

# KENYA

PROJECT NOTE 5 • JUNE 2012

## THE AFLACONTROL PROJECT: REDUCING THE SPREAD OF AFLATOXINS IN KENYA: SUMMARY REPORT

The economic losses associated with aflatoxin are estimated to be large; however, there is a dearth of systematic studies that empirically estimate a) economic losses (in terms of both health and income) for all stakeholders along the value chain, b) economic impact of interventions, and c) socio-economic factors affecting adoption. While there have been a number of scientific studies regarding aflatoxin control options, there has not been subsequent large-scale adoption of risk reducing technologies, particularly in the developing countries. Furthermore, there has not been systematic data collection regarding how the prevalence of aflatoxin changes as products move along the value chain.

The Aflaccontrol project focuses on smallholder production using a value chain approach: the maize value chain in Kenya and the groundnut value chain in Mali. The value chain approach in this context is vital: the risk of contamination and prevalence changes as products move along the value chain, as do strategies to mitigate that risk. Furthermore, the incentives to mitigate risks may depend on the price premium that an individual actor receives for their role in the value chain as well, as the perceived risk of contamination further down the chain.

The project is structured around five objectives:

- **Objective 1:** Economic impact of aflatoxin on stakeholders' livelihoods
- **Objective 2:** Aflatoxin prevalence along the value chain
- **Objective 3:** Evaluation of risk mitigation strategies along the value chain
- **Objective 4:** The impact of stakeholders' knowledge and perceptions on the adoption of control strategies along the value chain, stakeholders' willingness to pay for or adopt different control strategies, and consumer demand for labeled products
- **Objective 5:** Communication of results and advocacy for aflatoxin risk mitigation strategies

### PARTNERS:

This is a highly collaborative research effort. Our main collaborating partners are: ICRISAT, CIMMYT, IER (Mali), KARI (Kenya), ACDI/VOCA (Kenya), University of Pittsburg, and Uniformed Services University for the Health Sciences.

### OBJECTIVE 1: ECONOMIC IMPACT OF AFLATOXIN ON STAKEHOLDER'S LIVELIHOODS

#### Economic Impact of Health Consequences

The most common risk factor for liver cancer is hepatitis B virus (HBV). In many parts of Africa, both aflatoxin exposure and HBV prevalence are high, and increased exposure to these risk factors has resulted in liver cancer. Aflatoxin exposure results both from high levels of contamination in foodstuffs and high consumption of those foodstuffs, such as maize, which is a staple in diets in Kenya. Analyses using secondary data from the WHO GEMS food consumption database found that globally, 25,200-155,000 aflatoxin-induced liver cancer cases are seen each year, which translates to 328,000-2,000,000 DALYs suffered each year from aflatoxin-induced liver cancer. In addition to liver cancer, aflatoxin has also been linked to stunted growth in children, immune system disorders, and acute aflatoxicosis.

Analyses indicate that about 40% of the total cases and most DALYs are suffered in three world regions: Africa (sub-Saharan Africa), Southeast Asia, and Western Pacific (China).

Analyses using secondary data from Kenya Integrated Household Budget Survey (KIHBS) 2004-05 indicate that in Kenya, there are 55- 2,720 aflatoxin-induced liver cases with an average of 387 per year, which translates to 715-35,360 DALYs associated with

aflatoxin-induced HCC,<sup>1</sup> while the average expected number of aflatoxin-induced liver cancer cases in sub-Saharan Africa as a whole is 26,100 (11,380-59,900)<sup>2</sup>. Liver cancer, along with other major types of cancer, ranks third as a cause of death after infectious diseases and cardiovascular diseases in Kenya.

## Livelihoods Impact

In Kenya, production decisions are dominated by men, while storage and consumption decisions are dominated by women; planting and harvesting decisions are implemented jointly. In marketing maize, women mostly sell small quantities to local markets, while men sell in bulk. Small-scale farmers produce maize mostly for home consumption and sell only the surplus unless cash is needed immediately (e.g. to pay tuition fees in schools); many must buy grain later when prices are high. Storage in improved granaries is limited due to fear of theft. Maize is often stored inside the house in sacks, often laid directly on the floor.

The share of income from maize production in total household income on average is relatively small (17% on average) because of diversified income sources; likewise, returns to labor per ha is small for maize-producing households in Kenya, most likely because more than half of the sample households (56%) are subsistence households that depend mostly on their own harvest for consumption.

Aflatoxin contamination has a significant negative effect on maize production and hence results in 9.5 % loss of total household income on average across all regions.

For maize-producing households in high-risk areas where aflatoxin contamination is very high and where an aflatoxicosis outbreak occurred in 2004, aflatoxin contamination significantly reduced maize income by 33% on average. This translates to a 10% loss of total household income on average for these producers. An even higher reduction of total income-- 20%--is experienced by smallholder maize-producing households (smallholders are defined as those maize producers with land holdings of 1.01 ha and below).

## Trade Impact

Early studies looking at economic losses due to tighter regulations on mycotoxin contamination levels imposed by the EU predicted a huge economic impact and continue to be quoted (Wilson, Otsuki, Sewadeh 2001) with little reference to actual changes in trade levels since the tightening of regulations a decade ago. Analysis of the impact of SPS regulation relating to aflatoxin contamination in maize found that:

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1 Note that these estimated exposures do not take into account occasional very high aflatoxin levels, such as those experienced in Kenyan maize in 1982, 2004, and 2010. Those high aflatoxin levels are relatively unusual, which may lead to acute aflatoxicoses (such as in 1982, when 12 people died, and in 2004, when 317 people became ill and 125 people died) that are not typically associated with subsequent liver cancer.

2 This result is based on the following estimated average values: aflatoxin exposure at 3.5 to 133 ng/kg bodyweight/day, prevalence of chronic HBV at 11-15% in a population of 38 million Kenyans, aflatoxin contamination of foodstuffs at 5.2 to 200 ng/kg bw/day, per person, where foodstuffs include maize and peanuts; maize consumption is assumed at 462 grams per day and peanut consumption at 37 grams per day (KIHBS 2005; Hall and Wild 1994; Shephard 2008; Liu and Wu 2010).

- Aflatoxin regulations have a significant effect on bilateral trade flows (i.e., between high standard and low standard markets) for groundnuts but no significant effect for maize. Maize producers are finding alternative markets (e.g. feed, countries with less strict regulations).
- Actual contamination levels in many countries are far higher than the minimum levels allowed by Codex, and the actual levels of contamination need to be greatly reduced to meet EU or other importing countries' standards. It is possible that some of the trade losses that occurred in the 1970s were due to the initial adoption of aflatoxin standards, which shut out countries with high levels.
- For developing countries with a high health burden from aflatoxins, it is important to reduce the level of aflatoxin to the risk deemed acceptable for domestic consumers. In the process, trade and food industry development will be facilitated. The focus should not be on the trade effects of strict regulations in some countries, but on assisting producers to reduce the level of aflatoxin in their products.

## OBJECTIVE 2: AFLATOXIN PREVALENCE ALONG THE VALUE CHAIN AND CURRENT STORAGE PRACTICES

### Aflatoxin Prevalence Along the Value Chain

Between September 2009 and May 2011, a total of 4,414 samples (802 harvest, 1,627 post-harvest from farmers' stores, and 1,985 from markets) were collected from three regions: Upper Eastern (Embu/Mbeere), Lower Eastern (Makueni, Machakos), and South Western (Kisii/Rongo/Homa Bay), covering a range of agro-ecological zones.

Contamination starts in the fields; prevention and mitigation measures need to factor in environmental conditions that stress the crop such as high temperatures, drought, and damage from other abiotic and biotic factors, which vary by region and year. Strategies such as the use of aflatoxin-resistant germplasm, good crop husbandry to minimize damage from insects and diseases, and proper fertilization schemes might help minimize aflatoxin contamination.

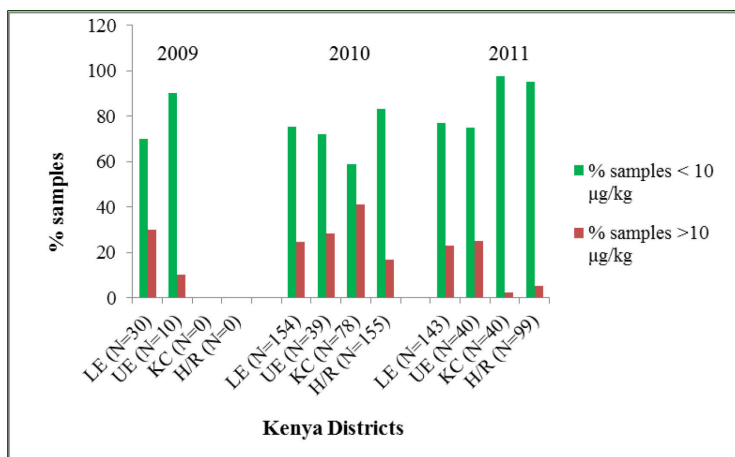
A frequent misconception is that the Kenyan maize aflatoxin issue is confined to Eastern Kenya (drylands); our findings clearly show that this problem is also present in the Rift Valley (high tropics) where appropriate agricultural ecological conditions exist.

A significant number of samples from farmers' fields in both Western and Eastern Kenya contained aflatoxin levels that were above 10 µg/kg, the legal limit set by Kenyan authorities (Figure 1). In Eastern Kenya, the mean aflatoxin level was 273.8 µg/kg, and the highest level detected was 9091.8 µg/kg, representing a level 909-fold higher than the legal limit allowed by government authorities. On average, the proportion of samples with aflatoxin levels greater than 10ppb varied between 25%-40% in both 2010 and 2011 (Figure 2). In Western Kenya, the mean aflatoxin level was 13.94 µg/kg, and the sample with the highest aflatoxin level contained 722.2 µg/kg. On average, 17% of samples from Western Kenya had aflatoxin levels above 10 µg/kg. A huge variation

( $P < 0.001$ ) was observed for Western Kenya, where 24.9 % of the samples were contaminated in 2010, compared to 4.3% in 2011. (Figure 3).

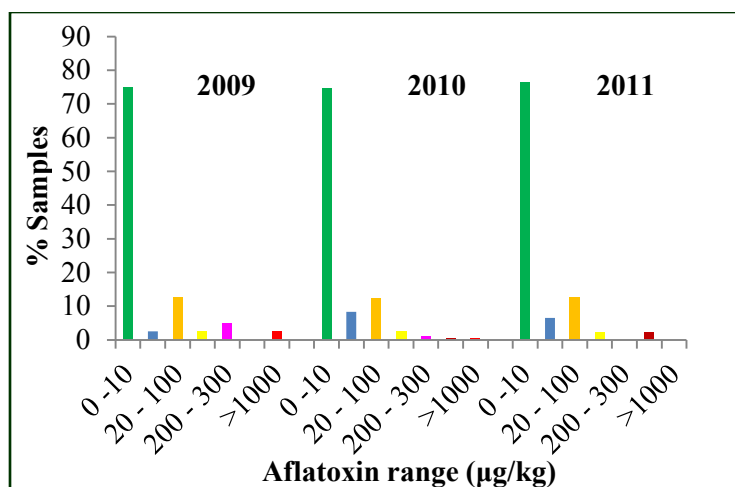
Overall, around 40% of all samples taken from farmers' fields in both Eastern and Western Kenya had aflatoxin levels above 10ppb in February 2010. Levels of contamination were consistently lower in the second harvest (August 2010).

On average, there are significantly more storage samples from Eastern Kenya that had aflatoxin levels above the legal limit compared to Western Kenya. The proportion of samples from stores in Eastern Kenya that were above the legal limit of 10  $\mu\text{g}/\text{kg}$  were 42.7% in 2009, 35.7% in 2010 and 44.5% in 2011, while in Western Kenya, 0% in 2009, 30.1% in 2010 and 8.5% of the samples in 2011 had aflatoxin levels above the legal limit of 10  $\mu\text{g}/\text{kg}$  (Figure 4). The mean aflatoxin levels for samples collected in 2009, 2010, and 2011 was 328.4  $\mu\text{g}/\text{kg}$  (range of 0 to 27393.7  $\mu\text{g}/\text{kg}$ ), 48.8  $\mu\text{g}/\text{kg}$  (range of 0 to 2641.7  $\mu\text{g}/\text{kg}$ ), and 19  $\mu\text{g}/\text{kg}$  (range of 0 to 685.6  $\mu\text{g}/\text{kg}$ ), respectively.



**FIGURE 1. PROPORTION OF MAIZE SAMPLES FROM FARMERS' FIELDS ABOVE AND BELOW THE LEGAL AFLATOXIN LIMIT**

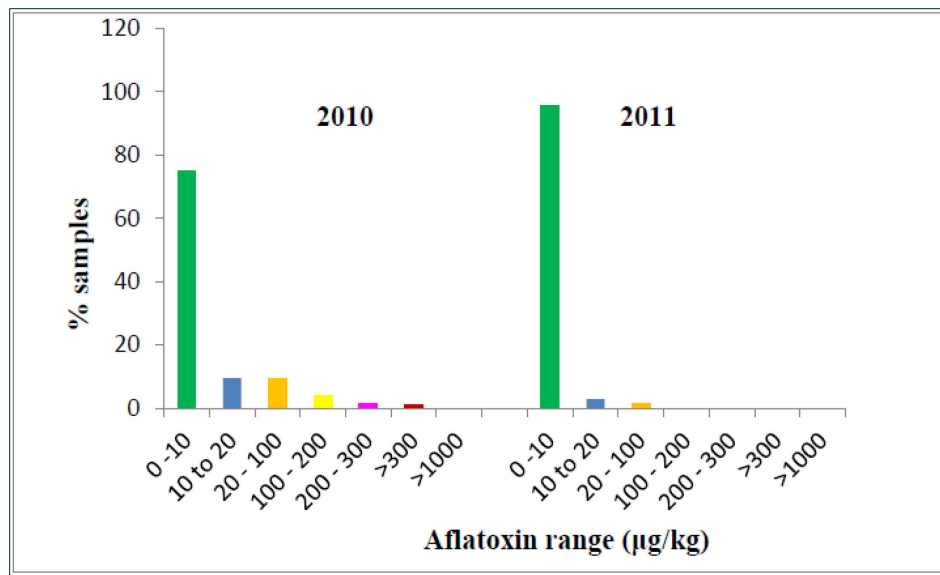
Note: Proportion of maize samples collected from farmer fields with aflatoxin levels below (green bars) and above (red bars) the legal limit of 10  $\mu\text{g}/\text{kg}$  set by the Kenyan government. Maize samples with aflatoxin levels  $\leq 10 \mu\text{g}/\text{kg}$  (green bars) are considered safe for human consumption, while samples with  $>10 \mu\text{g}/\text{kg}$  (red bars) are not safe for consumption. Samples were collected from two regions of eastern Kenya (LE = lower eastern and UE = upper eastern), and south western Kenya (KC = Kisii Central, H/R = Homabay/Rongo)



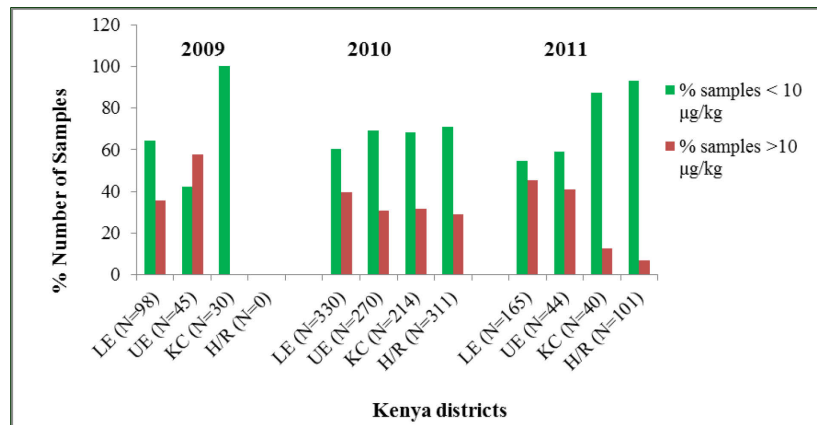
**FIGURE 2. DISTRIBUTION OF AFLATOXIN LEVELS IN MAIZE SAMPLES COLLECTED FROM FARMERS' FIELDS (PRE-HARVEST) IN EASTERN KENYA DURING 2009, 2010, AND 2011**

A significant number of market samples from both regions had aflatoxin levels above the legal level of 10  $\mu\text{g}/\text{kg}$  (Figure 5). For Eastern Kenya, the number of samples with aflatoxin levels above 10  $\mu\text{g}/\text{kg}$  was 47.8%, 43.3%, and 46.4% for 2009, 2010, and 2011, respectively. As was observed for pre- and post-harvest samples, a huge variation was observed for Western Kenya, where 53.8%, 24.8%, and 7.8% of the samples from 2009, 2010, and 2011, respectively, had aflatoxin levels above 10  $\mu\text{g}/\text{kg}$ . These results reveal the potential risk of aflatoxin contamination and shows that the risk of aflatoxin poisoning has been underestimated for Western Kenya.

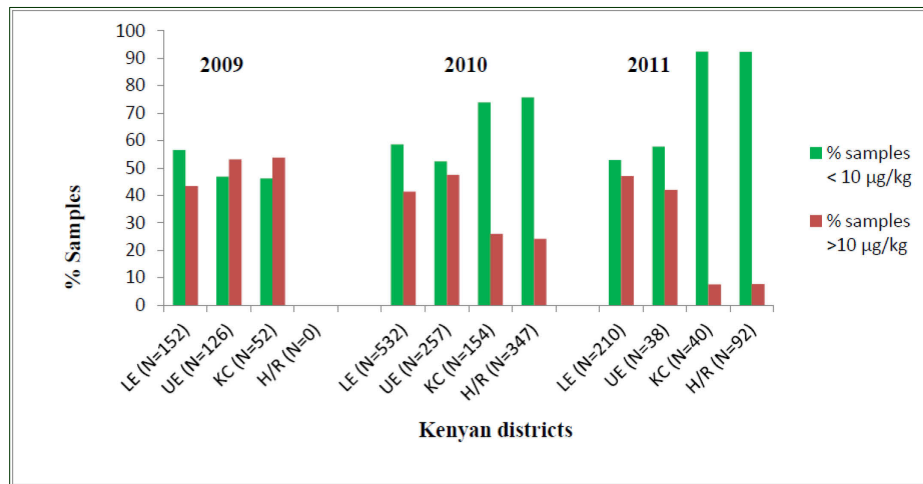
The proportion of maize with aflatoxin levels greater than 10ppb is higher in samples taken from farmers' stores and markets than maize samples taken from farmers' fields, suggesting that current storage practices are a significant factor in high levels of aflatoxin contamination. There is also a need to investigate and document the sources of maize grain sold in the markets.



**FIGURE 3. DISTRIBUTION OF AFLATOXIN LEVELS IN MAIZE SAMPLES COLLECTED FROM FARMERS' FIELDS (PRE-HARVEST) IN SOUTH WESTERN KENYA DURING 2009, 2010, AND 2011**



**FIGURE 4. PROPORTION OF MAIZE SAMPLES COLLECTED FROM FARMERS' STORES ABOVE AND BELOW THE LEGAL LIMIT OF 10 MG/KG SET BY THE KENYAN GOVERNMENT**



**FIGURE 5. PREVALENCE OF AFLATOXIN IN MAIZE SAMPLES COLLECTED FROM MARKETS IN EASTERN AND WESTERN KENYA IN 2009, 2010, AND 2010, RESPECTIVELY.**

### Post-harvest Storage

*Aspergillus flavus* is also considered a post-harvest pathogen, as the fungus is capable of growing, colonizing, and proliferating in storage. It is therefore recommended that maize grain be stored when the moisture content is less than 12.5% and that storage structures be well ventilated; in addition, the maize should be stored on a raised platform to avoid contact from the ground. Furthermore, damage from insects should be minimized, as insects create pockets of high moisture through feeding and respiration that are ideal for *A. flavus* proliferation and subsequent contamination. In Kenya, there are both permanent and temporary storage facilities. Temporary storage facilities include polypropylene and sisal bags, while permanent storage structures include metal silos, improved granaries, silos, baskets, large pots, traditional cribs, and separate structures for storage and living quarters.

An analysis of the economic efficiency (measured in terms of storage costs per ton) of the different storage structures, both per agro-ecological zone and overall, reveals that storage using separate structures is the most efficient about Kshs 1,650 (US \$ 17) per ton of maize, followed by traditional cribs with round bottoms, traditional granaries with flat bottoms, and improved granaries with wooden walls. On the other hand, it is costly or inefficient to store maize in baskets, metal silos, and large pots.

### OBJECTIVE 3: EVALUATION OF RISK MANAGEMENT OPTIONS

With this prevalence data, the project conducted two sets of modeling exercises: 1) predictive risk maps and 2) a baseline risk assessment with actual prevalence data and an evaluation of operations to reduce risk.

### Predictive Risk Maps

An ecological niche model, which estimates the actual or potential distribution of aflatoxin prevalence based on environmental layers to estimate the probability of potential distribution, has been developed to create predictive risk maps using first year prevalence data, as well as various climatic and ecological data available for Kenya.

Because the sampling was done in fairly small areas, the initial ecological niche model output maps of the pre-harvest data show clustered and very high predicted probabilities of aflatoxin prevalence in the sampled areas. Ideally, if more funds were available, sampling should be done over a wider geographical area (throughout the whole country, if possible) and within as many different environmental conditions—including levels of elevation, sizes of farm, climates, and so forth—as possible. To overcome the issue of clustered distribution, all data with aflatoxin levels greater than 10ppb, both pre-harvest and post-harvest, were used and the regularization multiplier was increased from a default of 1 to 10 to smooth out the model so that higher probabilities occur in areas other than the sampled region.<sup>3</sup> The resulting map spread out the probabilities rather than clustering around the sample sites (Figure 6). Findings of the sensitivity analyses indicate that among the data on environmental conditions available (temperature, elevation, and rainfall), average temperature seems to be more important in predicting aflatoxin prevalence in maize. The orange and yellow area identified below in the map show where prevalence is predicted to be highest. These are also areas with highest average temperatures recorded in 2009.

<sup>3</sup> “The “regularization multiplier” parameter on the settings panel affects how focused or closely-fitted the output distribution is. A smaller value than the default of 1.0 will result in a more localized output distribution that is a closer fit to the given presence records, but can result in fitting so close to the training data that the model doesn’t generalize well to independent test data (Philips et al. 2006).

**TABLE 1: PERCENTAGE OF FARMERS USING DIFFERENT TYPES OF STORAGE FACILITIES PER AGRO-ECONOMIC ZONE**

AEZ	Temporary storage facilities		Permanent storage facilities							
	Polypropylene	Sisal bag	Improved granary with wooden wall	Silo	Basket (adita)	Large pot	Traditional crib with round bottom	Separate structure for storage	Improved granary with flat bottom	Room in house for storage
Low tropics	15.44	4.24	4.05	0.00	0.28	0.09	0.38	1.98	1.22	11.58
Dry Midaltitude	17.61	2.92	2.26	0.19	0.38	0.28	2.17	0.85	4.33	9.89
Dry transitional	21.28	1.04	0.19	0.19	3.39	0.66	3.39	1.22	1.51	15.54
Moist transitional	17.51	0.75	2.54	0.00	1.22	0.19	0.56	1.22	0.66	11.86
High tropics	9.04	0.19	3.30	0.00	0.00	0.00	0.00	1.88	0.66	2.82
<b>Total</b>	<b>80.89</b>	<b>9.13</b>	<b>12.34</b>	<b>0.38</b>	<b>5.27</b>	<b>1.22</b>	<b>6.50</b>	<b>7.16</b>	<b>8.38</b>	<b>51.69</b>

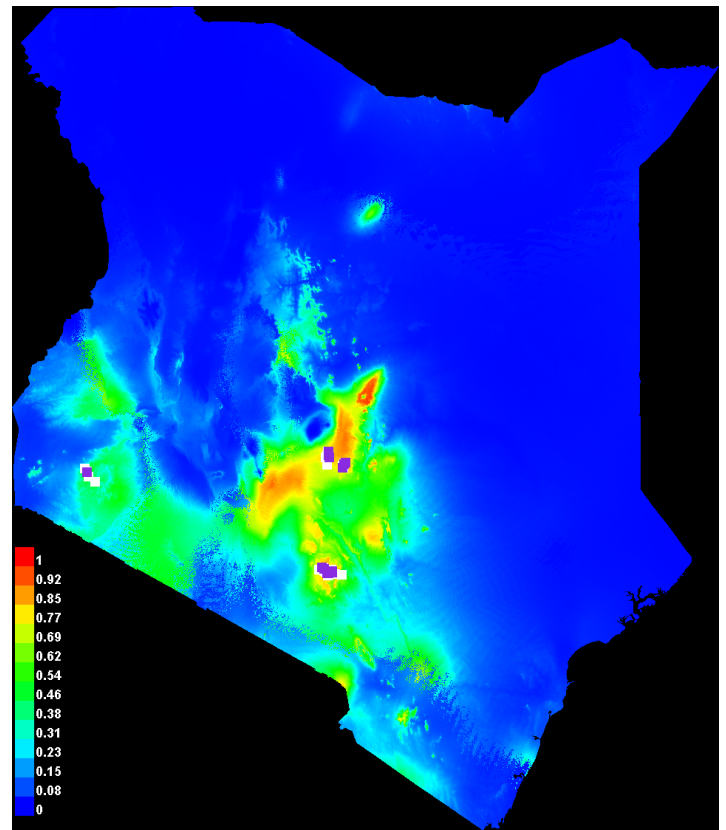
Additional collection points outside of the current sampling areas are necessary in order to determine the true distribution of aflatoxins in the study areas. The current models using the regularization parameter of 10 could be used to help guide the selecting future sample locations. New collection sites should include areas with both high and low predicted probabilities for presence of aflatoxins throughout the agricultural regions selection of new collection sites. Land cover maps should also be taken into consideration.

### Risk Assessment

A baseline risk assessment model was developed starting with initial soil concentration levels; the change in aflatoxin concentrations due to the environmental and operational characteristics of each farm is simulated using a probabilistic framework to quantitatively address the uncertainty and variability surrounding risk-increasing and risk-decreasing events. At pre-harvest and post-harvest, each step either increases or decreases the aflatoxin load of maize by an amount drawn from a probability distribution; each distribution represents either the range of contamination or the range of effectiveness of the operation applied to reduce aflatoxin loads.

Probabilistic models were developed starting with initial soil concentration levels; the change in aflatoxin concentrations due to the environmental and operational characteristics of each farm were the values drawn from a probability distribution.

Results of analyses indicate that adding pre-harvest operational practices (such as use of drought and pest resistant seeds, irrigation, and insecticides, and adoption of good agricultural practices and cropping system management), both singularly and in combination, reduced aflatoxin concentrations; the more operational practices added, the more reduction was seen.



**FIGURE 6. PREDICTED PROBABILITY OF PRESENCE OF AFLATOXIN IN MAIZE IN KENYA FROM THE ECOLOGICAL NICHE MODEL USING A REGULARIZATION PARAMETER OF 10**

Note: The legend on the left map shows predicted probabilities for the presence of aflatoxin. The model used 41 locations to build the model (shown in white) and 13 locations for testing (shown in purple)

## Cost Effectiveness Analysis

Currently, most control strategies to reduce aflatoxin risk are only in practice in the developed world, are implemented with subsidies in the developing world, or are part of an experimental situation in the developing world.

As the effectiveness of the measures in developing country conditions is not well known, a 2-stage Delphi expert elicitation of experts reported minimum, maximum, and most likely values for each measure's efficacy via email, with a panel of experts to provide guidance on the potential effectiveness of selected control measures in reducing aflatoxin prevalence in maize.

We use the mean effectiveness reported by the experts and the variance for each measure assigned a value that roughly corresponds to the confidence in the mean value consensus of the expert panel to assess the cost-effectiveness of combinations of aflatoxin control options in a Monte Carlo cost-effectiveness analysis for a select group of pre and post-harvest technologies to reduce the risk of aflatoxin in maize.

The control measures are characterized by a mean level of effectiveness, the variation around the mean level, and an annualized implementation cost per household, normalized to a 90 kg bag of maize. The modeled effectiveness of each control measure for each producer was drawn from a beta distribution with the mean and variance given in Table 2.

**TABLE 2: EFFECTIVENESS OF VARIOUS TECHNOLOGIES AND THEIR COSTS**

Technique	Effectiveness (%) *	Std (%)	Duration of effectiveness of method (years)	Price (ksh)	Capacity (# of 90 kg bags)	Cost per bag	Annualized cost per 90 kg
Biocontrol	63	14	1	2000	10.8	185.19	194.44
Drying	50		1	4.5	0.38	11.84	12.43
Tarpaulin	53	16	5	62,000	50	1240	286.41
Plastic containers S	50	19	10	4,600**	3.0	1533.33	198.57
Plastic containers M	60	19	10	11,132**	12.0	927.67	120.14
Plastic containers L	60	19	10	17,020**	20.0	851	110.21
Metal Silos Small	62	15	20	8,667**	3.0	2889	231.82
Metal Silos Medium	60	15	20	17,833**	12.0	1486.08	119.25
Metal Silo Large	60	15	20	24,883**	20.0	1244.15	99.83

\*from expert elicitation, \*\* from CIMMYT survey/ ACIDI/VOCA, \*\*\* starting price in survey

For each household, a final concentration level is computed by applying the realized reduction of each control measure employed to the initial concentration. Figure 7 shows the cost-effectiveness for the study population, measured in terms of the percentage of households with aflatoxin levels below a threshold of 10 ppb. Cost is expressed as cost of control per 90 kg bag of maize and effectiveness is measured as the percentage of households with a final aflatoxin concentration less than 10 ppb.

**TABLE 3: SELECTED NON-DOMINATED SETS OF CONTROL OPTIONS**

Point	Biocontrol	Plastic storage	Metal silos	Canvas Tarp
1	X			
2	X	X		
3	X	X	X	
4	X	X	X	X

Since the goal of aflatoxin control is to reduce the measured concentrations to an acceptable level, the fraction of households that fall below the threshold is an appropriate indicator of effectiveness. The curve in Figure 7 shows the efficient frontier of the set of 16 control option combinations; that is, the combinations that have the best performance at a given cost. There are seven combinations of control practices that define the frontier. The four numbered boxes identify four control packages that remain preferred over a relatively large range of cost.

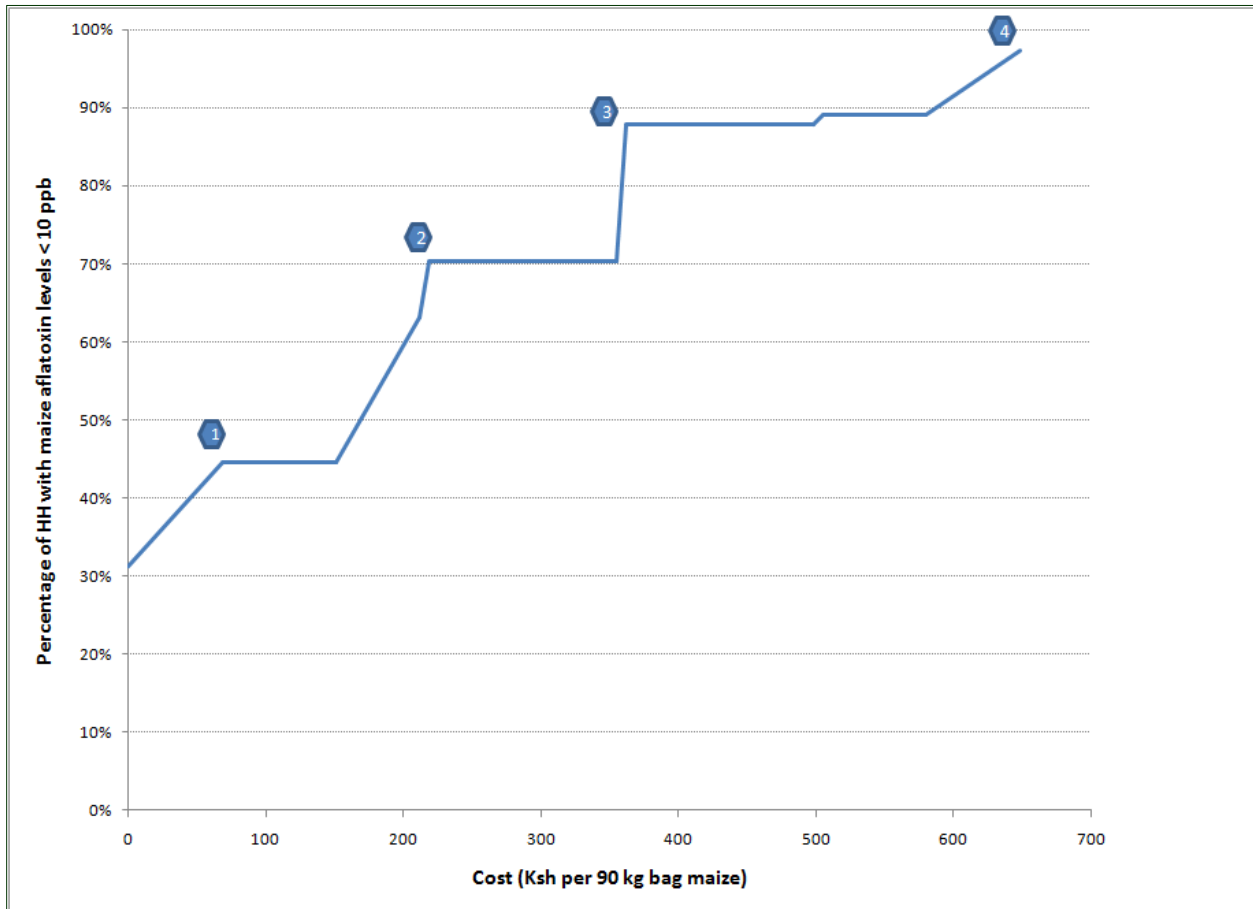
Table 3 shows the set of control options that make up each point. The table shows that there is a natural order to the value of each option to overall risk reduction and shows the benefit of employing multiple control options. As the implementation cost increases, options that are used at lower costs remain in the set of desired controls at higher costs. This implies that options do not become "obsolete" if standards become stricter or if a greater budget for aflatoxin control is available.

The results based on the expert elicitation indicate that the biocontrol option is the first to be employed, as it provides the greatest aflatoxin reduction for the least cost. The second option is the use of plastic containers. While this option is not as effective at reducing contamination as the other two remaining options (metal silos and tarps), it is significantly less expensive. The additional risk reduction for each option added is significant.

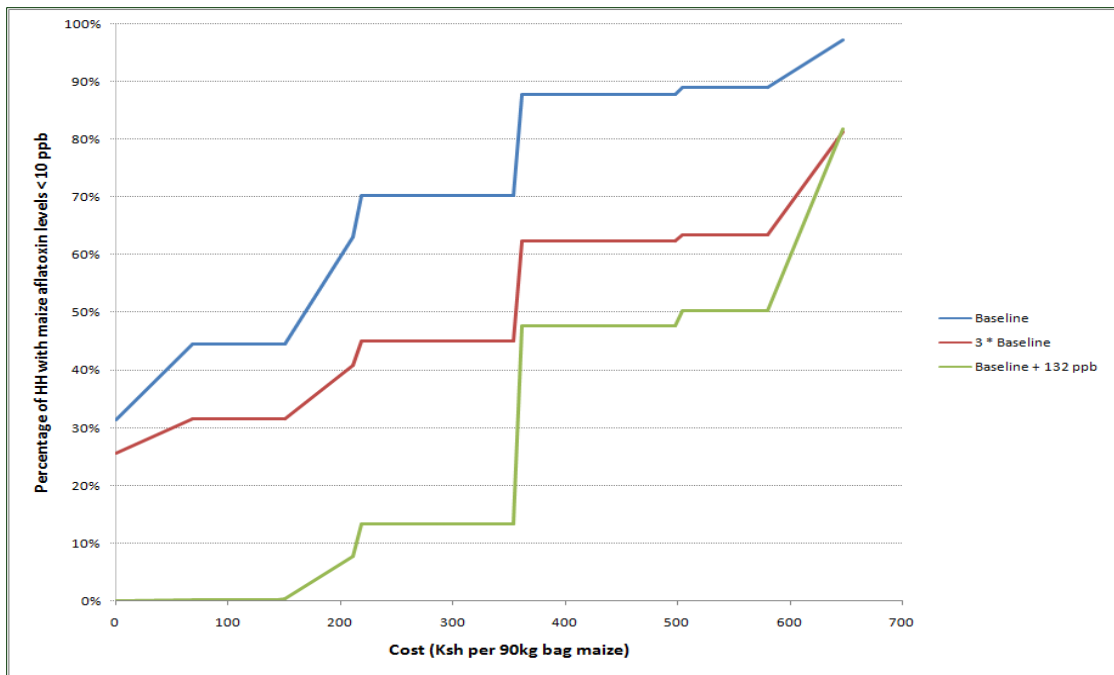
The shape of the cost-effectiveness curve shown in Figure 7 is dependent on the distribution of initial aflatoxin levels. If the aflatoxin contamination were worse, expressed as a higher mean value, the curve would be shifted down to reflect the fact that for a given cost, fewer households would achieve the target threshold since the baseline concentrations were higher. To illustrate the effect of a change in the distribution, two cases are considered. For the first case, the initial aflatoxin level (which has a mean level of 66 ppb) is multiplied by 3 for each household. For the second case, a constant value of 132 ppb is added to the concentration for each household. Each of the two cases has the same mean value (198 ppb), but the first case has a much wider distribution than the second case. The second case might correspond to an epidemic situation in which all producers in a given area are highly contaminated. Figure 8 (the baseline cost-effectiveness curve is shown again for reference) shows that in the epidemic situation, there is not much benefit to low levels of control. Even at the highest level of control for the set of given options, the maximum achievable benefit is much lower as the distribution shifts up or widens.

Economies of scale can play a role in cost-effectiveness. Two of the options have a cost per unit that declines with size. As an example of how this plays out in the current context, the cost-effectiveness curve is constructed for three cases, in which all producers fall into one of three size classes for each case (Figure 9). The original analysis assuming a uniform distribution of size is provided for comparison. The all-small producer case is similar to the baseline, shifted to the right (i.e., a lower level of effectiveness at each cost). The composition of the frontier points is the same as the baseline. In contrast, the all-medium and all-large cases have the cost-effectiveness curve shifted to the left. For these cases, the appearance of the plastic storage option and metal silo option are reversed, with the metal silo option being more cost-effective than the plastic storage option.

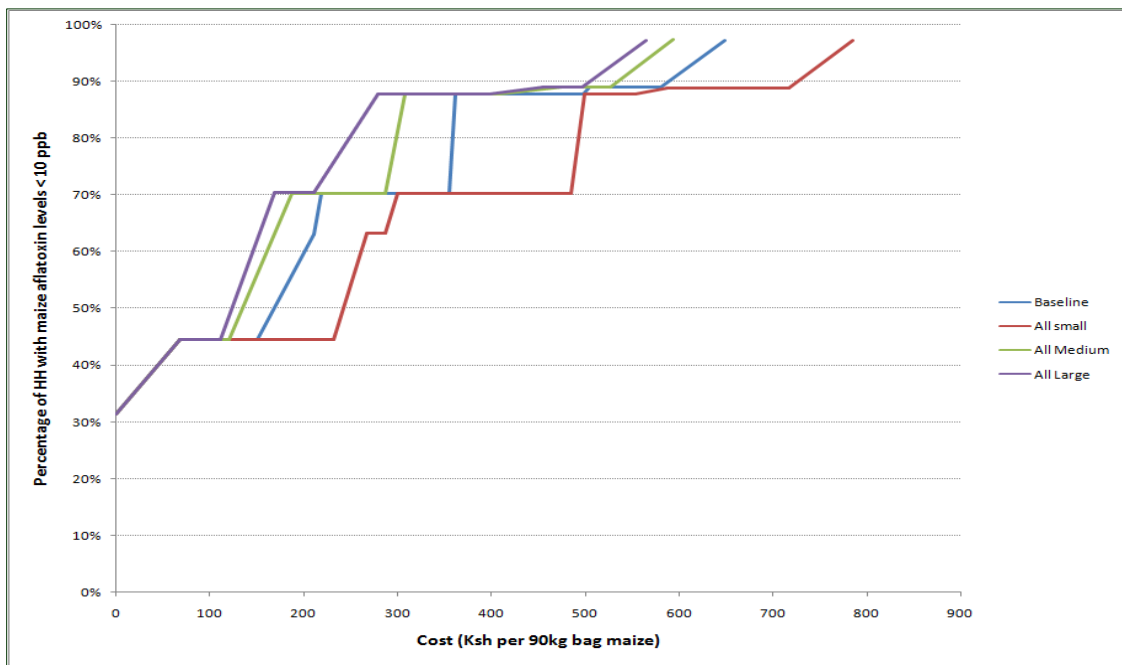
As these control measures are not currently in place in a farm situation, the method described allows one to clearly evaluate the trade-offs between the known and expected costs of adopting aflatoxin risk reduction technologies, singly or in combination, given how effective the experts consider these technologies/methods to be for reducing aflatoxin contamination. Given the uncertainty in the lifecycle of some of the technologies and the effectiveness of them in real-life situations, the analysis should be updated as more information becomes available.



**FIGURE 7. COST-EFFECTIVENESS OF AFLATOXIN CONTROL FOR MAIZE IN KENYA FOR A REPRESENTATIVE PRODUCER POPULATION**



**FIGURE 8. COST-EFFECTIVENESS SENSITIVITY TO DISTRIBUTION OF INITIAL CONCENTRATION**



**FIGURE 9 COST-EFFECTIVENESS FOR DIFFERENT PRODUCER OPERATION SIZE**

## OBJECTIVE 4: THE IMPACT OF STAKEHOLDERS' KNOWLEDGE AND PERCEPTIONS ON THE ADOPTION OF CONTROL STRATEGIES ALONG VALUE CHAINS, WILLINGNESS TO PAY/ADOPT DIFFERENT CONTROL STRATEGIES, AND CONSUMER DEMAND FOR LABELED PRODUCTS

There are increasing efforts being directed toward identifying effective ways to reduce the level of aflatoxin to which farmers are exposed. However, finding a solution does not mean it will be adopted. The Aflacontrol project looks into understanding the factors affecting producers' and traders' behaviour regarding the adoption of risk reduction strategies, and the potential value that consumers may place on maize labelled aflatoxin-free.

### Knowledge, Attitude, Perception, and Practices Analysis

Key findings from focus group work show that knowledge regarding aflatoxin exists in the Eastern Kenya (where levels are higher), but knowledge of the causes and nature of aflatoxin is generally poor. For example, farmers knew that neighbors had died because of aflatoxin and wanted to know what their level of exposure is and how to find out. At the same, their knowledge of how to limit aflatoxin or evaluate risks was poor. They wanted to know if it was safe to dry maize directly on the ground and considered moldy maize produced on their own farm safer than moldy maize purchased from stores.

Key findings from structural model analysis show:

- A general level of education was a household demographic characteristic that had a significant positive effect on knowledge of the risk and spread of aflatoxin contamination. However education also had a negative effect on the degree of concern about high levels of aflatoxin prevalence and aflatoxicosis outbreak in the village. This finding suggests that more educated households have the ability to make decisions to take appropriate actions in preventing or reducing exposure to aflatoxin contamination.
- Given that most farmers who had heard of aflatoxin heard about it through local language radio, efforts to expand the effectiveness of such media efforts are needed, especially to reach those who do not have access to formal education.
- Having children under 5 years of age in the household has a positive effect on knowledge of the attributes associated with safe consumption of food for human and animals and on storage practices that minimize the formation and growth of fungi/mold. This may have to do more with a concern that children are more likely to consume that which is freely available or lying around.
- Female household heads have higher knowledge about the harmful effects of feeding moldy grains to animals and eating moldy maize products.

- The income effect is negative for knowledge of safety attributes, but positive and significant for knowledge of the causes of fungi/mold growth and perception of aflatoxin risk spread or transmission.
- Those households in Eastern Kenya (drylands), where aflatoxicosis outbreaks occurred in 2004, had a higher perception of risk, which was expected, but less knowledge of safety attributes, moisture causes, and recommended storage practices such as use of plastic and metal silos, clay pots and plastic bags.

### Consumer Willingness to Pay for Reduced Aflatoxins

While new methods to reduce aflatoxin levels, as well as cheaper testing methods, are under development, consumers' willingness to pay for reduced aflatoxin levels are not known. A survey with an experimental auction was therefore conducted with rural consumers in all major maize-producing zones in Kenya.

- In Kenya, consumers showed a high discount for contaminated maize (-20 to -30 KShs/2 kg) and a high premium for labeled and tested maize (10-15 KShs/2 kg). The premium is positively associated with increased schooling and is higher in regions where aflatoxin awareness was high and where fatalities have been reported, but no effect from other characteristics such as knowledge, gender, and wealth was found.
- This would suggest that greater effort is needed to increase awareness of the aflatoxin problem and that technologies to reduce aflatoxin levels should be designed to put more emphasis on maize-producing zones where aflatoxin awareness was high and where fatalities have been reported. Other maize zones, although they reported low awareness and no fatalities have been reported, should be included to guard against fatalities occurring in future; this is particularly important because these areas reported feeding a lot of moldy maize to livestock. The cost of testing and labeling needs to be compared to the premium and the potential higher price in the market, as labeling would require the establishment of a credible institutional mechanism.

### Willingness to Pay for Control Strategies

A series of surveys were conducted to evaluate producers' willingness to pay for aflatoxin reducing measures. Survey respondents were asked whether they are willing to adopt a particular technology at the market price, if such existed, or at an expected price if otherwise. Then the respondents were asked the same question again but with a different price that was chosen randomly from an interval above or below the initial price depending on the initial response. Producers on average were willing to pay 77% more than the estimated market price for improved seeds, 60% more for biocontrol, and 39% more for tarpaulins. However, in the case of metal and plastic silos, the average willingness to pay was, respectively, 6% and 1% below the estimated market prices.

Adoption of risk reducing technologies was not very responsive to price changes. On the one hand, this serves as evidence of a lack of understanding among producers of the benefits of these technologies in reducing the risk of aflatoxin contamination. On the other hand, the small demand price elasticities may suggest that the technologies that are currently available are not adopted because of low overall rates of adoption of aflatoxin reducing technologies and concerns about free-riding. Yet we cannot reject the hypothesis that this finding is simply an artifact of the survey design and does not reflect the actual demand for risk reducing technologies. Nonetheless, the findings provide some support for the conclusion that large subsidies are needed to substantially increase the adoption rates.

In Eastern Kenyan drylands where outbreaks of aflatoxicosis have occurred, respondents were more willing to pay for improved seeds, metal silos, and tarpaulins. Producers with more assets are more willing to pay for aflatoxin risk reducing technologies. General knowledge that consuming food contaminated with aflatoxin is harmful to health appears to be limited only to those who have experienced aflatoxicosis (particularly those households living in Eastern Kenya), and it is possible that perceptions about aflatoxin risks are based on households' exposure to these outbreaks. Hence, there is a need to increase education on this subject, as well as a greater effort to disseminate information about the adverse health effects of aflatoxin contamination.

## **OBJECTIVE 5: COMMUNICATING RESULTS AND ADVOCATING FOR AFLATOXIN RISK MITIGATION**

Awareness of aflatoxin, the extent of contamination, and the means to prevent it are poorly understood, among both policy-makers and farmers. The goal of this objective is to ensure that the findings of the project reach different stakeholders through the design and provision of different materials and activities.

Controlling aflatoxin is no longer simply a food security issue; it is also fundamentally a major food safety issue of particular importance in rural areas.

Within Kenya, our local partner, ACDI/VOCA, has organized a series of meetings with government officials involved in aflatoxin contamination (public health and agriculture), as well as meetings with AGRA regarding how project findings might be incorporated into the materials these groups disseminate among farmer organizations.

ACDI/VOCA has also worked with extension workers, public health officials, and provincial administration to reach out to producers, traders, and consumers to raise awareness of the risk of aflatoxin and its effect on health, as well as simple, practical remedies to mitigate the risk

Through our website (<http://programs.ifpri.org/afla/afla.asp>) (developed with low bandwidth requirements), we are able to share background information regarding aflatoxin, links to other relevant sites, and the approach and results of this project.

The website, facilitated by IFPRI, includes the following information, which is available to the public: (a) an overview of the Aflacontrol project and collaborative relationships involved; (b) background information regarding aflatoxin and its role in food and nutrition in developing countries; (c) the objectives of the Aflacontrol project; (d) the working papers, project notes, workshop reports, and final manuscripts that resulted from the project; (e) presentations from workshops held throughout the life of project; (f) news and current events regarding aflatoxin and the Aflacontrol project; (g) links to partners' and collaborators' websites, as well as links to a variety of other information regarding aflatoxin, food contamination, nutrition, and human health; and (h) contact information for the administrators of the project at IFPRI.

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