Umbrella Paper

Aflatoxins and Nutrition

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What are aflatoxins?

Aflatoxins are very powerful, broad acting natural toxins produced as secondary metabolites by specific fungi (particularly *Aspergillus flavus*, *A. parasiticus* and *A. niger*). These fungi may grow in dried, or drying foods and feeds such as grains and seeds, dried fruits, dried yam and according to some authors dried cassava products but can also be found in dried meat and fish products. There are several types of aflatoxins with varying toxicity: B1, B2, G1, G2, M1 and M2. The most toxic type is aflatoxin B1. M1 and M2 are the metabolites of aflatoxin B1 and B2 and are only found in meat, milk, and milk products including human milk. Aflatoxins are among the most potent mutagenic and carcinogenic substances known (WHO and FAO 2017).

	Aflatoxins are colourless and cannot be detected under normal light. Most often, the fungus that produces them shows up as a surface mould. The fungus can be made visible under UV light (basic detection method).
	Aflatoxins are odourless and contaminated food most often does not have any special or bad smell. Sometimes grains can smell mouldy due to fungal contamination, when moisture content of the contaminated produce is still high.
	Aflatoxin are flavourless and even food that is dangerously contaminated usually does not have any off or mouldy taste. Sometimes groundnut kernels can have a bitter taste and those should be spit out.
	The only way to know if a food contains aflatoxins is by testing it in a laboratory using advanced technology (e.g VICAM, HPLC, UH-PLC, etc.) or a test kit (e.g. dipsticks, ELISA test kits).

Figure 1: Characteristics of aflatoxins (modified after aflasafe.com)

How do aflatoxigenic fungi infect plants?

Aspergillus spp. fungal spores survive in plant residues, soil, on dried plants and hay. Under hot and humid conditions, such as those found in tropical regions, spores are especially prevalent. The infection of crops and products can be facilitated by plant growth cracks, insect or bird damage, stress cracks, and in general weak plants due to a lack of nutrients and moisture. In Maize, spores travel via the corn silks to infect kernels.

Prevalence

Which are the fostering factors?

Aflatoxins are common between 40°N and 40°S. Several factors increase the risk of toxin development. Fungal growth and aflatoxin contamination are the consequence of interactions among the fungus, the host and the environment. The appropriate combination of these factors determines the infestation and colonization of the substrate, and the type and amount of aflatoxin produced. Fungal species and strains within species differ in their ability to form toxins. However, the precise factors that initiate toxin formation are not well understood. Water stress, high-temperature stress, and damage (insects, birds, and rats) of the host plant are major determining factors in mould infestation and toxin production. Similarly, specific crop growth stages, poor nutrient and soil fertility, high crop densities, and weed competition have been associated with increased mould growth and toxin production. Aflatoxin formation is also affected by associated growth of other moulds or microbes, and generally all factors that weaken a plant. Not all fungal infections necessarily lead to aflatoxins.

Which products are affected?

Commodities regularly contaminated with aflatoxins in decreasing order of risk include peanuts, maize, cottonseeds, tree nuts, sunflower seeds, spices, sorghum, millet, dried yam, rice, and wheat. Also, processed products including dried fish and meat can be contaminated with fungi at a later stage and toxins may develop. Toxins can be transmitted

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from feed to animals and via milk, meat, eggs, and fish to humans.

Effects on productivity in animal production

The susceptibility of individual animals to aflatoxins varies considerably depending on factors such as age, species, breed, sex, nutrition, and stress levels. Swine, cattle, aquatic animals, and poultry are the species, of greatest economic concern in terms of *aflatoxicosis* (severe aflatoxin poisoning). In all species, the evidence of disease is a general lack of growth and reduction in weight gains, feed efficiency, immunity, and productivity (number of offspring, number of eggs). In cattle, milk production is affected and aflatoxins in feeds can be converted into toxic metabolites in milk e.g. M_1 and M_2. The poultry industry probably suffers greater economic loss than any other livestock industry because of the greater susceptibility of poultry to aflatoxins. Dogs are also very susceptible and can become sentinel species in case of acute *aflatoxicosis* in a location.

Impacts on health and nutrition

Pathways of contamination of human beings

- **Through the frequent consumption of highly contaminated crops**: Food crops that are commonly contaminated by aflatoxins include cereals (maize, sorghum, pearl millet, rice, and wheat), oilseeds (groundnut, soybean, cottonseeds, and sunflower), spices (chillies, black pepper, coriander, turmeric, and ginger), tree nuts (almonds, pistachios, walnuts, and copra) (ICRISAT 2016). The food products maize and groundnuts are globally most affected. Therefore, an unbalanced maize-based diet may lead to high exposure to aflatoxins.
- **Through animal source foods**: Worldwide, aflatoxins are the most important contaminants of commercial animal feeds (Grace et al. 2015). The feed ingredients maize, wheat, oil cakes, and silage are frequently contaminated and major sources of aflatoxin exposure in animal feeds. Furthermore, in countries where aflatoxins are a chronic problem, the poorest quality grain or those sorted out may be used for animal feed.
- **Impact on the fetus:** Aflatoxins can affect the foetus already during pregnancy in the mother's womb through the consumption of contaminated food by the mother.
- **Postnatal**: The infant can be exposed to aflatoxins via breastmilk if the mother consumes food with high aflatoxin levels or through cumulative ingestion of contaminated food.

Levels of regulation

The permitted level of aflatoxins in food and feed by the World Health Organization is 0 ppb for children, 20 ppb for adults and 55 ppb for animals. In the EU, the intervention total aflatoxin level for cereals and oilseeds for direct consumption is set at 4 ppb, with a maximum of aflatoxin B1 at 2 ppb. In tree nuts (e.g. almonds, pistachios, hazelnuts, Brazil nuts), aflatoxin levels are limited to 10 ppb for total aflatoxins and 8 ppb for aflatoxin B1 as they are consumed in smaller quantities (EC 2006).

Short and long-term effects on health and nutrition

Roughly 5 billion people worldwide were estimated to be exposed to high levels of aflatoxins in 2010 (Brown 2018). Consumption of contaminated foods can have serious short and long-term consequences on health and nutrition.

- **Fatal effect**: High levels of aflatoxin ingestion can result in acute *aflatoxicosis*, which is often fatal. Recent evaluations about past outbreaks of *aflatoxicosis* have estimated acutely toxic and potentially lethal AFB1 doses in humans to be between 20 and 120 µg/kg body weight per day when consumed over a period of 1–3 weeks. In addition, the consumption of staple foods containing aflatoxin concentrations of 1 mg/kg or higher has also been suspected to cause acute *aflatoxicosis* (WHO and FAO 2017).
- **Liver cancer**: Consumption of aflatoxins is cumulative. Habitual consumption of contaminated food at lower levels causes liver cancer. Aflatoxins and hepatitis B and C viruses interact synergistically and substantially increase the risk of cirrhosis. Aflatoxins are estimated to cause some 90,000 cases of liver cancer each year (Jaffee et al. 2019).
- **Aflatoxin contamination and stunting**: The connection between aflatoxin exposure and stunting is until today not fully understood (Hoffmann et al. 2018). A number of mechanisms have been proposed regarding the effect of aflatoxins on growth, including immune dysfunction leading to increased risk of infections and energy loss, changes in intestinal integrity leading to poor nutrient absorption, amongst others (WHO and FAO 2017). Nevertheless, a growing number of research findings show that high levels of aflatoxin ingestion is strongly associated with stunting and immune suppression in children, although it is not yet possible to attribute causation. In addition, an increasing number of epidemiological data have become available to support the hypothesis that aflatoxin exposure in the utero and during early life has negative effects on growth. Further information on these relationships can be found in Hoffman et al. 2018 and JECFA 2018. However, uncertainty about the effect of aflatoxin on child growth remains.

Strategies and pathways to reduce *Aspergillus* spp. infection and aflatoxin levels

Aflatoxins cannot be destroyed through domestic cooking or pasteurization and are concentrated during cheese making. Most studies show the stability of aflatoxins in milk (M1) during various heat treatments and the manufacture of cultured dairy products such as kefir and yoghurt

(JEFCA 2018). However, some procedures used in the processing of products help to reduce the contamination of the resulting food product. Such processes include sorting out damaged, shriveled, discolored and small kernels or grains, proper winnowing and washing and disposing of the wash water.

Toxins can be effectively reduced through alkaline conditions or oxidizing steps, such as those used during tortilla making (nixtamalization) (De Arriola et al. 1988). Some effect has been shown when products are fermented during processing (Adelekan and Nnamah 2019, Roger et al. 2015, Hayo 2018). In literature, it has been described that fermentation reduces toxin content mainly through lactic acid bacteria. A review about detoxification methods concludes: "The efficiency of a physical, chemical and biological method to reduce aflatoxins depends, to a great extent, on the nature of the foods and its physicochemical properties, level of contamination and degree of association of aflatoxins with the food constituents. Therefore establishment of a unique detoxification method for all foods and feedstuffs is impossible. Using a combination of methods (such as heat and chemical, fermentation and steaming and so on) to reduce aflatoxins is more effective than each method alone." (Jalili 2016). The most desirable approach to control the presence of aflatoxins in feeds and foods is to prevent their formation during pre-harvest, harvest and post-harvest (Table 1). However, there are other processes that increase aflatoxin levels, e.g. the production of cotton and peanut press cake mostly for feed, and groundnut cake that is processed into sticks ('*kulikuli*') for food (Akano and Atanda 2008).

Table 1: Overview of pre- and postharvest management and control interventions in groundnuts (peanuts) and maize (corn) to reduce *Aspergillus* spp. infections and aflatoxin levels (coloured rows show especially successful and easily applicable interventions).

Phase	Explanation	Evaluation
Preharvest		
Early planting	Allows the groundnuts to mature before the end of rains to prevent moisture stress	Difficult under climate change, since need for rain
Use of agro-ecologically adapted varieties	Choosing varieties according to agroecological conditions and allowing groundnuts to mature before moisture stress	Easy - need to develop seed system
Crop rotation	Helps reduce toxigenic fungal population	Easy
Proper spacing of plants	Reduces stress factors that weaken plants, e.g. through pests and competition for nutrients and water (strengthens plants' resistance against fungal infestation)	Easy
Adequate soil nutrient supply and soil fertility management	Enhances plant vigor and consequently strengthens plants to withstand disease pressure, use of manure	Difficult – needs soil analysis
	Liming to adjust pH and provide optimal conditions for plant growth	Medium - labour
Ridging	PEANUT - Conserves soil moisture content and reduces cracking and infection with termites	Medium - labour
Pest and disease tolerant varieties	Withstand attacks by aflatoxin producing fungi (available for groundnut and maize); in addition, BT-maize may reduce the risk[1]	Easy - need to develop seed system
Proper weed management	Excessive weed growth may deplete available soil nutrients and moisture and increase risk of aflatoxin contamination	Medium - labour
Pest and Disease Management		
Fungicides	Use of fungicides can reduce population of causal organisms e.g. *Aspergillus* fungi	Medium/difficult – costly
Biological control	Non toxigenic fungi (*Aspergillus* spp. and *Trichoderma* spp.), bacteria and yeasts reduce aflatoxigenic fungi populations hence the levels of aflatoxins; a limitation has been improper timing of the application of Aflasafe®	Medium/difficult – costly development and not always effective, needs to be combined with good practices, little impact post-harvest
Protection of cobs against insect, rat and bird damage/ insecticides under heavy infestation	Preventing damage to kernels/grains that act as entry points for *Aspergillus* spp. MAIZE – Insecticides can reduce transfer of spores through insects, esp. stemborer; Another measure is the implementation of	Medium – costly

[1] BMZ Position on GMO http://www.bmz.de/en/issues/biosafety.html

	the "push-pull" system[2], for reducing ear- and cob-borers in maize	
Harvesting		
Timely harvesting	Early harvest under high aflatoxin risk conditions results in lower aflatoxin concentrations. However, under low aflatoxin risk conditions crops can be harvested later for (potentially) higher yields and better seed grades	Easy
Remove soil from pods	PEANUT - Shake the groundnut plant after lifting to remove excess soil from the pods. Soil stuck to the pods will prolong drying time	Medium - labour
Avoiding mechanical damage to pods and grains	Minimum damage of shells and grains during harvest significantly reduces mould contamination, attention to type of shelling machine – avoid those that can lead to mechanical damage of grains	Easy – highly effective
Burning crop residues	Burn mouldy cobs and those attacked by pests in the fields, crop residues can serve as sources of infection	Easy – highly effective
Post-harvest handling		
Transport	Use clean and dry containers for transporting produce from either the field to storage or from storage to markets	Medium/easy – protection against rain/humidity but also assuring good ventilation
Kernel moisture control, drying off ground	Rapidly drying groundnuts to safe moisture levels using appropriate drying technology reduces chances for mould proliferation and aflatoxin contamination, drying outside the field, using tarpaulin, drying off-ground, use of DryCard™	Medium/easy – highly effective, need for moisture meter; material for drying
Improved drying method	Drying unstripped pods on straw in windrows, ventilated drying of unstripped pods (ventilated stack) or A-frame, and drying stripped pods on clean soil surface or mats, tarpaulin	Medium/easy – highly effective, need for moisture meter; material for drying
Kernel sizing and sorting, blanching	Careful removal of mouldy kernels and blanching significantly reduces aflatoxin levels	Easy – highly effective
Shelling	Avoid sprinkling water on pods and nuts during shelling as this is one of the major conditions that encourage fungal growth	Easy – highly effective
Alternative uses of contaminated nuts/grains (blending)	Contaminated nuts and grains could be tested for residual aflatoxin levels. Knowing this, it could be exploited for animal feed and/or cooking oil production or blended with low contaminated grains and nuts to stay below limit	Medium/difficult - need to develop alternative market
Storage	Dry well-ventilated store room with adequate air circulation storage on pallets in jute bags or hermetic storage (PICS Bags) with oxygen-absorbing bags or injected carbon dioxide, periodic control of quality and moisture, aflatoxin levels usually increases during storage if conditions are good for fungal growth	Easy – highly effective, some cost which can be leveraged by higher price at sale
Cleaning of store	Store has to be cleaned of old crop residues and dust	Easy
Control of rats and insects in storage	Place rat guards and use storage insecticides if necessary	Easy/medium
Processing		
Sorting	Very efficient with manual labour, can be mechanized with UV sorters – which are difficult to install and maintain in developing countries though. Sort out small, discolored and damaged kernels/grains/nuts products.	Easy – highly effective

[2] The "push-pull" system is a strategy for controlling agricultural pests (e.g. stemborer, striga) by using repellent "push" plants within the field (e.g. *Desmodium* spp.) and attracting "pull" plants (e.g. Napier grass) outside the field.

Use of sorted grains/kernels	Sorted out grains need to be taken out of the circuit of human consumption; alternative use for feed using blending, testing and use of decontamination methods	Easy/medium – need for testing capacity
Floating and density segregation	Aflatoxin contaminated grains float in tap or natural water. Removal of bran	Easy/medium
Grain screening (based on size and broken kernels)	Small size and broken kernels usually contain several times the aflatoxin content	Easy – labour intensive, can be mechanized
Fermentation	Has been described in increasing but also reducing toxin contamination	Easy – impact not clear
Dehulling	Can be easily done with mortar and pestle, also mechanization – partially efficient in reducing aflatoxin content in bran, most aflatoxins in germ though	Easy – small amount of reduction
Degermination	Mechanization necessary- effective in taking out large amounts of aflatoxins but also reduces nutritional quality, in the case of GROUDNUTS, removal of the testa and polishing of grains	Medium/difficult – highly effective
Heating/roasting/ cooking/steaming	Reduction by 50-70% depending on aflatoxin concentration, the extent of binding between AFs and food constituents, heat penetration, moisture content, pH, ionic strength and processing conditions	Easy - medium efficient, low cost
Extrusion cooking	Especially extrusion cooking with high pressure and high moisture is useful in reducing toxins, reduces the variety of products that can be made from the flour	Highly effective - costly
Alkali cooking/ nixtamalization	Nixtamalization is a process for the preparation of maize, or other grain, in which the corn is soaked and cooked in an alkaline solution, usually limewater (but sometimes wood ash lye), washed, and then hulled	Highly effective – cultural acceptability in Africa low
Irradiation	UV and Gamma irradiation, not allowed in products for export to EU (might be permissible for spices)	Highly effective - costly
Ammoniation	Only usable for feeds	Highly effective - costly
Radio frequency (RF) and microwave (MW)	Experimental processes that are still in the stage of development for reduction of aflatoxin in products	Not known yet
Packaging	Use of packaging that is hermetic, vacuum packaging and materials that control moisture	Medium – can be costly
Marketing		
Aflatoxin analysis and monitoring	Analysis of aflatoxin levels using validated analytical methods along the above described key steps help to take corrective measures and decisions. If analysis is done and infected grains are taken out of the system this will avoid aflatoxin contamination at the processor or consumer level. However, no impact on small scale farmers that produce for their own consumption and are excluded from food safety measures in agricultural value chains	Medium/difficult – costly for maintenance of control system
Labeling of certified quality	Create label of good quality	Medium/difficult - need for quality control at several levels
Raising consumer awareness, e.g. through media campaigns (SPRING 2017)	Inform consumers on the need for consuming good quality and labeled or certified products to induce behaviour change	Medium/high impact (depending on campaign design) since personal choice, possibly high costs

How can we reduce aflatoxin contamination through good nutrition

Aflatoxins are virtually indestructible in normal food processing (boiling, frying, roasting), and the strain that contaminates milk is unaffected by normal dairy processing (pasteurisation and ultraheat treatment). Therefore, it is important to minimize the occurrence and spread of contamination along the food chain. Sorting out of poor quality products is an important method, but sorted out products need to be completely taken out of the food chain. However, to reduce aflatoxin exposure of populations, especially the most vulnerable such as women and small children, another very important approach is to reduce the frequent consumption of "high risk foods" especially maize and peanuts and to diversify household's diets. Dietary diversification has the benefit of reducing both exposure and consumption, while also directly improving nutrition. This may include:

- Integrating alternative food crops less prone to mycotoxin contamination, such as root and tuber crops: e.g. sweet potato-based recipes may lead to a reduction in the dietary intake of aflatoxins by infants and young children.
- In Africa, diets highly depend on grains. Evidence from China suggests that exposure levels and sources change when diets become less staple-based. Blending maize products with less risky cereals like rice, fonio, sorghum and millet is another option.
- Integrating more legumes such as cowpeas, beans, bambara beans, and soya beans, which are less prone to aflatoxin contamination than peanuts into the diet (Achaglinkame et al. 2017).
- Increasing consumption of fresh products like vegetables and fruits. Certain vegetables may have a protective effect; e.g. consumption of green, leafy vegetables seems to have some protective effect by impeding aflatoxin absorption. Cruciferous vegetables, onions, and garlic contain protective phytochemicals that impede the processes through which aflatoxins lead to liver cancer (Wu et al. 2014).
- Also purchasing products from countries that have a well-established food safety system such as Europe, America and some countries in Asia reduces risk.
- Consumers also need to become more aware of the health risks posed by exposure to aflatoxin-contaminated food and in return demand safe, high quality food. Such campaigns should also inform on the nutritional qualities of a more diverse and traditional African diet. Risk communication includes information about simple risk reduction measures. Food safety risks need to be addressed using a dietary rather than a commodity perspective.

Reduction of aflatoxin uptake during digestion through consumption of adsorbent compounds

Adsorption[3], a very common treatment for mycotoxin reduction, involves binding the toxin to an adsorbent compound during the digestive process in the gastrointestinal tract. The adsorption of aflatoxins requires polarity and suitable positions of functional groups. Some more common aflatoxin adsorbents include active carbon, diatomaceous earth, aluminium compounds (clay, bentonite, montmorillonite, sodium and calcium aluminum silicates mainly zeolite, phyllosilicates and hydrated sodium calcium aluminosilicate (HSCAS)), complex carbohydrates (cellulose and polysaccharides) present in cell walls of yeasts and bacteria (such as glucomannans, peptidoglycans), and synthetic polymers (such as cholestyramine, polyvinyl pyrrolidone, and its derivatives). Most often, these compounds have been used for binding aflatoxins in animals through their addition to feeds. But human trials in immune-compromised populations have also shown their efficacy if taken daily (Jolly et al. 2015). However, most adsorbents are not selective and thus also adsorb nutrients which are then washed out and can have adverse effects for nutrition.

Gender Issues

Both men and women, male and female farmers play a crucial role to reduce aflatoxin contamination in crops, foods and diets and the aflatoxin exposure of family members. Women are important risk managers and of greater vulnerability with respect to their reproductive role. There are critical exposure points in both food and feed value chains where women are critical for aflatoxin control. There are different reasons, why a gender perspective is required for effective aflatoxin control:

- It is critical to analyze and address the role of men and women in the food chains and the household for effective aflatoxin management and reduction strategies. Men and women may be targeted differently, in accordance to their specific roles and needs. E.g., additional strategies may be needed to ensure that women – who play key roles in managing risks in production of food for home consumption, post-harvest processes, preparing family meals, care of infants and feeding of livestock – are able to adopt and use improved practices for aflatoxin management from field to fork. Introduced technologies can result in a greater burden for women. It is necessary to ensure that the overall impact of improved aflatoxin control has no negative effects for women. Women often have less access to information, extension and education than men do. This implies that additional targeting is needed to reach women with information and options (Waithanji and Grace 2014). In addition, intra-

[3] *Adsorption is the adhesion of atoms to a surface. Not to be confused with absorption (uptake of atoms).*

household dynamics and decision making power of women should be taken into account when it comes to the implementation of aflatoxin control and mitigation options by women on the farm and in the household.

- Women and children are especially at risk for aflatoxin contamination since they consume lower quality foods due to cultural habits. The Gender Analysis of the Food Security Program in Togo (2016/2018) revealed that women would serve themselves smaller and less nutritious portions of the family food, mainly based on starchy staples with low or no consumption of animal protein, ultimately increasing their risk of toxin ingestion. Children would also be at higher risk to toxin contamination due to their low weight and their higher natural susceptibility to health risks.

Regional efforts, specific projects and initiatives

- The most notable regional bodies in sub-Saharan Africa regarding aflatoxin management is the Partnership for Aflatoxin Control in Africa (PACA), established under the African Union at the 7th Comprehensive Africa Agriculture Development Program (CAADP). PACA has raised awareness at regional and national levels through programs such as Pan-African workshops (bringing together scientific experts, lay people, policy makers, farmers and industries), policy briefs, and coordination of sensitization and surveillance exercises at regional and national levels. Through PACA's efforts, which are often in partnership with key organizations involved in aflatoxin management/mitigation, policies requiring the control of aflatoxins in foods is becoming mainstream. In 2014, PACA has implemented the Africa Aflatoxin Information Management System (Africa-AIMS) in pilot countries (Senegal, The Gambia, Malawi, Nigeria, Tanzania and Uganda) to collate and harmonize data on aflatoxins.
- There is generally poor awareness about aflatoxins, let alone the dissemination of appropriate control measures to monitor contamination at the field level, during storage, and in commercialization. Primary health care centers in Africa almost never relate liver cancer or other negative health effects to food consumption and aflatoxins. Knowledge in most African countries is only high in areas where outbreaks have occurred in the past and this also depends on the level of education. Severe aflatoxin poisoning (*aflatoxicosis*) is rather exceptional, but the media has reported on death resulting from and/or the presence of aflatoxins recently in Tanzania (July 2016), Ethiopia (October 2015), Kenya, Nigeria, South Africa, Ghana, and Uganda. Regulations have a very limited effect on the foods consumed on the farm or sold in informal markets, where the poorest farmers sell their products and the poorest consumers buy their products. On the contrary, a higher impact can be expected from awareness raising and intervention strategies which focus on "rediscovering" biodiversity and the nutritional qualities of a more diverse diet.

How can we measure aflatoxin contamination?

Most methods for aflatoxin determination are rather costly, and support for analyses including international accredited laboratories are rare in developing countries. Rapid test kits as described by Wolf and Schweigert (2018) are available and can be used in the field, but do not have the accuracy as high powered methods. ELISA test kits are especially suitable for analyses in the African context. However, ELISA test has very low sensitivity and could not be recommended for complex matrixes such as groundnut, cottonseeds, etc. Most analytical errors are made through poor sampling so that the sample take is not representative to the lot. The WFP sampling protocol prescribes sample size to be at least 10 kg (WFP 2010). The protocol also determines the number of bags to be sampled and the quantity of material taken for each sample. The method implies grinding the 10 kg preferably with a sampling mill e.g. Romer Mill®, mixing the flour thoroughly and then, only then, extracting the quantity needed for the analysis. It is preferable to take a homogenized sample from harvesting or handling operations. Sampling protocols must be harmonized at regional level to allow accurate data collection and collation ultimately leading to the establishment of regional science-based maximum limits for aflatoxins in the more susceptible crops on a case-by-case basis. This will contribute to access markets and facilitate trade.

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Organisations and websites

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International Crops Research Institute for the Semi-Arid Tropics (ICRISAT): Aflatoxin Timeline – ICRISAT

Videos

Managing aflatoxin in maize during drying and storage

Good Agronomic Practices Training Video (groundnuts)

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