

## APPENDIX 13.2-B MYCOTOXINS

### 1. INTRODUCTION.

- a. While we are familiar with a few mycotoxins that cause adverse health effects and even death in humans, other toxins are poorly understood. Health effects associated with mycotoxins, particularly from inhalation exposures, are controversial and more studies are needed. Additionally, we do not know the synergistic effects of exposure to multiple mycotoxins simultaneously, nor do we understand mycotoxin degradation and possible by-products. Further, the amount of mycotoxin needed to elicit an effect varies among people (due to differing levels of sensitivity), as well as among the toxins themselves (differences in potency).

### 2. MYCOTOXINS.

- a. **Aflatoxin** - Aflatoxin is one of the most potent carcinogens known to man and has been linked to a wide variety of human health problems. It is also mutagenic, hepatotoxic, cytotoxic, and tremorgenic (compounds capable of producing serious muscle tremor and/or seizures in vertebrates). The FDA has established maximum allowable levels of total aflatoxin in food commodities at 20 parts per billion. The maximum level for milk products is even lower at 0.5 parts per billion. Aflatoxin is produced by *Aspergillus*, particularly the species *flavus*, *parasiticus*, and sometimes *fumigatus*, and is usually associated with cultivation of maize and peanuts in warm, moist, climactic conditions. However, the culprit species are not usually found in indoor environments or associated with building materials.
- b. **Alternariol** – A cytotoxic compound derived from *Alternaria alternata*.
- c. **Cephalosporin** – toxin produced by *Acremonium* species that is used as a human antibiotic.
- d. **Citrinin** - a nephrotoxin produced by *Penicillium* (*citrinin* and *expansum*) and *Aspergillus* species. Renal damage, vasodilatation, and bronchial constriction are some of the health effects associated with this toxin.
- e. **Cytochalasin E** – a toxin from *Aspergillus clavatus* that inhibits cell division and protein synthesis, is nephrotoxic, and is considered carcinogenic.
- f. **Deoxynivalenol** – see Vomitoxin
- g. **Fumonisin** - a toxin associated with species of *Fusarium* (e.g., *moniliforme*) that is neurotoxic, hepatotoxic, nephrotoxic, and carcinogenic. Fumonisin is commonly found in corn and corn-based products, with recent outbreaks of veterinary mycotoxicosis occurring in Arizona, Indiana, Kentucky, North Carolina, South Carolina, Texas and Virginia. The animals most affected were horses and swine, resulting in dozens of deaths. Fumonisin toxin causes "crazy horse disease," or leukoencephalomalacia, a liquefaction of the brain. Symptoms include blindness, head butting and pressing, constant circling and ataxia, followed by death. Chronic low-level exposure in humans has been linked to esophageal cancer. The American Association of Veterinary Laboratory Diagnosticians (AAVLD) advisory level for fumonisin in horse feed is 5 parts per million.
- h. **Gliotoxin** - An immunosuppressive toxin produced by species of *Alternaria*, *Penicillium* and *Aspergillus* (*flavus*, *parasiticus*, *fumigatus*).
- i. **Ochratoxin A** - primarily produced by species of *Penicillium* (*verrucosum* and *viridicatum*) and *Aspergillus* (*ochraceus*). Ochratoxin is damaging to the kidneys and

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liver and is also a suspected carcinogen. There is also evidence that it impairs the immune system.

- j. **Patulin** - a mycotoxin produced by *Penicillium (expansum)*, *Aspergillus (clavatus)* and a number of other genera of fungi. It is believed to cause tumors and hemorrhaging in the brain or lungs. It is usually associated with apple and grape spoilage.
  - k. **Satratoxin H** - a macrocyclic tricothecene produced by *Stachybotrys chartarum*, *Trichoderma viridi* and other fungi. High doses or chronic low doses are lethal. This toxin is abortogenic in animals, is believed to alter immune system function, and makes affected individuals more susceptible to opportunistic infection.
  - l. **Sterigmatocystin** – a nephrotoxin and a hepatotoxin produced by *Aspergillus versicolor* and *nidulans*. This toxin is also considered to be carcinogenic.
  - m. **Tenuazoic acid** – a nephrotoxic, hepatotoxic, & hemorrhagic toxin produced by *Aspergillus alternata*.
  - n. **T-2 Toxin** - a tricothecene produced by *Fusarium (poeae and sporotrichoides)* that is one of the more deadly toxins (hemorrhagic, hepatotoxic, nephrotoxic, and carcinogenic). If ingested in sufficient quantity, T-2 toxin can severely damage the entire digestive tract and cause rapid death due to internal hemorrhage. T-2 has been implicated in the human diseases alimentary toxic aleukia and pulmonary hemosiderosis. Damage caused by T-2 toxin is often permanent.
  - o. **Tricothecenes** – Mycotoxins produced by *Fusarium*, *Stachybotrys*, *Myrothecium*, *Trichoderma*, and *Cephalosporium* species. The tricothecene toxins produced in grains by *Fusarium* species are usually associated with elevated humidity and temperature. Tricothecenes inhibit protein and DNA synthesis and interfere with growth, reproduction and the structural integrity of tissues. Primary diseases (mycotoxicoses) include alimentary toxic aleukia (ATA), stachybotryotoxicosis, moldy corn toxicosis, and red-mold toxicosis. The most frequently encountered tricothecene toxins include T-2, 2-deoxynivalenol (DON or vomitoxin), nivalenol and diacetoxyscirpenol (DAS).
  - p. **Vomitoxin (or Deoxynivalenol) (DON)** - Vomitoxin, chemically known as Deoxynivalenol, a tricothecene mycotoxin, is produced by several species of *Fusarium*, especially *graminraeum*. Vomitoxin has been associated with outbreaks of acute gastrointestinal illness in humans. The FDA advisory level for vomitoxin for human consumption is 1part per million.
  - q. **Zearalenone** – A mycotoxin produced by *Fusarium* molds. Zearalenone is similar in chemical structure to the female sex hormone estrogen and targets the reproductive organs.
3. **OTHER MYCOTOXINS.**
- a. **Aflatrem**
  - b. **Aspergillic acid**
  - c. **Austamide**
  - d. **Chaetoglobosin C**
  - e. **Chlamydosporol**

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- f. **Cladosporin** - produced by *Cladosporium cladosporioides*; used as an antibiotic
- g. **Cychlochlorotine**
- h. **Cyclopiazonic acid** – produced by *Aspergillus* and *Penicillium*; causes kodua poisoning
- i. **Cyclosporin** – produced by *Tolypocladium inflatum*; immunosuppressive
- j. **Echinulin**
- k. **Emodin** - produced by *Cladosporium cladosporioides*; used as an antibiotic
- l. **Epicladosporic acid** - produced by *Cladosporium* species; causes immunosuppression
- m. **Ergot alkaloids** – produced by *Claviceps purpurea*, *Cladosporium purpurea*; hallucinogenic and vasoactive (causes smooth muscles to constrict); causes ergotism (gangrene)
- n. **Ergovaline** – produced by *Acremonium coenophialum*; primarily a disease of grasses, especially fescue
- o. **Erythrokyrine**
- p. **Flavoglaucin**
- q. **Fumagillin**
- r. **Fumitremorgens** - produced by *Aspergillus* species; causes tremors and liver damage; carcinogenic and mutagenic
- s. **Griseofulvin** - produced by *Penicillium griseofulvum* and *viridicatum*; tumorigenic, teratogenic, and hepatotoxic
- t. **Isotrichodermin**
- u. **Kojic acid**
- v. **Luteoskyrin rugulosin**
- w. **Maltoyzine**
- x. **Nigragillin**
- y. **3-Nitropropionic** – produced by *Arthrimum* species; possibly associated with pediatric neurotoxicity
- z. **Paspaline**
- aa. **Penicillic acid**
- bb. **Penicillin** - produced by *Penicillium chrysogenum*; used as an antibiotic
- cc. **Penitrem** - produced by *Penicillium (crustosum)* and *Aspergillus* species; tremorgenic and neurotoxic
- dd. **Phylloerythrin** – produced by *Pithomyces chartarum*; photosensitization and eczema
- ee. **Roridins** – produced by *Stachybotrys*; see verrucarins
- ff. **Roquefortine C** - produced by *Penicillium crustosum* and *expansum*; can be tremorgenic, neurotoxic, nephrotoxic, and carcinogenic
- gg. **Rubratoxin (A & B)** – produced by *Penicillium rubrum*; hepatotoxic

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- hh. **Secalonic acid D** – produced by *Penicillium oxalicum*; teratogenic
- ii. **Sporidesmin** – produced by *Pithomyces chartarum*; hepatotoxic
- jj. **Stachybotrins** – produced by *Stachybotrys chartarum*; see verrucarins
- kk. **Verrucarins** – produced by *Stachybotrys chartarum*; inflammatory reactions, including dermatitis; immunosuppressive, hemotoxic, and hemorrhagic
- ll. **Verrucosidin**
- mm. **Versicolorin A**
- nn. **Viomellein**
- oo. **Viridicatumtoxin**
- pp. **Xanthomegnin**