# Building an Aflatoxin Safe East African Community

## Technical Policy Paper 7

# Aflatoxin Standards for Feed

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Situational Analysis for East Africa Region

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**Cover:** Mixed stock livestock farming in western Kenya. *ILRI*

# Foreword

The production of livestock has a rich cultural history in East Africa and plays an important role in the economies of nations across the region. The sector is largely informal, dominated by small-scale producers using forage as the primary feed source for cattle, goats, and sheep. The formal poultry, dairy, and aquaculture sectors are rapidly expanding, however, fueling the demand for manufactured nutritionally balanced and safe feeds. Aquaculture has been identified as a priority area for development, holding promise for export markets outside the region and the potential to fill critical indigenous micronutrient deficiencies.

The consequences of aflatoxin-contaminated feed use among small farmers as well as large-scale commercial producers are well documented, reflecting lowered productivity and higher mortality rates. Aflatoxin ingested through feed is also transferred into animal products. Milk is of particular concern since it is widely consumed by infants and young children in the region.

Currently, 90 countries worldwide have standards for aflatoxin levels in food and feed. These are derived through "risk assessment" studies, a scientifically based and statistically reliable determination of the likelihood that a hazard will actually cause harm, together with a measure of the harm. In developed countries, aflatoxin standards are based on the age of both humans and animals, with stringent limits on allowable levels for foods commonly consumed by infants and young children, and lower tolerance levels for young animals by species.

Standards come at a cost, but when managed well can reap great benefits. The pitfalls and gains of the particular standards a country chooses should be carefully weighed relative to their impacts on producers, consumers, traders, and processors, as well as the ability of governments to regulate and enforce. Without the sum of these elements moving harmoniously, standards can be ineffective. Even with the best standards in place, without voluntary compliance by the private sector, governments will find it impossible to safeguard the health of humans or animals.

This paper provides a comprehensive overview of the knowledge base that can be used by policy-makers, regulators, consumer groups, and the agriculture sector to develop modernized and appropriate standards for feed for the East Africa region.

## Table of Contents

## Tables

## Figures

# Executive Summary

This report presents the process, knowledge base, and logic for the development of standards for aflatoxin levels in animal and fish feeds in the East Africa region. The purpose of this discussion is to equip the East African Community (EAC) and its partner states to develop modernized and appropriate standards in regard to contamination of foods and feeds by aflatoxin. The analysis is based on an extensive review of the available literature, a situational analysis, interviews with standards officers and experts, and observations of the authors within the EAC.

Feed standards have the primary objective of safeguarding public health, protecting animal health, and fostering trade. In developing countries, decision makers may have to take into account other considerations, such as food security and poverty alleviation. Emergencies such as droughts may also require special measures.

Standards for aflatoxins exist at global, regional, and national levels. The Codex Alimentarius Commission (CAC), an inter-governmental organization, provides benchmarks on food and feed safety. It has three Codes of Practice relevant to aflatoxin standards.

Risk analysis is the most appropriate method for assessing the standards for aflatoxins in human food and for setting standards for livestock feeds where the primary objective is to reduce risk to human health from aflatoxins in animal source foods such as milk, eggs, and meat. Where risks to human health are not present or are deemed negligible, risk concepts along with cost benefit analysis are appropriate for setting standards for aflatoxins in animal feeds.

Different countries have set a wide variety of aflatoxin standards for livestock and fish feeds. In general, most standards are lower (that is, more strict) than the levels at which adverse effects from aflatoxins are seen in experimental trials, but may be less strict than the levels at which adverse effects to humans can result from on-farm feeding practices. A science-based way to approach setting standards is to start with the levels that studies have shown are generally tolerable and then to increase them by a margin of safety. The margin of safety depends on the weight given to the advantages and disadvantages of setting strict standards.

Anti-mycotoxin additives (AMAs), also known as binders or adsorbents, are substances that bind to mycotoxins and prevent them from being absorbed through the gut and into the blood circulation. When other preventive measures against molds and mycotoxins have

failed, the use of mycotoxin binders in animal feeds can be helpful. Current evidence shows that clays are the most effective AMAs. However, not all clays (even of the same type) are equally effective. In the absence of testing, a large proportion of products in a given market may be ineffective.

Safe feeding of aflatoxin-contaminated cereals to suitable classes of livestock can be an appropriate alternative use. Blending of contaminated grains with uncontaminated grains can produce feeds with an average level below permitted limits. Ammoniation is a safe and effective way to decontaminate cereals intended for livestock use. In some countries, cereals above national limits can be exported. But this is not recommended.

Aflatoxins are difficult to detect. Very low levels can do harm, and aflatoxins are not distributed evenly in foods or feeds. A variety of sampling protocols exists and should be followed where possible. Sampling protocols can be adjusted to avoid rejecting food or feed that is actually safe and to minimize the chance of accepting that which is not safe. Quality assurance and laboratory networks have an important role in ensuring accuracy of results. A number of tests are available with differing costs, advantages, and disadvantages.

Compliance with existing standards is constrained by multiple factors. Among these are a lack of well-equipped laboratories, and a shortage of competent personnel to conduct the necessary analysis and surveillance for compliance. Few government and agency officials or private-sector businessmen understand the benefits of compliance for agribusiness and consumers. Currently, standards development in the EAC partner states follows the format of the International Standards Organization (ISO). Although many standards have been developed, the standards for animal and fish feeds are scant and in most countries do not clearly address allowable limits for aflatoxin.

The feed sector in East Africa remains underdeveloped. Uganda, Tanzania, and Zanzibar lead in the production of poultry feed, while in Kenya, most manufactured feeds are for dairy cattle. With a growing emphasis on development of the dairy sector to lift families out of poverty, manufacturing and trade in animal feeds and raw materials for feeds is expected to rapidly increase. Standards to ensure a high-quality and safe food supply are required.

At present, the feed sector is not keeping pace with developments in disease control, animal genetic improvement, or anti-contamination standards. More information-gathering and analysis are needed to provide science-based information to inform policy and the development of standards for feed.

To date, few studies have addressed the problems of aflatoxin contamination of feeds for the region, and awareness remains low about the prevalence and consequences of aflatoxins as well as about standards across both the public and private sectors of the EAC partner states. It is imperative that awareness of the benefits of having, and the importance of complying with, standards is created among stakeholders along the feed value chain. Stakeholders should also understand that awareness will spur consumers to demand that the feed industry comply with standards in order to have safe food.

EAC partner states should develop policies that enable them to comply with national, regional, and international standards. Stakeholders from the level of the ISO through national and local governments have a part to play in this development process.

# Considerations for Setting Standards on Animal Feeds in Developing Countries

Developing countries have multiple issues to consider as they approach the process of setting standards for animal feeds:

***Feed and food security.*** Improvements in food and feed safety have direct and indirect benefits by improving health and productivity and reducing costs of illness (Caswell and Bach 2007). However, stringent regulation may cause food shortages and higher prices. To avoid harming the poor, policy-makers should always keep food security in mind when setting food safety regulations. Efforts to mitigate food safety risks should not be adopted at the cost of sacrificing food supply or diverting resources from agricultural production (Cheng 2009).

***Ability to comply.*** Stringent regulations may also provide incentives for producers and processors to evade regulations and thus create secondary markets where quality is even lower and regulation more difficult (Grace et al. 2010). Studies by the International Livestock Research Institute (ILRI) have found that 40-80 percent of food sold in East Africa does not comply with existing regulations. In these situations, a “ladder approach”—whereby stakeholders work with the informal sector to gradually improve standards—may be more effective than an “inspect and punish” approach.

***Feed trade.*** Many feed ingredients grown in tropical countries have potential markets in developed countries with intensive agricultural systems. Some studies suggest that high standards in importing countries can impose large costs on exporters even though the benefits of high standards on animal and human health are very small. However, other studies on trade in animal products have found that meeting standards is a relatively less-important barrier to exporting. Finally, some studies have even shown benefits to exporters from meeting higher standards.

***Harmonization.*** Conflicting legislations, codes, and standards can be an unintended impediment to trade, and harmonized standards (such as the Codex Alimentarius), have been shown to increase trade. However, where countries have different priorities, or different capacity to enforce regulations, it may not be possible or useful to move too quickly to harmonize regulations.

***Appropriateness.*** Legislation needs to fit the context. In the case of feeds, the different types of producers, and input providers, along with their different needs and how the legislation may impact them, need to be analyzed. In East Africa, most farmers are smallholders; some farmers mix their own feeds or buy from small mills. Organic farmers and fair trade value chains may also need special consideration.

***Coordination.*** In Africa, food safety is often the responsibility of multiple agencies and departments. It is important to align and coordinate food safety legislation across sectors.

***Emergencies.*** Parts of Africa are prone to simple or complex emergencies, which may include lack of feed and fodder for cattle. In these circumstances, one option is feeding programs for animals. Such efforts may be more cost-effective than restocking. However, in these circumstances sourcing feed and/or fodder may be difficult if regulations are too strict to allow flexibility. Such programs can strengthen reliance and livelihoods in farming communities.

# Global, Regional, and National Standards for Aflatoxins in Feeds

Standards pertaining to aflatoxins in feed exist at global, regional, and national levels.

## CAC Aflatoxin Standards

The CAC provides the global benchmark on food and feed safety. The Codex Alimentarius is a collection of international standards, codes of practice, guidelines, and other recommendations that have been adopted by the CAC. The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) established the CAC jointly in 1962 to protect the health of consumers and facilitate trade through development of international standards for food and feed. The CAC is composed of delegations from FAO and WHO member states that participate in developing food standards. The CAC develops standards on the basis of sound scientific evidence provided by independent FAO/WHO scientific committees. World Trade Organization (WTO) members are required to base sanitary and phytosanitary measures on international standards and Codex standards that are specifically recognized in the Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) as the international benchmarks for feed and food safety. However, Codex standards are advisory, not mandatory, and member countries can trade at other (and lower) standards if they agree to do so.

There is no Codex standard which deals with aflatoxins in animal feeds, but CODEX STAN 193-1995) gives the principles for setting limits for contaminants, including aflatoxins, in food and feeds.

CAC has three codes of practice dealing with aflatoxin standards.

## Codex General Standard for Contaminants and Toxins in Food and Feed (CODEX STAN 193-1995)

This standard is concerned with hazards in feeds that could affect human health and sets out guidelines that apply to establishing maximum levels (MLs) in food and feeds. It is concerned only with contaminants in feed, which can be transferred to animal source food and affect public health. In the case of aflatoxins in Africa, aflatoxin is likely to be a major public health risk only in the case of milk.

The principles for setting MLs for contaminants in food or feed are:

- MLs shall only be set for contaminants that present a significant risk to public health and trade.
- MLs shall be set as low as reasonably achievable to protect the consumer.
- MLs shall be set at a level slightly higher than the normal range of variation in levels in foods that are produced with current adequate technological methods, in order to avoid undue disruptions of food production and trade.
- Proposals for MLs in products shall be based on data from various countries and sources, including the main production and processing areas of those products.
- MLs shall apply to representative samples per lot and where necessary sampling methods should be set out.

## CAC Codes of Practice for Reduction of Aflatoxins for Milk-producing Animals (CAC/RCP 45-1997)

The Code of Practice for the Reduction of Aflatoxin $B_1$ in Raw Materials and Supplemental Feeding Stuffs for Milk-Producing Animals (CAC/RCP 45-1997) was adopted in 1997. This provides advice on reducing aflatoxins in crop production, harvest, storage, transport, and feed production. It recommends sampling to assess contamination. If feed is contaminated, it recommends feed restriction (limiting contaminated feed to the level that no significant residues of $AFM_1$ are found in milk). If this is not possible, it recommends diversion of feed to nonlactating animals only.

## CAC Codes of Practice for Good Animal Feeding (CAC/RCP 54-2004)

In 2004, the CAC adopted a Code of Practice for Good Animal Feeding (CAC/RCP 54-2004) developed by the ad hoc Intergovernmental Task Force on Animal Feeding. The code establishes a feed safety system for food-producing animals, which covers the whole food chain. It covers good ingredients, labelling, traceability, inspection, sampling, and recalls, and provides details on good practices for feed manufacture and on-farm feed mixing.

## Regional Aflatoxin Standards for Livestock Feeds

In 2002, the FAO initiated an international enquiry on aflatoxin regulations. Several regional bodies or groups have harmonized regulations, including the EU, the Southern Common Market (MERCOSUR), and Australia/New Zealand. The EU, MERCOSUR, and Australia have harmonized maximum limits. Other regional bodies—the Association of Southeast Asian Nations (ASEAN), the Economic Community of West African States (ECOWAS), and the Common Market for Eastern and Southern Africa (COMESA)—are in the process of harmonizing standards.

## National Aflatoxin Standards for Feeds and Feed Ingredients

The number of countries regulating mycotoxins has significantly increased over the years. Overall, 99 countries have mycotoxin regulations for food and/or feed, representing an increase of 30 percent from 1995 to 2003, when the FAO did the most recent official survey. Comparing the situation in 1995 and 2003, it appears that in 2003 more mycotoxins are regulated in more commodities and products, whereas tolerance limits have generally remained the same or tended to decrease. Regulations have become more diverse and detailed with newer requirements regarding official procedures for sampling and analytical methodology. See Appendix: Aflatoxin Standards by Country in 2003 for a list of aflatoxin standards by country in 2003. Of the EAC partner states, only Tanzania has formal aflatoxin standards for feeds and feed ingredients.

# Aflatoxins and Feed in the EAC

## Types of Feeds: Roughages and Concentrates

Animal feeds can be categorized as roughages or concentrates. Roughages are feeds with a low density of nutrients and include most fresh and dried forages and fodders. Grass, silage, hay, legumes, cottonseed hulls, bagasse, and peanut hay are examples of roughages. Usually, roughages contain high levels of fiber and are essential for correct gastrointestinal function of herbivores. Concentrates are feeds with a high density of nutrients and usually low fiber. Concentrates may be fed as individual feeds or blended and formulated into balanced rations (compound feed).

Concentrates include:

- Cereals: rice, wheat, barley, oats, rye, maize, sorghum, and millet
- Milling by-products: brans, hulls, pollards, etc.
- Cereal substitutes: dried cassava, dried sweet potatoes, brewers’ grains, molasses, etc.

- Oil meals and cakes: residue after oil is extracted from oilseeds (soybeans, peanuts, sunflower seeds, rapeseed, safflower, flax, linseed, palm kernels, mustard seed and cottonseed)
- Animal by-products: meat, fish blood, and bone meal; milk products; poultry litter, fish and animal oil
- Industrial products: urea.

The animal feeds most seriously affected by aflatoxin contamination are maize, cottonseed, copra, and peanuts (FAO 2008). Concentrates and supplements may also be contaminated, especially if stored under inadequate conditions.

*A small family farm in East Africa. ILRI*

## Challenges of Testing for Aflatoxins in Animal and Fish Feeds

Aflatoxins are difficult to detect because they are not evenly distributed in foods and feeds. This makes it difficult to detect low levels of contamination and take representative and reliable samples. A variety of sampling protocols exists and should be followed where possible. Sampling protocols can be adjusted to avoid rejecting products that are actually safe and minimize the chance of accepting those which are unsafe. . Quality assurance and laboratory networks have an important role in ensuring accuracy of results. A number of tests are available with differing costs, advantages, and disadvantages.

Since mycotoxins cannot be completely prevented in the crops, regulations to prevent highly contaminated crops from entering the food chain are necessary. However, regulations alone are not enough. There is also a need for reliable and affordable tests for aflatoxins, incentives for complying with regulations, and systems that effectively deal with the contaminated products. In Kenya for example, where the vast majority of crops are sold in informal markets, regulations regarding aflatoxins are enforced only in the formal market, leaving most of the population, especially the poor, unprotected. The same situation occurs for animal feeds, where only stakeholders in the formal market chain have tests imposed on them. Further, enforcement is irregular throughout the formal sector across the region.

Unfortunately, testing for aflatoxins is not easy. One challenge is that tests seek to find very small amounts of aflatoxins. Most standards are expressed in parts per billion (ppb). Finding one part-in-one-billion aflatoxin is the equivalent of detecting one second in 32 years, or finding seven people in the population of the world. Another problem is that aflatoxins are often not distributed evenly throughout the material being sampled. As a result, repeated tests on the same crops or feed products can often give different results. Molds do not grow uniformly in crops, and therefore toxins are unevenly distributed (Turner et al. 2009). In the case of maize and groundnuts, individual nuts or kernels can contain very high levels of aflatoxins. Considering that one kernel can have 50,000 ppb, just 30 of these kernels would be enough to put a 50 kg bag of corn above the limit of 10 ppb. Because of the non-uniform distribution of aflatoxins in crops, it is possible that subsequent tests on the same batch of cereals or oilseeds will give very different results, and there have been several studies to identify robust sampling protocols. Unlike analytical methods, sampling schemes cannot be collaboratively tested; usually a particular sampling plan is proposed, based on statistical consideration of the measured toxin distribution, and thereafter adopted as an official procedure.

The variability of aflatoxins in crops, and the dependence on a large sample size, was demonstrated early (Whitaker et al. 1976; Whitaker et al. 1979). When crops are ground for animal feeds, homogeneity increases, but variability will still depend on how sampling, mixing, and subsampling are done (Coker et al. 2000). For smallholders, it may not be feasible to attain the desired amount of animal feed for sampling; less may need to be taken (Pitt et al. 2012a, Pitt et al. 2012b). Since milk is more homogeneous, it is assumed that there is less variability in testing for AFM1, but this has not been proven.

Sampling errors can have different types of consequences. False positives occur when samples are rejected that are actually safe for consumption. This leads to losses for producers, and it will decrease the amount of feed available for animals and food for people. The other type of problem is a false negative (that is, accepting a sample as safe, even though it exceeds standards). This error exposes people and animals to contaminated food or feed.

A number of protocols for sampling of commodities for mycotoxins have been developed, with different risks for consumers (accepting food or feed that should have been rejected) and producers (rejecting food or feed that should have been accepted). Generally, the difficulty of obtaining a representative sample is recognized as the major cause of insecurity in aflatoxin testing. However, there is still variability among different laboratories and different laboratory methods. Most methods require a correct extraction and clean-up of samples, and the way this is done may affect the outcome (Turner et al. 2009). Which methods can be used in a lab are dependent on how reliable electric power is as well as the supply of reagents; in remote areas or poorly equipped labs, less advanced methods may need to be employed.

Highly reliable methods are liquid chromatography mass spectroscopy (LC/MS) and high (or ultra-high) performance liquid chromatography (HPLC/UPLC), and these often serve as references for other methods. Total aflatoxins can also be measured by direct fluorescence (DF) of purified extracts. Different immunoassays have also been developed, such as enzyme-linked immunosorbent assays (ELISA), which are easy and cost effective (Turner et al. 2009; Pitt et al. 2012). There are a number of rapid tests providing a result over or under a certain limit (agristrips and dipsticks). These may be used directly at millers and producers, or in markets (Pitt et al. 2012). Table 1 summarizes the characteristics of widely used tests.

*Table 1: Characteristics of different methods available for detecting aflatoxins in animal feed.*

| | Cost | Complex | Portable | Detects <10 ppb | Detects mycotoxins |
|---|---|---|---|---|---|
| LC-MS | $$$ | + | no | yes | yes |
| TLC | $ | ++ | no | yes | no |
| UPLC | $$ | +++ | no | yes | no |
| DF | $ | +++ | no | yes | no |
| ELISA | $ | +++ | no | yes | no |
| NIRS | $$ | + | yes | no | potentially |
| Agristrips/dipsticks | $ | ++ | yes | yes | no |

**Source: Modified from Harvey et al. 2013.**

While these current technologies can provide an accurate measurement of aflatoxin levels, they are generally expensive, have low throughput and are not portable for the African context. A promising technology is Near Infrared Spectroscopy (NIRS), a technique used to identify substances by measuring their absorption of infrared radiation (Harvey et al. 2013).

Due to the difficulties in assessing mycotoxin levels, it is important to have a reference system, both within a country and in a region, by which local labs can be accredited and ring tests performed. This way, the reliability of laboratory results can be established.

## Impact of Aflatoxins on Livestock and Fish Health

All animals are affected by aflatoxins, but some species more so than others. Rabbits, ducks, and pigs are highly susceptible; dogs, calves, turkey, and sheep are moderately susceptible; chickens and cattle are relatively resistant. Fish vary from highly susceptible to resistant and honey bees are relatively resistant.

The effects of aflatoxins depend on genetic factors (species, breed, strain); physiological factors (age, nutrition, exercise) and environmental factors (climatic, husbandry, housing) (Dhanasekaran 2011). A more detailed discussion of the impacts on animal health and transfer to livestock and fish products is given in the technical package on animal health, which is part of this series. An extensive literature review conducted by the International Livestock Research Institute (ILRI) came to the following conclusions:

- Impacts can be large. For example, depending on the amount of aflatoxin and the length of the trial, chickens fed contaminated feed weighed from 38 percent to 97 percent as much as birds fed normal diets; layers given 10,000 ppb reduced egg production by 70 percent (Huff et al. 1975) A review of multiple studies showed that mycotoxins in diets reduced pig weight gain by 21 percent (Andretta et al. 2012).

- In general, the effects of aflatoxins are dose responsive: the higher the amount of aflatoxins, the greater the impacts. In pigs, every extra 1000 ppb in pig feed was associated with a 3.9 percent additional decrease in weight (Andretta et al. 2012).
- In several trials there seems to be a threshold below which impacts are not seen. Some trials in poultry showed no body weight reduction at levels between 50 and 800 ppb. Other trials in poultry showed body weight reduction between 75 ppb and 500 ppb. All trials showed body weight reduction at over 1000 ppb (Hussein and Brasel 2001).
- Some studies show impacts in commercial herds or flocks at levels below those shown to cause impacts in laboratory trials. This could be because animals are exposed to other stressors or they ingest a mixture of mycotoxins.
- Some studies show impacts at low levels of aflatoxins; others do not show impacts even at high levels. This could be due to other factors (food quality, exercise, breed, and age of animals) or to trials being too short or having too few animals to detect affects.
- Dietary levels of aflatoxin (in ppb) generally shown to be tolerated are: ≤50 in young poultry, ≤100 in adult poultry, ≤50 in weaner pigs, ≤200 in finishing pigs, <100 in calves, <300 in cattle and <100 in Nile tilapia (Pitt et al. 2012). Dietary levels as low as 10–20 ppb may result in measurable metabolites of aflatoxin (aflatoxin M1 and M2) being excreted in milk especially where milk is from high yielding dairy cattle (Elgerbi et al. 2004).
- However, ill effects may be observed at lower levels, especially if animals are exposed to other stressors.
- Decrease in body weight due to aflatoxin exposure can be partially offset by exercise, protein, methionine, and good environmental conditions (Andretta et al. 2012).

## Reasons for Setting Aflatoxin Limits for Feed

There are three reasons for having standards for the maximum amount of mycotoxins in feeds: 1) to protect human health from possible harmful metabolites in animal products; 2) to protect livestock from potential negative health and production impacts of aflatoxins; and 3) to protect the environment from contamination. The reasons for protecting livestock health are: 1) to safeguard livestock resources and the benefits people derive from livestock (nutrition, income, livelihoods, trade); 2) to protect value-chain actors from fraudulent or defective products; 3) to encourage fair trade, competition and economic growth; and 4) to protect the welfare of livestock. The primary reason for mycotoxin regulations in pet food is concern about the health of the animal motivated by animal welfare and public opinion considerations. Most countries however, do not regulate pet foods separately from other animal feeds (Leung, Díaz-Llano and Smith 2006).

There is also a question as to whether there should be a choice of one standard for all feeds or different standards according to livestock and feed type. The sensitivity of different species to different classes of mycotoxins has caused some countries, including Canada and the United States, to have regulations that allow more contaminated feed to be directed towards more resistant species (Appendix: Aflatoxin Standards by Country in 2003). Other countries have a uniform level for all animals and animal feeds (e.g., Tanzania [10 ppb], Nepal [10 ppb]). Other countries select one overall standard but allow exceptions; these include European Union members, which have adopted a conservative level of aflatoxin $B_1$ in all animal feeds (20 ppb), apart from some components that may only be 5 ppb (European Commission 2003, 2009) Other mycotoxins, however, are regulated depending on species (European Commission 2006).

Standards are also designed to prevent carry-over of aflatoxins from livestock and fish feeds to human beings. Levels in animal feeds are primarily regulated to protect humans from exposure to Aflatoxin from animal products. Aflatoxins are carried over from the animal into animal products and therefore the regulation of aflatoxins in animal feeds is also protecting human consumers. Approximately 1-7 percent (around 2 percent on average) of the $AFB_1$ consumed by a dairy cow is transferred into the milk as the aflatoxin $M_1$ metabolite (Fink-Gremmels 2008). Although still toxic, this metabolite has been estimated to have only 3 percent of the mutagenicity of $AFB_1$ (Cullen, Ruebner, Hsieh, Hyde, and Hsieh 1987; Wong and Hsieh 1976). However, the difference in potential to inflict chronic disease has not been evaluated.

Transfer of aflatoxins from feed to eggs, meat, and viscera has been studied, and found to be much less than the transfer into milk. The transfer of aflatoxins into eggs seems to be around 2,000-5,000 times less than what was fed in the feed (Hussain et al. 2010; Oliveira et al. 2000). Similarly, retention rates of aflatoxins in the meat and viscera of pigs and beef have been shown to be very low, with less than 1 percent being retained, and disappearing rapidly after animals are given aflatoxin-free feed (Furtado, Pearson, Hogberg, and Miller, 1979; Jacobson, Harmeyer, Jackson, Armbrecht, and Wiseman, 1978; Richard et al. 1983).

## Principles for Aflatoxin Standards Setting in the EAC

The Codex Alimentarius provides some guidance on setting of maximum levels (MLs) for aflatoxin. Principles and their implications for standard setting in the East African context are summarized below.

***Principle 1.*** MLs shall only be set for contaminants that present a significant risk to public health and trade. Implications: Aflatoxins in milk may present a significant risk; aflatoxins in meat, eggs, and offal are unlikely to pose a risk (assuming feed containing aflatoxins is stopped for a period before slaughter). However, risk assessment is needed to evaluate if they may pose a risk to sub-groups.

***Principle 2.*** MLs shall be set as low as reasonably achievable to protect the consumer. Implications: More evidence is needed on what is the lowest level reasonably achievable for animal source foods and animal feeds in East Africa. It is probably higher than limits set in the EU and may be closer to limits set in India, South America, and the United States.

***Principle 3.*** MLs shall be set at a level that is slightly higher than the normal range of variation in levels in foods that are produced with current adequate technological methods, in order to avoid undue disruptions of food production and trade. Implications: Because current levels of aflatoxins are high in feeds, more stringent standards would result in disruptions of feed production and trade if applied.

***Principle 4.*** Proposals for MLs in products shall be based on data from various countries and sources, encompassing the main production and processing areas of those products. Implications: Data on this is presented in the situational analysis.

***Principle 5.*** MLs shall apply to representative samples per lot and where necessary sampling methods should be set out. Implications: Protocols for aflatoxin contamination sampling for animal and fish feeds in East Africa should be developed and regionally harmonized.

However, there is no single internationally accepted regulation on MLs for aflatoxin in feeds. Likewise, there is no guaranteed safe level for aflatoxins in livestock and fish feed. The effects of aflatoxins vary with species, breed, age, diet, exercise, and environment. They also vary depending on other mycotoxins present in the feed. There are many unknowns about aflatoxins, and much of the research and experimental work does not adequately reflect the real life conditions on farms. Aflatoxins are carcinogenic in some animals. As with many other carcinogens, it has been assumed that a single molecule could potentially cause a mutation that could lead to cancer, hence there is no safe limit for carcinogens. For aflatoxins in animal source food, there is evidence regarding the potential impacts of aflatoxins on human health and well-established conventions on the margins of safety that are applied in fixing limits for aflatoxins in human foods. These should be the basis for standards on aflatoxins in animal source foods. Most transfer to meat and viscera can be prevented by ceasing to feed aflatoxin containing feed for a period before slaughter, and this should be observed. Preventing transfer to milk requires keeping aflatoxins in dairy animal diets below certain limits.

However, aflatoxins are ubiquitous in tropical countries and cannot be completely eliminated from feeds. Aflatoxins are produced by fungi, which are found everywhere in soil and crops. It is not possible to completely eliminate aflatoxins from animal feed with current technologies. Hence, decisions have to be made as to what levels of aflatoxins in animal feeds are acceptable or tolerable and what is the best way of attaining those levels. Moreover, many of the effects of aflatoxins are dose-dependent and so at certain doses ill effects are minimal.

## Advantages and Disadvantages of Strict Aflatoxin Standards

The advantages of policies that specify strict standards (only small amounts of aflatoxin allowed) in animal feeds are that they:

- Give the widest margin of safety for livestock and animal source foods
- Allow harmonization with others setting strict standards (for example, the EU)
- Give additional protection against presently unknown effects
- Are often most acceptable to the public and decision makers
- Discourage countries with strict standards from dumping products on other countries.

The disadvantages of policies that specify strict standards (only small amounts of aflatoxin allowed) in animal feeds are that they:

- Are costly and/or impossible to enforce
- Add to the costs of farmers and the feed industry and hence the cost of livestock products
- Create greater competition with human food and reduce food security
- Make it more difficult to harmonize standards among neighboring countries
- Remove an alternative use for contaminated human food, making it more likely contaminated food will be eaten by people
- Create relatively higher compliance costs for poor farmers and those with less access to education and information (often women farmers)
- Can be protectionism in disguise, which hampers trade and increases costs for consumers.

# Aflatoxin Standards for Feed

Table 2 lists the aflatoxin limits for animal and fish feed by animal type. Table 3 lists the range and average aflatoxin limits in animal and fish feed by feed type.

*Table 2: Aflatoxin limits in animal and fish feeds by animal type.*

| Species | Range of aflatoxin limits (ppb) | Average aflatoxin limit (ppb) |
|---|---|---|
| All animals | 5-300 | 48 |
| Pigs | **0-300** | **40** |
| Cattle | 0-300 | 41 |
| Poultry | **0-300** | **33** |
| Sheep goats | 5-75 | 26 |
| Dairy | **0-75** | **19** |
| Duck/turkey/rabbit/trout | 10-10 | 10 |

**Source: Agag 2004.**

*Table 3: Range and average aflatoxin limits in animal and fish feeds by feed type.*

| Feed type | Range of aflatoxin limits (ppb) | Average aflatoxin limit (ppb) |
|---|---|---|
| Low risk feeds | 5-50 | 20 |
| Complementary/concentrates | **5-30** | **23** |
| Complete/combined/mixed | 25-100 | 25 |
| All feeds | **20-100** | **29** |
| Straight/cereal | 20-200 | 82 |
| Corn/cottonseed/peanut/copra | **5-300** | **85** |

**Source: Agag 2004.**

For the 24 countries whose borders fall within the tropics (where aflatoxins are particularly a problem) the average maximum level was 54.5 ppb, within a range of 0-300 ppb. For the countries whose borders are outside this area, the average maximum was a much lower 26.3 ppb, within a range of 1-200 ppb (Van Egmond and Jonker, FAO 2004).

## Standards and Methods for Using Anti-Mycotoxin Feed Additives

Anti-mycotoxin additives (AMAs), also known as binders or adsorbents, are substances that bind to mycotoxins and prevent them from being absorbed through the gut and into the blood circulation. AMAs may have additional benefits that reduce the toxicity of mycotoxins. When other preventive measures against molds and mycotoxins have failed, the use of anti-mycotoxin binders can be helpful. Current evidence shows that clays are the most effective AMAs. However, not all clays (even of the same type) are equally effective. In the absence of testing, a large proportion of products on the market may be ineffective.

While it is desirable to reduce aflatoxins in feed through good agricultural practices (GAP) and good manufacturing practices (GMP), these alone may not be sufficient to remove all contamination. In some situations, it may be preferable to salvage contaminated cereal by feeding to livestock, rather than destroy it or use it for non-feed-or-food purposes. In other situations, it is not practical to test feedstuffs on a regular basis or there may be concerns about the accuracy of testing. In these cases, addition of mycotoxin binders can act as a safety measure for feed manufacturers and farmers and an assurance to customers (Jacela et al. 2009).

### Current Products and Uses

The CAC recognizes that research suggests that the addition of the anticaking/binding agent hydrated sodium calcium aluminosilicate (HSCAS) to aflatoxin contaminated feeds may reduce $AFM_1$ residues in milk, depending on the initial concentration of $AFB_1$ in the feed (CAC 1997).

In most of the United States, AMAs are not approved because mycotoxins are considered carcinogens. However, several AMAs are approved for other uses such as anti-caking agents. The Office of the Texas State Chemist approved the use of aflatoxin binders in some feeds in 2011. Approved binders include Novasil™ Plus-TX and Myco-Ad™. Brazil has implemented a three-stage process for approval of AMAs. Four out of 12 products submitted for aflatoxin control were approved between 2005 and 2011 (Mallmann et al. 2012).

Characteristics of different binders are discussed below.

#### Clays or Aluminosilicates

***Description:*** Bentonite and zeolite are clays that originate from volcanic ash and are found throughout the world. HSCAS is derived from natural zeolite.

- HSCAS is one of the best-studied and most effective aflatoxin binders. HSCAS does not impair phytate, phosphorus, riboflavin, vitamin A, or manganese utilization. HCAS may vary with different origins. Brands[1]: Novasil Plus™
- Bentonite has shown benefits in numerous trials but clays can vary widely in effectiveness. Brands: Volclay 90™, AB20™
- Derived phylosilicates are more lipophilic and show some effectiveness against other mycotoxins. Brands: Myco-Ad™, TOXISORB™
- Zeolite has less adsorptive capacity than HSCAS or bentonite, but has been useful under particular conditions.
- Kaolin and diatomaceous earth: insufficient information to evaluate

***Effectiveness:*** At inclusion rates of 0.5 per cent in the final diet, these feed additives have the potential to reduce the negative effects of aflatoxins (up to 3000ppb) by 60 to 90 percent. It can be included up to 2 percent of the diet and can prevent aflatoxicosis at up to 7500 ppb.

***Availability:*** Sold as anti-caking agents.

***Disadvantages:*** Not bio-degradable; natural clays vary greatly in effectiveness and may be contaminated; not very effective against other mycotoxins; some clays may reduce absorption of trace nutrients.

### Activated Carbon

***Description:*** Formed by charring of organic material and long used as a general antidote against poisoning.

***Effectiveness:*** Early studies showed some effectiveness, but there were inconsistent results on mortality and performance.

***Disadvantages:***Not as effective as clays; not recommended for routine inclusion; adsorbs essential nutrients as well as aflatoxins; turns feed black(Huwig et al. 2001; Jaynes and Zartman 2011; Grenier and Applegate 2013).

### Yeast Cell Wall Extracts

***Description:*** Derived from yeast cell walls and contain complex carbohydrates such as glucomannans and mannanoligosacharides.

***Effectiveness:*** Of high nutritional value and can increase growth in animals independent of aflatoxin levels, but can also reduce the pathogenic effects of toxins. Biodegradable and effective against multiple types of mycotoxins.

[1] Brand names are given as examples and do not endorse the effectiveness or other aspects of the cited brand.

***Availability:*** Sold as feed additives which do not make health related claims.

***Disadvantage:*** Results inconsistent; product may be variable depending on composition; studies have shown inconsistent results on transfer of $M_1$ into milk. (Aravind et al. 2003; Taklimi 2012; Ghahri et al. 2009; Hady et al. 2012).

### Other Binders

There are two other types of binders that have been shown to be useful in reducing aflatoxin contamination of food and feed, humicacide and lactic acid bacteria.

Humic acid is produced by biodegradation of dead organic matter. It has also been shown to reduce the toxic effects of aflatoxins (Ghahri et al. 2009; Taklimi 2012). However, information is insufficient for recommendation.

Lactic acid bacteria are generally considered harmless food additives and are used traditionally in fermented milk products, in sourdough, and silage. Some strains have the ability to bind aflatoxins, and may prevent the fungi from creating toxins. However, insufficient information is available to recommend for practical use (El-Nezami et al. 1998; Pierides and El-Nezami 2000).

## Alternative Uses of Aflatoxin Contaminated Feed

Ammoniation is a safe and effective way to decontaminate cereals intended for livestock use. In some countries, cereals above national limits can be exported. However, this is not recommended.

Safe feeding of cereals contaminated with aflatoxins to suitable classes of livestock can be an appropriate alternative use. Blending of contaminated grains with uncontaminated grains can produce feeds with an average level below permitted limits.

Feeding to appropriate livestock is probably the best use of most aflatoxin-contaminated cereals, where it can be done without undue risk to animal health. Although there are no currently established levels at which aflatoxins can be guaranteed safe for livestock, many animals, especially mature animals, can tolerate aflatoxins well. Indeed, many experimental studies do not show statistically significant effects of low aflatoxin levels. There is a consistent pattern of fewer, less severe, or no signs at lower doses of aflatoxins and increasing effects at higher doses.

Growth depression associated with aflatoxins is affected by factors other than species and age. Rats on high-protein diets with 500 ppb aflatoxins had better growth than rats on low protein diets without aflatoxins. Exercise and absence of other mycotoxins from the diet are also protective. Depending on species, age, and length of trial, experiments have found no effects from aflatoxins at levels from 200 to 5000 ppb and significant effects at levels from 20 to 10,000 ppb. Tolerable ranges appear to be: ≤50 ppb in young poultry, ≤100 in adult poultry, ≤50ppb in weaner pigs, ≤200ppb in finishing pigs, <100ppb in calves, <300 ppb in cattle, and<100 in Nile tilapia (Bashir et al. 2001).

One method of reducing moderate levels of aflatoxin contamination is to blend contaminated grain with clean grain. Blending one kilogram of grain with aflatoxin contamination five times above the limits with nine kilograms of grain with no detectable aflatoxin would result in ten kilograms of grain with aflatoxins at 50 percent of the permissible amount (Grace 2013). Blending of contaminated crops has been practiced where highly contaminated crops are mixed with uncontaminated crops to produce a mix that has an average level below the legal limits.

In the USA, blending is not normally allowed and blended feed is considered adulterated. But exceptions have been given during contaminated harvests (Price et al. 1993; Bagley 1979). Usually waivers will state the maximum concentration to be blended (e.g., 500 ppm) and also state that blended feeds cannot be used for lactating animals. Blended feed can be traded interstate when appropriately labeled. Blending is allowed on the farm and is considered by some the most practicable use of contaminated feed.

In South Africa, the Code of Practice for the Control of Mycotoxins in the Production of Animal Feed for Livestock implies that blending is acceptable. If feasible “the opportunity of blending with ‘clean’ material is generally limited due to storage facility constraints at feed mills.”

Treatment with gaseous ammonium can reduce aflatoxin levels dramatically, and can make feed safe and tolerated by animals (Bagley 1979). The ammoniation process, using either ammonium hydroxide or gaseous ammonia, can reduce aflatoxins (100-4000 micrograms/kg) in corn, peanut meal-cakes, whole cottonseed, and cottonseed products by up to 99 percent (European Mycotoxins Awareness Network n.d.). Ammoniation is a safe and effective way to decontaminate aflatoxins; it has been used with success in many countries but is not legal in others. The average costs are 5-20 percent of the value of the commodity (Grace and Unnevehr 2013).

A quick summary of initiatives and acceptance of techniques for alternative uses follows.

- CAC: To date there has been no widespread government acceptance of any decontamination treatment intended to reduce aflatoxin $B_1$ levels in contaminated animal feeding stuffs. Ammoniation appears to have the most practical application for the decontamination of agricultural commodities, and has received limited regional (state, country) authorization for its use with animal feed under specified conditions (i.e., commodity type, quantity, animal) (CAC 1997).
- USA: Currently, there is no FDA-approved method for ammoniation of corn but the FDA has approved ammoniation for detoxifying cottonseed. At the state level, the ammoniation procedure is permitted for cottonseed products in Arizona, Texas, and California and for contaminated corn in Texas, North Carolina, Georgia, and Alabama.
- Senegal: Two local oilseed companies, SONACOS and NOVASEN, account for virtually all formal sector processing and export of groundnut cake, edible groundnut, and unrefined oil. Detoxification using ammonia was developed in the 1980s and ensures safer food for consumption by lowering aflatoxin levels in peanut oilcakes to 10 ppb, meeting European standards. Because ammoniation is costly and the technology is patented by SONACOS, it is not readily available for use in NOVASEN. NOVASEN sells its product as is to European feed companies that are able to detoxify the groundnuts themselves (Imes 2011).
- Mexico allows ammoniation for corn. France, South Africa, Senegal, and Brazil use this procedure to lower aflatoxin contamination levels in peanut meal used in animal feeds.
- EU: Decontamination is allowed for animal feed but not human food. "Proper handling and drying practices can keep the aflatoxin levels in the different feed materials low, and efficient decontamination procedures exist to reduce levels of the aflatoxin $B_1$" (2002/32/EC). In Europe, ammoniated feed cannot be fed to lactating cattle and sheep since the levels of residual aflatoxin $B_1$ in ammoniated products can be higher than the maximum permitted level (that is, 5 mcg/kg).

Nixtamalization, the traditional alkaline treatment of maize in Latin America, can reduce toxicity and has potential for wider applications. Other chemical and biological agents have been effective in experiments but are not yet commercially developed. Gaseous ozonisation has also been applied and shown to have an effect, especially on reducing $AFB_1$ (Proctor et al. 2004).

## Regulations for Export of Contaminated Feeds

In some countries, regulations permit the export of feed and feed ingredients which do not meet the national limits. This is problematic when grains are exported to countries where their ultimate use cannot be tightly controlled.

*Piglets suckling. Joseph Atehnkeng - IITA.*

# Situational Analysis: Standards for Feed in the EAC

## Livestock and Aquaculture in the EAC

In Africa, the majority of livestock is kept by pastoralists and smallholder farmers and sold through informal markets. Feed consists mainly of animal pasture, forage, or crop by-products. Additional feed is from natural pastures or feed mostly supplied by famers themselves or by feed manufactured in small, local mills. The majority of livestock products are sold through the informal sector. The majority of fish consumed is wild caught and feed is not required.

The diet of livestock consists mostly of pasture or forage, and little additional feed is given. Additional feed comes predominately comes from the farmers' own farm or from small, local mills. Large scale commercial farmers supply only a small fraction of livestock products, with the minority of the livestock and fish feeds supplied by large-scale

millers in the formal sector. Most feed mills in the region are operating under-capacity, and require "infant industry" government support to enable them to support the rapid intensification of livestock industries predicted to occur over the next decades.
The FAO estimates that 95 percent of aquaculture is produced through microenterprises and mostly relies primarily on fertilization and enhanced natural food for fish crops rather than commercial fish feed. While the majority of fish consumed are wild caught at this time, aquaculture is an expanding agribusiness throughout the region. Similar to livestock products, urbanization and income growth will continue to accelerate the demand for these products across East Africa in the near future.

## Aflatoxins in Animal and Fish Feeds

Animal and fish feeds are the major aflatoxin exposure routes for livestock and fish. Few studies have been conducted in East Africa to show the presence of aflatoxins in the feeds. Table 4 highlights the findings of these few studies. More research is needed to determine the magnitude of the problem.

*Table 4: Aflatoxin in animal feeds from studies in the EAC partner states.*

| Country | Feed type | Method of analysis | percent positive | >ppb | Reference |
|---|---|---|---|---|---|
| Kenya | Dairy meal (n=70)<br>Mixed (n=414) [a]<br>Dairy meal (n=72) | cELISA<br>cELISA<br>TLC | 98.6<br>85.3<br>100 | 83<br>37.4<br>95 | Kang'ethe et al. 2007<br>Kang'ethe and Langat 2009<br>Okoth and Kola 2012 |
| Tanzania | Animal feed (n=340) | cELISA | 60 | 49.7 | Kajuna et al. 2013 |
| Uganda | Animal feed (n=54)* | | 83.3 and 66.6 | | Sebunya and Yourtee 1990 |

***This study focused on detecting toxigenic *Aspergillus* species in poultry and other animal feed samples. The fact that toxigenic *Aspergillus* species were detected means that it can be concluded some samples may have been positive for aflatoxin.**
**a. Included raw materials for dairy, poultry, and dog feed.**

## Current Status of Standards

The animal feeds and milk industry sectors in the EAC have not developed an industry standard for aflatoxin contamination. There are two principal reasons for this.

First, private sector organizations are weak. Despite the existence of organizations such as the Tanzania Milk Producers Association (TAMPRODA), the Tanzania Milk Processors

Association (TAMPA), and the Association of Kenya Feed Manufacturers (AKEFEMA), some producers do not participate. Nonmembers may and do ignore the standards.

Second, some in the industry view standards for private producers as a detriment to small producers. Large producers have the capital to invest in meeting stringent standards that may even be above national body standards. When standards from GlobalGAP, the non-governmental organization that sets standards for the horticulture and the fisheries industry, were applied in Kenya, studies showed a number of negative constraints to compliance (Murithi et al. 2011).

## EAC Trade in Animal and Fish Feeds

During this study, export and import data on animal and fish products was not easily accessible from EAC government departments. Data was collected and used from the FAO and the Common Market for East and Southern Africa (COMESA) to illustrate trade patterns.

FAO provides data, volumes, and values for the top 20 commodities of export and import products, organized in tables. Additional FAO data are available for single commodities. When data were not available from the FAO, we used data from COMESA to show trade patterns within and outside of the common market. The data in Tables 5 and 6 show that East African countries do re-export imported products.

*Table 5: Imports of animal feed related products by EAC partner states.*

| Country* | Animal feed type | Volume (tons) | Value ($000) |
|---|---|---|---|
| Kenya | Soya bean cake | 69,215 | 14,523 |
| | Sunflower cake | 61,575 | 9,583 |
| | Maize bran | 57,694 | 3,228 |
| | Wheat bran | 3,440 | 3,340 |
| | Cotton seed cake | 18,150 | 5,870 |
| Uganda | Cotton seed cake | 11,728 | 364 |
| | Sunflower cake | 5,021 | 161 |
| Tanzania | Wheat bran | 16,717 | 1,062 |

**Source: FAOSTAT 2011**

*Table 6: EAC Exports of animal and fish feed products.*

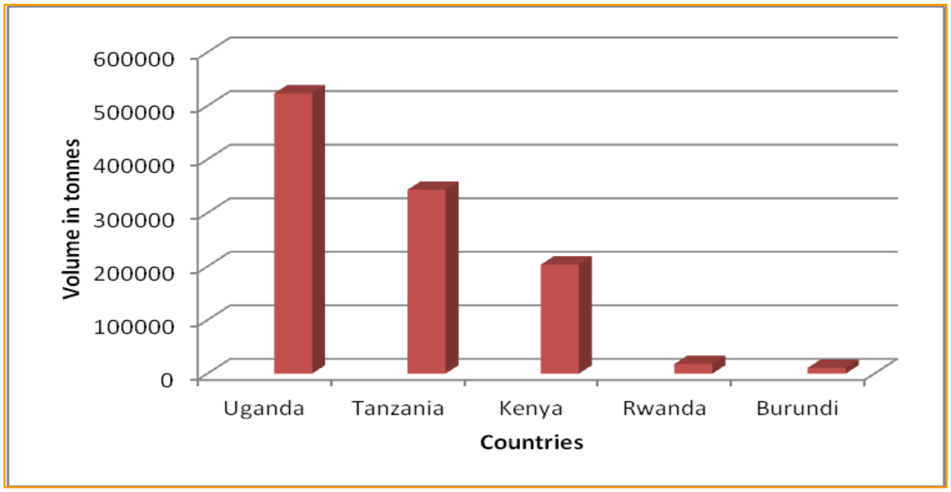
| Country | Product type | Volume (tons) | Value ($000) |
|---|---|---|---|
| Tanzania | Wheat bran | 100,646 | 7,699 |
| | Gluten feed and meal | 61,906 | 2,324 |
| | Bran of maize | 49,347 | 2,248 |
| | Sunflower seed cake | 32,756 | 7,524 |
| | Cotton seed cake | 27,811 | 4,708 |
| | Straw husks | 12,062 | 599 |
| Uganda | Soya bean cake | 46,711 | 3,549 |
| | Bran wheat | 36,140 | 3,777 |
| | Sunflower cake | 32,402 | 1,711 |
| Rwanda | Bran wheat | 8,704 | 92 |
| Kenya | Bran wheat | 10,743 | 2,019 |
| Burundi | Bran wheat | 172 | 3 |

**Source: FAOSTAT 2011**

## Trade in Animal and Fish Products

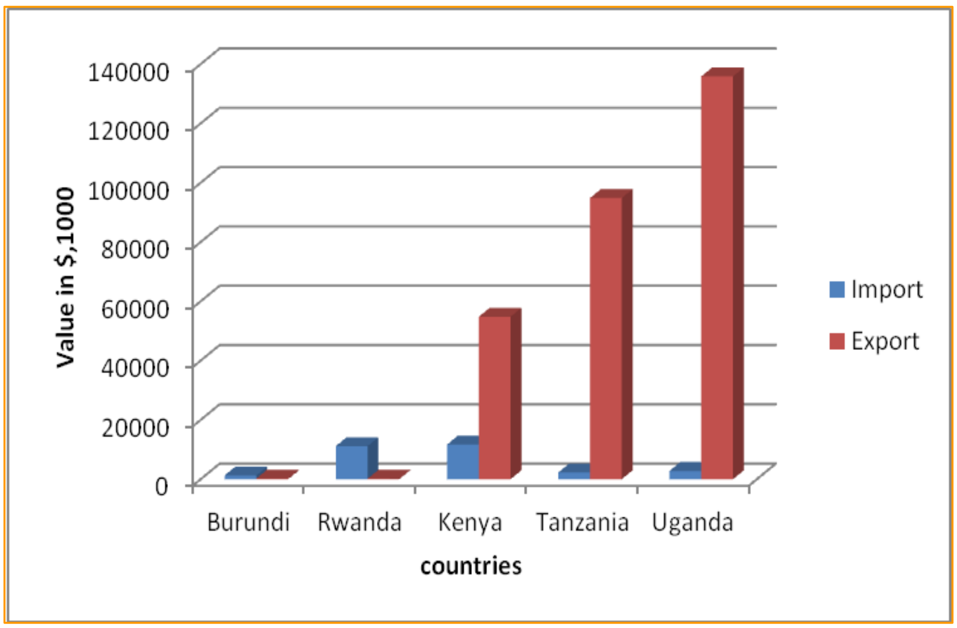
### Trade in Fish and Aquaculture Products

Fish production from fresh water, marine environments, and aquaculture varies across the EAC, with Uganda leading and Burundi producing the least (Figure 1). Zanzibar's production and trade of seaweed—which amounts to 150,876 tons annually—is not accounted for; it is used for cosmetics, and not as animal feed. Figure 2 shows the exports and imports of fish products from the EAC partner states. Uganda and Tanzania benefit more than other countries from the export of fishery products. There is currently a need for studies on aflatoxin contamination in fish feeds used in aquaculture.




**Source: FAOSTAT 2011**

*Figure 1: Volumes of fishery capture and aquaculture, EAC partner states.*




**Source: FAOSTAT 2011**

*Figure 2: Total value of exports and imports of fishery products, EAC partner states.*

## Trade in Animal Products

The EAC partner states trade in numerous animal products, but the data presented here is for a few selected products that are subject to contamination by aflatoxin. The major product of concern is milk. Liquid milk and dried powdered milk pose the highest danger to human health from aflatoxin contamination. Table 7 shows the trade figures for eggs and milk products.

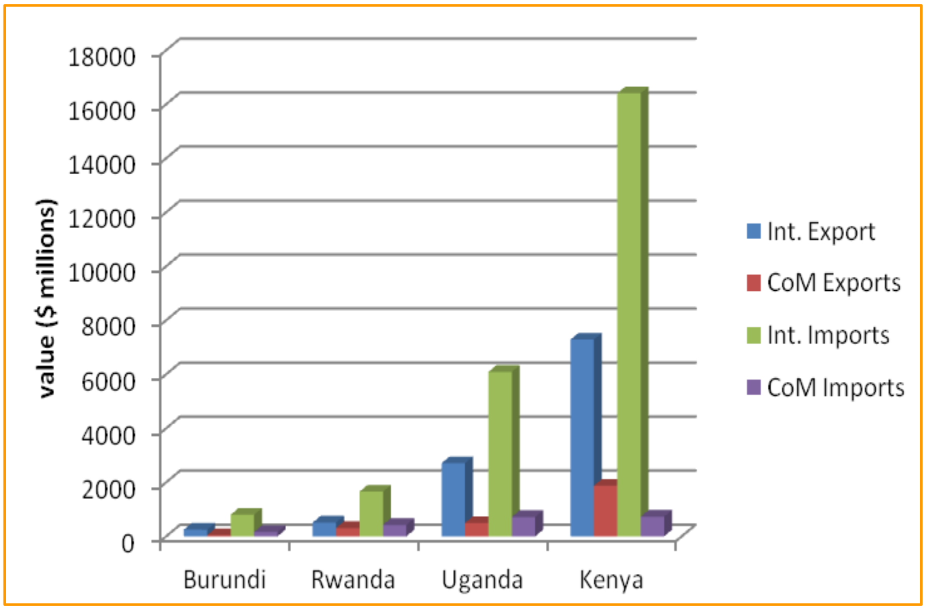
We have determined from interviews with EAC ministries responsible for trade, national standards bureaus, and food and drug oversight boards, that specified levels of aflatoxin and other mycotoxin contaminants are not mandatory quality requirements for imports into the EAC partner states. FAO data does not offer us the destination or source of exports and imports. While most of the listed trade items do not feature within the 20 top import/export commodities for EAC countries, trade within COMESA is vital. Figure 3 below quantifies the value of COMESA trade patterns.

*Table 7: EAC partner states imports and exports in animal products.*

| Country | Commodity | Imports | | Exports | |
|---|---|---|---|---|---|
| | | Volume (tons) | Value ($1000) | Volume (tons) | Value ($1000) |
| Burundi | Eggs, hen, in shell | 3 | 1 | | |
| | Milk, cow, fresh | 81 | 86 | | |
| | Milk, whole, dried | 113 | 651 | | |
| | Milk, skim, dried | 700 | 1200 | 1 | 2 |
| Kenya | Eggs, hen, in shell | 631 | 1444 | 550 | 559 |
| | Milk, cow, fresh | 7379 | 6000 | 4797 | 3988 |
| | Milk, whole, dried | 3664 | 17160 | 33 | 82 |
| | Milk, skim, dried | 753 | 3408 | 400 | 2554 |
| Rwanda | Eggs, hen, in shell | 1169 | 982 | 2 | 1 |
| | Milk, cow, fresh | 79 | 61 | 0 | 0 |
| | Milk, whole, dried | 47 | 135 | 46 | 50 |
| | Milk, skim, dried | 369 | 705 | 21 | 47 |
| Uganda | Eggs, hen, in shell | 12 | 45 | 69 | 111 |
| | Milk, cow, fresh | 1138 | 948 | 10424 | 7230 |
| | Milk, whole, dried | 433 | 1040 | 2236 | 8997 |
| | Milk, skim, dried | 375 | 1102 | 42 | 72 |
| Tanzania | Eggs, hen, in shell | 1183 | 1089 | 0 | 0 |
| | Milk, cow, fresh | 5515 | 5764 | 0 | 0 |
| | Milk, whole, dried | 738 | 797 | 11 | 85 |
| | Milk, skim, dried | 488 | 607 | 2 | 0 |

**Source: FAOSTAT 2011.**

Kenya tops the EAC partner states with the highest share of COMESA total exports (20.2 percent), with an import share of 7.2 percent. Uganda, Rwanda, and Burundi follow in that order. Human exposure to aflatoxin through animal and milk products should be a major concern to Kenya. However, the other partner states should not relax on this front. Their livestock sectors are growing, and along with them, the demand for animal feed products. To meet domestic needs, other EAC countries will be forced to import the raw materials which they now export. Under this scenario, quality control of these raw materials will have to include monitoring for aflatoxin contamination.




**CoM Imports = COMESA total imports; CoM Exports = COMESA total exports, Ont. Imports = International Total Imports; and Int. Exports = International total exports.**
**Source: COMSTAT 2012**

*Figure 3: Comparison of international and COMESA export and imports.*

## Pros and Cons of Aflatoxin Standards Setting for EAC Feeds

The Codex Alimentarius provides guidance on setting of MLs for aflatoxin. Principles and their implications for standard setting in the East African context were summarized under the section of this paper entitled “”Principles for Setting Aflatoxin Standards in the EAC”. As noted, these standards can be advantageous in that they provide a wide margin of safety for livestock and animal source foods, allow for harmonization with others setting strict standards, discourage protectionism, have been reached through process of consensus based in scientific evidence and analysis, and are useful in discouraging countries with stricter standards from dumping products on other countries. Conversely, when too stringent, such standards can be costly and/or impossible to enforce, transfer a cost burden to farmers and the feed industry, increase the price of fish and livestock products to consumers, impact negatively on food security, and make a wider geographical band of harmonized standards challenging to achieve. Finally, standards that are too harsh can disadvantage less educated and smaller producers. In the East Africa region, many of these will be women.

## Standards for Animal and Fish Feeds and Milk

The EAC partner states have developed a number of standards covering aspects of milk and feedstuffs for animals and fish. Figure 4 shows the number of standards developed for animal feeds, milk, and fish in three EAC partner states from which data were available. Zanzibar still uses standards from Tanzania Bureau of Standards as they develop their own. In Kenya, three standards specifically mention aflatoxin B1, B2, G1, and G2. In Uganda, two standards specifically mention aflatoxin B1, B2, G1, and G2. One standard in Kenya mentions aflatoxin M1 (AFM1). Uganda and Kenya indicated to our researchers that there are revised standards, which specifically indicate that aflatoxin will be regulated using standards approved by CAC. The numbers of those standards which have been revised with these new additions were not given.

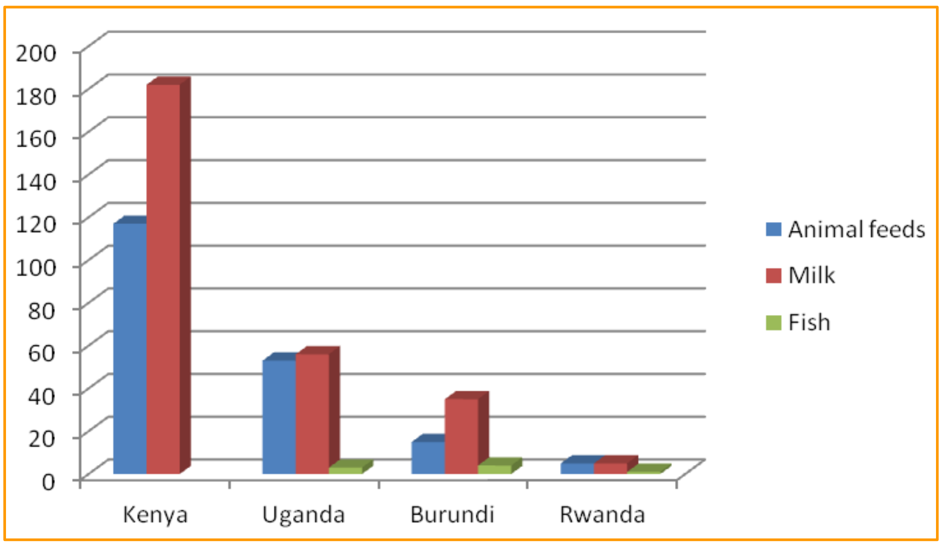



*Figure 4: EAC standards for animal and fish feeds and milk.*

# Conclusions

Aflatoxins, and other mycotoxins, can seriously reduce livestock productivity. In poor countries, livestock and fish are often fed highly contaminated grains considered unfit for human consumption and are at risk from acute aflatoxicosis. As livestock systems intensify, problems with aflatoxicosis in animals are likely to worsen. Chronic aflatoxicosis is potentially a major cause of economic loss, especially for pigs and poultry kept in intensive systems. Aflatoxins can transfer from feed to animal source products, but there is minimal information or testing of these products in developing countries. Risks are likely to be highest in the case of milk, processed fish, and indigenous fermented meat, fish, and dairy products.

Aflatoxins in milk are especially problematic because of the relatively high transfer rates of aflatoxins from cow feeds to milk, the relatively high consumption of dairy products, and the widespread use of milk as a weaning food for infants. Transfer of aflatoxins to meat and viscera is much lower than transfer to milk and can be prevented by not feeding livestock and fish feeds containing aflatoxin for a period of time before slaughter.

The feed sector in East African partner states remains underdeveloped. There is tremendous economic potential in this sector as dairy, poultry, and aquaculture continue to grow.

In all partner states but Kenya, which is the largest EAC consumer of cattle feed, milk production is principally from indigenous animals on the range. Nevertheless, the main consumer of compounded feeds in the EAC states is the dairy industry. Improvement of breeds and disease management are two factors contributing to dairy sector growth.

There is a need to nurture this sector to match the growth in demand for animal products like milk. At present, Uganda, mainland Tanzania, and Zanzibar use more manufactured poultry feed than manufactured cattle feed.

Aflatoxin contamination of animal and fish feeds and milk has not been widely investigated and there is little data on the current levels of contamination. The few studies that have been done were not well designed and did not include comprehensive coverage of all countries, feed types, and raw materials.

Despite their limitations, these studies have been sufficient to conclusively determine that the problem of aflatoxin contamination in animal and fish feeds is as widespread and serious as the problem of aflatoxin contamination in human foods. This is, of course, because animals are fed with foods that are left over from the same sources of production but not fit for human consumption. There is an urgent need for research to more precisely determine the magnitude of the problem in the feed types and raw materials used, to point the way forward to set comprehensive standards for animal and fish feeds and to develop strategies to control aflatoxin in the feed supply.

Some progress is being made. The EAC has developed common standards for maximum aflatoxin presence in maize and milk traded among partner states. The maize standard came in response to an outbreak of aflatoxin in Kenya in 2005 and provides both grading for quality and allowable levels of aflatoxin. The new milk standard, however, lacks controls on levels of aflatoxin M1.

Standards development for animal feeds is well advanced, but very few standards have been developed for fish feeds. This is partly because aquaculture has just been introduced in the EAC partner states. More widespread and better standards for fish feeds and fish management under aquaculture are needed to protect consumers as this sector expands.

Intra-EAC trade in animal feed and milk products is not well captured in the databases of the partner states. With the approval of the Common Market Protocol, which allows free movement of goods and services across the EAC partner states, it is hoped that data will be captured to facilitate implementation of Aflatoxin control so as not to unduly expose consumers through milk, poultry, fish, and meat products. Aflatoxin control and compliance with standards are also essential for continued growth in the export sector for global markets.

Stakeholder analysis has shown that government departments have interest, power, and influence. Unfortunately, consumer organizations with high interest lack power and influence. This is because the consumers are not sensitized to demand products that comply with the standards in regard to Aflatoxin. This can be addressed through a comprehensive and multisectoral approach to aflatoxin control for the EAC.

## Needs of Producers

The feed sector in EAC partner states consists of a small number of commercial farmers and professional feed producers and a much larger number of small-scale farmers and local feed-producers. Commercial and small-scale actors have different needs for support and regulation.

Commercial farmers and agro-industry facing the challenge of aflatoxin contamination need policies that:

- Promote GAPs and GMPs in order to reduce risk of mycotoxin contamination along the food-feed chain by improving the processes;
- Create awareness in the industry of the impact of contaminants on animal health and in transfer to livestock products;
- Assign producers and manufacturers with responsibility for monitoring contaminants.

Small-scale farmers and small-scale feed mills facing the challenge of aflatoxin contamination need policies that:

- Adapt GAPs to simple messages and practices that can easily be adopted;
- Create awareness among farmers and small-scale feed processors about the risks of mycotoxins and all other feed-related hazards;
- Develop simple methods for monitoring feed quality and group assurance of quality.

# Policy Recommendations

## General Recommendations on Standards

General recommendations from the literature and policy review conducted for this paper are as follows:

1. The primary considerations in formulating feed standards should be to safeguard human health, enhance productivity, and facilitate trade. Standards should also provide consumer protection and support animal welfare, but in the case of the EAC, the regulatory burden should be taken into account. Codification, recasting, and reviewing clauses are recommended as ways to reduce regulatory burdens. Self-regulation and co-regulation can be considered as simpler alternatives to detailed rules.
2. Harmonized regional standards should be adopted. Where there are no harmonized standards, then the Codex Alimentarius standards, codes, guidelines, and recommendations should serve as the reference.
3. Risk analysis should be used in setting standards whose primary objective is to reduce the risk to animal and human health in animal source foods. Where risk to human health is negligible, cost benefit analysis, distributional effects evaluation, and regulatory impact assessments should be used to provide information on the benefits and costs of regulation.
4. Aflatoxin specification for animal and fish feeds and feed materials standards should be based on tolerable ranges plus a margin of safety. Generally tolerable ranges are: ≤50 ppb in young poultry, ≤100 ppb in adult poultry, ≤50 ppb in weaner pigs, ≤200 ppb in finishing pigs, <100 ppb in calves, <300 ppb in beef cattle and <100 ppb in Nile tilapia. The current high levels of aflatoxins, tropical context, desirability of having an alternative use for highly contaminated foods, and implications for food security and livelihoods would support feed standards that are less rather than more strict. Protocols for sampling feed and feed ingredients should be developed.
5. Protocols for sampling feed and feed ingredients should be developed and harmonized.
6. EAC partner states should explore the avenues to identify and approve safe and suitable anti-mycotoxin additives for livestock and fish feeds.
7. Feeding contaminated cereals and feeds to livestock may be an acceptable use that reduces risk to public health. Where blending of contaminated materials can be done accurately and safely, it should be considered as an alternative use.

8. Ammoniation is a safe and effective way to decontaminate cereals intended for livestock and fish feed. It should be considered as an alternative use where the resources for establishing and maintaining the necessary infrastructure are available.

9. Standard protocols should be developed and followed for sampling and testing feeds and feed ingredients for aflatoxins. Within laboratories, quality assurance systems need to be developed and monitored. There should be a reference system whereby laboratories are accredited and ring tests performed in EAC partner states.

## Recommendations on Standards Setting for the EAC

Within the EAC in particular, the following recommendations are made for the standards setting process.

1. Standards for countries with similar conditions should be harmonized.
2. Standards for countries that wish to trade should be harmonized
3. Standards should specify the species, age, and purpose of the animals to which they apply.
4. Standards should specify the type of feed to which the standard applies.
5. Standards should be based on the levels generally tolerated plus a margin of safety.
6. Standards should take into account the needs of stakeholders, especially small-holder farmers,
7. Regulators should focus on improving processes through GAPs and GMPs.

## Recommendations to Foster an Enabling Environment

The following recommendations are made as the means to create an enabling environment across the EAC partner states in which standards can be created and enforced:

1. Continue research and data collection and analysis. More information on the aflatoxin contamination levels in animal and fish feeds and milk and milk products across the EAC partner states, and strategies for aflatoxin abatement are required to inform policy and standards development.
2. EAC partner states at the national and regional level, should work together to revise the existing animal feed standards to include aflatoxin analysis and permissible limits for animal and fish feeds and feed ingredients.
3. National government should separate their standards-setting agencies from their enforcement and compliance entities.

4. Regional, national, county, and community organizations should work together to create awareness of the benefits of aflatoxin contamination standards for farmers, industry, consumers, and other stakeholders.
5. A national structure of testing laboratories and a cadre of technically qualified personnel to monitor and test for aflatoxin contamination of human and animal food stuffs should be created within each partner state.
6. Other measures should be taken regionally and nationally to ensure that industry and the private sector share the burden of compliance with appropriate aflatoxin standards for animal and fish feed and products.
7. Programs and interventions to adequately address aflatoxin in feed and animal products consumed on-farm and/or sold through informal trade should be designed and implemented.

# Appendix: Aflatoxin Standards by Country in 2003

Table 8 summarizes the aflatoxin standards used in different countries in 2003. It can be seen that the standards varied from 0 ppb (which is probably impossible to achieve) to 300 ppb. The average for all countries, categories of feed, and animals was 39 ppb.
In general, average limits reflected the evidence of susceptibility of livestock and the risk of transfer to human food (which is greatest for milk). However, the maximum limits for pigs seem abnormally high.

*Table 8: Aflatoxin standards by country in 2003.*

| Country | Aflatoxins regulated | Feeds regulated | Animals regulated | Maximum limits (ppb) |
|---|---|---|---|---|
| Bangladesh | B1, B2,G1, G2 | Mixed feed | Poultry | 100 |
| Barbados | B1, B2,G1, G2 | All feedstuffs | | 50 |
| Brazil | B1, B2,G1, G2 | Feed and ingredients | | 50 |
| Canada | B1, B2,G1, G2 | All feeds | All animals | 20 |
| Chile | B1, B2,G1, G2 | Complete | Poultry goat, cattle | 30 |
| Chile | B1, B2,G1, G2 | Complete | Other | 10 |
| Chile | B1, B2,G1, G2 | Feed ingredients, except groundnuts, cottonseed, maize, and their derivatives | | 50 |
| Chile | B1, B2,G1, G2 | Groundnuts, cottonseed, maize, and their derivatives as feed ingredients | | 200 |
| Colombia | B1, B2,G1, G2 | Feed | Rabbit/trout | 10 |
| Colombia | B1, B2,G1, G2 | Feed | Poultry/dog/cat/fish | 20 |
| Colombia | B1, B2, G1, G2 | Feed | Bovine/pig | 50 |
| Colombia | B1, B2,G1, G2 | Maize and products | | 20 |
| Colombia | B1, B2,G1, G2 | Sorghum | | 40 |
| Costa Rica | B1, B2,G1, G2 | Maize | | 50 |
| Cote d'Ivoire | B1, B2,G1, G2 | Complete | Pigs, poultry (except ducks and young animals) | 38 |
| Cote d'Ivoire | B1, B2,G1, G2 | Complete | Dairy cattle | 50 |
| Cote d'Ivoire | B1, B2,G1, G2 | Complete | Cattle, sheep, goats | 75 |

# Aflatoxin Standards for Feed

| Country | Aflatoxins regulated | Feeds regulated | Animals regulated | Maximum limits (ppb) |
|---|---|---|---|---|
| Cote d'Ivoire | B1, B2,G1, G2 | Complete | | 10 |
| Cote d'Ivoire | B1, B2,G1, G2 | Straight | | 100 |
| Cuba | B1, B2,G1, G2 | Feed and ingredients | | 5 |
| Egypt | B1 | Feed | Animal, chicken | 10 |
| Egypt | B1, B2,G1, G2 | Feed | Animal, chicken | 20 |
| El Salvador | B1 | Supplementary feeds | Pigs, poultry, dairy cattle | 20 |
| El Salvador | B1 | Composite feedstuffs | Cattle, sheep, goats | 20 |
| El Salvador | B1 | All feedstuffs | | 10 |
| Estonia | B1, B2, G1, G2 | Ingredients of vegetable origin | | 100 |
| Estonia | B1, B2,G1, G2 | Complete feed stuffs for cattle, pigs, and other farm animals | | 100 |
| Estonia | B1, B2, G1, G2 | Complete feed stuffs for young cattle, young pigs, and other young farm animals | | 50 |
| Estonia | B1, B2, G1, G2 | Complete feed stuffs for milk producing animals | | 20 |
| Estonia | B1, B2, G1, G2 | Complementary feed stuffs for cattle, pigs, and other farm animals | | 50 |
| Estonia | B1, B2, G1, G2 | Complementary feed stuffs for young cattle, young pigs, and other young farm animals | | 10 |
| European Union | B1 | Complete | Pigs, poultry (except young animals) | 20 |
| European Union | B1 | Complementary feed stuffs | Pigs, poultry (except young animals) | 20 |
| European Union | B1 | Complete | Dairy cattle | 5 |
| European Union | B1 | Complete | Cattle, sheep, goats (except young animals) | 20 |
| European Union | B1 | Complementary feed stuffs | Cattle, sheep, goats (except young animals) | 20 |
| European Union | B1 | Complete | Calves, lambs | 10 |
| European Union | B1 | Other complete feed stuffs | | 10 |
| European Union | B1 | Other complementary feed stuffs | | 5 |
| European Union | B1 | All feed materials | | 20 |
| Guatemala | B1, B2, G1,2 | Feed concentrate | | 20 |

# Aflatoxin Standards for Feed

| Country | Aflatoxins regulated | Feeds regulated | Animals regulated | Maximum limits (ppb) |
|---|---|---|---|---|
| | | | | |
| India | B1 | Peanut meal | Export | 120 |
| Iran | B1 | Fish meal, meat meal, bone meal, blood meal, single cell protein, rice and wheat bran | Sheep, goats, beef cattle | 10 |
| Iran | B1 | Soya bean meal, sunflower meal, sesame seed meal, olive meal and other meals from oil producing seeds | Sheep, goats, beef cattle | 10 |
| Iran | B1, B2, G1, G2 | Soya bean meal, sunflower meal, sesame seed meal, olive meal and other meals from oil producing seeds | Sheep, goats, beef cattle | 20 |
| Iran | B1, B2, G1, G2 | Premixes including vitamins and mineral premixes | Sheep, goats, beef cattle | 10 |
| Iran | B1 | Complete | Sheep, goats, beef cattle | 50 |
| Iran | B1 | Soya bean meal, sunflower meal, sesame seed meal, olive meal and other meals from oil producing seeds | Poultry, calf, lamb, kid, dairy sheep, dairy goats, dairy cattle | 5 |
| Iran | B1, B2, G1, G2 | Soya bean meal, sunflower meal, sesame seed meal, olive meal and other meals from oil producing seeds | Poultry, calf, lamb, kid, dairy sheep, dairy goats, dairy cattle | 20 |
| Iran | B1 | Fish meal, meat meal, bone meal, blood meal, single cell protein, rice and wheat bran | Poultry, calf, lamb, kid, dairy sheep, dairy goats, dairy cattle | 5 |
| Iran | B1, B2, G1, G2 | Fish meal, meat meal, bone meal, blood meal, single cell protein, rice and wheat bran | Poultry, calf, lamb, kid, dairy sheep, dairy goats, dairy cattle | 20 |
| Iran | B1, B2, G1, G2 | Premixes including vitamins and mineral premixes | Poultry | 10 |
| Iran | B1 | Complete | Layers and broiler parent and grandparent stocks | 5 |
| Iran | B1, B2, G1, G2 | Complete | Layers and broiler parent and grandparent stocks | 20 |
| Iran | B1 | Complete | Layers and breeders (broilers and layers) | 10 |
| Iran | B1, B2, G1, G2 | Complete | layers and breeders (broilers and layers) | 20 |
| Iran | B1, B2, G1, G2 | Premixes including vitamins and mineral premixes | Calf, lamb, kid, dairy sheep, dairy, goats, dairy cattle | 5 |
| Iran | B1 | Complete | Calf, lamb, kid, dairy sheep, dairy goats, dairy cattle | 5 |
| Iran | B1 | Complete | Broilers and pullet | 10 |

# Aflatoxin Standards for Feed

| Country | Aflatoxins regulated | Feeds regulated | Animals regulated | Maximum limits (ppb) |
|---|---|---|---|---|
| Iran | B1 | Maize | All animals | 5 |
| Iran | B1, B2, G1, G2 | Maize | All animals | 20 |
| Iran | B1 | Cottonseed meal | | 15 |
| Iran | B1, B2, G1, G2 | Cottonseed meal | | 50 |
| Israel | B1, B2, G1, G2 | Grain | All animals | 20 |
| Japan | B1 | Complete | Cattle, pigs, chicken, quail (except young and dairy cows) | 20 |
| Japan | B1 | Complete | Calves, dairy cows, piglets, young chicken/broilers | 10 |
| Jordan | B1 | Feedstuffs | All animals | 15 |
| Jordan | B1, B2, G1, G2 | Feedstuffs | All animals | 30 |
| Latvia | B1 | Animal feed | | 5 |
| Mexico | B1, B2, G1, G2 | Cereals | Fattening cows, pigs | 200 |
| Mexico | B1, B2, G1, G2 | Feedstuffs | Dairy cattle, poultry | 0 |
| Morocco | B1 | Complete feedstuffs | Pigs, poultry (except young animals) | 20 |
| Morocco | B1 | Complementary feedstuffs | Pigs, poultry (except young animals) | 30 |
| Morocco | B1 | Complete feedstuffs | Dairy animals | 5 |
| Morocco | B1 | Other complementary feedstuffs | Dairy animals | 10 |
| Morocco | B1 | Complete feedstuffs | Cattle, sheep, goats (except dairy and young animals) | 50 |
| Morocco | B1 | Complementary feedstuffs | Cattle, sheep, goats (except dairy and young animals) | 50 |
| Morocco | B1 | Complete feedstuffs | Calves, lambs | 10 |
| Morocco | B1 | Simple feedstuffs (except peanuts, copra, cottonseed, bagasse, maize, and their products) | | 50 |
| Morocco | B1 | Peanuts, copra, cottonseed, babassu, maize, and their products | | 20 |
| Morocco | B1 | Other complete feedstuffs | | 10 |
| Mozambique | B1, B2, G1, G2 | Peanut, maize, peanut butter | All animals | 10 |
| Mozambique | B1, B2, G1, G2 | Cereals and feedstuffs | All animals | 10 |

## Aflatoxin Standards for Feed

| Country | Aflatoxins regulated | Feeds regulated | Animals regulated | Maximum limits (ppb) |
|---|---|---|---|---|
| Nepal | B1, B2, G1, G2 | Feedstuffs | All animals | 50 |
| Oman | B1 | Complete feedstuffs | Poultry | 20 |
| Philippines | B1 | Mixed feed | All animals | 20 |
| Philippines | B1 | Copra and copra products | All animals | 20 |
| Republic of Korea | B1 | Complete | Other | 20 |
| Republic of Korea | B1 | Complete | Calves, chicken, piglets, broilers (early stage),dairy cattle | 10 |
| Republic of Korea | B1 | Feed ingredients: vegetable proteins, grains, by-products of grains and food | | 50 |
| Senegal | B1 | Straight feedstuffs: peanut products | All animals | 50 |
| Senegal | B1 | Feedstuff ingredients: peanut products | All animals | 300 |
| Serbia and Montenegro | B1, B2, G1, G2 | Feed | Pig/poultry | 20 |
| Serbia and Montenegro | B1, B2, G1, G2 | Feed | Ox/sheep/goat | 50 |
| Serbia and Montenegro | B1, B2, G1, G2 | Feed | Chicken, pigs (until 50kg), calf, young turkey, duckling, cow | 10 |
| Suriname | B1, B2, G1, G2 | Feedstuffs | All animals | 30 |
| Sweden | B1 | Feedstuff ingredients | Other | 50 |
| Sweden | B1 | Cereal grains and forages as feedstuff ingredients | Dairy cattle | 1 |
| Sweden | B1 | Feedstuff ingredients | Dairy cattle | 10 |
| Sweden | B1 | Complete feedstuff (including forage) | Dairy cattle | 1.5 |
| Sweden | B1 | Mixed feedstuffs (excluding forages) | Dairy cattle | 3 |
| Switzerland | B1 | Complementary feeds | Pigs, poultry (except young animals) | 30 |
| Switzerland | B1 | Complete feeds | Pigs, poultry (except young animals) | 20 |
| Switzerland | B1 | Complete and complementary feeds | Other | 10 |
| Switzerland | B1 | Complementary feed | Dairy cows, dairy sheep, dairy goats | 5 |
| Switzerland | B1 | Complete and complementary | Cattle, sheep, goats (except dairy and young animals) | 50 |

# Aflatoxin Standards for Feed

| Country | Aflatoxins regulated | Feeds regulated | Animals regulated | Maximum limits (ppb) |
|---|---|---|---|---|
| Switzerland | B1 | Babassu seed, cotton seed, peanut, coconut, maize kernel, palm kernel and their products as raw materials | All animals | 200 |
| Switzerland | B1 | Babassu seed, cotton seed, peanut, coconut, maize kernel, palm kernel and their products as single feed materials | All animals | 20 |
| Switzerland | B1 | Other single feeds/raw materials | All animals | 50 |
| Syria | B1, B2, G1, G2 | Complete | Other | 20 |
| Syria | B1, B2, G1, G2 | Complete | Cattle | 10 |
| Taiwan | B1, B2, G1, G2 | Maize: raw material | All animals | 50 |
| Taiwan | B1 | Feedstuffs | All animals | 25-100 |
| Tanzania | B1 | Complete | All animals | 5 |
| Tanzania | B1, B2, G1, G2 | Complete | All animals | 10 |
| Turkey | B1 | Mixed feed | Ruminants (except young) | 50 |
| Turkey | B1 | Mixed feed | Poultry (except young) | 20 |
| Turkey | B1 | Mixed feed | Other | 10 |
| Turkey | B1 | Feedstuffs | All animals | 50 |
| Ukraine | B1 | Combined feed | Poultry | 25 |
| Ukraine | B1 | Combined feed | Non-productive animals | 10 |
| Ukraine | B1 | Combined feed | Dairy cows/ piglets | 50 |
| Ukraine | B1 | Combined feed | Calves and sheep older than 4 months/ animals for meat/ breeding bulls | 100 |
| USA | B1, B2, G1, G2 | Maize, peanut and other products except cottonseed meal | Immature animals | 20 |
| USA | B1, B2, G1, G2 | Maize and peanut products | Finishing swine over 100 lbs. | 200 |
| USA | B1, B2, G1, G2 | Maize and peanut products | Fattening beef cattle | 300 |
| USA | B1, B2, G1, G2 | Corn, corn products, cottonseed meal, and other animal feeds and feed ingredients | Dairy animals, for animal species or uses not specified above, or when the intended use is not known | 20 |

# Aflatoxin Standards for Feed

| Country | Aflatoxins regulated | Feeds regulated | Animals regulated | Maximum limits (ppb) |
|---|---|---|---|---|
| USA | B1, B2, G1, G2 | Maize and peanut products | Breeding beef cattle, breeding swine, or mature poultry | 100 |
| USA | B1, B2, G1, G2 | Maize and peanut products | Beef cattle/swine/poultry | 300 |
| Zimbabwe | B1, G1 | Complete | Poultry | 10 |

**Source: FAO 2004.**

# Appendix: Other Mycotoxins

Hundreds of millions of poor smallholders are dependent on livestock for their livelihoods, and livestock production is worldwide the main supply of animal-source foods. Livestock productivity is hampered by many factors, especially in developing and tropical countries, such as infectious diseases and lack of adequate water and feed. Suboptimal harvesting of crops and storage contribute to increased infestations of mycotoxin-producing fungi and mycotoxin-contaminated products enter both the food and the feed markets.

All species kept for product are susceptible to the negative health impacts caused by mycotoxins, but susceptibility differs between species and toxin. The main health impacts of the most important mycotoxins are listed in Table 9.

*Table 9: Mycotoxins with important health impacts on livestock.*

| Mycotoxin | Main fungi | Impact on animal health | References |
|---|---|---|---|
| **Aflatoxin** | *Aspergillus* spp | All livestock susceptible to different degrees. Acute toxicity, hepatotoxic and nephrotoxic. Carcinogenic and mutagenic. Growth impairment. Immunosuppression. | (Coulombe 1993) (IARC 1993) (Khlangwiset et al. 2011) (Richard 2007) |
| **Ochratoxin A** | *Aspergillus* spp, *Penicillum* spp | Nephrotoxic. Immunosuppression. Possibly carcinogenic. | (Bayman and Baker 2006) (IARC 1993) (Richard 2007) |
| **Fumonisin** | *Fusarium* spp | Toxic to liver and central nervous system. Possibly carcinogenic. | (IARC 1993) (Coulombe 1993) (Richard 2007) |
| **Zearalenone** | *Fusarium* spp | Swine highly sensitive, cattle less sensitive. Endocrine disruption. Estrogenic effects, reduced reproduction, feminization, malformations. | (D'Mello et al. 1997) (Coulombe 1993) (IARC 1993) (Richard 2007) |
| **Trichothecene** | *Fusarium* spp | Gastrointestinal disturbance. Reduced feed intake. Ill-thrift. Immunosuppression. | (Coulombe 1993) (D'Mello et al. 1999) (IARC 1993) (Richard 2007) |

# Appendix: Case Study: Standards for Aflatoxins in Poultry Feed

This compilation of standards for aflatoxins in poultry feed from different sources illustrates the wide variety of standards that are available for poultry (5 ppb to 900 ppb), and how some standards are general as regards species, strain, and feed, with others more specific.

**Bureau of Indian Standards**

| | |
|---|---|
| Poultry | 20 ppb |

**ICAR, New Delhi-aflatoxins not specified**

| | | | |
|---|---|---|---|
| Broilers | 150 ppb | Layers | 900 ppb |
| Chicks | 400 ppb | Breeding stock | 300 ppb |

**U.S. Food and Drugs Administration-aflatoxins not specified**

| | |
|---|---|
| Immature poultry | 20 ppb |
| Mature poultry | 100 ppb |
| Cottonseed meal for poultry | 300 ppb |

**European Union-aflatoxin $B_1$ specified**

Maximum content relative to a feed stuff with moisture content of 12 percent

| | |
|---|---|
| Complete feed for pigs and poultry | 20 ppb |
| Complementary feed for pigs and poultry (except young animals) | 20 ppb |
| Other complementary feeding stuffs | 5 ppb |

**South Africa-aflatoxin $B_1$ specified**

| | |
|---|---|
| Feed ingredients except those listed | 20 ppb |
| Groundnut, copra, palm kernel, cottonseed, maize, and derivatives | 50 ppb |
| Complete feed for pigs and poultry (except young animals) | 50 ppb |
| Other complete farm feeds | 10 ppb |

**Technical Package Literature Review:**

Dietary levels of aflatoxin (in ppb) generally tolerated are: ≤50 in young poultry, ≤100 in adult poultry.

# Appendix: Further Reading

**Aflatoxins: Finding Solutions for Improved Food Safety**. Edited by Laurian Unnevehr and Delia Grace, International Food Policy Research Institute (ILRI), Washington http://www.ifpri.org/publication/aflatoxins-finding-solutions-improved-food-safety

The nineteen briefs in this set provide perspectives on aflatoxin risks and solutions. They cover: 1) what is known about health risks from aflatoxins; 2) how to overcome market constraints to improved aflatoxin control; 3) the international policy context for taking action in developing countries; and 4) the state of research on new aflatoxin control technologies, including methods for aflatoxin detection, crop breeding, biological control, food storage and handling, and post-harvest mitigation.

**Improving Public Health through Mycotoxin Control, IARC Scientific Publication, No. 158.**

http://apps.who.int/bookorders/anglais/detart1.jsp?codlan=1andcodcol=73andcodcch=158

This book aims to sensitize the international community to the mycotoxin problem in a format that is accessible to a wide audience and is useful to decision-makers across a broad spectrum of disciplines, including agriculture, public health, marketing, and economics. The book not only provides a scientific description of the occurrence and effects of mycotoxins but also goes further by outlining approaches to reduce mycotoxin exposure aimed at improving public health in low-income countries.

**Global Mapping of Aflatoxin Risk.** Atherstone, C., Grace, D., Lindahl, J., Waliyar, F. and Osiru, M. 2014.Technical Report. Kampala, Uganda: ILRI.

A systematic literature review was undertaken to capture information on aflatoxin prevalence, risk factors and control options and costs to support risk maps and evidence around costs and controls. Twenty-three databases were searched using a combination of the Medical Subject Headings (MESH) terms from National Institutes of Health National Library of Medicine. An initial 2500 papers were identified. After screening, 501 were retained for data extraction and included in this report and compiled into a prevalence database by region and commodity. The prevalence database was then converted into risk maps. GPS coordinates for the location of samples collected in each study included in the database were mapped and included in this report.

# List of Abbreviations and Definitions

| Term | Definition |
|---|---|
| **AFB1** | Aflatoxin $B_1$ |
| **AFM1** | Aflatoxin $M_1$ |
| **AKEFEMA** | Association of Kenyan Feed Manufacturers |
| **ALARA** | as low as reasonably achievable |
| **ALARP** | as low as reasonably practicable |
| **AMA** | anti-mycotoxin additives |
| **CAC** | Codex Alimentarius Commission |
| **CBA** | cost benefit analysis |
| **CGAIR** | Consultative Group for International Agricultural Research |
| **COMESA** | COMESA |
| **EAC** | East African Community |
| **EU** | European Union |
| **FAO** | Food and Agriculture Organization |
| **FDA** | US Food and Drug Administration |
| **GAP** | good agricultural practices |
| **GLOBAL GAP** | Global Good Agricultural Practices |
| **GMP** | good manufacturing practices |
| **HSCAS** | hydrated sodium calcium aluminosilicate |
| **IITA** | International Institute of Tropical Agriculture |
| **ILRI** | International Livestock Research Institute |
| **ISO** | International Standards Organization |
| **MERCOSUR** | Southern Common Market |
| **ML** | Maximum levels |
| **NGOs** | nongovernmental organizations |
| **Ppb** | Parts per billion |

| Term | Definition |
|---|---|
| **Q** | Quality mark |
| **RIA** | risk impact analysis |
| **SME** | small micro enterprise |
| **SPS** | Sanitary and Phytosanitary |
| **TAMPA** | Tanzanian Milk Processors Association |
| **TAMPRODA** | Tanzanian Milk Producers Association |
| **TC** | Technical Committee |
| **WG** | Working Group |
| **WHO** | World Health Organization |
| **Zanzibar** | Islands of Zanzibar and Pemba |
| **ZFDA** | Zanzibar Food and Drug Authority |

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