FAQs about Cyanide or "Prussic Acid" Poisoning in Ruminants

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Usually within the month of October when the first frosts are expected in KY, the questions begin regarding the risk of prussic acid poisoning from Johnsongrass (*Sorghum halepense*) after frost and when is it "safe to graze again". Prussic acid, cyanide, or hydrocyanic acid are all terms relating to the same toxic substance. Hydrogen cyanide was first isolated from a blue dye (Prussian blue) and because of its acidic nature, it became known by the common name "prussic acid". No matter which name is used, cyanide is one of the most rapid and deadly toxins that affects cattle.

Where does the cyanide come from in a plant?

Certain plants contain compounds called "cyanogenic glycosides" which are not toxic by themselves but only when the plant is damaged. These cyanogenic glycosides and the enzymes necessary to convert them to free cyanide gas are separated in different locations within the plant cells. *Sorghum* species including Johnsongrass, sorghum, sudangrass and hybrid sorghum-sudangrass contain the cyanogenic glycoside "dhurrin". When plant cells are damaged, the plant enzymes can reach dhurrin and cleave it, releasing cyanide gas (abbreviated as HCN). A freezing event very effectively converts dhurrin to cyanide. Dhurrin concentrations are highest in the leaves, particularly new growth. Peak concentrations occur in the first week after germination, declining markedly once the plant reaches approximately 2 ft in height. Regrowth (for example, after a light frost) contains extremely high dhurrin concentrations.

How does cyanide attack the animal's system?

As ruminants consume these plant materials, hydrogen cyanide gas is released in the rumen. In addition, the rumen microflora contains enzymes that, in the presence of water, are also capable of converting cyanogenic glycosides in plants to free cyanide gas. Cyanide is rapidly absorbed from the rumen into the bloodstream. Once present in the blood, cyanide prevents hemoglobin in red blood cells from releasing its oxygen to the tissues and the animal subsequently dies from lack of oxygen.

Under conditions of low-level exposure, cattle can detoxify cyanide to thiocyanate which is excreted in the urine. If large quantities of cyanide are absorbed rapidly enough, the body's detoxification mechanisms are overwhelmed and the animal soon dies. Rumen pH is an important factor in determining rate and amount of HCN released in the rumen. The enzymes are more active at a higher pH of 6.5-7 so cattle on grass or hay diets are at higher risk than those on grain diets. Consumption of water, either before or after grazing, also increases the HCN risk.

Why is Johnsongrass and other *Sorghum* species only risky at certain times of the season but safe in others?

The cyanogenic glycosides are used by the plant as protection from grazing animals, insects and parasites when the plant is most vulnerable. The cyanogenic "potential" of plants is affected by the type (species and variety) of the plant, weather, soil fertility and stage of plant growth. Cyanide poisoning of livestock has been associated with *Sorghum* species including johnsongrass, sorghum-sudangrass, and other forage sorghum; *Prunus* species (e.g., wild cherry, black cherry, and chokecherry); elderberry (*Sambucus* spp); serviceberry (*Amelanchier alnifolia)*; and less frequently arrowgrass (*Triglochin* spp), white clover (*Trifolium repens*), birdsfoot trefoil (*Lotus* spp); and many others.

Certain environmental conditions reduce protein synthesis within a plant but nitrate conversion to amino acids continues and these form the "building blocks" of cyanogenic glycosides. Obviously factors that damage the plant such as crushing, wilting, freezing, herbicide treatment, drought, insects, and plant disease will reduce growth and protein synthesis. However, cool, cloudy days and moist growing conditions, high nitrogen fertilization, high soil nitrogen:phosphorus ratio, and low soil sulfur can also increase the cyanogenic potential. Application of herbicides such as 2,4-D have been shown to increase the cyanogenic potential of plants and potentially increases palatability.

Highest cyanide potential occurs when these plants are growing rapidly after a period of retarded growth such as after drought or frost. The early stages of plant growth, especially young, rapidly growing areas and areas of regrowth after cutting also contain high levels of cyanogenic glycosides. The risk of poisoning decreases as forages mature. Leaf blades are higher risk than leaf sheaths or stems, upper leaves are higher risk than older leaves, and seed heads are considered low risk.

How much cyanide is considered dangerous?

The lethal dose of cyanide is in the range of 2 to 2.5 mg/kg body weight. Forages can be tested for cyanide content at certain veterinary diagnostic labs and forage laboratories (for example, Purdue University: https://vet.purdue.edu/addl/tests/fees.php?id=231). Always refer to the ranges provided by the testing laboratory for interpretation of results. Generally, hay, green chop, silage or growing plants containing >220 ppm cyanide on a wet weight basis are very dangerous and <100 ppm is considered safe. On a dry weight basis, >750 ppm is considered

hazardous, < 500 ppm is considered safe and suspect in between. Animals that are most at risk are hungry and/or have not had time to adapt to these plants as they may develop a tolerance to higher amounts over time.

There is conflicting information available with regards to risk of cyanide in hay. A study from 2012 investigating methods to prepare sorghum for cyanogenic analysis found that whole leaves or entire plants can be harvested and dried then analyzed at a later date, so air drying plants did not decrease dhurrin concentrations during storage. However, the enzyme beta-glucosidase which converts dhurrin to cyanide was significantly decreased during drying. Bottom line- hay is rarely hazardous if adequately cured but testing is prudent if the cyanide risk was high when cut. Ensiling plants will significantly reduce the cyanogenic glycoside content.

What does an animal with cyanide poisoning look like?

Affected animals may begin showing signs of poisoning within 15-20 minutes and rarely survive more than 1-2 hours after consuming lethal quantities of cyanogenic plants. Death may be sudden without symptoms. If seen alive, cattle may exhibit rapid labored breathing, frothing at the mouth, dilated pupils, muscle tremors, and staggering prior to death. There may be a "bitter almond" smell to the breath but the ability to detect this smell is genetically determined in people so this is an unreliable sign. The mucous membranes are bright red in color due to oxygen saturation of the hemoglobin but may become more cyanotic (blue) at the end of life.

How is cyanide poisoning diagnosed?

History, clinical signs, and detection of cyanide in rumen contents support a diagnosis of cyanide poisoning. Cyanide is rapidly lost from animal tissues unless collected within a few hours of death and sealed in airtight containers. Liver, muscle (heart, especially the ventricular myocardium), whole blood, and rumen contents should be collected in airtight containers before shipment to a laboratory capable of performing cyanide analysis. Personal protective equipment should be worn when gathering samples from the animal. Minimal lethal blood concentrations are approximately 3 mcg/ml or less. Perhaps most important in the diagnosis of cyanide poisoning is to identify plants in the area accessible to the animals and determine if they are likely to contain cyanogenic glycosides. Cyanide concentration determinations in suspect plants can be performed if samples are collected and immediately sent on ice overnight to a diagnostic laboratory. Some diagnostic laboratories prefer samples to be frozen immediately after collection and prior to shipment.

Is there an effective treatment?

Treatment can be attempted if affected animals are discovered quickly, but often animals are found dead. Contact a veterinarian immediately if cyanide poisoning is suspected. The intravenous administration of sodium thiosulfate by a veterinarian is an effective treatment for cyanide poisoning although this compound has been difficult to find in recent years. The dose

can be repeated after a few minutes if the animal does not respond. Administering 0.5-1.0 liter of a diluted vinegar solution (one gallon of vinegar diluted in 3 to 5 gallons of water) via stomach tube can lower rumen pH, reducing the production of hydrogen cyanide, however, stress of handling may exacerbate signs and possibly lead to the animal's death. Most animals that survive treatment recover fully.

What can be done to prevent cyanide poisoning in cattle?

1. Graze sorghum, sorghum crosses, or Johnsongrass plants only when they are at least 18-24 inches tall. Young, rapidly growing plants or regrowth have the highest concentrations of cyanogenic glycosides, especially in the newest leaves and tender tips. Do not graze plants with young tillers. Do not turn out hungry animals in high-risk pastures because they may consume forage too rapidly to detoxify the cyanide released in the rumen. Animals should be turned out to new pasture later in the day as potential for cyanide release is highest in the morning.

2. Do not graze plants during drought periods when growth is severely reduced or when the plant is wilted or twisted. Drought increases the chance for cyanide because slowed growth and the inability of the plant to mature favors the formation of cyanogenic compounds in the leaves. Do not graze sorghums after drought until growth has resumed for a minimum of 4-5 days after rainfall and tests negative on a rapid test (see #7).

3. **Do not graze potentially hazardous forages when frost is likely (including at night). Frost allows rapid conversion to hydrogen cyanide within the plant. Do not graze for at least two weeks after a non-killing (>28 degrees) frost. Grazing after a light frost is extremely dangerous and additional frost events will likely occur before there is enough time for the cyanide risk to subside.**

Plants may be grazed after a killing frost once the plant material is completely dry and brown (the toxin is usually dissipated within 72 hours).

4. Do not allow access to wild cherry leaves. After storms or before turnout to a new pasture, always check for and remove fallen cherry tree limbs.

5. If high cyanide is suspected in forages, do not feed as green chop. If cut for hay, allow to dry completely before baling. Allow slow and thorough drying because toxicity can be retained in cool or moist weather. Delay feeding silage 6 to 8 weeks following ensiling. Sorghum hay and silage usually lose > 50% of prussic acid during curing and ensiling. However, these feeds should be analyzed before use whenever the forage likely had an extremely high content prior to cutting.

6. Forage species and varieties may be selected for low cyanide potential. There are wide differences among plant varieties. Some of the sudangrasses, such as Piper, are low in cyanide.

7. Test any suspect forages before allowing animal access. A rapid field test is available that can provide on-site results. Contact your county Agricultural Extension Agent for further information.