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Mycotoxin Binders

Mycotoxin Detoxifying Agents

An approach to reduce the exposure to mycotoxins in feed is to decrease their bioavailability by the inclusion of mycotoxin detoxifying agents in the feed.

Cont. …

- **These detoxifiers can be divided into two different classes:**
  1. Mycotoxin binders.
     - Mycotoxin binders adsorb the toxin in the gut, resulting in the excretion of a toxin binder complex in the feces.
  2. Mycotoxin modifiers.
     - Mycotoxin modifiers transform the toxin into non-toxic metabolites.

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Mycotoxin Binders

Adsorbing or Sequestering Agents

Mechanism of Binding

1. They are large molecular weight compounds that are able to bind with the mycotoxins in the GIT.
2. The toxin binder complex (toxin-toxin binder) passes through GIT, and is eliminated via the feces.
3. This prevents or minimizes the exposure of animals to mycotoxins.

Efficacy

The efficacy of inorganic binders depends on the chemical structure of both the adsorbent and the mycotoxin.

Adsorbent	Adsorbed Mycotoxins
1. The total charge and charge distribution. 2. The size of the pores. 3. The accessible surface area.	1. Polarity 2. Solubility 3. Shape 4. Charge distribution

Cont. …

- The binding capacity increases with surface area and chemical affinities between adsorbent and mycotoxin.

Classification of Toxin Binders

Silica-based inorganic compounds

1. **Aluminosilicates**
   - **Phylosilicates**
     - Bentonites - Montmorillonites
     - HSCAS - Smectites
     - Kaolinites - Illites
   - **Tectosilicates**
     - Zeolites
2. Activated charcoal
3. Synthetic polymers
   - Dietary fibre
   - Polyvinylpyrrolidone
   - Cholestyramine

Carbon-based organic polymers

1. ***Saccharomyces cerevisiae***
   - Live yeast
   - Yeast cell wall components Glucomannans
2. **Lactic acid bacteria**
   - *Lactococcus*
   - *Lactobacillus*
   - *Leuconostoc*
   - *Pediococcus*

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Aluminosilicate Minerals (clays)

- Aluminosilicate minerals (clays) are the largest class of mycotoxin binders.
- There are two different subclasses:
  1. Phyllosilicate subclass
     - Includes bentonites, montmorillonites, smectites, kaolinites and illites
  2. Tectosilicate subclass.
     - Includes zeolites.

Mechanism of Binding

1. In Aluminosilicate minerals (clays), some of the tetravalent silicon are replaced by trivalent aluminum.
2. This gives rise to a deficiency of positive charge
3. Then, it is balanced by inorganic cations such as sodium, calcium and potassium ions.

Binding Spectrum

- Clay products are effective in binding aflatoxins in vitro as well as in vivo.

- Because of their fairly nonpolar properties, they **lack the ability of adsorbing** *Fusarium* mycotoxins, such as fumonisins, zearalenone (ZON) and trichothecenes, as well as ochratoxin A (OTA).

Side Effects

1. They do not exert any binding potential towards mycotoxins other than AFTB1.
2. They can adsorb vitamins and minerals.

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Activated Charcoal

- Also called active carbon (AC).
- AC is a nonsoluble powder formed by pyrolysis of several organic compounds.
- It is manufactured by an activation process to develop a highly porous structure.

Efficacy

- **The sequestrant properties of AC depend on many factors:**
  1. Pore size
  2. Surface area
     - The surface-to-mass ratio of AC varies from 500 to 3500 m2/g.
  3. Structure of the mycotoxin
     - AC has been shown to be an effective binder of a wide variety of drugs and toxic agents.
  4. Dose

Cont. …

- **AC has been proven an effective adsorbent of:**
  1. Deoxynivalenol (DON)
  2. ZON
  3. AFB1
  4. Fumonisin B1 (FB1)
  5. OTA

Side Effect

- The unspecific binding is the major drawback in the practical use of AC as a feed additive.
  1. It diminishes nutrient absorption, such as vitamins and minerals.
  2. Consequently impairs the nutritional value of feed.

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Synthetic Polymers

- Several agents belong to this group, such as:
  1. Dietary fibre
  2. Polyvinylpyrrolidone (highly polar amphoteric polymer)
  3. Cholestyramine

Cont. …

Cholestyramine

- It is an insoluble, quaternary ammonium anion exchange resins, which strongly binds anionic compounds.
- This compound has been proven to be an effective binder for FB1, OTA and ZON in vitro.
- The cost of polymers is high, limiting their practical use in animal feed.

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Saccharomyces cerevisiae Yeasts

› Organic mycotoxin binders which are commonly used are cell wall components from *Saccharomyces cerevisiae* yeasts.

Yeast Cell Wall or Whole Yeast

- Mycotoxin binding can be enhanced by using only yeast cell walls (composed of β-glucans and mannan oligosaccharides) instead of the whole cell.
- The fact that dead cells do not lose their binding ability shows that the interaction of such products with mycotoxins is by adhesion to cell wall components rather than by covalent binding or by metabolism.

Mechanism of Binding

β-D-glucan

- It has been recently demonstrated that the β-D-glucan fraction of yeast cell wall is directly involved in the binding process with ZON, and that the structural organization of β-D-glucans modulates the binding strength.

Efficacy

- Based on in vitro assays, this **glucomannan** (GMA) binder has shown to effectively bind to:
  1. DON
  2. T-2 toxin (T-2)
  3. ZON
  4. OTA
  5. AFB1

Cont. ..

- Protective effects of GMA against the detrimental consequences of mycotoxins on animal production parameters have been demonstrated in several studies:

Cont. ..

Broilers feed were contaminated with:

1. AFB1 (0.3 mg/kg)
2. OTA (2 mg/kg)
3. T-2 (3 mg/kg).

GMA incorporation leaded to:

1. Increased body weight and feed intake
2. Decreased liver weight
3. Improved some serum biochemical and hematological parameters which were negatively influenced by the mycotoxins in the feed (Raju and Devegowda, 2000).

Cont. ..

GMA:

1. Alleviate the adverse effects of AFB1 (1 mg/kg) on performance, liver weight and mortality in broiler chickens.
2. Counteracts most of the plasma parameter alterations caused by a DON contaminated diet (3 mg/ kg) in chickens.
3. Showed a protective effect of GMA against antioxidant depletion in chicken livers caused by the intake of T-2 contaminated (8 mg/kg) diet

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Lactic Acid Bacteria (LAB)

- LAB are gram-positive, catalase-negative, non-sporulating, usually non-motile rods and *cocci* that utilize carbohydrates fermentatively and form lactic acid as major end product.
- These bacteria are mainly divided into four genera:
  1. *Lactococcus*
  2. *Lactobacillus*
  3. *Leuconostoc*
  4. *Pediococcus.*

Mechanism of Binding

- The interaction mechanism between LAB and mycotoxins is thought to be similar to the interactions involved in adsorption by GMA.
- The polysaccharide components (glucans and mannans) are common sites for binding, with different toxins having different binding sites.

Efficacy

- The most extensively investigated mycotoxin binding LAB are strains of *Lactobacillus rhamnosus. L. rhamnosi* strains have a demonstrated *in vitro* binding capability of:
  1. DON
  2. T-2
  3. ZON
  4. FB1
  5. AFB1
  6. OTA

Side Effects

1. The in vitro adsorption capacity is strain and dose dependent
2. It is a reversible process balancing between adsorption and desorption.
3. All the available literature on LAB-mycotoxin interactions is based on in vitro results.
   - To date, no in vivo trials have been conducted to effectively demonstrate their mycotoxin binding potential, and therefore caution regarding their effectiveness is recommended.

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