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The impacts of aflatoxin standards on health and nutrition in sub-Saharan Africa: The case of Kenya

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ABSTRACT

Human food and animal feed can contain many different hazards, which may be biological, chemical, or physical. In most countries, there are regulations that limit the levels of these hazards permitted in food and feed so as to protect consumers. Optimally, the levels specified in the standards should make the food safe enough for everyone to consume, and often this is done by carrying out a risk assessment, based on scientific evidence of the levels that can be considered safe and the amount of contaminated products consumed. However, for some substances, especially carcinogens, it is difficult to calculate how much is safe to consume and some groups of people, such as small children or pregnant women, may be more sensitive than the population at large. While imposition of standards is motivated by health benefits, standards also have costs. These include the costs of compliance and verification, which translate- into increased costs of purchase and reduction of the products available.

In this paper we summarize current standards in sub-Saharan Africa related to aflatoxins, a priority hazard, and discuss their coherence and evidence-base. Next, using our recent research findings, we estimate the health risks of consuming foods contaminated with aflatoxins in Kenya. We also estimate the negative health and economic effects that would arise from strict application of different standards for aflatoxins. We discuss the results in light of health and nutrition goals.

1. Introduction

Is there a trade-off between food security and food safety? When people are struggling to find food for their daily needs, and governments are relying on relief food to supply food for the poorest, the safety and quality of the food may sometimes be compromised. In Africa, most livestock products are produced by small-scale farmers who sell mainly through informal markets (Grace et al., 2015). These farmers and retailers, many of them women, have limited resources, information and capital. This can constrain their ability to provide safe food.

Absolute safety, or 'zero risk', is not a realistic goal in any human domain; safety is always determined by a compromise between the two objectives of using limited resources most effectively (minimising cost) and of achieving the highest levels of safety (minimising risk) (Black and Niehaus, 1980). Because of their potential for harm, aflatoxins are commonly regulated by food safety standards.

Kenya is an east African country with a large smallholder and informal sector but also many well-documented food safety problems (Oloo, 2010). In Kenya, food safety is the responsibility of multiple agencies coordinated by the Ministry of Health. Standards for food and agricultural products are developed by technical committees, numbering about 30, with their secretariats at Kenya Bureau of Standards. Kenya is also a member of the East African Community (EAC) which has a mandate to harmonise standards across member states. Intergovernmental organizations have an increasing role in establishing food control standards. The main intergovernmental agency is the Codex Alimentarius Commission, established jointly by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) to protect the health of consumers and facilitate trade through development of international standards for food and feed.

Aflatoxins are considered a food safety priority in Kenya. This is

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probably related to high-publicity outbreaks in which dozens of people died (Lewis et al., 2005). Aflatoxins are toxic byproducts produced by certain kinds of molds, mainly *Aspergillus flavus*. Aflatoxins are class 1 carcinogens (meaning they are known to cause cancer in humans (Pitt et al., 2012)) and there are also strong associations between aflatoxin exposure and immunosuppression and stunting, although a causal relation is yet to be shown (Khlangwiset et al., 2011; Leroy, 2013). Aflatoxins are found in many different crops, but especially maize and groundnuts, which are staples in many African countries. Aflatoxins can also be present in animal-source foods. This is most problematic in dairy products. When cattle eat contaminated feed, a small amount of Aflatoxin B1 (AFB1) is metabolised to aflatoxin M1 (AFM1) in the liver and excreted in the milk of dairy cows. The amount of AFM1 excreted in milk is typically only around 1–2% of the total amount of AFB1 ingested (Fink-Gremmels, 2008). Aflatoxins may also be carried over from feed to poultry eggs and some remains in the body as residues in meat and organs; however, because very small amounts are carried over, this is not likely to be a problem in developing countries (Grace and Unnevehr, 2013). Globally, most countries have regulations for aflatoxins, especially AFB1, and there are also recommendations by FAO/WHO; however, the allowed levels vary between different countries (van Egmond et al., 2007).

This paper discusses food and feed safety standards for aflatoxins in different countries and their development. It then presents a case study from Kenya where we assessed the aflatoxins present in different foods and developed a quantitative risk assessment to assess their public health impact. The public health hazards of consuming aflatoxins are discussed in relation to the impacts on availability of key nutrients if the standards were to be strictly applied. Conclusions are drawn about tradeoffs between food safety and nutrition security, and appropriate food safety standards in developing countries.

The work was conducted in the context of the first major research project on aflatoxins in the dairy value chain in Kenya. This was funded by the Ministry of Foreign Affairs, Finland, and implemented by the International Livestock Research institute and partners including LUKE and the University of Nairobi. It was a multi-disciplinary study which surveyed prevalence of aflatoxins in food and feed, knowledge, attitude and practice with respect to aflatoxins, the health and economic burdens of aflatoxins, interventions to mitigate aflatoxins, capacity building of actors and engagement with the media and policy makers.

2. Materials and methods

We conducted a literature review to identify standards for aflatoxins in food and feed in Africa and globally and synthesized evidence on the levels of aflatoxins in feed tolerated by different animal species. We next summarized findings from two aflatoxin prevalence surveys in food and feed conducted by the project in Kenya. We used this data to generate estimates of the health impact of aflatoxins in cereals consumed by Kenyans, using a quantitative risk assessment model developed by the project and described in full by Sirma et al. (2018). Finally, we estimated the health impact of removing all food which exceeds the permitted standards for aflatoxins. For this, we used a naïve model in which all food removed for non-compliance translated into number of adults with that food removed from their diet.

3. Results

3.1. Literature review of standards for aflatoxins in food and feed

The FAO has conducted several international surveys on standards for aflatoxins (FAO, 2004, 1997). In 2004, the most common standard for total aflatoxins in food was 4 parts per billion (ppb) (0–35 ppb); the most common standard for AFB1 in food was 2 ppb (1–20ppb); and for AFM1 in milk the most common standard was 0.05 ppb (not detectable to 15 ppb). Since then, some additional papers have emerged on aflatoxin standards.

Our analysis of literature revealed several interesting features of standards in general:

1. A lack of uniformity. Aflatoxin standards may specify food in general, specific foods, feed in general and specific feeds. Moreover, standards may be for total aflatoxins (B1, B2, G1, G2), AFB1 only or, in the case of milk, AFM1 only.
2. Standards becoming more common: In the first study (FAO, 1997), 77 countries had specific regulations for mycotoxins in different foods and feeds, 13 countries had general provisions, while about 50 countries did not have data. By the second survey (FAO, 2004), 99 countries had mycotoxin regulations.
3. Standards becoming more rigorous: A study in 2009 of 11 regions and countries found that two had not changed legislation on aflatoxins but nine had changed to lower the legal limits and/or to extend the number of food categories covered.
4. Countries with more aflatoxin problems tend to have laxer standards; for example, in tropical countries, the average limit for aflatoxins in feed is 54.5 ppb (0 − 300) and in non-tropical countries 26.3 ppb (1 − 200). Similarly, the Texas State is one of the USA states most prone to aflatoxins and has laxer standards than other states.
5. Some countries with zero tolerance: In dealing with hazards ubiquitous in nature, such as fungi and fungal toxins, and given ever increasing ability to detect molecules in miniscule amounts, zero tolerance is usually considered not a sensible approach.
6. Countries and nations that share strong food trade relations tend to have similar regulations on allowable levels of aflatoxins in maize: in most of top 20 trade relationships, importing and exporting country have the same aflatoxin standard for maize (Wu and Guclu, 2012).

Additional trends were found when focusing only on standards with fewer foods.

7. Little relation between standards and consumption: For example, USA has both one of the world's highest milk per capita consumption levels and also the most lenient standard for aflatoxins in milk. Similarly, five countries have per capita maize consumption greater than 100 kg per year, but standards are either absent or lenient (Table 1).
8. Little relation between standards and aflatoxin vulnerability: The same is seen for countries with high hepatitis B prevalence, a major contributor to the development of liver cancer after aflatoxin exposure (Shephard, 2008). Among countries with prevalence of 15%

Table 1
Aflatoxin standards for countries with per capita maize consumption greater than 100 kg per person per year.

Country	Maize kg/person/year	Aflatoxin standards status	References
Lesotho	167	• No standards reported	
Malawi	131	• 5 ppb AFB1 in exported groundnuts	(FAO, 2004)
Zambia	119	• No official standards reported	
Mexico	116	• 20 ppb total aflatoxins in cereals and products • 12 ppb total aflatoxins in corn flour for tortilla	(FAO, 2004)
South Africa	100	• 5 ppb AFB1 in food • 10 ppb total aflatoxins in food • 0.05 ppb aflatoxin M1 in milk	(FAO, 2004)