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Nitrate in the Ration

effects on the health and performance of cattle

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The prospect of nitrate toxicity in cattle fed drought-stricken corn silage and other forages is a common concern of dairymen and cattle feeders.

The capacity of the ruminant to consume large quantities of nitrate in the diet without harmful effects is well documented by research.

Studies show that cattle can safely handle feeds containing up to 2% nitrate (20, 000 ppm) in their ration dry matter. Feeds containing more than 2% nitrate should be limited or diluted with other feed. Ruminants gradually adapt to feeds containing nitrates. Feedlot cattle fed a fattening (high grain) ration have consumed diets containing up to 8% nitrate when the nitrate was gradually increased in the ration. A sudden change to feed containing high levels of nitrate is probably the major cause of nitrate toxicity. Cattle should be fed only a small amount of feed suspected of containing low nitrate for the first couple of days, then the feed can be increased gradually.

Subclinical effects such as lowered milk production, daily gains or noticeable health problems are not readily produced by feeding sublethal levels of nitrates. The extra nitrate nitrogen is normally metabolized to ammonia and used by rumen microbes for synthesis of microbial protein similar to other sources of protein in the rumen.

NITRATE CONTENT OF FEEDS

Plants normally take up their nitrogen from the soil in the form of nitrates. The nitrate (NO_3) is rapidly converted to ammonium ion (NH_4^+) and then to amino acids for formation of plant proteins. When the amount of nitrate absorbed from the soil is greater than the amount the plant can convert to amino acids some nitrate may accumulate, generally in the lower parts of the plant. Heavy application of nitrogen fertilizer or manure and severe drought or other factors which reduce plant metabolism tend to cause some accumulation of nitrates.

Analysis of several hundred samples of drought-stricken corn samples indicate that only about 3% of the samples contained more than one-half percent (0. 5%) nitrate on a dry weight basis. Thus, the probability of drought-stricken corn or corn silage causing nitrate toxicity in cattle is rather low and should not be a cause for alarm since it seldom occurs.

Heavy application of nitrogen fertilizer (or poultry manure) increases the nitrate content of corn, cereal and other grass forages. Applications of 0, 200 and 800 lb. of nitrogen resulted in corn forage dry matter containing 602 ppm (.06%), 2319 ppm (0.23%) and 4438 ppm (0.44%) nitrate, respectively. After nearly 90 days in the silo the nitrate content had dropped to 380 ppm (0.038%), 1468 ppm (0.14%) and 2861 ppm (0.286%) which represents a decrease of 36 to 41% during ensiling. These levels were all below the levels likely to cause toxicity.

Oat forage also accumulates high levels of nitrates, particularly under drought conditions and has been responsible for nitrate poisoning in some cases. Oat forages causing toxicity may contain 6 to 8% nitrate. Pigweed, ragweed, lambsquarter, nightshade and other weeds store large quantities of nitrate, but normally comprise a small part of the livestock diet.

ACUTE NITRATE TOXICITY

Death and/or abortion in pregnant cattle can occur when cattle are fed large amounts of nitrate or nitrate-containing feeds without an adaptation period. Greenchopped corn or corn silage suspected of being high in nitrate should be gradually included in the ration over a 7 to 14-day period. Forages containing less than 2% (20,000 ppm) nitrate are not likely to cause nitrate toxicity. Cattle can metabolize 20 grams of nitrate per 100 pounds of body weight daily without affecting their health or reproduction.

SYMPTOMS

When cattle receive more nitrate than can be reduced to ammonia, an intermediate product nitrite (NO_2) accumulates in the rumen and is absorbed in the blood. This may cause toxicity when the levels are too high.

Toxic levels of nitrate will cause the blood to turn brown (black-coffee discoloration of blood is positive evidence of nitrate poisoning in a live animal, but not in a dead animal). Peak levels of methemoglobin generally occur 2 to 4 hrs. after feeding of nitrates. Labored breathing (due to lack of oxygen carrying capacity of the blood), frothing at the mouth, and brownish to bluish-grey color of the non-pigmented skin and mucous membranes are symptoms of nitrate toxicity.

Pregnant cows may abort when the oxygen carrying capacity of the blood is seriously reduced. Methemoglobin levels usually comprise 60 to 90% of the hemoglobin before death occurs. Sublethal methemoglobin levels will return to normal within 2 or 3 days when the rumen microbes become adapted or the nitrate intake is reduced. Total blood hemoglobin levels increase with prolonged nitrate feeding and partially compensate for methemoglobin formation.

NITRATE RELATIONSHIP TO OTHER NUTRIENTS

Cattle fed well-balanced rations regularly are less susceptable to nitrate toxicity. Feeding fairly high levels of grain with forages causes the rumen contents to be more acid and increases the reduction of nitrates to ammonia. Studies indicate that feeding high levels of nitrate has no effect on either blood or liver levels of vitamin A. Some research with rats showed that animals deficient in iodine are more susceptable to nitrate toxicity. However, there is strong evidence that feeding nitrates does not cause iodine or thyroid deficiency in cattle and sheep.

NITRATES IN WATER

Water containing nitrate is often contaminated with microorganisms, and this combination makes the water very dangerous for human infants. The most common microbial contaminant is Eschericia coli, which enters the water supply from drainage water. It is doubtful that nitrate in water causes chronic toxicity any more than nitrate in forage. Experiments show that swine can consume up to 1, 300 ppm of nitrate in water, and sheep can consume up to 2, 900 ppm without interfering with reproduction or growth. The spread of subclinical diseases by microorganisms present in contaminated water is probably a more serious hazard.

NITRATE-UREA RELATIONSHIPS

Both urea and nitrate (at least the small amount of nitrate normally contained in feeds) are degraded to ammonia in the rumen and utilized by microbes to form bacterial protein. Many researchers have tried to determine the effects of feeding high nitrate levels or nitrate-containing feeds when urea was contained in the diet.

Missouri workers fed two lots of sudan grass hay, which contained 0. 5% and 5. 0% potassium nitrate (KNO_3), to milking cows receiving a grain ration of 2% urea fed at 80% and 110% of energy requirements. There were no differences in milk production and only slight non-significant differences occurred in methemoglobin content of the blood. High nitrate feeding resulted in slightly higher blood-urea (BUN) nitrogen levels (14. 7 vs. 12. 1 mg/100 ml) and higher excretion of nitrate in the urine. The urinary nitrate levels were highest from cows fed the low energy-high nitrate ration. Thus, feeding forage containing 5% KNO_3 had little effect on blood and milk components, and no effect on milk production. Any excess of protein in the diet tends to increase BUN and urinary NPN levels.

Similarly, addition of 1% KNO_3 to a feedlot ration using urea with corn silage or shelled corn had no effect on animal performance when compared to soybean meal in Minnesota experiments. Virginia workers noted a reduction in feed intake and daily gain when 1% KNO_3 was added to a shelled corn fattening ration containing 1. 68% urea. The added nitrate apparently made the ration less palatable, since cattle fed nitrates gained as rapidly as controls when both groups were fed the same amount of feed.

The small amount of nitrate normally contained in forages and the considerable capacity of ruminants to utilize nitrates in the diet make nitrates of little significance in ruminant rations. Exceptions exist in rare occasions when the nitrate level may exceed 2% of the ration dry matter or feed changes are too abrupt, and can cause acute toxicity symptoms.

EXPRESSIONS OF NITRATE CONCENTRATION

The nitrate content of feeds may be expressed on several different bases on laboratory reports and must be converted to nitrate ion (NO_3) to be meaningful. Table 1 shows the conversion factors to use for comparing nitrate when different reporting methods are used.

TABLE 1. Conversion factors necessary for comparing nitrates when different reporting methods are used.

Method of Expression	Chemical Designation	To Convert to Nitrate Multiply by
Nitrate	NO_3	1.0
Nitrate-Nitrogen	NO_3-N	4.4
Potassium Nitrate	KNO_3	0.6
Sodium Nitrate	$NaNO_3$	0.7

Note: Nitrate levels in feed and water are frequently reported in parts per million (ppm). To convert to percent move the decimal point four places to the left or vice versa. Example: 5500 ppm = 0.5500% or 0.55%
550 ppm = 0.0550% or 0.055%

AVOID SILO GAS POISONING

Nitric oxide (NO) gas is a colorless, odorless gas produced by reduction of nitrate as silage acids are formed. Nitrogen dioxide (NO_2), a reddish-brown gas, and nitrogen tetroxide (N_2O_4), a yellow gas, both have a sharp, irritating odor. All three gases are lethal and may be present in any silo, at least for several days after filling

The gases are heavier than oxygen and accumulate just above the silage surface, in the silo chute. or the feed room. Be sure to ventilate the silo and feed room adequately by removing the door just above the silage level, and open doors and windows of the silo room to the outside. Run the blower for several minutes before entering and leave it on while working in the silo.

Carbon dioxide is produced rapidly by fermentation after ensiling. The concentration may be so high as to exclude oxygen from the silo air and cause sickness or death. Never enter a sealed silo without proper equipment, and never enter any silo soon after filling unless someone is available to help in an emergency.

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