



Information Sheet

Nitrate Toxicity



Information on nitrate toxicity in ruminants.

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Are high nitrates really something that I should be worried about?

Yes, it is actually something that is more common than one might think! In fact, just in the last year, I can think of at least a dozen cases where Ranch-Way's sheep, goat, and cattle customers were dealing with high nitrate forages on some level and we were involved with coming up with a feeding program that helped them manage the intake of those high nitrate forages....and these are just the cases that we *know* about! Anyone who feeds forages (i.e. pasture, hay, harvested hay meadows, crop aftermath, etc.) that have had fertilizer applied to them and/or was grown under "drought" conditions (or any variation of "low precipitation" and cloudy, overcast weather that that may have impeded the plant's normal growth potential), or anyone who runs livestock on fields that are over-run by weeds, should be concerned. Unfortunately, some of us buy hay from farmers or brokers where we don't necessarily know the background of the fields where the hay was grown, so that puts us at risk for purchasing a pile of high-nitrate hay without even knowing it! Nitrate concentrations can also be elevated in ponds or runoff water, which can be additive to the levels in forages. We advise to always test your forages (and water sources) if you are concerned, a typical nitrate test runs ~\$6-10/sample and it takes about a week to get lab analysis back, so it is worth the effort to get it tested.

What happens with high-nitrate feedstuffs?

Because plants assimilate nitrogen (N) from the soil to synthesize amino acids (and ultimately protein), excess nitrogen in the soil can lead to excess nitrogen in the plant, in the form of nitrate (NO_3^-). As mentioned above, if the growing conditions are substandard (or excess nitrogen was applied to the fields through fertilizer), then the nitrate becomes elevated ($> 0.2\%$). Ruminants are the most susceptible to high-nitrate forages because the rumen microflora reduce the nitrate to nitrite (NO_2^-), which is 10 times more toxic than nitrate, and then to ammonia (NH_3). Both nitrite and ammonia can be directly absorbed across the rumen wall into the bloodstream. Once in the bloodstream, nitrate toxicity is manifested by the formation of "methemoglobin" (which renders the ferrous iron in hemoglobin (Hb) incapable of binding to and transporting oxygen) by animals, primarily ruminants, ingesting feeds with an excess level of nitrate. Chronic ingestion of elevated nitrates can cause abortions in pregnant animals and lead to the death of the subsequently affected fetus (due to an oxygen-starved placenta). Therefore, pregnant animals should not be fed forage or hay with nitrate content $> 0.2\%$ (Nicholson, 2007). Toxicosis is most likely to occur in animals that are hungry (causing increased consumption of nitrate-burdened feedstuffs) or not acclimated to the nitrate-burdened feeds. High nitrates in the water, cold stress, and intake of a low-energy (low carbohydrate) diet is also likely to exacerbate the susceptibility to nitrate poisoning (Rogers, 1999).

What are the signs of nitrate toxicity?

Nitrate poisoning can be acute, subacute, or chronic (which can go undetected until the animal is "stressed"). Signs of nitrate toxicity may appear when $> 20\%$ of Hb is converted to methemoglobin and usually appear suddenly due to tissue hypoxia and low blood pressure as a result of vasodilation. Early signs of toxicity can result in lethargy, ataxia, head pressing, diarrhea, frequent urination, accelerated respiratory and pulse rate, and impaired animal production as evidenced by depressed appetite, reduced BW gain, lowered milk production, reproductive inefficiency, and increased susceptibility to infection. Chronic toxicity is difficult to identify and often results in misdiagnosis and incorrect or lack of appropriate treatment. In pregnant animals, abortions and stillbirths are most likely to occur 5-14 days after exposure to excess nitrate in feedstuffs (Robson, 2007). Affected animals may die suddenly without appearing ill. Upon necropsy, affected blood will have a chocolate-brown appearance, as will highly-metabolic organs such as the liver and kidney.

What plants and forages are typically the highest in nitrates?

Crops that most commonly accumulate nitrate include cereal grasses (especially oats, millet, and rye), corn, sunflower, and sorghums. Weeds can also be a source of high nitrates, especially in fields or pastures where weeds have over-run the stand. The weeds that most commonly accumulate nitrates are pigweed, lamb's quarter, thistle, *Kochia* (fireweed), smartweed, and Johnson grass. Hay fields that are normally high-yielding and then have a low-yielding year, can have a potential for nitrate. Corn fields that were weather damaged (by drought or hail storms) can often be high in nitrates, as can the stalks that remain after corn harvest. It also worth mentioning that any feed supplements (liquid or dry - pellets, cake, tubs, or blocks) that have added NPN (non-protein nitrogen) in the form of urea and/or biuret can cause the same kind of toxicosis, so they must also be handled as if they are "high nitrate" feedstuffs.

What is the best strategy for feeding "high-nitrate" feedstuffs?

Nitrate toxicity may be prevented by ensuring that the total feed nitrate concentrates are < 0.6 % in non-pregnant animals or < 0.1% in pregnant animals, which may be difficult to do. However, there are some "work-arounds" that sound nutrition management can offer. For example, toxicity can also be avoided if animals are acclimated slowly to partial inclusion of high-nitrate feedstuffs (meaning that nitrate-feedstuffs are diluted with, or fed along with, "safe feed") and are also fed along with grain-based (carbohydrate-based) feeds. Because the rumen microflora will synthesize *denovo* (new) amino acids out of the carbon back-bone of carbohydrate feeds with nitrogen, the nitrate can be utilized by the microbes as long as adequate carbs are in the diet. For example, feedlot cattle fed a high inclusion of grains (such as corn, barley, or wheat) in the finish diet can usually handle high-nitrate hay, whereas cows maintained on dormant winter range or on over-grazed corn stalks will have a much harder time. Ensiling suspect forages can help reduce the nitrate concentration by 50%. Keep in mind that water sources can also be high in nitrates and can add to the total dietary intake of nitrates, so these tips are assuming that the water does not also contain high levels of nitrates. When in doubt, Ranch-Way is here to so assist you with the proper diets that can be fed to avoid nitrate toxicity, which may include designing a carbohydrate-based supplement to be fed along with your high-nitrate forages.

Table 1. Recommendations for inclusion of high-nitrate feedstuffs in ruminant diets. Horses are more tolerant to nitrates than ruminants and can handle forages up to 1.5% nitrate.^{1,2}

| % Nitrate | ppm Nitrate-Nitrogen | Feeding Recommendations: |
|-------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| < 0.44 | < 1012 | Safe to feed. |
| 0.44 - 0.66 | 1012 - 1518 | Safe for nonpregnant animals. Limit to 50% of ration dry matter intake. Animals may go off feed, experience a slow drop in milk production or abort in some cases. |
| 0.66 - 0.88 | 1518-2024 | Limit to 50% of the ration dry-matter. Above symptoms, some deaths. |
| 0.88 - 1.54 | 2024-3542 | Limit to 35-40% of the ration, dry-matter. DO NOT FEED TO PREGNANT ANIMALS. |
| 1.54 - 1.76 | 3542-4048 | Limit to 25% of the ration, dry-matter. DO NOT FEED TO PREGNANT ANIMALS. |
| > 1.76 | >4048 | TOXIC - DO NOT FEED. |

¹Values in this chart are derived from Dairy One Forage Analysis Laboratory, Ithaca, NY. Accessed 2011. Available at: <http://www.dairyone.com/Forage/FactSheet/Nitrates.htm>.

²Note that not all forage analysis labs will report in the units indicated above (% Nitrate or ppm Nitrate-Nitrogen) and therefore some conversion may need to be done to the values reported in order to cross-compare with this chart and employ the feeding recommendations outlined above.

