3-2014

Nitrate Poisoning

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**Repository Citation**

Arnold, Michelle; Gaskill, Cynthia; Lehmkuhler, Jeff; and Smith, S. Ray, "Nitrate Poisoning" (2014). *Agriculture and Natural Resources Publications*. 165.  
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Forage-Related Cattle Disorders

Nitrate Poisoning

Michelle Arnold and Cynthia Gaskill, Veterinary Diagnostic Laboratory; Jeff Lehmkuhler, Department of Animal and Food Sciences; and Ray Smith, Department of Plant and Soil Sciences

Sources of Nitrates

Nitrate poisoning in ruminants may also result from consumption of nitrate fertilizer. Cattle that gain access to stored nitrate fertilizers, especially when deprived of salt, may consume toxic quantities very quickly.

Nitrates in water sources may also poison livestock. Surface water or water from shallow wells may contain nitrates, especially if there is run-off from fertilized land contaminating the water. Both water and forage should be analyzed to ensure that total nitrate does not exceed toxic levels.

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Signs of Poisoning

The first indication of nitrate toxicity may be the discovery of one or more dead animals while others may be exhibiting clinical signs. These first signs of nitrate poisoning in an animal include weakness; rapid, labored breathing; rapid, weak heart beat; staggering; muscle tremors; and recumbency (inability to stand). Affected animals typically show signs of poisoning within a few hours after consumption of a toxic dose of nitrates. Examination of the mucous membranes, especially the vaginal mucous membranes, may reveal a brownish discoloration that occurs well before other clinical signs. Chocolate colored blood and a brownish cast to all tissues are hallmark signs of nitrate poisoning. Most deaths occur within the first six to eight hours after onset of clinical signs and largely depend on the quantity and rate of absorption of nitrite and the amount of stress or exercise the animal is forced to do. After death, nitrate concentration can be measured in the eye fluid and is a reliable indicator of poisoning. Pregnant cows that survive toxicity will likely abort three to seven days following recovery from nitrate poisoning.

Treatment

Animals showing signs of nitrate poisoning should be removed from the source of toxicity and a veterinarian should be contacted immediately. Animals severely deprived of oxygen are subject to sudden death so stress associated with handling must be minimized. Administration of a two-percent solution of methylene blue intravenously by the veterinarian will aid in converting methemoglobin back to hemoglobin. Mineral oil or other emollients may be given to protect the lining of the digestive tract.

Cause of Poisoning

When consumed more rapidly than they can be converted in the rumen to protein, nitrates enter the bloodstream as nitrite, which combines with hemoglobin in red blood cells to produce methemoglobin, a form incapable of transporting oxygen. Death occurs as a result of asphyxiation as methemoglobin levels approach 80 percent.

Nitrate and nitrite poisoning can occur in all animals but cattle are considered most susceptible because of the rapid conversion of nitrate to the more toxic nitrite form by rumen microorganisms.

Horses are much less sensitive to nitrate than are cattle or other ruminants, and can tolerate much higher concentrations of nitrate, but exact threshold values have not been established. Horses are extremely sensitive to nitrite, so any preformed nitrite in forages can pose a significant risk. Consult with a veterinary clinical toxicologist for interpretation of nitrate/nitrite concentrations in horse feeds.

Sheep and goats are less susceptible than cattle to nitrate toxicity and camels are rarely affected.

Drought-stressed sorghum and/or corn are the source of most of the forage-related cases of nitrate poisoning in Kentucky, but wheat, sudangrass, rye, pearl millet, soybeans, beets, Brassica spp. (rape, kale, turnips, swedes) and oats can also accumulate nitrates. Common weeds that are nitrate accumulators include ragweed, pigweed, thistle, bindweed, dock, jimsonweed, and johnsongrass. These lists are not complete, but these weeds and forages cause the most problems within the state.

Nitrate/nitrite concentrations in horse feeds can pose a significant risk. Consult with a veterinary clinical toxicologist for interpretation of nitrate/nitrite concentrations in horse feeds.

Animals severely deprived of oxygen are subject to sudden death so stress associated with handling must be minimized. Administration of a two-percent solution of methylene blue intravenously by the veterinarian will aid in converting methemoglobin back to hemoglobin. Mineral oil or other emollients may be given to protect the lining of the digestive tract.
Vinegar given orally via stomach tube will help prevent further nitrate reduction in the rumen.

**Prevention**

Several management strategies are available to reduce the risk of nitrate poisoning.

- Nitrate fertilizer should be stored where cattle do not have access to it and accidental spills should be cleaned up promptly.
- Avoid grazing warm season grasses fertilized with high amounts of nitrogen when growth ceases due to drought, cold damage, hail, or herbicide exposure. Warm season grass stands that have received multiple sources of nitrogen (such as nitrogen fertilizer, manure, previous legume crops) can occasionally show elevated nitrate levels without environmental stress. When in doubt, take the time to send samples for nitrate testing before introducing cattle to the pasture.
- Cool season grasses and small grain pastures that have been heavily fertilized with nitrogen may be high in nitrates during early spring when cool, overcast days retard growth. Test before grazing.
- Corn forage should be properly ensiled at least 3 weeks and tested for nitrates before feeding. Do not green chop forages suspected to be high in nitrates.
- All suspected forages including silage and hay should be tested for nitrate levels. Instructions are provided in this publication—see “Nitrate Testing.” A field test is also available to give a quick indication if the forage is potentially dangerous. If the test strip reacts, a forage sample should be sent to a laboratory for an accurate analysis of nitrate and a feeding recommendation. Consult your county Extension agent for agriculture for information concerning sampling, sample preparation, field test, and location of a testing laboratory.
- Forage with high nitrate levels can be mixed with forage known to be low in nitrate to reduce the risk from feeding.
- Feeding low nitrate forage or hay before turning cattle on to high nitrate forages will reduce the amount of nitrate consumed. Splitting grazing times will also allow nitrates to be utilized properly by the rumen microflora.
- Cattle have the ability to increase their tolerance to nitrates in their diet with time. A period of adaptation of at least a week is recommended. To aid in increasing this tolerance, the diet should be sufficient in vitamin A and trace minerals.
- A gradual increase in the total energy content of the ration enhances metabolism in the rumen and helps cattle tolerate higher nitrate levels in their diet. This may be in the form of a high carbohydrate feed such as corn that aids microbes in the conversion of nitrates to protein.
- Delay harvest of high nitrate forages until nitrate levels are safe. If not feasible to delay harvest, raise the cutter bar to 18 inches to avoid the base of plants.
- Propionibacterium products such as Bova-Pro® are available in bolus or powder form that are reported to reduce nitrate and nitrite levels in the rumen by approximately 40 percent. These products must be established in the rumen for at least 10 days before allowing cattle to consume high nitrate feedstuffs.

**Nitrate Testing**

Contact the laboratory you intend to use or your local county agent for specific instructions, but some general guidelines are listed below.

**Taking Samples**

Proper sample collection is crucial for proper interpretation of results. The sample should represent what the animals will be eating, so collect the entire part of the plant that will be fed. Collect a number of smaller samples to form a large representative composite sample. If different regions of a field were treated differently, then separate composite samples should be submitted for each different region. Different cuttings, batches, or fields should be sampled separately, and submitted as separate samples.

Preferably at least a pound of total composite sample should be submitted. More sample is better than too little, so when in doubt, collect more. Be sure to mark each bag legibly with forage/sample type and identification information.

**Dry forage (hay, bedding)**—Use a hay probe to take core samples. Randomly select 10 or more bales that are representative of a cutting/batch. Take one or more core samples per bale, and mix all the cores to make one large composite sample.

**Silage, balage, haylage**—Use a hay probe to take core samples if possible. Randomly select 10 or more bales that are representative of a cutting/batch. Take one or more core samples per bale, and mix all the cores to make one large composite sample. Resume the hole created in the wrap with tape after sampling. For bagged silage, select at least 10 areas to sample that are representative. If core sampling is not possible, unload some silage material and collect large handfuls from 10 or more different locations. Mix to form a large composite sample.

**Corn stalks**—Cut the stalks at the anticipated harvest level and submit the entire part of the stalk that will be fed. Collect stalks from several areas of the field; 5 or more stalks are recommended. Stalks can be cut or folded prior to shipping. Alternatively, if the corn stalks are going to be chopped, you can collect representative samples from the fresh chop. Or, if shipping volume is an issue, only the bottom halves of the stalks could be submitted, but remember that the result will be higher than the actual overall average nitrate concentration for the entire plant.

**Pasture grasses**—Collect handfuls of forage from 10-20 different areas in the field. Cut the grass at the anticipated harvest or grazing height and submit the whole part of the plant that will be ingested. Mix thoroughly to make one large composite sample.

**Storage and Shipment**

Moist samples (such as fresh green grasses, silage) should be placed in plastic bags and immediately put in a cooler on ice or ice packs. These samples should be kept chilled or frozen until shipment, and should be shipped with ice packs. Dry samples such as relatively dry corn stalks and hay should be placed in paper bags and kept at room temperature until shipped; ice packs are not needed for shipment of dry samples. Regardless, samples should be shipped as soon as
Feeding guidelines

7.20 3
1.00 NO
NO equivalent, as they
1.00 0.23
1.63 KNO

Very dangerous; can cause acute nitrate poisoning and
dead.

Be aware that nitrate levels can
be reported a variety of ways and the
method of expression can differ between
laboratories. Nitrate can be reported as
nitrate (NO₃), nitrate-nitrogen (NO₃-N), or potassium nitrate (KNO₃). These
numbers are not equivalent, as they
represent different chemical structures.

Testing Laboratories

The two veterinary diagnostic laborato-
ries in Kentucky that perform nitrate
testing on forages are the University of
Kentucky Veterinary Diagnostic Lab-
oratory and the Murray State University
Breathitt Veterinary Center. Both are
accredited by American Association of
Veterinary Laboratory Diagnosticians.

Several commercial laboratories, such
as Dairy One Forage Laboratory, conduct
the nitrate testing as well.

University of Kentucky Veterinary
Diagnostic Laboratory (UKVDL)
Carrier (UPS/FedEx) Shipping Address:
1490 Bull Lea Rd
Lexington, KY 40511
Contact for nitrate questions:
Dr. Cynthia Gaskill
(859) 257-7912

Murray State University
Breathitt Veterinary Center
715 North Drive
Hopkinsville, KY 42241-2000
Phone: (270) 886-3959
Fax: (270) 886-4295
Contact for nitrate questions:
Dr. Ramesh Gupta
(270) 886-3959

Interpreting Results

All sources of dietary nitrate, includ-
ing feeds, forages, supplements, and water
should be taken into consideration when
determining total dietary nitrate concen-
tration (Table 1). Representative sampling
is crucial for proper interpretation of re-

sults. Also, nitrate, a breakdown product
of nitrate that can be found in forages, is
much more toxic than nitrate, and much
lower levels of nitrate can cause poisoning
and death.

Be aware that nitrate levels can
be reported a variety of ways and the
method of expression can differ between
laboratories. Nitrate can be reported as

<table>
<thead>
<tr>
<th>Total dietary nitrate (NO₃) in dry matter</th>
<th>Feeding guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5,000 ppm (0.5%)</td>
<td>Generally safe for cattle. Be cautious with pregnant and young animals when nitrate concentrations approach 5,000 ppm and dilute with other feeds</td>
</tr>
<tr>
<td>&gt;5,000 but &lt;10,000 ppm (&gt;0.5% but &lt;1%)</td>
<td>Dilute with other feeds and introduce slowly. Consider options to reduce nitrate in fresh forage (ensiling, delayed harvest, other). Limit to a maximum of 50% of the total dry matter in pregnant animals</td>
</tr>
<tr>
<td>&gt;10,000 ppm (1%)</td>
<td>Very dangerous; can cause acute nitrate poisoning and death in cattle. Do not feed.</td>
</tr>
</tbody>
</table>

Table 1. Nitrate levels and feeding options for cattle.

<table>
<thead>
<tr>
<th>Method of expression</th>
<th>Chemical designation</th>
<th>To convert to NO₃, multiply by</th>
<th>To convert to NO₃-N, multiply by</th>
<th>To convert to KNO₃, multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate</td>
<td>NO₃</td>
<td>1.00</td>
<td>0.23</td>
<td>1.63</td>
</tr>
<tr>
<td>Nitrate-nitrogen</td>
<td>NO₃-N</td>
<td>4.40</td>
<td>1.00</td>
<td>7.20</td>
</tr>
<tr>
<td>Potassium nitrate</td>
<td>KNO₃</td>
<td>0.61</td>
<td>0.14</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 2. Conversion options for different reporting methods.

Conclusion

Few plants normally contain high nitrate levels, since under normal growing con-
ditions the nitrates are converted to protein as quickly as they are absorbed from the
roots. However, under certain conditions such as high nitrogen fertilization, drought
or abrupt changes in weather, plants can develop dangerously high nitrate levels. The
main problem with excess nitrates is that they are converted in the rumen to nitrites
that are absorbed in the bloodstream and ultimately prevent the red blood cells from
carrying life-giving oxygen. Death or abortion may result as a consequence of nitrate
intoxication. Care must be taken to recognize possible toxic forages and manage
them appropriately to avoid animal loss. The laboratory you intend to use or your
local county agent can provide specific instructions for nitrate testing.

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prietary product, or firm in text or figures
does not constitute an endorsement and
does not imply approval to the exclusion of
other suitable products or firms.