

Technologies and strategies for aflatoxin control in Kenya: A synthesis of emerging evidence

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1. Introduction

Aflatoxin is a poisonous substance produced by a fungus, *Aspergillus flavus*, that occurs naturally in soils of cultivated and non-cultivated areas. The fungus commonly produces the toxin in maize, groundnut, and other staple grains and vegetables, and is especially prevalent in Africa. When animals consume feed contaminated with aflatoxin, milk and (at very low levels) meat, fish and eggs, can also be contaminated. This note brings together recent research from the CGIAR and others on technologies for aflatoxin control in Africa and provides recommendations for catalyzing their adoption.

2. Human Health effects of dietary exposure

Long-term exposure to low levels of aflatoxin increases the risk of liver cancer (Liu and Wu, 2010). Liver cancer is one of the most prevalent cancers globally, and has an outsized impact in low-income countries, where aflatoxin contamination is widespread and the rate of Hepatitis B infection, which multiplies the impact of aflatoxin on cancer 30-fold, is high (Torre et al., 2015). Emerging evidence also ties exposure to aflatoxin during gestation and early childhood to stunting (Gong et al., 2016; Hoffmann et al., 2018a). In areas of very high prevalence such as eastern Kenya, high levels of aflatoxin exposure occasionally lead to acute illness and death (Azziz-Baumgartner et al., 2005).

Based on a 2015 assessment by the World Health Organization (WHO), exposure to chemicals and toxins in food account for only 2% of the total burden of foodborne illness in Africa. Contamination with disease-causing organisms, such as those which cause diarrhea, and intestinal worms, leads to a much larger impact on both illness and death. However, as the possible effects of aflatoxin on child growth and other developmental outcomes associated with physical stunting are not included in this assessment, it is difficult to assess the true impact of aflatoxin.

3. Foods affected by aflatoxin and priorities for control

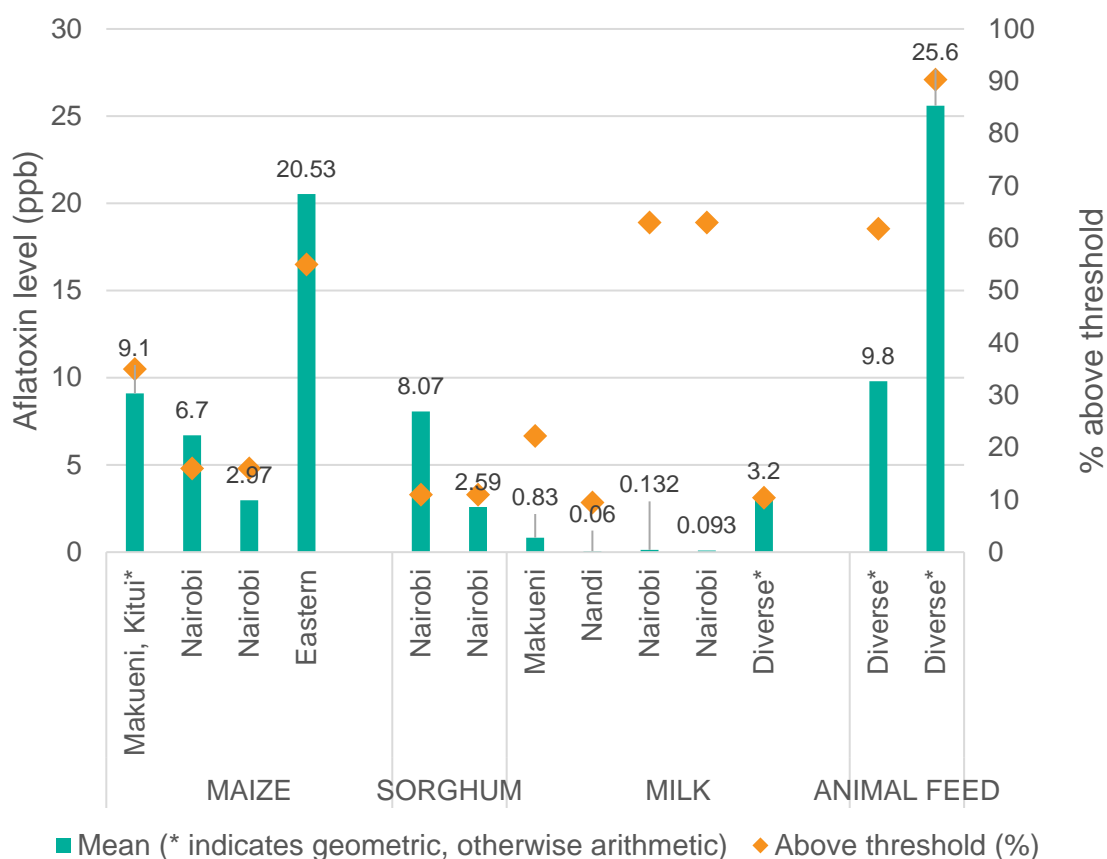
The highest levels of aflatoxin are generally found in maize and groundnut. Other grains and legumes, such as sorghum, sesame seed, and soybean, can also be contaminated. Aflatoxin is also found in chili peppers and other spices (Akpo-Djèntonin et al., 2018), and in fish, edible insect skin, and meat which have been preserved by sun-drying (Adeyeye, 2016; Kachapulula et al., 2018). Figure 1 summarizes evidence on aflatoxin prevalence in Kenyan cereals crops, milk, and feed. Each blue bar indicates the mean level of aflatoxin found in a particular commodity by one study, and orange diamonds show the proportion of samples that exceeded the relevant regulatory limit for aflatoxin at the time (the limit is lower for milk than for other products, and has also become more stringent over time, so this varies by study).

In Africa, most human exposure to the toxin is through consumption of maize due to heavy reliance on this grain as a dietary staple (Abizari et al., 2016). In addition, very high concentrations of aflatoxin have been found in processed groundnut products, including in premixed cereal blends sold as infant food (Florkowski and Kolavalli, 2013; Opoku et al., 2018). Because of the possible negative effects of aflatoxin exposure on child development on one hand, and broad population-wide impact through maize on the other, control of aflatoxin in infant foods and maize should be prioritized.

Since aflatoxin contamination tends to be concentrated in certain geographical areas, and because levels can become very high under traditional storage conditions, smallholder producers in high-risk areas are at greatest risk of high levels of aflatoxin exposure. Deaths and acute sickness due to aflatoxin poisoning in Kenya have been linked to maize grown and stored by smallholder farmers (Azziz-Baumgartner et al., 2005).

If feed contaminated with aflatoxin B1 (the most common type of aflatoxin present in crops) is consumed by dairy cows, this is converted to aflatoxin M1 (AFM1) and is excreted into milk. The pass-through rate of aflatoxin from feed to milk is 1–7% (Masoero et al., 2007; Fink-Gremmels, 2008) and much lower for other animal products. Because of this low pass-through rate, the level of aflatoxin present in milk is generally far lower than that found in grains, despite often high levels of contamination in animal feed (Figure 1). However, as with groundnut products, milk consumption among young children is relatively high and this should be considered in risk-based strategies for aflatoxin management. Further, aflatoxin contamination in animal feed has important economic consequences for species such as pigs, fish, chicken and other poultry, in which growth and survival are affected by the toxin (Andretta et al., 2012; Monson et al., 2015). Susceptibility varies widely depending on species, breed, diet, sex and other factors: in general adult ruminants are relatively resistant to aflatoxins.

Figure 1: Aflatoxin prevalence in cereals, milk, and animal feed in Kenya, various studies



Source: Table 1, Mutegi et al., 2018. Studies that did not report mean levels are not shown.

In addition to its public health impacts, aflatoxin contamination of export crops can be an impediment to trade. For many African countries, groundnuts constitute an important potential source of export earnings. EU rejections of West African groundnuts due to excessive aflatoxin are common and constitute one of several barriers to restoring the continent's groundnut exports to aflatoxin-discerning markets (Rios and Jaffee, 2008)

4. Technologies for aflatoxin control in crops

Pre-harvest

At the pre-harvest stage, biocontrol products have been used since the 1990s in the United States. Their use allows the production of aflatoxin-compliant crops even in areas considered hotspots of contamination (Cotty, 2006; Ortega-Beltran and Bandyopadhyay, 2019). In Africa, biocontrol products have been developed by IITA and partners under the trade name Aflasafe. Usage of Aflasafe products in Senegal (6 year data; Aflasafe SN01) and Nigeria (12-year data; Aflasafe) in multiple agro-ecologies and under diverse cropping systems has resulted in aflatoxin reductions in maize and groundnut of 82-89% (95% confidence interval) compared to untreated plots after storage or simulated storage conditions

(Atehnkeng et al., 2014; Bandyopadhyay et al., 2019; Senghor et al., 2019). The product developed for use in Nigeria was also found to be effective to decrease aflatoxin content in chili peppers (Ezekiel et al., 2019). Data on efficacy of Aflasafe products developed and used in other countries (i.e., Kenya, Tanzania, Burkina Faso, Ghana, Malawi, Mozambique, and Zambia) is available but has not been published in scientific journals.

Over 95% of maize treated by farmers in Nigeria on nearly 100,000 hectares was compliant with US regulatory standard for aflatoxin of 20 parts per billion (ppb), and over 90% was compliant with the stricter 4 ppb EU standard (Bandyopadhyay et al., 2019). In this setting, the biocontrol product was obtained by farmers through contract farming arrangements as part of a package of inputs including fertilizer to improve both maize productivity and safety.

Significant technical support may be required for successful use of this technology among smallholders in less organized farming systems. A recent experiment in Kenya reported by Hoffmann et al. (2018b) found that among the smallholders who purchased the product, almost all applied it later than required for maximum impact despite being trained on application methods in a group setting. Manufacturing and distribution partners in several nations, including Kenya, have been selected, and those these entities are expected to train farmers and farmer associations on correct biocontrol usage, along with other management practices. Research by IITA and IFPRI is ongoing to assess the level of farmer training required to achieve aflatoxin reduction goals.

Drying

Good post-harvest practices, including adequate drying and controlled storage, have long been the standard recommendation for controlling aflatoxin in crops. Providing groundnut farmers with training on aflatoxin control and plastic sheets on which they could dry their crops was shown to reduce aflatoxin by approximately 50% in Ghana, compared to similar farmers who were trained but not given drying sheets (Magnan et al., 2019). In a separate study in Kenya, maize farmers were given drying sheets as well as access to other technologies. Drying sheets were the most widely used technology; the stored maize of farmers who reported drying their maize on these and not using any of the other technologies offered was 79% less contaminated with aflatoxin three months after harvest than that of farmers in villages where no intervention was offered. Overall, aflatoxin levels in intervention villages were 53% lower than in control villages, similar to the Ghana study (Pretari et al., 2019).

A biomass drying technology is slightly more effective, leading to an 85% reduction in contamination after three months of storage in an experimental study (Kayaa and Kyamuhangire, 2010). This approach was developed into a mobile drying technology, the EasyDry M500, by ACIDI-VOCA, which has made engineering drawings available online.¹ In the Pretari et al. study through which drying sheets were also provided, maize stored by those who had used a prototype of this mobile dryer was 78% less contaminated than that stored by farmers in control villages; some of this effect may be due to use of other technologies offered through the study.

¹ Open source engineering drawings for the dryer are available at <https://www.acdivoca.org/easydry/>.

Storage

Hermetic storage bags, designed to reduce insect pest losses, have been shown to reduce aflatoxin contamination by between 40 and 66% after three months of storage, depending on the starting moisture content, level of contamination, and other environmental factors (Ng'ang'a et al, 2016; Walker et al., 2018).

Cost-effectiveness

Figure 2 shows the efficacy and cost-effectiveness of four aflatoxin control technologies. Efficacy is shown in terms of percentage aflatoxin reduction after three months of storage in typical smallholder conditions, as reported in the literature cited above. To compare the cost-effectiveness of technologies, we calculate the cost of reducing aflatoxin in one KG of maize by 50%.

For both efficacy and cost-effectiveness, we show estimates based on an upper and lower bound of published efficacy results. For technologies with only two independent efficacy estimates in the literature (plastic drying sheets, biomass dryers), we use these as the upper and lower bounds of efficacy. When additional evidence on efficacy is available (e.g. for biocontrol, PICS bags), we calculate the 95% confidence interval of these.

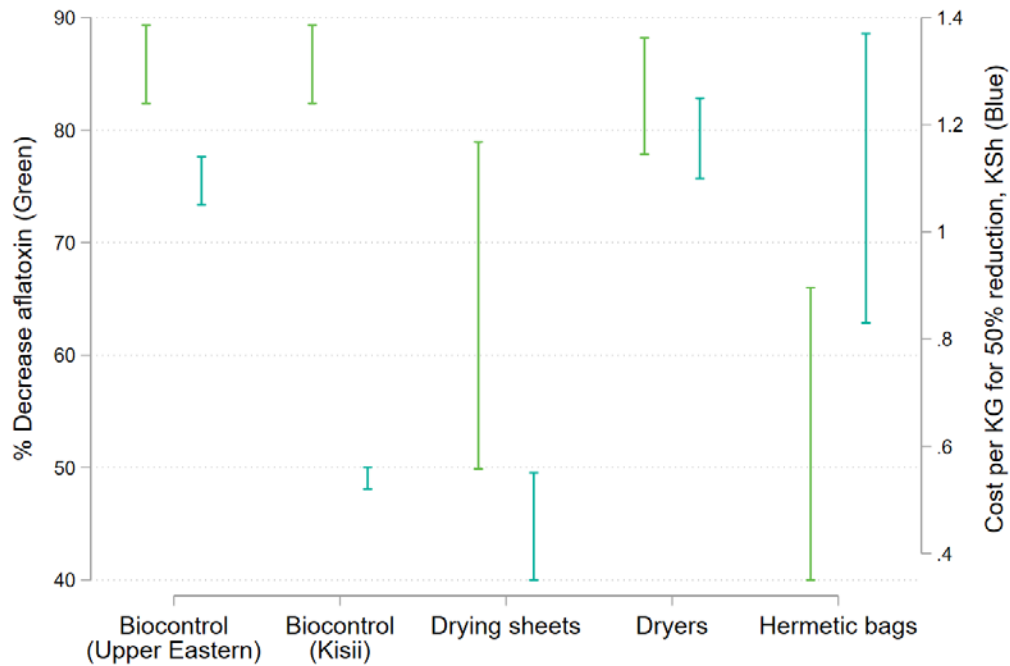
Cost-effectiveness of biocontrol depends on yield. Since the cost of treating a given area of land is constant, the cost of reducing per KG will be lower on higher-yielding farms and in higher-productivity regions. For this technology, we show the costs based on maize yields in two regions: Kenya's Upper East region, the most aflatoxin-prone region in the country with significant maize production, and Kisii county, where maize yields are higher at 2274 KG/ha and aflatoxin can also be a problem. For an average yield of 1121 KG per hectare in Upper East (MoALF, 2015), the cost of a 50% reduction in aflatoxin per KG of maize using Aflasafe varies from 1.05 to 1.14 KSh, based on the suggested retail cost per KG of 210 KSh. In Kisii county, this cost is 0.54-0.56 KSh/KG.

Based on the 416 KSh retail cost of a 14.4 square meter piece of plastic sheeting, and calculating from survey data that the mean volume of maize dried per sheet is 377 KG, we calculate that the per-KG cost of a 50% reduction in aflatoxin is between 0.35 and 0.55 KSh.

The biomass-fueled dryer can be fabricated in Kenya at an estimated cost of 85,000 KSh; assuming a for-profit model, drying a 500 KG batch of maize is estimated to cost approximately 970 KSh, including operator profit (ACDI-VOCA). This implies a per-KG cost between 1.1 and 1.25 KSh/KG to cut aflatoxin by half.

In terms of aflatoxin control, hermetic storage bags are slightly more cost-effective than the mobile dryer. Based on a cost of 220 KSh/100 KG bag, and assuming a 2-year lifespan, the cost for a 50% aflatoxin reduction through hermetic storage is 0.83-1.37 KSh/KG. Storage of grain in these bags has been shown to reduce post-harvest losses. This additional benefit is not considered in the calculations above and could make the technology attractive.

Figure 2: Efficacy and cost-effectiveness of technologies for aflatoxin control in crops



Aflatoxin control in livestock

When animals consume feed contaminated with aflatoxin, the milk, eggs, organs and flesh of those animals will also contain some level of the toxin. The extent of pass-through depends on the product and is highest in milk, as described above. Aflatoxin residues in edible muscle tissue constitute only 0.2–0.5% of that in the feed (Njapau et al., 2015). Based on this, most high-income countries have species- and use- specific aflatoxin limits for animal feed. In the United States, where aflatoxin prevalence can be as high as in Kenya, maize feed for mature beef cattle, swine, or poultry may contain aflatoxin up to 100 ppb, and in finishing feed for beef cattle, the limit is 300 ppb (US FDA, 2019).

Feed additives called binders can reduce the proportion of aflatoxin and other mycotoxins passed through to animal products. Binders are increasingly available in Kenya, where the quantity imported increased by a factor of three between 2017 and 2018 (Mutua et al., 2019). However, the effectiveness of binders in reducing aflatoxin in milk varies greatly, depending on the product, amount used, and milk yield, with one review citing reductions of AFM1 in milk between 4% and 65% (Giovati et al. 2015). Many countries do not have any standards that govern the use of mycotoxin binders, and in Kenya for example, use of binders does not affect the maximum allowable level of aflatoxin in feed, which is set at 10 ppb, the same as for human food.

Regulatory authorities could help farmers make informed choices regarding binders by assessing and publicizing evidence of their impact on the rate of aflatoxin pass-through to animal products and ensuring the accuracy of marketing claims made by binder manufacturers. Further, as the required dose for mycotoxin binders is small (approximately 0.5 KG / MT of feed) making binders available in smaller packets would increase smallholder accessibility of this technology. Clay binders have been most tested and most studies show they are effective and do not affect animal performance at inclusion rates varying from 0.25

to 5% (Neeff et al., 2013). The major advantages of adsorbents include low cost, safety and easy administration through addition to feeds (Wan et al., 2013).

While binders are generally effective in reducing negative effects of aflatoxins the extent of this depends on many factors such as the type of binder, level of contamination, and species. Further, there is evidence that the use of binders can have downsides. For example, one study found higher a feed conversion ratio when binders were used, though another did not (see review by Oğuz et al., 2018). Findings from studies on the impact of binders on bioavailability of other pharmaceuticals are similarly inconsistent (summarized in the review by Wielogórska et al., 2016). In a poultry study conducted by IITA, the aflatoxin binder used was not sufficient to counteract the harmful effects of aflatoxins at high levels (Aikore et al., 2019); in other poultry studies (reviewed in Grace, 2013) other types of binders have been fully effective at levels of contamination commonly encountered. In general, aflatoxin binders vary in their efficacy, effects, operational range and costs. The scientific consensus is that, while the ideal approach would be to minimize animal exposure to mycotoxins, if this is not possible feed additives have a role in protecting human and animal health (EFSA, 2009).

Further, implementation of species-specific aflatoxin standards for feed that take into account the use of effective binders (if this can be shown through site-specific evaluations) would provide an opportunity for legal use of contaminated grain. Without this option, contaminated grain is currently sold through the informal sector or to processors without strong aflatoxin testing capacity. Allowing food that exceeds the aflatoxin limit for human consumption to be fed to meat animals would be a way to get the toxin out of the food supply.

5. How to increase use of aflatoxin management technologies?

Availability of effective technologies for aflatoxin control is an important first step but does not necessarily imply these will be used. As for any new technology, various factors impede farmers' adoption, including knowledge of and access to the technology, appreciation of its benefits, and ability and willingness to pay. In Nigeria, aflatoxin biocontrol was promoted from 2014 to 2018 through a project that offered aggregators an incentive of \$18.75 US per MT of maize grown treated with the product, beyond any private premium they were able to obtain. By 2017, 0.4% of maize in the country was grown with aflatoxin biocontrol (Narayan et al., 2019). This was driven by demand from exporters, domestic food manufacturers, and feed millers, which provided the product to maize out-growers. Certainly, the uptake of on-farm aflatoxin control technologies, including biocontrol, remains at early stages in Africa. To increase the use of these technologies, it will be necessary to increase awareness of aflatoxin and its health consequences, and to develop new market opportunities and incentives for aflatoxin-compliant crops (Johnson et al., 2018, 2019).

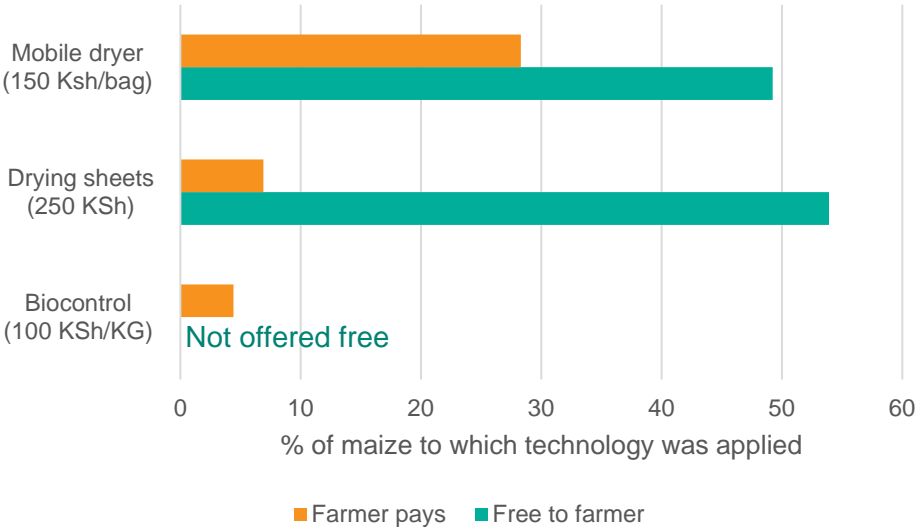
Subsistence producers

Subsidies increase use of aflatoxin control technologies and can stimulate demand

Maize and groundnut in Kenya are primarily produced by smallholder farmers, who also consume a large share of production themselves. Several recent studies show that without access to premium markets or

significant subsidies, smallholders' take-up of technologies to manage aflatoxin is generally low. For example, 6.9% of groundnut farmers in Northern Ghana were observed to use plastic drying sheets after receiving training on aflatoxin prevention and an opportunity to purchase these (Magnan et al., 2019), maize farmers in the Upper East region of Kenya dried 28% of their harvest when offered access to a maize dryer (Hoffmann and Jones, 2018), and 13% of maize farmers in the same area purchased enough biocontrol product to treat approximately a third of their land under maize when the product was offered at less than 50% of its recommended retail price (Hoffmann et al., 2018b). When the drying sheets and the drying service were offered free of charge, directly observed usage rates climbed to 54%, 62% respectively.

Figure 3: Farmer use of technologies when offered for a price and free of charge



Farmers in field trials through which hermetic storage bags are offered typically purchase only one bag, not enough to store all their maize (Pretari et al., 2019). In a large-scale field experiment in Uganda, fewer than 5% of farmers purchased the bags after heavy promotion, but demand was higher among farmers who had previously been given free bags to try, as well as those in villages where the bags were given to others (Omotilewa et al., 2019). Contrary to oft-cited fears that subsidies may discourage market demand, this shows that providing discounts or free trials of new technologies can stimulate experimentation and lead to higher demand in the long run.

Market linkages can increase subsistence producers' investment

Even if farmers produce primarily for subsistence, opportunities to sell aflatoxin-safe produce at a premium price can increase the area they treat. Offering a modest premium price of 100 Ksh/bag for aflatoxin-safe maize to smallholder farmers in Kenya was found to have no impact on the proportion of farmers who used biocontrol, but it did increase the area treated (Hoffmann et al., 2018b). Most farmers in this study reported using the product to treat maize for home consumption. Access to a premium market gave farmers a place to sell their excess treated maize at a profit in case of a good harvest.

Promote diversification away from maize

In many regions, smallholders rely on just one or two crops, both for income and consumption needs. When these crops are maize or groundnut, this can imply high levels of aflatoxin exposure. Promoting other crops in aflatoxin-prone regions, as well as dietary diversity, can have multiple benefits, including lower aflatoxin exposure and improved resilience, as maize can be sensitive to drought.

Control other risk factors

Health education and outreach in populations with high aflatoxin exposure should tackle the other major risk factors for liver cancer. In Africa these are hepatitis B and C viral infections and alcohol consumption. (Bahari et al., 2011; Kew, 2013). Vaccination for hepatitis B is particularly important, as infection with this virus multiplies the effect of aflatoxin exposure on cancer 30-fold (FAO/WHO, 2002).

Commercial production

While farmers have a personal interest in controlling aflatoxin in crops produced for home consumption, extrinsic motivators, such as premium prices and market access, are necessary to encourage investment in the safety of maize produced for sale. Without such incentives, farmers tend to take fewer precautions to improve the safety of the food they sell, compared to when food is used for household consumption (Hoffmann and Jones, 2018; Kadjo et al., 2019).

Formal sector maize processors in Kenya with the most stringent quality requirements, including aflatoxin safety, offer the higher prices in the market. However, these millers are located far from parts of the country where aflatoxin levels tend to be highest, and mostly source from relatively aflatoxin-safe areas.

Don't expect consumers to drive demand, though they do value food safety

Health effects of aflatoxin are not immediate in humans except at very high levels that are seldom observed. Consumers therefore rely either on labeling of aflatoxin-safe products, or warnings from government or others that particular products are not safe.

A recent study of consumer demand for a maize flour labeled and promoted as aflatoxin-tested and third party verified, with no mark-up, found that demand was only higher during an active in-store marketing effort, and that this effect wore off after the first week of marketing. A temporary discount on the flour increased post-discount market share, but its impact on sales also disappeared after 7 weeks (Hoffmann et al., 2018c).

The limited effect of food safety focused promotion could stem from an assumption that if food is packaged and labeled with the KEBS mark of quality, it must be safe. An experiment that provided information to maize flour consumers in Meru, Kenya found that providing information on which maize brands were safest had no impact on purchase behavior. However, when consumers were in addition given the opportunity to have their maize tested, they were nearly twice as likely to be buying one of the safer brands over two months later, regardless of the outcome of the test (Kariuki and Hoffmann, 2019). This demonstrates that consumers do value food safety once they are aware of the risk of contamination.

Enforce standards – while also building capacity

Enforcement of aflatoxin regulations in marketed maize by county governments can create the conditions under which processors in high-aflatoxin areas demand that the maize they purchase is safe. However, if implemented in isolation, consignments rejected by regulated firms will likely be sold to the informal market. This simply shifts aflatoxin exposure – likely to poorer consumers – without improving public health.

It is therefore important to combine enforcement of regulations with interventions that make the tools to manage aflatoxin available to farmers. In addition, farmers need to be linked directly to buyers that value aflatoxin safety. When crops are handled by one or more intermediary between farmer and end buyer, farmers are unlikely to reap the rewards for their work to control aflatoxin, discouraging such efforts.

Current regulatory standards are low relative to contamination levels. This means that in some regions, a large proportion of commodities are non-compliant, and enforcement may not be feasible. Enforcement agencies may consider taking a tiered approach, whereby the action in response to a violation ranges from informing the firm at near-compliant levels of contamination, to issuing a mandatory product recall at very high contamination levels.

Educate producers to ensure they benefit from health gains

While linking farmers to premium markets is important, such linkages are not sufficient to ensure that farmers also benefit from reduced aflatoxin exposure. In the example from Nigeria described above in which biocontrol was promoted through a market incentive, there is evidence that close to half of maize was consumed by producers or sold through informal markets, indicating significant spillover effects beyond the premium value chain (Schreurs et al., 2019). However, farmer awareness of the health concerns associated was not a targeted outcome. As a result, knowledge of the health risks, particularly among household members responsible for food preparation, remained low, and an independent evaluation of the project found limited effects on household consumption on safe maize (Narayan et al., 2019).

This highlights a risk of entrusting promotion of aflatoxin control solely to commercial actors, who have an incentive to ensure that the technologies provided are applied to the outputs they buy. To address this risk, the public sector could require (with support) that firms provide information on the health benefits of aflatoxin control, as well as sufficient inputs to treat food grown for home consumption as well as that which is sold. A few firms have prioritized mycotoxin management in smallholder settings as part of their corporate social responsibility strategies (Hanlon et al., 2019).

6. Improving capacity for sampling and testing

Accurate sampling and testing for aflatoxin by private value chain actors as well as regulatory authorities is critical to effective aflatoxin control. This can be achieved through adoption of a quality systems approach. An example of such a program is Aflatoxin Proficiency Testing and Control in Africa (APTECA), a program launched in Kenya in 2014 by Texas A&M AgriLife Research.

The program mobilized large-scale private sector millers through Kenya's Cereal Millers Association as well as government agencies in collaboration with an outreach effort by the Common Market for Eastern and Southern Africa (COMESA). The principle focus of APTECA was the introduction of a quality systems approach to manage aflatoxin risk based on a similar program in the state of Texas (Sasser et al 2018). Characteristics of the quality system included development of a food safety plan, analyst qualification to accurately test for aflatoxin, use of test kits validated using the United States Department of Agriculture's Federal Grain Inspection Service aflatoxin validation protocol (USDA, 2018), use of working controls (reference material prepared by an ISO 17034:2016 accredited laboratory), and participation in an accredited proficiency testing program (ISO/IEC 17043:2010).

The food safety plan contains management's commitment to implementation of a statistically derived risk-based plan including sampling incoming ingredients and finished product based on national or international standards. The overall effectiveness of the food safety plan implementation is verified through use of an ISO/IEC 17025:2017 accredited reference laboratory.

Since its inception in 2014, the APTECA program offered hands-on Aflatoxin Testing and Qualification Workshops in 5 African countries, resulting in 300 qualified analysts working in public and private sector laboratories. The proficiency testing portion of the APTECA program now includes 201 laboratories in 62 countries. The aflatoxin proficiency testing program is provided free of charge to participants who may register online at the program website (pt.tamu.edu). A quality systems approach to measuring aflatoxin employs universal principles for testing accuracy suitable to all laboratories and the introduction of these principles in Texas and Kenya have resulted in similar testing accuracy improvement (Sasser et al., 2018; Herrman et al., 2020). The APTECA program has expanded to include policy development and introduction of regulatory risk management strategies at a county and national level (Fannin, 2017; Fannin, 2019).

7. Distributional considerations

Exposure to aflatoxin, like many food safety hazards, tends to be higher among socio-economically disadvantaged groups (Leroy, Wang and Jones, 2015). Increasing access to testing, while important for building aflatoxin management systems and supporting market incentives to produce and maintain safer food, carries the risk of exacerbating this disparity. To mitigate this potential consequence, interventions should always aim to reduce the overall level of contamination in the food supply. This can be achieved by increasing farmer access to the biocontrol, drying and storage technologies described above widely available, and through the diversion of contaminated crops to uses that reduce the level of human exposure (for example to the feed of less aflatoxin-susceptible species, augmented with binders as appropriate, or to non-food industrial uses).

8. Summary of recommendations

- ▶ Prioritize aflatoxin control in foods consumed by infants, for whom exposure may imply additional risks, and widely consumed staples, especially maize.
- ▶ Provide targeted subsidies for aflatoxin control technologies to smallholder farmers in highly affected regions.
- ▶ Some interventions (e.g. aluminosilicate binders) are mainly effective against aflatoxins: others, (e.g. proper storage) are effective against a much broader range of mycotoxins.
- ▶ Consider cost-effectiveness in selecting technologies to subsidize; for biocontrol cost-effectiveness depends on yield. Combining biocontrol with yield-increasing inputs such as fertilizer and high-yielding seeds can improve cost-effectiveness.
- ▶ Ensure that farmers know how to use technologies as effectiveness depends on appropriate use. This is especially important for correct timing of biocontrol application and adequate drying of crops prior to hermetic storage.
- ▶ Demand for aflatoxin safe food is likely to remain limited outside of niche markets, but compliance can be encouraged through enforcement of regulations. To improve public health, enforcement must be accompanied by capacity building of all value chain actors, and support of direct links to farmers.
- ▶ Impacts of a private sector led approach to aflatoxin control will be concentrated in niche premium markets. Some spillover impacts on the safety of food consumed by producers can occur, and the public sector has a role to play in expanding such gains by ensuring that producers are educated about the health risks of aflatoxin exposure.
- ▶ Testing capacity in both the public and private sector can be improved through verification of test results by independent laboratories.
- ▶ Improved testing for aflatoxin should always be accompanied by programs that reduce the overall level of contamination, and high-aflatoxin food should be diverted to non-food uses. Programs that rely on testing alone to achieve compliance in the formal sector could increase aflatoxin exposure among low-income populations who rely on food informal markets.
- ▶ All infants and older unvaccinated individuals should be vaccinated against hepatitis B virus; this greatly reduces the effect of aflatoxin exposure on cancer risk.
- ▶ Promote crops other than maize and groundnut in aflatoxin-prone areas.
- ▶ Promote dietary diversity through nutrition education.

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ADDITIONAL RESOURCES

<https://aflasafe.com/resources/policy-briefs/>

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