CAST
COUNCIL FOR AGRICULTURAL SCIENCE AND TECHNOLOGY

INTERPRETIVE SUMMARY

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MYCOTOXINS: RISKS IN PLANT, ANIMAL, AND HUMAN SYSTEMS

INTRODUCTION

Modern mycotoxicology began with the discovery of the aflatoxins in the early 1960s. Disease due to ergot alkaloids (ergotism), however, has been known since the Middle Ages. Presently, toxic metabolites of fungi are considered to number in the thousands. Mycotoxins are of concern for human and animal diseases. And the plant pathogenic nature of many of the mycotoxin-producing fungi cause food-safety concerns and impact grain trade and marketing of food and feed.

MAJOR CLASSES OF MYCOTOXINS

The major classes of mycotoxins include the aflatoxins, trichothecenes, fumonisins, zearalenone, ochratoxin A, and the ergot alkaloids. Toxins from the genus *Stachybotrys* also are candidates for potential inclusion in this list of major mycotoxins because they are considered by many to be involved in indoor air-quality problems throughout the world.

MAJOR MYCOTOXIN-PRODUCING FUNGI

Most mycotoxins of concern are produced by three genera of fungi, namely, *Aspergillus*, *Penicillium*, and *Fusarium*. The major mycotoxin-producing fungi are not aggressive pathogens in plants; however, mycotoxins are produced by several genera in plants during the growing season when portals of entry are provided and environmental conditions are appropriate.

MYCOTOXIN CONTROL

Control strategies are being developed around attempts to influence some of these conditions through management of agricultural practices prior to and at harvest. The occurrence of mycotoxins depends on favorable conditions being met for their production by fungi, and specific mycotoxins appear to be limited to certain environmental loci and to specific crops. Other fungi may produce their toxic products in a wide variety of crops. Regional and other geographic distributions of the fungi and their toxins also may cause differences in the crops affected.

MYCOTOXINS IN PROCESSED FOODS

Mycotoxins can be present in processed foods made from mycotoxin-contaminated commodities, and they also can pass through animals and occur in meat, eggs, and milk. Mycotoxins may exist in food products as the parent compound or they may be changed to another toxic metabolite in the animal.

MYCOTOXICOSES IN HUMANS AND ANIMALS

While mycotoxins produce diseases (mycotoxicoses) in humans, as exemplified by aflatoxin, selected trichothecenes, and ergot alkaloids, the diseases caused by them in animals are more completely understood. The outcome of most intoxications in animals is loss of production and is dependent on species susceptibility to the individual mycotoxins. Most mycotoxins have specific effects on a given system in an animal, such as aflatoxin being primarily a hepatotoxin (liver toxin); however, many mycotoxins affect several systems simultaneously. Every system of the body is known to be affected by at least one mycotoxin.

DIAGNOSIS OF MYCOTOXICOSES

Diagnosis of mycotoxicoses in animals is difficult as they may be similar to diseases with other causations. This is even more difficult in cases where more than one mycotoxin is involved because the toxins can produce additive, and sometimes synergistic, effects in animals.

ANALYTICAL TESTING FOR MYCOTOXINS

The presence of mycotoxins in commodities is presently unavoidable and, therefore, to avoid their occurrence in the food chain requires management strategies that would prevent contaminated commodities from entering food and feed processing facilities. Testing of the commodities is required to accomplish this process. This involves proper sampling, sample preparation, and analysis using a quality testing procedure, which may require processing samples in-house using test kits or sending samples to a qualified laboratory.

MYCOTOXIN CONTROL AND REGULATION

While controlling the occurrence of mycotoxins in finished products is possible, it may not be economically feasible. Therefore, regulatory bodies are continually assessing the levels of allowable exposure to humans by using a risk assessment process to establish tolerable daily intakes of selected mycotoxins. In some cases, biomarkers for certain mycotoxins are available to determine exposure in certain populations of individuals. These kinds of assessments are needed to establish problem areas for mycotoxin disease throughout the world.

Currently, worldwide regulations exist for mycotoxins but they need to be harmonized from country to country, especially for better trade negotiations. Approximately 77 countries are known to regulate mycotoxins, and the Food and Agriculture Organization (FAO) currently is updating information in this regard for a 2003 publication. Postharvest methods to decrease or eliminate mycotoxins are being studied and several approaches such as physical methods of separation and detoxification, biological and chemical inactivation, and decreasing bioavailability to host animals are being used and/or investigated.

ECONOMIC COSTS OF MYCOTOXINS

The economic costs of mycotoxins are impossible to accurately determine, but the U.S. Food and Drug Administration (FDA) has utilized a computer model to estimate the losses due to selected mycotoxins. In the United States only, the mean economic annual costs of crop losses from the mycotoxins, aflatoxins, fumonisins, and deoxynivalenol, are estimated to be $932 million. Sufficient information is not available for other mycotoxins to determine economic losses on crops, livestock, and humans.

MECHANISMS OF MYCOTOXICITY

Understanding the mechanisms of mycotoxin action on the host animals at the cellular and biochemical level is important in the overall goal to treat or inhibit the action of mycotoxins, thereby potentially controlling illnesses and deaths attributed to them. Obviously, this is a long-range

process and immediate results are not to be expected. Regardless, new information and new technologies over the last 10 years have greatly facilitated our ability to detect mycotoxins and diagnose mycotoxicoses, and to decrease the content of mycotoxins in feeds through control and management practices.

Research and Policy Needs

Listed below are areas of research and public policy that need to be addressed to provide a safer food and feed supply in the twenty-first century.

1. Public Policy

- Develop uniform standards and regulations for mycotoxin contamination.
- Support joint international cooperation (FAO/WHO/UNEP) to adopt standardized regulations.
- Develop a safe food supply for local populations.

2. Mycotoxin Detection

- Develop new technologies for mycotoxin analysis and improve detection (with specificity) of mycotoxins in prepared foods.
- Develop biomarkers for human and animal exposure to single and multiple mycotoxins.

3. Human and Animal Interactions

- Assess mycotoxins as virulence factors.
- Research the effect of mycotoxins as immunosuppressors.
- Evaluate toxicological interactions of toxins with the host.
- Examine population variation for sensitivity to mycotoxins.
- Assess interactions among mycotoxins and with drugs, diet, and nutrition.
- Assess role of fumonisins on humans and their involvement in esophageal cancer.
- Assess risks of ochratoxin exposure due to its occurrence in a variety of foods and environmental loci.

4. Plant and Fungus Interactions

- Establish a better understanding of the factors affecting mycotoxin formation in the field and in storage.
- Improve understanding of the ecology and epidemiology of mycotoxin-producing fungi.
- Develop sound agronomic-management practices to decrease mycotoxin contamination.
- Develop host-plant resistance to mycotoxin-producing fungi and to mycotoxin occurrence.
- Develop models to better forecast the potential of mycotoxin contamination.
- Research the genetic regulation and biosynthesis of mycotoxins by the producing organisms.

5. Indoor Air Quality

- Determine mycotoxins responsible for indoor air-quality problems.
- Develop sound sampling protocols for assessing fungal populations.
- Establish limits for respiratory exposure to mycotoxins.

6. Economics of Mycotoxin Contamination

- Develop accurate loss estimates for mycotoxin contamination.

7. Bioterrorism

- Assess potential for use of mycotoxins as bioterrorism agents.
- Assess mycotoxin-producing fungi as bioterrorism-agent candidates.

Mycotoxins: Risks in Plant, Animal, and Human Systems was written by a task force of 11 scientists cochaired by Dr. John L. Richard, Romer Labs, Inc., Union, Missouri, and Dr. Gary A. Payne, North Carolina State University, Raleigh. The 199-page publication, Report 139, is available for $50.00 plus $3.00 shipping from CAST. Individual, retired, and student members of CAST may request a free copy; please include $3.00 postage and handling. Linda M. Chimenti, Managing Scientific Editor. World Wide Web: http://www.cast-science.org.