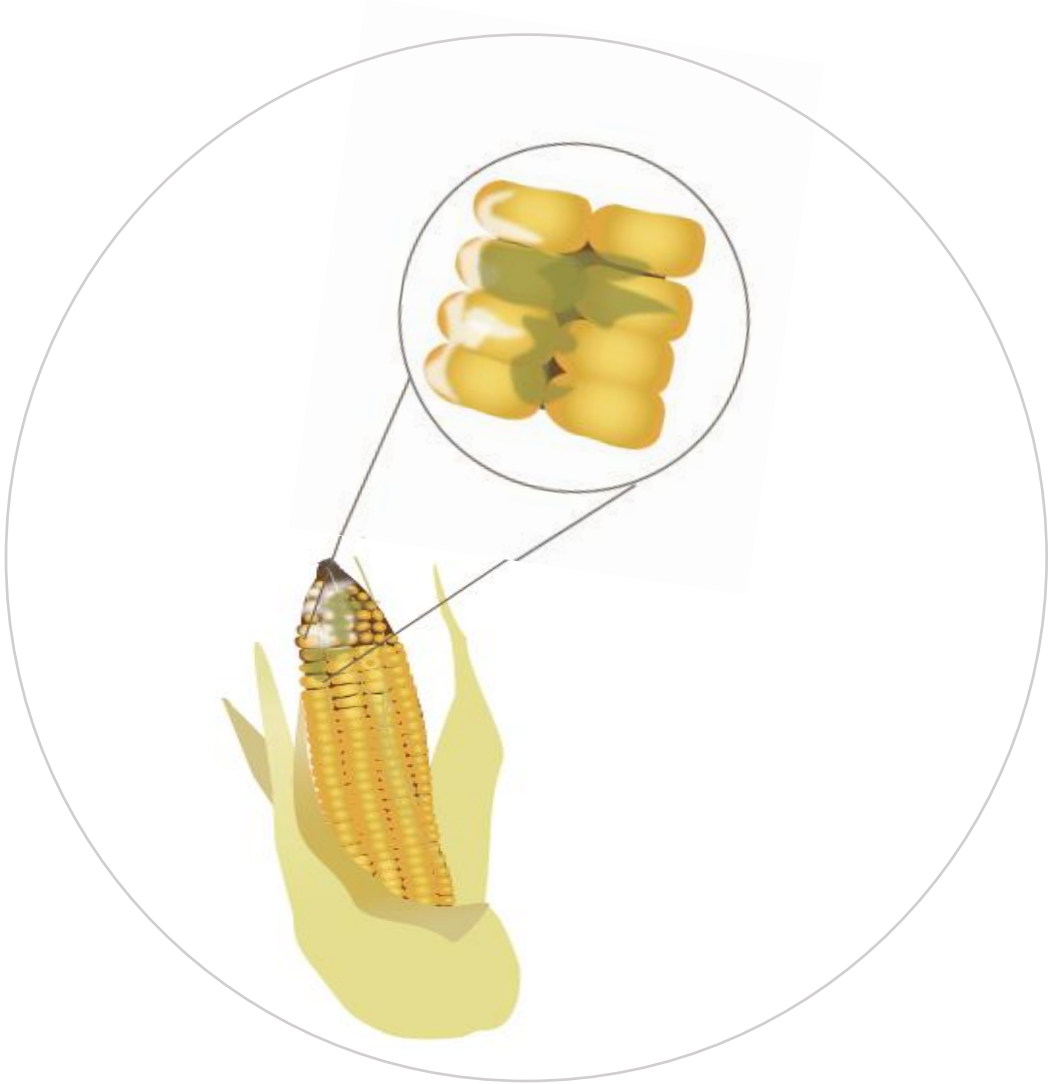
Theme 3: Animal Nutrition and Feeding

MYCOTOXIN IN DAIRY CATTLE NUTRITION (Level 3)

Topic	Training & information Content
3.1	Estimating feeding value of fodder & feed on dairy farms
3.2	Sampling feeds & forages/analysis interpretation
3.3	Estimating Dry Matter intake for various breeds/age categories of dairy cattle in the tropics
3.4	Reviewing feed intake, rumen fill, Body Condition Scoring (BCS)
3.5	Life weight estimation of cows
3.6	Rumen fermentation
3.7	Mineral & vitamin requirement, guidelines
3.8	Manure scoring and evaluation
3.9	Guidelines for ration calculations for various breeds, heifers, lactation stage (Rumen8)
3.10	Use of Rumen8 software for ration calculation
3.11	Optimization of ration with Rumen8
3.12	Feeding management guidelines
3.13	Feeding management of dry cows/close-up
3.14	Feeding systems
3.15	Metabolic disorders
3.16	Scoring locomotion and hoof condition
3.17	Mycotoxin in dairy cattle nutrition
3.18	Heat stress in dairy cattle nutrition
3.19	Monitoring feeding management, using KPIs (based on Rumen8)

1. You will learn about (learning objectives):

- ❑ Sources of mycotoxins.
- ❑ Mycotoxins in animal feedstuffs.
- ❑ Examples of mycotoxins and their effects to dairy cattle nutrition.
- ❑ Management of mycotoxins at farm level.

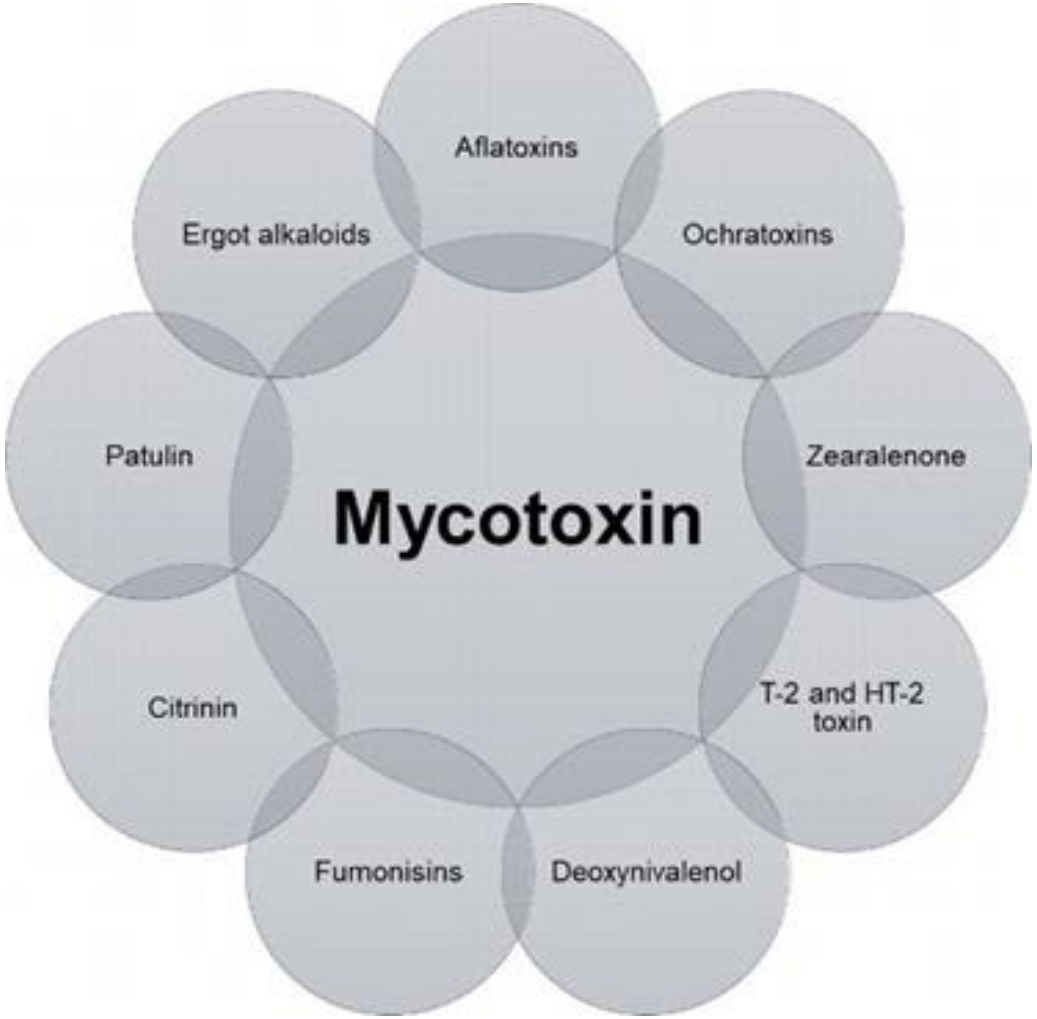


2. Introduction

- Mycotoxins are one of the key factors that affect feed safety.
- They are caused by fungi that attack crops in the field while some get in contact with feeds during storage.
- Managing fungal growth aids in managing mycotoxins.
- Farmers should re-evaluate this to avoid exposure of animals and humans to health risk.
- Diseases resulting from mycotoxin toxicities are known as Mycotoxicosis.

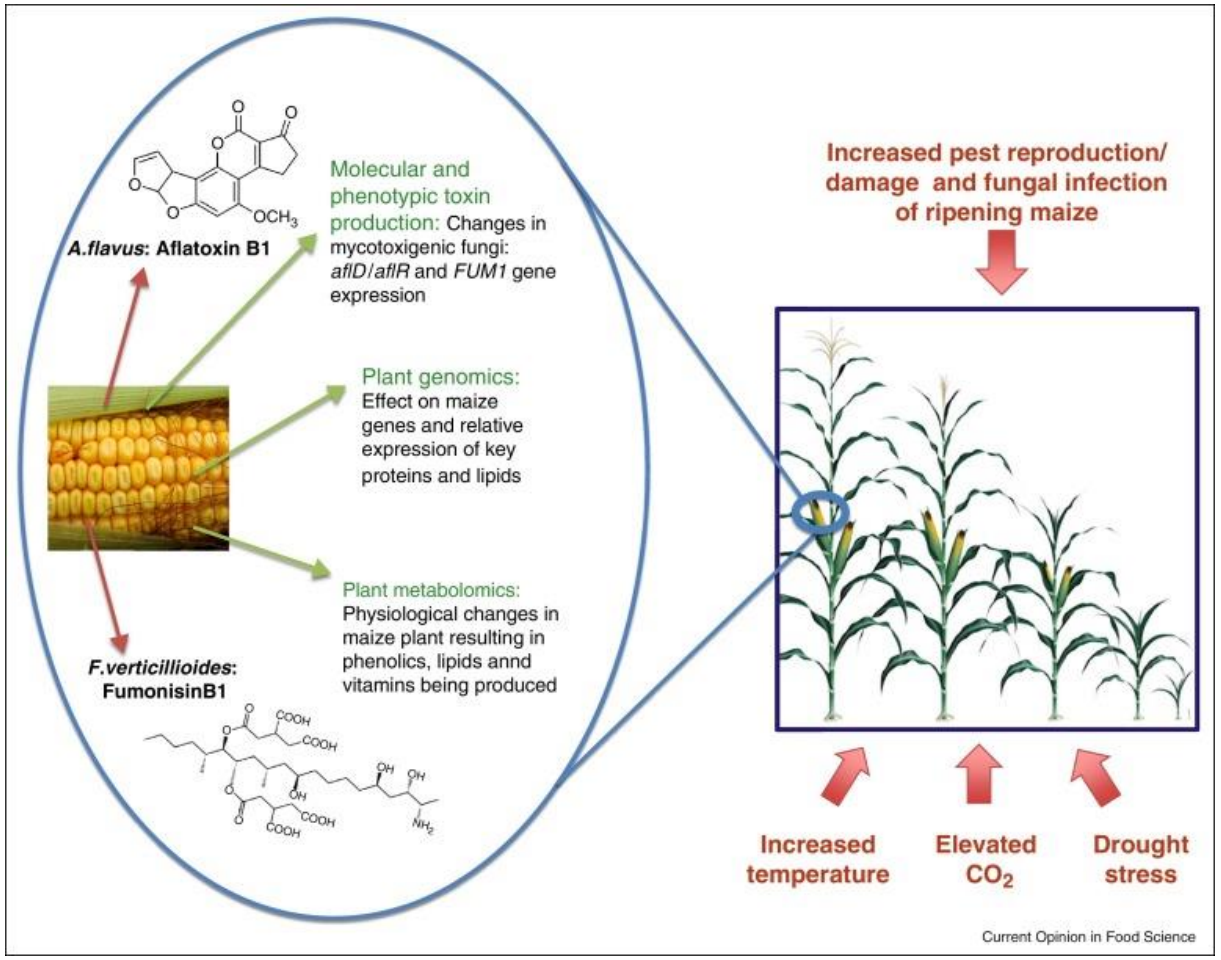
2.1 Introduction cont'd: Mycotoxins

- Mycotoxin is a general cluster of various toxins found in animal feeds.
- They are produced as secondary metabolites of fungi.
- Different fungi produce different toxin substances that have different molecular structures.
- This different molecular structures provide solutions to manage the impact of a particular toxin.



3. Mycotoxins and the environment

- Fungi are adapted to conditions that are moist in nature.
- For example, damaged grains (by insects) allow remaining kernel to absorb more water from the environment stimulating growth of mold.
- Fungi affect forages and feeds during pre-harvest and at post-harvest periods.
- With the changing climatic condition, fungal growth may be encouraged by extreme weather patterns.



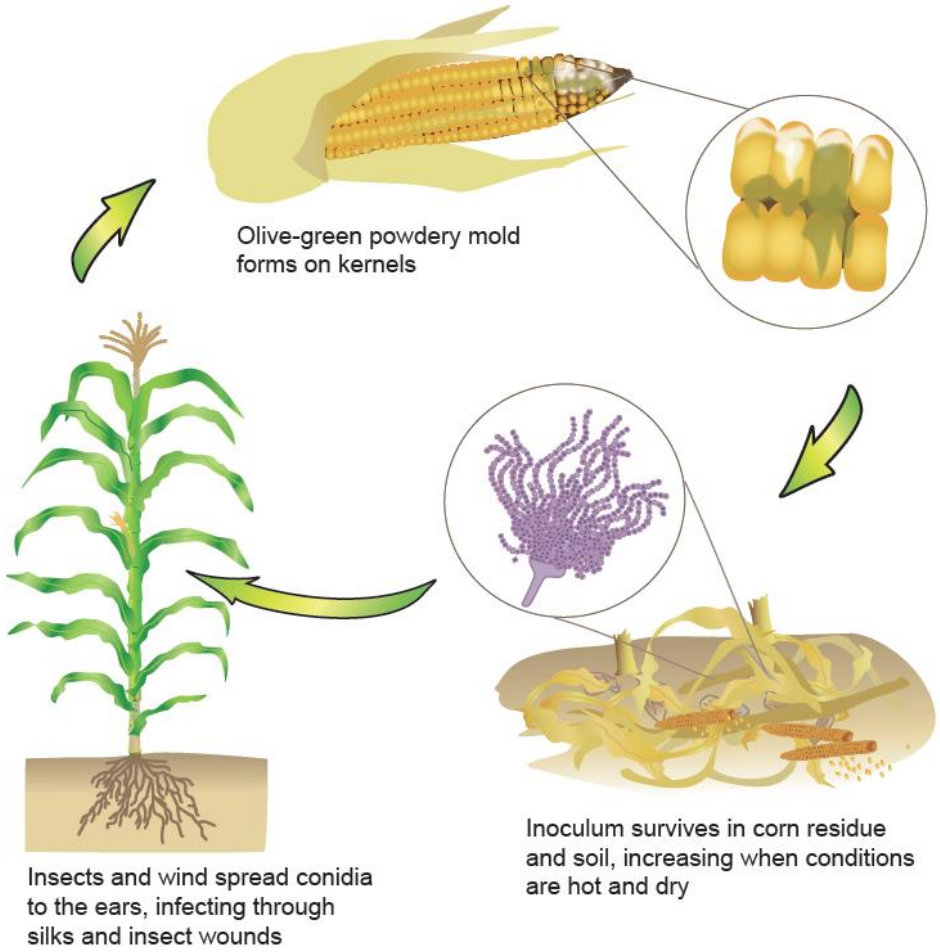
Effect of extreme weather pattern on fungal growth

4. Conditions for fungal growth

- Mycotoxins are adapted to damp conditions.
- This is encouraged by;
    i. High humidity (wet condition) - Above 50%. This is a key mold growth factor.
    ii. High temperature - Encourages rate of mold production, hence mycotoxin contamination.

5. Insects and fungal growth

- Crops that are damaged provide place for fungi to enter and cause fungal infections.
- Damaged grains by insects allow seed to absorb more water from environment.
- When insects utilize nutrients in crops (grains) they produce water as a metabolic by product.
- This encourages fungal growth leading to mold growth.



6. Fungal growth in dry fodder

- Dry forages while in the field are susceptible to fungal growth when it rains.
- Do not cut grass if there is possibility of rainfall during wilting or before baling.
- Bale hay at low moisture above 80% DM.
- Hay baled at high moisture content has an increased risk of fungal growth. This fungi will eventually produce mycotoxins.
- Forages should be properly dried before storage.
- Stores bales properly;
    - Above the ground and well spaced.
    - Area fully protected from rain damages. Hay bales stored on wet surfaces/under leaking roofs allow also prone to fungal growth.
- Do not feed moldy hay to dairy cows and their young stock.

7. Fungal growth in grains

- Fungi infect cereal/pulse crops while in the field.
- These crops may be infested by fungi if no crop protection was applied. The harvested product is likely to be contaminated with mycotoxins.
- Damaged grains are more susceptible to fungal growth.
- Grains and pulses that are not sufficiently dried (high moisture content) before storage have higher chance of fungal growth.

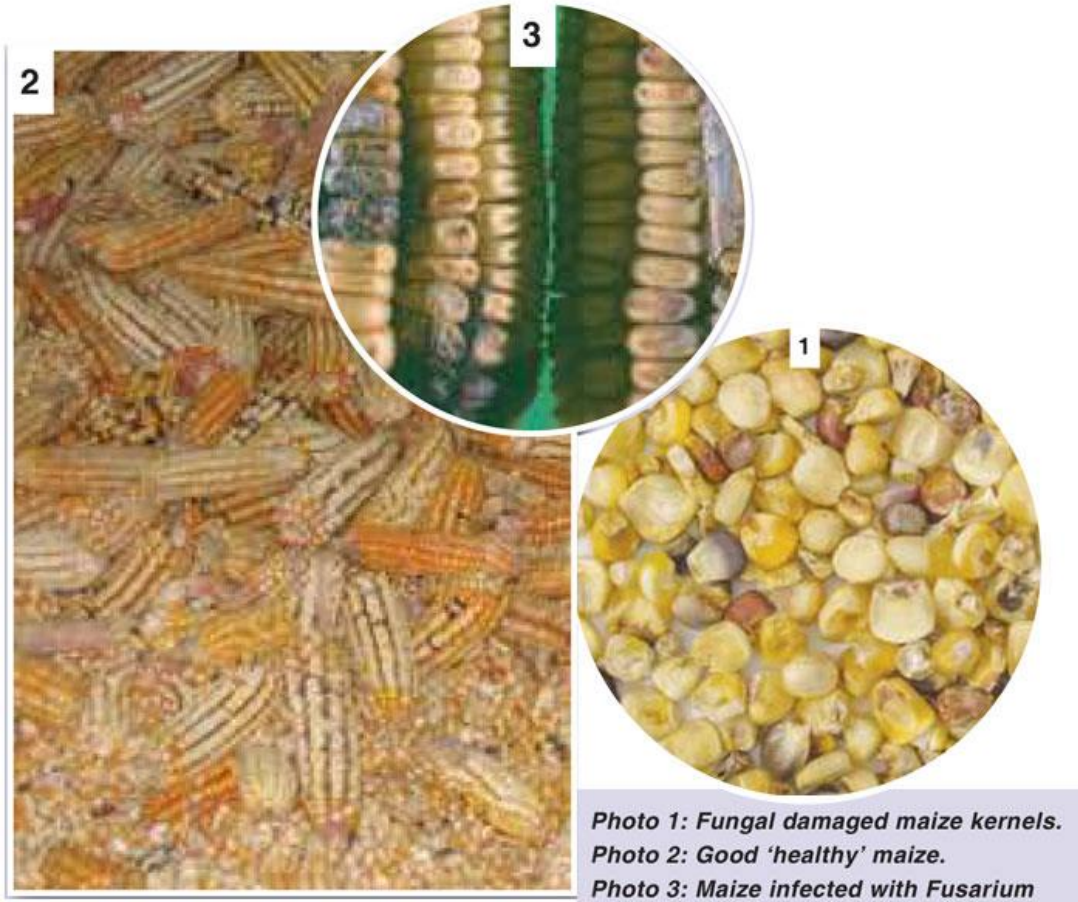


Photo 1: Fungal damaged maize kernels.
Photo 2: Good 'healthy' maize.
Photo 3: Maize infected with Fusarium verticillioides (fungi).

8. Fungal growth in wet forages (silage)

- Silage which is not properly compacted is at high risk of fungal infections.
- Silage is prone to fungal growth especially at feed out.
- Low feeding speed increases the risk of heating at the face surface, which encourages mold growth.
- Puncturing/damaging of the polythene sheet/cover also allows air to enter the silage, encouraging fungal growth.

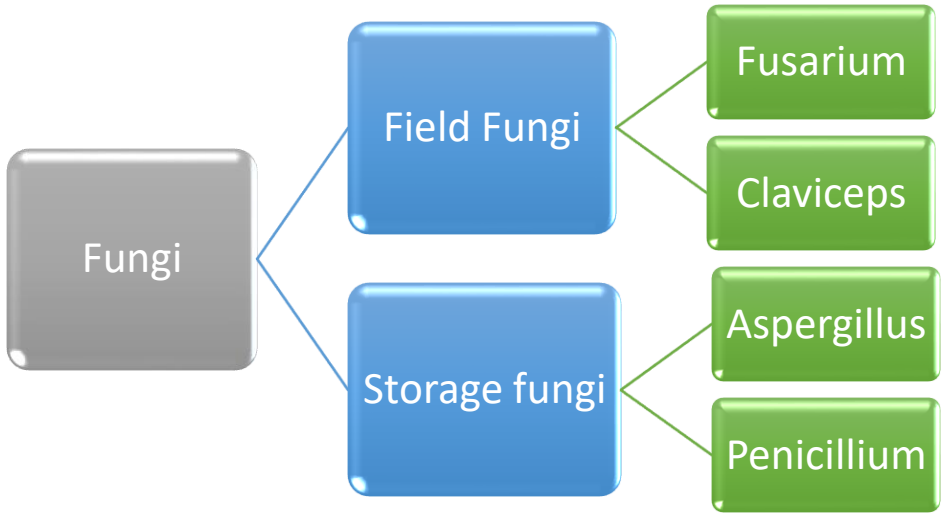
Silage attacked with mold

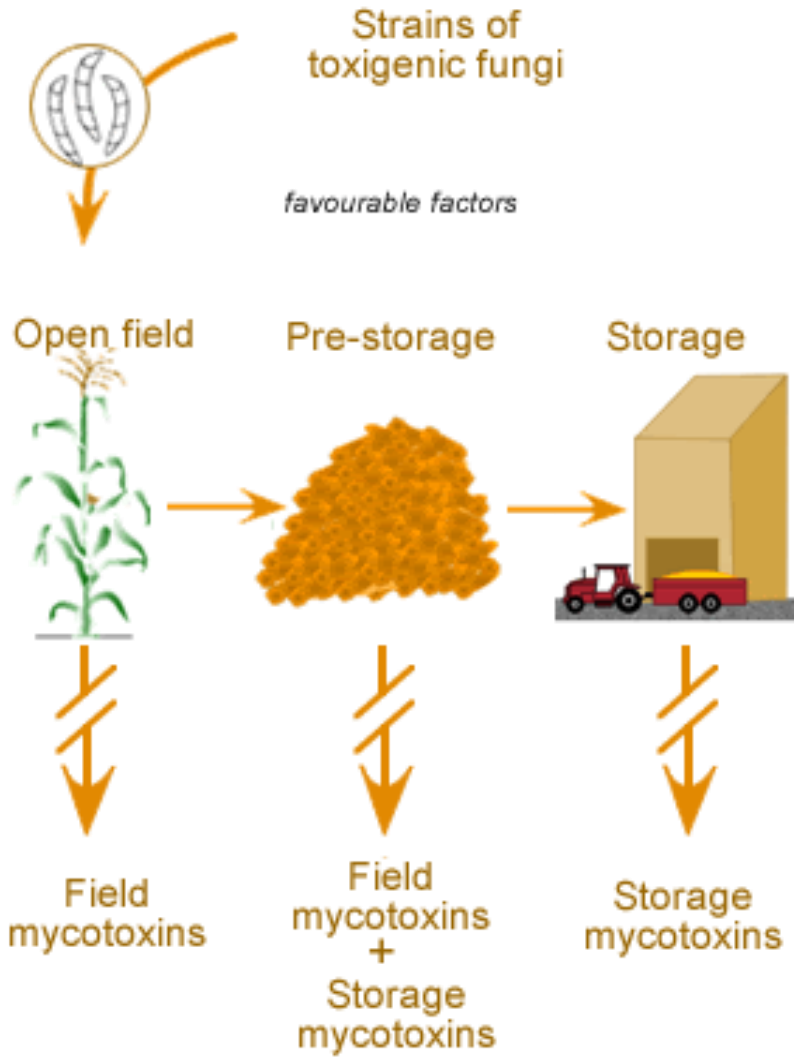
9. Fungal spores

- Fungal spores are microscopic (not visible by the naked eye) biological particles that allow fungi to be reproduced.
- Fungal spores invade both grains and forage plant parts. They invade the endosperm and later causes physical damage to grains.
- Forages are invaded through soil contamination during seedling stage affecting plant tissue, causing diseases.
- Physical damage to parts of the plant by insects is an entry path for fungal spores.

10. Types of Fungi

- Fungi-producing mycotoxins get in contact with plants at different stages in the fields. For example with grain/pulses during harvesting and storage, or with forages such as hay and silage.
- These fungi are clustered into:
  1. Field fungi
  2. Storage fungi





10.1 Field Fungi

- These fungi invade crops before and after harvest for example; during transportation and storage.
- Examples of field fungi include;
  - Fusarium
  - Claviceps
  - Neotyphodium
- Many plant diseases are produced by fungi. Examples of diseases are: Ear rot, stalk rot, anthracnose, smut disease.

10.2 Storage Fungi

- These fungi invade forages and grains during storage.
- Mostly affects forages and silages.
- Examples of storage fungi include;
  - Aspergillus
  - Penicillium
- Aspergillus is responsible for production of aflatoxins.

11. Identifying mycotoxins in forages & feeds

Grains

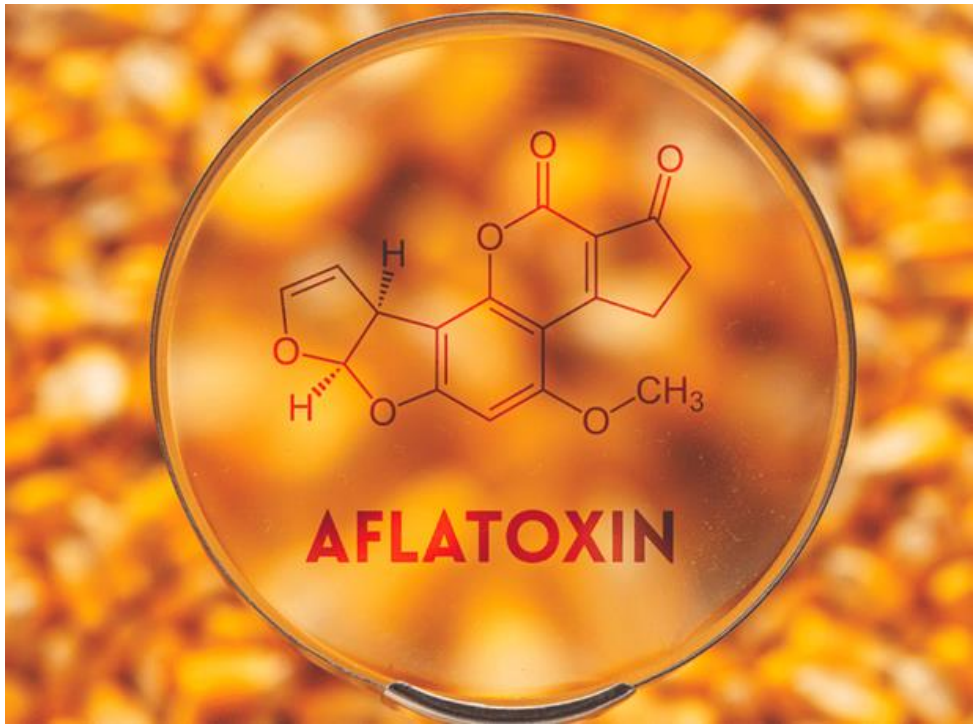
- Light weight of grains.
- Soft seedcoat.
- Easily breakable grains that seem moist.
- Discoloration of grain by mold, grey-green mold is associated with Aspergillus and white-pinkish with Fusarium.
- Musty smell in some cases.

Forages

- Discoloration by molds on forages white, reddish to dark brown color.
- Dump forages.
- Musty to no smell in some cases especially silage.

12. Competitive advantages of mycotoxins

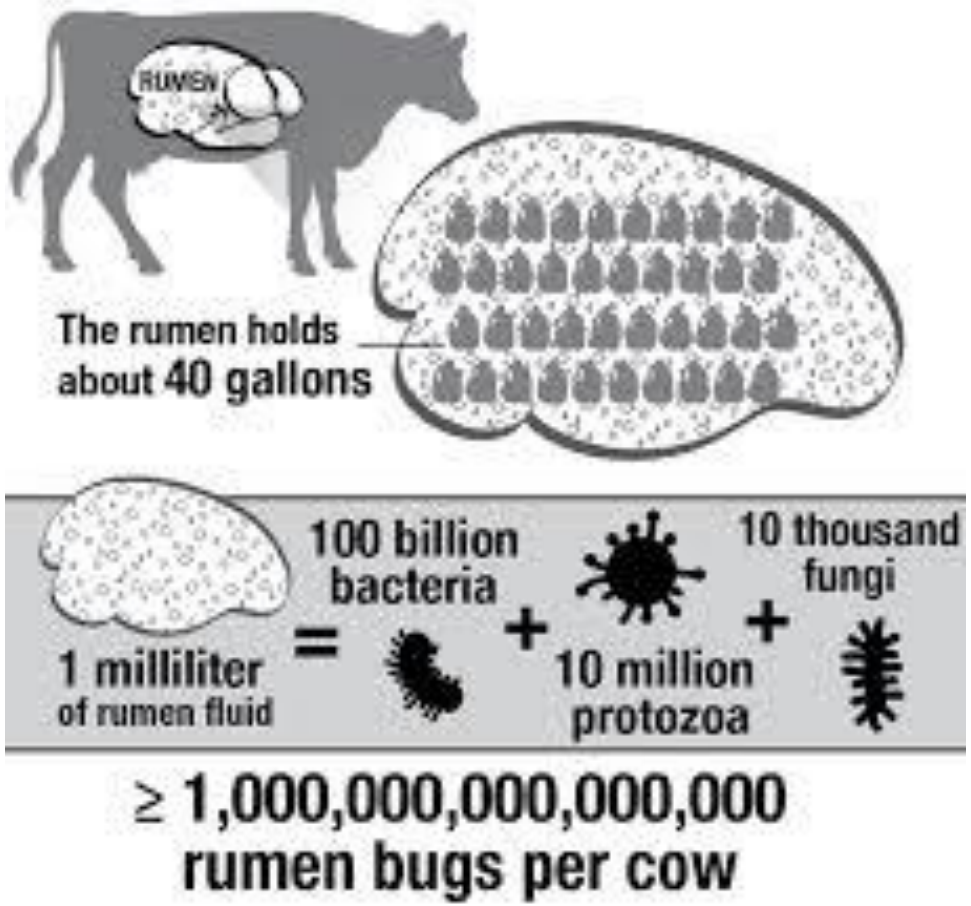
- Mycotoxins in farms are not easy to detect for a couple of reasons:
  i. They cannot be detected by naked eyes.
  ii. Fungicides only act on the fungi but not the toxins produced.
  iii. They are tasteless.
  iv. They are chemically stable and temperature resistant.
- This means that manufacturing processes do not destroy/incapacitate mycotoxins.



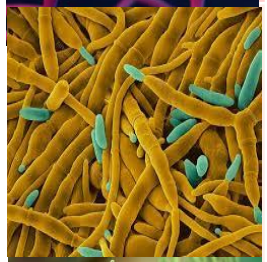
Mycotoxins are chemically stable

13. Rumen as a toxin filter

- Ruminants are able to detoxify mycotoxins i.e. the rumen acts as a toxin filter so to speak.
- This is because the rumen microbes (protozoa) degrade toxins to a certain extent.
- Microbial environment affect detoxification processes.
- The degraded toxins are excreted mostly through faeces.



14. Fungus and the toxins they produce

Image	Fungus	Species name	Toxins produced
	**Aspergillus**	A. favus/A. parasiticus A. versicolor/A. nidulans A. ochraceus	Aflatoxins Sterigmatocystin Ochratoxin A
	**Fusarium**	F. graminearum/F. culmorum F. sporotrichioides/F. langsethiae F. roseum F. verticillioides	Trichothecenes (DON) Trichothecenes (T-2 Toxin) Zearalenones Fumonisins
	**Penicillium**	P. expansum P. Citrinum/P. monascus P. verrucosum	Patulin Citrinin Ochratoxin A
	**Claviceps**	C. purpurea	Alkaloids (Ergot)
	**Alternaria**	A. alternata	Alternariol (AOH) Tenuazonic acids (TEA)

15. Penicillium fungus

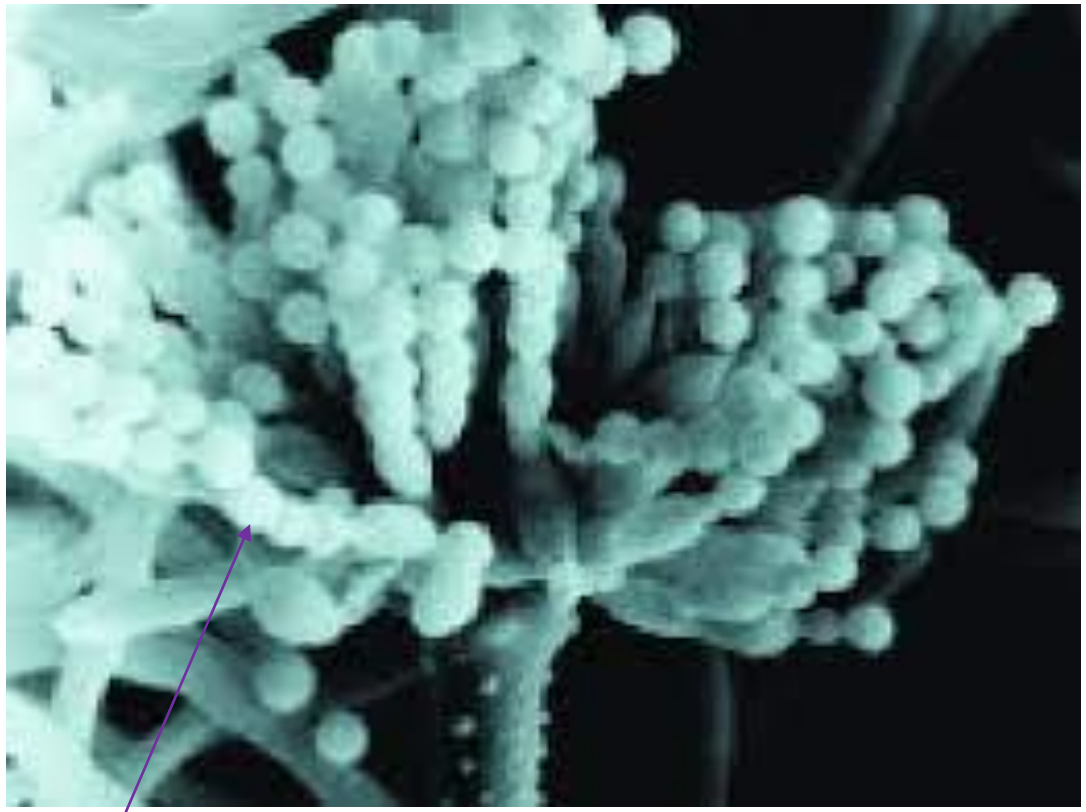
- This fungus is mostly found in silages. This is because it can tolerate low pH unlike other fungus species.
- When silage is poorly made and air penetrates stored silage, it encourages growth of yeast. This leads to production of yeasty silage.
- The yeasts consume lactic acid in the silage raising the pH and causing heating up.
- Heated silage has an increased risk of fungal growth.

16. Ochratoxin A (OTA)

- *Penicillium verucosum* and *Aspergillus ochraceus* produce OTA toxin.
- It is mostly present in wheat and barley. However it is known to be more in oil seed crops like soybeans.
- Non ruminants are more sensitive than ruminants.
- Has nephrotoxicity, causes kidney damage.

Effects

- Decreases feed intake.
- Reduces milk production potential.

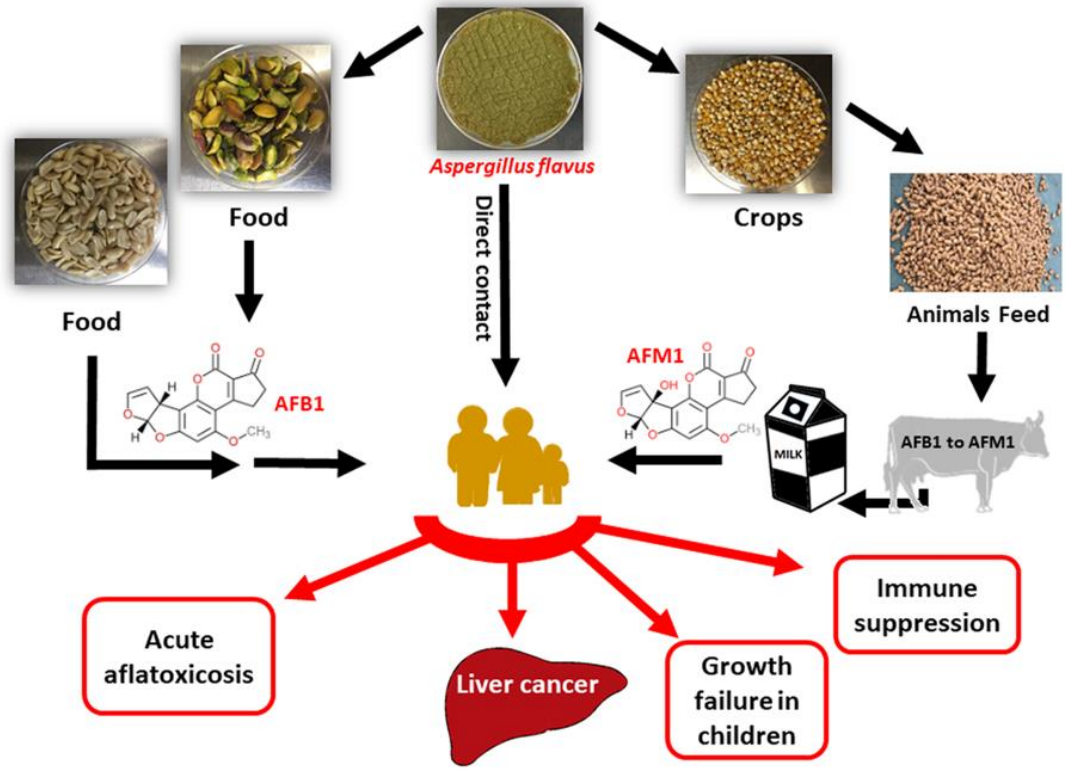


Aspergillus ochraceus

17. Aspergillus fungus

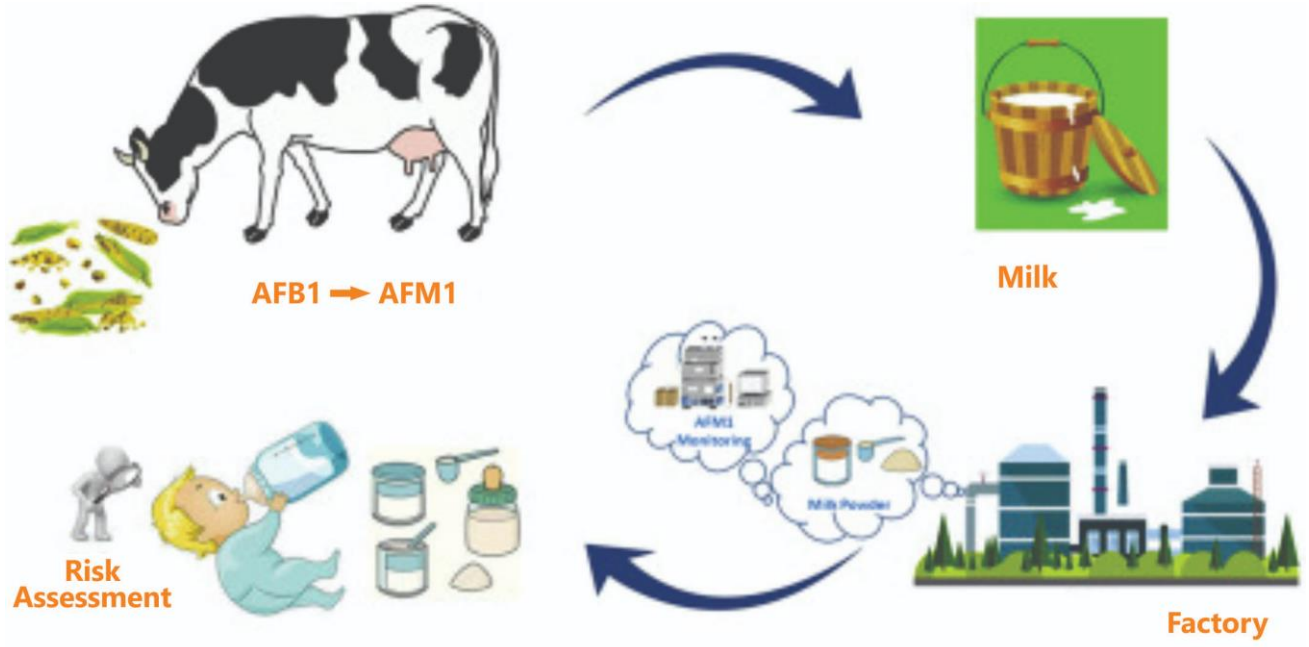
- There are various types of aspergillus namely:
  - *Aspergillus favus*
  - *Aspergillus parasiticus*

- These fungus produce aflatoxins (AFLA B1,B2, G1 and G2).
- Another form of aflatoxins is AFLA M1 and M2.
- The M1 &M2 are not produced by fungus but converted when another form of toxin is taken in (AFLA B1).



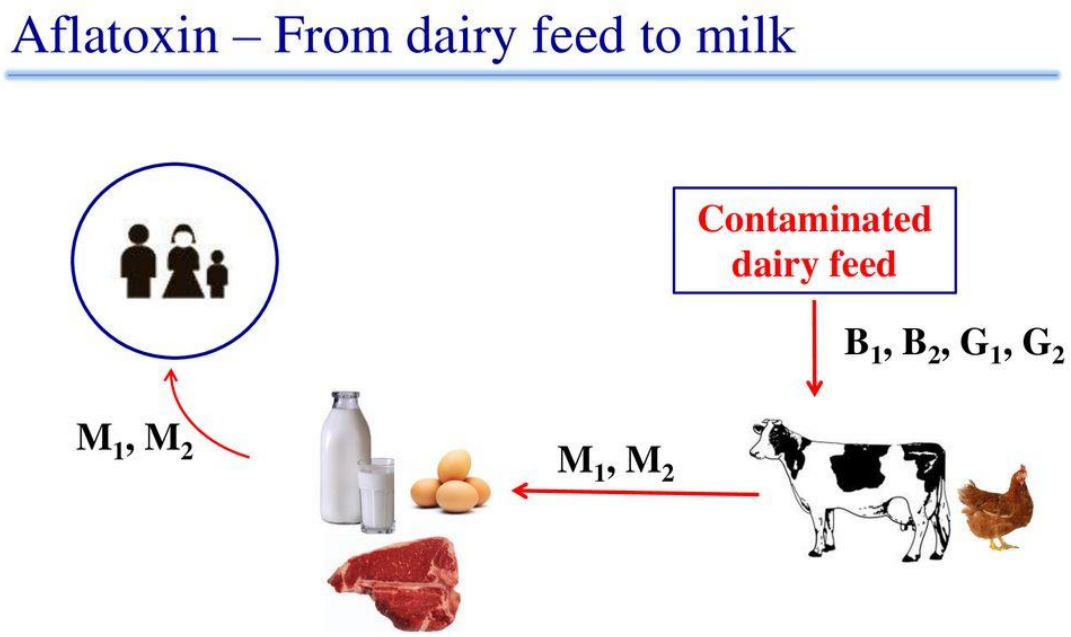
18. Aflatoxin in milk

- When cows take AFLA B1 through contaminated feeds, the liver metabolizes it to AFLA M1. Therefore AFLA M1 and M2 are metabolic by-products.
- After metabolism the AFLA M1 makes way into milk.
- Consumption of this milk passes effects to humans and calves.



18.1 Aflatoxin in milk Cont'd…

- Aflatoxin is tolerated in feeds at certain threshold that will not impact either animal/human.
- The thresholds for animals and humans differ.
  - Highest concentration of AFLA B1 allowed in dairy feed ration is 20 parts per billions (ppb).
  - Threshold of aflatoxin (AFLA M1) level in milk is 0.5 parts per billion (ppb).



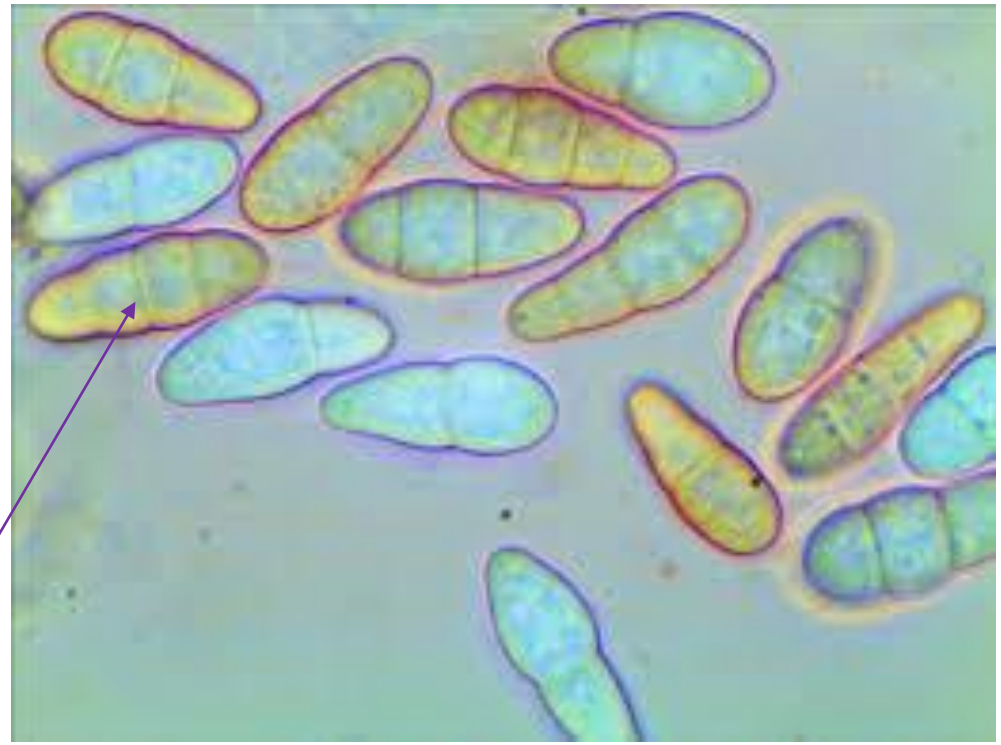
18.2 Effects of Aflatoxin

- It is toxic when it becomes a residue in milk (affects milk quality) hence affecting calf health.
- Reduces milk production.
- Decreases animal performance.
- Causes hemorrhaging.
- Affects immune system by reducing disease resistance.
- Affects reproduction of cows, for example abortion and abnormal estrous cycle.
- Causes liver cell damage (hepatotoxicity).

Aflatoxins reduces milk production

19. Fusarium roseum fungus

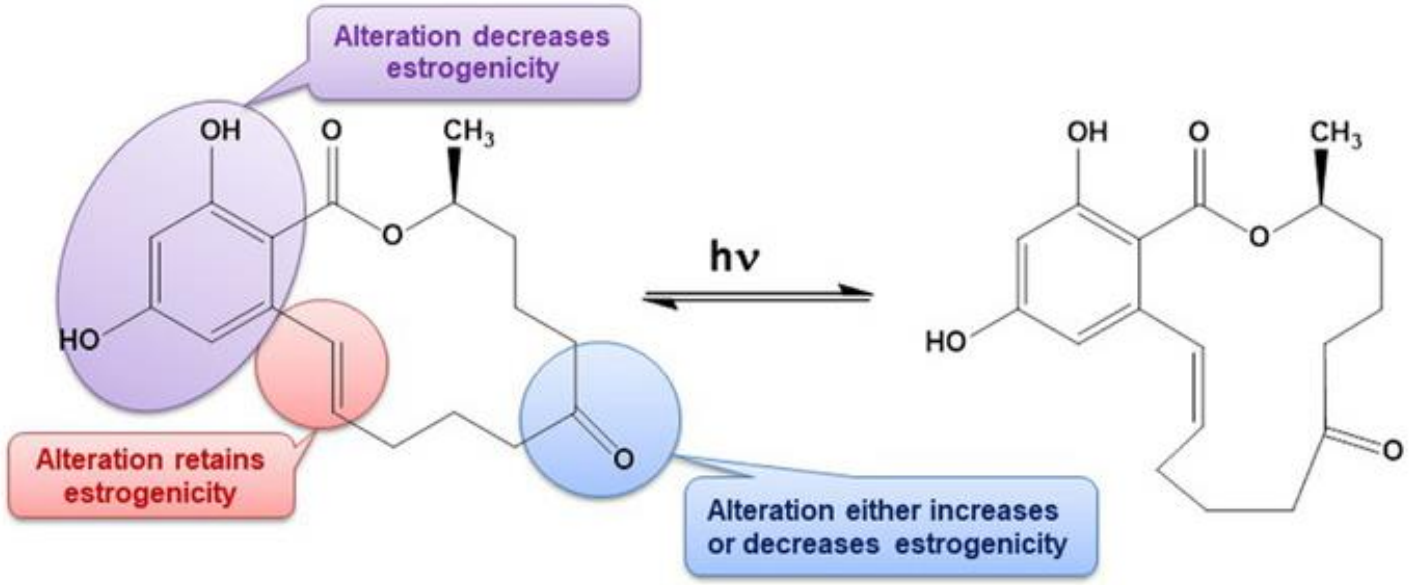
- *Fusarium roseum* species produces zearalenone (ZEA).
- This fungus is also responsible for production of other toxins like deoxynivalenol and T-2.
- Fusarium roseum fungus is identifiable by pink mold.
- Zearalenone is an estrogenic mycotoxin. This means it competes with estrogen for binding sites.
- This fungus is mostly associated with mammary changes and reproductive problems.



Fusarium roseum

19.1 Zearalenone and reproduction problems

- Zearalenone fits to the oestrogen receptors.
- Zearalenone (ZEA) is converted to alpha-zearalenol through metabolism in the rumen.
- This new form fits easily to estrogen receptors than ZEA.
- Alterations can either increase or decrease its estrogenicity effect.



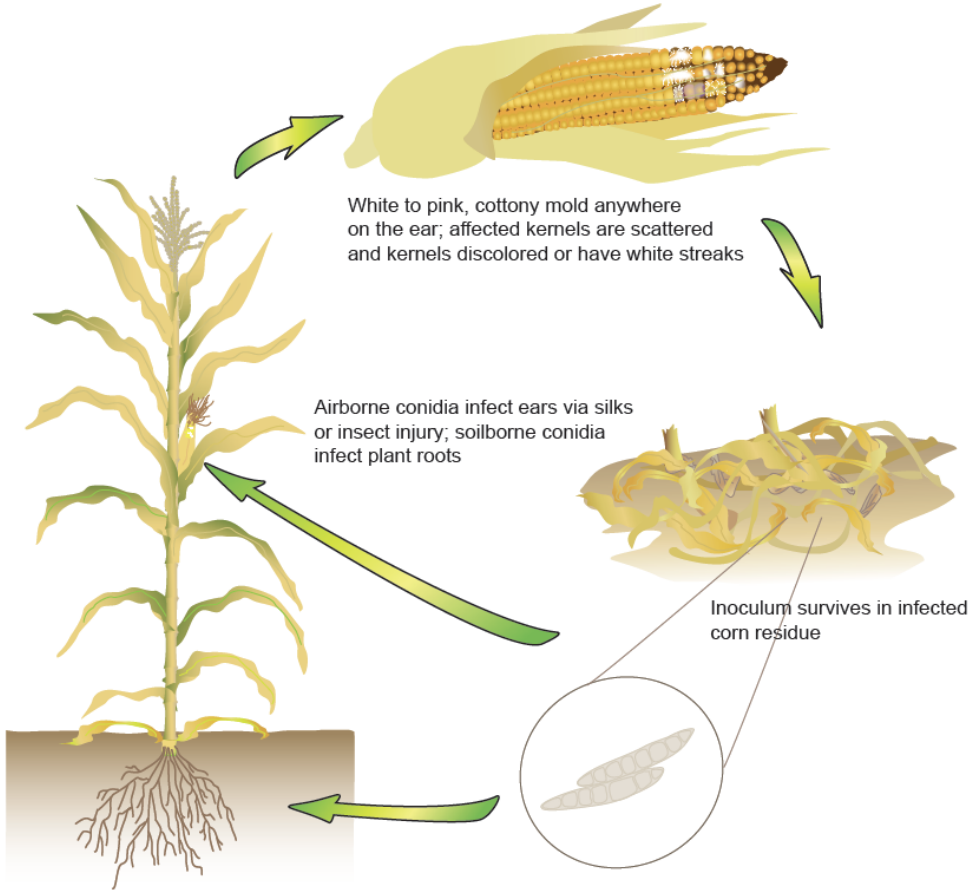
19.2 Effects of zearalenone

- Decreases fertility in cows.
  - Causes abnormal estrus cycle.
  - Reproductive tract infections.
  - Causes vaginitis and metritis.
  - Causes malformations in reproductive tract like swollen vulva.
  - Causes reduced semen quality in bulls.
- Reduces milk production.
  - Mammary gland enlargement & mastitis
  - Causes metabolic disorders.

Reproductive problem caused by Zearalenone toxin

20. Fusarium graminearum

- *Fusarium graminearum* produces vomitoxin or deoxynivalenol (DON).
- It causes pink ear rot in maize grain and stalk rot.
- Mostly affects immune and gastro-intestinal systems.
- It also affects protein & nucleic acid synthesis (DNA & RNA), which impacts defence against pathogens and feed intake.



20.1 Effects of Deoxynivalenol (DON)

- Causes digestive disorders.
- Interferes with feed intake.
- Induces vomiting and causes diarrhea.
- Leads to weight loss in animals.
- Reduces animal performance.

21. Claviceps purpurea fungus

- *Claviceps purpurea* produces Ergot alkaloids.
- Mainly affects grains like wheat and barley.
- Farmers can easily spot this in the field or at harvesting.
- It comprises of a dark brown to black growth on grain heads extending outwards.

21.1 Effects of Ergot alkaloids

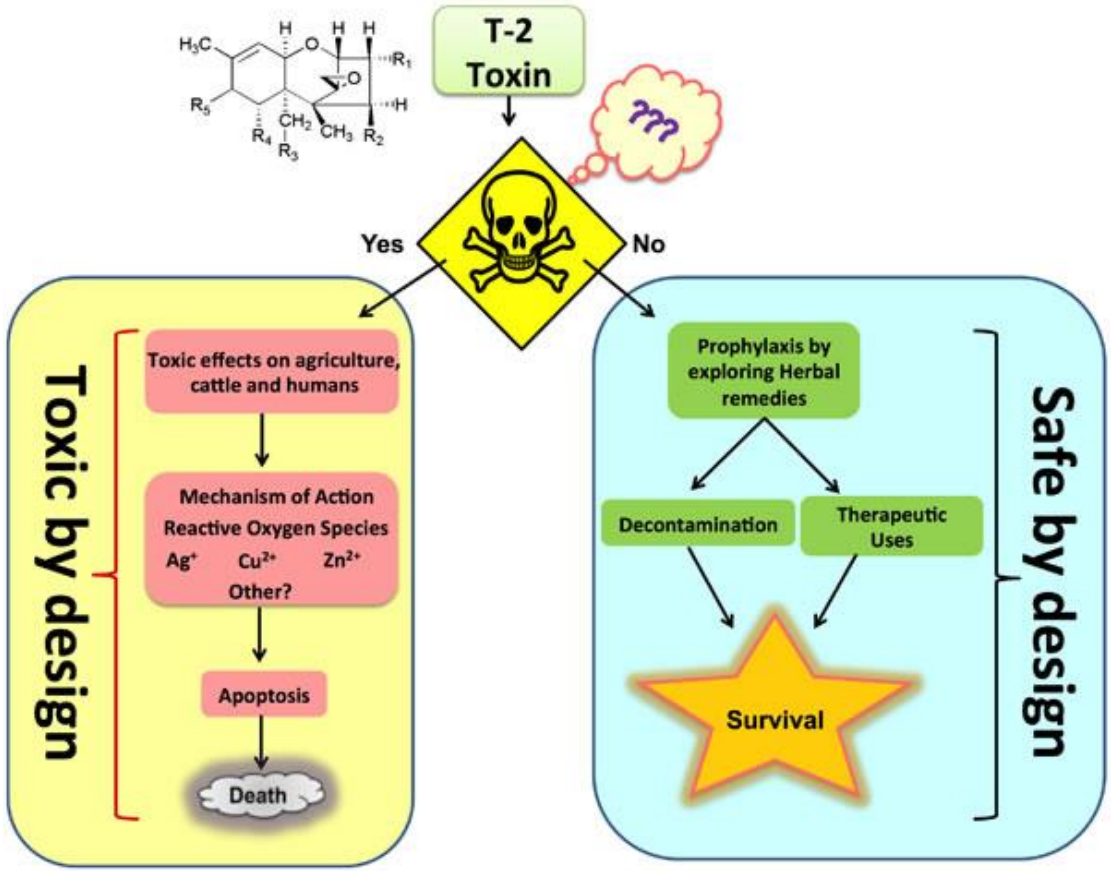
- Known to restrict blood flow as it causes vasoconstriction.
- Affects hoof health.
- Impacts heat stress.
- Impact reproduction.
- Can influence mastitis.

22. T-2 toxin

- *Fusarium sporotrichioides* produces T-2 toxin.
- It is identified mostly by white mold or other times pink/reddish mold.

Effects of T-2 toxin

- Diarrhea.
- Bloody gut and hemorrhages.
- Causes immune suppression in calves.
- Increases incidences of disease occurrences.
- In fatal conditions may lead to death.

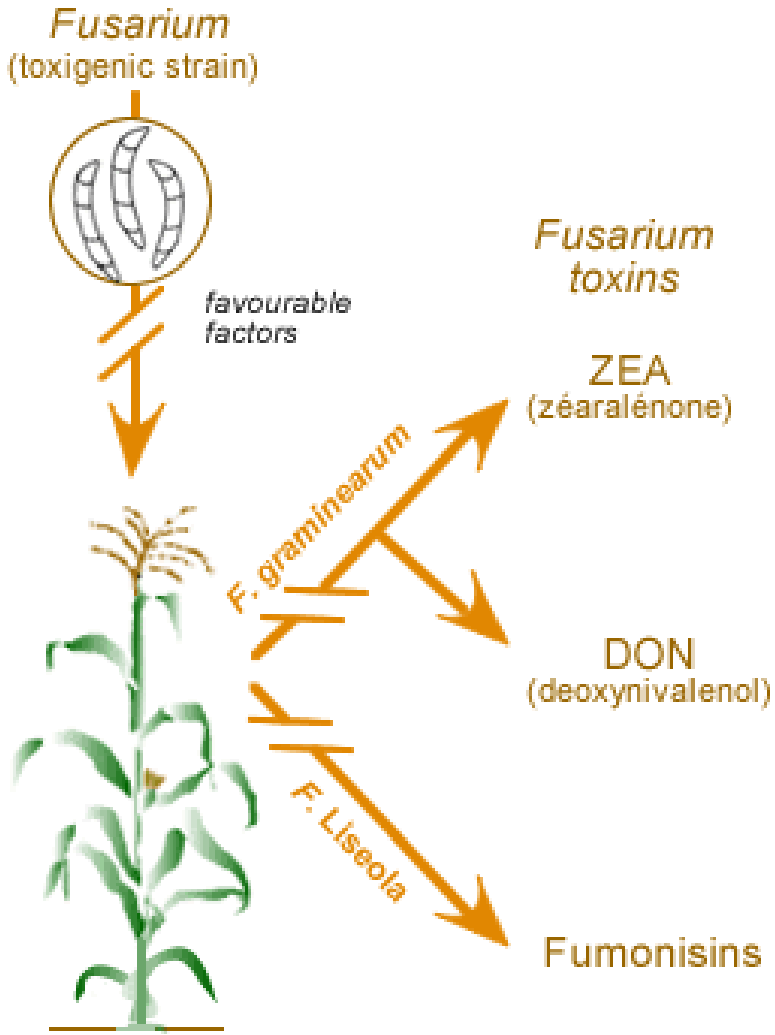


23. Fusarium verticillioides fungus

- *Fusarium verticillioides* (= *Fusarium moniliforme*) produces fumonisins.
- Causes disease especially to corn ears.
- Known to affect horses the most.
- Identified by white-pink mold.

Effects

- Interferes with metabolism of lipids
- Causes nerve degeneration.
- Causes liver and kidney lesions.

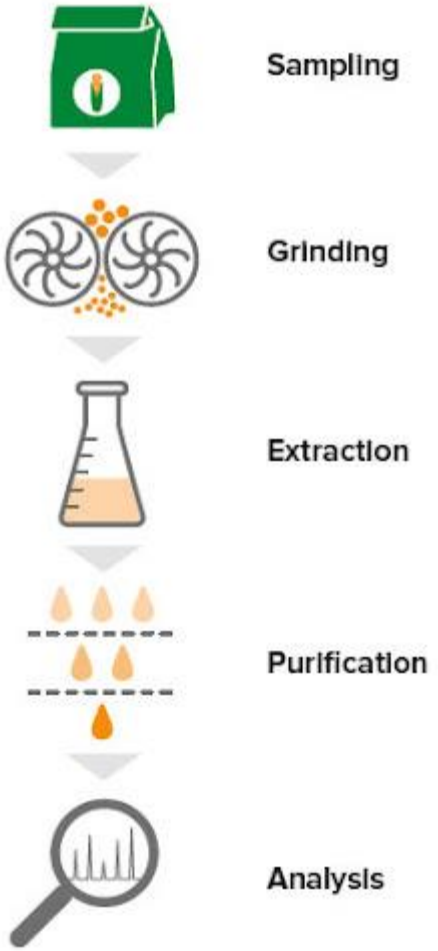


24. Effects of Mycotoxins

- Signs of mycotoxin toxicities are hard to identify but they;
  i. Reduce feed intake and utilization.
  ii. Influence mastitis in the farm.
  iii. Influence incidence of metabolic disorders.
  iv. Cause reproductive problems (ZEA).
  v. Cause immune suppression. Some are known to have carcinogenic effect.
  vi. Cause hemorrhaging of organs and can lead to death.

25. Mycotoxin analysis in forages & feeds

- Concentration level of mycotoxins during analysis are measured in parts per billion (ppb).
- Forage analysis measures concentration level of mycotoxin in the dry matter of forage in ppb.
- Mycotoxins taken in small amounts may cause sub-clinical effects only.
- However, continuous intake leading to high concentration of mycotoxins in the body causes clinical effects.



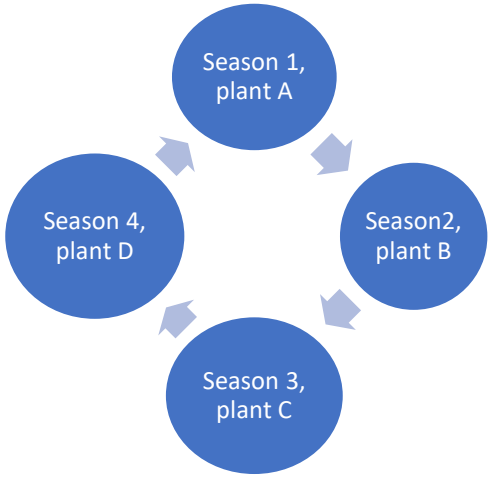
26. Detection of mycotoxins

- Laboratory analysis of feed detects mycotoxins using various methods:
  - Thin layer chromatography (TLC)
  - High performance liquid chromatography (HPLC) – combined with UV/MS detection
  - Ultra performance liquid chromatography (UPLC)
  - Enzyme-linked immunosorbent assay (ELISA)
  - Rapid strip screening tests
  - Gas chromatography – combined with ECD, FID/MS detection

27. Managing fungi in farms

Crop management practices

- Enhance crop management strategies through;
  - Crop rotation
  - Growing hybrid crop varieties. Example: Fusarium resistant crops (hybrid) to break the cycle of diseases (Fusarium ear rot).
  - Spraying fungicides to control fungi that cause diseases to crops.
  - Timely crop harvesting

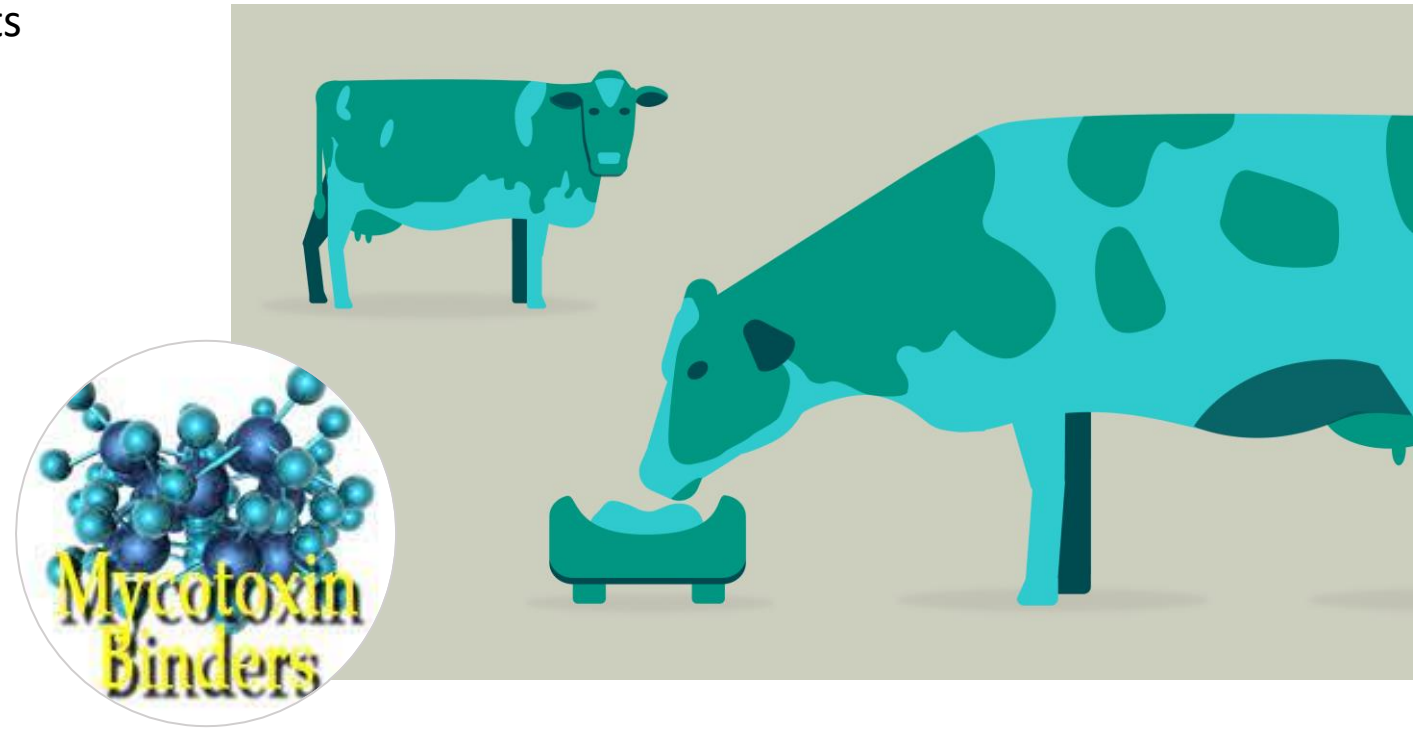


- Remove and avoid feeding moldy feeds to cows.
- Store feeds dry (low moisture content, well ventilated and intact roof and walls).
- Avoid damages to the silage covers, exposure to air and heating of the silage.
- Enhance rumen fermentation to reduce the effect of toxins by;
  - Feeding adequate fiber buffers (roughages).
  - Introducing microbials to feeds.
- Add adsorbents that bind toxins to feed (mycotoxin binders).

Damages on silage cover

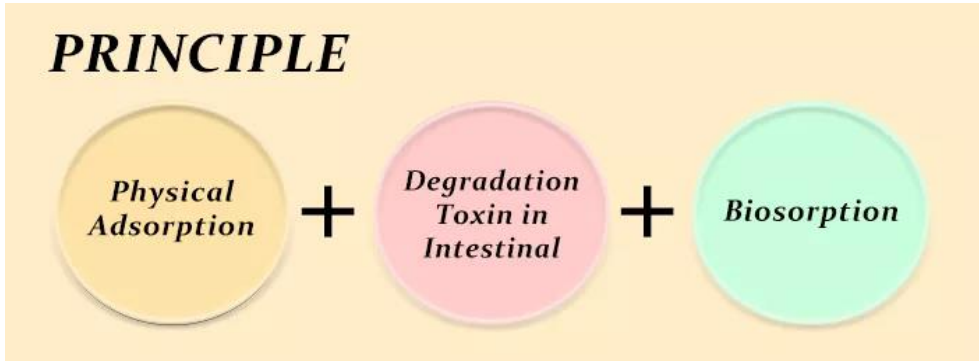
28. Mycotoxin binders

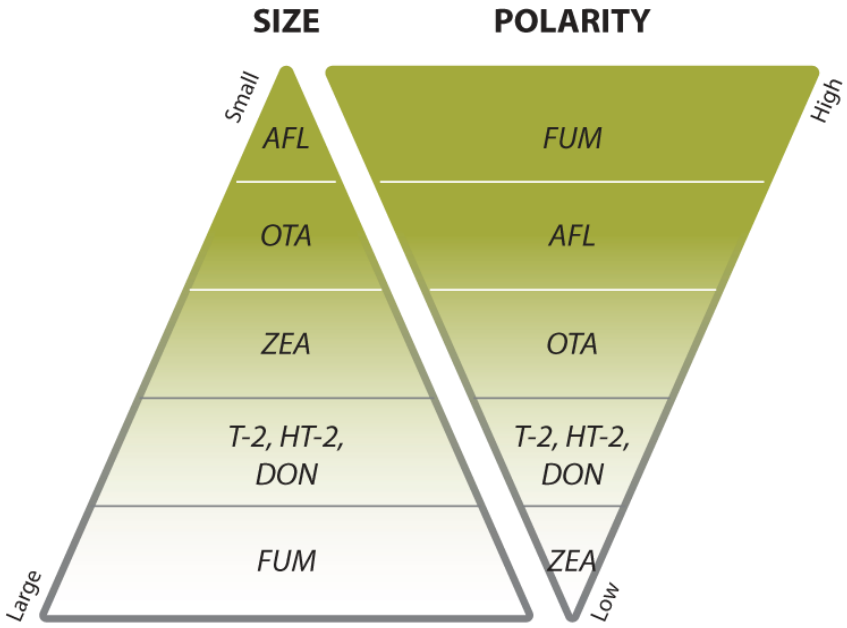
- Mycotoxin binders are substances added to feeds in small quantities to prevent serious harm of toxins.
- The use of binders should be as per instructions of the manufacturers or nutritionist.
- These binders can either be;
  - Clay based compounds
  - Yeast cell extracts



28.1 How mycotoxin binders work

- Binders work by binding (adsorbing) compounds of toxins.
- Bioavailability of bound toxins are reduced and eliminated from cows body through faeces.
- Binders should be specific to avoid binding compounds that are needed by the cow, like minerals.
- This also because chemical compounds of different toxins call for different approaches. Some are more polar and distinct in shape i.e. thickness.





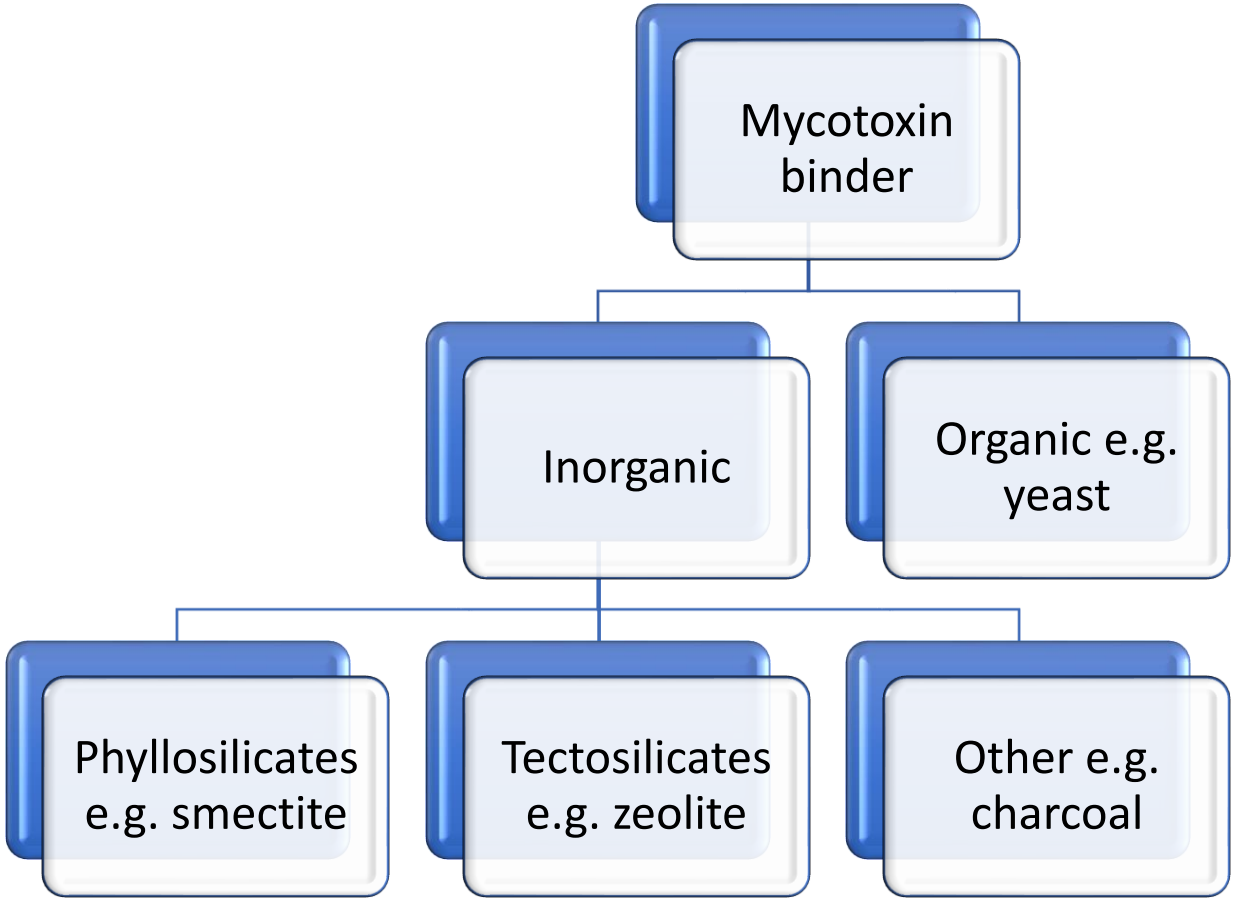
29. Types of mycotoxin binders

Inorganic mycotoxin binders

- Clay-based compound are used when dealing with aflatoxins.
- Examples are; Calcium aluminosilicate and bentonite zeolite.

Organic mycotoxin binders

- Yeast cell wall extracts uses enzymes to reduce toxins.
- Can be used when handling DON, Toxins T-2 and Zearalenone.



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