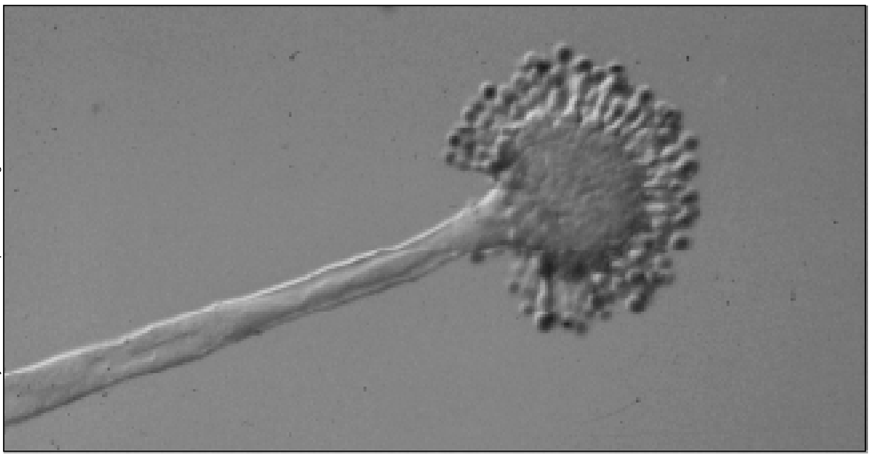
Integrated mycotoxin management systems

R. Lopez-Garcia, D.L. Park and T.D. Phillips

Rebeca Lopez-Garcia is Research Associate and Douglas L. Park is Professor of Food Toxicology and Head, Department of Food Science, Louisiana State University, Baton Rouge, Louisiana, United States. Timothy D. Phillips is Professor of Toxicology, Intercollegiate Faculty of Toxicology (Department of Veterinary Anatomy and Public Health), College of Veterinary Medicine, Texas A&M University, College Station, Texas, United States.

Mycotoxins are toxic secondary metabolites produced by certain fungi in agricultural products that are susceptible to mould infestation. Their production is unavoidable and depends on a variety of environmental factors in the field and / or during storage. Mycotoxin contamination is unavoidable and unpredictable, which makes it a unique challenge to food safety (Park and Stoloff, 1989; FAO, 1997). New mycotoxins and co-contamination of known mycotoxins are being discovered at high rates. Considerable evidence supports an association between mycotoxins and certain animal syndromes (CAST, 1989). Although definitive evidence on the cause and effect relationship of mycotoxins and human diseases is limited, this does not necessarily imply that dietary exposure does not represent a potential risk.

Unfortunately, information on toxicity, stability and



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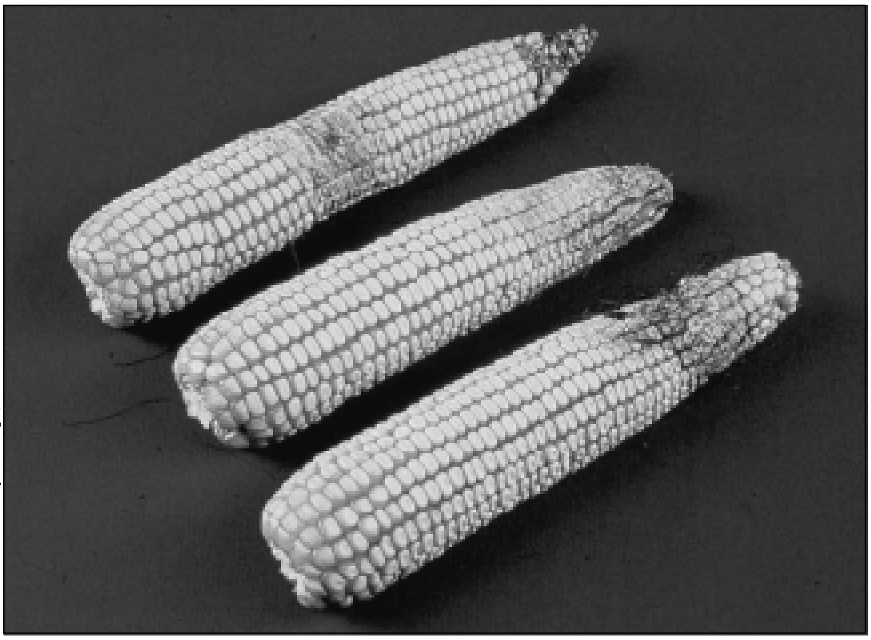
Aspergillus flavus*, primary mould responsible for aflatoxin contamination in numerous agricultural commodities, including maize, peanuts, tree nuts and cottonseed*



David M. Wilson/University of Georgia, Tifton

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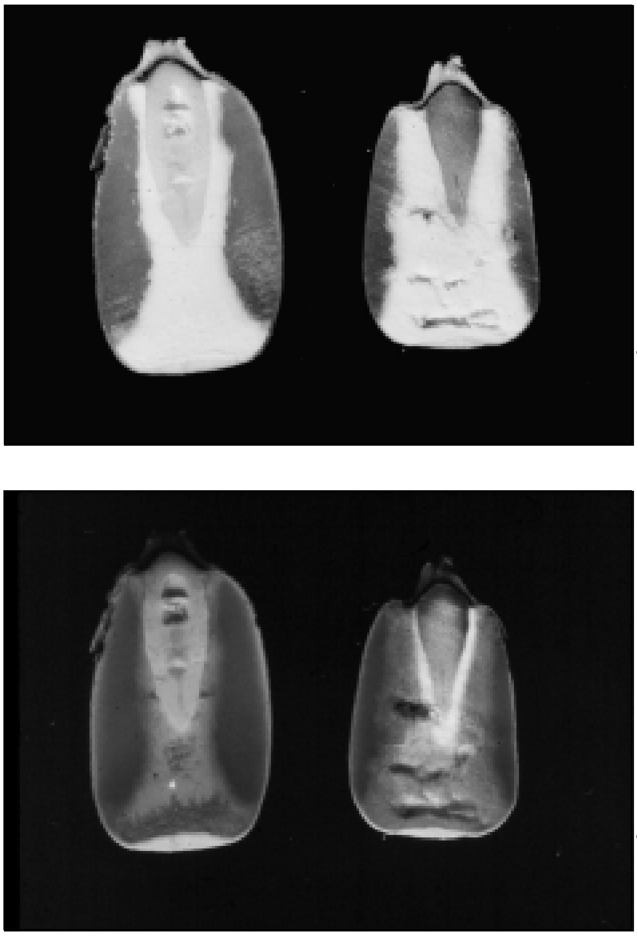
Aspergillus flavus*-contaminated maize showing the heterogenous nature of mould infestation*

extent of occurrence is limited for many of the mycotoxins that have been identified. The decision-making process for their control is, therefore, complicated (Park and Stoloff, 1989). In addition, there have been several reports on the co-contamination of various toxins, such as aflatoxin B_1 / fumonisin B_1, ochratoxin A / aflatoxin B_1, ochratoxin A / citrinin, ochratoxin A / deoxynivalenol, ochratoxin A / penicillic acid, ochratoxin A / T-2 toxin / aflatoxin / cyclopiazonic acid, aflatoxin / kojic acid, aflatoxin B_1 / deoxynivalenol, and aflatoxin B_1 / T-2 toxin (Lopez-Garcia and Park, 1998). The presence of multiple toxins in the same system is a new cause for concern, since toxicological information on the effects of simultaneous exposure is still very limited. However, in a diverse human diet, exposure will be to multiple toxins at low concentrations and intermittent rates over long periods of time. The ultimate effect of such constant exposure is still unknown. Although it is difficult to predict the effect of multiple toxins, certain *in vitro* studies can help to forecast the outcome. Recent studies have shown that simultaneous exposure to aflatoxin B_1 and fumonisin B_1 may elicit responses that are different to those arising from exposure to the toxins individually (Lopez-Garcia, 1998; Burgos-Hernandez, 1998). This effect could be caused by the combination of a multitude of factors which may include direct chemical interaction or enhancement / inhibition of different metabolic pathways. The overall response may be owing to equilibrium of several reactions. Direct chemical reaction, as well as involvement in mechanistic pathways, may participate in the interactive effects of these two toxins. Different responses were observed depending on different combination ratios. Therefore, different levels of contamination can pose different health hazards.

FOOD SAFETY PROGRAMMES

Mycotoxins cannot be considered a group of toxicants on the basis of their mechanism of action because they are very chemically diverse. For the same reason, it would be impossible to develop one single control method that would ensure the reduction of every mycotoxin present in every agricultural commodity. In addition, mycotoxin contamination is heterogeneous in nature, so sampling and analysis are complicated by the presence of “hot spots”. Considering all these factors, it can be concluded that the development of food safety programmes for mycotoxin control is not a simple issue (Park, 1993; Park and Liang, 1993).

One possible approach to management of the risks associated with mycotoxin contamination is the use of an integrated system. The proposed control programme for processed foods and feeds should be based on the Hazard



Leonard Stoloff/United States Food and Drug Administration

Leonard Stoloff/United States Food and Drug Administration

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Aflatoxin-free (upper) and contaminated (lower) maize in daylight and under ultraviolet light showing diffusion of aflatoxin to interior of kernel with no apparent mould damage

Analysis and Critical Control Point (HACCP) approach and should involve strategies for prevention, control, good manufacturing practices and quality control at all stages of production, from the field to the final consumer. Prevention through pre-harvest management is the best method for controlling mycotoxin contamination but, when contamination does occur, the hazards associated with the toxin must be managed through post-harvest procedures, if the product is to be used as human food or animal feed. Ideally, the risks associated with mycotoxin hazards should be minimized at every phase of production. Control parameters for the processing of commodities that are susceptible to mycotoxin contamination would include time of harvesting, temperature, moisture during storage and transportation, selection of agricultural products prior to processing, processing / decontamination conditions, temperature, addition of chemicals, and final product storage and transportation.

In integrated mycotoxin management, each phase of production should follow most of the steps outlined in

Box 1. The concept behind an integrated management system is similar to a "hurdle" effect, where at each phase of production, i.e. pre-harvest, harvest and post-harvest processing, the risks are minimized (Lopez-Garcia and Park, 1998).

PRE-HARVEST CONTROL

Prevention through pre-harvest control is the first step in ensuring a safe final product. While an association between mycotoxin contamination and inadequate storage conditions has long been recognized, studies have revealed that some seeds are contaminated with mycotoxins in the field. During the growing period, the seeds are exposed to environmental factors, such as weather, that are impossible to control. Once the crop becomes infected under field conditions, fungal growth will continue during post-harvest stages and storage. Thus, pre-harvest management is focused on controlling critical factors that have been shown to enhance mycotoxin production. Some of the most common strategies used for pre-harvest management are:

- *Management of insect infestation*. Although it has been reported that damage is not a prerequisite for aflatoxin formation, the incidence of *Aspergillus flavus* and *A. parasiticus* is usually higher in damaged kernels. Insect-damaged kernels are routes for infection and are likely to dry to moisture levels that are more favourable for the growth of *A. flavus* and aflatoxin production than of other fungi. Control of insect infestation may, therefore, help to prevent *A. flavus* and *A. parasiticus* proliferation and subsequent aflatoxin production.
- *Management of crop residues and crop rotation*. Inoculum potential is a prerequisite for *Aspergillus* infection and subsequent aflatoxin production. Soil type and condition, as well as availability of viable spores, have been considered important factors in aflatoxin production. When the crop is harvested, some residues remain on the field. These provide an environment that is conducive to the survival of fungal spores and the subsequent infection of the next crop. Proper management of crop residues would help avoid this problem.

  Crop rotation has also been recognized as an important factor in the spread of the inoculum. Adequate rotation may, therefore, aid the prevention of mycotoxin contamination. For example, field trials have reported that a maize-soybean rotation yielded a less extensive outbreak of *Fusarium* than did maize-maize planting operations.
- *Irrigation and soil condition*. Soil fertility and drought stress have been found to be contributing factors in pre-harvest aflatoxin contamination of maize. Moisture and temperature play the most important roles in the planning of any control strategy for fungal development. High moisture and high relative humidity are essential for spore germination and fungal proliferation. Therefore, adequate efforts should be made to avoid extreme conditions of either drought or excessive moisture. Some studies have shown that drought stress followed by high-moisture conditions is ideal for *Fusarium moniliforme* proliferation and fumonisin production. When this type of weather condition is present, it can be assumed that some degree of mycotoxin contamination will occur and other prevention / management strategies should be explored.

Development of resistant plant varieties

There has been extensive research on the development and promotion of plant varieties that are naturally resistant to fungal infection. Host resistance may present a promising

BOX 1
PHASES IN A FOOD SAFETY MANAGEMENT PROGRAMME

When developing a food safety management programme for naturally occurring toxicants, different phases such as the ones outlined below should be considered (Park and Stoloff, 1989; Park, 1993).

Setting of regulatory limits:
- commodity surveys to determine contamination levels;
- dietary intake surveys to determine consumption levels;
- evaluation of toxicological data:
- establishment of analytical capabilities;
- availability of food/feed supply based on different regulatory limits.

Establishment of a monitoring programme:
- establishment of a sampling plan:
  - sample collection;
  - preparation of test portion;
  - analysis of test portion;
- permitted uses of mycotoxin-contaminated products.

Control through good agricultural practices

Control through processing:
- good manufacturing practices;
- quality control.

Decontamination through specific treatments:[1]
- evaluation of the final product;
- designation of use of treated product.

Consumer/producer education

[1] Chemical decontamination procedures are usually applied to animal feeds only.

strategy for the pre-harvest prevention of mycotoxin contamination. Until recently, the search for naturally resistant maize genotypes had not been successful. However, during extensive field testing, maize breeding populations with aflatoxin resistance have been identified. Genetic studies of these specific populations have yielded useful information for the development of resistant lines. Studies have identified the chromosome regions associated with aflatoxin resistance. This line of research is, therefore, a good option for future pre-harvest control and prevention of mycotoxin formation.

Genetic engineering has also been useful in the development of host resistance through the addition or enhancement of antifungal genes. Many endogenous compounds with low molecular weight and biomacromolecules in kernel tissues have been identified as antifungal compounds. Enhancing the production of these compounds may also enhance resistance to mycotoxin contamination. There may be toxicity implications associated with these antifungal compounds.

HARVEST CONTROL

During harvesting, it is important to control factors such as timeliness, clean-up and drying of the agricultural product. Such control is essential for preventing mycotoxin formation during storage. Studies have shown that the timing of harvesting greatly influences mycotoxin production. In some geographical regions, the planting date should be selected to take advantage of periods of higher rainfall.

Harvesting should take place as soon as the crop is fully grown and the crop cycle is completed. Studies have reported that crops left on the field for longer periods of time may present higher levels of toxin contamination. Adequate drying is also essential to prevent fungal proliferation during storage.

POST-HARVEST CONTROL AND DECONTAMINATION

Although prevention is the best control strategy, mycotoxin contamination will still sometimes occur. Post-harvest control and decontamination procedures represent, therefore, an important tool in avoiding consumer exposure. Several decontamination strategies have been reported for various mycotoxins, and specific information on each method is readily available in the literature. Some traditional processing methods are good either for physically separating toxins or for chemically inactivating them. However, the effectiveness of each processing method should be evaluated for the specific commodity and toxin present in the system.

BOX 2

CRITERIA FOR EVALUATING MYCOTOXIN REDUCTION OR DECONTAMINATION PROCEDURES

Procedures for the evaluation and acceptance of given mycotoxin reduction or decontamination should (Jemmali, 1979; Park *et al.*, 1988; Jemmali, 1989):

- inactivate, destroy or remove the toxin;
- not produce or leave toxic residues in the food or feed;
- retain nutritive value and food/feed acceptability of the product;
- not alter significantly the technological properties of the product;
- destroy fungal spores, if possible.

COMMON POST-HARVEST STRATEGIES

Physical methods of mycotoxin removal

Once a contaminated product has reached a processing facility, clean-up and segregation are the first control options. These procedures are usually non-invasive and, except for milling, will not alter the product significantly. In some cases, these are the best methods of reducing mycotoxin presence in final products. For example, when peanuts are processed, a significant amount of aflatoxins can be removed by electronic sorting and hand-picking (Table 1) (Dickens and Whitaker, 1975; Kirksey, Cole and Dorner, 1989). Separation of mould-damaged maize (Figure 4) and / or screening can significantly reduce fumonisin and aflatoxin concentrations (Bennett, Rottinghaus and Nelson, 1992; Murphy, Rice and Ross, 1993). In addition, the removal of rot from apples significantly reduces the patulin content in the final product (Lovett, Thompson and Boutin,1975). Although some contamination may persist, physical removal represents a good alternative for industry (Lopez-Garcia,

TABLE 1
Effectiveness of post-harvest aflatoxin management strategies at the processing level[1]

Technology	Aflatoxin level (µg/kg)	Reduction (%)	Cumulative reduction (%)
Farmer's stock	217.0	-	-
Belt separator	140.0	35	35.0
Shelling plant[2]	100.0	29	54.0
Colour sorting[2]	30.0	70	86.0
Gravity table[2]	25.0	16	88.0
Blanching/colour sorting	2.2	91	99.0
Colour re-sorting[2]	1.6	27	99.3

[1] Results from the processing of a 40 000 kg segregation I lot of contaminated peanuts.
[2] Data based on medium-category peanuts only.
Source: Park and Liang, 1993.

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Mould-damaged maize in a ship's hold (typical hot spot); process of physical separation of damaged from intact kernels

Park and Gutierrez de Zubiarre, 1999; Lopez-Garcia and Park, 1998).

Milling is traditionally used for grain processing. This method will separate the grain into different fractions (Bennett and Anderson, 1978; Bennett *et al.*, 1976; Bennett and Richard, 1996; Bennett *et al.*, 1978; Seitz *et al.*, 1986; Schroeder, Boller and Hein, 1968). It is, therefore, important to identify the fractions that remain toxic so that they can be diverted to lower-risk uses or subjected to decontamination procedures (Scott, 1984; Wood, 1982).

Physical methods of decontamination

Some phases of industrial processes can reduce specific mycotoxins to a certain degree through thermal inactivation, but some mycotoxins are chemically stable and will not be completely destroyed at processing temperatures. Thus, thermal inactivation for a particular toxin should be evaluated for the temperatures of a specific process. Roasting is a good method for such commodities as peanuts and coffee. As mentioned before, if a traditional processing method is an effective decontamination procedure, it should be the first choice for management of a particular product (Lopez-Garcia and Park, 1998).

Irradiation may also be an option for mycotoxin control. A completely satisfactory way of destroying mycotoxins that have already been formed has not been identified. However, irradiation may be considered as a method to control mycotoxin-producing moulds in certain products (Lopez-Garcia and Park, 1998).

A novel approach to the prevention of aflatoxin intoxication in some animals is the dietary inclusion of aflatoxin-selective clays that tightly bind these poisons in the gastrointestinal (GI) tract, significantly decreasing their bio-availability and associated toxicities (Phillips, Clement and Park, 1994). These methods aim at preventing the deleterious effects of mycotoxins by sequestrating them to various sorbent materials in the GI tract, thereby altering their uptake and disposition to the blood and target organs. In pioneering studies, a phyllosilicate clay which was commonly used to reduce caking in animal feeds (NovaSil or hydrated sodium calcium aluminosilicate [HSCAS] clay) was reported to adsorb aflatoxin B_1 with high affinity and high capacity in aqueous solutions (including milk); reduce markedly the bio-availability of radio-labelled aflatoxins in poultry; diminish significantly the effects of aflatoxins in young animals such as rats, chicks, turkey poults, lambs and pigs; and decrease the level of aflatoxin M_1 in milk from lactating dairy cattle and goats. The effects of HSCAS clay in the diet did not alter the hyperoestrogenic effects of zearalenone (Grant, 1998; Grant and Phillips, 1998; Machen *et al.*, 1988; Lemeke, Grant and Phillips, 1998; Ramos and Hernandez, 1996).

A variety of other HSCAS binding agents are purported to adsorb aflatoxins, as well as other chemically diverse mycotoxins such as T-2 toxin, ochratoxin, deoxynivalenol, zearalenone and fumonisins. It is, therefore, possible that these agents may be non-selective in their action and pose significant hidden risks arising from their interaction with critical nutrients, etc. In addition, *in vitro* (test-tube) evidence indicated that some of these binders may provide little (if any) protection from aflatoxins or other mycotoxins.

Granulated activated carbon (GAC) has also been studied for its ability to bind aflatoxins, both *in vivo* and *in vitro*. Results from studies using GAC varied widely according to the type of activated carbon used. Activated carbon has also proved effective in reducing patulin in naturally contaminated fruit juices (Sands, McIntyre and Walton, 1976; Walton, Sands and McIntyre, 1976; Decker, 1980).

Clay and zeolitic minerals comprise a broad family of functionally diverse silico-aluminosilicates. Although, these agents have shown promising effects on the binding of mycotoxins, there may be significant risks associated with the inclusion of non-selective clays (or other adsorbents) in the diet. Aflatoxin adsorbents should be rigorously tested, with particular attention to their effectiveness and safety in aflatoxin-sensitive animals and their potential for interaction with nutrients.

Biological decontamination

Biological methods have been explored as options for mycotoxin decontamination. In the fermenting industry it has been found that aflatoxins are not degraded during fermentation; although the toxins are absent from the alcohol fraction after distillation. Aflatoxins are usually concentrated in the spent grains. When contaminated products are used for fermentation, it is therefore important to determine the end use of the contaminated by-products. It should be emphasized that biological methods demonstrating effective decontaminating properties usually depend on specific compounds produced by selected microorganisms. When a specific compound is found to be a good decontaminating agent, it is usually more efficient and economical to add the active agent directly. Studies suggest that certain fungi, including *A. parasiticus,* degrade aflatoxins, possibly through fungal peroxidases. Fermentation with yeasts has also been effective in destroying patulin and rubratoxin B (Lopez-Garcia and Park, 1998).

Chemical inactivation

Numerous studies have evaluated the use of chemicals for the inactivation and hazard reduction of selected mycotoxins. Most studies have, however, focused on aflatoxins and application to animal feeds. Ammoniation is the chemical method that has received the most research attention. Extensive evaluation of this procedure has demonstrated that it is an efficacious and safe way of decontaminating aflatoxin-contaminated feeds. More than 99 percent effective, this process has been used selectively with success in the United States, France, Senegal, the Sudan, Brazil, Mexico and South Africa, in some cases for almost 20 years. The two ammoniation processes primarily used for aflatoxin contamination in maize, peanuts, cottonseed and meals are: high pressure / high temperature(HP / HT); and atmospheric pressure / ambient temperature (AP / AT) where the HP / HT process is used for feedmill operations (Figures 5 and 6) and AP / AT is primarily for on-farm use (Figure 7). The AP / AT process is limited to dealing with aflatoxins in whole-kernel seeds / nuts. Ammoniation has been shown to be less effective against fumonisin decontamination. For aflatoxin control, however, practical applications together with research results strongly support the use of ammonia treatment. Other chemical-based procedures utilizing, for instance, monomethylamine, lime or urea / urease have been reported. In-depth reviews and articles have been published and these can be used as a basis for policy-making decisions (Lopez-Garcia, Park and Gutierrez de Zubiarre, 1999; Lopez-Garcia and Park, 1998; Park *et al.*, 1988; Park and Stoloff, 1989; Phillips, Clement and Park, 1994; Piva *et al.*, 1995).

Nixtamalization, the traditional alkaline treatment of maize used to manufacture tortillas in Latin America, partially degrades aflatoxins and fumonisin, but the residual molecules can either be regenerated by digestive processes or become more toxic (Price and Jorgensen, 1985). The addition of oxidizing agents, such as hydrogen peroxide, has been shown to be an effective aid in nixtamalization. These chemicals degrade aflatoxins and fumonisin, thereby reducing toxicity (Lopez-Garcia, 1998; Burgos-Hernandez, 1998). Some recent studies have shown that hydrogen peroxide and sodium bicarbonate are effective for simultaneous degradation / detoxification of aflatoxins and fumonisin.

Other chemical processes that have shown promise in controlling aflatoxins are the use of sodium chloride during thermal processing, sodium bisulphite at various temperatures and ozonation. Wet and dry milling processes, which are widely used for maize and cereal

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Ammonia mycotoxin decontamination plant (Walker Cottonseed, Stanfield, Arizona) using the high temperature/high pressure process

R.D. Walker/Walker Cottonseed

R.D. Walker/Walker Cottonseed

6
Mobile ammonia mycotoxin decontamination unit capable of on-site processing using the high temperature/high pressure process

7
Ambient temperature/atmospheric pressure mycotoxin decontamination process showing addition of aqueous ammonia and bagging operations

Ralph L. Price/University of Arizona, Tucson

Douglas L. Park/Louisiana State University, Baton Rouge

grains, have been shown to result in reduced mycotoxin levels (zearalenone, fumonisins, aflatoxins, trichothecenes and ochratoxin A) in several fractions such as milling solubles, gluten, fibre, starch and germ (Lopez-Garcia and Park, 1998).

Processing alters food matrices into different complex systems. It also adds new ingredients and conditions. These new factors change the environment, and innumerable new interactions may take place. Exploring the application of known food additives to the control of mycotoxins during processing may provide new opportunities for risk management by chemical methods.

CONCLUSIONS

Mycotoxins are a chemically diverse group of fungal metabolites that have a wide variety of toxic effects. In a normal varied human diet, constant exposure to low levels of several toxins is possible. Information on the potential interactions among all these compounds is still very limited. Furthermore, some mycotoxins, such as aflatoxin B_1, are known to be associated with animal and human disease. The development of practical control and management strategies is, therefore, essential to ensure consumer safety. Because of the unpredictable, heterogeneous nature of mycotoxin contamination, 100 percent destruction of all mycotoxins in all food systems is not considered a practical option. However, a practical approach would be the use of a HACCP-based "hurdle" system, in which contamination is controlled throughout production and post-production operations. An example of this is presented in Table 1 (p. 41) – the procedures referred to are used by the peanut industry in the United States in processing peanut butter for human consumption.

Integrated mycotoxin management systems should consider control points from the field to the consumer. This type of management system considers the communication between experts in pre-harvest, harvest and post-harvest control. With this approach, every phase of production would help reduce the risk, so by the time the

TABLE 2
Purpose, status and application of pre-harvest, harvest and post-harvest procedures for removing mycotoxins from human foods and animal feeds

Procedure	Mycotoxins	Commodities	Purpose/status/application
Pre-harvest			
Reduction of insect infestation	Aflatoxins, fumonisins	Maize, cottonseed	Avoid insect infestation which can serve as a vector for mould invasion to agricultural commodities; use integrated pest management control programmes
Crop rotation	*Aspergillus*, *Fusarium* toxins	Maize, soybean	Limit mould inoculum in the field
Irrigation	*Aspergillus*, *Fusarium* toxins	Maize, cottonseed, peanuts, tree nuts	Avoid drought stress during crop growth
Planting of resistant varieties	Aflatoxins	Maize	Strong potential for control of mycotoxin formation during crop growth
Harvesting operations			
Timeliness of clean-up and drying of commodities	Aflatoxins	Maize	Reduce exposure to toxigenic moulds and and moisture levels in commodities
Post-harvest procedures Physical separation of damaged, immature and mould-infested kernels, nuts, seeds, etc.	Aflatoxins, fumonisins	Maize, peanuts	Effective in reducing mycotoxin levels in final product; mycotoxins can diffuse into apparently good commodities
Thermal processing	*Aspergillus*, *Fusarium* toxins	Maize, cereal grains, coffee	However, many mycotoxins are thermally stable
Dietary mycotoxin-selective clays	Aflatoxins, *Fusarium* toxins, ochratoxin A	Maize	Strong potential and application for clays shown safe and effective; some non-selective clays may pose significant risk by binding critical nutrients, etc.
Chemical inactivation by ammoniation	Aflatoxins, fumonisins	Maize, peanuts, cottonseed and meals	Feed mill and farm applications
Chemical inactivation by ozonation	Aflatoxins	Maize	Strong potential; more research needed
Nixtamalization with addition of hydrogen peroxide and sodium bicarbonate	Aflatoxins, fumonisins	Maize	Minor modification of an industrial process; good potential practical application

final food or feed reaches the consumer the hazards associated with mycotoxin contamination have been minimized. These concepts are summarized in Table 2.

Continued research is required in these areas to provide more effective management of the risks posed by mycotoxin contamination. In the meantime, procedures that have proved effective for specific mycotoxins and / or commodities should be evaluated for other applications. ♦

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Integrated mycotoxin management systems

Naturally occurring toxicants pose a unique challenge to food safety. They are unavoidable and their occurrence is unpredictable. The destruction of contaminated products or their diversion to non-human uses is not always practical and could seriously compromise the food supply. Procedures for the prevention of mycotoxin formation in the field as well as during storage have been developed but, in spite of these efforts, contamination continues to occur. The hazards associated with toxins must, therefore, be managed through appropriate post-harvest procedures if the safety of food and feed is to be assured. One approach to the management of the risks associated with mycotoxin contamination is the use of an integrated system. The proposed control programme would entail strategies for the prevention of mycotoxin formation, the establishment of regulatory limits and monitoring programmes, and the use of processing and decontamination operations to remove, destroy or inactivate the toxins while, at the same time, preserving an adequate, safe and wholesome food supply.

Systèmes de gestion intégrée des mycotoxines

La présence naturelle de toxiques est inévitable et imprévisible, et pose un problème spécifique en matière d'innocuité des aliments. La destruction des produits contaminés ou leur affectation à des usages non humains n'est pas toujours pratique, et peut compromettre gravement les approvisionnements alimentaires. Des procédures destinées à éviter la formation de mycotoxines sur le terrain comme pendant l'entreposage ont été mises au point; toutefois, malgré tous ces efforts, la contamination continue de se produire. Il faut donc gérer les dangers liés aux toxines au moyen de mesures après récolte appropriées si l'on veut s'assurer que le produit destiné à la consommation humaine ou animale soit réellement sain. L'utilisation d'un système intégré est une approche possible de la gestion des risques associés à la contamination des mycotoxines. Le programme de lutte proposé comporte des stratégies pour la prévention de la formation des mycotoxines, l'établissement de limites réglementaires et de programmes de suivi, et le recours à des opérations de transformation et de décontamination pour retirer, détruire ou désactiver les toxines tout en préservant la qualité et l'innocuité des approvisionnements en denrées alimentaires.

Sistema integrado de gestión de micotoxinas

Las sustancias tóxicas de origen natural son inevitables y su presencia es imprevisible, y por lo tanto plantean un problema especial para la inocuidad de los alimentos. La destrucción de los productos contaminados o su utilización con fines distintos del consumo humano no siempre es posible y puede poner en grave peligro el suministro alimentario. Se han elaborado procedimientos para prevenir la formación de micotoxinas tanto en el campo como durante el almacenamiento, pero a pesar de estos esfuerzos se siguen produciendo casos de contaminación. Por consiguiente, para asegurar la inocuidad de alimentos y piensos, el peligro asociado con las toxinas debe afrontarse también mediante procedimientos aplicados después de la cosecha. Un modo para afrontar los riesgos asociados con la contaminación por micotoxinas consiste en utilizar un sistema integrado. El programa de control propuesto entrañaría estrategias para impedir la formación de micotoxinas, el establecimiento de límites reglamentarios y programas de vigilancia y la utilización de operaciones de elaboración y descontaminación para eliminar o inactivar las toxinas conservando al mismo tiempo un suministro suficiente de alimentos inocuos y sanos. ♦