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O. E. Olson
South Dakota State University

R. J. Emerick

E. I. Whitehead

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Forage Nitrate Poisoning

(A SUMMARY)

O. E. Olson, R. J. Emerick, and E. I. Whitehead

Instructions for Sampling

In collecting material for submission for analysis, it is most important that the collection be made to insure as representative a sample as possible. When a field is sampled, combine material from various parts of the field. When a stack is sampled, forage from many points within the stack should be combined. In the case of a silo, only unspoiled material from several points should be collected. The amount to send will be determined by the amount that is necessary to obtain a reasonably representative sample.

Silages should be sent in plastic bags or tight containers to prevent loss of moisture. The time between sampling and delivery to the laboratory should be kept as short as possible. The same is true for green forages.

Do not send grains, stomach contents, blood or tissues, since these do not assist in diagnosis.

Send samples to Station Biochemistry, South Dakota State University, Brookings, South Dakota 57006. Be sure to enclose a note with your name and address and the analysis you wish made.

Occasionally forages accumulate nitrates in quantities that are toxic to some farm animals. As long ago as 1895, the literature reported cases of this. In the 1930's heavy cattle losses from what was then termed "oat hay poisoning" were reported in the Great Plains and Rocky Mountain areas. These losses were found to result from the high nitrate content of the hay. It has now been well established that several forage plants and weeds accumulate nitrates in toxic amounts under certain soil and environmental conditions.

Nitrates, regardless of their source, can cause livestock poisoning. However, this pamphlet deals with the problem when forages are concerned. Some mention is made of the occasional involvement of livestock water since nitrates in water contribute to this problem.

In recent years, nitrate poisoning has been reported in many states. The number of established cases occurring annually, is nevertheless, relatively small, and its occurrence is often overemphasized. When nitrate poisoning does strike it can be disastrous, wiping out a large part of the herd. It is, therefore, well for anyone feeding roughages to acquaint himself with this problem.

How Nitrates Poison

Nitrates in forages do not in themselves cause the poisoning of farm animals. Instead, they are converted to nitrites in the animal, and nitrites are toxic. In cows and sheep this conversion takes place in the rumen (paunch), in horses in the caecum.

The nitrites get into the blood stream and cause a change in hemoglobin, converting it to methemoglobin. This reduces the oxygen-carrying capacity of the blood. When a large part of the hemoglobin has been converted, the blood can no longer supply the tissues with oxygen and the animal actually suffers from a type of asphyxiation.

Symptoms

The usual symptoms of this poisoning are a rapid acceleration of pulse rate, quickened respiration followed by labored breathing, trembling of certain muscles, weakness, staggering gait, and sometimes apparent blindness. The animal may sink to the ground, fall on its side, and lie with its mouth open. The tongue and whites of the eyes turn blue. Death usually takes place with little or no struggling.

Pregnant animals that are affected, but do not die, may abort later.

Autopsy of dead animals may show some petechial hemorrhages on certain membranes, congestion of the

mucous membrane of the fourth stomach (abomasum), and blood of reddish-brown color which turns red on exposure to air.

It has been suggested that feeds containing less than what are considered toxic levels of nitrates reduce milk production in dairy cattle and rate of gain in beef cattle. The economic significance of either of these effects has not been established. Until further work is done on this matter, there appears to be no reason to caution against the use of feeds containing less than potentially lethal amounts of nitrates.

Feeds Involved

Oats—as hay, straw, or pasture—is one of the most commonly involved feeds. However, barley, wheat, or rye—as hay or straw—may occasionally contain toxic amounts of nitrate. The green corn plant and corn fodder have also caused losses from the poisoning. The same is true of sorghum and sudan grass, and in view of the similarity of symptoms, livestock losses from the feeding of these crops may be mistakenly attributed to prussic acid poisoning.

Many weeds (wild sunflower, pigeon grass, pig-weed, kochia, thistle) are also known to accumulate toxic amounts of nitrate. However, as is true for any of the plants involved, such accumulation is not the usual thing but happens only under certain conditions.

The conditions under which plants accumulate excessive amounts of nitrates are not fully understood. Unless the soils in which they grow are relatively high in nitrates, the plants do not accumulate them. On the other hand, high nitrate soils produce toxic vegetation only occasionally. Usually it takes a combination of factors along with the high nitrate content of the soil to produce vegetation of high nitrate content. Drought, hail, or frost damage to the plant, causing a stunting or cessation of growth, are often involved. Rarely, trace element deficiency, phosphorus deficiency or spraying with herbicides that affect the normal metabolism of the plant may be involved. Shortened sunlight periods, as in narrow valleys of the Black Hills, may sometimes contribute to the problem. As a general rule, the nitrate content of plants decreases with maturity and young vegetation is more likely to be toxic than that which is more mature.

So far as is known, the grain of oats, other cereals, corn, and sorghum does not contain nitrates in toxic amounts. Alfalfa, timothy, and brome grass hays, as well as native grasses, apparently are not involved.

Drought and Nitrate Accumulation

Of the many factors mentioned, nitrate content of the soil and drought seem to be the most important in

causing high levels of nitrates in plants. A fairly high level of nitrate must be present in the soil or plants will not accumulate it.

Fertilizing with nitrogen or plowing under legumes can contribute to the nitrate content of the soil. However, these practices should not be restricted because of the possibility of nitrate poisoning, since nitrogen is one of the most important factors in crop production and in profits. Furthermore, nitrate accumulation does occur where these practices have not been used. Recommended fertilizer and soil management practices should be followed without regard to the possibility of nitrate poisoning.

Even on soil high in nitrates, nitrate accumulation by plants in toxic amounts is the exception rather than the rule. Anything that limits the normal growth of the plant could, however, result in high nitrate forage. Drought is by far the factor most commonly involved in South Dakota. One reason for this is that dry weather usually strikes at a time when nitrogen is being rapidly absorbed by the plant, and the drought appears to cause a reduction in the conversion of nitrates to protein. If it rains following a dry period and the plants resume growth, the risk of nitrate poisoning is reduced.

Nitrates in Silage

When crops are put up as silage, they usually lose some of their nitrate. The amount they lose will vary from an insignificant amount to a large percentage of that present. Most of the loss occurs during the first few weeks of storage. The unpredictability of the disappearance of nitrate from stored silage makes the estimation of its nitrate content from an analysis of the fresh, green material unreliable, unless the green material was of low nitrate content in the first place. Therefore, where there is a reason to suspect that the ensiled material was toxic, an analysis for nitrates just prior to the time when it will be fed is recommended.

When high nitrate material is ensiled, under certain conditions not well understood, there will on occasion be a rapid reaction which results in the discharge of nitrate from the silage as a mixture of nitrogen oxide gases. These are often visible as yellow-red fumes. While this may significantly reduce the nitrate content, the gases are toxic to man and to livestock. Therefore, proper precautions should be taken during filling the silo and for some weeks thereafter to prevent poisoning of persons or livestock by gases. These precautions consist of providing proper ventilation whenever anyone is in the silo, and preventing the gases (which are heavier than air) from settling in closed barns to which silos are attached.

The gases formed from nitrates also destroy carotene (vitamin A). Therefore, high nitrate material may contain but little carotene after silage has formed. It is easy, however, to include another source of vitamin A in the ration to take care of the needs of livestock.

Vitamin A and Nitrates

Poor performance of cattle has sometimes been attributed to sub-optimum vitamin A nutrition resulting from the presence of nitrates in feeds. Experimental work to date indicates that under practical feeding conditions nitrate in the ration does not adversely affect the vitamin A nutrition of animals, except possibly when the level of nitrate is so high as to make the feed potentially acutely toxic. The most important effect on vitamin A is probably that discussed under "Nitrates in Silage."

Toxic Levels

It is not possible to determine the toxic level of nitrates with any great degree of accuracy. The level varies with environmental conditions, the kind of animal concerned, and for unknown reasons.

Experimental work and observations indicate that forages containing over 0.45% of nitrate nitrogen are potentially very toxic. They may not necessarily cause poisoning, but the risk in feeding them is great. The risk decreases as nitrate levels decrease. Feeding practices which limit the nitrate content of the total daily ration to 0.15% or less, should allow for use of the feeds containing up to 0.45%. At 0.15% nitrate nitrogen, forages are considered safe to feed without restrictions.

With high-moisture forages (over 75% moisture), the intake of dry matter will be reduced because of the large amount of water which is consumed with the forage. Therefore, the recommendations in this publication may be somewhat overcautious for this type of feed.

It should be noted that the percentages discussed above and presented in the table below are expressed on a moisture-free basis.

Nitrates in Waters

Well waters, especially from shallow wells, are sometimes high in nitrates. These waters may cause livestock losses. Occasionally, when a water contains insufficient nitrate to be toxic by itself, it may add to the toxicity of nitrate-containing feeds.

Waters containing nitrates have been purported to cause pig losses. Extensive research at this Experiment Station has shown that even at the highest levels of nitrate or nitrite nitrogen one might expect to encounter in South Dakota waters, swine are not adversely affected.

Control Measures

In considering control measures, it should first be well understood that the chance that nitrate poisoning will strike is small, even during periods of drought. Forages, and especially silages, will usually not contain excessive amounts of nitrates. Often, even if they should contain dangerous levels of nitrates, conditions for their conversion to nitrites may not be proper and no poisoning will result. A large percentage of farmers and ranchers in the state will never have trouble from nitrate poisoning, operating as they normally do without practicing control measures. With this in mind, the following suggestions are offered:

1. Pasturing or feeding green chopped crops suspected to contain dangerous levels of nitrates makes control difficult. However, providing a fill of low nitrate feeds before turning onto pasture will reduce the hazard. In corn or sorghum, the stalks—especially the lower portions—are highest in nitrates, and in pasturing this should be kept in mind. Regrowth in small grain stubble has in isolated cases been found to be high in nitrates.

2. The danger from any forage is reduced by offering it along with other feeds, since this should reduce the intake of nitrates by the animals.

3. Animals on a restricted ration will usually consume less nitrates than those allowed free access to feeds. Limited feeding would therefore be expected to give less trouble than full feeding.

4. A nitrate analysis of suspected feeds can be helpful, and in some instances is advisable. The analysis may not give a "yes" or "no" answer, but can be helpful.

5. Damp hays, straws, or fodders are considered more toxic than the same feeds when dry.

Treatment

The treatment of nitrate poisoning is not generally highly effective because it is usually applied too late. Occasionally, however, when animals are lost and the cause is immediately recognized as nitrates, other animals stricken, but still alive, may be saved by a veterinarian. A 4% solution of methylene blue (100 c.c. per 1,000 pounds live weight), injected intravenously, is generally used. When livestock losses occur and nitrate poisoning is suspected:

1. *Contact your veterinarian.*

2. Send samples for analysis as follows: hays, straws, fodders, pasture grasses, and waters the animals were consuming just prior to the losses. Do not send grains, stomach contents, or blood samples. Always send an explanatory letter with the samples.

3. Change feeds, if possible, until results of analyses are returned.

4. Specimens from animals that have died are of no particular value to the chemist in establishing losses from nitrate poisoning.

Interpreting a Nitrate Analysis

Individual animals vary in their susceptibility to poisons. With nitrates, toxicity being dependent upon their conversion to nitrites, this is especially true, since the process of nitrite formation is itself so variable. One animal may, for instance, consume what is considered to be rather highly toxic levels of nitrates but not be poisoned because nitrites fail to concentrate. Another may consume less nitrate,

convert it rapidly to nitrite, and die. Furthermore, animals may vary in their susceptibility to this type of poisoning.

The following guide must, therefore, be used with judgment. It is based upon experimental work and observations, and provides for a reasonable margin of safety. If the sample analyzed is representative of what is being fed, an analysis should be helpful.

Nitrate Nitrogen Content (Moisture-free basis)	Comment
0.0-0.15%:	This level is considered safe to feed under all conditions.
0.15-0.45%:	Feeds in this range vary from those safe to feed under most conditions to those for which the risk of poisoning is great. Feeds containing 0.15-0.3% nitrate nitrogen can be fed safely by limiting their daily use to 1/2 of the total dry matter in the ration. Feeds in the range of 0.3-0.45% should be limited daily to less than 1/4 of the total dry matter in the ration. Hay, straws, and fodders in this range should not be fed when damp.
Over 0.45%:	Forages containing over 0.45% nitrate nitrogen are all potentially toxic. It is recommended that they not be fed.

NOTE: Often nitrate content is reported as percent of potassium nitrate (KNO_3) or as percent of nitrate (NO_3). This laboratory, however, reports in terms of nitrate nitrogen (N), and our values must be multiplied by 7.22 to convert them to KNO_3 or by 4.43 to convert them to NO_3 .

Also note that the analyses from this laboratory are reported on a moisture free basis and that feeding recommendations are given in terms of dry matter. Usually 3-4 pounds of silage or green chop is considered equal in its dry matter content to 1 pound of hay, straw, fodder, or concentrate.



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A Summary

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Cooperative Extension Service
South Dakota State University
U.S. Department of Agriculture