Mycotoxin Monitoring: Safeguarding Co-Products Quality & Safety

Patricia Jackson
Market Development Manager
Our History in the Agriculture and Food Industries

- VICAM launched its first product in 1987 – AflaTest

- Aflatoxin outbreak impacted poultry/egg production

- Specialization in antibody-based diagnostics and laboratory sample prep

- Our First Work: Enable prevention and confirmatory testing for mycotoxins on-site or in the food and agricultural laboratory.
Mycotoxin Testing & Management Through The Years

- **1985**: AflaTest for fluorometer & LC
- **1995**: Multiple mycotoxin IA columns launched
- **2006**: VICAM acquired by Waters Corporation
- **2010**: Vertu quantitative lateral flow test strips launched
- **2019**: …and beyond
- **2021**: …and beyond
What are mycotoxins?

- Penicillium
- Aspergillus
- Fusarium
- Fumonisin
- Zearalenone
- Aflatoxin
- Citrinin
- Deoxynivalenol
- Ochratoxin A
### Food & Agricultural Products Affected by Mycotoxin Contamination

- Tree Nuts
- Peanuts
- Grain
- Wine
- Coffee
- Flour Milling
- Cereals
- Feed
  - Hemp/Cannabis
- Oats
- Ethanol
- Dairy
- Rice
- Botanicals
- Spices
- Snack Foods
- Pet Food
- Hemp/Cannabis
<table>
<thead>
<tr>
<th>Mycotoxins</th>
<th>AFLATOXINS B1, B2, G1, G2, M1</th>
<th>VOMITOxin (DON)</th>
<th>FUMONISINS B1, B2, B3</th>
<th>OCHeRATOxin A</th>
<th>T-2/HT-2</th>
<th>ZEARALENONE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Selected Molds That Produce Toxins</strong></td>
<td>Aspergillus flavus, Aspergillus parasiticus</td>
<td>Fusarium graminearum</td>
<td>Fusarium verticillioides</td>
<td>Aspergillus ochraceus Penicillium verrucosum</td>
<td>Fusarium and other mold species</td>
<td>Fusarium graminearum</td>
</tr>
<tr>
<td><strong>Foods Susceptible to Contamination</strong></td>
<td>Maize, groundnuts, nuts, cottonseed, copra, spices, milk, wheat, oats, barley, and rice</td>
<td>Maize, wheat, barley, malted barley, and oats</td>
<td>Maize and other cereal grains</td>
<td>Maize, wheat, barley, beer, oats, sorghum, dried vine fruits, wine, coffee, and cocoa</td>
<td>Maize, wheat, barley, oats, rice, sorghum, and other cereal grains</td>
<td>Maize, wheat, barley, grain, and sorghum</td>
</tr>
<tr>
<td><strong>Health Effects</strong></td>
<td>▪ Liver cancer and damage ▪ Immunosuppression ▪ Decreased milk and egg production</td>
<td>▪ Damage to digestive tract, bone marrow, spleen, reproductive organs ▪ Weight loss, vomiting, and feed refusal</td>
<td>▪ Cancer in rats ▪ Brain decay in horses ▪ Lung congestion in pigs ▪ Human Esophageal Cancer</td>
<td>▪ Kidney damage and cancer ▪ Immunosuppression</td>
<td>▪ Skin and oral lesions in livestock and humans ▪ Alimentary toxic aleukia in humans ▪ Considered 10x more toxic than DON</td>
<td>▪ Negatively impacts reproduction, fetal development, and the health of newborns ▪ Causes feminization in animals at 1 ppm</td>
</tr>
</tbody>
</table>

- Diverse range of toxins
- Array of health impacts
- Economic Impact
Mycotoxins: Economic and Health Risks

Figure 6.1. Factors affecting mycotoxin occurrence in the food chain (Pestka and Casale, 1989) from CAST report 1989.
Mycotoxin Monitoring from Field to Market: Where is the Need?

- Field
- Storage/Processing/Transport
- Market
When Should I Suspect Mycotoxins?

- Weather conditions…..
- Where did my ingredients come from???
- How was it stored???
Ethanol Co-Products In Animal Feeds

- High energy, middle protein content
- Longer shelf-life compared with traditional grain or oilseed meals
- DDGs, Dried and Pelletized Forms enable protective storage, easier handling and long-distance shipments
- Used as a 1:1 substitute for corn grain in feed rations
- May be used for cattle, dairy cows, swine and some poultry diets

# Poultry Feed & Mycotoxins

<table>
<thead>
<tr>
<th>Mycotoxins</th>
<th>Commodity</th>
<th>FDA level</th>
<th>Health effects</th>
<th>Performance effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxin</td>
<td>Corn/peanut/other ingredients excluding cottonseed meal</td>
<td>100 ppb*</td>
<td>Liver damage, Liver cancer, Lower immunity, Embryo death, Birth defects, Hemorrhage</td>
<td>Reduced egg production, Contaminated eggs/poultry</td>
</tr>
<tr>
<td>Aflatoxin</td>
<td>Cottonseed meal</td>
<td>300 ppb†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DON</td>
<td>Grain/byproducts</td>
<td>10 ppm</td>
<td>Lower immunity, Intestinal disorders</td>
<td>Impaired performance/productivity</td>
</tr>
<tr>
<td>Fumonisins</td>
<td>Corn/byproducts</td>
<td>100 ppm‡</td>
<td>Diarrhea, Liver damage</td>
<td>Decreased egg production/quality</td>
</tr>
<tr>
<td>OTA</td>
<td></td>
<td></td>
<td>Liver/kidney damage</td>
<td>Reduced egg production, Decreased feed intake/growth, Contaminated eggs/poultry</td>
</tr>
<tr>
<td>T-2</td>
<td></td>
<td></td>
<td>Intestinal symptoms, Oral lesions, Bruising, Lower immunity</td>
<td>Reduced feed intake/weight loss, Reduced egg production</td>
</tr>
</tbody>
</table>
### Dairy Cow Rations & Mycotoxins

<table>
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<th>Health effects</th>
<th>Performance effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxin</td>
<td>Corn/peanut/other ingredients</td>
<td>20 ppb*</td>
<td>Liver damage, Embryo death, Birth defects, Hemorrhage, Diarrhea</td>
<td>Reduced reproductive performance, Contaminated milk, Lower milk production</td>
</tr>
<tr>
<td>DON</td>
<td>Grain/byproducts</td>
<td>10 ppb</td>
<td>Digestive symptoms</td>
<td>Feed refusal, Lower milk production, Reduced reproductive efficiency</td>
</tr>
<tr>
<td></td>
<td>DDG/brewers grains/gluten</td>
<td>30 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fumonisins</td>
<td>Corn/byproducts</td>
<td>60 ppm†</td>
<td>Liver/kidney damage</td>
<td>Weight loss, Lower milk production</td>
</tr>
<tr>
<td>OTA§</td>
<td></td>
<td></td>
<td>Depression, Dehydration</td>
<td>Feed refusal/weight loss</td>
</tr>
<tr>
<td>T-2</td>
<td></td>
<td></td>
<td>Intestinal symptoms/hemorrhage, Lower immunity</td>
<td>Decreased milk production, Feed refusal, Reduced reproductive performance</td>
</tr>
<tr>
<td>ZEA</td>
<td></td>
<td></td>
<td>Hormonal disorders, Abortions</td>
<td>Reproductive problems, Reduced feed intake, Lower milk production</td>
</tr>
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# Beef Cattle Feeds & Mycotoxins

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<th>Performance effects</th>
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<tbody>
<tr>
<td>Aflatoxin</td>
<td>Corn/peanut/other ingredients excluding cottonseed meal</td>
<td>300 ppb*</td>
<td>Liver damage, Embryo death, Birth defects, Hemorrhage</td>
<td>Reduced reproductive performance, Contaminated meat, Feed refusal</td>
</tr>
<tr>
<td>Aflatoxin</td>
<td>Cottonseed meal</td>
<td>300 ppb†</td>
<td>Diarrhea</td>
<td></td>
</tr>
<tr>
<td>DON</td>
<td>Grain/byproducts</td>
<td>10 ppm</td>
<td>Digestive symptoms</td>
<td>Reduced feed intake, Impaired reproductive performance</td>
</tr>
<tr>
<td>DON</td>
<td>DDG/brewers grains/gluten</td>
<td>30 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fumonisins</td>
<td>Corn/byproducts</td>
<td>60 ppm‡</td>
<td>Liver/kidney damage</td>
<td>Weight loss</td>
</tr>
<tr>
<td>OTA⁵</td>
<td></td>
<td></td>
<td>Depression, Dehydration</td>
<td>Feed refusal/weight loss</td>
</tr>
<tr>
<td>T-2</td>
<td></td>
<td></td>
<td>Intestinal symptoms, Lower immunity</td>
<td>Decreased feed intake, Reduced reproductive performance</td>
</tr>
<tr>
<td>ZEA</td>
<td></td>
<td></td>
<td>Hormonal disorders, Abortions</td>
<td>Reduced reproductive performance</td>
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<tbody>
<tr>
<td>Aflatoxin</td>
<td>Corn/peanut/other ingredients excluding cottonseed meal</td>
<td>200 ppb*</td>
<td>Liver damage, Liver cancer, Lower immunity</td>
<td>Reduced reproductive performance, Feed refusal/weight loss</td>
</tr>
<tr>
<td></td>
<td>Cottonseed meal</td>
<td>300 ppb†</td>
<td>Embryo death, Birth defects, Hemorrhage</td>
<td></td>
</tr>
<tr>
<td>DON</td>
<td>Grain/byproducts</td>
<td>5 ppm</td>
<td>Vomiting/intestinal symptoms, Lower immunity</td>
<td>Feed refusal/decreased weight gain</td>
</tr>
<tr>
<td>Fumonisins</td>
<td></td>
<td>20 ppm</td>
<td>Porcine pulmonary edema (PPE), Heart/liver/pancreas damage, Lower immunity</td>
<td>Reduced feed intake/growth</td>
</tr>
<tr>
<td>OTA§</td>
<td></td>
<td></td>
<td>Liver/kidney damage</td>
<td>Decreased productivity, Decreased feed intake/weight loss, Contaminated meat</td>
</tr>
<tr>
<td>T-2</td>
<td></td>
<td></td>
<td>Intestinal symptoms, Blood disorders, Lower immunity, Intestinal lesions</td>
<td>Reduced feed intake/lower weight gain</td>
</tr>
<tr>
<td>ZEA</td>
<td></td>
<td></td>
<td>Embryo death, Vomiting/diarrhea, Hemorrhage, Hormonal disorders</td>
<td>Reduced reproductive performance, Feed refusal/weight loss</td>
</tr>
</tbody>
</table>
# Horse Feed & Mycotoxins

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<tr>
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<th>FDA level</th>
<th>Health effects</th>
<th>Performance effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxin</td>
<td>Corn/peanut/other ingredients</td>
<td>20 ppb</td>
<td>Liver damage Seizures Lower immunity Embryo death Birth defects Hemorrhage</td>
<td>Reduced reproductive performance Weight loss</td>
</tr>
<tr>
<td>DON</td>
<td>Grain/byproducts</td>
<td>5 ppm</td>
<td></td>
<td>Feed refusal/decreased intake</td>
</tr>
<tr>
<td>Fumonisins</td>
<td>Corn/byproducts</td>
<td>5 ppm</td>
<td>Equine leukenoencephalomalacia</td>
<td></td>
</tr>
<tr>
<td>OTA</td>
<td></td>
<td></td>
<td>Kidney damage</td>
<td>Reduced growth/performance</td>
</tr>
<tr>
<td>T-2</td>
<td></td>
<td></td>
<td>Intestinal symptoms Lower immunity</td>
<td>Decreased feed intake</td>
</tr>
<tr>
<td>ZEA</td>
<td></td>
<td></td>
<td>Hormonal disorders</td>
<td>Reduced reproductive performance</td>
</tr>
</tbody>
</table>
How do I know if I have a problem with mycotoxins in my facility?

FDA-FSMA: food manufacturers must assess risk, plan for monitoring and management for raw materials suppliers and products

Identifying credible sources of information for risk assessment and ongoing routine testing

Where do I go to find information on testing of mycotoxins?

Which mycotoxins should I be testing in my inbound raw materials stream?

Which testing approach, or combination of them, best serves our operation?

How often testing occur?

Do I have the right staff and know-how to perform these tests?

SOP to ensure consistent action for each potential mycotoxin risk for raw materials, processing and finished products.

Research test kit options and evaluate suitability for each facility.

Select, set up, train and routinely test where needed – may adjust based on risk factors

Establish data handling protocols, ongoing test performance review.

Prepare for relevant auditing/governance Governing bodies.
Technologies for Analysis of Mycotoxins

Lower complexity and cost
Less information

Qualitative Strip tests

Quantitative Strip tests or Immunoaffinity columns with Fluorometer

HPLC/UPLC LC-MS UPLC-MS-MS

Higher complexity and cost
More information
Rapid Detection: Field, Process & Laboratory Approaches

- **Imunoaffinity Columns with Fluorometer**
  - Wide dynamic range (0-1,000 ppb Aflatoxin)
  - AOAC & USDA-GIPSA Certified Methods

- **Qualitative Strip Tests**
  - Quick screening
  - Simple procedure
  - Yes/No visual indication

- **Quantitative Lateral Flow Strip Tests**
  - Fully Quantitative
  - USDA-GIPSA Approved Methods
  - Sustainable, simple and solvent-free extraction
  - Single Extraction for analysis of up to 5 mycotoxins
Inbound Corn Testing

- Qualitative Strip Tests
  - Yes/No Result
  - 6-7 Minutes
  - No Equipment Investment Required

- Quantitative Strip Tests
  - Aflatoxin, Fumonisin, DON, Ochratoxin, Zearalenone and T-2/HT-2
  - Water-based extraction
  - Single extraction used for all strip tests
  - Results for 6 toxins in less than 10 minutes
Optimizing For Multi-Mycotoxin Testing in Corn

One Extraction Enables up to 6 Different Toxins to be Tested

- Ideal for incoming raw materials
- Select only the toxins you are targeting
- Apply 100 μL of filtered extract to each strip
- Results for up to 6 toxins in less than 10 minutes
DDGS - Single Extraction For Multiple Mycotoxins

- One Water-Based Extraction

- Aflatoxin, Vomitoxin (DON) and Fumonisin Results

- Less Than 10 Minutes
Thank you!