PACA

Partnership for Aflatoxin Control in Africa | Partenariat pour lutter contre l'aflatoxine en Afrique | Parceria para o Controle da Aflatoxina em África | الشراكة من أجل مكافحة الافلاتوكسين في أفريقيا

Aflatoxin Impacts and Potential Solutions in Agriculture, Trade, and Health

A Background Paper for the PACA Strategy Development – Stakeholder Consultation Workshop

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Introduction

Aflatoxins are naturally occurring toxins produced by certain fungi, most importantly *Aspergillus flavus and Aspergillus parasiticus.* Aflatoxins contaminate many African dietary staples such as maize, groundnuts, rice, and cassava, particularly under certain conditions: dry weather during planting, high moisture during harvest, inadequate drying and storage of crops. Countries in latitudes between 40°N and 40°S—which includes all of Africa—are susceptible to aflatoxin contamination.

Aflatoxin contamination of key staples—maize, groundnuts and sorghum—occurs above safe levels in many African countries. Prevalence data from Africa suggests that aflatoxin contamination in maize, groundnuts and sorghum is higher than the European Union aflatoxin standard (4 ppb) and that of USA (20 ppb) in many countries. However, even aflatoxin exposure at low levels can result in measurable human health impacts.[i]

This paper provides an overview of the impacts of aflatoxin in the agriculture, trade, and health sectors in Africa, as well as the range of solutions that are being developed. The paper serves as background reading for the *Partnership for Aflatoxin Control in Africa (PACA) Strategy Development – Stakeholder Consultation Workshop*.[1]

Impacts on Agriculture and Food Security, Trade, and Health

Agriculture and Food Security. Aflatoxin contamination of key staples can affect the agricultural sector output, generally, and each of the four pillars of food security (availability, access, utilization, and stability), specifically. Contamination in staples such as maize, sorghum and groundnuts can directly reduce *availability* of food. Producers of the affected crop may also earn less because of product rejection, reduced market value, or inability to gain access to the higher-value international trade market. Lower farmer income in turn limits ability to purchase food for the family, which translates into reduced *access* to food. Contamination reduces use options for the affected produce through complete rejection or need to put it to other safe uses. Given the link between aflatoxin and adverse human health impact—particularly the confirmed linkages to liver cancer, synergistic effects with Hepatitis B, and potential association with stunting and immunosuppression — contaminated food presents a clear food security threat.

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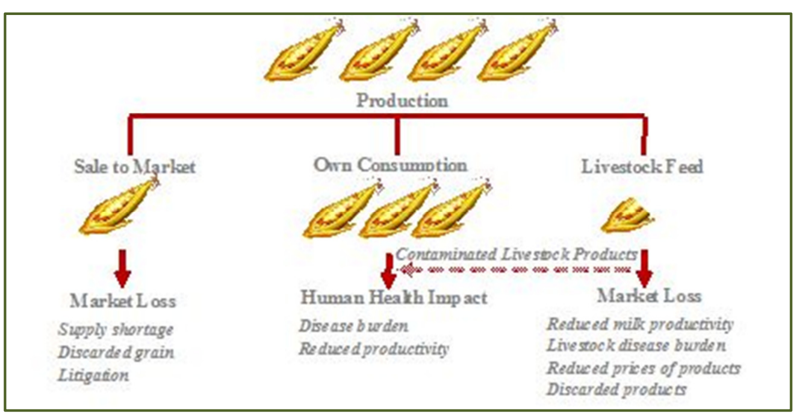
[1] This paper is largely based on a Technical Brief developed by Abt Associates in 2012.

Trade. Many countries have established regulations to limit exposure to aflatoxin, typically expressed in parts per billion (ppb). Some countries have different limits depending on the intended use, the tightest applying to human consumption and exports, and the highest to industrial products. These regulations can result in foregone trade revenues arising from increased cost of meeting the standards – including cost of testing, rejection of shipments and even eventual loss of admissibility into foreign markets. The direct economic impact of aflatoxin contamination in crops results mainly from a reduction in marketable volume, loss in value in the national markets, inadmissibility or rejection of products by the international market, and losses incurred from livestock disease, consequential morbidity and mortality. Specifically, in the international market, products that do not meet the aflatoxin standards are either rejected at the border, rejected in channels of distribution, assigned a reduced price, or diverted to non-human or even non-fee uses. Similar economic losses may occur in domestic markets if consumer awareness about the problem rises, if leaders in marketing channels begin to pay more attention, and/or if regulations are either tightened or more strictly enforced. Under any of these circumstances, premiums for aflatoxin-free commodities may be realized for a limited period of time. In the long run, the premium will eventually vanish as compliance becomes a threshold condition for being accepted as a supplier. While it may seem that tighter phytosanitary standards imply more costs than benefits, in fact once suppliers internalize the economic costs of non-compliance and bear them as a financial cost, greater economic benefits for society will arise in several forms, including larger and more stable markets and reduced burden of disease.

Health. If aflatoxin-contaminated crops are consumed by humans, aflatoxin poisoning (i.e. aflatoxicosis) can occur. Chronic exposure to even low levels of contamination in crops consumed regularly increases liver cancer risk and can suppress the immune system. Aflatoxin can also enter the human diet through livestock products if the livestock are given contaminated feed. High levels can be fatal. Children can also be affected through breast milk or direct consumption of weaning foods. Some experts suspect association of aflatoxin exposure with child growth stunting.

Prevalence and the Relative Magnitude of Impacts

The relative magnitude of impact on agriculture and food security, human health, and trade for a country depends on the uses of aflatoxin contaminated crops in the country.



The economic impact of aflatoxin contamination depends on the contribution that the susceptible commodity makes to a country's consumption and income. In particular, it depends on the commodity's share in the nutrient requirements for the household, its share as a source of income derived via domestic and international trade, and the extent of awareness about the problem within households and markets. If there is general awareness of aflatoxin in a country and there are supporting regulations and institutions, then the human health impact of aflatoxin contamination will be low but market impact will be high. This is because producers will have to bear the burden of reduced revenues from discarded grains or costs borne for prevention and control strategies. On the other hand, if awareness is low and there are inadequate regulations to control it, aflatoxin-contaminated grain will trade freely, in which case the health impacts will be high – this is largely true in Africa. The majority of maize production in Africa is used for a producer's own consumption, implying that the human health impact will be the greatest if there is lack of awareness about aflatoxin.

Aflatoxins disproportionately impact the poor. Food-insecure households are more likely to consume contaminated food rather than sell it at lower prices or discard it. The poor may also not be able to adopt costly control strategies. A well-intentioned awareness campaign can reduce prices for aflatoxin-contaminated food, resulting in direct market losses for the poor and more severe health impacts because of farmers' own consumption of low-price-yielding, contaminated grain. Therefore, policies and regulations to control aflatoxins require particular care in accounting for the distributional impact.

In many African countries, women make up the majority of the agricultural labor force. Therefore, it is critical to consider how aflatoxin recommendations and mitigation interventions will be accessed by men and women, as gender may influence access to and adoption of agricultural technologies, information, inputs, finance and decision making authority with regard to planting, marketing and harvesting. Studies in Nigeria and Uganda found that women did make final decisions about pre- and post-harvest production, including storage and marketing practices. Thus deliberate focus on women in the development and implementation of aflatoxin prevention and control programs and strategies is crucial (Ogunlela and Mukhtar, 2009).

In addition to information flows, gender roles, flows of income, and divisions of labor, women's access to inputs (insecticides, storage equipment, bio-controls), and finance (loans, credit and savings schemes) as well as time, are key factors affecting their ability to effectively prevent and control aflatoxin contamination at the household and community level. Further, local customs or regulations affecting land tenure, mandates for extension services, and education for women and girls also determines women's access to and adoption of new technologies and practices. Customs, norms and laws that affect women's access to resources, assets and inputs affect their standing in the household, community and market. Women's standing in turn affects their autonomy to make household health and consumption decisions such as diversifying the household's diet, spending household resources on vaccinations, or using agricultural revenue to invest in promising technologies such as bio-controls, storage cribs, or wooden pallets (World Bank, FAO, IFAD 2009).

Action is Needed Now

Crops affected by aflatoxins such as maize and groundnuts are important for household food security in many African countries. Conditions across Africa contribute to widespread aflatoxin prevalence and chronic exposure, which has devastating impacts on Africa's farmers, consumers, and economic development. Action is needed now because:

- Even at low levels of aflatoxin contamination of key staples, there is measurable health impact because of high contribution of the staples in the African diet.[ii]
- Liver cancer risk attributable to aflatoxins is higher for countries with greater prevalence of aflatoxins.[iii]
- A recent study from Kenya shows that populations from all economic strata have high aflatoxin exposure. The level of aflatoxin B1—the most toxic of the aflatoxins—in blood serum was similar across rich and poor, with the highest burden amongst the middle wealth quintile.[iv]
- Aflatoxin contamination can result in direct economic impact through export rejections from importers with stringent aflatoxin regulations such as the European Union (EU) countries. Between 2007 and 2012, the EU alone has issued 346 notifications to African countries.[v]
- Aflatoxin contamination in Africa contributes to the inability of most African countries to access high-value international trade markets. Lowering aflatoxin prevalence in key crops could reduce the barrier to trade in maize and groundnuts especially, and could result in increase in export of maize by Africa[vi].

Potential Solutions for Aflatoxin Control in Africa

Actions to mitigate the problem of aflatoxin should ensure that information and resources on aflatoxin control are targeted towards areas that result in high impact whether in agriculture, trade, or health. Interventions must recognize that aflatoxin contamination may disproportionately impact the poor. At the same time, poor farmers may not be able to access control strategies or afford commercially available agricultural inputs known to directly or indirectly reduce aflatoxin levels. Design of aflatoxin control strategies must also take into account the role that women play in management of pre- and post-harvest production and household consumption. The following table outlines examples of potential solutions that are being developed in some countries, or could be developed, to control aflatoxin in Africa.

Agriculture and Food Security

Good Agricultural Practices at planting, harvest and post-harvest handling

- Use aflatoxin-resistant planting materials including conventional and transgenic breeding.[vii]
- Use bio-controls such as Aflasafe™, proven to reduce aflatoxin levels in soil.[viii]
- Use irrigation, fungicides, herbicides and insecticides for healthier plants that resist fungus.[ix]
- Adopt moisture-control measures like solar drying, tarp drying, and promote improved storage (including hermetic storage of maize, sorghum).[x]
- Emphasize the importance of sorting and discarding crops with physical flaws and deformities (e.g., visible mold or damaged shells).[xi]
- Conduct further research on use of aflatoxin-resistant planting materials, including conventional and transgenic breeding.

Explore alternative uses of unsafe commodities.

- Promote research on safe disposal and alternative use of unsafe commodities, such as biofuels or blended feeds (which in the aggregate conform to safe maximum levels) and finishing feeds, which can have slightly higher levels (300ppb) of aflatoxin without harming the animal.[xii]
- Conduct further research on ammoniation and other commercial processing techniques.[xiii]

Incorporate messages about aflatoxin mitigation into agricultural extension messages.

Evaluate how these recommendations affect labor burdens on men vs. women and recommend labor-sharing strategies for both.

Trade

Awareness campaigns to increase demand for aflatoxin safe products and incentivize adoption of aflatoxin control strategies along the value chain

- Increase agro-dealer education and partnerships to promote commercial/subsidized distribution of aflatoxin-reducing inputs (e.g. bio-controls, drought and disease resistant seeds) to farmers.
- Collaborate with existing agriculture development projects to promote safe production through Aflasafe, improved seeds and other agricultural inputs.
- Educate and persuade retailers and consumers to incentivize safer crops and harvest among buyers and sellers.
- Provide training to traders, processors, manufacturers and livestock producers.

Food safety control system upgrading

- Establish robust regulatory foundation to address aflatoxin in national food safety standards.
- Establish country-specific standards that account for consumption patterns building on Codex Alimentarius, consistent with the World Trade Organization Sanitary and Phytosanitary Agreement.
- Ensure that official and private food safety standards reflect Good Manufacturing Practices (GMP) and the Hazard Analysis and Critical Control Point (HACCP) approach.
- Adjust national food safety standards based on ranges of consumption of different commodities (e.g Average Daily Intake) and considering the tolerance level of the consumer.
- Set standards for animal feed at higher levels than for commodities destined for human consumption; use grading system to ensure safe levels for both.

Enhanced laboratory capacity and availability of rapid test kits, trained users, documentation of results, and withdrawal of contaminated products to enable greater separation of contaminated crops in markets, assembly points, export points and prior to processing. This could include carrying out more regular testing of aflatoxin levels in major foods, and establishing reference laboratories for mycotoxin studies.

Improved trader compliance with national regulatory codes

- Widely disseminate specifications for acceptable aflatoxin maximum limits.
- Enhance inspection capacity of the national enforcement agencies for food safety.
- Create public campaigns to increase visibility and perceived value of a certification of inspection, signifying that commodities and products are below regulated levels of aflatoxin contamination.
- Provide technical support to improve capacity of medium to large traders and enforcement agencies to recognize 'mark of quality' by the national enforcement agency.

Commodity exchange systems. Create warehouse receipts systems to encourage proper detection, culling, warehousing and storage and incorporation of aflatoxin and food safety concerns in the key crop marketing boards.

Import and export controls. Improve controls on cross-border movement of contaminated products.

Health

Dietary diversity and food safety promotion to minimize aflatoxin exposure at home

- Reduce excessive caloric dependence on susceptible products,

- Reduce daily and long-term intake of products at risk,
- Conduct multi-sectoral food safety behavioral change campaigns,
- Promote improved household food processes[xiv].

Protect infants through routine testing for levels of aflatoxin in mother and breastmilk.

Prevent absorption of the toxic effects of aflatoxin through enterosorbents such as NovaSil™ clay, calcium chrlorophyllin, which capture aflatoxin in the gastrointestinal tract and facilitate its elimination. Some enterosorbents may be appropriate for treatment for acute outbreaks of aflatoxicosis, but not for chronic treatment due to cost and possible side effects.[xv]

Reduce the carcinogenic effect of aflatoxin through use of chemopreventive agents such as Oltipraz, green tea polyphenols, and Sulforaphane, which trigger detoxifying enzymes or inhibit enzymes required for the activation of procarcinogens.[xvi]

Reduce co-morbidity effects through Hepatitis B Vaccine.

Promote animal health through use of aflatoxin-safe feed or chemical toxin binders and anti-caking agent (e.g. NovaSil) in animal feed.[xvii]

Conduct advocacy campaigns among major institutional representatives from the health field to shore up awareness and coordinated efforts that include the health sector.

Conduct population monitoring and mapping of the exposure to aflatoxins using biomarkers.

Conclusion

Comprehensive, multi-sectoral approaches are required to control aflatoxin and improve the health, income, and livelihoods of African farmers, farm households and consumers. A comprehensive aflatoxin program will include a range of complementary components, including: effective policies, standards and regulations; policy-relevant information from economic, food security and health assessments; campaigns to raise consumer demand for safe, high-quality food; distribution and adoption of improved inputs and improved quality of production; (market) mechanisms to inspect commodities, regulate quality, and ensure proper storage; access to safe and high quality food ingredients; and efficient withdrawal of and alternative uses for contaminated commodities. Actions are needed at all levels (continental, national, regional and local) to reduce aflatoxin prevalence and exposure in Africa.

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End Notes

[i] Abt Associates review of a range of reported means from published studies (ppb); provided to PACA in 2012, compiled from articles published after 1990, with mean aflatoxin occurrence data on maize, groundnuts and sorghum in Africa.

[ii] In Tanzania, given the consumption patterns for maize and groundnuts in 2008/9, even at prevalence rates of 5 ppb, the monetized burden is between $18 million and $147 million (in 2010 U.S. dollars), while at 10 ppb the monetized burden is between $35 million and $294 million (in 2010 U.S. dollars). See Country Assessment for Aflatoxin Contamination and Control in Tanzania, Abt Associates 2013. The estimates for liver cancer impact are based on (i) aflatoxin liver cancer potency values recommended by JEFAC 1998; (ii) age and region specific maize and groundnut consumption levels estimated using national representative weekly consumption data from the Living Standards Measurement Survey-ISA, 2008/9; (iii) estimated 2010 population by age and sex from the United States Census Bureau International Database and Tanzania census; (iv) region (west and east sub-Saharan Africa), age- and sex-specific hepatitis B (HBV) prevalence from Ott et al (2012); (v) WHO-region and sex-specific DALY estimates from WHO 2008 and (vi) mortality valuation estimates (value of statistical life) derived using methods in Hamitt and Robinson, 2011. The monetized estimates assume that the willingness to pay for to avoiding risk of death in Tanzania differ from U.S. only in scale because of differences in the level of incomes, and income elasticity. In reality it is possible that in places where level of income is lower, health is considered a luxury and is undervalued so that willingness to pay avoid risk of deaths is lower. To this extent, our estimates may be an overestimate.

[iii] In Nigeria, given the consumption patterns in 2010/2011 imply at aflatoxin contamination at 10 ppb, 1,152 liver cancer cases can be attributed to aflatoxins, while at 20 ppb 2,305 liver cancer cases can be attributed to aflatoxins. At prevalence rates of 10 ppb, the monetized burden is between $56 and $471 million (in 2010 U.S. dollars), while at 20 ppb the monetized burden is between $112 and $942 million (in 2010 U.S. dollars). It is noteworthy that in 2010, Nigeria GDP was $197 billion (in 2010 U.S. dollars), so the high estimate at 20 ppb constitutes roughly 0.5% of Nigeria GDP. See Country Assessment for Aflatoxin Contamination and Control in Tanzania, Abt Associates 2013. The estimation was similar to Tanzania estimates except that the average weekly consumption estimates came from Nigeria Living Standard Measurement Survey-ISA, 2010-2011. As before, the monetized estimates assume that the willingness to pay for to avoiding risk of death in Nigeria differ from U.S. only in scale because of differences in the level of incomes, and income elasticity. In reality it is possible that in places where level of income is lower, health is considered a luxury and is undervalued so that willingness to pay avoid risk of deaths is lower. To this extent, our estimates may be an overestimate.

[iv] 2007 Kenya AIDS Indicator Survey – Serum Aflatoxins Analysis Final Report, Center for Disease Control and Prevention and National Center for Environmental Health.

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[vi] Munasib, Abdul and Devesh Roy, (2012) "Nontariff Barriers as Bridge to Cross," International Food Policy Research Institute.

[vii] Conventional seed breeding for aflatoxin resistance has reduced aflatoxin by >70% and 82–93%) Transgenic breeding for aflatoxin resistance has reduced aflatoxins by 47% in maize (Khlangwiset, 2011).

[viii] Several studies have found significant levels of aflatoxin from the competitive use of fungus including a 60-87% reduction (Donner et. al 1999), a 70-91% reduction (Donner and Horn 2007), and an 80% reduction (Cline, 2005).

[ix] One study found 99% reduction in aflatoxin from irrigation+insectide, though irrigation costs were $120-1200/acre (Khlangwiset, 2011).

[x] In Guinea a post-harvest package for groundnut growers included; education on hand-sorting and sun drying, use of natural-fibre bags for storage, wooden pallets for storing the bags and insecticides applied to storage floor under wooden pallet lowered aflatoxin-albumin concentrations in blood 57.2% compared to a control (Turner, 2005).

[xi] Turner, 2005.
[xii]The United States Department of Agriculture, for example, allows for aflatoxin contamination of up to 300 ppb for maize and groundnuts destined for finishing feed (feed used for up to 2 weeks before slaughter) for cattle, <200 ppb for finishing feed for swine, <100 ppb for breeding cattle, swine, and mature poultry, and <20 ppb for dairy cows and young animals. (Dohlman 2008, US FDA 2000, Rowe, 2007).
[xiii] Placing maize crops in a sealed container for 1-2 weeks and applying ammonation gas could could reduce aflatoxin levels by 90% (Nyandieka et al 2009).
[xiv] In Benin, preparation of traditional dishes: akassa (maize-based thick paste, stew) and makume resulted in 93% and 92% reduction in aflatoxins. Sorting, winnowing, washing, crushing combined with dehulling of maize grains were the unit operations that appeared very effective in achieving significant mycotoxin removal. Aflatoxins were significantly recovered in discarded mouldy and damaged grains and in washing water (Breinig et. al 2007).
[xv] (Khlangwiset, 2011)
[xvi] Chemopreventive agents may be more viable for preventive use, and further research is ongoing. Some enteroasorbents may be more appropriate only to address acute aflatoxicosis and may not be suitable for daily or ongoing use. Continued research on side effects and long term effects of chemopreventive agents and enteroasorbents is ongoing. Green tea polyphenols which have lowered contaminated in human blood levels are viewed as potentially viable and affordable dietary inhibitors (Khlangwiset, 2011). Studies have shown a 43% lower AFM1 in humans; and > 15% lower aflatoxin albumin adducts at 500 mg dose at costs of approximately $0.20 – $1 per day (Strosnider et al., 2006).
[xvii] To prevent the harmful effects of aflatoxins in animals, chemical compounds and polymers known as 'binding agents' can be added to animal feed for pennies on the metric ton of animal feed. These binders can neutralize up to 90% of contaminants from maize during processing (Whitlow 2006).

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