BIHAR ANIMAL SCIENCES UNIVERSITY, PATNA

Animal Nutrition

UNIT-1 : Principles of Animal Nutrition and Feed Technology

UG Lecture on

Harmful Natural Constituents and Common Adulterants

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Point to be discuss……..

- ➢ Anti-nutritional factors
- ➢ Classification of Harmful Natural Toxicants by chemical structure
- ✓ Alkaloids
- ✓ Glycosides
- ✓ Proteins
- ✓ Amino Acids and Amino Acid Derivatives
- ✓ Carbohydrates
- ✓ Lipids
- ✓ Metal binding substances
- ✓ Resins
- ✓ Mycotoxins
- ✓ Phenolic compounds
- ✓ Other toxins
- ➢ Classification of natural toxicants by their occurrence in feeds
- ➢ Management of Toxicosis
- ➢ Common adulterants in feed and fodder

Anti Nutritional Factors

- **ANFs may be defined as those substances generated in natural feed stuffs during normal metabolism & by different mechanisms exert effects contrary to optimum nutrition.**

- **Harmful natural constituent is a substance which under practical circumstances can impairs animal metabolism & produce adverse biological or economic effects in animal production.**

Classification of Harmful Natural Toxicants by chemical structure

1. Alkaloids :

- **Alkaloids (alkali-like) are compounds that contain nitrogen, usually in a heterocyclic ring.**
- **They are usually bitter and toxic in nature.**

Name	Source
Nicotine	Tobacco
Ricinine	Castor plant seeds
Atropine	Deadly nightshade
Cocaine	Leaves of coca plant
Jacobine	Ragwort
Strychnine	Seeds of *Nuxvomica*
Morphine	Dried latex of opium poppy
Solanine	Unripe potatoes and potato sprouts

2. Glycosides:

- It contains glycan (carbohydrate moiety) & a non-carbohydrate moiety (aglycone) joined with an ether bond.
- It is usually bitter substances.
- They are classified on the basis of structure & properties of the aglycone.

i. Cyanogenic glycosides:

- They yield hydrocyanic acid (prussic acid) when hydrolysed.
- It is hydrolysed by Beta-glycosides to release HCN, glucose and benzaldehyde.
- However, glycosides occur in vacuoles in plant cell and enzymes are found in the cytosol. So, damage to the plant results in the enzymes and glycoside coming together and producing HCN.

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- The hydrolytic reaction can take place in the rumen by microbial activity, hence, ruminants are more susceptible to cyanogen toxicity than non-ruminants.
- The HCN is absorbed and is rapidly detoxified in the liver by the enzyme rhodanase which converts CN to thiocyanate (SCN).
- Excess cyanide ion inhibits the cytochrome oxidase and stops ATP formation, tissues suffer energy deprivation and death follows rapidly.
- Drying of cyanogenic leaves may reduce the risk of cyanide toxicity.
- Cattle are more susceptible to HCN poisoning than sheep, horse and pig.
- Immature green Jowar, sudan fodder and linseed may cause HCN toxicity.

- **Immediate treatment of cyanide poisoning:** Injecting i/v 3 g sodium nitrate and 15 g sodium thiosulphate in 200 ml distilled water for cattle and for sheep 1 g sodium nitrate and 2.5 g sodium thiosulphate in 50 ml H2O.
- Some glycosides such as Amygdaline (Almond), Dhurrin (Jowar and, Dhatura, immature grasses), Linamarin (Linseed, cassava, pulses).

ii. Goitrogenic glycosides:

- It decreases production of the thyroid hormones (Thyroxine, T4 & Triiodothyronine, T3) by inhibiting their synthesis by thyroid gland.
- As a result, the thyroid enlarges to compensate for reduced thyroxin output, producing goitre.

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- Goitrogenic glycosides are commonly found in Brassica spp. such as cabbage, turnip, kale, rapeseed, mustard green etc.
- Glucosinolates are formerly called thioglucosides.
- Myrosinase is released from plant tissue by crushing (mastication) and is also produced by rumen microorganisms.
- Glucosinolates are always accompanied by the enzyme myrosinase (thioglucosidase) which are capable of hydrolyzing them to thiocynates and isothiocynates to venyloxazolidinethione which is potently goitrogenic causes depressed iodine uptake and liver damage.
- Ruminants are less susceptible than pig and poultry.

Brassica anaemia factor:

- Two types of sulphur containing compounds, limit the feeding value of brassica crops such as glucosinolates and S- methylcysteine sulfoxide (an amino acids) .
- In the brassica it may occur at levels as high as 4-6% of the dry matter.
- The SMCO is a fairly rare amino acid, found only in brassica, garlic, and onion.
- It leads to RBC hemolysis and cause anaemia.
- However, SMCO is probably not the primary haemolytic agent.

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- It is metabolized in the rumen, producing dimethyl disulfide.
- Dimethyl disulphide attacks the red cell membrane.
- It is inactivated by reacting with reduced glutathione (GSH), producing methylmercaptan.
- The toxic principle in onions is n-propyl disulfide and SMCO. This compound is an oxidant that will cause RBC hemolysis and Heinz-Ehrlich bodies. It is reduced by the glutathione peroxidase system.
- Garlic contains S-allylcysteine sulfoxide, which is metabolized to allyl disulfide oxide. The cholesterol lowering properties of garlic may be due to reaction of disulfide group with sulfydryl group of CoA, leading to inhibition of lipid synthesis.

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iii. Coumarin glycosides:

- **Found in sweet clover (Melilotus spp.) as melilotoside.**
- **Coumarin is converted by mould growth to dicoumarol an antagonist of vitamin K.**
- **Sweet clover poisoning, caused by feeding mouldy sweet clover hay, is therefore an induced vitamin K deficiency.**

iv. Steroid and Triterpenoid glycosides:

a) Cardiac glycosides:

- **Best known CG is digitonin, contained in foxgloves (digitalis spp.).**
- **Physiologically, they are potent stimulators of heart rate & are used medicinally.**

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b) Saponin:

- Saponins are glycosides containing a polycyclic aglycone moiety of either C27 steroid or C30 triterpenoid (collectively termed as sapogenins) attached to a carbohydrate.
- They are widely distributed in the plant kingdom.
- Saponins are characterised by a bitter taste and foaming properties.
- Erythrocytes lyses in saponin solution and so, these compounds are toxic when injected intravenously.
- In non-ruminants (chicks and pigs), retardation of growth rate, reduction in feed intake occurs & in ruminants, implicated in causing bloat.
- The adverse effects of saponins can be overcome by repeated washing with water which makes the feed more palatable by reducing the bitterness.

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v. Vicine:

- **Vicine is a glycoside in Fava beans (*Vicia faba*).**
- **It causes haemolytic anaemia (favism) in people who have a genetic deficiency of glucose-6-PO4-dehydrogenase activity in their RBC.**
- **Fava beans are being utilized as a protein supplement for livestock.**

vi. Isoflavones:

- **Which are called phytoestrogens, contain a flavones nucleus (ex- genistein, formononetin and coumestrol).**
- **It cause reproduction problems in ruminant especially sheep.**

3. Proteins:

- **Several important inhibitors in plants are proteins.**
- **In some cases, effect of these are to inhibit the utilization of other proteins by animals.**

i. Protease (Trypsin) and Amylase Inhibitor:

- **Inhibitors of enzymes, such as trypsin, chymotrypsin, carboxpeptidases, elastase appear in many food products (legumes, cereals, potatoes etc.).**
- **Adverse effects following short- and long-term ingestion of raw soybean meal (the richest source of dietary trypsin inhibitors) by mammals & birds on protein utilization & growth, attributed to presence of trypsin inhibitors.**

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Protease inhibitors fall into 2 main categories:

1. Kunitz inhibitor: MW- 21.5 kilodalton with 2 disulfide bridges and possess specificity mainly against trypsin.

2. Bowman-Birk inhibitor: MW- 8 kilodalton with a high proportion of disulfide bonds & capability of inhibiting chymotrypsin & trypsin at independent binding sites.

- Levels of trypsin inhibitors (mainly as the Kunitz trypsin inhibitor) in soybeans have been reported to vary from 17-48 mg/g sample or from 37-123 mg/g protein.
- Protease inhibitors can be inactivated by the heat-processing method, such as extrusion, IR, micronizing, autoclaving, steam processing, or flaking.

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Mode of action of trypsin inhibitors:

- Raw soybean feeding cause an enlargement of the pancreas (hypertrophy), i.e. an increase in the size of acinar cells of pancreas.
- The pancreatic enzymes (trypsin and chymotrypsin) are rich in sulfur-containing amino acids.
- Therefore, hyperactive pancreas would divert these amino acids from the synthesis of body tissue protein to the synthesis of these enzymes, which are subsequently lost in the faeces.
- When the level of active trypsin in the gut is depressed due to the presence of the inhibitor, the pancreas would respond in a compensatory fashion by producing more enzymes.

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- The mediating agent between trypsin & pancreas has been reported to be the hormone cholecystokinin (CCK), which is released from jejunal endocrine cells when level of trypsin in small intestine becomes depleted.

- Protein and/or amino acid digestibility have been reported to be negatively affected in animal by high levels of dietary trypsin inhibitors.

ii. Hemagglutinins (lectins):

- **Hemagglutinins, are proteins which agglutinate red blood cells.**
- **Soyabean lectin strongly binds to mannose of RBC & cause agglutination.**
- **The highest concentrations of lectins are found in seeds but, in the leaves, their concentration is low due to translocation.**
- **Lectins may bind to the carbohydrate moieties of cells of the intestinal wall & cause a non-specific interference with nutrient absorption.**
- **Robin, a lectin from *Robinia pseudoacacia*, has been reported to cause symptoms of anorexia, weakness and posterior paralysis in cattle.**
- **Ricin, castor bean (*Ricinus communis*) seed press cake, and foliage are poisonous and not used as a livestock feed but the oil is non toxic.**

iii. Enzymes:

- **Thiaminase, found in bracken fern (*Pteridium aquilinum*) and certain fish.**
- **Enzyme cleaves the B vitamin thiamine and inactivating it & causes thiamine deficiency (Chastek's paralysis).**
- **Other enzymes in feeds which produce deleterious effects in livestock includes Lipoxidases in soybean and alfalfa, which degrade fat soluble vitamin.**

4. Amino Acids and Amino Acid Derivatives

(a) Mimosine:

- Toxic amino acid
- A non-protein amino acid structurally similar to tyrosine, occurs in *Leucaena leucocephala* forage plant.
- Concentration of mimosine in the leaf is about 2–6%, varies with seasons & maturity.
- In non-ruminant animals, mimosine causes poor growth, alopecia (loss of hair), eye cataracts & reproductive problems.
- Levels of Leucaena meal above 5–10% of the diet for swine, poultry and rabbits result in poor animal performance.

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- MoA of mimosine is not clear but it may act as an amino acid antagonist or may complex with pyridoxal phosphate, leading to disruption of catalytical action of trans-aminases, or may complex with zinc metal.
- Toxicity symptom in ruminants are poor growth, loss of hair & wool, swollen hooves, lameness, mouth & oesophageal lesions, depressed serum thyroxine level & goitre.
- These symptoms may be due to mimosine toxicity & metabolite of mimosine in the i.e. 3, 4 -dihydroxypyridine (DHP).

(b) Avidin:

- Glycoprotein in egg albumin, which is an antagonist of B vitamin Biotin.
- Raw eggs can be used to induce biotin deficiency in experimental animals.

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5. Carbohydrates:

- Few toxicity problems arises due to carbohydrate
- Xylose (hexose sugar)- cause decrease growth & cataracts in pigs & poultry.
- Raffinose are not digested in small intestine, hence promote bacterial growth in the hind gut (flatulence factors in beans).
- Beta- glucans in barley cause nutritional problems in poultry.

6. Lipids:

- Several fatty acids are toxic such as;
- Erucic acid in rape seed.
- Cyclopropenoid fatty acid- such as sterculic & malvalic acids in cottonseed, have toxic properties & cause pink albumins to develop in stored eggs.
- Trans fatty acid may have carcinogenic effect in human.

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7. Metal binding substances:

i. Oxalates:

- Chelating agent which chelates Ca very effectively.
- Plants with a high oxalate content may produce acute metabolic Ca deficiency (hypo calcemia) in livestock.
- Oxalic acid converted to Ca-oxalate.

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ii. Phytates:

- Phytic acid in cereal grains & soyabean meal causes reduced mineral availability.
- Organic P (phytin P) is of low availability to non-ruminant animals.
- Phytate is synthesized in plants by successive phosphorylation of inositol.
- Breakdown of phytate involves successive dephosphorylation by phytases present in plants, microorganisms & certain animal tissues.
- Phytase supplementation improves the availability of minerals & digestibility of proteins and ME.

8. Resins:

- Soluble in organic solvents, insoluble in water, and do not contain nitrogen.
- Examples are cicutoxin, a poisonous principle of *Cicuta spp*. (water hemlock).
- It is one of the most spectacular known poisons- acting directly on the CNS to produce violent convulsion.

9. Phenolic compounds: Contain an aromatic ring with one or more hydroxyl groups.

i. Gossypol:

- **Gossypol is a phenolic compound found in pigment glands of cotton seed (*Gossypium* spp.).**
- **The main concern from a toxicological point of view is with free gossypol.**
- **The bound gossypol is physiologically inactive, but because it is bound to protein and particularly lysine, so, it reduces the biological value of the protein.**
- **The physiological effects of free gossypol- olive green yolks in hen's eggs, depress appetite & growth, ascites & tissue edema, cardiac lesions & male infertility may happens.**
- **Gossypol form complex with iron and cause iron deficiency in livestock.**
- **Supplement iron source as ferrous sulphate, when fed with CSK to livestock.**

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ii. Tannins:

- **Tannin have the ability to precipitate protein by forming hydrogen bonding, which contributing to the stability of the protein-tannin complex.**
- **Mainly there are two types of tannins- Condensed & Hydrolysable tannin.**
- **Condensed tannin are not readily hydrolysed and have complex structure (formed from the condensation of flavanols such as catechin and epicatechin).**
- **Hydrolysable tannins can readly hydrolysed by hot mineral acid to yield the sugar core.**
- **HT are astringent and adversely affect feed intake.**

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- Low to moderate concentrations of Condensed tannin precipitate soluble plant proteins & thus protect them against degradation in the rumen, but if the proteins are too firmly bound to the tannins they are not digested in the small intestine.
- By protecting proteins from hydrolysis in the rumen, they increase amino acid absorption from the small intestine.
- They also modify gas production in the rumen, thereby reducing the danger of bloat & possibly reducing methane production.
- Condensed tannins are also claimed to restrict the growth of gut parasites.

10. Mycotoxins:

- **Metabolites of fungi (molds) is toxic to animals.**
- **Toxigenic species within the three dominant genera as Aspergillus, Penicillium and Fusarium, occupy a wide range of habitats.**
- **Most common chronic effects in livestock are decreased growth rate & feed intake.**
- **Subclinical effects occurring in the liver, kidneys, GIT may be responsible.**
- **Diagnosis of mycotoxicoses is generally imposible from clinical signs or post-mortem examination or residues in tissues.**
- **Some toxic effects are secondary, for aflatoxin B1 and T2 toxin which interfere with the immune system, increasing the susceptibility to infectious diseases.**
- **Acute death in poultry (Turkey X-disease), liver cancer, lupinosis, sweet clover poisoning, facial eczema of sheep, ryegrass staggers & ergotism.**

11. Other toxins:

i. Plant Carcinogens:

- **Carcinogenic effects in livestock may occurs due to consumption of a poisonous plant**
- **Bladder and intestinal cancer in cattle consuming braken fern.**
- **Pyrolizidine alkaloids have carcinogenic properties.**

ii. Trimethylamine oxide & formaldehyde:

- **Occurs in certain types of marine fish & impair iron absorption when the fish are used in the diet of animals.**
- **Iron deficiency signs such as reduced growth, anemia & loss of hair pigmentation (achromotrichia) are observed.**

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iii. Nitrates:

- **Nitrate toxicity in ruminant is also known as "Oat hay poisoning".**
- **Large amounts of nitrate present in green oats & heavy dressings of nitrogenous fertilizers may enhance its concentration.**
- **Nitrate per se is relatively non-toxic to animals.**
- **Toxic effect in ruminants is caused by the reduction of nitrate to nitrite in the rumen.**
- **Nitrite, oxidises the ferrous iron of haemoglobin to the ferric state, producing a brown pigment- methaemoglobin (incapable of transporting oxygen to the body tissues).**
- **Toxic signs include trembling, staggering, rapid respiration and death.**
- **Non-ruminants can tolerate nitrate but ruminants do not because the rumen bacteria convert nitrate to nitrite.**

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- **As reported, toxicity may occur in animals, grazing herbage containing more than 0.7 g nitrate-N/kg DM (2.8 g NO3), although the lethal conc. is much higher than this.**
- **Acute nitrate toxicity is treated with I/v methylene blue solution (2 to 4 mg/kg to 15 mg/kg BW i/v in 1% solution) or ascorbic acid (reducing agents) which accept electrons for NADPH reductase in blood & accelerate the reconversion of methaemoglobin to functional haemoglobin.**
- **Oral dose of mineral oil (1 lit. For adult cattle) or 500 g sodium sulphate in saline drip per cattle as supportive therapy.**

Classification of natural toxicants by their occurrence in feeds:

Feedstuffs	Toxicants
Grains	
All	Phytates, Mycotoxins
Rye, Triticale	Trypsin inhibitors, Ergot
Milo	Tannins
Tubers	
Potato	Solanum alkaloids
Cassava	Cyanogenic glycosides
Protein supplements	
Soybean	Trypsin inhibitors, Lectins, Goiterogens, Saponins, Phytates, Mycotoxins.
Cottonseed	Gossypol, Tannin, Cyclopropnoid fatty acid, Mycotoxin

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Feedstuffs	Toxicants
Rapeseed / Mustard oil cake	Glucosinolates, Tannins, Erucic acid, Sinapine
Linseed meal	Linamarin, Linatine
Fava beans	Tripsin inhibitors, Vicine, Lectins
Forages	
Legumes:	
Alfalfa	Saponins, Phytoestrogens, bloating agents
Red clover	Slaframine, Phytoestrogens, bloating agents
Sweet clover	Coumarin
Leucaena spp.	Mimosine
Grasses:	
Tropical grass, Paddy straw	Oxalates
Forage Brassicas	Brassica anemia factor

Management of Toxicosis:

The management plan for toxicologic emergencies, as follows:

- **Institute the necessary emergency and supportive therapy to keep the animal alive.**
- **Establish a tentative clinical diagnosis on which to base therapy.**
- **Institute the appropriate remedial and antidotal procedures.**
- **Identify the toxic agent as rapidly as possible.**
- **Determine the source of the toxin.**
- **Counsel the livestock owner on the hazards of the implicated toxicant, & provide instruction for the avoidance of the problem in the future.**

Common adulterants in feed and fodder:

- **Adulterant can be defined as intentional admixture of a pure substances with some low quality substances for earning more profit.**
- **Feed adulterant can be checked in lab. By different methods: Chemical analysis, Bioassay assessment (less common method) & Feed microscopy**

Feed ingredients	Adulterants
Groundnut cake	GNC husk, urea, UNCF cakes
Mustard cake	Argimona maxicana seed, urea, UNCF cake
Soyabean meal	Urea, hulls
DORB, Wheat bran	Ground rice hulls, saw dust
Fish meal	Common salt, urea
Mineral mixture	Common salt, marble powder, sand, lime stone
Molassses	Water
MBM	Leather meal, blood meal, sand
DCP	Calcite powder, rock phosphate

Discussions……..

Questions, if any……??

THANKS