

AFLATOXINS IN MALI: AN OVERVIEW

THE AFLACONTROL PROJECT: REDUCING THE SPREAD OF AFLATOXINS IN MALI

WHAT ARE AFLATOXINS AND WHY ARE THEY DANGEROUS?

Aflatoxin is a naturally occurring highly carcinogenic toxic substance, produced in minute quantities, that permeates groundnuts, maize, and other crops.¹ They are produced by various species of *Aspergillus* fungi, which live in the soil and are prevalent in many parts of the world, including the southern United States, eastern Europe, and many developing countries.

Agricultural produce is prone to aflatoxin contamination, particularly during crop growth periods, harvesting, threshing, and drying. Contamination can also occur when grains are in storage; this can be caused by pest infestation or poor storage conditions that lead to accelerated growth rates of *Aspergillus* fungi.

You cannot see, smell, feel, or taste aflatoxin in grains; laboratory testing is required to detect its presence. The best way to avoid aflatoxin is to avoid groundnuts suspected to be contaminated or test them before using.

Acute exposure to high levels of aflatoxins leads to aflatoxicosis, which can result in rapid death from liver failure. In 2004, during the worst known outbreak of aflatoxicosis in Kenya, 317 cases were reported and 125 people died. The minimum level of aflatoxin exposure required to cause aflatoxicosis is not known, but the disease mainly affects children.

Chronic exposure to aflatoxins affects humans and livestock in a number of ways:

- Immunodeficiency and immunosuppression
- Stunting and kwashiorkor, which interferes with the metabolism of micronutrients in children
- Liver cancer, especially in people with hepatitis B or C
- Liver disease

The Center for Disease Control has estimated that more than 4.5 billion people in developing countries are chronically exposed to aflatoxins in their diets. Unfortunately, the presence of aflatoxins in food products cannot be completely eliminated; it can, however, be controlled in order to mitigate human risk

¹Crops that are frequently affected include cereals (maize, sorghum, pearl millet, rice, wheat), oilseeds (peanut, soybean, sunflower, cotton), spices (chili peppers, black pepper, coriander, turmeric, ginger), and tree nuts (almond, pistachio, walnut, Brazil nut). Dairy milk and meat are also affected.

BOX 1: AFLATOXIN AND GROUNDNUTS IN WEST AFRICA

Groundnuts play an important role in terms of nutrition and income for the rural people of Mali, who consume on average 5-12kg of groundnuts or groundnut paste per month. Groundnuts are an important source of nutrients, particularly for children, due to their high protein, fat, and carbohydrate content, as well as their high concentration of the micronutrients calcium, potassium, phosphorus, magnesium, and vitamin E. Groundnut haulms and groundnut cake, a by-product of groundnut oil extraction, are also an important livestock feed. Furthermore, as legumes, groundnuts provide an important source of soil nutrients through nitrogen fixation.

Worldwide, approximately 25.7 million tons of groundnuts are produced annually from about 21 million hectares of cropped land. 23 percent of the world's groundnut production comes from sub-Saharan Africa, of which about 78 percent comes from Western Africa.

The European Union has banned the import of groundnuts with an aflatoxin content above 4 µg kg⁻¹. CODEX categorizes samples with over 10 µg kg⁻¹ as unfit for human consumption. Much attention has been given to aflatoxin contamination and other quality issues in groundnuts produced for export, but far less has been given to groundnuts produced for local consumption. This is a problem: It is estimated that 95 percent of groundnuts produced in West Africa is consumed by the household or traded locally.

This project note describes preliminary results from aflatoxin research conducted in western Mali by the **Aflacontrol Project**—a partnership of eight research institutions developed to evaluate the prevalence of aflatoxins along the groundnut value chain and to identify critical points where intervention strategies are likely to have the greatest impact. In Mali, this analysis is being led by ICRISAT and IER.

Since 2009, the Aflacontrol Project has been working in three areas in Mali—Kayes, Kita, and Kolokani—representing different agro-systems. This country note is primarily based on initial data collected and analyzed by ICRISAT and the Institut d'Économie Rurale (IER), in collaboration with IFPRI.

THE AFLACONTROL PROJECT

The Aflacontrol Project is facilitated by the International Food Policy Research Institute (IFPRI) and funded by the Bill & Melinda Gates Foundation. The project aims to **reduce the risk of aflatoxin in contamination of groundnuts and maize along their value chains by providing empirical evidence regarding the cost effectiveness of existing risk reduction technologies and the constraints to their adoption.**² In Mali, the project includes partners from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the University of Pittsburgh (Pennsylvania, United States), the International Maize and Wheat Improvement Center (CIMMYT), the United States Uniformed Health Services, and the Institut d’Economie Rurale (IER).

The project takes a step-by-step approach to understanding the risks of aflatoxin contamination and the constraints to known technology interventions:

1. Quantify the economic and health impacts of aflatoxin contamination in terms of cost to both the household and the national economy.
2. Measure the prevalence of aflatoxins along the length of the value chain.
3. Determine the effectiveness of different mitigation techniques at different points along the value chain.
4. Understand local knowledge, attitudes, practices, and perceptions in relation to aflatoxin contamination and the potential willingness of people to pay for different mitigation techniques.
5. Based on the results of these preceding steps, map and model the risk of aflatoxin contamination and model the cost effectiveness of different risk reduction strategies for farmers.

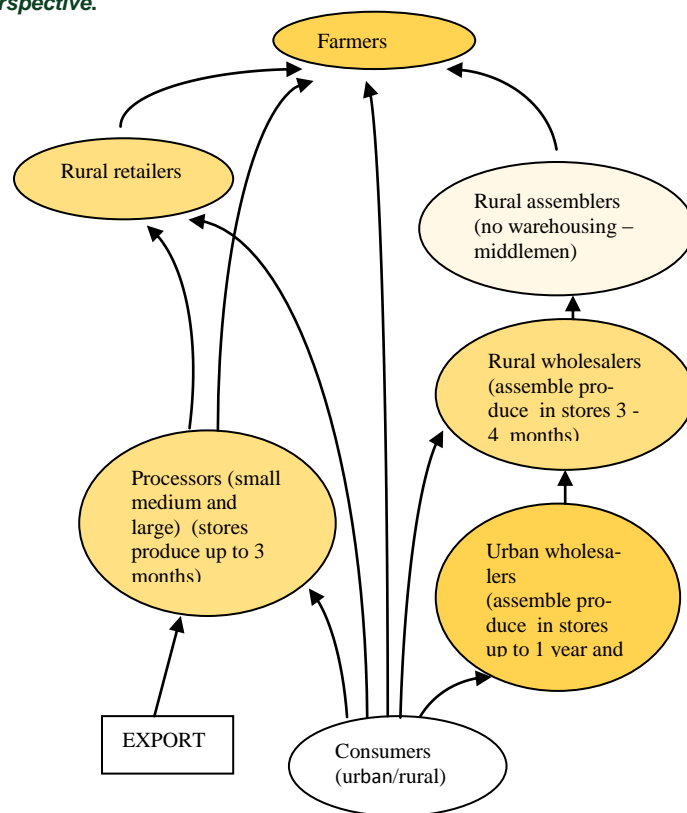
AFLATOXINS AND THE GROUNDNUT VALUE CHAIN IN MALI.

The groundnut value chain in Mali starts with the farmers who either consume their produce or sell it locally at markets to rural retailers or local “assemblers”—middlemen who collate and transport groundnuts to larger wholesalers or processors. Larger wholesalers and retailers tend to store the produce for 3–12 months depending on their size and capacity. If the quality of this storage is poor, then these facilities can act as incubators for *A. flavus* proliferation and aflatoxins production and are a key point for intervention to reduce aflatoxin contamination before products reach consumers. (Figure 1)

Processors that extract peanut oil often sell the cake by-product as livestock feed. If these groundnuts are contaminated with aflatoxin, about 70 percent of the toxin tends to concentrate in the cake, leaving low levels of toxin in the artisanal oils. Refined oil is free of aflatoxin.

Knowledge of aflatoxin and its health implications was found to be very poor among producers, traders, retailers and consumers. Furthermore, the POLICY ENVIRONMENT controlling Aflatoxin along the value chain is weak in Mali. At the national level, there are no policies or institutions that set standards and norms related to aflatoxin levels in the local or regional markets. As a result, quality insurance institutions are lacking. Because of a lack of awareness and knowledge of aflatoxin hazards, the Ministry of Commerce and Industries and the Ministry of Health supposedly responsible for setting such institutions have failed to institutionalize aflatoxin as a major health issue or a major constraint to trade. Even if norms and standards were developed and available, their enforcement would be weak. Tax and tariff regimes that could regulate the flow of good quality groundnut seed are non-existent.

Figure 1: Groundnut value chain in Mali. Darker shading indicates higher potential risks of aflatoxin contamination due to poor storage practices. The arrows show the flow of income from markets to primary producers, emphasizing a demand led perspective.



MEASURING AFLATOXIN ALONG THE VALUE CHAIN

A total of 4,923 groundnut samples were collected between December 2009 and May 2010 from farmers, traders, and retailers along the value chain in each of the three regions covered by the project, as well as from markets in Bamako. All samples were analyzed at the ICRISAT labs in Bamako using Enzyme Linked Immuno-Sorbant Assay (ELISA). (see <http://programs.ifpri.org/afla/afla.asp> for method details).

² The Aflacontrol Project is working on the groundnut value chain in Mali and the maize value chain in Kenya. This note is specific to work in Mali. A similar document has been produced for Kenya.

Prevalence of Aflatoxin at the Producer Level

Samples were taken from 270 farmers in 90 villages across the three regions at harvest (once the crop was dried in the field) and then on a monthly basis from the same farmers' granaries. A standard protocol was followed for sampling from farmer fields, using either storage structures to collect and pool samples from different areas within the farmer field or storage areas or containers to obtain a 1 kg pod sample.

Analysis of samples taken from farmers' fields and granaries revealed aflatoxin contamination at all three sites, both at harvest time and post-harvest, with an alarming proportion of samples showing contamination at levels greater than 10ppb (Table 1). There was considerable variation both within and between the sites. Of the three locations, Kolokani is more drought prone, with an average rainfall of 700 mm, which might explain the presence of higher levels of aflatoxin at this site than at either Kita or Kayes. Results presented here are preliminary.

Table 1. Prevalence of aflatoxin among farmer samples taken at harvest and from granaries post-harvest

	Mean Aflatoxins (ppb)		% samples showing Aflatoxin contamination > 10ppb	
	At harvest	After 5 months	At harvest	Max in storage
Kolokani	172	450	35	96
Kita	76	311	61	71
Kayes	35	176	46	39

Post-harvest samples taken monthly from farmers granaries from December 2009 to May 2010 showed an increase in toxin concentration of 261 percent in Kolokani, 410 percent in Kita, and 521 percent in Kayes for the 4–5 month storage period. It is clear, therefore, that pre-harvest aflatoxin management is insufficient for the maintenance of healthy value chains; post-harvest handling strategies in storage are also necessary so as to mitigate the aflatoxin problem in groundnuts.

This increase was followed by a surprising drop in Aflatoxin levels in May in the case of Kolokani, and in April in the case of Kita and Kayes (e.g. figure 2). It is hypothesized that this drop is due to the fact that fewer farmers had grain left by April and May (as indicated by a reduction in the total number of samples during April and May) and by the fact that farmers tend to hold on to their cleanest groundnuts for planting the following season as their stocks run low (moldy groundnuts do not germinate well).

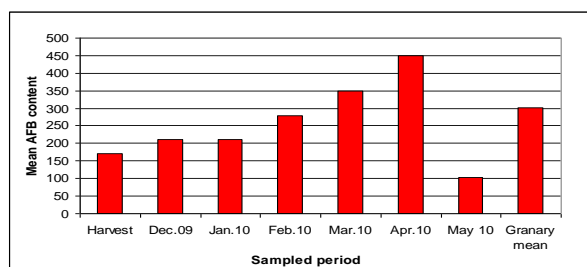


Figure 2 Monthly individual samples mean aflatoxin content (ppb) in farmer granaries of 30 villages in Kolokani Cercle

In Kolokani and Kayes, the increase in levels of contamination was matched by an increase in the proportion of samples with contamination levels greater than 10ppb (see Table 1). The data from Kolokani were particularly alarming, with the proportion of samples showing contamination >30ppb peaking at 96 percent.

Prevalence of Aflatoxin among traders, wholesalers, and retailers

100 samples of groundnut kernels were collected each month from five traders in Kolokani and Bamako. Levels of aflatoxin in 350 samples taken from five traders in Kolokani between December 2009 and May 2010 mirrored those taken from farms, with a gradual increase from a mean of 68ppb in December to a mean of approx 280ppb in April, followed by a reduction in May. In Bamako, there was no clear trend over time, with mean aflatoxin levels ranging between 80ppb–130ppb and a dip in April 2010 to 30ppb. In Bamako, groundnuts are sourced from all over the region, as well as being imported.

Moving from traders to wholesalers, 20 samples of groundnut kernels were collected monthly from two large wholesalers in Bamako & Kolokani between January and June 2010. Levels ranged from 0-1492ppb and 0-1012ppb in Kolokani and Bamako, respectively, with a spike in Kolokani in April, reflecting the spike seen in farmer stores. The same spike was not seen in Bamako; overall, the six month mean was 34 percent higher in Kolokani (113ppb) than in Bamako (74ppb).

At the processors point in the value chain, 15 samples of pastes and seed were taken from five women processors in Kolokani at monthly intervals. Aflatoxin content varied over the period, peaking in March and again in June, with levels lowest in January and in May 2010. Overall, the mean aflatoxin content in paste (309ppb) was almost 100 percent higher than in seed (161ppb)

At the marketplace, between November 2009 and June 2010, 90 samples of seed were collected monthly from small and large retailers from Bamako and Kolokani markets, while paste samples were collected from small retailers. Levels of aflatoxin in paste were consistently higher than in seeds for both small- and large-scale retailers. Levels of aflatoxin in paste again peaked in June 2010 with a mean of 601ppb. (Figure 3). This could be due to the fact that groundnut paste is prepared from poor quality or almost discarded groundnuts (after good kernels are sorted for markets), leading to high aflatoxin concentrations.

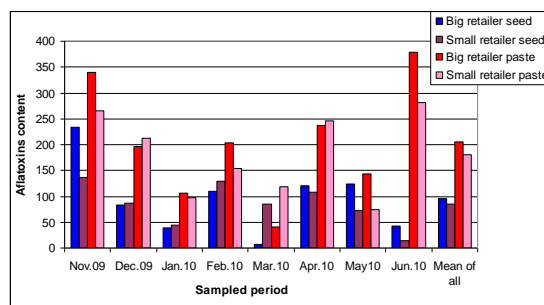


Figure 3. Monthly mean aflatoxin levels (ppb) in samples from 4 markets in Bamako

PRACTICES AND STRATEGIES TO MITIGATE AFLATOXIN CONTAMINATION ALONG THE GROUNDNUT VALUE CHAIN

Preventive practices along the length of the groundnut value chain can help to reduce the risks of Aflatoxin contamination.

Pre-harvest: *Aspergillus* fungi often infect plants that are subject to stress: late planting and harvesting, lack of crop rotation, poor plant population, inadequate irrigation, moisture stress at critical stages of plant development, unseasonal rains at harvest, and pests and diseases, can all increase susceptibility to *Aspergillus* and aflatoxin contamination. Conversely, treating soils with lime, manure, and crop residues, and engaging in other good farming practices—such as timely planting, weeding, and pest and disease control practices—reduce groundnut susceptibility to aflatoxins.

Groundnut varieties are being developed that show resistance to fungal invasion and aflatoxin production. However, the general level of resistance in the germplasm is low. Additionally, research is underway to develop pre-harvest biocontrol techniques, such as using native nontoxigenic strains of *Aspergillus* that do not produce aflatoxins and that would compete with their toxin-producing sister strains. Examples have been developed in Nigeria by the International Institute for Tropical Agriculture.

Harvest: Harvesting as soon as the groundnuts reach maturity, drying quickly, and immediately stripping the pods can reduce aflatoxin levels by 68 percent.

Drying: Traditionally, farmers lay their harvest in small heaps to dry in the sun, leaving the pods in touch with the soil and in the shade of the plants' leaves. Placing, harvested groundnuts in inverted windrows so that the bunched pods are placed in such a way that they are fully exposed to the sun, leaving the leaves next to the soil, can reduce aflatoxin contamination by 73 percent, compared with traditional methods.

Storing: To avoid aflatoxin contamination, groundnuts must be stored in conditions that prevent growth of *Aspergillus* fungi, such as cool air temperatures and low humidity. Aeration is important to increase the rate of drying and to reduce aflatoxin contamination during storage.

Traditional storage methods are a traditional granary, either a mud building with a straw roof raised on piles or bricks or a mud building with a mud roof at ground level. Occasionally, groundnuts are stored in a multipurpose room adjacent to the main

building. These granaries tend to encourage growth of *A. flavus*, since temperature, humidity, and insect damage tend to be high.

There are a number of practical recommendations for improved storage to address these problems:

- Construction of water-proofed storage facilities with large openings to improve aeration, a ceiling and floor made of a solid material, preferably with cement, and sheet metal roof.
- Use of insecticides and reinforced packing materials or sacks
- Use of a storage room adjacent to a kitchen area with an opening that funnels smoke from the kitchen fire into the granary to reduce insects and humidity.

Preserving and sorting: Ash, acetylic, or phostoxin in storage units can prevent pests. Removing potentially contaminated kernels can also reduce the likelihood of contamination.

Trading and selling: Traders often offer payment based on the percentage of mold in the bags they inspect. Traders have developed a set of criteria to assess groundnut quality, including a measure of rottenness and mold, maturity, seed size and seed color. Traders will then store groundnuts for about 3 months in storage facilities that are not treated and tend to have high levels of humidity. There is little or no quality control for storage facilities or stocks in storage.

WHAT ARE THE NEXT STEPS?

Key areas for future research, investment, and development for the reduction of aflatoxins in developing countries include:

1. Development of maize varieties and hybrids with tolerance to infection by *Aspergillus* fungi and, subsequently, to aflatoxin accumulation;
2. Increase awareness among producers and consumers about the health and economic impacts of aflatoxin contamination;
3. Create market incentives to implement aflatoxin-mitigation techniques (e.g. through a market premium for aflatoxin-free food);
4. Develop and promote cost-effective technologies to reduce contamination along the entire maize value chain;
5. Promote alternative uses for grains infected with aflatoxin (for example, in biofuels);
6. Development low-cost sampling and testing technologies and improve the intensity of testing to reduce the amount of contaminated maize entering the market place; and
7. Strengthen institutions that are responsible for food-safety regulation.

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