Controlling field and storage mycotoxin problems

Gbola Adesogan

Department of Animal Science

UF | UNIVERSITY of FLORIDA

The Foundation for The Gator Nation

Outline

- The current challenge
- Predisposing factors
- Sources, types and effects
- Challenges with diagnosing mycotoxin problems
- Prevention of field mycotoxin problems
- Prevention of storage mycotoxin problems
- Controlling mycotoxin problems

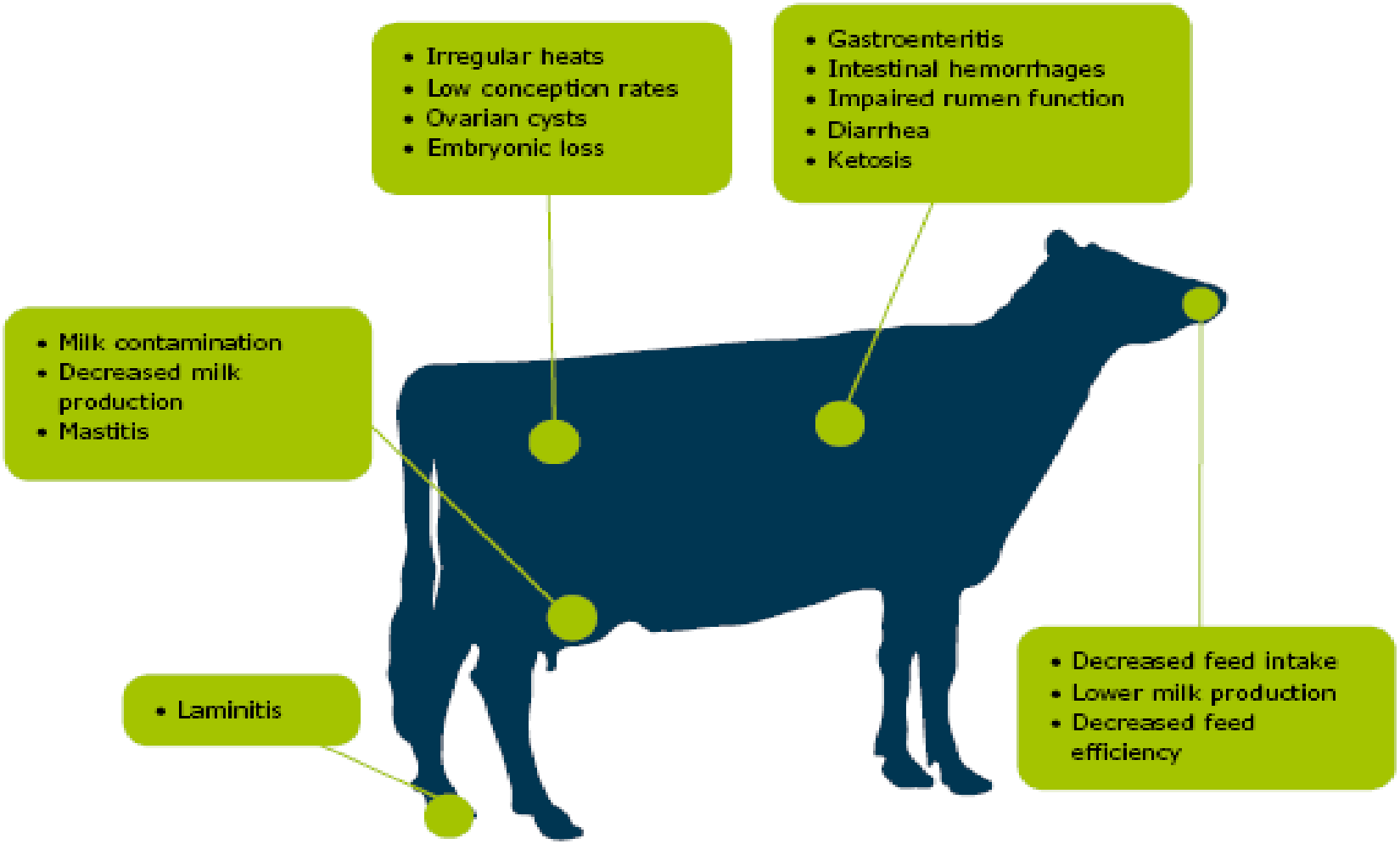
Introduction

- Mycotoxins are secondary compounds that have a defensive role in plants
- Over 400 are known but thousands exist
- Produced by molds (fungi) under stressful conditions
- Molds cause diseases directly (mycoses) or via mycotoxin production (mycotoxicoses)

Current Challenge

- Greater-than-normal mycotoxin load in current feeds
- Wet, late spring delayed planting and cool damp conditions during flowering of corn/ small grains in the North/corn belt increased growth of Fusarium molds and mycotoxin production
- Hence high load of mycotoxins in grains, milling byproducts and some wet feeds (DDGS)

Mycotoxin impacts on cattle



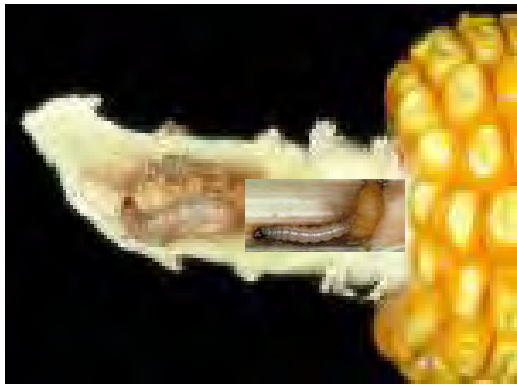
(Rodrigues, 2008)

Predisposing factors

- Field factors
  - Adverse weather (temperature & rainfall)
  - Disease, insect or pest damage
  - Excess fungicide spray / weed pressure
  - Late harvest, hail, lodging
- Storage factors
  - Inadequate drying (>12-15% moisture) in grains, hay, byproducts
  - Silages: Oxygen, late harvest, poor packing, late or poor sealing

http://www.ent.iastate.edu/pest/cornborer/

European corn borer (*Ostrinia nubilalis*)
www.plant.uga.edu



Common spoilage molds

- Fusarium (field mold)
- Aspergillus (storage mold)
- Penicillium (storage mold)

Most common causes of nutrient loss and mycotoxins

- *Monascus*
- *Rhizopus*
- *Geotrichum*

Toxic molds and mycotoxins in cattle feeds

Fusarium	Aspergillus	Penicillium	Claviceps/ Neotyphodium
Fumonisin	**Aflatoxin**	Ochratoxin	Ergot alkaloids
DON	Sterigmatocystin	**PR Toxin**	Ergotamine (rye)
Zearalenone	Ochratoxin	Patulin	Ergovaline (fescue)
T-2 toxin	Fumitremorgens	Roquefortin C	Lolitrem B (ryegrass)
Diacetoxyscirpernol	Fumitoxins	Mycophenolic acid	
Nivalenol	Cyclopiazonoic acid	Citrinin	
Moniliformin	Gliotoxin	Penetrem	
Fusaric acid		Cyclopiazonic acid	

(Asher and Whitlow)

Fusarium molds

- Examples F. verticilliodes, F. roseum, and F. proliferatum
- Common in corn, wheat, barley, sorghum,
- Favored by cool damp conditions during growth
- Cause ear and stalk rots, leaf blight etc

Fusarium ear and stalk rot

(Photos by Gary Munkvold)

Fusarium mycotoxins

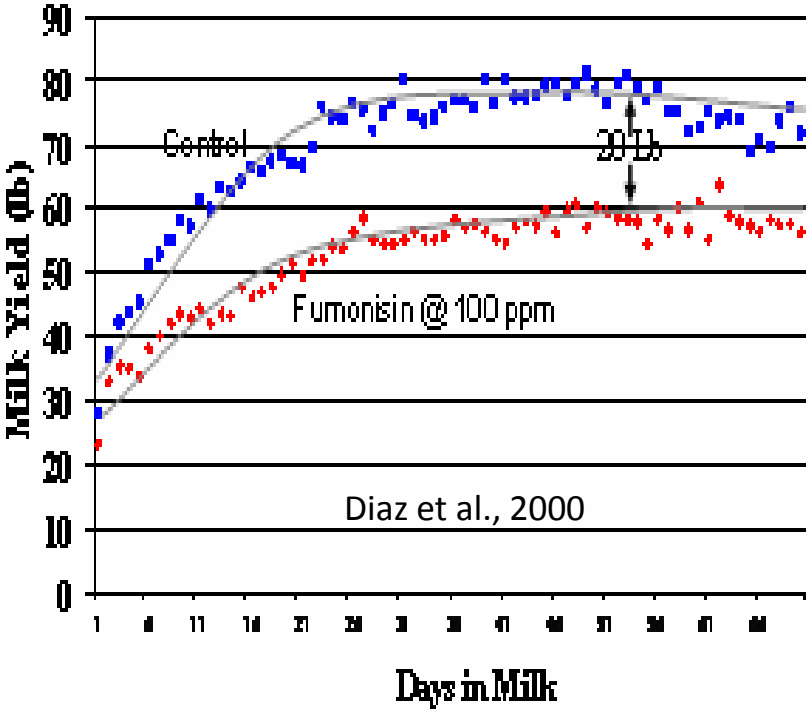
Fumonisin

- Common in corn, wheat, barley, sorghum
- Forms: B_1 (most common and toxic), B_2 and B_3
- Symptoms: anorexia, weight loss, reduced milk production, and liver damage, death
- FDA guidance: Corn should have < 30 ppm and be < 50% of diet

Zearalenone

- Common in grains, rarely found in forage
- Mimics estrogen function; binds to receptors
- Symptoms: infertility, prolonged oestrus, reduced conception, decreased litter size, rectal or vaginal prolapse and malformed fetus and abortions
- Limit to < 300 ppb

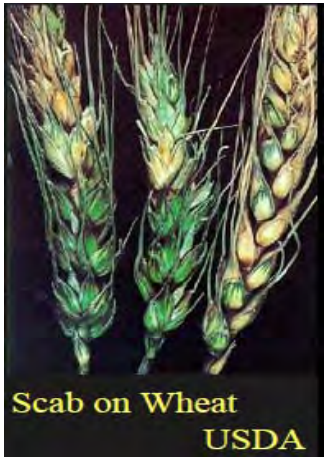
Fumonisin and zearalenone problems



Rectal prolapse

Enlarged vulvas

Fusarium verticillioides;



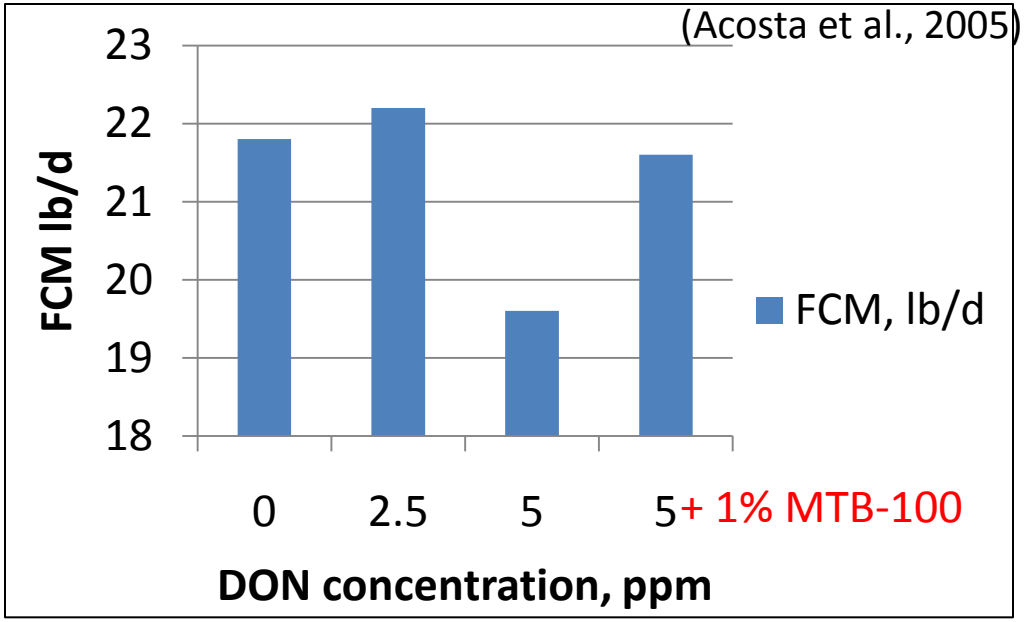
Photos by Whitlow 2006 and Asher 2010

Fusarium mycotoxins - Deoxynivalenol

- DON/Vomitoxin; a trichothecene
- Marker for other mycotoxins
- Symptoms: Reduced milk yield & rumen function, diarrhea, emaciation
- FDA advisory: Feeds should have < 5 ppm of DON and be limited to < 40% of diet. *(>500 ppb may reduce milk yield)*

Photos by Gary Munkvold

Gibberella spp. *causes Giberella ear rot and produces DON*



Aspergillus Molds

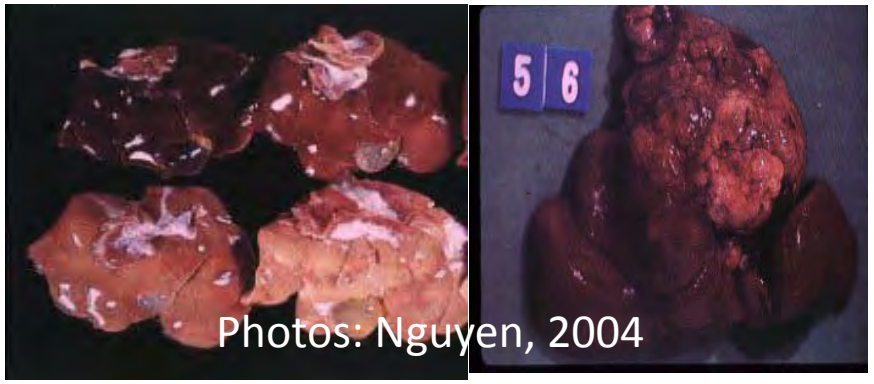
- Most common in peanuts, corn, sorghum & cottonseed, DGGS
- Produced by A. flavus and A. fumigatus
- Favored by hot, humid conditions or drought stress
- Causes:

  1.Aspergillosis (coughing blood, pneumonia, bloody urine)

  2.Farmers lung (hypersensitivity pneumonia, inflamed alveoli)

  3.Hemorrhagic bowel (bloody gut)

Aspergillus toxins



Aflatoxin

Very toxic and carcinogenic

- Forms: B_1, B_2, M_1, G_1, G_2
- About 1.7% of B_1 in feeds can end up as M_1 in milk
- Symptoms:Reduced gain, rumen motility and milk production, immunosuppression, liver damage or cancer, abortions
- FDA Action levels :20 ppb in dairy feed; 0.5 ppb in milk (100 ppb for breeding beef cattle; 300 ppb for feeder cattle)

Penicillium molds & mycotoxins

- Mold: Penicillium roquefortii
- Acid tolerant therefore common in silages
- Prefers cool wet conditions

Ochratoxin A

- Also produced by Aspergillus ochraceus
- Rapidly ruminally degraded except on a high grain diet
- Symptoms: reduced protein synthesis, abortions, cancer, and immunosuppression, impairs enzyme and kidney function and cellular respiration

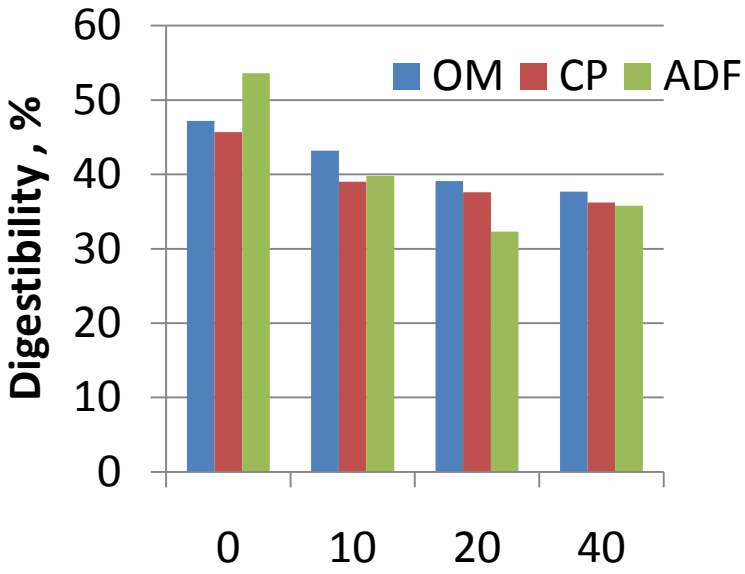
Penicillium mycotoxins

Patulin

- Also produced by Aspergillus and Byssochlamys spp
- Reduced digestibility and rumen fermentation, Carcinogenic, mutagenic, gastric paralysis and death

PR Toxin

•Reduced intake, rumen stasis, intestinal irritation, abortion and retained placenta (Whitlow,



(Tapia et al., 2004)

Ergot toxin

- Ergot in small grains (rye, sorghum, wheat)
  - Also in argentine bahiagrass
  - Caused by by Claviceps purpurea
  - Symptoms:Lameness,, reduced fertility, vasoconstriction, gangrene of extremities

- Fescue toxicosis
  - Caused by Neotyphodium coenophialum fungus
  - Symptoms: Vasoconstriction, foot problems, retained winter coat, High body temp, & respiration, reduced fertility, calving difficulties

Images from Roberts & Andrae (2004)

Challenges of dealing with mycotoxins

- Representative sampling is a huge challenge
- Mycotoxins may be present without obvious molds
- Tests for detection of toxin in tissues are uncommon
- Contaminated feed may have been eaten
- Cost of mycotoxin analysis
- Mycotoxins occur together and act in synergy
- Effective antidotes/therapies to mycotoxins are unavailable

Preventing field mycotoxin problems

85% of feed mycotoxins are from the field

- Plant adapted, disease and insect -resistant hybrids e.g. bt-corn
- Apply pesticides/fungicides
- Irrigate/ fertilize / use herbicides to mitigate plant stress
- Maintain harvesting equipment – reduce kernel damage
- Avoid harvesting lodged forage at harvest
- Seeding of non-toxic strains

Preventing mycotoxin problems in stored dry feeds

- Feeds
  - Store grains, hay, by products at <12% moisture
  - Inspect feeds often
  - Avoid condensation, seepage, rainfall on stored feed
  - Clean storage facilities between loads
- Hay
  - Ensure hay is dried to <12% moisture
  - Ensure stacks have adequate aeration and are covered
  - Use additives (mold inhibitors)
- Ensure commodity contracts include mycotoxin clause

Preventing mycotoxin problems in silage

- Use locally adapted, disease/pest resistant hybrids
- Harvest at the right moisture
- Chop properly, fill silo promptly, pack well
- Seal immediately and maintain seal
- Feedout at 12 inches/day (match to herd size)
- Maintain a clean silo face
- Discard spoiled silage
- Use an antifungal inoculant / mold inhibitor
- Greater risk with tropical / later hybrids

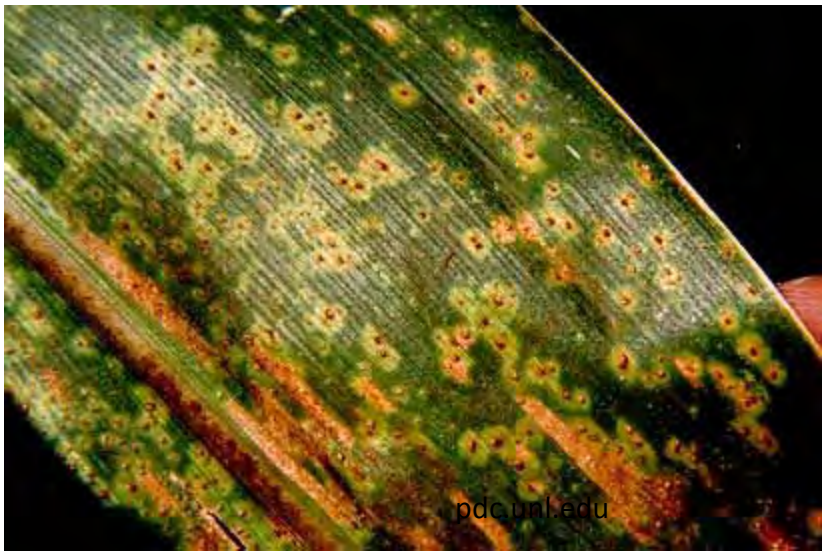
Detecting mycotoxin problems

- Monitor performance, review records
- Rule out other causes & identify source
- Representatively sample suspect feeds
  - Take several samples (>10/load), composite and mix well
  - Send to lab (freeze silage/wet samples)
  - Ask for HPLC or Mass spec analysis
  - Test for (AF, DON, ZEN, FB and T2) or base test on symptoms

Note: Negative test does not imply mycotoxin absence

Controlling mycotoxin problems

- Dilute contaminated feed in ration
- Offer contaminated feed to less sensitive animals
- Feed well balanced diets
- Ensure fiber adequacy / add buffers to limit acidosis
- Add antioxidants Vit A and E, Se, Cu, Mn , Zn to feeds
- Use a binding or deactivating agent



Strategies to protect against mycotoxins

- Microbial inactivation
- Cleaning/separating fines
- Thermal inactivation
- Irradiation
- Ammoniation
- Ozonation
- Mold inhibitors (Propionic acid)
- Bunk life inoculants (Buchneri)
- Adsorbents

Impractical for forage mycotoxins

Best for forage mycotoxins

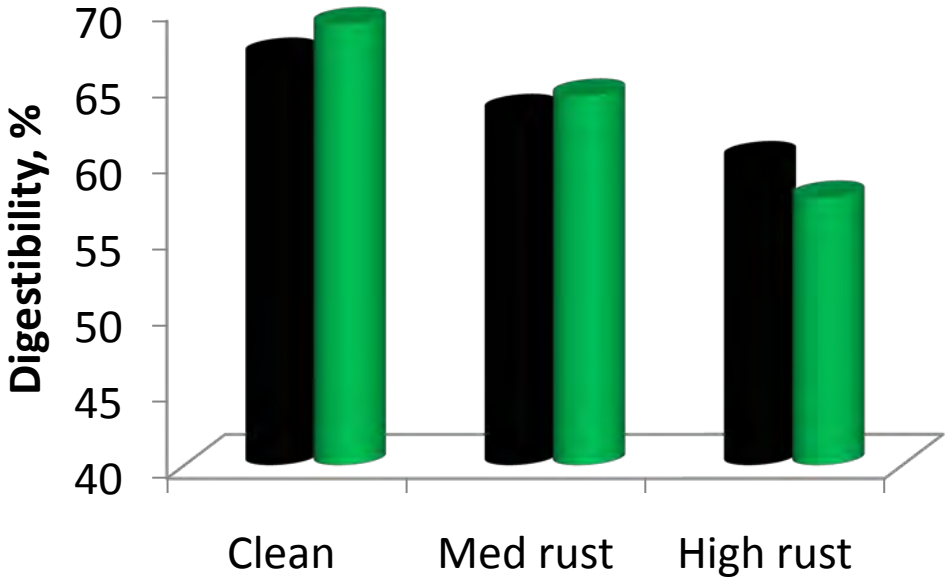
Does rust affect forage quality and mycotoxin load? Can inoculants help?

(Queiroz et al. 2009)

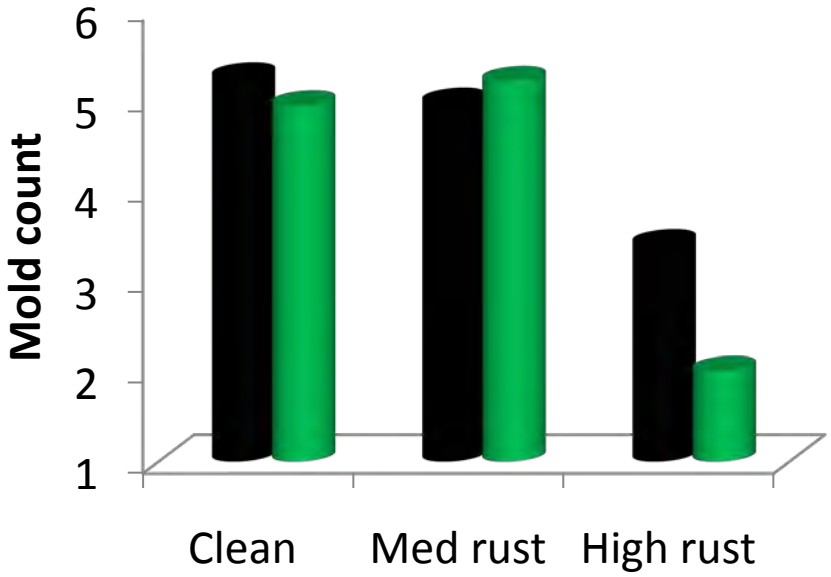
No rust (clean)

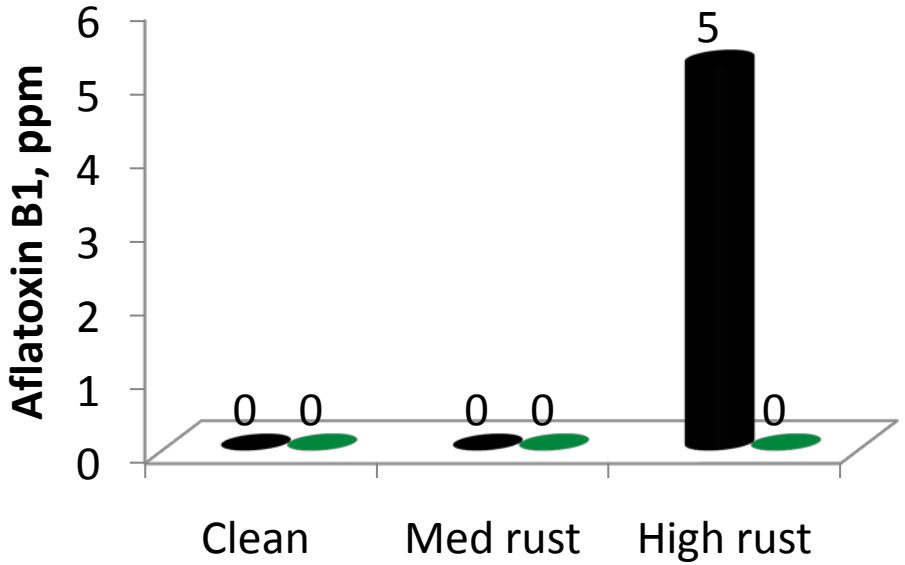
Medium rust

High rust



(Quieroz, 2008)



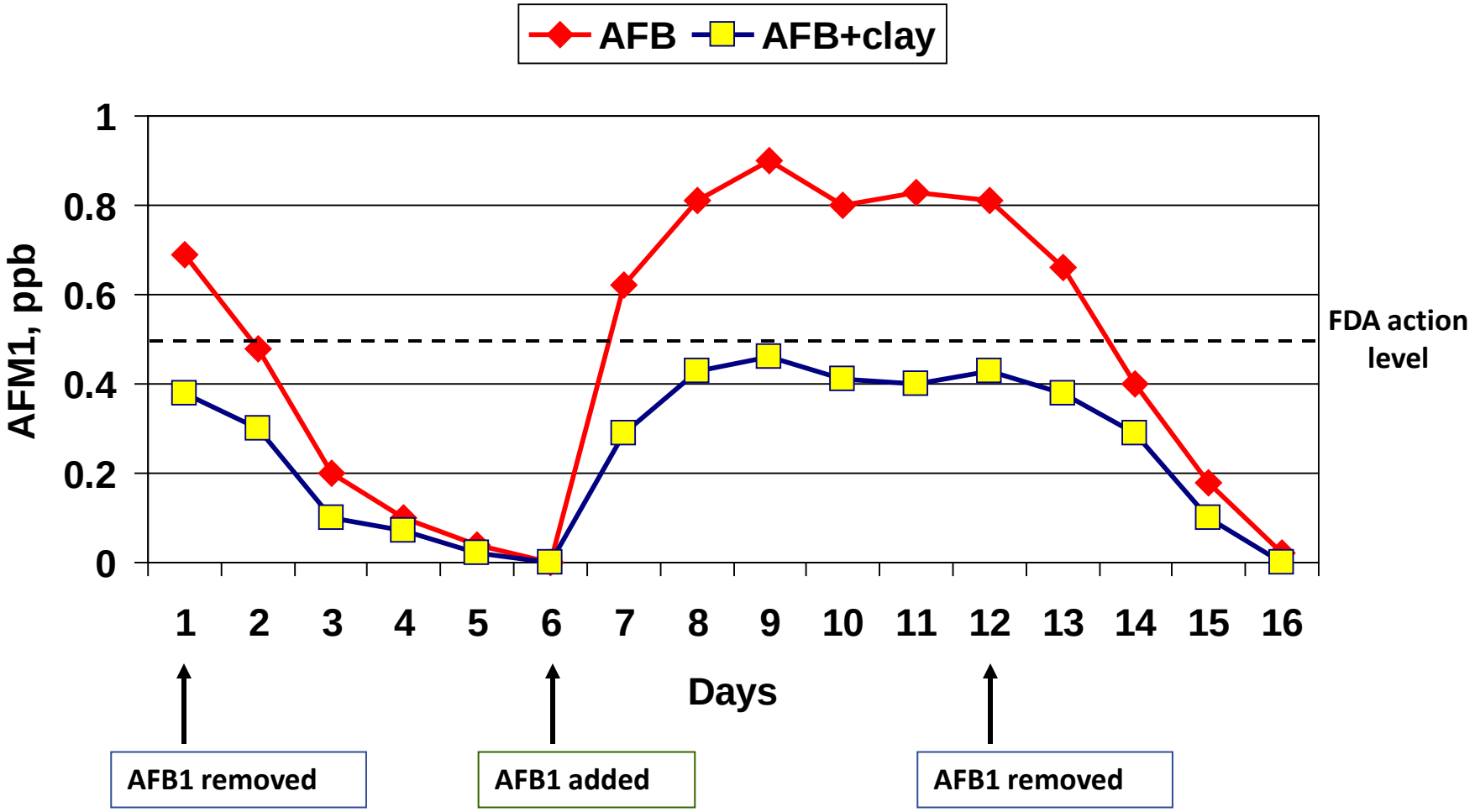


Mycotoxin adsorbents (binders)

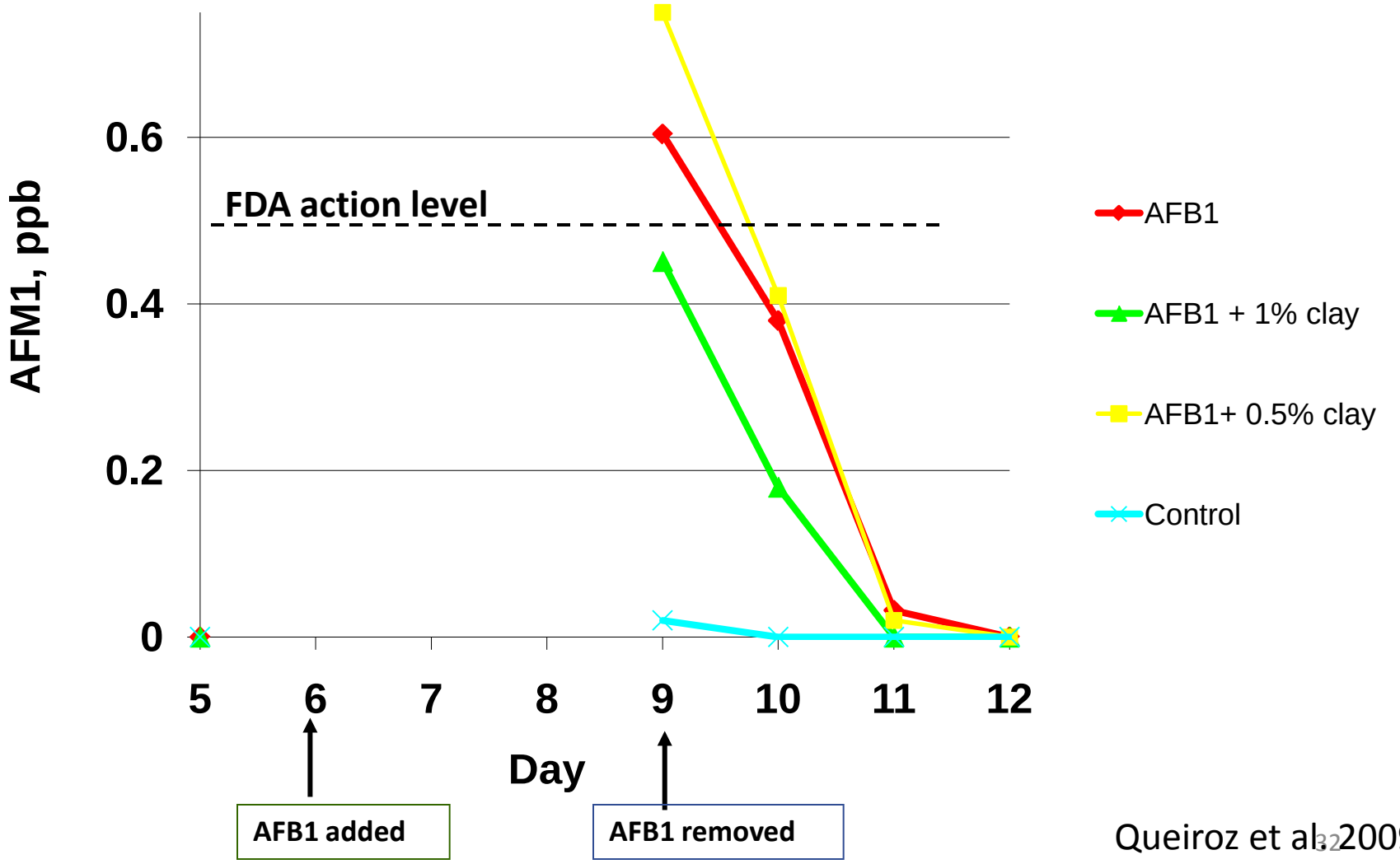
- None are approved by FDA as binders
- Added as flow agents to diets
- Many are effective on specific mycotoxins
- In vitro binding data does not always predict in vivo result
- Types:
    1. Activated Carbon or charcoal
    2. Silicates (clays) e.g. bentonite, montmorillonite, HSCAS etc
    3. Cell wall carbohydrates (glycans e.g. glucomannans, peptidoglycans)-
    4. Synthetic polymers – polyvinylpyrollidone and cholestryamine

Effect of adding clay binders at 1% to diets containing 55% AFB on milk AFM1 concentration

Diaz et al. 2004



Effect of adding a clay binder (Calibrin A)to diets with 75 ppb of AFB1 on milk AFM1



Queiroz et al 2009

Effect of rate of adding a clay binder (Calibrin A)to diets with 75 ppb of AFB1 on milk

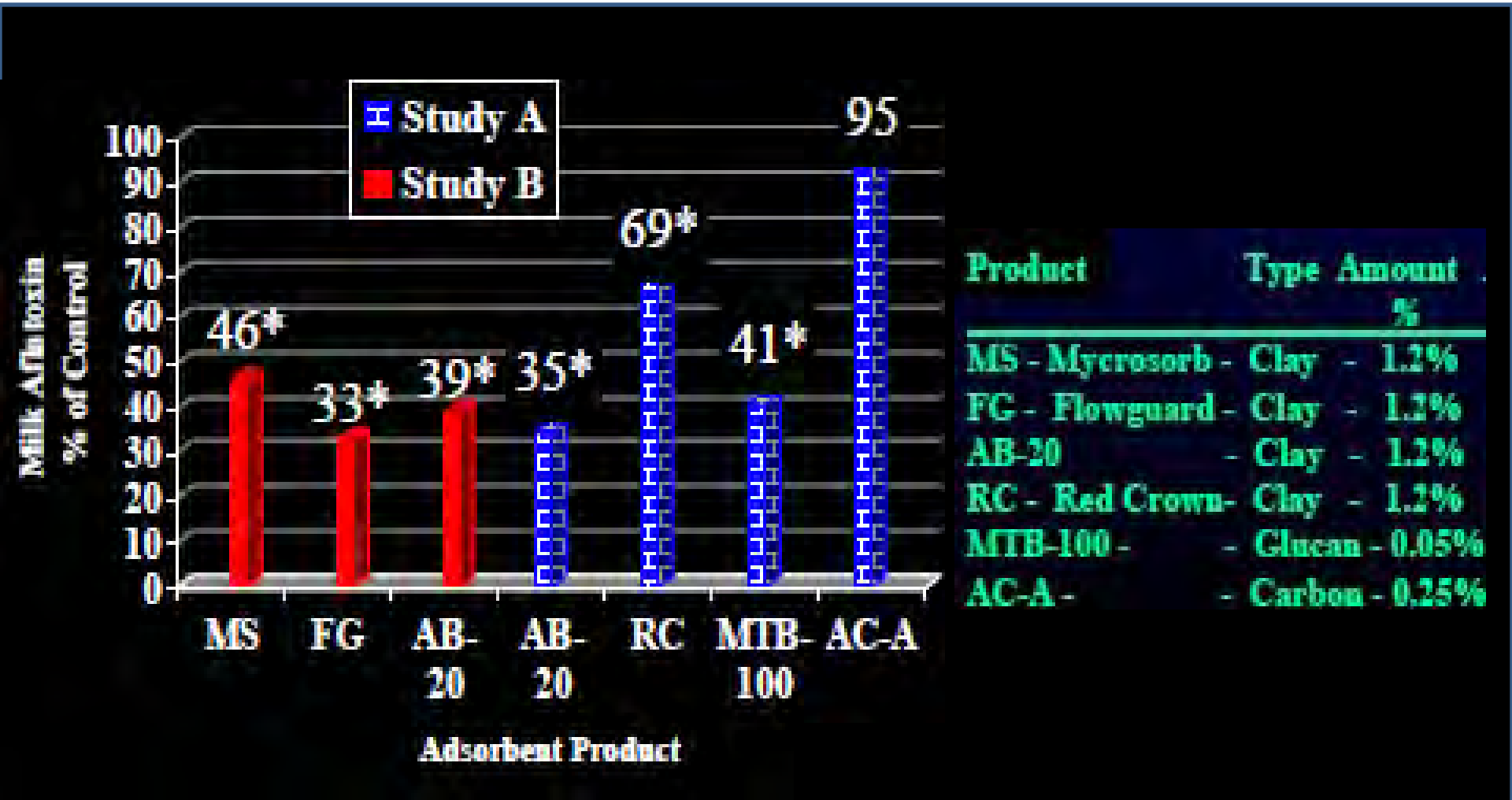
	Control	AFB1	AFB1+ 0.2% clay	AFB1 + 1% clay
DMI, kg/d	20.8	18.0	18.1	20.4
3.5% FCM yield, kg/d	20.8 ^{x}	19.0 ^{y}	20.5 ^{x}	19.4^{x}
Milk Protein %	3.36^{ab}	3.28^{c}	3.35^{b}	3.41^{a}
Milk Fat Yield, kg/d	0.74 ^{a}	0.67 ^{b}	0.73 ^{ab}	0.69 ^{ab}
Haptoglobin	14.4^{b}	22.0^{a}	14.7^{b}	16.0^{b}

x,y means in the same row differed, $P < 0.1$

a, b, means in the same row differed, $P < 0.05$)

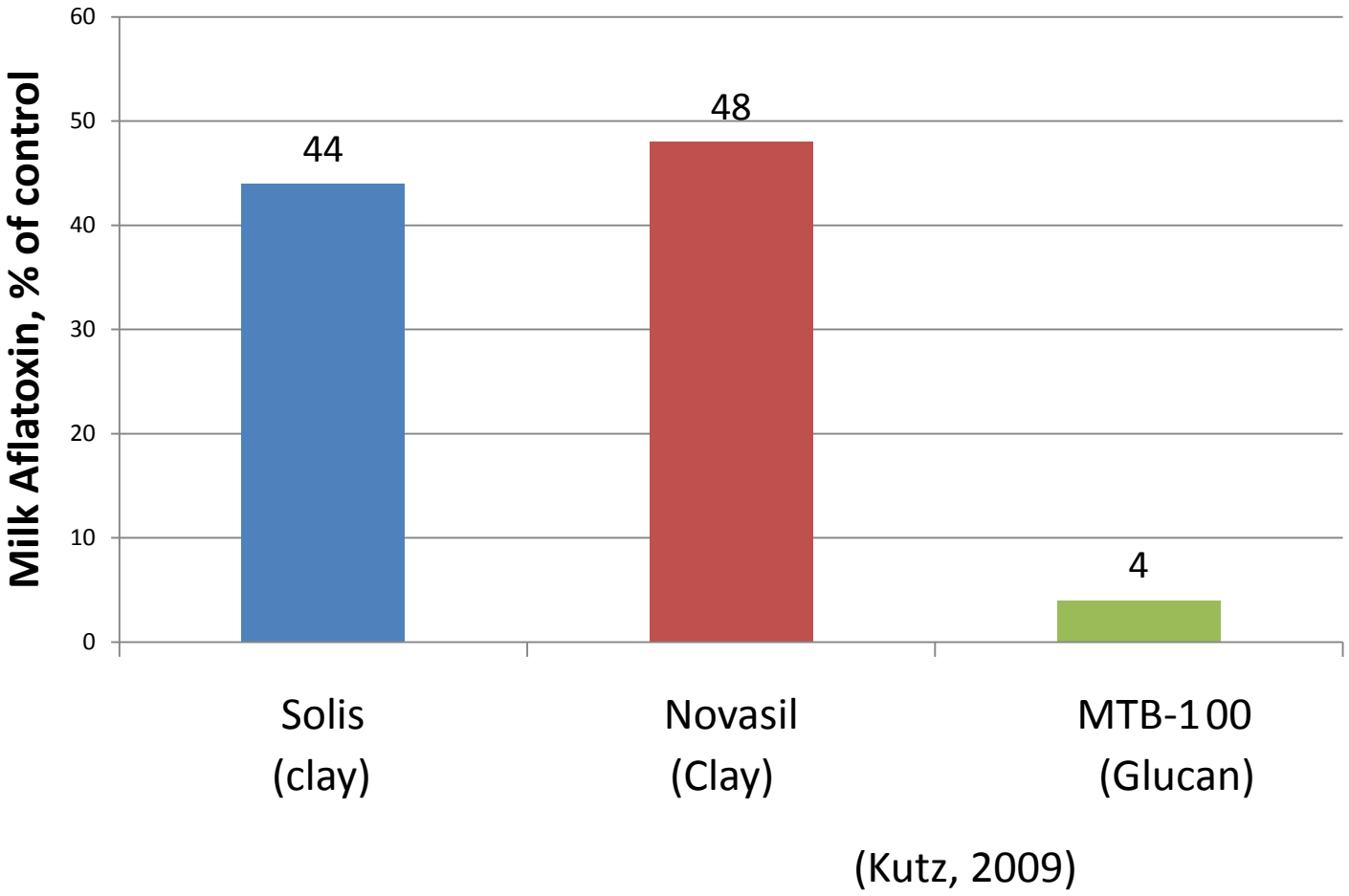
Queiroz et al. 2009

Effect of adding binders to diets with 55 ppb of AFB1 on milk AFM1



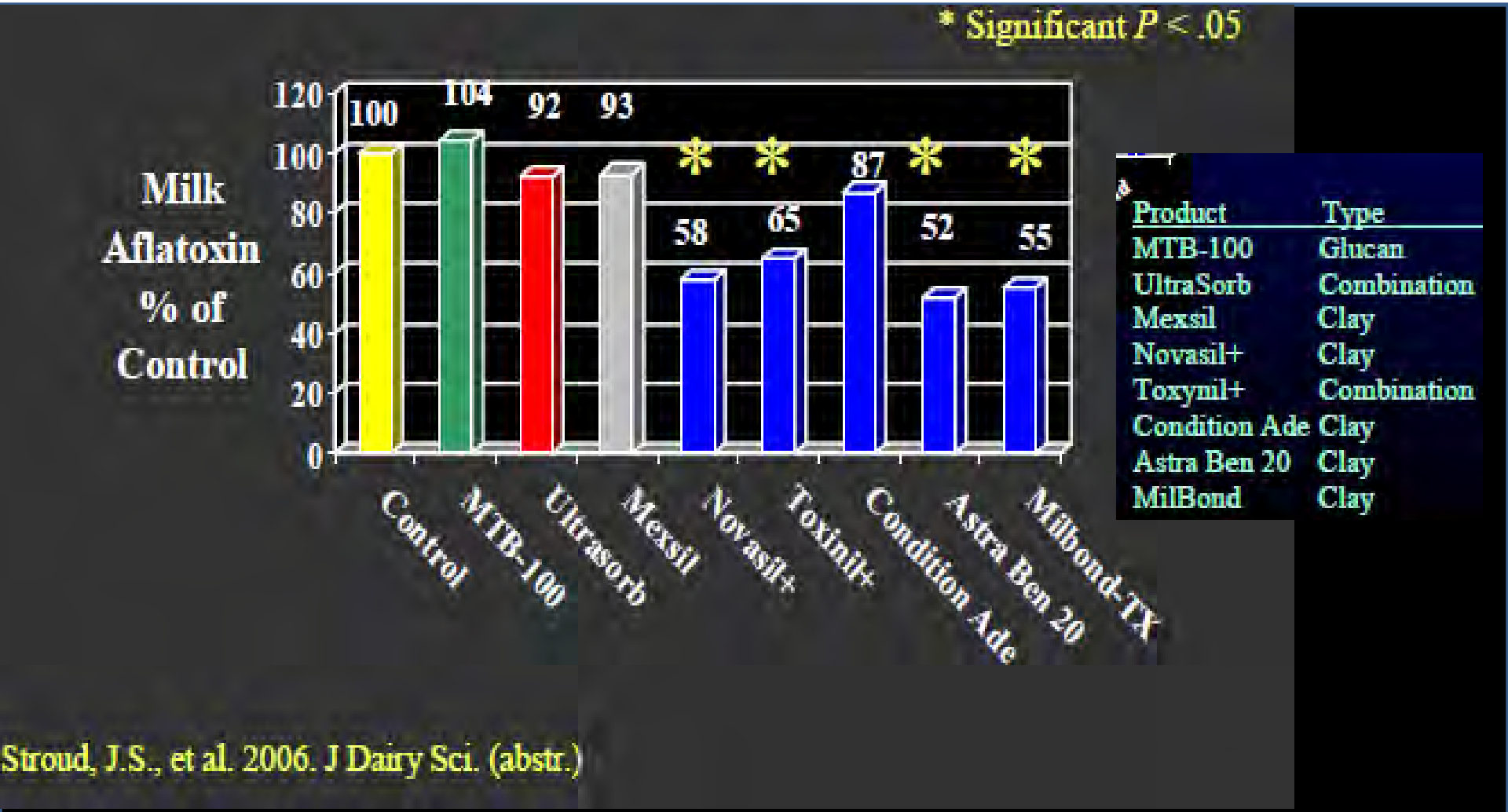
Adapted from Whiltolw, (2007)

Effect of adding binders at 0.5% to diets with 112 ppb of AFB1 on milk AFM1



(Kutz, 2009)

Effect of adding binders at 0.5% to diets with 170 ppb of AFB1 on milk AFM1



Adapted from Whiltolw, (2007)

Effect of adsorbents on mycotoxins across species: Summary (Whitlow, 2008)

(Positive Responses/Trial Observations)

Mycotoxin	Carbon	Glucan	Clay	PVP
Aflatoxin	6/8	7/9	35/35	1/2
DON		0/1		
ZEN	1/1	0/1	1/2	
T-2	3/3	1/1	0/5	
DAS			01	
FB	0/1	0/1	0/1	
Ergot		2/2	2/2	
OA	1/2	0/3	0/5	0/1

Clays are most effective on aflatoxin, less effective on others
Carbon & glucans have wider scope but have been less consistent on aflatoxin
Research needed on effects of mycotoxin biotransforming agents in cattle feeds

Take home messages

- Mycotoxin contamination occurs in the field /storage
- Stress/damage to plants, excess moisture in dry feeds, oxygen in silages can increase mycotoxin load
- Mycotoxins reduce performance and welfare or cause severe diseases and death
- Prevention is the best solution
- Effective strategies exist e.g. mold inhibitors, adsorbents
- Adsorbent efficacy varies with the mycotoxin