# Impact and management of anti-nutritional factors and mycotoxins in poultry feed

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# Feed-cost of poultry production

- Feed comprises 65-75 % of production cost
- Only means by which profitability can be manipulated
- Feed-cost can be reduced by

1. Nutrient supply befitting requirements
2. Use of low-cost alternate feed resources
3. Improved feed utilization
4. Improving feeding management & reducing waste

**Anti-nutritional factors & mycotoxins**

# Anti-nutritional factors??

- Inherent intrinsic constituents of feed.
- Generated in natural plant feedstuffs
- Have deleterious effects when consumed by livestock and poultry.

# Anti-nutritional factors in certain plant feedstuffs

| Ingredient | Anti-nutritional factors |
|---|---|
| Maize, yellow | Phytate, trypsin inhibitor |
| Wheat | Arabinoxylans, gluten-sticky protein (gluten intolerance or allergy in human being). |
| Bajra | Polyphenolic compounds |
| Sorghum (Jower), red | Tannins (Red-1.8-2.2%, Brown- 0.5-0.6% & White 0.25-0.35%) |
| Rice, broken | Phytoestrogen, haemagglutinins |
| Rice bran/polish | Fibre, phytic acid, trypsin inhibitor, thiamine antagonists, lipase |
| Rice bran, deoiled | Fibre, phytic acid, thiamine antagonists |

# Anti-nutritional factors in certain feedstuffs

| | |
|---|---|
| Tapioca flour (cassava) | Prussic acid (Cyanogenic glucoside, HCN: 1000 – 3000 mg/kg DM) |
| Raw soybean meal | Trypsin inhibitor, haemagglutinin, urease, antigens, lipoxygenase, goiterogen, saponin, estrogen, phytic acid, rhamnogalactans |
| Groundnut meal | Trypsin inhibitor, goiterogen, tannins, oligosaccharides, lectins |
| Mustard/rape seed meal | Goitrogens (glucosinolates), tannic acid, erucic acid, sinapine (cholinester), pectins |

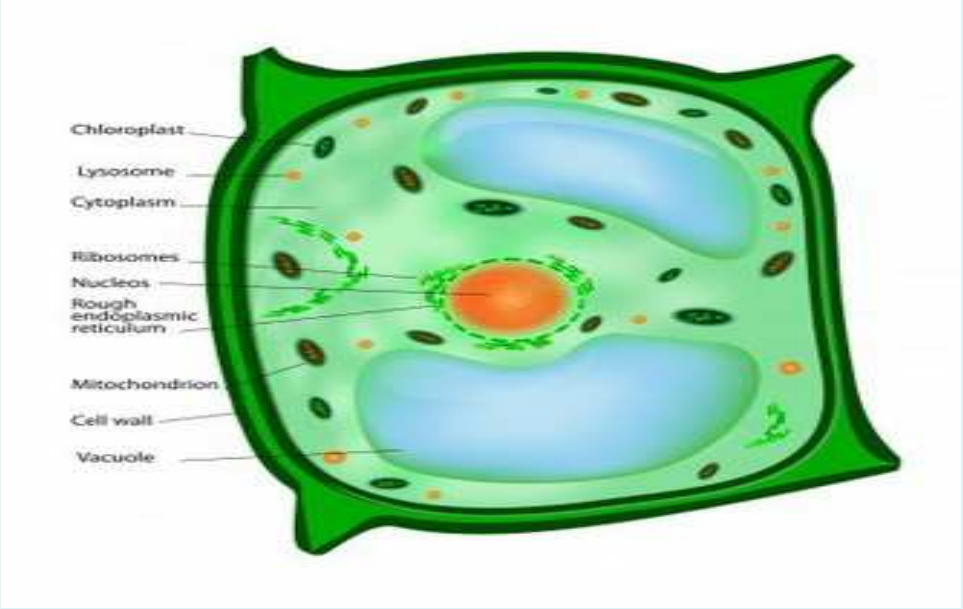
# Anti-nutritional factors

| | |
|---|---|
| **Sunflower seed meal** | **Chlorogenic acid, quinic acid and Fibre** |
| **Sesame cake** | **Phytate (5g/100g) and oxalates (35 mg/100g)** |
| **Linseed/its cake** | **Linamarin (cyanogenic glucoside), antipyridoxine (Linatin) factor and mucilage** |
| **Cotton seed and its meals** | **Gossypol (phenol like), cyclopropenoid fatty acids, tannins** |
| **Raw guar meal/korma** | **Gum (2.5-15%), trypsin inhibitor, anti-vitamin E** |
| **Peas** | **Protease inhibitors, tannins, lipoxygenase and lectins** |

# Non-starch polysaccharides (NSPs)

- **Insoluble Fibre: Plant cell wall (Cellulose, pectins, hemicelluloses, lignin & protein)**

Cell wall polysaccharides encapsulate valuable nutrients present in cell content and hinder their utilization.




- **Soluble: β-glucans, arabinoxylan, arabinogalactans, galactomannans, xyloglucans, galactouronans, rhamnogalactans, etc.**
- **Sources: Almost all feedstuffs of vegetable origin**

# Impact of soluble NSPs

- Produce **viscous** solutions in gut
- Reduce diffusion and contact of lipase, oil and bile salt micelles & other enzymes
- Form thick layer adjacent to inner gut surface
- Reduce activity of surface enzymes.
- Impair digestion & absorption of nutrients
- Increase endogenous loss

# Impact of soluble NSPs

- More excreta volume
- Wet litter
- Bad aroma in poultry house.
- Increased number of *Clostridium perfringens*, inducing necrotic enteritis and high mortality.

# Dietary Management

- Avoid or have judicial use of ingredients rich in soluble NSPs
- Use mixed enzymes (cellulase, ß-glucanase, xylanase, arabinoxylanase, pectinase, galactosidase, proteases, amylase, phytase, etc. )
- Feed Enzymes decrease deleterious factors,
- Increase saccharification of NSPs
- Help in breakdown of cell wall -exposing nutrients
- Augmenting host enzymes through exogenous supply. **Lipase** : lower first 4 d, platueaues at 21-28 d of age.
- **Proteases:** decrease after hatching, increase up to 11-14 d
- **Under heat processed SBM** requires more protease
- **Amylase**

# Formulation & Selection of enzymes

- **Extensive studies : responses are mixed**

**Differences in effectiveness :**

- **Variations in application rate, composition & activities present in premix**
- **Composition of feed NSP and their chemical linkages.**
- **Certain feedstuff require specific enzyme(s).**
- Enzymes are imported in pure or premixed forms.
- Preparations are not always tested for activities before use.
- **Need for enzyme formulation**
- **Considerations for commercial value: FCR, droppings quality, poultry house aroma, incidences of necrotic enteritis & profitability**

# Protease inhibitors -Impact

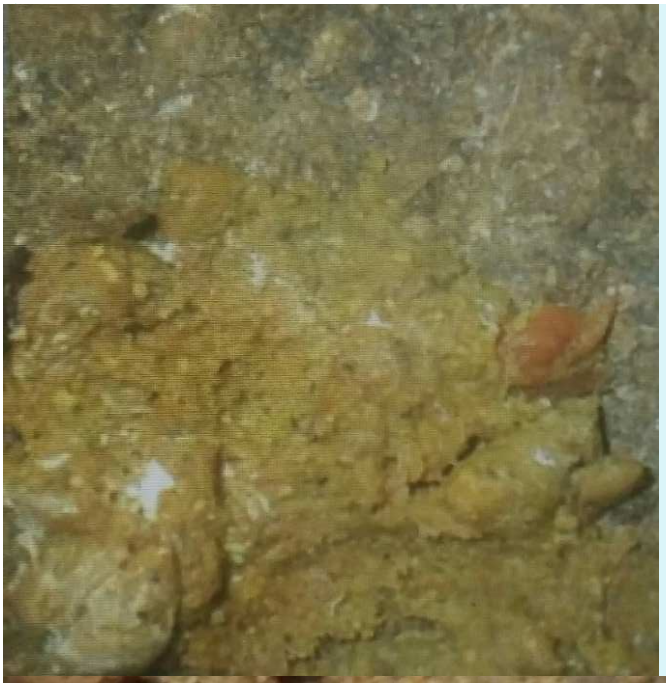
- Sources: Leguminous seeds & their meals
- **Soybean meal** (not adequately processed)

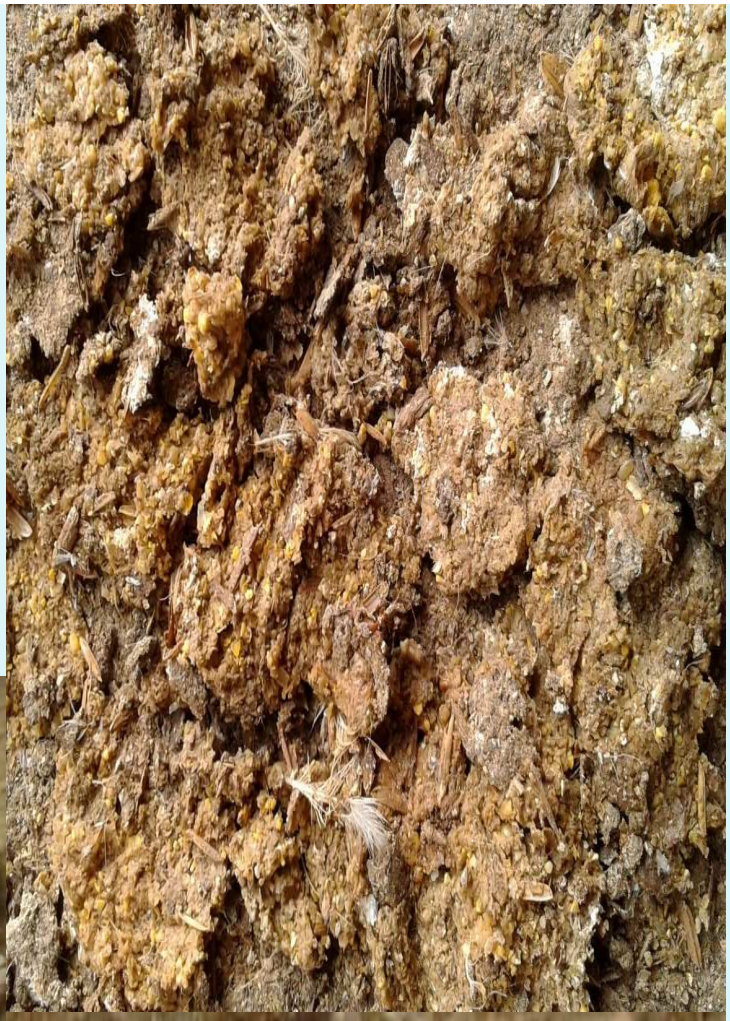
**Impact**:

- Reduced protein digestion
- Growth depression
- Lack of uniformity in live weight
- Enlargement of pancreas
- Poor FCR
- **Rapid feed passage syndrome in broilers**

# Rapid feed passage syndrome

- Yellowish-orange color droppings
- Abnormal shape and consistency
- Absence of characteristic white uric acid cover
- Visible undigested feed & sloughed intestinal tissue
- Water droppings, litter becomes wet and slippery.
- Dirty feathers
- Decreased performance
- Poor pigmentation
- Economic losses





# Rapid feed passage syndrome -management

- Trypsin inhibitors (TI) > 3.5 mg/g of SBM @ 20% in diet may cause rapid feed passage syndrome
- TI concentration in SBM should be < 2.0 mg/g with at least **78% KOH** protein solubility (**highest digestibility**)
- Commercial SBM: 0.05-0.35 mg N/g/min at 30°C against 1.80mg N/g/min in raw SBM
- SBM with low UI > 0.2 and protein dispersibility index (PDI) 40 to 45% - high quality
- KOH solubility 80-85% ≈ urease activity 0.3mg N/g (max)
- Urease activity= ml of 0.1N ammonia per 20-mg samples

## Relation- degree of SBM processing & urease activity

| Degree of processing | Urease activity (□pH) |
|---|---|
| Under processed | >0.2 |
| Adequately processed | 0.05-0.2 |
| Over processed | <0.05 |

- **PDI more consistent & sensitive index of adequate heat processing of SBM than urease index or KOH protein solubility.**

- **Optimum PDI is 40-45%**

**Phytoestrogen (Isoflavones):**

# Phytic acid/Phytate

- Storage form of **Phosphorus (P)** in grains & oil seeds.
- P in feedstuffs (0.1% in tubers -2.0% in rice bran)
- **Phytate P**: **Bran 80%, oilseed meals 40 - 65%, grains 50-70% , beans -30-40%**
- **Average 70% of total P**
- Av. P. = **plant P x 0.30** + supplemental P + P of animal feed origin

# Phytic acid-impact & Management

- Phytate P is not always available to birds.
- Availability of phytate P depends upon presence of phytase in feedstuffs (wheat, rye and barley).
- Reduces availability of amino acids & minerals (Ca, Mg, Zn, etc.)
- Reduces solubility and digestibility of proteins and carbohydrates.
- **Exogenous phytase** (fungus *Aspergillus niger* & bacteria *E. coli or Peniophora lycii*).

# Phytate-Management

- Phytase -two types: Type 3 (*A. niger*) & 6 (bacteria)
- Type 3 initiate dephosphorylation at point 3.
- Type 6 initiates from 6th position.
- 3-phytase may not completely dephosphorylate phytic acid but 6-phytase can.
- Phytase increases availability of minerals, amino acids and carbohydrates.
- Phytase is sensitive to high temperature and humidity.
- **500 phytase units/kg can spare 0.1% Av. P.**
- **Additional 20% when feeds are pelleted.**

# Free-Gossypol

- Phenolic compound present in **cottonseed meal.**
- **Impact:**

- **Reduces availability of lysin & iron**
- **Reduced feed intake, body weight gain, respiratory problems, weakness, reduced immune function, and death after several days.**
- **Olive oil egg yolk colouration in layers.**
- **Affects male and female reproduction**

- Exposure of heat, solvent extraction and dietary iron addition (1 mol for each mol of gossypol)
- Total gossypol content may be increased from 50 to 150 ppm for laying birds and from 100 to 400 ppm in broilers by iron addition

# Glucosinolates

- Present in rapeseed or mustard meal
- Concentration - higher in tropical than temperate
- Glucosinolates : goiter and growth depressant.
- Tolerance level is 9.12µmol/g of feed.
- Glucosinolates may be removed by hot water extraction , dilute alkali or acetone or decomposed with iron salts.
- Genetically modified mustard double zero
- Rapeseed meal : About 40µmol glucosinolates/g

**Sinapine (cholinester)**

# Miscellaneous

- Sticky gluten (**wheat**): Beak impaction & reduced feed intake (Allergy in human being), Avoid finely ground
- Phenolic compounds/tannins (Jower, Bajra & mustard cake)
- Cyanogenic glucosides/Hydrocyanic acid (Cassava )

# Mycotoxins

- **Secondary metabolites produced by several fungi**
- **Moulds = Mycotoxins (Everywhere)**
- **Produced in field, during storage and sometimes in finished feeds.**
- **Adverse effects are many fold- a cause of persistent danger.**
- Important mycotoxins: Aflatoxin $B_1$ ($AFB_1$), ochratoxin A (OTA), zearalenone (ZEA), deoxynivalenol (DON, "vomitoxin"), T-2 and HT-2 toxins, and fumonisins (FUM).

# Mycotoxins-impact on nutrition

i) Availability of feed: 20-40% wastage (FAO)

ii)Reduction of Nutritive value

- Moulds use proteins, carbohydrates and fats of feedstuffs .
- Badly fungal infested maize may lose 10% of ME & 5% of its protein value due to infestation
- Produces thiaminase- causing thiamin deficiency

iii) Reduction of feed intake : Reduced palatability

iv) Reduction of nutrient utilization

- Reduce absorption & assimilation of nutrients (Fat excretion)
- Increase demand of certain critical nutrients
- Decreases utilization of vitamin D

# Mycotoxins-impact on production& Health

- Carcinogenic, nephrotoxic, hepatotoxic, neurotoxic, immunotoxic, mutagenic, teratogenic
- Decreased growth (14%)
- Feed refusal (12%) & Poor FCR
- Impairment of gut & skeletal health
- Reduced fertility, hatchability & early chick mortality
- Residues in meat and carcass condemnation.
- Immuno- suppression & more incidence of **IBH & IBD**
- Increased cost of production
- Pre-harvest losses (AF x 2.8 ) due to morbidity & mortality
- **Degree of losses : concentration, type, interaction, nutritional plane & age of birds.**

# Impact on organs & blood

- Enlargement of liver (15%), kidney (11%), lungs (9%), gizzard (3%) and spleen
- Reduction of bursa of Fabricius & thymus
- Change in colouration of liver & bursa of Fabricius
- Reduction in serum proteins, WBC, lymphocytes

# Mycotoxins-Management strategies

- Presence of mycotoxins in feedstuffs is unavoidable

## To avoid occurrence in food chain

- Good agricultural practice : Harvest, post-harvest drying
- Good storage practice of feeds
- Good feed processing facilities & sanitation
- Decrease or elimination of mycotoxins, through physical separation and detoxification, biological and chemical inactivation
- Decreasing bioavailability to birds
- Understanding **patho-physiology** and ameliorating their toxicities accordingly through nutritional & therapeutic means.

# Mycotoxins-chemical preservatives

- Organic acids or their salts : propionic, acetic, butyric, fumaric, formic, sorbic and benzoic acids
- Propionic (0.1-0.25%) or formic acid (1%)
- Application rate depends on moisture & type of acid (propionic acid @ 0.25% for maize 11-12% moisture to 0.5% for having 18% moisture).
- Propionic acid is more efficacious than benzoic acid
- Copper sulphate
- Dioxime copper (Faster diffusion-smallest ionic Cu & solubility in fat)
- Calcium Propionate (0.25 to 0.5 kg/ton against 2 kg to 5 kg/ton of feed)

# Determination & dilution of mycotoxins

- Monitoring of mycotoxins in feedstuffs being used
- Dilution of contaminated feed ingredient (s) accordingly
- Set dietary level of mycotoxins below tolerance levels
- Tolerance levels varies: genetic, age, sex, nutritional status of birds, exposure to stress, other mycotoxins
- **Tolerance levels of AFB1** : White broiler ≈ 50 ppb
  Coloured broiler ≈ 100 ppb
  WL chicks and layers ≈ 100 ppb
  Japanese quails ≈ 150 ppb
  Turkey ≈ 50 ppb
  Ducks ≈ 20 ppb

**Growing poultry should not receive > 20 ppb AF**

**Laying hens should receive < 50 ppb**

**Breeders: > 20 ppb**

# Tolerance levels of other mycotoxins

Ochratoxin A : 100 ppb

Fumonisin : 5 ppm

Deoxynivalenol : 2-10 ppm

T-2 toxin : 100 ppb

Zearalenone 100 ppm

# Toxin binders

- Sodium bentonite (0.5 to 1%)
- Hydrated sodium & calcium aluminosilicate(HSCAS, 0.5 to 1%)
- Diatomaceous earth (0.5 to 1%)
- Sodic montmorillonite (MNT - 0.25 and 0.5%)
- Activated charcoal (200g per ton of feed)
- MOS (0.05-0.2% of diet)
- Yeast or yeast cell wall (0.2%)
- Esterified glucomannan (EGM, 0.1%)
- Polyvinylpolypyrrolidone (synthetic resin, 0.04%)
- Efficacy: HSCAS > sodium bentonite > diatomaceous earth (DE, SB & Zeolite at 0.33% each was effective)
- MOS>Yeast or yeast cell wall

# Herbs & Enzymes

- Acacia catechu (Babla Khair)-30%
- Phylanthus niruri (Bhumi amlaki)-60%
- Andrographis paniculata (Kalmegh)-30%

(@ 0.5 to 0.75 kg/ton)

- Turmeric 0.5% in diet (curcuminoids)
- Herbs and spices like cloves, cinnamon oil, mustard, garlic and oregano have strong antimycotic properties
- Plant materials rich in antioxidants (Sea buckthorn)
- Herbs having liver tonic properties

**Enzymes:** Epoxidases and Esterases

# Antioxidants (Balancing oxidative stress)

- Vitamin E @ 100 mg/kg & Selenium
- Ascorbic acid (Vitamin C): 250-500 mg/kg
- BHA/other synthetic antioxidants : 50 g/ton

# Nutrients

- **Dietary protein:  5-10% increase**
- **Dietary fats/oils:**
- **DL –methionine (additional 0.05 to 0.1%)**
- **Choline**
- **Zinc (additional 40ppm)**
- **Vitamin A & D**
- **Thiamin**
- **Phenylalanine (Ochratoxin)**

# Management of mucotoxins at farm level

- Replace infested feed
- Keep feeders and waterers clean
- Provide acidified copper sulphate solution in drinking water for 6-12 hr
- Provide vitamins (A.E, C) and minerals (Se, Zn) associated with immunity for remaining hours through water
- Add choline chloride, methionine & liver tonic
- Follow strict bio-security measures

# What to do

- Regular monitoring of soybean meal and full-fat soya for quality (UI, PDI & KOH solubility)
- Use of alternate feedstuffs strictly following safe level of inclusion
- Addition of suitable enzymes (preferably mixed)
- Mycotoxins will remain endanger for ever
- Monitoring quality of maize, ricebran, maize gluten, cottonseed meal, groundnut cake for mycotoxins
- Proper sanitation of feed plant
- Strict bio-security measures at farm level


Thank you.....