Aflatoxins and Their Management

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Outline

• Aflatoxin facts
• Impact of aflatoxins in people’s lives
• Prevalence and exposure
• Aflatoxins and trade
• Aflatoxin management practices
• Promise of Biocontrol
• Summary
• Highly toxic metabolite produced by the ubiquitous *Aspergillus flavus* fungus
• The fungus infects crops and produces the toxin in the field and in stores
• Fungus carried from field to store
• Contamination possible without visible signs of the fungus

• Some predisposing factors:
  – pre-harvest high temp and drought stress
  – wet conditions at harvest and post-harvest periods
  – insect damage
Aflatoxin Contamination Occurs in Two Phases

**Phase I: Before Crop Maturity**
- Developing crops become infected.
- Associated with crop damage (insect, bird, stress).
- Favored by high temperature (night) and dry conditions.

**Phase II: After Crop Maturity**
- Aflatoxin increases in mature crop.
- Seed is vulnerable until consumed.
- Rain on the mature crop increases contamination.
- Associated with high humidity in the field & store, insect damage, and improper crop storage or transportation.
Aflatoxin Problem Starts in the Field

64% fields above 20 ppb at harvest in northern Nigeria

Increases in stores; interventions required in field and stores
Contamination is most severe at low elevations and during dry periods. During drought the zone with contamination expands.
Aflatoxin Impacts People’s Lives

~2.3 million bags contaminated maize not ‘officially’ tradable in 2010 in Kenya
Prevalence of Aflatoxins in Food & Feed

- Several African staple commodities affected
- High human exposure in Africa – mother to baby
- Levels and frequency of occurrence high
  - >30% maize in stores with >20 ppb aflatoxin
  - ~90% stores are contaminated with Afla fungi
- Concern for food and feed processors, government and emergency food reserve agencies, school feeding
- Aflatoxins disproportionately impact the poor
- Highly toxic strains, conducive environmental conditions, traditional farming methods and improper grain drying and storage practices, unregulated markets
Aflatoxin Contamination in West Africa

**Primary products**
- Maize: 4,000 – Benin
- Peanut: 925 – Burkina
- Sorghum: 80 – Ghana
- Rice: 372 – Nigeria
- Millet: 200 – Nigeria
- Tiger nuts: 120 – Nigeria

**Food products**
- Peanut paste: 3,278 – Ghana
- Peanut sauce: 943 – Ghana
- Leaf sauce: 775 – Gambia
- Maize dough: 313 – Ghana
- Kenkey: 524 – Ghana
- Cashew paste: 366 – Ghana
- Peanut oil: 500 – Nigeria
- Yam flour: 7,600 – Nigeria
- Local beer: 135 – Nigeria
- Infant food: 19* – Burkina

MTL = 10 - 20 ng/g
Aflatoxin Exposure in Africa, Europe & USA

The graph shows the number of individuals (% of the total number of individuals) exposed to aflatoxin-albumin adducts (pg AFB1-lysine eq./mg albumin) in different regions:

- **Gambia**: 950 individuals, with the majority falling in the 26-100 range.
- **Benin**: 479 individuals, with a higher percentage in the <5 range.
- **USA**: 48 individuals, with a mix across different ranges.
- **Europe**: 74 individuals, with a significant portion in the >100 range.

The vertical axis represents the number of individuals (%) exposed to aflatoxin-albumin adducts.
Aflatoxin and Poultry (Broilers)

Aflatoxin levels in feeds in Nigeria

<table>
<thead>
<tr>
<th>Aflatoxin level (ppb)</th>
<th>Samples (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20 (safe)</td>
<td>38</td>
</tr>
<tr>
<td>&gt;20 to 100 (up to 5x)</td>
<td>14</td>
</tr>
<tr>
<td>&gt;100 to 500 (up to 25x)</td>
<td>41</td>
</tr>
<tr>
<td>&gt;500 to 1,000 (up to 100x)</td>
<td>7</td>
</tr>
</tbody>
</table>

- 500 ppb AF diet
- AF-free diet

~40% reduction in live weight (8 weeks)
Trade Losses due to Aflatoxins

- Export compliance with food safety and quality standards.
- Total losses: $1.2 billion
- World Bank estimate of unrealized trade
  - 2005 study: ~ Tens of millions of $
- Reasonable estimate: US$ 450 million
- Some countries active to meet standards by putting in place relevant institutions
- Best quality exported; poorer quality consumed domestically.
Meeting Aflatoxin Standards Benefits Exporting Nations

- Nigeria and Senegal major groundnut exporters in 1960s, but completely lost the export market since 1980s.
- **Senegal**: US$ 4.1 million added capital investment and 15% recurring cost would attract 30% price differential to oil cake.
- Export would increase from 25K tons to 210K tons.
- Increased export volume and price differential would annually add $281 million value to groundnut export for the capital investment.
- For confectionary groundnut, adherence to Good Management Practices would increase export value by US$ 45 million annually.
- **Malawi**: Fair Trade groundnut export improved with better aflatoxin testing protocol.

*Source: World Bank; Mbaye (2004)*
Agriculture & Medical Prevention of Aflatoxin-related Food Security and Health Effects

(Adapted from Wild and Hall, Mutation Res., 2000)

Aflatoxin Intervention

Medical

Awareness

Regulation

Agriculture

Early diagnosis

Surveillance

Provision of safe food

Enterosorption
  e.g. Novasil clay

Pre-harvest
  Crop resistance to fungal infection or aflatoxin biosynthesis
  Biocontrol e.g. nonaflatoxigenic strains
  Reduce crop stress - irrigation, Insecticides, fungicides

Post-harvest
  Improved drying, sorting, insect control and storage
  Detoxification, e.g., ammoniation
  Alternative uses
Agriculture Based Prevention of Aflatoxin-related Food Security and Health Effects

- **Pre-harvest**
  - Resistant cultivars, if available
  - Biological control, e.g., aflatan
  - Irrigation and water conservation practices
  - Lime and FYM application

- **Post-harvest**
  - Sorting
  - Insect control
  - Improved drying and storage
  - Detoxification, e.g., ammoniation
  - Alternative uses including blending
Contaminated Crops have Uses and Can be Valuable

Markets are needed to provide value to crops unsafe for human consumption

<table>
<thead>
<tr>
<th>US FDA Action Level</th>
<th>Permitted Use (Examples)</th>
</tr>
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<tbody>
<tr>
<td>500 ppb</td>
<td>Middleman (Blender)</td>
</tr>
<tr>
<td>300 ppb</td>
<td>Finishing Beef</td>
</tr>
<tr>
<td>200 ppb</td>
<td>Finishing Swine</td>
</tr>
<tr>
<td>100 ppb</td>
<td>Breeding beef and swine; mature poultry</td>
</tr>
<tr>
<td>20 ppb</td>
<td>Human Food, Feed</td>
</tr>
<tr>
<td>0.5 ppb (M₁)</td>
<td>Milk</td>
</tr>
</tbody>
</table>
Ammoniation is highly effective in eliminating aflatoxin.
Trade Based Prevention of Aflatoxin-related Food Security and Health Effects

- **Awareness campaigns** to increase demand for aflatoxin safe products and incentivize adoption of aflatoxin control strategies along the value chain
- Upgrade **food control system**
- Enhanced **laboratory capacity** and availability of rapid test kits, trained users, documentation of results and withdrawal of contaminated products
- Improved trader **compliance** with national regulatory codes
- Create a **commodity exchange** system such as warehouse receipts
- Improve **enforcement mechanisms** for domestic, import and export trades
Awareness and Training
Branding for Aflatoxin Testing as a Case for Self-Regulation
In nature, some strains produce a lot (toxigenic), and others no aflatoxin (atoxigenic)

- Atoxigenic strains identified from nature, introduced in a carrier, and applied in fields to exclude toxigenic strains
- Shift strain profile from toxigenic to atoxigenic
- Thus, aflatoxin contamination reduced
- Strains move from field to stores
- Multiple year carry-over effect

**We identify and promote only native beneficial strains**

![Natural Biocontrol Incidence (%)](image-url)
Product: Aflasafe

Mixture of 4 native atoxigenic strains

Nigeria
Farmers treating maize and groundnut fields with AflaSafe

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<thead>
<tr>
<th></th>
<th>Harvest</th>
<th>Storage</th>
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<tbody>
<tr>
<td><strong>2009</strong></td>
<td>80%</td>
<td>90%</td>
</tr>
<tr>
<td><strong>2010</strong></td>
<td>89%</td>
<td>96%</td>
</tr>
</tbody>
</table>

71% and 52% carry-over of inoculum 1 & 2 years after application

Aflatoxin reduction of peanut at harvest:

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<thead>
<tr>
<th></th>
<th>Nigeria</th>
<th>Senegal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2009</strong></td>
<td>96%</td>
<td>X</td>
</tr>
<tr>
<td><strong>2010</strong></td>
<td>98%</td>
<td>87%</td>
</tr>
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</table>
Impact of Aflasafe on Trade and Health

Productivity increased of communities in aflasafe-treated areas

DALYs saved: 103,000 - 184,000

cost-effectiveness ratio: 5.1 - 24.8

Source: Felicia Wu, Pittsburgh Univ.

www.iita.org
Ownership and Advocacy by the Nigerian Government

Billboard

A commercialization strategy for distribution and adoption being piloted
Consider Aflasafe as public health intervention for aflatoxin
14 tons inoculum produced in 2011 for deployment
Innovative Product, Excellent Efficacy...... SCALING!

Manufacturing facility in Africa is the missing piece for SCALING
• **G20: Aflasafe incentivization selected for implementation in Nigeria**

• Aflasafe will be used by smallholder farmers in 200,000 ha
National Products

Products ready for registration
Products under testing in farmers’ fields
Strain development in progress

Regional Products

Aflasafe-Nigeria™
Aflasafe-Senegal™
Aflasafe-Kenya™ etc…

Aflasafe-West™
Aflasafe-East™
Aflasafe-South™

Senegal
Mali
Nigeria
Burkina
Ghana
Kenya
Tanzania
Zambia
Mozambique
Aflatoxins in food and feed pervasive in Africa

Increased awareness + good management + effective regulations + strong institutions = low human health & high market impacts

Low awareness + low management + inadequate regulations = high human health & low market impacts

Aflatoxin is a public health issue in Africa

Technologies available but must be implemented to reduce aflatoxin burden in African economies and food system

Support needed to coordinate and galvanize partnerships