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Monograph

A Monograph on hydrogen cyanide (HCN) poisoning in farm animals

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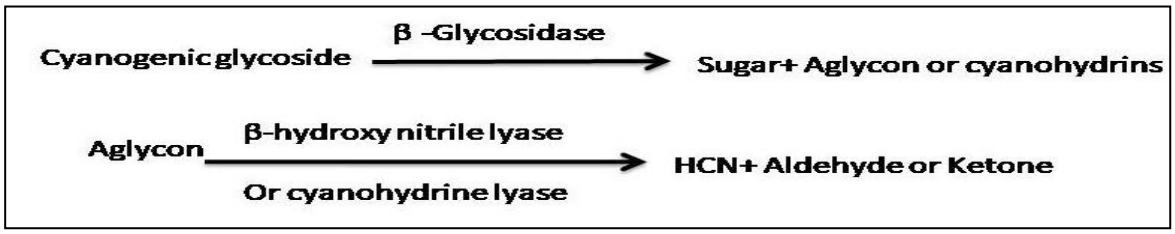
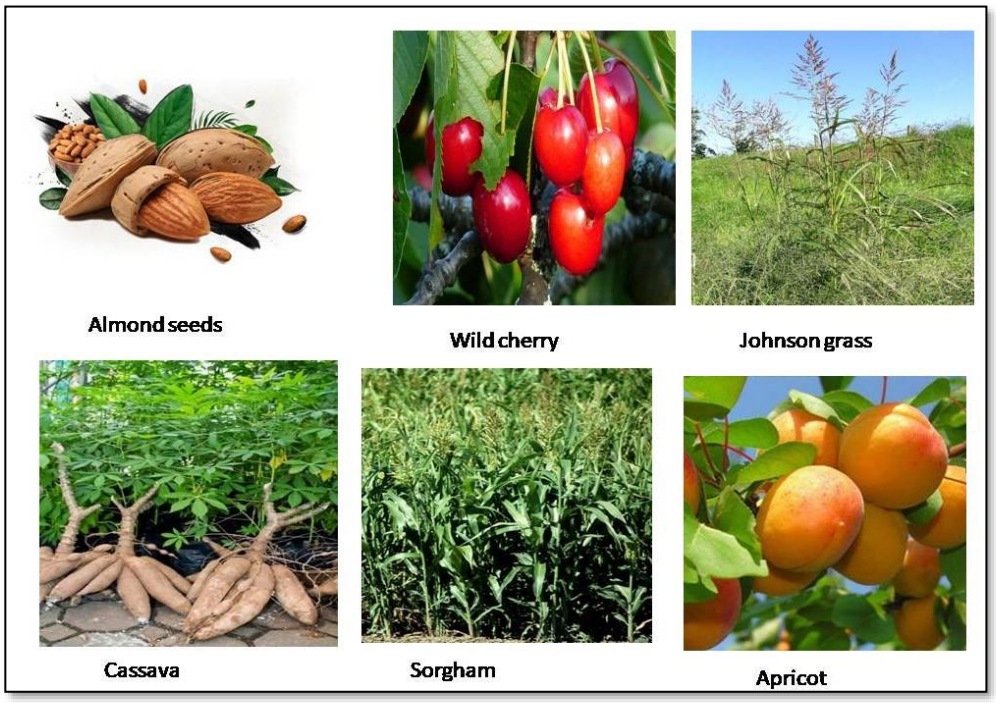
Introduction

HCN (hydrogen cyanide) or cyanide (CN-) poisoning in animals generally ingests certain plants that contain cyanogenic glycosides. Cyanogenic glycoside yield HCN upon acid or enzymatic hydrolysis during digestion or crushing (Francisco and Pinotti, 2000). A solution of HCN in water is called hydrocyanic acid or prussic acid. HCN is generally not present in the plant but in non-toxic organic form as cyanogenic glycoside which is formed from nitrate and amino acid as a part of normal plant metabolism. These cyanogenic glycosides are located in the epithelial cell of plants and β glycosidase is also present in the leaf (mesophyll cell of leave) any event which causes rupture cyanogenic glycoside binds with β glycosidase to produce HCN. The acute lethal dosage of HCN in most animal species is ~2 mg/kg. Plant materials containing ≥200 ppm of cyanogenic glycosides are dangerous. CN- block molecular oxygen transport in the cytochrome oxidase system in mitochondria and causes tissue anoxia. CN- along with hydrogen forms hydrocyanide which is also called prussic acid or hydrocyanic acid (HCN). When HCN is formed in ruminants' forestomach, it is quickly absorbed and inhibits cellular respiration by interacting with a trivalent iron. system of intracellular oxidative enzymes. This results in cytotoxic hypoxia and a reduction in energy production, eventually leading to cellular death (Huzar et al, 2013). The first time was isolated by the Swedish chemist Carl Wilhelm Scheele.



Plants	Cyanogenic glycosides
Sorghum	Dhurrin
Prunus (wild cherry) + bitter almonds	Amygdalin+ prunasin
Lin seed	Linamarin
Lotus	lotusin



1.1 Cyanide used as fumigants in buildings and shipping air containing CN^-.

1.2 CN used in electroplating of Nickel (Ni), chromium (Cr) and gold (Au)

1.3 Calcium cyanide (CaCN) used as a fertilizers

1.4 CN^- salts used in cleaning of metal, hardening and refining of gold

Source:https://bulawayo24.com/index-id-news-sc-national-byo-101389.html

Source:https://u.osu.edu/beef/2021/11/03/faqs-about-cyanide-or-prussic-acid-poisoning-in-ruminants/

3. Factor affecting CN^- toxicity

I. Plant factor

1. Stage of growth of plant: young maturing plant containing more leaves with high CN^- content than mature plants. Regrowth or new shoots after cutting also contain more CN^-
2. Part of plants: young leaves contain more CN^-
3. Height of plant: a plant with 2 feet in height contains more CN^-
4. Drought condition: increases nitrogen content during drought period which will contribute to the accumulation of CN^- content in the plant.

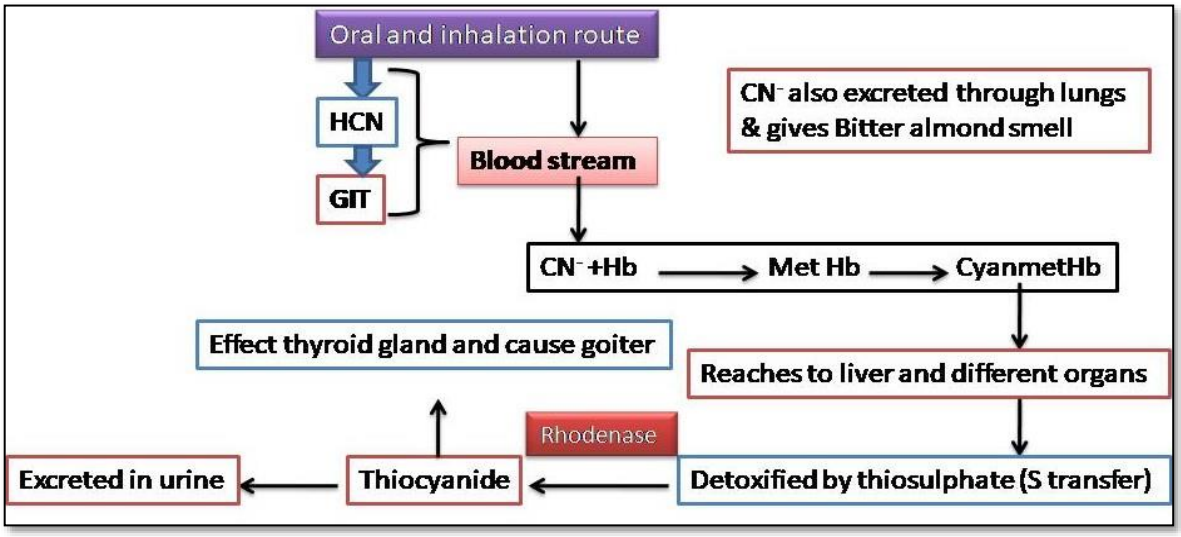
II. Soil factor

1. Soil rich in nitrite and low phosphorus or potassium favours the accumulation of CN^-
2. Fertilizers favour the accumulation of CN^-, nitrogen fertilizers increase glycoside content in the plant example: 2,4,D (2,4, Dichlorophenoxy acetic acid)- a Herbicide
3. In the winter season increases CN^-

III. Animal factor

1. Quantity & route of ingestion is directly proportional to the degree of toxicity
2. Ruminants are more susceptible because they have β- glycosidase enzyme which causes hydrolysis of cyanogenic glycosides and releases CN thereby causing its toxicity. The rumen microbiota also contains beta-glucosidase and hydroxy nitrile lyase, and a rumen pH of 6.5 to 7.0 encourages the conversion of cyanogenic glycosides to cyanide. Ruminants fed high-energy grain feeds are less vulnerable because cyanide synthesis is inhibited by their lower rumen pH (4-6). Before grazing on cyanogenic grasslands, drinking water seems to enhance the danger. Additionally, cyanogenic glycoside poisoning is less likely to affect monogastric animals with low stomach pH.
3. Amount of CN^- ingested, 2mg/kg of HCN is toxic and the lethal dose could be 50-150mg/kg, KCN 150-250mg/kg
4. Frezing, crushing, maceration, witting, biting and drying will result in release of CN^-

5. In ruminants' alkaline pH favors HCN hydrolysis while acidic pH unfavorable for hydrolysis



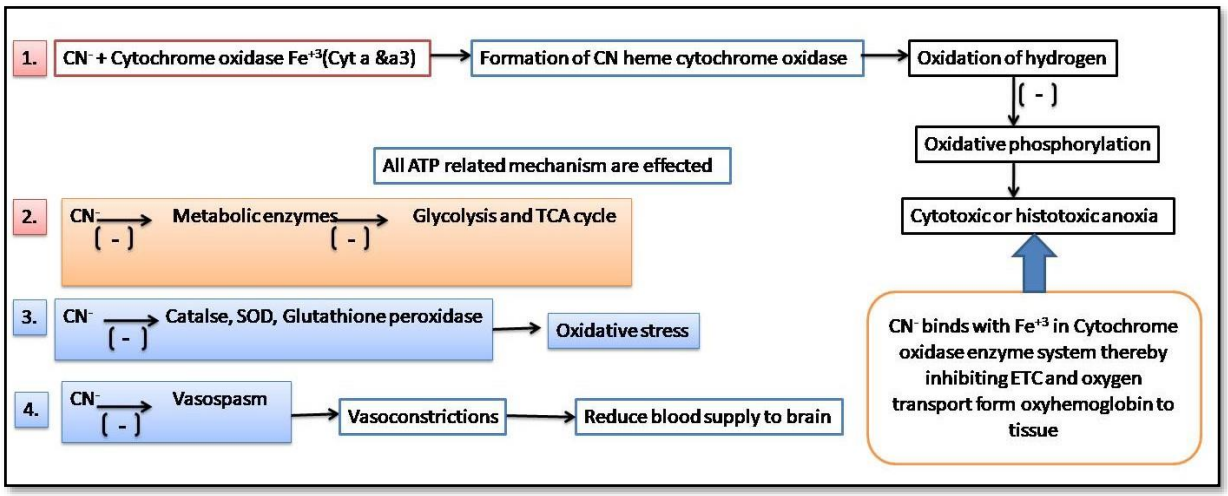
4. Toxicokinetics: The route of exposure in the animals by oral and inhalation.

5. Toxicodynamics: CN^- will bind with Fe^{+3} and prevents utilization of molecular oxygen therby causing histotoxic anoxia

At low-level exposure to CN^-, mammals detoxify ~80% of ingested cyanide by different detoxification mechanism

1. CN^- converted to thiocyanate via mitochondrial rhodanese and excreted in urine. rhodanese depend upon thiosulfate
2. combination of cyanide with hydroxycobalamin (vitamin B12a) to yield cyanocobalamin (vitamin B12),
3. the nonenzymatic combination of cyanide with cysteine to form beta-thiocyanoalanine, which is converted to 2-iminothiazolidine-4-carboxylic acid and subsequently excreted.
4. Dietary levels of sulfur amino acids (L-cysteine and L-methionine) strongly influence the rate of detoxification of cyanide, and low dietary intakes are associated with higher blood cyanide levels, particularly under conditions of chronic, low level exposure.

5. Dietary sulfur and sulfur amino acid intake are known to strongly affect the neurologic toxidromes associated with chronic cyanide/cyanogenic glycoside exposure in people.



Clinical signs

Acute signs: Sudden death without symptoms, bright red or healthy pink mucous membrane due to super saturation with oxygen, salivation, lacrymation, urination, diarrhea, delaying clotting and oozing of un clotted blood from nostrils.

Respiratory signs: Rapid and deep respiration, exhaled air has bitter almond smell, respiratory depression

Nervous signs: Muscle fasciculation, trembling, animals may stagger and struggle before collapse. Progression to generalized spasms and coma before death. convulsion

Cardiac signs: cardiac rhythm irregular, initially tachycardia later bradycardia, coma and death in few minutes

Chronic cyanogenic glycoside poisoning may also present as hypothyroidism

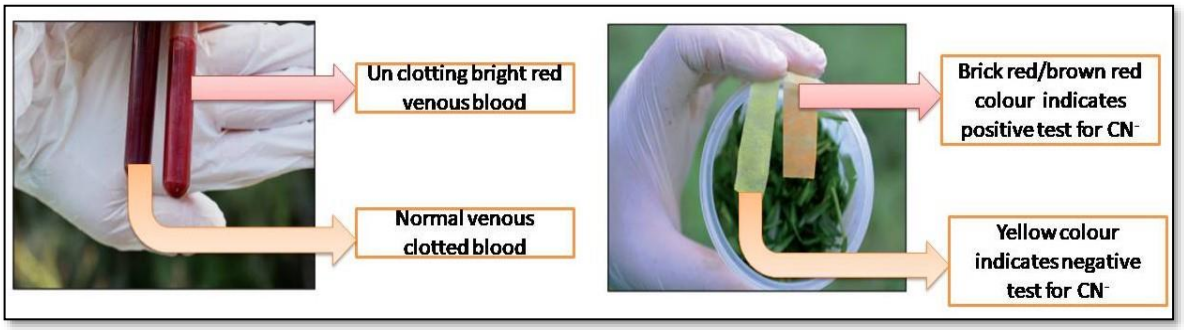
Post mortem examination

1. Mucous membrane: bright red or healthy pink
2. Venous blood: Cherry red or bright red due to oxyhaemoglobin
3. Bitter almond smell- when stomach opened
4. GIT: congested
5. Lungs: haemorrhages
6. Subendocardial, subepicardial petecchial and ecchymotic hemorrhages

7. PM materials are refrigerated rumen content, heart or skeletal muscle for cyanide ion detection. Blood samples should be kept in air-tight containers at 4°C (Egekeze and Oehme, 1979). or plant material in freezing condition otherwise CN^{-} will evaporated
8. Muscle eliminates CN^{-} slowly that can be collected in 3% mercuric chloride to prevent hydrolysis.

Diagnosis

1. Based on the history:
2. Based on clinical Signs
3. PM lesions: oozing of unclothed blood from nostril, bright red color blood
4. Lab diagnosis: Na picrate filter paper test in plant material: filter paper turns from yellow color to brown color which is indicative of positive test



Source: Gris, et al, 2013

bright red conjunctival mucous membrane Souce:https://curofy.com/discussion/successful-treatment-of-sorghum-cyanide-poisoning-in-cattle-courtesy-prof-venkatesh-

Diffuse hyperaemic and oedematous abomasum with multifocal to coalescing irregular pale white foci (Kennedy et al 2021)

kumar-sir-lavatn-2f19c99b1d66f8b4194255d14a7a83b2

Differential diagnosis:

1. **Nitrate poisoning**: sudden death but cyanotic mucous membrane and dark brown-red colour of blood
2. **Carbon Monoxide:** the colour of blood is bright red but the chance of toxicity is rare in animals
3. **Hydrogen sulphide (H2S):** sudden death, stomach content rotten egg smell, the colour of blood is dark and brown
4. **Urea poisoning:** acute (sudden death), nervous signs, behavioural signs, urine and stomach smell like ammonia smell

Treatment:

1. Regeneration of Cytochrome oxidase enzyme by giving Sodium nitrate: 1mol of Na nitrite will convert 2 moles of Hb to 2 moles of metHb and met Hb remains as it is for some time then converts to Hb by the enzyme NADPH-diaphorase enzyme
2. 2nd agent used is sodium thiosulphate: in excess sulphur presence covert CN to thiocyanate is formed and get excreted in the urine (Dose Na Nitrite @20mg/kg BW or 20% 10cc I/V route Na thiosulpahte @500mg/kg as 25% solution 50 CC I/V)
3. Vitamin B12 is also used as a cyanide antidote. Hydroxocobalamin detoxifies cyanide by binding to it and forming cyanocobalamin (ie, another decoy receptor approach), which is then excreted in urine
4. 4- Dimethyl Aminophenol (4DMAP): It can be given in place of sodium nitrate
5. Cobalt chloride or Di Cobalt EDTA which forms a stable complex
6. In the case of sorghum eaten animals can be treated with a drenching of honey or sugar syrups, in this case, CN^- + carbohydrate forms cyanohydrins which is a safe complex not available in the blood and excreted from the body.

Prevention:

- Do not allow the animals for grazing in the morning hours on the young growing crops of cyanogenic plants.
- Animals are free to access to plenty of water
- Ensure the diet included a rich amount of cysteine and methionine

References:

Francisco I.A. & Pinotti M.H.P. 2000. Cyanogenic glycosides in plants. Brazilian Archives of Biology and Technol ogy. 43(5): 487-492. DOI: https://doi.org/10.1590/S1516-89132000000500007

Huzar T.F., George T. & Cross J.M. 2013. Carbon monoxide and cyanide toxicity: etiology, pathophysiology and treatment in inhalation injury. Expert Review of Respiratory Medicine. 7(2): 159-170. DOI:

Gris, A., Bavaresco, L.H., Perosa, F.F., Gomes, T.M.A., Fronza, N., de Oliveira, J.R., Peripolli, V., de Souza Surian, C.R., de Gasper, A.L. and Mendes, R.E., 2021. Plant Poisoning Containing Hydrocyanic Acid in Cattle in Southern Brazil. *Acta Scientiae Veterinariae*, *49*.

Egekeze JO, Oehme FW (1979) Blood and liver cyanide concentra tions in rats poisoned with oral doses of potassium cyanide. Toxicol Lett 3: 243–7.

Kennedy, A., Brennan, A., Mannion, C., & Sheehan, M. (2021). Suspected cyanide toxicity in cattle associated with ingestion of laurel-a case report. Irish Veterinary Journal, 74(1), 1-6.