

# The Implications of Aflatoxin Contamination for Local Food Safety in Senegal

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## Executive Summary

Senegal is one of the lead producers of groundnuts, also known as peanuts, in the world. Since groundnuts are a cash crop and food crop in Senegal, their production contributes significantly to food security, poverty reduction, livestock feeding, and national trade development. In response to rising global food prices in early 2008, the Government of Senegal (GOS) supported increased agriculture production, focusing specifically on the groundnut sector, through the Great Agricultural Offensive for Food and Abundance (GOANA). But groundnuts in Senegal are also highly susceptible to aflatoxin contamination; the country is one of several aflatoxin hotspots in sub-Saharan Africa. A recent study documented the distribution of aflatoxin contamination in different agro-ecological zones within Senegal and verified that the soil is a reservoir for field infections<sup>1</sup>, as are poor storage practices. Samples<sup>2</sup> collected in 1993 showed aflatoxin mean levels were well above acceptable levels for humans<sup>3</sup>.

Between 2009 and 2010 groundnut production reached 1 million tons, an increase of 41 percent when compared to the previous year production levels of 731,000 tons and nearly three times the amount produced between 2007 and 2008. In response to this surplus and trade deficits, the GOS lifted restrictions on peanut exports to the European market in order to include all varieties, with the exception of seeds<sup>4</sup>. The GOS intended for this Decree to increase the revenue of groundnut farmers, but limited capacity at the few local oil-processing companies that account for nearly all the formal sector groundnut purchases have left many farmers with no options but to sell to unofficial markets at a lower price and informally process animal feed cakes, oil, and other products within homes for consumption or sale in local markets. As a result, the groundnut production system and consumption landscape in Senegal has changed drastically. These changes have created a dietary environment where local consumers are relying more on peanuts and peanut-based products for food. This lack of dietary diversity coupled with the lack of safeguards to prevent or mitigate aflatoxin contamination within the groundnut sector has serious health implications for local populations.

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<sup>1</sup> Diedhiou et al. (2011)

<sup>2</sup> Given that data on dietary levels of aflatoxin are so difficult to collect, biological markers for exposure are used as a proxy.

<sup>3</sup> Wild et al. (1993)

<sup>4</sup> GAIN Report, 12/3/2010

Aflatoxins are a group of highly toxic and cancer causing mycotoxins that can cause immune-suppression, impaired growth<sup>5</sup> and have severely impacted food safety and quality in various countries in Africa, Asia, and South America. Major agricultural commodities most susceptible to *Aspergillus* fungus are groundnuts, maize, oilseeds, spices, cottonseed and various tree nuts. Humans and animals can be affected acutely and chronically when they ingest foods contaminated by aflatoxins. It is also possible for animals that eat contaminated feed to produce meat, eggs, and milk that are also contaminated. Crops can become contaminated with the fungus that produces aflatoxin both before and after harvest. Prior to harvest a crop can become contaminated because of stress caused by high temperatures, damage from insects, and dry conditions. Once the crop has matured the likelihood of aflatoxin contamination increases when it is exposed to rain or high humidity levels, improperly dried and stored, or transported. Regulation of the acceptable levels of aflatoxins and other mycotoxins in food to be consumed by people and animals varies from country-to-country.



Studies in Benin, Togo, and the Gambia have linked aflatoxins exposure to kwashiorkor, liver cancer and increased susceptibility to hepatitis. The most effective way to minimize aflatoxin contamination is through prevention and management. Recent interviews with farmers located in Diourbel and Nioro zones in Senegal provided insight into the local impact of aflatoxin contamination on food safety, knowledge and attitudes on the health impact of aflatoxins, groundnut drying and storage techniques, along with information on the acceptability of a pre-harvest technology called Biocontrol<sup>6</sup> that can be applied to peanut, corn, and cottonseed crops in order to prevent the growth of aflatoxin.

The following paper highlights the impact of aflatoxin contamination on food-safety within local communities in Senegal. Based on interviews and group discussions with smallholders in the Nioro and Diourbel areas in late April 2011, this paper also gives an overview of current pre-harvest and postharvest practices being used. Policy recommendations are made on how to promote better local aflatoxin management in Senegal.

## Background

Since the 1960s the agricultural community has known that *Aspergillus* fungi can produce mycotoxin or poisonous byproducts in certain crops. A few mycotoxin producing fungi are also

<sup>5</sup> Williams et al. (2004)

<sup>6</sup> Technology that uses native strains of *A. Flavus* that do not produce aflatoxins to competitively exclude aflatoxin-producing strains in the crop environment.

capable of producing specific secondary metabolites<sup>7</sup> called aflatoxins. Exposure to certain levels of aflatoxin can result in immune-system suppression, impaired growth, liver disease, and death in both humans and animals. Mycotoxin contamination occurs more frequently in tropical conditions and many environmental factors, including weather and insect infestation, can also contribute to contamination. *Aspergillus* fungi have severely impacted food quality and safety in various countries in Africa, Asia, and South America. Major agricultural commodities most susceptible to the fungus are groundnut, maize, oilseeds, spices, cottonseed and various tree nuts. These staple crops are especially susceptible to fungal invasion during the pre-harvest and postharvest stages.

Serious attention has been given in recent years to aflatoxin, a food-borne mycotoxin, because populations in many developing countries lack dietary diversity and may be chronically ingesting contaminated foods. The United Nations Food and Agricultural Organization (FAO) found that 25% of the world food crops are affected and over 4.5 billion people are at risk of chronic aflatoxin exposure. International standards for aflatoxin levels for groundnuts vary according to whether the peanut will be directly consumed by humans or further processed. Groundnuts are usually divided into two categories: oilseed groundnuts<sup>8</sup> and edible groundnuts<sup>9</sup>. Levels of aflatoxin are generally regulated according to parts per billion (ppb). US standards allow for a maximum of 20 ppb for food for human consumption on a lot-by-lot basis<sup>10</sup> and for animal feeds other than corn or cottonseed meal, while Australian and European Union (EU) standards are set at 15 ppb for nuts for direct consumption and 4 ppb for those nuts that are to be processed. The EU standards were harmonized among member states in the late 1990s following an analysis by the Joint FAO-WHO Expert Committee on Food Additives (JECFA), which assessed the safety and associated health risks of the aflatoxin levels for groundnuts intended for processing and for direct human consumption<sup>11</sup>. As a result the maximum allowable of aflatoxin B1 is set at 2 ppb for edible groundnuts, while the allowable content for groundnut cakes is 20 ppb<sup>12</sup>.

The food crops most susceptible to aflatoxins are groundnuts and maize. Consequently, populations in parts of Africa are more vulnerable to the health risks associated with acute and chronic consumption of contaminated food. Because populations in many tropical developing countries lack dietary diversity and rely heavily on the staples maize and groundnuts, these individuals are more likely to be exposed to aflatoxins on a daily basis. One of the largest and most recent occurrences of severe aflatoxin poisoning was in Kenya in 2004. Individuals from over seven districts ate locally produced maize that was contaminated with extremely high levels of aflatoxin. As a result, 125 people died and 317 people became ill. Smaller outbreaks were also reported in Kenya in 2005 and 2006<sup>13</sup>.

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<sup>7</sup> Organic compounds that are not directly involved in the normal growth, development, or reproduction of organisms. The metabolites are produced by *Aspergillus parasiticus* and include aflatoxins B1, B2, G1, and G2; those produced by *Aspergillus flavus* include aflatoxins B1 and B2 (Montesano et al. 1997).

<sup>8</sup> Used to produce oil and groundnut cake (Mbaye 2005).

<sup>9</sup> Used for human consumption (Mbaye 2005).

<sup>10</sup> Testing is carried out on several samples of groundnuts pulled from a batch (USDA-GIPSA Aflatoxin Handbook 2009).

<sup>11</sup> Otsuki et al. (2001)

<sup>12</sup> Mbaye (2005)

<sup>13</sup> Centers for Disease Control (2004)



Some amount of mycotoxin contamination in foods is unavoidable. Many developed countries such as the United States grapple with aflatoxin on a day-to-day basis, but the implementation of sanitary and phytosanitary standards, enforcement of acceptable mycotoxin levels by the Food and Drug Administration and access to diagnostic technologies prevent these crops from reaching the market and adversely affecting human and animal health. Unfortunately these mechanisms and safeguards are not in place in most developing countries.

### **Aflatoxin Contamination in West Africa**

The public health and trade implications of aflatoxin contamination are far-reaching. A few studies completed in sub-Saharan Africa (SSA) have measured molecular biomarkers for aflatoxin and found a significant percentage of people consume contaminated food on a daily basis. A cross-sectional study in Benin and Togo<sup>14</sup> found a high prevalence of aflatoxin in blood samples taken from children 9 months to 5 years old that were weaned using maize. The study also revealed that the children exposed to the highest levels of aflatoxin were those eating solid foods and no longer breastfeeding, while children that were receiving breast milk and solid foods were found to be exposed to lower levels. Another study found that high aflatoxin levels in children were also associated with growth faltering, particularly stunted growth<sup>15</sup>. Additionally, a cross-sectional study of children in the Gambia found that 93% of the children had been exposed to some level of aflatoxin<sup>16</sup>.

Liver cancer or hepatocellular carcinoma is a common disease in males in the Gambia and can be caused by chronic infection with the hepatitis B virus (HBV). Turner et al. (2000) evaluated the relationship between HBV infection and exposure to aflatoxin in West African children and found levels that reflected a daily consumption of aflatoxin exceeding 100 ppb within the study sample. The study also found that children exposed to high levels of aflatoxin were at higher risk of becoming infected with HBV<sup>17</sup>.

Many developing countries relying on international export markets find it very challenging to adhere to the stricter allowable levels of aflatoxins that set by the Codex Alimentarius<sup>18</sup> commission. These standards have been especially difficult for groundnut producers in SSA. According to the recent World Bank Discussion Paper on *Standards, Competiveness, and Africa's*

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<sup>14</sup> Gong, et al. (2002)

<sup>15</sup> Gong, et al. (2003)

<sup>16</sup> Turner et al. (2003)

<sup>17</sup> Turner et al. (2000)

<sup>18</sup> The United Nations Food and Agriculture Organization and World Health Organization have developed a set of guidelines for organically produced food as part of an overall international project known as Codex Alimentarius. In the event of an international dispute, the World Trade Organization is expected to treat the Codex Alimentarius guidelines as neutral and consensus based.

*Groundnut Exports to Europe*, SSA has experienced a decrease in exports over the decades, as the market demands have shifted from oil to edible groundnuts. This is because the production of edible peanuts requires a higher quality groundnut and is subject to stricter safety standards<sup>19</sup>.

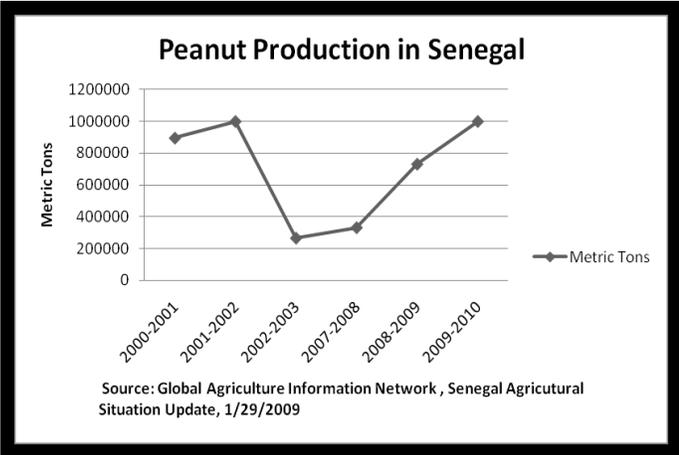
Most recently food safety has become an obstacle for farmers participating in initiatives like Purchase for Progress, which purchases food in the country where actual program operations take place. Through this World Food Programme initiative smallholders are able to access markets with the surpluses that they produce. This initiative and other types of programs such as home-grown school feeding aim to offer food produced and purchased within a country. In some cases programs have rejected maize and other food crops from local farmers because they have levels of aflatoxins that are too high for human consumption. Effective food safety and aflatoxin management techniques will need to be adopted as local and regional food procurement and school feeding becomes more widespread.

### Implications of Aflatoxin Contamination in Senegal

In addition to being a significant barrier to international trade, aflatoxin contamination is also a serious food safety problem for local communities in Senegal. Over the past several decades the once lucrative groundnut sector has been on a steady decline. In 2008 the GOANA initiative set out to increase agricultural productivity in this sector. Unfortunately this push to increase food and cash crop production did not produce the intended outcome for smallholders, and instead it has drastically changed the domestic groundnut market system and local consumption patterns. Smallholders are unable to benefit from peanut production no matter how much they produce.

### Recent Trends in Groundnut Production

As part of GOANA the GOS subsidized peanut seed and fertilizer inputs. Since the initiative began, Senegal’s farmers have had some of the largest harvests in decades. According to the Global Agricultural Information Network (GAIN) report by the USDA Foreign Agricultural Service, production increased from 331,000 tons in 2007-2008<sup>20</sup>, to 710,000 tons in 2008-2009, and recently reached 1 million tons from 2009 to 2010. On the surface it would appear that the groundnut sector in Senegal is going through revitalization; the past five years have seen an 83 percent increase in production<sup>21</sup>. In actuality there is only demand for a fraction of what is being produced (see Table 1: Senegal’s Peanut Exports by Destination). According to data collected from the Senegalese national Statistics Agency<sup>22</sup> Senegal peanut exports increased between 2006 and 2007 from 935



<sup>19</sup> Rios, L. B. D., and Jaffee, S. (2008)  
<sup>20</sup> GAIN Report, 1/29/2009  
<sup>21</sup> GAIN Report, 12/3/2010  
<sup>22</sup> GAIN Report, 2/2010

tons to 2,236 tons but were on a steady decline in 2008 and 2009, totaling 485 tons and 141 tons respectively. This shows that the majority of the groundnuts being produced in Senegal are not being processed for export. A possible explanation for the decline in peanut exports may be limited peanut processing capacity. The two local oilseed companies, SONACOS and NOVASEN, account for virtually all formal sector processing and export of groundnut cake, edible groundnut and unrefined oil, but they lack the capacity to absorb the volume of peanuts being produced. These oilseed companies can only receive small quantities at a time because of limited space and transportation capability<sup>23</sup>. This has resulted in increased storage time for peanuts, making them more susceptible to aflatoxin contamination.

Table 1: Senegal's Peanut Exports by Destination (MT), 2006-2009

DESTINATION	2006	2007	2008	2009	MARKET SHARE
UNITED KINGDOM	396	899	288	18	42%
NETHERLANDS	90	1,170	0	0	33%
MAURITANIA	228	161	100	120	16%
MOROCCO	180	0	0	0	5%
MALI	0	1	92	0	2%
ANGOLA	29	0	0	0	1%
ITALY	0	5	5	2	0%
CAPE VERDE	4	0	0	0	0%
PORTUGAL	1	0	0	0	0%
GUINEA		0	0	0	0%
FRANCE	1	0	0	0	0%
SPAIN	7	1	0	0	0%
CANADA	0	0	0	1	0%
OTHERS	0	0	0	0	0%
<b>WORLD</b>	<b>935</b>	<b>2,236</b>	<b>485</b>	<b>141</b>	<b>100%</b>

Source: Senegalese national Statistics Agency (ANSD)

An important step in groundnut production is the process of detoxification using ammonia. This process was developed in Senegal in the 1980s and ensures safer food for consumption by lowering aflatoxin levels in peanut oilcakes to 10 ppb, meeting European standards. Because ammoniation is costly and the technology is patented by SONACOs, it is not readily available for use in NOVASEN. NOVASEN sells its product as is to European feed companies that are able to detoxify the groundnuts themselves. The peanuts that are not purchased by SONACOs or NOVASEN are being sold through informal or unofficial markets for a lower price, consumed directly in the household, or processed in the household and sold in local markets<sup>24</sup>. None are detoxified.

### Food Safety Concerns in Local Communities

In late 2010 an informal survey of roasted snack peanuts, groundnut oil and groundnut feed cakes in several markets across Dakar and within the groundnut-growing region of the country, revealed aflatoxin levels ranging from 25 to 236 ppb<sup>25</sup>. A recent study looking at aflatoxin contamination of maize and sesame crops in Senegal surveyed two different agro-ecological zones in the country and found high levels of aflatoxin in maize samples from the Nioro zone located in the groundnut basin, where crops are commonly rotated between groundnuts and maize. This study found samples in Nioro



<sup>23</sup> Mbaye (2005)

<sup>24</sup> Based on interview with Dr. Lamine Senghor of the Ministry of Agriculture, DPV

<sup>25</sup> Based on interview with Dr. Papa Madiallacke Diedhiou, Universities Gaston

with extremely high levels at 852.5 ppb<sup>26</sup>. These findings are further proof that concern over the impact of aflatoxin contamination on postharvest losses, or measurable quantitative or qualitative loss in a given product, should be secondary to the public health threat of contamination in local food systems. Aflatoxin contamination should be a public health priority in Senegal because it is jeopardizing food safety within local communities.

Within Senegal aflatoxin poisoning is a largely under-diagnosed and under-reported health problem. Little is known about the prevalence of aflatoxin in the general population, but in 2001 researchers assessed peanut oil from Senegal and found that Aflatoxin B1 was found in over 85% of the samples and that the mean levels were at 40ppb<sup>27</sup>. Since exposure to aflatoxin and HBV infection are two major risk factors for liver cancer, the high incidence of liver cancer in Senegal has oftentimes been used as an indicator for chronic exposure to low levels of aflatoxin. The country has one of the highest rates of liver cancer in the world. According to 2008 statistics at the country-level a total of 713 men and 328 women were seeking treatment for cancer. Among men a reported 697 died due to liver cancer while the reported deaths for women was 330<sup>28</sup>.



Lack of actual country-level data on the epidemiology of aflatoxin exposure has hindered Health Ministry discussions on how to mitigate the health risks associated with it. In 2010 blood samples were collected for approximately 70 husband-wife pairs to determine the level of exposure to aflatoxins, but there is no recent reportable data on human aflatoxin exposure in Senegal. General data on attitudes and knowledge on the health impacts of contamination would also be useful in determining what steps should be taken in order to better inform the public of this food safety hazard.

### **Documented Decontamination and Detoxification Strategies**

Insufficient drying, pests, contamination of soil with toxic *Aspergillus* fungus strains, and poor storage conditions are environmental factors that contribute to the growth of the toxic mold on grains. There are several methods used to prevent contamination and reduce levels in food crops. Within developing countries where resources are severely limited, traditional techniques have more practical use. These practices should focus on controlling the moisture content, temperature, and the amount of time that grains spend in storage. Informal focus group discussions with over 30 smallholders in Niore and Diourbel and interviews of researchers, government, and civilian staff conducted between April 30 and May 5, 2011, revealed three methods that are currently being used to reduce contamination were documented. These strategies include biological control, drying, and storage practices.

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<sup>26</sup> Diedhiou et al. (2011)

<sup>27</sup> Deriba and Ashenafi (2001)

<sup>28</sup> International Agency for Research on Cancer

### **Pre-Harvest Technique in Diourbel and Nioro: Biological Control Pilot**

In 2010 a nine-month field study was initiated to introduce a biological control technique to groundnut farmers in the groundnut basin region. The project was implemented in order to evaluate the effectiveness of a pre-harvest technique that has been used commercially in the U.S. and Nigeria. In order to implement this study native non-toxic or atoxigenic strains of *Aspergillus* were identified and processed into a product that was applied to crops. The International Institute of Tropical Agriculture (IITA) provided the resources for the identification of the native strains and USDA/ARS contributed molecular tools necessary to make the final product that was applied to the fields of thirty-eight farmers. Dr. Lamine Senghor of the Ministry of Agriculture, DPV (Direction de la Protection des Vegetaux) and Dr. Papa Madiallacke Diedhiou supervised this trial.

The initial samples were analyzed in October 2010 and the percentage reduction in aflatoxin contamination among farmers is promising though the official results have not yet been released



because this trial is still ongoing.<sup>29</sup> Earlier field studies carried out in Nigeria using the biological control product *Alfasafe* showed an 80-90 percent reduction in aflatoxin contamination of maize and groundnut. In order to gauge the acceptability of this technique among farmers, the research team asked them *why they decided to participate in the biological control pilot*, the responses included the following:

**Farmer #1** shared that he was using the biological control because he's a peanut farmer, he is dependent on

peanuts, and he believes that it will help with the aflatoxins.

**Farmer #2** said that he was familiar with the past work of the DPV and he was confident that this technique would work.

**Farmer #3** said that the technicians came to their village to assist them because the village does not know what to do with the aflatoxins.

In order to get a better understanding of the basic attitudes and knowledge on the health impacts of aflatoxins among the farmers, the farmers were also asked *when they first heard or learned about aflatoxins*. The responses provided a great deal of insight and included the following:

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<sup>29</sup> Unfortunately the Senegal pilot recently lost funding so activities are on hold until other resources can be located.

**Farmer #1** said that he learned about the health impacts of aflatoxin poisoning through the radio and in the past doctors explained that there is poison in the peanuts.

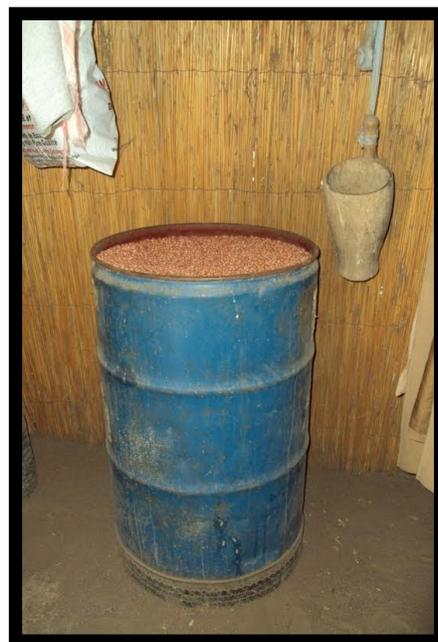
**Farmer #2** was not aware of the health impact of aflatoxins; he just knew that there was a problem with peanuts and locally pressed oil and that if you eat a peanut and it tastes bitter it has aflatoxin in it.

**Farmer #3** learned about it under the Senghor government (1960-1980) because he worked as a technician for the local peanut oil company and had to wear a mask during the ammoniation process/extraction that they used.

**Farmer #4** has always known about it and recalled that in the past farmers separated their peanuts (the bad from the good) for sale to the processing company, but today the farmers are selling their peanuts to operators who are not manually separating them and this is how aflatoxin is getting into the local markets.

### **Postharvest Techniques in Diourbel and Nioro: Drying and Storage**

In Nioro many of the farmers participating in the biological control pilot were also members of an agricultural cooperative called ASPRODEB<sup>30</sup>. Through the cooperative the farmers have been receiving training in low-technology postharvest techniques yearly since 2007. When asked *what process they used for harvesting and sorting* the smallholders did not talk in detail about manually sorting groundnuts, but instead focused primarily on the drying practices they used and how they stored their seeds and grains. The farmers shared that in the past they manually harvested the groundnuts by shaking the dirt off the pods. The next day the women would come along and gather these into small piles and let them dry for 10 days. Afterwards the small piles would be combined into a larger pile that was dried for a minimum of 20 days. Today, however, the farmers use plows and other machines to help with the harvests, and the women work alongside them shaking the soil off the pods and gathering them into small piles. After 10 days they are combined into a larger pile in order for the groundnuts to fully dry for 20 days, but leaving the piles out to dry for 20 days has become an issue recently because some farmers want to rush and collect the harvest before 20 days have passed so that they can get them to the market faster<sup>31</sup>.



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<sup>30</sup> Senegalese producer's organization that is involved in the "Edible Groundnut Program" where price incentives are given for high-quality groundnuts, along with access to credit. Technical support is also provided to the small farmers who participate in the program. Good agricultural practice and traceability manuals have been produced (Rios and Jaffee 2008).

<sup>31</sup> Based on focus group discussions with farmers in Diourbel and Nioro.

Storage is another important factor in reducing of groundnut exposure to aflatoxin and is where most of the contamination occurs. When asked *where* they stored their groundnuts, there was no uniform answer from the farmers and responses seemed to rely entirely on what resources each individual farmer had readily available. Some of types of storage that were listed included empty rooms, outside bins, and small storage room within houses. A few farmers were able to treat their stored bags with insecticides. Typically they stored their groundnuts for 1 to 3 months.

## **Policy Recommendations**

The Government of Senegal should implement the following:

### **Collect Baseline Levels of Exposure for Health Impact and Burden of Disease Studies**

The agriculture sector in Senegal has long acknowledged the impact of aflatoxin contamination on postharvest loss and exports, but the health and food technology sectors have been slow to respond to the health problems that are usually associated with acute or chronic exposure to aflatoxin in food. Involvement of the health sector in this matter is essential for surveillance and diagnostic purposes. Food safety measures and standards that are followed for international markets should also be followed for food consumed domestically. Several studies have been completed in the West African region on the far-reaching impact of mycotoxins rates on liver cancer, stunting, and susceptibility to several infectious diseases, but epidemiological data on population levels of aflatoxin are still needed for Senegal.

### **Engage with the Partnership for Aflatoxin Control in Africa (PACA)**

A series of meetings and stakeholder interviews were held in late 2010 and early 2011 in order to work toward the creation of an African-led partnership for the development of a comprehensive strategy to control aflatoxin contamination. The goals of PACA are to reduce the incidence of aflatoxin in food, improve public health, increase trade, augment smallholder income, and enhance food security in Africa. The aim is for this process to become a part of the Comprehensive Africa Agriculture Development Programme (CAADP) framework. Several PACA focal countries were announced earlier this spring and it was surprising to learn that Senegal was not included in this group. Linking up with PACA is an opportunity for ideas and lessons learned to be exchanged with other countries (i.e. Kenya and Nigeria) that are dealing with the same issues. For example, the International Food Policy Research Institute (IFPRI) Aflacontrol project is currently completing a study in Mali and Kenya to collect data on aflatoxin prevalence along maize and groundnut value chains, consumption, biomarkers, livelihood and behavioral indicators. The results of this study will be the first step in identifying some cost-effective aflatoxin management strategies that are accessible to smallholders. The United States Government recently announced that it is committing \$12 million to PACA, of which \$9.5 million are USAID funds and \$2.5 million is ongoing USDA funding.

The Government of the United States should contribute to the following:

**Identify Sanitary and Phytosanitary Research Gaps and Other Potential Opportunities for Collaboration Under the Feed the Future Research Strategy**

Over the years agricultural research and development in Senegal has been on the decline because of reduced donor support and government funding. Many qualified researchers are leaving Senegal because of decreasing research opportunities, aging equipment, and poor laboratory capacity. Most of the molecular techniques required for the biological control pilot described earlier were completed outside of Senegal because the government and universities lacked the capacity to do many of the tests in-country. The current state of the country's capacity to conduct applied agricultural research is something that can be addressed through the U.S. Government's Feed the Future (FTF) Research Strategy. The FTF Country Implementation Plan for Senegal specifically includes opportunities for building research capacity in higher education institutions. There is also the possibility of collaborating with FTF in more comprehensive Sanitary and Phytosanitary development activities that would focus on working to implement the regulatory infrastructure and identifying constraints.

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