# GUIDELINES FOR PREVENTION OF AFLATOXIN CONTAMINATION IN GROUNDNUT AND MAIZE IN GHANA

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# Contents

# Foreword

In West Africa, groundnut and maize are important crops chiefly grown by smallholder farmers. A major constraint to increased productivity and market competitiveness is the contamination by fungal toxins also called mycotoxins. These toxins, the most common of which is aflatoxin, are produced by *Aspergillus flavus and A. parasiticus*. These fungi are free-living organisms. In sub-Saharan Africa, mycotoxin contamination is widespread in staple crops such as groundnut, maize, millets, wheat, rice, sorghum, and soybean and in processed food and feed such as milk and meat products derived from contaminated crops.

Due to its harmful effects on human and animal health, aflatoxin contamination has gained global significance in the last four decades. Consumption of aflatoxin-contaminated food products retards growth and productivity in both humans and animals. Furthermore, poor nutrition, usually attributed to food insecurity, may be exacerbated by exposure to aflatoxins, which can increase prevalence of liver-associated diseases.

The Modernizing Agriculture in Ghana (MAG) Project which is funded by the Canadian Government forms part of efforts by the Government of Ghana to reverse the declining growth of the agriculture sector over the past years. In addition, the project geared towards the modernisation of Ghana's agriculture and ensure food security for the country. It is spearheaded by the Ministry for Food and Agriculture (MoFA). The Research-Extension Farmer Linkage Committees (RELCs) are supposed to create a bridge between research, extension, farmers and agribusiness. Also they are to encourage active participation, enhance interaction and bring decision making in technology development and dissemination closer to farmers and agribusiness. The RELCs purport to disseminate improved methods and technologies on key aspects of conservation agriculture, such as appropriate seed varieties, irrigation, storage systems, land and water use and good agricultural practices, with the hope that they may serve different stakeholders to improve their resilience-building efforts. A multi-sectoral approach and solid partnerships are seen as key to the success of resilience-building work.

This manual which is an output of the RELCs planning session in Northern and Upper West Regions is designed to help address the threat posed by exposure to aflatoxins in farming communities in Ghana. The production of this material has been supported with funding by MAG Project from the Global Affairs Canada (GAC). This booklet has been developed to provide extension personnel,traders, farmers and consumers with knowledge about mycotoxins (particularly aflatoxins) and their implications on human and animal health as well as marketing of agricultural commodities. We sincerely hope that it will provide the needed technical support to help fight this deadly problem and improve the well-being of the people. 

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# List of abbreviations

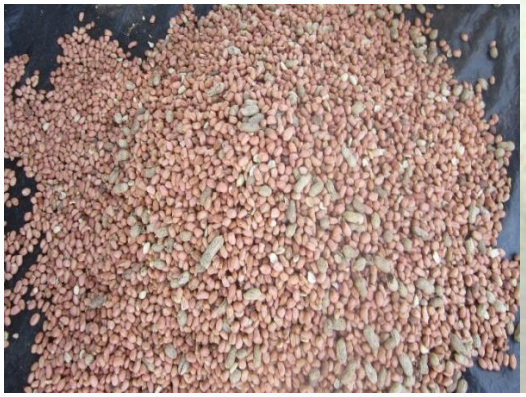
CSIR- Council for Scientific and Industrial Research
MAG – Modernizing Agriculture in Ghana
MoFA - Ministry of Food and Agriculture
NR – Northern Region
SARI – Savanna Agricultural Research Institute
UWR - Upper West Region
PPB – Parts per Billion

# 1.0. Introduction

Many fungi are free-living organisms capable of surviving in the environment (soil, air and water) and can easily find their way into crop products especially when the weather conditions are suitable. They grow over a wide range of temperature (between 10 - 40$^{o}$ C) and also thrive at high relative humidity and kernel moisture content (>8%).

## 1.1 What are aflatoxins?

The toxins produced by fungi are called mycotoxins (Myco=fungus; toxin=poison). The fungi *Aspergillus flavus* and *Aspergillus parasiticus* are the most common source of food contamination . These fungi produce a special mycotoxin called aflatoxin (From *Aspergillus flavus* toxin), which, when consumed via contaminated crops/products can cause several harmful health effects on humans and livestock. Aflatoxins contamination can occur at all stages of production – preharvest, harvest, handling and storage.



*Healthy groundnuts*

*Groundnut infected with Aspergillus flavus*

## 1.2. Food products that are commonly contaminated by aflatoxins

Food products that are commonly contaminated by aflatoxins include:

- Cereals (maize, sorghum, pearl millet, rice and wheat),
- Oilseeds (groundnut, soybean and sunflower),
- Spices (chillies, black pepper, coriander, turmeric and ginger),
- Tree nuts (almond, pistachio, walnut and coconut)
- Processed food and feed such as milk and meat products derived from contaminated feeds.

It is important to note that aflatoxin cannot be destroyed by cooking and so measures should be taken to prevent it's occurrence in food products.

### 1.3. Effects of aflatoxin

Two (2) main effects of aflatoxin contamination of food products are:

1. Health effects

- Eating food contaminated with aflatoxins can lead to aflatoxin poisoning also called *aflatoxicosis*.
- Regular consumption of low dosages for a long time (Chronic exposure) predisposes victims to liver damage, immune suppression, loss of appetite, malnutrition and stunted growth in children as well as slow recovery of malnourished children.
- Ingestion of high doses of the toxin (Acute exposure) may lead to fatal liver failure or even death.
- Aflatoxins can cause reproductive disorders such as reduced egg production, abortion, impotence and decrease milk and egg yield in poultry and livestock.
- Critical population dietary exposure to aflatoxins leads to increased cost of health care.

2. Effects on grain quality

- Losses in quality of human food and livestock feeds.
- Reduced markets for aflatoxin contaminated food products leading to financial losses.
- Reduction in grain quality leading to low pricing of produce.

#### 1.3.1. Permissible levels of aflatoxins

The permissible limit of aflatoxin in foods for human consumption is 4-30 ppb, depending on the country involved. In the United States, 20 ppb is the maximum aflatoxin residue limit allowed in food for human consumption. EU (4-15 ppb) Canada (15 ppb) and Nigeria (4-20 ppb). The Ghana Standards Board set a limit of 20 ppb of total aflatoxin contamination in groundnut kernels.

## 2.0. Aflatoxin Management in Groundnut

### 2.1. How crops get contaminated

- Aflatoxin-producing members of *Aspergillus* are common and widespread in the environment.
- Crops are particularly susceptible to infection by *Aspergillus* following prolonged exposure to high-humidity environment or damage from stressful conditions such as drought, a condition that lowers the barrier to entry.
- The fungi can enter (colonize and contaminate) at any point of the crop value chain.
- The entry or infection points for aflatoxin-producing fungi could be at any/all of the following stages:

(i) Pre-harvest entry of fungus (during plant growth).
(ii) Entry of fungus during harvest.
(iii) Postharvest entry of fungus (after harvest and during processing).

### 2.1.1. Pre-harvest contamination

Pre-harvest contamination (i.e. aflatoxin contamination that occurs in the field during crop growth) is usually influenced by farming practices that make crops susceptible to infection. These include:

- **Repeated cultivation of host plants:** Repeated cultivation of the same crop or susceptible crops species on the same piece of land supports rapid buildup of *A.flavus* populations leading eventually to pre-harvest contamination of crops in field.

- **Late planting/ harvesting:** Late planted crops will usually be affected by end-of-season drought as well as insect pest attacks, especially termites. Such insect-damaged pods create easy entry points for the fungus.
- **Drought:** Under drought stress the groundnut pods crack and facilitate entry and growth of *Aspergillus*.
- **Poor farm sanitation:** Using fields with a history of termite infestation provides an environment that supports pod damage by termites and eventual easy entry by the fungus. Weedy fields also support termite and pest damage of developing pods, increasing chances of *Aspergillus* infection.
- **Pod damage by millipedes, nematodes, disease and insects**
- **Low soil fertility: poor soils reduces the plants ability to withstand fungal infection**
- **Plant density and poor water management:** Low plant population and limited ground cover leads to soil erosion, loss of soil moisture and destruction of soil structure.. These conditions predispose the land to increase *A. flavus* buildup.

Low plant populations due to overly wide spacing

Weed compete with crops for water and soil nutrients

### 2.1.2. Contamination during harvest

The manner in which a crop is handled during harvesting will determine the extent to which it is predisposed to infection. Practices that favor fungal infection during harvesting include:

- **Poor harvesting techniques:** Groundnuts are often harvested using hand hoes that can easily damage the nuts, creating easy entry points for the fungus. Groundnuts can get infected with *Aspergillus* from the soil if they are harvested with soil adhering to the pods. Maize, when harvested and dried on bare ground, may also easily get attacked by fungi present on the ground.
- **Premature harvesting:** Immature crops have high moisture content, a condition that favors fungal infestation. Harvesting immature nuts increases opportunity for infection by fungi.
- **Delayed harvesting**
- **Mechanical damage to pods at harvest**

### 2.1.3. Post-harvest contamination

Post-harvest handling such as poor drying and storage conditions also increases aflatoxin contamination. The predisposing factors are:

- **Delayed stripping of pods after harvest**
- **Poor stripping:** Stripping groundnuts together with soil carries the fungus into storage and that provides a conducive environment for fungal infection and aflatoxin contamination.
- **Improper drying:** Drying on roofs or on bare floor exposes the grains to moisture that leads to growth of fungus.
- **Improper shelling:** Practices like sprinkling water on pods to soften the shells to make shelling easy and also to improve the weight of the nuts to get more market value lead to *Aspergillus flavus* infection and aflatoxin contamination. Another bad practice is threshing of groundnuts in a sack.
- **Poor curing techniques:** Over-drying nuts results in the cracking of the pod and seed coat, thus exposing the nuts to infection.
- **Improper sorting of pods before storage:** Poor grading especially the wounded nuts before storage is a source of contamination. Wounded, broken, shriveled and cracked kernels need to be separated from healthy kernels before storage. Sorting can reduce infection levels to acceptable standards
- **Poor storage conditions:** Storing nuts with high moisture content, exposure to rain or high humidity and poor ventilation leads to fungal growth
- **Damage of pods by pests during storage**
- **Use of airtight containers:** Using non-porous nylon bags and other airtight storage materials decreases insect pest attack and subsequently infection by fungus.
- **Poor transport**: Transporting the grains in vehicles with open roofs can expose the grain to sudden rain and moisture which leads to fungus growth.

Drying groundnut on bare floor exposes the pods to fungus growth

## 2.2. How to reduce aflatoxin contamination

Aflatoxin contamination can be reduced in the following ways:

### 2.2.1. Appropriate pre-harvest practices

These approaches target minimization of pre-harvest infection by fungi. They aim at providing crops with the best possible growth environment so as to avoid infestation by insects, drought and subsequently infection by fungi.

- **Choice of seed:** Use healthy seeds of improved varieties. Treat seeds with appropriate seed dressers before sowing
- **Land preparation**: Ensure adequate land preparation before sowing
- **Early planting**: plant early to avoid end of season drought. Maintain optimum plant population by adhering to the recommended spacing.
- **Maintaining field hygiene:** observe good farm sanitation through timely weeding to enure proper plant growth and avoidance of dry conditions that predisposes developing pods to cracking. · Remove dead and/or diseased plants promptly
- **Crop rotation:** Groundnut must be cultivated in a crop-rotation system. A groundnut crop should never be followed by another groundnut crop to avoid pest and disease build up. At best it should be rotated with cereals to improve the yield and seed quality by breaking down pest and disease cycle
- **Harvesting of water in the field:** Drought conditions while the crop is growing in the field is a prerequisite to fungal contamination and subsequent aflatoxin contamination. Farmers should avoid end-of season drought by retaining moisture through irrigation or soil moisture conservation practices such as tied ridges and mulching.
- **Soil amendments:** Application of lime to the crop supports development of strong shells (pod resistance). Strong shells provide the first line of defence against pest and fungal attack. Apply fertilizer and other soil amendments to ensure adequate plant nutrition.
- Pest and disease control: Control soil-borne pests such as insects, nematodes and millipedes. Termite control is very important to prevent damage to developing pods.

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|  Healthy groundnut plants |  Healthy groundnuts |

### 2.2.2. Harvesting practices

These are harvesting practices that reduce contamination of pods and grain by reducing and/or avoiding exposure of grain to fungi.

- **Harvest at the right stage:** Harvest as soon as the crop is matured. Harvesting at the right time will minimize the exposure of the crop to extreme heat, sudden rain or drought, which also influence infection. Pod maturity should be determined by verifying that the pod is well filled and 70% of the inside wall is dark. Premature kernels have high moisture content and support fungal infection and growth, and aflatoxin contamination. Also, premature harvesting reduces oil quantity and quality, while delayed harvesting predisposes seeds to fungal infection.
- **Avoid injuries to pods:** Care should be taken when using hand hoes to avoid injury to the pods. Proper harvesting of groundnuts ensures that the hoe is focused at the plant's rooting zone to avoid damaging pods or kernels.
- **Remove soil:** It is important to remove all the soil attached to the pods during harvesting to avoid carrying the fungus into stores and processing facilities.
- Wind-rowing: strip pods as soon as possible. The plant should be turned upside down to expose nuts if pods cannot be plucked immediately. Avoid heaping harvested produce in the field to reduce aflatoxin contamination. Ideally pods should be plucked and dried immediately after harvest.

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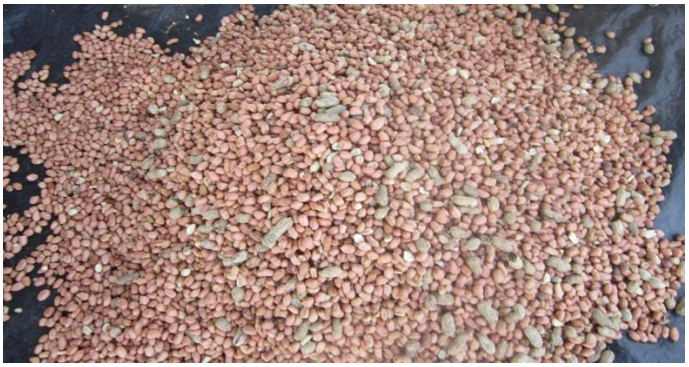
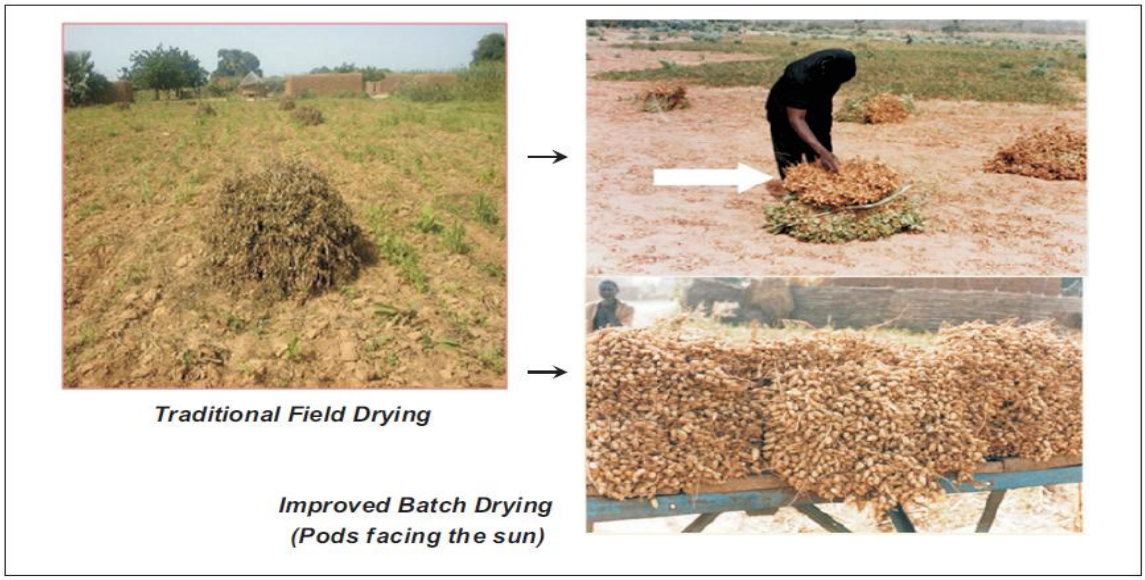
|  **Immature groundnut** |  **Shelled nuts** |
|  **Wind-rowing of harvested plants** |  **Mature groundnuts** |

### 2.2.3. Post-harvest

Postharvest handling of crops is another major point of contamination that if well managed will minimize infection by fungus and aflatoxin contamination. Post-harvest management practices may be implemented at two levels: Household and processor's levels.

**At the household level**

- **Proper drying:** Dried nuts move freely inside pods when shaken. Dry on tarpaulin, raised platforms, cemented floor or on black plastic sheet. When pods are moistened prior to shelling, dry immediately after shelling.
- **Proper shelling: use appropriate shelling method to avoid cracking of nuts which can expose it to aflatoxin contamination**
- **Grading and sorting:** Fungi readily invade kernels with cracked or damaged pods or seed coats. Reject damage pods and stained nuts. Removal of such damaged, discolored, small and shrivelled pods reduces the amounts of infected produce in the lot.
- **Proper storage:** Entry of insects and moisture into storage lots allows the entry of fungus and eventually aflatoxin contamination. Grains should be stored in a dry and secure place where the entry of insects and moisture is not possible. Store groundnuts in-shell (pods) as this minimizes levels of insect and fungal attack in storage facilities.



**Tips to minimize storage contamination**

- Store grains in cool dry conditions.
- Stack gunny bags on wooden planks to avoid dampness.
- Ensure the storage has good roofing to prevent groundnuts from getting wet if it rains.
- Ensure the storage rooms are hygienic to avoid the contamination from the previous lot.
- Using good packaging materials for storage, gunny bags are most appropriate for groundnuts. If nylon bags are used additional perforations need to be made to facilitate air circulation or store them only for a short time.
- Ensure groundnuts are not exposed to pest and rodents to minimize damage.

- Ensure good aeration in the storage room.

Gunny/jute bags stacked on pallets

- **At the processors' level**
- **Sorting before shelling:** Sort out damaged and mouldy grains/nuts after shelling/threshingSorting alone can reduce contamination and keep it within the acceptable levels.
- **Grading after shelling:** After shelling, all kernels must be sorted into various grade categories based upon size, colour and shape.
  **Note: Avoid using grade-outs:** Grade-outs usually have higher amount of toxins and should not be used for consumption and animal feed. Consuming the grade-outs with high aflatoxin content will expose humans or animals to very high levels of aflatoxin that may lead to sudden death.

## 3. Aflatoxin Prevention in Maize

Mycotoxin contamination of maize are challenges to food safety and security, especially in the tropics where maize is a staple grain. Maize, like other cereals growing above ground, gets infected with airborne fungal spores and aflatoxin contamination during plant growth (pre-harvest), during harvesting and after harvest during handling (postharvest). Improper practices during cultivation will carry the fungus to the postharvest processing and storage stage. Improper storage also leads to fungus attack and aflatoxin contamination. Like any other crop, maize can get contaminated with not only aflatoxin but also fumonisin and other mycotoxins which are harmful for humans. The aflatoxin management practices for maize is similar to that for any other crop except for a few specific practices described below:

### 3.1 How crops get contaminated

#### 3.1.1 Pre-harvest contamination

Pre-harvest contamination can occur in the growing plant due to:

- **Damage to the cobs:** Pre-harvest contamination in cereals like maize mostly occurs when there is a crack in growing cobs and damage due to pest attack.
- **Airborne spores:** Fungal infection can occur through airborne spores in the field during grain filling or during storage and handling. The fungus usually colonizes the silk and kernels when the silk is cut or the cob is damaged due to excessive drought.

#### 3.1.2 Contamination during harvest

Fungal attack occurs during harvest mostly because of drying cobs on bare ground. This allows easy pick up of the fungus from the soil to storage facilities.

#### 3.1.3 Post-harvest contamination

- **Improper drying:** Improper drying of cobs easily leads to retention of moisture. Cobs drying on the roof absorb more moisture while those drying on bare soil also encourage growth of the fungus which leads to aflatoxin contamination.
- **Damaged cobs:** Drying infected and damaged cobs with the healthy cobs can lead to spread of the fungus. Hence, grading is important to avoid contamination.

- **Improper storage:** Storage of poorly dried cobs exposes them to excessive moisture and humidity and these are preconditions that support fungal infection.

Drying maize cobs on the floor exposes the cobs to moisture

## 3.2. How to reduce aflatoxin contamination

### 3.2.1. Pre-harvest prevention

- **Pest management techniques:** Using appropriate insect management techniques will reduce formation of holes and damage to the cobs which, in turn, will reduce the entry points for the fungus.

- **Biocontrol:** This involves the use of non-aflatoxin producing fungus to reduce the population of aflatoxin producing ones. E.g. the use of Aflasafe$^{TM}$, which uses native strains of A. *flavus* that do not produce aflatoxins.
- A single application of Aflasafe two to three weeks before maize flowering can prevent aflatoxin contamination throughout, even when grains are stored (Achia 2011).

### 3.2.2. During harvest

- **Proper harvesting:** during harvesting, cobs should not be left to dry in the field on bare soil, where they can easily pick up soil borne fungus.

### 3.2.3 Postharvest management

- **Proper drying:** Harvested produce should be dried as quickly as possible to safe moisture levels of 10-13% to prevent growth of mycotoxigenic fungi and reduce insect infestation. . It is advised that cobs should be dried on polyethylene sheets laid on the ground instead of directly drying them on the ground.

- **Sanitation:** Clearing the remains of previous harvests and destroying infected crop residue reduces the spread of the fungal spores and aflatoxin contamination. Cleaning the stores before storing the new harvest also reduces aflatoxin contamination.
- **Proper storage:** Cobs should not be heaped in stores but rather packed in a clean, sealed container to avoid exposure to excessive moisture and humidity. Farmers should dry immediately after harvest to reduce risk of damage from insect pests and mycotoxins.
- **Grading after shelling:** After shelling, all kernels must be sorted into various grade categories based upon size, colour and shape. Damaged cobs should not be mixed with healthy ones to reduce spread of spores and subsequent infection

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| •  <br>*Women sorting maize. This process can reduce infection levels to acceptable standards.* |  <br>*Using machine to clean and sort seed* |

**Public awareness on aflatoxins**

- Promote pre- and post-harvest technologies that minimize aflatoxin contamination of groundnut and maize
- Information dissemination
- Awareness campaigns
- Participatory variety selection of tolerant varieties
- Participatory evaluation of cultural practices to reduce aflatoxin contamination
- Demonstration of best-bet harvest and drying techniques
- Training for technology dissemination

# Conclusion

- Producing aflatoxin-free maize, groundnuts and other grains ensures food safety.
- The health and economic well-being of a farmer is an important investment in the agricultural sector.
- Since it is difficult to identify groundnuts that are contaminated, it is important to avoid consuming groundnuts that are shriveled, broken, discolored, or show symptoms of fungal infection.
- As much as farmers grade groundnuts for the market, they also need to grade for consumption. Use of good crop production practices and postharvest handling techniques can effectively reduce fungal contamination and maintain the quality of the produce.
- Such efforts would then open up opportunities for farmers to access rewarding markets that currently have stringent quality standards.

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