PAEPARD

FARA
Forum for Agricultural Research in Africa

Research to Action

Recommendations and action plan to mitigate aflatoxin contamination of food and feed

Synthesis of a dialog between policy makers, scientists and research users at the Roundtable of aflatoxin experts, Brussels, Monday 25th January 2016

Solutions:

- Testing for mycotoxins
- Raising awareness of all actors through education, information and knowledge sharing
- Good pre-harvest agricultural practices
- At harvest practices
- Good postharvest practices
- Good Manufacturing Practices

The *Roundtable of aflatoxin experts* was organized by **PAEPARD** – the Platform for African-European Partnership in Agricultural Research for Development — with the support of the Directorate General Santé of the European Commission and the East African Farmer Federation (**EAFF**), and in collaboration with the Partnership for Aflatoxin Control in Africa (**PACA**) and the African Society of Mycotoxicology (**ASM**), Acknowledgments

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This report provides a synthesis of concepts, practices and interventions coming from PAEPARD's Round Table of aflatoxin experts.

It aims to provide decision makers and development professionals with new and practical perspectives – to add value to their programs and inform decision making on agriculture and rural development policies, practices and programs in Africa.

Key words:
food safety, aflatoxins, value chains, crop improvement, post-harvest management, maize, groundnuts

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About Aflatoxin

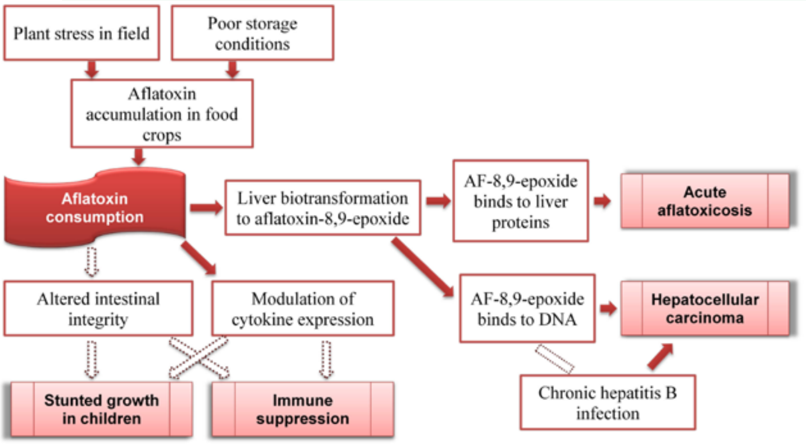
Aflatoxins are a group of approximately 20 related fungal metabolites produced primarily by the fungi Aspergillus flavus and A. parasiticus. The four major naturally produced aflatoxins are known as B1, B2, G1, and G2. Aflatoxin B1, the most toxic of the aflatoxins, is the most potent naturally occurring chemical liver carcinogen known.

Aflatoxins and their health consequences

Aspergillus flavus and A. parasiticus colonize a wide variety of food commodities including maize, oilseeds, spices, groundnuts, tree nuts, milk, and dried fruit (Strosnider et al. 2006). Whether these fungi produce aflatoxin depends on drought stress and rainfall, suitability of crop genotype for its climate, insect damage, and agricultural practices (Wu and Khlangwiset 2010). These fungi can also produce aflatoxin in postharvest conditions: storage, transportation, and food processing. aflatoxins get in milk mainly from cows eating contaminated feed. *Aspergillus flavus and A. parasiticus* can colonise cheese.

Aflatoxin contamination is a particular problem in maize, oilseeds, spices, peanuts, tree nuts (almonds, pistachios, hazelnuts, pecans, Brazil nuts, and walnuts) and dried fruit (Shephard, 2008). Maize and peanuts are the main sources of human exposure to aflatoxin because they are so highly consumed worldwide and unfortunately are also the most susceptible crops to aflatoxin contamination (Wu and Khlangwiset 2010).

The figure below (Wu 2010) depicts the pathway by which aflatoxin accumulates in food crops and contributes to various adverse human health effects.



"Aflatoxin is a good example of "how" to improve impact on global challenges of European Research and Innovation. It is not only a local issue but has global impacts (through international trade), it affects (in different ways) all stakeholders along the value-chain, and it needs public regulation (for the protection of consumers) with collaboration of private actors. It is also a domain where Europe has invested a lot in Research and Innovation and has made some substantial progress."

Philippe PETITHUGUENIN
Directeur général délégué adjoint à la recherche et à la stratégie
CIRAD, Montpellier

"The mitigation of aflatoxin contamination in the food chain can set an example for other multi stakeholder approaches related to food safety affecting food and feed in Africa and in other continents"

Antonio LOGRIECO
Istituto Scienze delle Produzioni Alimentari (ISPA), Bari,

Evidence from Africa

Evidence on association of aflatoxin exposure and child growth

Geography	Findings (correlation)	Reference
Ghana, The Gambia	Exposure during pregnancy and smaller babies during the first weeks of life	Barett (2005), Review
Tanzania	Exposure and reduced weight and height among breast fed infants under 6 months	Magoha et al. (2014)
Benin, Togo	Between higher levels of aflatoxins and lower growth rates	Gong et al. (2002)
Togo, Iran, Kenya, UAE	Exposure and stunting in children	Barett (2005), Review

Current research on aflatoxin and stunting (funded by BMGF)[1]

Study	Expected contribution	Lead organization
The relationship between aflatoxin exposure and child stunting in W&S Africa	Determine mechanism by which aflatoxin inhibit early growth Validating biomarkers	Queen's University of Belfast, UK, led by Yun-Yun Gong
Association of aflatoxin exposure and childhood stunting in Bangladesh	Improve understanding of how aflatoxin affect the growth of children under 5 in Bangladesh	ICDDR, Bangladesh with Univ. Venda, SA; Univ. Virginia, Univ. Pittsburgh, USA
Mycotoxins as a risk factor in childhood growth impairment worldwide	Integrated information on the role of dietary mycotoxins in child growth impairment	Michigan State University, USA, led by Felicia Wu
Assessing aflatoxin exposure and malnutrition among children in East Africa	Pathogenesis of toxin-induced gut dysfunction and child stunting	Cornell University, USA

Economic Impact Estimates: Case Studies (PACA, 2012; 2015)

- Costs based on monetization of the DALYs[2] is economic loss due to mortality and morbidity.
- Estimates capture only the amount of money that would be saved from DALYs, if efforts to reduce aflatoxin exposures were exercised.
- Estimates do not take into account potential impact on national and international trade.
- Senegal estimated cost of action to achieve 20 ppb standard: USD 35 million

Country	DALYs lost	Monetized burden
Nigeria	100,965	between USD112 and 942 million
The Gambia	93,638	USD 94.4 million
Senegal	98,304	between USD 78 and 138 million
Tanzania	546,000	between USD 92 and 757 million

[1] There is also work by IFPRI funded by DFID

[2] DALYs = Disability Adjusted Life Years. The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability.

New ideas, new collaborations, new communications to fight aflatoxin

Climate change brings rising temperatures, and has increased the variability and intensity of rainfall, contributing to the spread and severity of aflatoxin contamination. Scientists and agricultural specialists around the globe are working to more effectively monitor, track and combat the effect of aflatoxin contamination. Early detection and well-organized reporting are the keys to better managing and reducing aflatoxin in regions at risk. This helps farmers, policymakers, national agricultural research and extension services to rapidly respond to outbreaks. Information flows, knowledge and collaboration across countries are key.

The purpose of this Round Table of aflatoxin experts meeting report is to provide new perspectives, share experiences and highlight potential solutions to the contamination of food and feed with aflatoxins that are re-emerging today in Europe but since decades have been threatening livelihoods and productivity growth in Africa and many other low-income countries throughout the world.

This is a synthesis of the debates of over 40 scientists, development actors and policymakers from 22 different countries – during the Roundtable of aflatoxin experts, Brussels, Monday 25th January 2016.

- It is a synthesis of the evidence debated and best practices shared by a group of leading scientists, with agriculture and development policy makers from many countries.
- It is an effort to quickly capture the knowledge and experiences shared at the meeting, and share these with all concerned.

It takes the discussion of the Round Table one step further:

- It examines the practical steps that can be taken to reduce the risk aflatoxin contamination.
- It is a call for interventions, action and long- term investment in combating aflatoxin contamination of food and feed.
- The concepts and approach summarized in this report are based as much as possible on technologies that can be used by farmers and the private sector in Africa.
- It has been prepared to inform the donor community (bilateral and multi-lateral) investing in agricultural research for development in Africa about what is needed to effectively manage the contamination of food and feed.
- It is also intended for national budget decision-makers and agricultural planners in countries affected by aflatoxin, and for a multitude of actors in the international development cooperation, whether they are supporting farmers' organisations, non-governmental organisations or agribusiness.

A long-term investment is needed to reduce aflatoxin

Acute aflatoxicosis, associated with extremely high doses of aflatoxin, is characterized by hemorrhage, acute liver damage, edema, and death in **humans**. Conditions increasing the likelihood of acute aflatoxicosis in humans include limited availability of food, environmental conditions that favor fungal development in crops and commodities, and lack of regulatory systems for aflatoxin monitoring and control. There have been several reported cases of acute aflatoxicosis in Africa associated with consumption of contaminated home-grown maize, including the outbreaks in Kenya in 1982, in which 12 people died, and in 2004, in which 317 people became ill and 125 people died in the central provinces (Nyikal et al. 2004; Azziz-Baumgartner et al. 2005; Probst et al 2007; Lewis et al. 2005; Stosnider et al. 2006; Siame and Nawa 2008).

Acute aflatoxicosis can also occur in **animals**. In 1960, more than 100,000 turkeys died on in the United Kingdom over the course of a few months, prompting the name "Turkey X disease" (Asao et al 1963). Later investigation revealed that the source of the disease was toxic peanut meal. In 1981, several hundred calves that had been fed on peanut hay died in Australia (McKenize et al 1981), and in 2007, several hundred animal deaths occurred on a chinchilla farm in Argentina; both these occurrences were linked to aflatoxin (González Pereyra et al, 2008).

A call to action from for continued investment

In summary, what is needed to reduce the level of aflatoxin contamination in harvests and people's livelihoods is a sustained investment in strengthening (presentation by PACA):

- **Knowledge and information:** less well documented health and nutritional impacts of aflatoxin; further research
- **Evidence-based and coherent policy development**: Avoiding parallel structures and developing AfricaAIMS as a one-stop shop for data on aflatoxins in Africa
- Support innovation: **revive worst affected crop value chains and other subsectors and increase market for smallholders and promote agribusiness**
- **Strong commitment** to serve Africa (smallholders and business)
- **Embedding aflatoxin control in nutrition and value chain development projects** involving susceptible commodities, for better impact

"There is an urgent need for having an incentive/motivation mechanism along with technology dissemination. In order for farmers to adopt the technologies and practices, they need to be affordable and available to relevant decision makers and to deliver expected benefits under farm household conditions"

Dr. Benoit Gnonlonfin, INRAB.

The predisposing factors

The main predisposing factor in **pre-harvest aflatoxin contamination** is stress of the host plant (such as maize or peanuts). Stress can be caused by multiple factors, including use of a hybrid type that is unsuitable for the local geography, drought stress, high temperatures, and/or insect damage and inoculum levels. All these factors increase the risk of the crop plant being infected by A. flavus or A. parasiticus.

The main predisposing factor in **postharvest aflatoxin accumulation in food** is poor storage conditions; namely, excessive heat and moisture, pest-related crop damage, and extensive periods of time spent in storage (exceeding several months).

When aflatoxin is consumed, it can exert toxicity in several ways. It may alter intestinal integrity (Gong et al. 2008) or modulate the expression of cytokines, proteins that "signal" to each other and to immune system components.

Both of these effects may result in stunted growth in children and/or immune suppression (Wu 2010).

The urgency of combating aflatoxin for food safety

For two decades now the problem of aflatoxin has been mainly confined to the research area. A meeting of experts in research and development in Berlin demonstrated that all kinds of actors get mobilized to tackle the problem, but bridging research and development in this field is still challenging due to the complexity of the contamination sources at pre- and post-harvest levels[3].

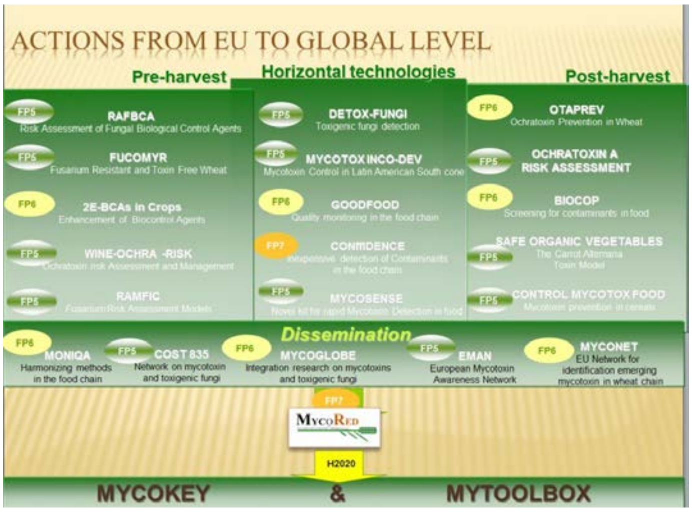
In Europe 39 nations (99 % of inhabitants of the region) have regulations and harmonized limits for aflatoxins, ochratoxin A, patulin, DON, zearalenone, fumonisins. There are EU food limits for T-2/HT-2, ergot alkaloids and other mycotoxins. EU feed limits exist for aflatoxin B1 and EU feed guidance values for ochratoxin A and some Fusarium toxins.

In Africa there are15 nations (59 % of inhabitants of the region) with known regulations. But for a majority of countries the regulations are unknown or non-existent. Several countries indicate regulations should be developed while regulations exist mainly for aflatoxins. The country with most detailed set of regulations in Africa is Morocco.

The EU Imported products with high risk of mycotoxin contamination are:

- maize, (fumonisins and aflatoxins) from all continents
- cereals (deoxynivalenol, ochratoxin A) mostly from north and south America
- coffee, (ochratoxin A) mostly South America & Africa
- pistachio nuts, (aflatoxins) mostly from North Africa & Asia
- Peanuts & other nuts, (aflatoxins) mostly North, South America & Africa
- Spices (aflatoxins) mostly from Asia & Africa

The trade losses due to Aflatoxins in Africa and export compliance with food safety and quality standards are estimated at: US$1.2 billion. The World Bank estimates the lost trade at US$ 450 million. The consequence is that the best quality is exported and the poorer quality is consumed domestically.



Because of the scale of the problem, which also affects European crops, the European Commission (EC) has funded a number of research projects to investigate several aspects related to toxic fungi and mycotoxins in food crops: the FP6 MYCO-GLOBE Specific Support Action (launched in October 2004), the FP7 MycoRed project which organised a number of international conferences in Africa (2006 Ghana, 2010 Egypt, 2011 South Africa), the FP7 MYCOHUNT project that developed rapid detection methods of mycotoxins in wheat.

[3] PAEPARD policy brief on the aflatoxin contamination of food and feed in Africa, October 2015, 8 pages

The 1st African Symposium on Mycotoxicology - Reducing mycotoxins in African food and feed - was held in April 2015, Livingstone, Zambia under the auspices of the International Society on Mycotoxicology (ISM), with the support of the Partnership for Aflatoxin Control in Africa (PACA) and from the European Union (through MycoRed).

The US government also gives considerable attention to aflatoxin contamination in Africa. A number of projects are financed by USAID/Washington under its Post-Harvest Loss and Mycotoxins Research Investments. The specific technologies that can be implemented at field level from below research needs to be assessed.

- The Peanut & Mycotoxin Innovation Lab has a portfolio of research projects focused on research along the peanut value chain in Haiti, Ghana, and a regional program for Malawi, Zambia, and Mozambique.
- Under the Norman Borlaug Commemorative Research Initiative USAID is funding marker-assisted maize breeding for aflatoxin resistance, and RNAi research in peanut.
- The Venganza (biotech company in North Carolina) is a public/private sector partnership using advanced RNAi breeding techniques to find genes that govern resistance to aflatoxin formation in maize.
- The Food Processing Innovation Lab (FPL) at Purdue University supports and strengthens the post-harvest segment of the value chain using a market-led approach to overcome constraints that create food losses in targeted Feed the Future countries. This is achieved through development and use of on-farm drying and storage technologies coupled with food processing innovations and mechanisms of dissemination that link farmers to markets.
- The Reduced Post Harvest Losses and Food Waste Innovation Lab at Kansas State University will provide global leadership to reduce post-harvest loss and food waste of durable staple crops (grains, oilseeds, legumes, root crops, seeds) and their processed value-added products. It will develop improved grain drying and storage technologies and moisture detection methods in Ghana, Ethiopia, Bangladesh and Guatemala.
- AflaSTOP (a Multi-donor funded project between USAID and Gates) aims at identifying the most promising storage options and dryers that will impede the growth of fungi-producing aflatoxin and ensuring that these are accessible to smallholder farmers through African businesses.
- Sanitary and phytosanitary (SPS) Work on Aflatoxin.
- Policy Support to PACA Secretariat.
- Programmatic Environmental Assessment of Manufacture, Field Testing, and Licensing of the Use of Aflasafe (TM) in Sub-Saharan Africa
- AgResults is a multi-donor initiative (U.S. Government, along with the governments of Australia, Canada, the United Kingdom, in partnership with the Bill & Melinda Gates Foundation) incentivizing high-impact agricultural innovations to promote global food security through design and implementation of pull mechanism pilots.
- AVRDC-PHL (Vegetable Post Harvest Handling Project). The purpose of this project is to minimize loss, preserve quality, maintain nutritional content, and ensure year round availability of exotic and indigenous vegetables through postharvest-focused research.
- Feed the Future Innovation Lab for Collaborative Research on Horticulture. Since the inception of the Lab in 2009, key postharvest activities have included: 1) establishment of a postharvest training center for East Africa in collaboration with AVRDC/Tanzania, 2) R&D on low cost cool storage technologies such as the "Cool Bot", 3) advanced approaches to solar drying technologies, and 4) postharvest handling of vegetable seeds through applications of ceramic drying beads and

Beginning in 2014, the AflaSTOP project selected, tested, and deployed low-cost storage and drying options for maize and other staple grains in Kenya. In 2014 through to 2016, the project will work with locally operating businesses to pilot commercialization models and identify ways to stimulate full commercialization and adoption of effective, low-cost storage and drying options. In 2015 and 2016, the project will also explore opportunities for scaling up the commercial pilot to other African countries. The project will also capture and distribute lessons learned on the business case and models for smallholder storage and drying.

Portable Shallow Bed Batch Dryer

Key features:

- Investment cost (Kenya) around $750
- Handles between 1.5 – 2.5mt per day
- Burns 12 kgs cobs per hour as heat source
- 1.4 litre petrol per hour
- Transport by trailer, pick up, donkey cart, motor bike
- Manufacturing requires some specialized skills but can be built by the informal sector
- Offers profit margins to manufacturers and service providers

Vision:

- Medium to large scale farmers investing in 2 – 3 units
- SME's investing in 1 – 6 units servicing smallholder farmers (1 – 5 acres)
- Grain aggregators (including cooperatives and traders) or equipment operators running fleets of dryers 6 – 50 units
- Lease financing options to increase rapid scale out of technology

hermetic containers.

"Whilst I am not an expert in the domain, the roundtable is of great interest to us in the framework of the EU-Africa policy dialogue on science, technology and innovation."

Nienke BUISMAN,
Policy Officer STI relations with Africa
European Commission
DG Research & Innovation

Strategies and best practices to reduce the risk of aflatoxin

Sharing experience and approaches across the value chain

An effective strategy for reducing aflatoxin contamination along the value chain has a number of key components: testing for mycotoxins ; raising awareness of all actors through education, information and knowledge sharing ; good pre-harvest and post-harvest agricultural practices ; and good manufacturing practices. This multi-faceted approach is needed by countries to combat aflatoxin.

1. Testing for mycotoxins

The poor infrastructure for testing for mycotoxins is a major bottle neck. Laboratories are under- resourced (equipment), there is often inappropriate equipment (technically); a lack of knowledge of available infrastructure; poor maintenance (in lab and supplier) and the testing facilities are based in inappropriate locations. This can be remediated through the acquisition of appropriate equipment; the assistance to acquire appropriate equipment; the establishment of regional or reference labs. A survey of available infrastructure on the African continent would be most welcome to improve the access of researchers to test facilities in neighbouring countries.

"The initiative of building a multi-stakeholder approach to mitigate aflatoxin contamination of food and feed in Africa is indeed noteworthy. Looking for a better way to assess needs, identifying synergies on aflatoxin research and bringing together partners around this issue, will certainly improve measures to mitigate this threat. Aflatoxin contamination remains a growing concern to public health, particularly in developing countries, and therefore requires strategies for prevention, control, good manufacturing practices and quality control in all stages of production."

Bernard REY
Deputy Head of Unit
European Commission
DG for International Cooperation and Development
DEVCO/C1 - Food security, rural development, nutrition

Besides the provision of affordable and accessible rapid test kits for tests at all critical points of the value chain (VC) there is a need to develop novel ways to reduce solvent consumption in residue testing. Food samples can routinely be screened for mycotoxins by liquid chromatography tandem mass spectrometry (LC-MS/MS) at chromatography flow rates that are in excess of 500 microliters per minute in combination with high pressures and smaller particle size HPLC columns to maintain sharp peaks and fast chromatography. These flow rates produce fast speeds and excellent peak shapes and results, but have a draw back in that they require higher volumes of organic solvents - these being acetonitrile and methanol in most methods – which adds to the cost of analysis. Furthermore, they could be an environmental menace if not properly disposed of. Therefore, novel ways to reduce solvent consumption in residue testing would be beneficial to the environment and also reduce the running costs of a testing laboratory.

"Thank you for the invitation to the round table last Monday and all the information. It was a very fruitful and useful event."

Bruno Schuler
GIZ, Agricultural Policy
Food Security Sustainable Agriculture, Sector Project Sustainable Agriculture

Afla-what?
Making training videos on aflatoxins with and for farmers

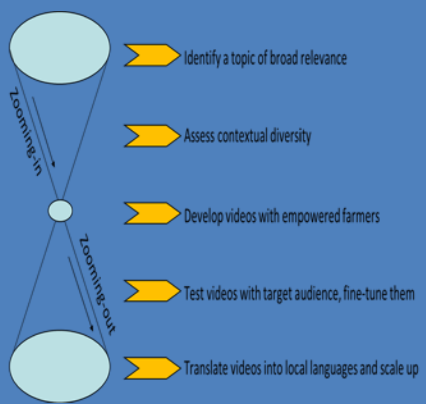
Agro-Insight partners with Access Agriculture, an NGO that manages two open-source video-sharing platforms:

- the Access Agriculture website for quality, scripted farmer training videos (www.accessagriculture.org)
- Agtube for any other agric-related videos (non-scripted, participatory video, short clips showing local innovations, videos for policy makers,…) (www.agtube.org)

Produce videos
with trained farmers only

Think beyond moulds
Women want to learn how soil health and pest management can reduce both the white worms that drill holes in the underground pods and the harmful fungi in the soil.

Enriching porridge with groundnuts is great, as long as it is safe



Anybody can show videos

- *specialised agencies*
- *extension staff*
- *local entrepreneurs*
- *rural information centres*
- *mobile phone businesses*
- *cable tv operators*
- *farmers*
- *…*

2. Raising awareness of all actors

Effective communication tools for farmers and others involved in the value chain require quality training videos to be developed with farmers who are trained in aflatoxin prevention and management. An inventory will need to be developed of which organisations have conducted farmer training in which countries and on which value chains and aspects of aflatoxin prevention and management. Agro-Insight has started to interact with ICRISAT on identifying possible video modules on groundnut aflatoxin managament in Mali, but experiences from other organisations would be needed to enrich the portfolio of learning tools. The audio-visual materials could be developed in such a way that they will serve as source for future radio programmes and awareness raising.

3. Good pre-harvest agricultural practices

Large-scale deployment of aflatoxin biocontrol can immensely benefit African farmers.

A manufacturing plant (capacity 5 tons/hour) has begun to produce AflasafeTM in Nigeria. Plans are underway to construct small-scale manufacturing plants in Kenya and Senegal. A model for creating sustainable market demand for AflasafeTM in the maize value chain is being piloted under the AgResults Initiative in Nigeria. Some African governments are providing biocontrol products to smallholder farmers in public health interest and to improve marketability of maize grains.

Good Agricultural practices have been shown to have a 60% reduction of aflatoxin one of the key steps for any system is sorting which can be mechanized via colour sorters, but there is need to have parallel markets (e.g. feed, oil industries) for bag quality products which need to be absorbed into other product streams.

System of aflasafe is only viable if a quality conscience market is identified – presently most markets in Africa do not have this consciousness and only export market pay higher prices for better quality, but the volumes of export markets are still small.

Need for qualified and decentralized testing capacity for aflatoxin that certifies crops at different levels in the chain so that aflasafe becomes a standard – which adds cost to the final product.

Risk of aspergillus as an allergen and potential risk for aspergillus infecting the lungs is increased with aflasafe since more fungi are available for a short while in the environment; also no protective equipment is worn during distribution of aflasafe product effectively increasing the risk of exposure especially in immune compromised individuals. Various tests have been done on the potential allergenic and toxicological potential of non aflatoxigenic strains. *IITA would be the best placed to give some clarification on this and the tests done if available.*

No effect on other mycotoxins – aflasafe does not impact levels of other mycotoxins such as fumonisin and ochratoxin A which have similar health impacts since it is a specific biocontrol agent, which are very well controlled by Good Management Practices.

Lastly the risk of recombination of Aspergillus atoxigenic strains (aflasafe) with toxigenic strains needs to be evaluated – this is a possibility potentially resulting in a super-strain. Available evidence suggests this probability is rather low.

In-situ detoxification of mycotoxins in genetically engineered crop plants has been demonstrated but such varieties are not available commercially.

Biological control using microbial antagonist strategy has emerged as a promising approach for control of pre-harvest contamination of aflatoxins. The antagonist microorganisms include competitive atoxigenic strains of yeasts or bacteria, and symbiotic fungi (Trichoderma spp., Beauveria spp., mycorrhiza). In Africa, some microorganisms almost exclusively atoxigenic strains of Aspergillus spp. are already available as branded products. However, several challenges ranging from economic to environmental sustainability have not yet been addressed .

A less known yet effective measure to reduce mycotoxin contamination of plant products is their protection against insect pests. Genetically modified crops expressing Bacillus thuringiensis proteins active against pests and thus reducing mechanical damage proved efficient in reducing the content of certain mycotoxins, such as fumonisins in maize (but not aflatoxins specifically).

There is a potential of plant extracts to be used as possible flour fortifiers with the ability to reduce toxin production by Aspergillus species. Plant extracts have been utilised widely as antimicrobials due to a wide range of secondary metabolites that they possess. Additional research is needed to investigate the ability of some plants extracts in Africa which inhibit the production of aflatoxin.


Aflatoxins Pose New Risk to European Maize Production

March 14, 2013

The European Commissions' Rapid Alert System for Food and Feed (RASFF) has reported 10 notifications on aflatoxin B1 in maize of European origin since the last maize harvest in autumn 2012. In the 10 years prior to the last harvest -- between 2001 and 2011 -- a total of nine cases of aflatoxins were reported in maize. Aflatoxins have been mainly an "import problem" up to now. However, global warming is increasingly affecting the mycotoxin map in Europe, producing "tropical toxins" within Europe's borders.

This is most likely not the last case of aflatoxins in maize for European farmers. "Conditions are very favourable for the growth of *Aspergillus* in southern areas of the European mainland due to climate change. This means that Europe will have more homemade aflatoxin cases in its crops in the future." says **Prof. Rudolf Krska**, an international mycotoxin expert from the University of Natural Resources and Life Sciences (BOKU) in Vienna, Austria. "The food & feed industry has to adapt its risk management to cope with this new threat and minimize aflatoxin exposure in Europe."

The origins of the contaminated maize reported in the RASFF were mainly southeastern Europe, including Bulgaria, Greece, Romania, Serbia and in Italy. The average level of aflatoxin B1 was 59.28 ppb (parts per billion or µg/kg) and the maximum 204 ppb in Serbian maize – 10 times above the maximum level for feed. The EU regulatory limit for aflatoxin B1 in feedstuff is 20ppb, whereas in food it is 5ppb.

4. Good postharvest practices

Postharvest management of mycotoxins begins with the separation of infected from healthy grains from harvested commodities. Manual sorting is an efficient means of reducing mycotoxin exposure suitable for smallholder farmers. Industrial systems remove infected grains one-by-one from grain streams passing optical sensors with a throughput of dozens of tons per hour. There is however a need to develop simpler, more cost-effective driers or sorters that may be used at subsistence level.

Storage conditions preventing mycotoxin accumulation include low humidity and low temperature. Stored commodities can also be protected by the exclusion of oxygen, by fumigation or by treatment with preservatives such as propionic acid. Mycotoxins that are already present in the commodity can be destroyed by physical and chemical treatments.

In Africa plastic and other polyethylene packaging materials are widely used for grains and other commodities. This practice also could significantly contribute to worsen the situation.
Contaminated food or feed can be treated postharvest in order to detoxify aflatoxin in the body so that it would present no more risk for human or animal health.

Recently developed postharvest approaches include the removal of fumonisins from food by natural clay adsorbents, while there is an increased interest in enzymatic degradation of fumonisins in food through decarboxylation and deamination by recombinant carboxylesterase and aminotransferase enzymes.

Cultural specific biologically based intervention strategies could impact positively on food security and the health of rural subsistence maize farming communities that are exposed to high levels of mycotoxins.

Strategic interventions to manage the two Aspergillus spp. can greatly contribute to management of the aflatoxin problem in groundnut value chains. Plant health clinics in Sub-Saharan African countries such as Malawi offer opportunities for disseminating extension advisory services on Aspergillus spp. and aflatoxin management technologies. In Malawi a total of 42 plant clinics are operating in six districts of Malawi. These have so far diagnosed plant health problems on 56 different crops, including ground nuts where the visible mouldy growth is the obvious evidence of Aspergillus infection. Diagnosis and consequent advice to farmers by agricultural extensionists, who are trained as plant doctors under the CABI led Plantwise programme (http://www.plantwise.org), was backed by the use of reference materials in the form of aflatoxin management fact sheets written in a layman's terms and deposited on the Plantwise Knowledge Bank (http://www.plantwise.org/KnowledgeBank/home.aspx), an open access technical resource for plant health.

Sanitation and improved storage structures

Airtight storage of moist-harvested maize (approx. 34–30% moisture content) combined with biocontrol agents is a promising, cheap and energy-efficient technique for minimizing mould growth and the risks for mycotoxin production during storage. Storage of moist grains is not effective, irrespective of airtightness. This is because at the end of the storage, the grain would have been 'spoilt' by anaerobic fermentation, except if fermented grains are desired.

There is a need for further evaluation of storage technologies for climatic variables that favor mycotoxin producing fungi to design appropriate storage structure. As other fungal pathogens are also able to produce secondary metabolites, further investigation is required to understand the multiple mycotoxins profile along the maize value chain according to the type of storage structure.

Air-drying cobs reduces the risk for mould growth during storage, but is sensitive to weather fluctuations. Smoke-drying enables greater control of drying, but is costly and detrimental to the environment and health. When grain is harvested and stored moist in airtight conditions, lactic acid bacteria (LAB) naturally initiate fermentation – the decreased pH due to lactic acid production, together with the anaerobic environment, generates a stable storage system in which moulds and other microbes are inhibited. Inoculating grain with the biocontrol yeast *Wickerhamomyces anomalus* (syn. *Hansenula anomala*, formerly *Pichia anomala*) confers additional storage stability. This yeast inhibits moulds and minimizes the risk for mycotoxins via products of glucose metabolism, mainly the volatile, ethyl acetate.

Moisture control

Moisture control is crucial during the storage of raw, intermediate and processed food and feed. Drying is an age-long food preservation technique, with sun- solar-, artificial-, and hybrid-drying, widely practised in Africa to varying levels of sophistication. The relevance of these drying techniques in mycotoxin research is highlighted, with their advantages and limitations. With special reference to solar-drying, different types are presented to guide the choice for drying in Africa. Controlling and managing mycotoxins in Africa will benefit from designing and government- or donor-assisted distributions of appropriate dryers to farmers, like improved seeds and farm inputs. This should be supplemented with simplified extension on moisture control, and possibly assisted with smartphone alerts on meteorological changes, akin to storm warnings in developed countries. Storage stability can also be controlled by using natural preservatives from African plants or spices as a green technology. Some African plants with antimicrobial properties are mentioned, with possible ways of harnessing their active components to prevent mycotoxins in materials.

There is a need for research into how traditional food processing in Africa affects mycotoxin levels in various products. The steps in African traditional food processing can involve sorting, grading, salting, drying, pH or acidity changes, fermentation, cooking, steaming, and grilling to different extents. Advanced food processing technologies have been used to decontaminate mycotoxin-contaminated grains. Africa probably needs a dedicated post-harvest and processing centre to research, study and specifically explore how food and nutrition security in the continent can be assisted by effective control and management of mycotoxins in food and feed. (1st Symposium on African Mycotoxicology, Zambia, May 2015)

When animals are given mouldy grains rejected for human food, the toxins from contaminated feed will move to milk and end up in humans after all.

When cows ingest aflatoxin-contaminated feed, they secrete aflatoxin M1 (AFM1) in their milk. Aflatoxin M1 has been detected in high concentrations throughout sub-Saharan Africa in cow's milk and in human breast milk, putting infants at high risk.

5. Good Manufacturing Practices

Decontamination

Waste and livestock feed

When dairy cows are given mouldy grains rejected for human food, the toxins from contaminated feed will move to milk and end up in humans after all, but at a much lower level than when consumed by the cow.

Contaminated food or feed can be treated postharvest in order to detoxify aflatoxin in the body so that it would present no more risk for human or animal health. Nixtamilisation is one option, but applying this approach at a large scale in Africa has not been researched yet. Nixtamalization refers to a process for the preparation of maize (corn), or other grain, in which the grain is soaked and cooked in an alkaline solution, usually limewater, and hulled. However, the detoxified products from nixtamalization can actually be reversed in the digestive system, thus reactivating the aflatoxin[4]. This may be the case with some of the biological binders as well, such as lactic acid bacteria. Other research questions regarding the binders, are: How do they bind mycotoxins under *in vivo* conditions? Are there local foods/binders that give protection? Have these been researched?

Converting waste to energy

When contaminated raw or processed products are segregated it can be a source of energy. Contaminated meal or shells offer energy options in rural communities that need off-grid energy. Contaminated grain can be used as a source of bio-energy. By adding value to products that should otherwise have no value there are opportunities to build confidence in chains that handle responsibly contaminated / waste material and should provide some scope to offset some of the costs of other interventions. By converting this material from waste to energy there is also an offset against the cost and energy related to production of this material.

[4] Méndez Albores, J. A., Villa, G. A., Rio García, D., & Martinez, E. M. (2004). Aflatoxin detoxification achieved with Mexican traditional nixtamalization process (MTNP) is reversible. Journal of the Science of Food and Agriculture, 84(12), 1611-1614.

Aflatoxin research in some CGIAR centers

- A series of aflatoxin briefs published by **IFPRI** in 2013 compiled approaches and solutions from leading experts.
- An IFPRI discussion paper of 2015: *"The potential of farm-level technologies and practices to contribute to reducing consumer exposure to aflatoxins: A theory of change analysis"* assessed how a theory of change (an approach for analyzing complex problems and guiding impact) can help explain adoption of farm-level technologies and practices for reducing aflatoxin exposure among consumers (see below some extracts).
- As part of the CGIAR reforms initiated in 2009, a nutrition and health objective was added to CGIAR's traditional objectives of food security, poverty reduction, and environmental sustainability. In 2012, the CGIAR Research Program on Agriculture for Nutrition and Health (**A4NH**) was created, raising the profile of food safety work in general and aflatoxin work in particular. The aflatoxin research agenda in A4NH includes research on measuring and understanding the prevalence and impacts of aflatoxins as well as developing and testing technological, market, and policy solutions.
- The two main areas of aflatoxin-related technology research and development in CGIAR continue to be host plant resistance and biocontrol, both combined with Good Agricultural Practices (GAPs) in production and postharvest handling (drying, storage, processing). Aflatoxin-resistant groundnut varieties developed by **ICRISAT** and partners have been tested in India, Mali, and Niger.
- Developing stable, aflatoxin-resistant varieties of maize and groundnuts has been very difficult to achieve due to high genotype and environment interactions; however, progress has been made in developing diagnostics and screening methods for detecting and identifying sources of resistance. In both maize and groundnuts, "indirect" approaches to breeding for low aflatoxin contamination are also used, for example, breeding for drought tolerance, resistance to insects, or short duration, because these factors are also associated with lower aflatoxin contamination. Despite their effectiveness, adoption of these varieties and practices is generally low due to lack of appropriate seed distribution systems and limited interest by the private sector.
- The most promising biological control technique in maize and other grains involves the application of competitive atoxigenic strains of Aspergilli fungi to the field in order to displace the toxigenic fungi that produce aflatoxins. The atoxigenic strains inhibit the development of the toxigenic strains, reducing aflatoxin contamination. Products based on this approach are widely used in the United States and have been adapted for Africa. The International Institute of Tropical Agriculture (**IITA**) in partnership with USDA has developed Aflasafe™, a biocontrol product, for use with maize, groundnuts, chili peppers, and cassava using native atoxigenic strains of A. flavus. The first large-scale production plant for Aflasafe opened in Nigeria in 2013, and the registration and approval process for commercial production is ongoing in other countries in East and West Africa.
- Other methods of biocontrol by competitive exclusion have been developed. **ICRISAT** has used isolates of Trichoderma spp. and strains of Pseudomonas and Actinomycetes for reducing groundnut seed colonization by competitive exclusion or inhibition of Aspergilli. However, because of the cost, there is very little adoption of these other biocontrol methods by poor farmers.
- The **Grain Legumes CGIAR Research Program** (CRP) has set a goal of a 10 percent increase in consumption, particularly by women and children, of aflatoxin-safe groundnut in 2 countries in Asia and 10 countries in Africa. Targets still need to be developed for maize and milk consumption.
- Several CGIAR centers are working on diagnostics tools that could play an important role at least for large-scale purchasers of commodities and farmers associations (for example, ICRISAT's work in Malawi with NASFAM and other peanut butter companies). Smallholders who adopt good practices can meet the standards, though they may face challenges in supplying these markets due to transaction costs
- The **BecA-ILRI Hub** (Biosciences eastern and central Africa hosted by the International Livestock Research Institute) is a shared agricultural research and biosciences platform that exists to increase access to affordable, world-class research facilities. Located at and managed by ILRI in Nairobi, Kenya, the BecA-ILRI Hub provides a common biosciences research platform, research-related services and capacity building opportunities to eastern and central Africa and beyond.
- ILRI is also assessing the human health risk and economic cost resulting from aflatoxins in dairy chains; the impact of aflatoxin on livestock growth and production; strategies for mitigating aflatoxin in animal feed; and presence of aflatoxin in animal source feed,

Sharing country examples

Country profile – Kenya

Number of habitants: Population 42.7 million
Territory: 582,646 sq km (224,961 sq miles)
Capital: Nairobi
Major languages Swahili, English
Population density: 78.83 per sq. km
Population average age: 57 years (men), 59 years (women)

Prevalence of Aflatoxin in maize in Kenya

- Maize is grown by over 90% of the rural farm households with a per capita consumption of 100kg per year.
- The country is a hotspot for aflatoxin contamination in maize.
- First recorded outbreak of aflatoxicosis took place in 1981.
- The most serious aflatoxicosis incidences occurred in 2004 and 2010.
- In 2004 total of 317 aflatoxin infection cases were reported with a case fatality rate of 39%.
- Since 2004 aflatoxin contamination along the maize value chain has been reported almost on yearly basis.
- In 2010, 10 per cent of the maize harvest was made unfit for food or feed due to aflatoxin contamination (>10ppb aflatoxin), with losses valued at US$ 1.15 billion adversely affecting farmers, millers, traders and consumers.

Contaminated milk

When feed contaminated with aflatoxin B1 are fed to animals, the Aflatoxin B1 is hydroxylated by ruminal enzymes to Aflatoxin M1. Aflatoxin M1 (AFM1) is excreted through the milk. The translation of AFB1 in feed to AFM1 is about 200:1The prevalence of aflatoxin in milk in Kenya is estimated at 72%. This translates into 3.744 billion litres out of 5.2 billion which are annually are contaminated. 20% is with aflatoxin above 50 ppt (FAO/WHO) = 748 million liters should be discarded annually and hereby create insufficiency. AFM1 is used as a non-tariff barrier in trading with milk and milk products. The destruction of 748 Million liters of milk would cost $249 million annually – lost in trade or more to import.

Representative of Ministers for Agriculture from five East African countries during a forum for mobilizing policy action to scale-up best bet agricultural practices.

Chairlady of Kyeni SIMLESA *(Sustainable Intensification of Maize and Lugume Systems in Eastern and Southern Africa)* Innovation Platform (IPs) in Eastern Kenya is explaining to visitors conservation agriculture technology. Mycotoxins research is part of research being carried out. (IPs include stakeholders along the value chain and is a P-P-P arrangement)

In Kenya 60% of farmers use rotten grains as animal feed. 55% do not think the milk from animals feed contaminated maize is a risk. They associated reduced milk production and quality, susceptibility to diseases and reduced weight gain with feeding rotten maize – but NOT with aflatoxin. The extended technologies are not adapted and adopted because the illiteracy level is very high –majority are primary school graduates or no formal education. The capital and time invested outweighs benefits. It needs to first build practical capacity on good husbandry practices. Livestock is not considered when national food estimates are calculated – Farm for livestock. Feed inspection and aflatoxin surveillance should be incorporated into national surveillance systems.

Aflatoxin Research in Kenya

- A wide range of research activities on aflatoxin in maize has been carried out by an array of stakeholders.
- The research topics are: Biological control; Post-harvest drying and storage; Surveys along the value chain; Studies on aflatoxin accumulation; Quick test methods for aflatoxin detection; Use of endogenous enzymes to control aflatoxin; Capacity building (training and infrastructural development); Alternative use of contaminated grain.
- The Kenya Agricultural and Livestock Research Organization (KALRO) collaborates with country's development partners, International Agricultural Research Centers (IARCs), local and foreign universities, NGOs and stakeholders along the value chains to generate agricultural information, knowledge and technologies.
- Most but not all research activities on aflatoxin in maize are carried with KALRO collaboration.

The International Livestock Research Institute (Biosciences eastern and central Africa-ILRI Hub) in Nairobi

Visit of the BecA Hub at ILRI during a Horizon 2020 write shop organized by PAEPARD and funded by EC/DevCo in Nairobi, 26 March 2015.

- The BecA-CSIRO aflatoxin project (Commonwealth Scientific and Industrial Research Organisation - CSIRO, Australia) has established a lab, procedures and a network of partners that has focused on gathering information on and coming up with a set of interventions to reduce aflatoxin risk. These include sampling/testing procedures (see policy brief), as well as decision support tools for the wider community.
- BecA's African National Agricultural Research Institute and university partners who have used the BecA-ILRI Hub aflatoxin lab and generated a broad set of data are involved in data sharing (in addition to the data already generated by the CAAREA project team itself. Over 40 researchers have used the aflatoxin platform to conduct aflatoxin (and mycotoxin research more broadly) research since 2009, forming a broad base of information.
- The Capacity and Action for Aflatoxin Control in Africa (CAAREA) project was the flagship of Australia's African Food Security Initiative, bringing Australian funding (approximately $3 million from Australian AID and now the Department of Foreign Affairs and Trade, from 2011-2015) and scientific expertise to bear on this challenging issue. The project is continuing in another phase, as the Aflatoxin Action Alliance (AAA).
- The purpose of the AAA is for researchers, the private and public sector actors, women and men farmers and civil society to collaboratively develop and apply new knowledge and innovations that contribute to reduced exposure to aflatoxin from maize.
- Scientists from CSIRO are leading the risk mapping and predictive model development, based on field trials and on farm surveys conducted by the Kenya Agricultural and Livestock Research Organisation, the Tanzanian Agricultural Research Institute and Ministry of Agriculture and Food Security, and other CAAREA/AAA project partners.

Joint FAO/ Embassy of Finland meeting on Aflatoxin 24th November 2014

- There is inadequate government extension staff to disseminate information on aflatoxin.
- Based on the current body of knowledge, action needs to be taken to address the occurrence of aflatoxin and private sector should be involved.
- There is a weak policy and regulatory framework and no market incentives for aflatoxin
- There is need to do a mapping of fungal species in the various agro-ecological zones of Kenya, coupled with rainfall and temperature data to inform predictability of the likelihood of the fungus to develop toxins.
- An inventory of available and affordable technologies for use at community level to fight aflatoxin should be done with a view to making them available to the farmers.
- Private sector needs to be brought on board to take up research results to implementation level.
- Due to the large number and diversity of players, an inclusive platform is required that brings them

together in a better coordinated approach to enhance the impact of the work on aflatoxin. Such a platform would also facilitate piloting of research with farmers.

- The need for all stakeholders along the value chain to work together as equal partners to address the aflatoxin issues.

Aflatoxin Stakeholders Meeting of 14th October 2015

- Kenya Agricultural and Livestock Research Organization (KALRO), University of Nairobi (UoN), Ministry of Agriculture Livestock and Fisheries (MoALF) and East Africa Farmers Federation (EAFF) were represented.
- Agreed that Aflatoxin stakeholders constitute an Innovation Platform
- KARLO, EAFF, UoN, MoALF, ILRI, GIZ, SNV, Kenya Dairy Board, Association of Kenya Feeds Manufacturers (AKEFEMA), Kenya Livestock Producers Association (KLPA), Food and Agricultural Organization of United Nations (FAO), Kenya Bureau of Standards (KEBS), National Cereals and Produce Board of Kenya (NCPB), Kenya Plant Health Inspectorate Service (KEPHIS), Kenya National Farmers Federation (KENAFF), Cereal Growers Association (CGA), Ministry of Health (MoH) and Kenya Dairy Processors Association (KDPA) as members of the platform.

Country profile – Serbia

Number of habitants: 7,2 mill.
Territory: 77.592 km²
Capital: Belgrade (1,7 mill. habitants)
Major language: Serbian
Population density: 91,9 hab./km²
Population average age: 72 years (men), 77 years (women) (UN)

The Rapid Alert System for Food and Feed

In 2012 Serbia was affected by a heavy drought. The *Rapid Alert System for Food and Feed – Europe* returned in **2012** maize to Serbia after reports about aflatoxin M1 in milk due to problems with differences in AFB1 limit in feed Serbia and EU feed.

Beginning of 2014, the milk industry declared that they are ready to implement European regulations. But due to a catastrophic floods and rainy summer on **2014** there was a very low level of aflatoxin B1 in maize. In July 2014, just 15 days after a decrease, the aflatoxin M1 level increased again, this time to 0,25 microgram/kilogram. 23% of produced milk did not meet the standard and 30-40% of farmers could not achieve the requirement. As a consequence 10 000 families were at the risk of losing their income.

From 506 samples in the harvest period of **2015**, 12 samples contained aflatoxin B1 above permitted limit even for animal consumption.

Major challenges

- There are a lot of small producers without clustering
- It is difficult to control all the small producers by phytosanitary and veterinary inspectors- huge number of official controls and samples are needed, high cost
- No precise data of remained corn quantities from previous year-silos and private cribs
- Sampling from big storage facilities
- Need to increase storage hygiene
- Low number of inspectors
- According to food safety law every producer is responsible for own product, but...the ministry alway has a heavy responsibility to social component

Aflatoxin Research in Serbia

With partners from Hungary during 2012 and 2013 the University of Novi Sad has implemented the research project HUSRB/1002/1.2.2/062 (2012-2013).

The Partner institutions were: University of Szeged, Hungary; Cereal Research Institute, Szeged, Hungary; University of Novi Sad, Serbia; Institut for Food Technology, Novi Sad, Serbia.

The purpose was the improvement of safety of corn-based feedstuffs through using more resistant hybrids and management of corn processing (Hungary-Serbia IPA Cross-border Co-operation Program). It has found differences between commercial hybrids from Hungary and Serbia in susceptibility to Aspergillus flavus and toxin accumulation.

Country profile – Zimbabwe

Number of habitants: 13 million
Territory: 390,759 sq km (150,873 sq miles)
Capital: Harare
Major languages English (official), Shona, Sindebele
Population density: 33 persons per square kilometer
Population average age: 54 years (men), 53 years (women)

Cultivate Africa's Future research project

The Post Harvest Management Technologies for Reducing Aflatoxin Contamination in Maize Grain and Exposure to Humans in Zimbabwe research project want to investigate the efficacy of hermetic storage technology in the reduction of aflatoxin contamination in maize grain and hence reduction in exposure to humans to these toxin, in Makoni and Shamva districts.

The specific objectives are: (a) to assess knowledge, attitudes and practices with regard to good pre- and post- harvest management practices that minimizes mycotoxin contamination in maize; (b) to assess the reduction of aflatoxin B1 and fumonisin B1 in stored grain from use of different postharvest storage practices ; (c) to assess the reduction of aflatoxin exposure to humans including infants in households using different storage methods ; (d) to determine levels of aflatoxins in legumes (groundnuts, bambaranuts, beans, and cowpeas) produced by the communities in Shamva and Makoni districts ; (e) to identify and assess different models for delivery of post harvest management technologies to smallholder grain producers.

Expected research outputs: (a) Efficacy of hermetic technologies to reduce aflatoxin levels in stored grain
Aflatoxin levels in legumes ; (b) Infants exposure to aflatoxin M1 from breast milk from mothers ; (c) Association between anthropometric data and levels of aflatoxins in children under five ; (d) Knowledge, attitudes and perceptions of farmers in managing aflatoxin risks in maize (e) understanding of the household behaviours and perceptions in handling risks of aflatoxin contamination

Main Players

- University of Zimbabwe, Institute of Food, Nutrition and Family Sciences (UZ, IFNFS)
- Action Contre la Faim (ACF)

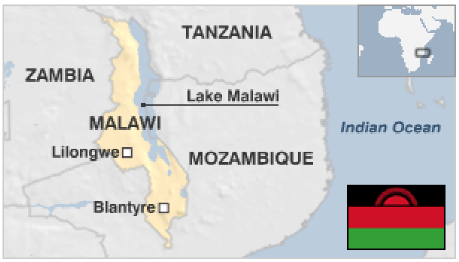
Third Party

- International Rescue Committee (IRC)

Government stakeholders

- Ministry of Health and Childcare
- Ministry of Agriculture, Mechanisation and Irrigation Development

Country profile – Malawi



Number of habitants: 15.9 million
Territory: 118,484 sq km (45,747 sq miles)
Capital: Lilongwe
Major languages: English, Chichewa (both official)
Population density:
Population average age: 55 years (men), 55 years (women)

Prevalence of Aflatoxin in maize in groundnut in Malawi and Zambia

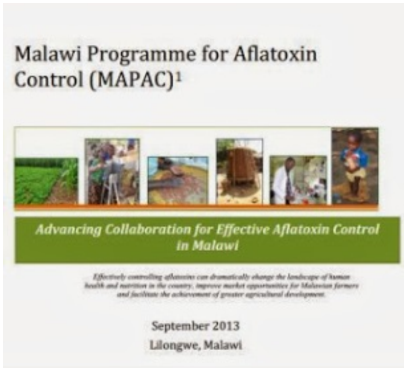
Groundnut is an important crop economically and nutritionally in Malawi and Zambia (and other countries in the Tropics and Subtropics). However, groundnut is one of the most susceptible hosts for certain pathogenic fungi resulting in aflatoxin contamination.

- 1970's > 40,000 mt pa exported to Europe;
- 1980's exports & production collapsed;
- 2000's production revived;
- Priority crop for 2012 National Export Strategy;
- 2015 poor rains (2.8 million people in need for food aid - FEWS)

75% consumed by domestic market;

- Very little is wasted (NB. Current food shortage).
- Most exports now go to low enforcement markets;
- Almost no exports now to high enforcement markets;
- Some uncertainty about the current volumes of informal exports

It is predominantly produced by small scale farmers. Farmers have little knowledge of control and management of aflatoxins. The aflatoxin problem is complicated by frequent and more intense droughts. Innovative technologies not accessible to farmers: groundnuts are predominately cultivated on ridges prepared by hand-hoe. Farmers claim that pre-harvest mold development is exacerbated by crop residue incorporation. So they avoid it in groundnuts field.


Malawi Programme for Aflatoxin Control (MAPAC)[1]

Advancing Collaboration for Effective Aflatoxin Control in Malawi

September 2013
Lilongwe, Malawi

The Malawi Programme for Aflatoxin Control (MAPAC)

The Malawi Programme for Aflatoxin Control (MAPAC) (September 2013, 54 pages) represents an effort to create a shared vision, prioritize entry points and create mechanisms for effective coordination and collaboration of aflatoxin control in the country. The program is proposed as a tool for collaborative advantage in the fight against aflatoxins in Malawi, contributing to the achievement of established nutrition and health; trade; and agriculture and food security objectives.

MAPAC is proposed as the national platform/forum on which collaboration and synergies among government agencies and relevant stakeholders can be built upon. It is also a channel/conduit to facilitate the implementation of regional strategies and aflatoxin-related efforts in the country. It analyses key capacity needs and gaps (based on existing government and development partner programmes / interventions), identifies critical components of a collaborative programme for aflatoxin control, and outlines implementation strategies and recommendations for follow-up by various stakeholders.

It gathers the views of several stakeholders consulted during the preparation phase. It is the result of a concerted effort towards advancing collaborative advantage for aflatoxin control in the country. But, while MAPAC is a response to the need for concerted action, it is at the same time a call for it.

PAEPARD Applied Research Fund (ARF) research project: Stemming Aflatoxin pre- and post-harvest waste in the groundnut value chain (GnVC) in Malawi and Zambia

To address the problem, a consortium comprising of: FANRPAN (RSA), NASFAM (Malawi), DARS (Malawi), ZARI (Zambia), EPFC (Zambia) and Univ. of Greenwich-NRI (UK) collaboratively sought financial support from EU through CRF PAEPARD project.

The objectives are to: (a) assess, validate and further develop promising pre and post-harvest technologies ; (b) document and disseminate successfully tested practices ; (c) To advocate for conducive national and regional policies and regulatory frameworks for stemming Aflatoxin.

The research activities are focusing on: (a) the evaluation of effect of residue incorporation on pre-harvest aflatoxin contamination ; (b) the optimization of groundnut plant densities as a means of pre-harvest aflatoxin control ; (c) the determination of the most effective and feasible way of drying groundnuts ; (d) the evaluation of kernel sizing and hand sorting on partitioning aflatoxin into various shelled groundnut grade sizes ; (e) the exploration of effective ways of accelerating adoption of proven aflatoxin reduction techniques.

AfriNut, pro-poor peanut processing in Malawi

In this venture with Twin, the National Association of Smallholder Farmers of Malawi (NASFAM), and other investors, processing company Afri-Nut aims to move Malawian smallholders up the value chain, while expanding the volume of Fairtrade and other value-added peanuts produced for international and domestic markets.

- Proportion of all Afri-Nut samples in 2013: : 26% > 4ppb; & 16% > 15ppb.
- Groundnut flour had most contaminated samples: 73% > EU 4ppb level ; 25% above 100ppb ; highest = 3871 ppb. Sources: ICRISAT (2011) & Twin GPAF (2013)
- 70% of families add groundnut flour to meals ca. twice/ week

Triangular collaboration

Last November 2015 two top-ranking proposals were finally selected for funding under the EC Horizon 2020 research programme. The winning projects 'MyToolBox' and 'MycoKey' will be carried out by consortia composed of various EU countries and several non-EU countries (**Argentina, Canada, China, Nigeria, Norway, Serbia, Switzerland, Turkey and Ukraine**).[5] Both projects will start in March 2016 and will be conducted over a period of 4 years.

- The MyToolBox consortium led by Rudolf Krska (BOKU/IFA – Tulln, Austria) will not only pursue a field-to-fork approach along the food and feed chain, but will also consider safe-use options of mycotoxin-contaminated batches, such as microbial energy conversion to efficiently produce biogas and bioethanol assisted by novel enzymes. Intervention technologies considered within MyToolBox include the investigation of genetic resistance to fungal infection, cultural control, the use of novel biopesticides, competitive biocontrol treatment and the development of forecasting models to predict mycotoxin contamination.

  Research into post-harvest measures includes real-time monitoring during storage, e.g. in China, innovative sorting of crops using vision-technology and novel milling technology. Research into the effects of baking on mycotoxin levels will provide a better understanding of process factors used in mycotoxin risk assessment. The developed measures will be combined with existing knowledge and will become accessible via a dynamic web-based MyToolBox e-platform. MyToolBox mobilises a comprehensive multi-actor approach with **23 partners** with >40% industry participation including 5 end users from the farming community, agronomists and professionals working in agriculture and food manufacturing.

- The MycoKey consortium led by Antonio F. Logrieco (CNR ISPA – Bari, Italy) will provide innovative and integrated solutions that will support stakeholders in effective and sustainable mycotoxin management along food and feed chains. The project will contribute to reducing mycotoxin contamination mainly in Europe and China, frequently affected areas where international trade in commodities and contaminated batches are increasing. A number of advanced key technologies available, such as -omics, sensors, aerial imaging and new analytical methods (i.e. dipsticks, immunoassays, DNA aptamers based strip tests) will be integrated into the real world of the field, storage, and processing management, in order to provide effective solutions and modern tools for mycotoxin contamination control.

  Key information and practical solutions for mycotoxin management will be integrated into a smart ICT tool (MycoKey App), by providing stakeholders with rapid, customised forecasting, description of contamination risk/levels, decision support and practical economically-sound suggestions for intervention. Tools and methodologies will be strategically targeted for cost-effective application in the field (i.e. biocontrol, breeding), during storage and processing (i.e. cleaning, biological detoxification). MycoKey will address the crops most affected, i.e. maize, wheat and barley, their associated toxigenic fungi and related mycotoxins (aflatoxins, deoxynivalenol, zearalenone, ochratoxin A, fumonisins). The project will integrate the multi-disciplinary consortium, composed of scientific, industrial and association **partners (34), and includes 11 Chinese institutions**.

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[5] Hans P. van Egmond, Foreword, World Mycotoxin Journal, 2016; 9 (1): 1-3

Planning a value chain strategy

"The essence of life is to plant a tree under whose shade you do not expect to sit"

E.K.Kang'ethe

University of Nairobi

From the Round Table of aflatoxin experts emerged that agricultural planners and managers as well as research and development administrators could benefit from a more structured approach – or framework – for planning and tasking specific research and development projects with responsibility for the various practical aspects of managing aflatoxin contamination and mitigation by a diversity of actors.

The first table below refers to practical approaches presented during the Round Table meeting. It is proposed as a guide and planning tool for decision makers to integrate new initiatives and approaches to manage aflatoxin in Africa alongside the value chain – linking them with other ongoing initiatives.

The next tables give an overview of the research needs related to technology adoption; the role of intermediaries: traders, processors and livestock producers; and the consumption of aflatoxin-safe products by consumers. [6]

The integration of new initiatives and approaches alongside the value chain

The action plan for research activities and development initiatives is organised according to possible solutions alongside the value chain:

Solutions:

- Testing for mycotoxins
- Raising awareness of all actors through education, information and knowledge sharing
- Good pre-harvest agricultural practices
- At harvest practices
- Good postharvest practices
- Good Manufacturing Practices

An excellent example of improved health outcomes after a switch from a food source at high risk of aflatoxin contamination to one at lower risk occurred in Qidong, China.

A government policy to grow foods that are eaten locally, combined with a prohibition on interregional shipments of food products, had forced residents of Qidong County to produce and consume primarily maize for several decades. Liberalization of the transboundary provincial trade policy allowed rice to be imported from other regions of the country, replacing maize as the staple cereal. Since aflatoxin contamination is much lower in rice than in maize, the result was reduced aflatoxin exposure and a precipitous drop in liver cancer incidence (Chen et al., 2013).

...

Changing food preferences where there are no economic constraints can be a matter of social marketing and awareness.

However, changing food preferences and access for people living in food-insecure conditions presents an enormous challenge.

In 1950, by far the major source of dietary starch in sub-Saharan Africa was sorghum and millet (40%), followed by cassava (30%) and maize (15%) (Miracle, 1966). The subsequent shift towards maize is part of a global trend; over the past 50 years, consumption of sorghum and millets has declined by 50% and consumption of cassava by 40% (Khoury et al., 2014). In turn, this may have had a major role in increasing aflatoxin exposures. In West Africa, for example, aflatoxin concentrations in pearl millet and sorghum were substantially lower than those in maize (Bandyopadhyay et al., 2007).

Mycotoxin control in low- and middle-income countries / edited by Christopher P. Wild, J. David Miller, John D. Groopman,
The International Agency for Research on Cancer (IARC) Working Group Reports; 9
2015, 66 pages

[6] IFPRI discussion paper of 2015: *"The potential of farm-level technologies and practices to contribute to reducing consumer exposure to aflatoxins: A theory of change analysis"*

Issue	Challenges	Examples of tasks	Action Plan for research and development initiatives
Testing for mycotoxins	• The poor infrastructure for testing for mycotoxins is a major bottle neck. • need to develop novel ways to reduce solvent consumption in residue testing **without affecting accuracy**	• Provide affordable and accessible accurate rapid test kits for tests at all critical points of the value chain (VC). o The lateral flow device or dipstick is applicable to African countries. It is rapid (5-10 min), simple, no expensive equipments is required, portable, limited use of organic solvents, suitable for screening purposes, can be used in situ. o DISADVANTAGES: qualitative or semi-quantitative (cut off level), matrix interferences may affect result, possible false positive/negative results, cross-reactivity of antibody with other mycotoxins, sensitivity not acceptable at levels close to regulatory limits • Build capacity in testing laboratories. • Establish national and regional testing/reference labs.	• Inventory of laboratory infrastructure and testing facilities • Potential EU/USAID collaboration – Peanut Mycotoxin Innovation Laboratory (PMIL) carried out an inventory of laboratory and testing facilities in Feed the Future / PMIL target countries in 2015. (AE to follow up with Francois to provide relevant linkage with PMIL)
Raising awareness of all actors through education, information and knowledge sharing	• The aflatoxin problem is invisible • It is essential to avoid creating panic. • Targeting aggregators (ex. store keepers, feed processors) and "hotspots" (critical control points) is more efficient (and morally responsible) than targeting [all] farmers. • Farmers need to be involved and made responsible. Must be a farmer incentive	• Training of producers and other value chain actors • ICT and mobile phone apps to share information and good practices • Knowledge sharing about good practices • Engage with PACA efforts to broaden the scope by establishing Nutrition and Health working group. • Intermediaries have the potential to play an important role in spreading information and incentivizing technology adoption by farmers, though their own incentives for doing this are not yet clear. Potential interventions need to be based on a realistic assessment of trader motivation, including the potential to take advantage of lack of information and inability to enforce standards to increase profits.	• Target the Swedish call for proposals on ICT for Health: Mobile phone App to create awareness + monitoring. • A Skype meeting was held between Agro Insight and ICRISAT on 29/01 to discuss the aflatoxin videos. • Join the nutrition and health PACA Workshop on "*Engaging the Health and Nutrition Sectors in Aflatoxin Control in Africa*" on **23-24 March 2016** at the AUC Headquarters, Addis Ababa, Ethiopia, and will bring together experts, stakeholders and partners working on aflatoxins especially in the health and nutrition sectors across Africa and beyond. The meeting goal is to foster and reinforce multi-sectoral engagements for aflatoxin control against health and nutritional hazards in Africa. • The DG AGRI Conference "Designing the path: a strategic approach to EU agricultural research and innovation" (26-28/01/2016, Brussels) was a first opportunity to present the outcome of the Round Table of Aflatoxin experts. Contacts were made with the Chinese Academy of Agricultural Sciences (see MycoKey and MyToolBox) and the Department of Research Planning and Coordination of the Japanese National Agriculture and Food Research Organization (Dr. Christine C. Bii (PhD. Medical Mycology-Tokyo-Japan is Principal Research Officer-Kenya Medical Research Institute). • Another opportunity is the HLPD Stakeholder Forum: *Implementation of an EU-Africa Research and Innovation Partnership on Food and Nutrition Security and Sustainable Agriculture*. This stakeholder forum is association with the EU-Africa High Level Policy Dialogue on Science, Technology and Innovation: (**5th - 6th April 2016**, Addis Ababa, Ethiopia).

Good pre-harvest agricultural practices ➢ Complex (too many factors) ➢ Limited control ➢ Problems and side effects of corrective actions	• **Resistant varieties** • **Crop rotation** • **Soil treatment cultivation** • **Fungicide application** • **Weed and pest management** • **Agronomic measures** • **Biological control**	• Seed – aspergillus resistant, multiple disease resistant and drought resistant, purity of seeds according to maturity duration + selection of healthy seeds • Depending of the different ecosystems: early planting, avoidance of mono-cropping, application of Trichoderma at 1 kg/ha • Plowing before sowing, prevent soil erosion, appropriate weeding. Plowing is however known to increase soil erosion and reduce soil moisture levels thus causing conditions favourable to aflatoxin production in drought prone areas. • Application of farmyard manure at 2.5 tons/hectare before planting • Treatment of foliar diseases using 1–2 sprayings Application of lime or gypsum at 400 kg/ha at flowering • Expensive, potential harm to beneficial insects and environment,residues in food, hazard for the health and safety of workers handling fungicides, pathogens resistance • Mulching with crop residues at 40 days after planting. No-till where stubble is retained is a form of mulching. • Maintenance of optimal density of plants in the field • Avoidance of end-of-season drought through irrigation (if possible). Reduced or no-tillage increases soil moisture retention • Removal of dead plants from the field before harvest • Expensive (high distribution cost of aflasafe), unreliable (variation in the application due to environmental conditions), limited efficiency (survival), impact on ecosystem and health. Scaling – up of aflasafe could work better if integrated in a good agricultural practices package. The following needs more attention o Long time and high funding level prior to available product – usually it takes 3-5 years to have a testable product for a given country that can be tested in farmers' fields. But once in place costs would relatively be reduced over time. o There is need for specialized people and facilities – so that each strain development would cost between 1-5 mill. of $. o Products need to be developed for each country due to ecological situation but also due to regulatory aspects (Convention of Biosecurity – only indigenous strains can be used for biocontrol in a given country; except if prior agreements) o Need for specialized facility for production of aflasafe product – there is need for a highly specialized facility to produce aflasafe which should be available on a regional or country level (this would cost at least 2 mill $ in production and 2-300 000$ annually for running cost. *It also has the potential to develop local industries. If farmers are paid a premium for aflatoxin free grain they should be able to afford the product.* o High distribution cost (not affordable by small scale farmers) -since these are bulky inputs with a need of 10kg-ha which need to be distributed to far away locations – who bears this cost, would this be through input distribution scheme or on credit o Use of sorghum as the carrier for fungal spores – this effectively takes out high level of grains in already food insecure areas eg. 10kg per ha; usually farmers have no visible difference between treated and untreated grains the treatment with aflasafe does not improve the visual quality of the treated commodities, which is one of the ways of achieving higher prices in undeveloped food systems. o Year on Year only about 30 to maximal 50% of the crops have a toxin level beyond the WHO or the EU level respectively so that large amount of fields are treated unnecessarily *Efficacy of product would come down to predictability of toxins and or identification of aflatoxin hotspots.* o There is a need for a better targeting mechanism to find out years and regions of high risk which could reduce the effort needed for combating aflatoxin. *This could be done with efficient **disease modeling systems** for predicting potential aflatoxin levels.*	• There is need for other options or more research work to enable scaling-up. • Early-maturing varieties are less prone to aflatoxin contamination, which could be another way in which traders (and possibly also consumers) can differentiate groundnuts based on likelihood of aflatoxin contamination • Develop commercial seed business; Private sector to multiply the seeds; • Developing and deploying low susceptibility varieties. There is need to integrate this with good agricultural practices and handling and packaging. Also attention should be given to the Agro ecological zones factors. • Potential EU/USAID collaboration eg: with ongoing Peanut Mycotoxin Innovation Laboratory (PMIL) research activities

Good at-harvest practices	•	• Harvesting the crop at the correct maturity • Use of water-harvesting to preserve available **moisture** • Avoidance of damage to pods during harvest • Avoiding long-term contact of groundnut pods with soil after harvest. *This also applies to lodged maize where ears are in contact with the ground.*	• There is evidence that **moisture testing** provides a financial incentive to farmers to invest in good drying practices that would also reduce the risk of aflatoxin contamination (Emmot 2013). The implications of these types of proxy indicators for aflatoxin contamination need further study.
Good postharvest practices ➢ Simple ➢ Good Agricultural Practice (GAP) limit toxin accumulation ➢ No side effects	• **Sorting** ➢ loss of uncontaminated materials ➢ disposal of refuses ➢ flexibility needed • **Storage** ➢ expensive treatments ➢ integration of data regarding parameters/ conditions	• Manual sorting is an efficient means of reducing mycotoxin exposure suitable for smallholder farmers • Drying of groundnut pods on tarpaulin sheets rather than on bare ground • Drying seed to 8 percent moisture level • Stripping the pod immediately after drying • Removing immature pods attached to the haulms • Removing damaged, shriveled, and immature pods • Not mixing clean harvested pods with gleaned pods • Avoidance of re-humidification of pods during shelling or in storage • Fumigation of pods with insecticide to avoid insect damage during storage • There is a need to develop simpler, more cost-effective driers that may be used at subsistence level. Eg: Aflastop project • Storage conditions preventing mycotoxin accumulation include low humidity and low temperature. Stored commodities can also be protected by the exclusion of oxygen, by fumigation or by treatment with preservatives such as propionic acid. • Air-drying cobs reduces the risk for mould growth during storage, but is sensitive to weather fluctuations. Smoke-drying enables greater control of drying, but is costly and detrimental to the environment and health • Moisture control is crucial during the storage of raw, intermediate and processed food and feed. Drying is an age-long food preservation technique, with sun-solar-, artificial-, and hybrid-drying, widely practised in Africa to varying levels of sophistication. • Airtight storage of moist-harvested maize (approx. 34–30% moisture content) combined with biocontrol is a promising, cheap and energy-efficient technique for minimizing mould growth and the risks for mycotoxin production during storage • There is a potential of plant extracts to be used as possible flour fortifiers with the ability to reduce toxin production by *Aspergillus* species. • Plant extracts have been utilised widely as antimicrobials due to a wide range of secondary metabolites that they possess.	• There is a need to adapt commercial optical sorting equipment for groundnuts for the African value chain for both large and small operations. • Targeted training in manual sorting for rural women would appear to be a good investment. In Africa, **food security is the major barrier to implementation of sorting** • Safe alternative uses for rejected lots need further research • Define recommended technologies (basic - advanced) for every process step (drying, sorting, grading, product segregation, storage and transport) • Implement at country level the recommended technologies in the VC. There is a need to develop the economic justification or market pull mechanisms to justify these value chain investments. • There is a need for further evaluation of storage technologies for climatic variables that favor mycotoxin producing fungi to design appropriate storage structure • Additional research to investigate the ability of some plants extracts in Africa which inhibit the production of aflatoxin. • Additional research on the relevance of existing drying techniques in mycotoxin, with their advantages and limitations.eg: converting the Aflastop maize dryer to work with other crops eg: groundnuts • Establish local manufacturing of appropriate dryers for farmers • Simplified moisture control, and possibly assisted with smartphone alerts, at point of harvest and later in the year after extended periods of storage, on meteorological changes, akin to storm warnings in developed countries. • Control storage stability can be controlled by using natural preservatives from African plants or spices as a green technology. • Some African plants with antimicrobial properties can harness their active components to prevent mycotoxins in materials.

Good Manufacturing Practices	• **Detoxification** Contaminated food or feed can be treated postharvest in order to detoxify aflatoxin in the body so that it would present no more risk for human or animal health. ➢ low efficacy of existing approaches (chemical, physical, biological) ➢ potential toxicological risks ➢ lack of standard validated procedures	• *Detoxification* can be applied anywhere in the food and feed chains, from the harvest to the distribution of final products. Enzymatic detoxification is the most promising decontamination method because it relies on highly specific catalytic processes and the active agents are proteins, which can be produced by plants and microorganisms. Feed additives binding mycotoxins by physical adsorption and destroying mycotoxins enzymatically are available. Integration of chemical and particularly enzymatic detoxification of mycotoxins into food processing pipelines is currently being evaluated by food companies. • *Ammonisation* is a costly technology and the final product may be more toxic. There is need to leverage the decontamination by other means. • *Nixtamilisation* is another option, but applying this approach at a large scale in Africa has not been researched yet. Nixtamalization refers to a process for the preparation of maize (corn), or other grain, in which the grain is soaked and cooked in an alkaline solution, usually limewater, and hulled. However, the detoxified products from nixtamalization can actually be reversed in the digestive system, thus reactivating the aflatoxin. This may be the case with some of the biological binders as well, such as lactic acid bacteria. • *Ozone use* for the degradation of aflatoxin in corn has become quite popular recently. There is a-lot of interest into the potential of ozone in this application. There is a great deal of data available that does prove that ozone will destroy aflatoxin. Ozone can be produced as a gas from oxygen in air, or concentrated oxygen. Ozone is the second most powerful oxidant in the world and can be used to destroy bacteria, viruses, and odors.	• Evaluate efficacy of local clay in decontaminating groundnut cake and oil • Adopt ammonisation technology for decontaminating groundnut cake • Research small capacity filtration and refinement process for groundnut oil • More research on decontamination or alternative uses for contaminated grain would reduce the risk that it would be sold and consumed. • There is some evidence that increasing the protein content of the diet or using binders can be relatively inexpensive (Grace 2013) and might involve less uncertainty regarding quality assurance than buying low-aflatoxin grain. More work is needed on the cost-effectiveness of alternative strategies in different contexts.
	• **Intake prevention** ➢ **safe chemoprevention strategies** ➢ **lack of scientific models**	• The steps in African traditional food processing can involve hand and laser sorting, grading, salting, drying, pH or acidity changes, fermentation, cooking, steaming, and grilling to different extents. • Advanced food processing technologies can be used to decontaminate mycotoxin-contaminated grains. • Africa needs a dedicated post-harvest and processing centre to research, study and specifically explore how food and nutrition security in the continent can be assisted by effective control and management of mycotoxins in food and feed.	• There is a need for research into how traditional food processing including hand sorting in Africa affects mycotoxin levels in various products and where investments such as laser sorters are needed. • The strategy of using food additives, such as antioxidants, to protect livestock may also provide effective and economical new approaches to protecting human populations from the mycotoxin. • When contaminated raw or processed products are segregated it can be a source of energy.

Technology adoption

Issue	Challenges	Examples of tasks	Action Plan for research and development initiatives
Technologies Affordable and Available to **Farmers**	Mitigation technologies and practices are costly to implement, not only in terms of cash for purchasing inputs but also in terms of time and managerial capacity. Where adoption is not driven by a clear market incentive, and where postharvest practices are required to maintain benefits, changes in the behavior of multiple household members may be required, each of whom may have different constraints in terms of accessing technology and information. While pilot projects can stimulate adoption, it is not clear whether this can be maintained at scale without outside support.	• Some low-cost mitigation options (for example, drying technologies) can be as cost-effective as more expensive options. More information is needed on the size and distribution of their costs and benefits among household members. • In pilot projects that link small farmers to markets, farmers are provided with financial and technical support and in some cases are provided with services directly to ensure a large amount of high-quality production. While this may be feasible in pilots, it is not clear whether support could be provided at scale or sustained • Investments in increasing adoption should be informed by a good understanding of reasons why current adoption levels are low. This needs to be reconciled with findings that consumers, including farm household members, value and are willing to pay for aflatoxin-safe foods.	• More information is needed on whether and how adoption of these technologies and practices affects intrahousehold resource allocation (including labor), decision making, and control of production and income. • A better understanding of household members' incentives, preferences, and constraints will facilitate development of appropriate technologies that have a high probability of being adopted.
Deliver **economic benefits** in farm households	Various technologies and practices have been shown to be effective in reducing aflatoxin contamination under experimental conditions on station and on farm. However, low levels of adoption suggest that benefits may have been overestimated or constraints to adoption overlooked. Where the decision to adopt risk-mitigating technologies and practices is mainly motivated by economics—as in the case of production for premium markets—farmers may not need to be aware or convinced of health consequences in order to adopt. However, if the goal is to achieve reduced exposure among farm households, then health information would need to be provided, perhaps along with additional incentives to encourage on-farm consumption (as in the AgResults case). Where market access is not the primary driver for adoption of improved practices, it is expected that a combination of health and economic benefits will drive adoption.	• A particular challenge in the case of aflatoxin risk-mitigating technologies and practices is that not all benefits will be visible to farm household members, making it difficult to justify continued investment in them. • For example, ICRISAT's improved groundnut varieties are not only aflatoxin resilient but are early maturing and drought resistant and produce both larger pods and a higher number of pods, increasing farmers' yields while also reducing aflatoxin contamination risk. However, to the extent that the aflatoxin reduction is obtained from a combination of technologies and practices, only some of which yield direct economic benefits, it may be difficult to incentivize full adoption of recommended packages over time.	• A better understanding of whether low levels of adoption are due to failure to adopt initially or disadoption would help clarify whether the problem is related to access or performance. • Lessons from projects which have successfully reached thousands of farmers, will be important for understanding these dynamics. • More information is needed on perceived benefits and costs in farm households and constraints to adoption, differentiated by type of household and by household member. • Lessons need to be fed back into the research process to ensure that future techniques and practices experience greater uptake.
Deliver **health benefits**	Reaching the right people requires knowing how and by whom specific production and postharvest decisions are made. This is likely to vary by context. Where home consumption and health benefits are expected to be important drivers of adoption, women play an important role.	• Targeting the broader community may be as important as targeting individual decision makers. • Where access to a premium market is expected to drive adoption, awareness-raising efforts may focus only on the person making the production decision and mainly on the economic benefits. This approach may or may not translate into home consumption and a reduction in exposure among farm household members.	• More and better evidence on the public health benefits of aflatoxin mitigation, will be important to making the case for investment in supporting adoption. • A better understanding of how farm household members gain access to information about agricultural and postharvest practices and what sources are most effective for what type of information will be important for devising well-targeted awareness-raising strategies. • A much better understanding is needed of how households make these decisions, especially how they balance potential trade-offs between income, risk, health, and other objectives.

The role of intermediaries: Traders, Processors, Livestock Producers

Issue	Challenges	Examples of tasks	Action Plan for research and development initiatives
Develop market pull	Technologies, controls etc will not make a difference unless there is market pull for food with low levels of aflatoxin.	• Create a holistic, integrated approach: Private sector-led Value chain centric aflatoxin management program • A market pull may be driven by regulation or by business that is concerned about reputation or by individuals concern about the health of their family members. • There is a need to establish value chains that deliberately remove food or by-products that are contaminated by mycotoxins.	• Leverage and scaling-up available technology • Evaluation of available technology • Cost benefit analysis of technology
The role intermediaries are expected to play varies with market context.	Differentiated markets are expected to provide economic incentives for farmers who are able to meet standards to adopt risk-mitigating practices. Another market for aflatoxin-safe grain is as feed for livestock. There is a significant body of evidence from animal studies showing that aflatoxins have a negative effect on animal health and production; however, the size and economic importance of the effects are highly variable across studies (Grace 2013). Large-scale livestock producers, the most likely source of demand for aflatoxin-safe feed, are currently a small share of the market but are likely to grow in the future. Because poultry is especially sensitive to aflatoxins, poultry value chains are a promising value chain for risk-mitigating technologies and practices (James et al. 2007).	• Intermediaries need to adopt good storage and handling practices to prevent further contamination. • A. flavus on contaminated grain may spread to other grain under less-than-ideal storage conditions and produce aflatoxins. Aflatoxin on contaminated grain does not multiply in itself and may become diluted by mixing. • The impacts of some storage practices are ambiguous; for example, where there are visible signs of poor-quality grain, mixing it with better-quality grain is a common strategy to be able to sell the grain and would have the effect of spreading the risk of exposure.	• Where livestock producers have alternative ways to reduce contamination or offset negative effects of aflatoxins in feed, aflatoxin-safe grain would need to be economically competitive. • Even if intermediaries do not pay a premium for aflatoxin-safe grain, they could provide an incentive to farmers to adopt good practices if they reward other quality characteristics that may be associated with lower aflatoxin levels. In the case of improved varieties, there may be perceptible differences between these and other varieties that would motivate traders to keep varieties separate. • At present, the use of perceptible differences as a way to differentiate improved varieties has not been explored. • In feed markets, the cost-effectiveness of purchasing aflatoxin-safe grain versus other ways of offsetting the negative productivity impacts of aflatoxins needs additional study, as does the importance of these markets for smallholder producers.

Consumption of aflatoxin-safe products by consumers

Issue	Challenges	Examples of tasks	Action Plan for research and development initiatives
Consuming aflatoxin contaminated products	The impact of consumption of aflatoxin-safe maize and groundnuts, either directly or through consumption of livestock and other products for which they are inputs, on aflatoxin exposure will depend on the extent to which consumers are currently consuming the contaminated staples and on whether there are other sources of contamination in their diets.	• It is important to keep in mind that exposure among individuals, even within the same household, will vary because diets and susceptibility to aflatoxins vary by sex, age, and health status. This needs to be considered when identifying target beneficiaries — for example, children or people living with HIV and AIDS and liver diseases are especially vulnerable. • For consumers who purchase or otherwise access grain in markets where standards based on human health consequences of aflatoxin consumption are already enforced, current contamination levels are likely to be low. This is the case for grain sold for export to the EU (limit 4 ppb), the United States (limit 20 ppb), and international food aid programs such as the World Food Programme (limit 20 ppb maize meal) • Compliance with standards is rare in developing countries but likely to grow over time in domestic markets. Demand for aflatoxin-free grain for complementary foods is currently small but is growing quickly	• There are few studies to date that document reductions in aflatoxin exposure from agricultural interventions. More studies will be needed to be able to estimate an appropriate target for this outcome at scale. • In markets where regulations are not currently enforced, exposure to aflatoxins is widespread in areas where susceptible crops are staples in the diet. How these markets can be cost-effectively developed and maintained and what the public health impacts would be are important questions for which there is currently little evidence.
Other sources of contamination in diets	While aflatoxins have been documented in a wide range of foods, primary sources of aflatoxin exposure are through consumption of maize, groundnuts, and milk due to their risk of aflatoxin contamination and the quantity and frequency of consumption. Data from Kenya show that by far the largest source of potential contamination is maize. In areas where groundnuts are the staple, similar findings might be expected. This suggests that risk of exposure from foods other than staples is currently low, though this could change over time if diets diversify.	• Diversification of diets away from susceptible staples could result in reduced exposure.	• Maize and groundnuts are likely to be the main sources of contamination among target populations, at least for the near future. A better understanding of how exposure levels are likely to change as diets evolve would improve the design and targeting of research and development interventions.
Availability of aflatoxin-safe foods	Evidence on whether consumers will consume aflatoxin-safe foods is mixed. Assuming that consumers are willing to eat aflatoxin-safe products, whether they actually do so will depend on whether the products are available to the persons in the household who make decisions about food consumption, and whether decisionmakers are able to differentiate aflatoxin-safe products. In the absence of diagnostic tests, it is not possible to reliably differentiate. In the case of home production, it should in theory be possible to differentiate based on production and postharvest practices. In the market, consumers generally do not know for sure whether the products they are buying have aflatoxins. Labeling is an option; however, there are strong ethical and economic concerns about labeling food on the basis of safety. In addition, in most domestic markets in developing countries, consumers have little trust in labeling and the certification systems that underlie them.	• Among households that produce for the market, whether household members consumed low-aflatoxin grain will depend on the results of storage, sale, purchase, and consumption decisions. Past studies have documented consumption outcomes but have not looked in detail at how they came about. • Since regulation on aflatoxin allowable limits is not enforced, there is no way to know whether food available in domestic markets is contaminated. To the extent that price is correlated with quality in local markets, poor buyers may not be able to afford food that is more likely to be low in aflatoxin. • Where consumers do not have complete information about aflatoxin levels, they may use other quality characteristics (for example, presence of mold) as a proxy.	• Where farm households adopt risk-mitigating practices, aflatoxin-safe food will be available in the households but it is not clear whether it is available to the person making household food consumption decisions. • More information is needed on where consumers get their maize and groundnuts; how households make consumption, purchase, and sale decisions; and what the implications are for the potential to influence aflatoxin levels in local, undifferentiated markets. • The development of cheap, rapid diagnostics for food safety, which could be used by consumers, would address some of these problems; however, as will be discussed below, this would raise concerns about what to do with the food that does not meet standards.

Consumer awareness	A number of studies find evidence that consumers, when provided with information about aflatoxins and their health consequences, are willing to pay a premium for aflatoxin-safe milk, maize, and groundnuts. Where efforts have been made to raise awareness—either as part of research (for example, willingness-to-pay studies) or as part of dissemination campaigns, awareness has increased, though this has been on a relatively small scale.	• The fact that it is difficult to differentiate aflatoxin-safe products from other products implies that consumers would be unlikely to reject them based on consumption characteristics. • In order for consumers to be aware and convinced that there is a health risk from consuming contaminated products, it will be important to reach the persons responsible for food acquisition, storage, processing, and consumption decisions with appropriate, actionable information about the health risks of aflatoxins and of what they can do to mitigate them	• Awareness has been raised in pilots; however, more information is needed about how to raise awareness at scale, in particular how to identify and reach key decisionmakers in households.
	People's willingness to undertake costly behavior changes to control aflatoxin will depend on what information they are given about aflatoxin-related health risks and the advantages and disadvantages of alterative control mechanisms, as well as how that information is presented and to whom.	• Evidence from public health suggests that scare-tactic approaches are not always the most effective in terms of changing behavior, especially where there is a disconnect between what people hear and what they observe. As this is likely to be the case with aflatoxins, especially chronic exposure, designing and delivering effective messages is a challenge that will require a good understanding of the target decision makers and their contexts.	• Past and ongoing research on willingness to pay for aflatoxin-safe products may provide some insights on what types of approaches appear to be most effective in influencing attitudes and, eventually, behavior. • This information will be an important input into the design of effective communication strategies.

Participants list

	Country	Name	Organisation/Instiution
1.	Austria	Franz Berthiller	Lab for mycotoxin-metabolism at BOKU/IFA-Tulln, Vianna / project MyToolBox
2.	Belgium	Paul Van Mele	Agro Insight
3.	Belgium	Sarah De Saeger	Department of Bioanalysis, Laboratory of Food Analysis - Faculty of Pharmaceutical Sciences Ugent
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5.	Belgium	Tina Ajdic	ADS Insight
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9.	Belgium	Marc DUPONCEL	Directorate General Agriculture H-5
10.	Belgium	Tereza HASOVA	Directorate General Agriculture A-3
11.	Belgium	Frans Verstraete	Directorate General Sante/Health
12.	Benin	Benoit Gnonlonfin	Food safety specialist
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15.	Ethiopia	Amare Ayelew	PACA
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17.	France	Catherine Brabet	CIRAD
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21.	Germany	Bruno Schuler	GIZ, Agricultural Policy, Food Security, Sustainable Agriculture, Sector Project Sustainable Agriculture
22.	Germany	Wolfgang Buechs	Federal Research Centre for Cultivated Plants (Julius-Kuehn-Institute)
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27.	Kenya	Stephen Muchiri	EAFF
28.	Kenya	Sophie Walker	ACDI/VOCA
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33.	Serbia	Ferenc Bagi	project MyToolBox
34.	South Africa	Brad Flett	African Mycotoxicology Society - AMS
35.	Sweden	Monica Olsen	Risk Benefit Assessment Department, National Food Agency
36.	Switserland	Gennadiy Shulga	Agricultural Services, Global Business Development, SGS Group Management Ltd, Geneva
37.	the Netherlands	Hans Marvin	RIKILT Wageningen UR, Institute for Food Security
38.	the Netherlands	Monique Denijs	Wageningen University
39.	the Netherlands	Jantien Meijer	Stichting Cabi Bioscience Nederland
40.	United Kingdom	Andrew Emmott	Senior associate (Nuts), Twin & Twin Trading, London
41.	United Kingdom	Bruno Tran	Natural Resources Institute (NRI)
42.	United States	Lynn Brown	Consultant PACA
43.	Zimbabwe	Loveness Nyanga	University of Zimbabwe

Programme

9:30 Welcoming by DG Sante
Frans Verstraete
Welcoming by PAEPARD and EAFF
Stephen Muchiri, EAFF, the Chairperson of the morning session
Remi Kahane, PAEPARD

Keynote speaker
Comments on the PAEPARD policy note: "The role of multi-stakeholder partnerships between Africa and Europe exemplified by the issue of aflatoxin contamination of food and feed"
Dr. Habiba Wassef, Bio-NCP Egypt (H2020 National Contact Point), nutritionist and senior reviewer FP5, FP6, FP7 and Horizon 2020.

Session 1: Lessons
10:00 *The role of the Partnership for Aflatoxin Control in Africa (PACA)*
Amare Ayelew , Program Manager, Addis Ababa, Ethiopia.

10:30 *Improving Food Safety in Africa*
Brad Flett - Agricultural Research Council - Grain Crops Institute, Potchefstroom, RSA. President of the African Society of Mycotoxicology

11:00 *Twenty years research on aflatoxin in Europe: what benefits for Africa?*
Antonio Logrieco, Istituto Scienze delle Produzioni Alimentari (ISPA), Bari, Italy (coordinator of the Mycokey project under H2020- SFS-13-2015 call on Biological contamination of crops and the food chain: A contribution to a long-term collaboration with China on food safety).

11:30 *The impact of hand shelling in Malawi*
Andrew Emmott, Twin&Twin Trading, Senior Associate (Nuts), London, UK.

12:00 **Respondents: Below experts reacted to the presentations in a panel discussion. The PPTs below will not be presented but serve as background for the participants**
Sarah De Saeger (Faculty of Pharmaceutical Sciences, Ghent University) *The expertise of Mycotox at the laboratory of Food Analysis*
Monica Olsen (National Food Agency of Sweden) *Risk Benefit Assessment*
Monique Denijs (WUR, The Netherlands) *Wageningen ur approach to aflatoxin*
Catherine Brabet (CIRAD, France) *Expertise of CIRAD-UMR Qualisud for aflatoxin control in Africa*
Ferenc Bagi, University of Novi Sad, Serbia (member of the MyToolBox project under H2020- SFS-13-2015 call as well). *Experiences about aflatoxins in Serbia: what could be relevant for Africa?*

12:30 – 14:00 Lunch break and networking (self-service cafeteria, same floor of the building)

Session 2: Actions
14:00 Chair person: Lynn Brown (Global Donor Platform for Rural Development)
Panel discussions: Presentations in 3 consecutive panels (pitching type of panel without slide show).

14:15 **Panel discussion on pre-harvest mitigation**:
Limbikani Matumba (LUNUAR, Malawi) *Stemming Aflatoxin pre- and post-harvest waste in the groundnut value chain*
Benoit Gnonlonfin (INRAB Benin/Consultant independant) *Crops drying to a safe moisture content and handling: challenges facing African countries.*
Bruno Schuler (GIZ Germany) *African Cashew initiative* + *Prevention and control of aflatoxin contamination in value chains: Contribution of GIZ*

15:00 **Panel discussion on post-harvest technologies**:
Charles Nkonge (Kenya) *Highlights of maize aflatoxin research in Kenya*
Erastus Kang'ethe (EAFF) on *Aflatoxin in milk*
Loveness K. Nyanga (University of Zimbabwe/Action contre la faim) *Postharvest management technologies for reducingaflatoxin contamination in maize grain and exposure to humans in Zimbabwe*
Sophie Walker (ACDI/VOCA) *AflaSTOP: Storage and drying for aflatoxin prevention project*

15:45 **Panel discussion on Education and awareness creation:**
Paul Van Mele (Agro Insight) *Quality training videos to be developed withfarmers who are trained in aflatoxin prevention and management*
Bruno Tran (NRI, UK) *African postharvest losses information system (APHLIS)*
Kouadio James (University Félix Houphouet-Boigny, Abidjan - Côte d'Ivoire) *Toxicologie et hygiène alimentaire (title tbc)*
Daniel Gad (Exporter and entrepreneur in horticulture - Ethiopia) *The importance of consumer awareness on the risks of aflatoxin contamination*
Hailemichael Desmae *Management of aflatoxin contamination in groundnut – ICRISAT Approach* (International Crops Research Institute for Semi-Arid Tropics -West & Central Africa, Bamako, Mali)

Session 3: Funding

16:30 **Panel discussion on Funding opportunities**:

Marc Duponcel (DG Agriculture H5) *H2020 priority setting, themes and the current selection process (cfr. multi stakeholder consortia)*

Francois Stepman (PAEPARD) *The Swedish Program for ICT in Developing Regions and the Apps4aflatoxin H2020 proposal*

Wolfgang Buechs (Federal Research Centre for Cultivated Plants - Julius-Kuehn-Institute) *AflaNET project: Minimization of aflatoxin contamination in the value chain*

17:00 **Recommendations and action plan**: the recommendations and commitments to an action plan from this meeting will be presented during the panel session 3 of the ARCH Pre-event (on 26/01) to the DG-AGRI Agricultural Research and Innovation Conference (on 27-28/01).

17:45 - 18:00 Conclusion and closure of the Roundtable meeting.

PPT business cards

Ida Skaar (Norwegian Veterinary Institute Section of Mycology) *NVI`s interests and available expertise*

Bruno Schuler (GIZ Germany) *Rapid Loss Appraisal Tool (RLAT)*+ *Prevention and control of aflatoxin contamination in value chains: Contribution of GIZ*

Tina Ajdic and Aida Axelsson-Bakri (ADS Brussels) *ADS Insight & aflatoxins*

Gennadiy Shulga (Agricultural Services, Global Business Development, SGS Group Management Ltd, Geneva) *SGS monitoring program for mycotoxins*

Opinion

– SciDev.Net website, September 2015

Farm-level solutions key to halting aflatoxins exposure

This article has been produced by SciDev.Net's Sub-Saharan Africa desk.

10/09/15 Sam Otieno

[NAIROBI] Adopting suitable technologies and practices at the farm level could significantly help reduce the high risk of consumer exposure to aflatoxins, according to researchers.

In a discussion paper published in July 2015[7], researchers assessed how a theory of change — an approach for analysing complex problems — could be used to explain adoption of farm-level technologies and practices for controlling aflatoxins exposure among consumers.

"The theory of change analysis identifies some key areas where impact pathways need more clarification and highlights gaps for future research," the researchers note in the paper.

> *"Technology is key in addressing the aflatoxin problem but so are well-designed policies, programmes and regulations."*
>
> Nancy Johnson, International Food Policy Research Institute (IFPRI)

According to the researchers, important food crops such as maize — a staple food in African countries including Kenya, South Africa, Zambia and Zimbabwe — and groundnut are susceptible to aflatoxin exposure, which if not addressed could lead to public health problems. *"The best documented health impact of chronic exposure to aflatoxins is liver cancer; up to 172,000 cases per year are attributable to aflatoxin exposure,"* the paper says.

Nancy Johnson, a co-author of the paper and a senior research fellow at the US-headquartered International Food Policy Research Institute (IFPRI), calls for interventions to control aflatoxins, but she tells *SciDev.Net*: *"Technology is key in addressing the aflatoxin problem but so are well-designed policies, programmes and regulations, and education and awareness among consumers".*

Johnson, who also leads the evaluation of the CGIAR Research Program on Agriculture for Nutrition and Health, explains: *"Creating the theories of change helps us to see better how the different parts fit together, and we can use that knowledge to help identify key partners and to target our research to the key evidence gaps."* She adds that developing the theory of change is a process of connecting the on-farm research all the way to the end result: reducing exposure to aflatoxins among consumers. Based on the theory of change analysis, Johnson says that more evidence is needed to determine whether a large number of farmers will adopt risk-mitigating technologies and practices and whether the food produced by these farmers, which will be lower in aflatoxin than conventional production, will be consumed by the people who are currently consuming contaminated food. But she notes there is a risk that even if many farmers use the new technologies, they **may sell their produce to high value markets which is good for them economically but may not have a big impact on local public health**.

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Dan Mukambi, a scientist at the International Maize and Wheat Improvement Center, CIMMYT, Kenya, commends the authors for their analyses, but says fighting aflatoxins in developing countries faces challenges. *"One of the biggest challenges farmers and experts face in dealing with this problem is that it is usually expensive to analyse crop samples for aflatoxins,"* Mukambi says.

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[7] Nancy Johnson and others *The potential of farm-level technologies and practices to contribute to reducing consumer exposure to aflatoxins: a theory of change analysis* (International Food Policy Research Institute, July 2015)