Harmful Natural Constituents and Toxic Substances in Animal Feeds

By Dr Manju

Gossypol

- It is found in cotton seed. It is available in free form as well as bound form as gossypol-protein complex.
- Whole cotton seed contains 1.09-1.53 % of gossypol. Heat treatment of Cotton seed meal decreases the gossypol content.
- The physiological effects of free gossypol are reduced appetite, loss of body wt., reduced heamoglobin content, cardiac irregularities, accumulation of fluid in body cavities and depress liver function.

- Gossypol is more toxic to non-ruminants than ruminants because in rumen gossypol combines with soluble protein.
- This complex is resistant to enzymatic break down. Gossypol also combines with Iron and lysine.
- So, ferrous sulphate supplementation reduces the toxic effect

Glucosinolates

- Glucosinolates are glycosides of β-D-thioglucose with an aglycone that yields an isothiocyanate, nitrile or thiocyanate or similar structure upon hydrolysis.
- Most of the glucosinolate containing crucifers are the genus Brassica that includes cabbage, broccoli, rapeseed, mustard and turnips.
- Glucosinolates are responsible for pungent flavours found in plants belonging to the genus Brassica.

Conti.....

- The glucosinolates are hydrolysed by an enzyme system (glucosinolase or thiglucosidase or myrosinolase).
- The enzyme is found in plant and is released when the plant material is crushed.
- It is also produced by the rumen microorganisms. The major effect of the hydrolysis products of glucosinolates is inhibition of the function of thyroid gland and results in goitre.
- The thyroid produces hormone known as thyroxine that are important in regulating the rate of cellular metabolism.

Conti.....

Signs of glucosinolate toxicity

- Goiter in humans has been observed.
- Poultry and swine fed raw rapeseed meal exhibited enlarge thyroid, growth depression, perosis, low egg production, off flavours in egg and liver damage.
- Treatment-
- Feeding of iodinized salt reduces the incidence in man and animals.
- Heat treatment of rapeseed reduces the glucosinolate.
- Thyroxine therapy may be useful for curing the disease.

Mimosine

- Subabul (*Leucaena leucocephala*), commonly referred to as leucaena, is a tropical legume with great potential as a protein source for livestock.
- It is vigorous, rapidly growing, drought tolerant, palatable, high yielding crop and its leaves contain 25-30% crude protein.
- These potential attributes are presently limited by the occurrence of the toxic amino acid mimosine in leucaena.

- Mimosine is structurally very similar to tyrosine and in rumen it is metabolized to 3,4 dihydroxypyridine (DHP).
- DHP is a goitrogen, impairing the incorporation of iodine in to iodinated compounds in the thyroid gland.

Conti.....

- In non- ruminant mimosine causes poor growth, alopecia and eye cataracts.
- Ruminant animals may show various symptoms such as poor growth, loss of hair, swollen and rough coronets above the hooves, lameness, mouth and oesophageal lesions, depressed serum thyroxine level and goiter developed.
- Sundrying reduce the mimosine content to the extent of 10%.

Cyanogens

- Cyanogens are glycosides of a sugar (usually glucose) and cyanide containing aglycone.
- They can be hydrolysed by enzymatic action with the release of hydrogen cyanide which is a potent toxin.
- The major cyanogens of importance in animal nutrition are the following.

❖Amygdalin

❖Dhurrin

❖Linamarin

Amygdalin (laetrile):

- This glycoside found in Rosaceae, such as chokecherries, wild cherries, Mountain mahogany and the kernels of almonds, apricots, peaches and apples.
- Prunasin is also found in these plants; it has the same structure as amgydalin except it has one glucose rather than two attached to the aglycone.

Dhurrin

- This occurs in sorghum species such as grain sorghum, forage sorghum (sudan grass) and Johanson grass.

Linamarin

- This compound is found in white-clover, flax (Lin seed), cassava and Lima beans.

➢ Hydrogen cyanide (prussic acid) is formed when the glucosides are hydrolyzed by plant enzymes (f3-glucosidase and hydroxyl nitrile lyase).

Mode of action of HCN:

HCN is readily absorbed and enters in tissue cells. It affects the electron transport system at two sites by affecting the cytochrome oxidase.

(i) Cytochrome-b is reduced to lesser extent in the presence of cyanide.

(ii) The electron transfer from cytochrome-a to water is completely inhibited, ATP formation ceases and the tissues suffer energy deprivation and death follows rapidly.

Conti.....

- Ruminants are more susceptible to HCN poisoning than Horses and pigs.
- The enzyme required for the release of HCN is destroyed in horses and pigs by the gastric HCl.
- Cattle are more susceptible than sheep.
- In subacute conditions oxygen is not taken up by the tissue because blood does not transfer the oxygen. So that arterial blood remains like venous blood.
- In acute condition when the quantity eaten is more it paralyses the medula oblongata in brain where respiration receptors are located, therefore, respiration stops and leading to death.

- Sign of HCN toxicity: Sign of cyanide poisoning are dyspnoea (difficult breathing), excitement, gasping, paralysis, staggering, convulsion, coma and death.
- Cyanide is readily detoxified.
- Liver, kidney and thyroid tissue contain an enzyme rhodanase which catalyzes conversion of cyanide to thiocyanate, which is excreted in the urine.
- Ammonia and nitrite inhalation is also useful during mild toxicity.
- Feeding of immature jowar green fodder should be avoided to prevent HCN poisoning.
- In cattle intravenously 3g sodium nitrate and 15 g sodium thiosulphate in 200 ml water while in sheep 1 g sodium nitrate and 2.5 g sodium thiosulphate should be given.

Antivitamins

- organic compounds which either destroy certain vitamins or combine and form unabsorbable complexes or interfere with digestive and/or metabolic functions.
- Antivitamin A: raw soybean contains enzyme lipoxigenase which catalyses oxidation of carotene, the precursor of vitamin A. detoxification can be done by autoclaving (heating 5 min with steam at atmospheric pressure).

- **Antivitamin E:**

❖ lipoxigenase found in kidney bean destroys vitamin E also.

❖ It causes muscular dystrophy in chicks and lambs by reducing plasma vit. E.

❖ Autoclaving

- Antivitamin K: dicoumerol present in sweet clover causes fatal haemorrhagic condition in cattle. This is known as sweet clover disease. Dicoumerol reduce the prothrombin levels in blood and affects blood clotting.
- Antivitamin D: rachitogenic activity of isolated soya protein (unheated) has been found with chicks and pigs. Autoclaving
- Anti-pyridoxine: an antagonist of pyridoxine from linseed has been identified as 1-amino-D-proline. It occurs naturally in combination with glutamic acid as a peptide and it is called linatine. Water treatment and autoclaving.

- Anti-niacin: an antagonist of niacin, niacytin is found in maize, wheat bran etc. which cause perosis and growth depression.
- Anti-thiamine: the enzyme thiaminase present in bracken fern (*Pteridium aquilinum*) acts as antithiamine factor.

Mycotoxins

- Mycotoxins are the secondary metabolites of fungi, especially moulds.
- Mycotoxin' refers to a group of toxic compounds which are produced by the fungi, Aspergillus flavus and Aspergillus parasiticus, mostly in improperly stored feedstuffs such as cereal grains and oil meals
- Eg. Wheat, barley, maize and groundnut.
- Although other fungi such as *Penicillium* spp, *Rhizopus* spp, *Muco* spp. and *Streptomyces* spp. are capable of producing aflatoxins, but their toxicity to livestock production has not been established.

- One mould species can produce different mycotoxins, and on the other way one mycotoxin can be produced by different mould species.
- The name “aflatoxin" derives from- Aspergillus (a-), flavus (-fla-) and toxin.
- *A. flavus* and *A. parasiticus* produce four major toxins: B1, B2, G1 and G2.
- These were named according to their fluorescence properties under shortwave ultraviolet light on thin-layer chromatography.
- BI and B2 fluoresce blue, whereas G1 and G2 fluoresce green.

- Aflatoxins were first discovered as toxic factors when heavy mortality occurrred amongst turkeys, ducklings and patridges in early 1960 in England.
- The cause was known to be mycotoxins in mouldy groundnut meal that was imported from Brazil to England for the use as protein supplement in animal diets.

- The relative humidity surrounding the substrate was the most improtant factor for the growth of *Aspergillus flavus*.
- Optimum temperature for alfatoxin production by *A. flavus* has been shown to be 25°C for aflatoxin B1 and 30°C for G1.
- *A. flavus* is primarily a seed colonizing mould and is usually referred to as a storage mould.
- Three major feedstuffs with high potential for invasion by Aspergillus spp. during growth, harvest, transportation or storage are corn, cotton seed and groundnut (Peanut).

- The principle target organ in all species is the liver.

Treatment of mycotoxins:

- The mycotoxin reducing methods are mainly categorized into 4 methodologies:
- Physical methods, thermal methods, chemical methods, and mycotoxin controlling feed additives.
- The first three methodologies mainly focus on how to reduce mycotoxins in feed ingredients during processes, while the last one on how to compensate the adverse impacts of mycotoxin-contaminated diets in animal bodies.

1. Physical methods: In this part, mycotoxin reducing effects of several feed manufacturing processes (cleaning, sorting, dehulling and milling) have been introduced. In all these processes, mycotoxins are mainly decreased due to the physical separation rather than chemical and biological deactivation, and thus they are classified as 'physical removal methods'.
2. Thermal processes: It helps to increase feed quality by deactivating some microbes like Salmonella or transforming kernels' physicochemical properties. In addition, anti-nutritional factors in cereals and legume seeds can be significantly inactivated through thermal process

3. Chemical methods: ammonia and ozone application are effective to reduce the mycotoxins.
4. Biotransformation of mycotoxins: Some microbes can turn mycotoxins into less toxic or non-toxic derivatives by transforming their physical and chemical characteristic. These natural detoxifying microbes occurring in animal GI tracts seem to be adaptive.
5. Mycotoxin-binding by feed additives: Main mycotoxin-restricting mechanisms involved with these additives include:

1) physically binding the mycotoxins and thus decreasing the gastrointestinal absorption of mycotoxins
2) inactivating mycotoxins
3) modifying animals' enzymes to transform mycotoxins into some less toxic metabolites or improve animals' defence against mycotoxin

- Inorganic binding agents: hydrated sodium calcium aluminosilicates (HSCAS), activated coat (AC), montmorillonite clays (MC), etc.
- Organic 'binding agents': the most noticed organic binder now is the yeast cell wall. live yeast *Saccharomyces cerevisiae* can effectively suppress adverse effects of some mycotoxins (e.g. aflatoxins) in animals (e.g. chicks)

Alkaloids

- Alkaloids are basic substances that contain nitrogen in heterocyclic ring.
- They are widely distributed in the plants; it has been estimated that 15-20% of all vascular plants contain alkaloids.
- Most alkaloids are derived from amino acids in their synthesis by plants.
- Amino acids are decarboxylated to amines and the amines are converted to aldehydes by amine oxidase.
- Condensation of the aldehyde and amine groups then yields the heterocyclic ring.

- Various alkaloids with their sources are tabulated below:
- Atropine — Atropa belladonna (Deadly nightshade)
- Cocaine — Leaves of Coca plant
- Coniine — Poison Hemlock (*Conium maculatum*) **-** piperidine alkaloid.
- Morphine — Dried latex of opium poppy
- Nicotine — Tobacco (pyrrolidine alkaloid)
- Quinine — Cinchona bark
- Solanine — Unripe potatoes
- Strychnine — Seeds of nux vomica

Nitrate poisoning

- also known as Oat hay poisoning found in cattle due to the consumption of nitrates in some grasses.
- The nitrates are reduced to nitrites in the rumen.
- Nitrites oxidize the ferrous iron of haemoglobin to the ferric iron of methaemoglobin which does not transport oxygen.

Nitrate poisoning

- In severe cases, the blood becomes almost chocolate brown and there is a brownish discolouration of nonpigmented areas of the skin and mucous membranes.
- The pulse is rapid and breathing is labored. Death may result because of anoxia.
- Nonruminants can tolerate nitrate but ruminants don’t because the bacteria in the rumen convert to nitrite.

- Sources of nitrate/nitrite: water contaminated with industrial or animal wastes, feeds containing high levels of nitrate.
- Cornstalks and oat hay were two of the feeds first reported to occasionally contain high level of nitrate. Hay and straw containing more than 2.2% potassium nitrate is toxic.
- Treatment: reducing agents such as methylene blue (2-4mg/kg to 15mg/kg body wt.), thionin or ascorbic acid which convert the methaemoglobin into oxyhaemoglobin.

. Bloat- producing proteins

- Bloat is a distension of the rumen as a result of the inability of the animal to eructate gases produced in normal processes to rumen fermentation.
- The principle gases are carbondioxide and methane and these gases are trapped in the form of stable foam.
- The eructation mechanism is inhibited by the presence of foam at the base of the oesphagus; eructation of foam would result in it getting in to the lungs.
- Bloat producing plants, primarily legumes, contain substances which causes the production of stable foam in the rumen.
- The most important bloating species in temperate regions are alfalfa (*Medicago sativa*), red clover (*Trifolium pratense*) and white clover (*T. repens*).
- Tropical legumes are not bloat producers.
- In addition, animal factors as well as rumen microbes are also involved in bloat condition. The use of antifoaming agents such as poloxalene (Bloat Guard) and vegetable oil in legume pastures has vastly reduced the bloat problems.

- Toxic substances such as dioxins, mycotoxins, heavy metals, pesticides, veterinary drugs and polycyclic aromatic hydrocarbons are almost ubiquitous in the environment. Thus, they are also present in ingredients for animal feed.
- Generally, toxic substances are metabolized before or after absorption through the intestinal tract.
- Depending on their physico-chemical characteristics, some substances are metabolized into naturally occurring and generally harmless constituents. Most veterinary drugs and feed additives fall into this group.
- Other substances are persistent and remain in the animal and in animal products, like dioxins.

  (**Dioxins** are released into the air from combustion processes such as commercial, municipal or medical waste incineration, from burning fuels e.g., wood, coal, oil and burning of household trash)
- Heavy metals are not metabolized at all. Some metals irreversibly are bound to body tissues, e.g. lead to bone or cadmium to kidneys.

- Risk management of chlorinated pesticides and environmental contaminants:
- Cessation of direct application on animals or presence of persistent compounds in their feed, housing or pasture is logically the first measure to control residues. Prevention of occurrence of residues in products of animal origin (a control point in HACCP) can be achieved via control of levels in (fat containing) feedstuffs.
- This approach has proven to be efficacious in reducing residue levels over the past 30 years.
- Residues of contaminants in products of animal origin due to environmental contamination are harder to control.
- When (legally) acceptable limits for residues have been surpassed, removal of the contaminated items from the human food chain is the only option.

- Heavy metals:

  Contamination by cadmium, lead and mercury as well as arsenic.

- Risks and risk management:

  The HACCP (Hazard Analysis Critical Control Point) approach suggests the following: reduction of exposure via feed is relatively easy by avoiding the use of certain contaminated feedstuffs.

  However, environmental and incidental exposure is hard to control.


Thank
you