (mg) of supplemental iodide.

D. **Determine iodide concentration in the total diet: total iodide intake (mg)** ÷ kg total feed (dry matter) from hay, silage and supplements. The result will be mg/kg or ppm supplemental iodide in the diet.
Note: Iodide intake from natural feeds such as hay, silage and grain can be calculated as indicated above if the iodine content has been determined by reliable chemical analysis. Since meaningful iodine values for Michigan feeds are not available, they were excluded from the illustration.
Since the recommended dietary allowance is approximately 0.5 mg/kg and lactating cows normally consume approximately 20 to 22 kg feed daily (dry matter), 10 to 12 mg supplemental iodide represents the total daily allowance. Larger amounts are not recommended and the iodide intake should be adjusted accordingly.

IODIDE TOXICITY

Iodide toxicity may result when excessive amounts of iodide are fed for long periods (13). Sometimes 10 to 50 times the iodide requirement is fed in forms such as ethylenediamine dihydriodide (EDDI) to prevent footrot or soft tissue lumpy jaw. The iodide content of certain protein, mineral and salt supplements is greatly in excess of dietary requirement. In some cases, several sources of excessive iodine are fed at the same time. In addition, small (1 lb) packages containing 5 to 11% iodine are used as a therapeutic agent for mild respiratory infections. Current federal regulations prohibit feeding therapeutic amounts of EDDI to lactating cows. Feeding excessive amounts of iodide greatly increases iodide concentrations in blood, urine and milk of lactating cows, and is toxic when feeding is prolonged (1, 5, 7, 10, 13).

Signs of Iodide Toxicity

Tearing from the eyes (lacrimation), a watery nasal discharge and increased salivation, as shown in Figure 1 can result from prolonged feeding. The nasal discharge may become thickened or may be accompanied by infection as in Figure 2.

Coughing due to bronchial and tracheal irritation is common. In experiments conducted at Michigan State University, two calves given very large doses of iodide (1250 mg iodide daily) died from bronchopneumonia. Tracheal constriction and choking has occurred in newborns from dams given excessive iodide.

Clinical respiratory infections such as *pasturellosis* (pneumonia) may occur more frequently apparently because of lowered resistance to invading organisms that are otherwise harmless. Such infections developed in calves fed excessive iodide but not in controls fed nutritional amounts of iodide. Bacteria were cultured from nasal swabs of calves with or without infections in the MSU experiments.

Conjunctivitis, inflammation of the tissues in contact with the eyeball, and a reddened appearance of the sclera (white of the eye appears blood shot) is common in cattle and humans consuming excessive iodide. Conjunctivitis and corneal ulcers occurred in calves given 250 and 1,250 mg iodide daily (1.5 and 9.0 mg iodide/kg body weight) at MSU. This is further indication that cattle given excessive iodide are more susceptible to infectious organisms such as those which cause pinkeye.

Alopecia (hair loss) commonly occurs around the eye and neck region of cattle fed excessive iodide (Figure 3). The hair loss and swelling around the eye (Figure 1) are normally associated with hypothyroidism which can result from several causes including high dietary iodide.

Dermatitis, characterized by rough scaly skin, occurred on cattle fed excessive iodide in MSU experiments (Figure 4).

Figure 1. Signs of iodism in adult cow. Tearing of the eyes, conjunctivitis, hair loss around the eye, purulent nasal discharge in cow receiving 236 ± milligrams iodide daily as EDDI.

Figure 2. Purulent nasal discharge of calves fed 50, 250 and 1250 milligrams iodide as EDDI in experiments at Michigan State. Note the matted eyelids from conjunctivitis. Calves were more susceptible to infections.

Figure 3. Hair loss around the eye occurred in calves fed excessive iodide (EDDI) in experiments at Michigan State University, but not in calves fed nutritional amounts of iodide.

Bulging or protruding eyeballs with increased amount of the white of the eye visible (exophthalmus) (Figure 5) is commonly seen in cattle fed excessive iodide for a prolonged period (1). Large fat deposits were removed from behind the eyeball (postmortum) as occurs in exophthalmic goiter.

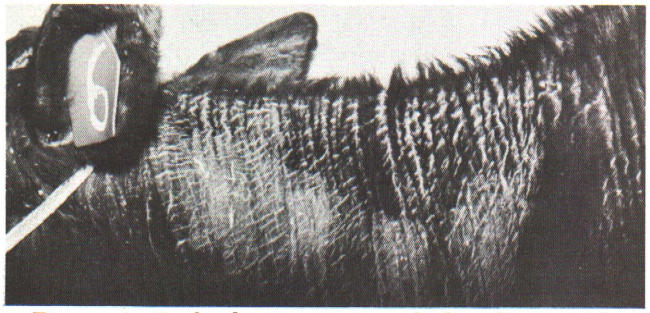

Figure 4. Scaly dermatitis (rough dry skin) and loss of hair occurred on calves fed excessive iodide in experiments at Michigan State.

Figure 5. Protruding of the eyeballs (exophthalmus) is commonly seen in dairy cows receiving excessive iodide.

Effects on Metabolism

Body temperature may be increased 1 to 2 degrees Fahrenheit above normal (hyperthermia) by feeding excess iodide. Heart rate and respiration rate increase and body weight loss of lactating cows increases more rapidly than normal as in hyperthyroidism (1, 9, 11, 15, 16). This is further antagonized by high environmental temperature (heat stress).

Blood glucose, blood urea nitrogen and urinary nitrogen excretion increase due to breakdown of muscle protein, and fat and carbohydrate reserves are depleted when excessive iodide or thyroprotein (iodinated casein) is fed (2, 3, 7). Blood cholesterol is reduced and conversion of carotene to vitamin A is inhibited when excessive iodide is fed. These effects may be related to hormonal changes and lowered immunity.

Milk production may increase slightly initially, but eventually declines more rapidly than normal (15, 16).

Reproductive efficiency may be lower. The first heat period (estrus) after calving was delayed (16) and the number of services per conception and length of calving interval were increased when excessive iodide (iodinated casein) was fed for three lactations in experiments at Cornell University and U.S.D.A. (15, 16). Delayed estrus and increased

embryo mortality have been associated with hyperthermia (heat stress) such as caused by excessive iodide and changes in adrenal and pituitary hormones (12).

Effects on the Immune System

Experiments with calves at Michigan State University (5, 8) indicate that excessive iodide (.5 mg or more iodide/kg body weight daily) reduced the number of circulating white blood cells (leukocytes), reduced phagocytosis (engulfing of invading bacteria) by lymphocytes, and reduced lymphocyte mitosis (multiplication of white blood cells). Antibody titers associated with vaccination against leptospirosis were significantly reduced in calves given excessive iodide. Brucellosis antibody titers were measurably affected only at the highest level of iodide (9 mg/kg). These findings concur with the higher incidence of clinical infections in these cattle and suggest that feeding excessive iodide for prolonged periods may reduce expected benefits from vaccination. Effects on the immune system may account for the high death rate (30%) and poor response to therapy of calves born from cows fed excessive iodide (iodinated casein) compared to 14% death loss of calves born to other cows in the U.S.D.A. herd (16); and reduced number of pigs born per litter, or surviving from sows fed excessive iodide in experiments at Michigan State University (4).

Numbers of lymphocytes were lower and neutrophils higher in blood of dairy cows fed excessive iodide compared to cows fed normal amounts of iodide in Michigan herds. High blood neutrophils can result in high somatic cell counts in milk.

Differences in white blood cells, glucose, serum protein, globulin and cholesterol in blood from farm herds were highly related to iodide concentrations in milk. Involvement of adrenal and pituitary hormones is suggested by the finding of enlarged adrenal glands (3, 13) and smaller pituitary glands from calves and sheep fed excessive iodide (8). Iodide is secreted in milk in proportion to the dietary intake (7 to 10% of intake). High iodide milk may have adverse effects on the health of offspring or humans consuming such milk (17).

SUMMARY

Iodide is an essential nutrient in the diet of livestock and man. Supplementation of dairy cattle rations with nutritional amounts of iodide is generally recommended to avoid iodide deficiency. Since adverse effects have occurred from feeding excessive iodide to livestock, the amount fed should be limited to nutritional requirements. Prolonged feeding of prophylactic or therapeutic amounts should be avoided.

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