Aflatoxin: food chain transfer from feed to milk

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According to the Food and Agriculture Organization of the United Nations (FAO), a quarter of the world's food crop is spoiled by filamentous fungi and thus should be rejected for food safety reasons at the expense of the food supply of a steadily rising world population. More than 250 mold types that produce mycotoxins are particularly problematic. Among the approximately 300 known mycotoxins, aflatoxins the most important. Aflatoxins are potent, naturally occurring carcinogenic mycotoxins with a genotoxic effect and chronic and acute liver toxicity, especially in combination with hepatitis. Aflatoxins are categorized as group 1 carcinogens by the FAO because they lead to liver cancer. They are produced by the *Aspergillus* (A.) species, mainly by *A. flavus* and *A. parasiticus* and less frequently by *A. nomius*. *Aspergillus* species are common and widespread in nature, their native habitat being the soil and decaying vegetation. They invade certain types of organic substrates whenever conditions are favorable. The natural occurring aflatoxins are AFB1, AFB2, AFG1, and AFG2 with AFB1 as the most common and most toxic metabolite. These species have their growth optimum between 30 and 37 °C and with high

humidity (>85%). The fungi also respond with increased aflatoxin production under drought stress before harvest in the field. *Aspergillus* species mainly occur in tropical and subtropical regions worldwide. Due to climate change, chances are that also regions with moderate temperatures (like Europe) may be more affected in future.

The uptake of aflatoxins with the diet, even the regular uptake of minor amounts, poses serious health risks that should be avoided at any rate. In the first WHO report on global burden of foodborne diseases, aflatoxin is one of the main issues. To protect consumers, limits are fixed in many countries, both for primary agricultural products and for processed foods. Aflatoxins can enter the feed chain in regions with moderate temperature as imported feed material. In the past, problematic components were e.g. corn gluten meal, sunflower- or soybean and different oil meals from tropical and subtropical exporting countries.

Approximately 500 million people of the poorest regions in Sub-Sahara Africa, Latin America and Asia are exposed to the pervasive natural toxins like aflatoxins on a daily basis by eating their staple diet of groundnuts, maize, and other cereals. Exposure occurs throughout life at levels far in excess of internationally accepted norms. This contrasts heavily with the situation in developed countries, where people and livestock are protected by good agricultural practices, regulation and monitoring.

Aflatoxins are causing disease in many African countries, but there are some hotspots like Kenya, with historical outbreaks like in 2014, where 125 people died and nearly 200 others were treated after

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eating aflatoxin-contaminated maize. The Kenyan population consumes high amounts of both maize and milk. Both staples, livestock feed, and milk has been found to be frequently and highly contaminated, and people are continuously exposed to levels which are high above the recommended levels.

In children, aflatoxins can cause growth failure and delayed development. Stunting and low weight put children at increased risk of death. In a comprehensive study, the International Agency for Research on Cancer (IARC) demonstrated that due to exposure to mycotoxins in low-income countries, more than 160 million children under 5 years are stunted worldwide. Maternal aflatoxin exposure during pregnancy has been correlated to decreased growth during the first year of an exposed infant's life. Aflatoxin M1 is a major carcinogenic metabolite found in milk of lactating women and animals exposed to aflatoxin B1; it is considered a particular risk to infants and young children as milk is often part of their diet. It is important that aflatoxin levels in crops be carefully controlled to prevent feeding aflatoxin contaminated supplemental foods to already vulnerable populations.

The concern of mycotoxin contamination in dairy products began more than 50 years ago in the 1960s. The first reported case on aflatoxin M1 contamination was in ovine milk, after feeding contaminated feed with AFB1. This hepatic hydroxylated form of AFB1 was originally called "milk toxin". The singular phenomenon of the high transfer of aflatoxin B1 to the milk-borne AFM1 results from a preventive decontamination triggered by the animal. AFM1 is about tenfold less toxigenic than AFB1. In more than 60 countries there are regulations to control AFB1 levels in food-stuff and to establish the maximum permissible levels of AFM1 in milk and dairy products in order to reduce disease risks. A maximum residue limit is 5 µg/kg AFB1 in feed for dairy cattle and 20 µg/kg AFB1 for fed materials according to the European Union (EU 574/2011) and 0.05 µg/kg for milk (EU 165/2010) which is lower than the limits established e.g. by the Codex Alimentarius (0.5 µg/kg).

The carry-over rates of aflatoxin B1 through oral intake and the metabolism to aflatoxin M1 in milk depend on the animal species, but there is also a large variation within species. For dairy cattle, carry-over-rates of 1–6% with an average of 2.5% for the total milk were determined, i.e. approximately 0.1% per kg of milk. Carry-over rates deviate for goats, dairy ewes and mares with 1.5, 0.8 and 0.03% per kg milk, respectively. Except for the products above, there is no uniform maximum level for aflatoxin contents in

dairy products in the EU. Some countries introduced their own cheese limits, e.g. Italy with 0.450 µg/kg for hard cheese, Switzerland and the Netherlands with 0.250 µg/kg and Turkey with 0.200 µg/kg. The semipolar aflatoxin M1 mainly binds to casein and to approximately 30% of fat-free solid milk ingredients. This results in enrichment of skimmed milk products. Process steps like pasteurization or sterilization of the milk do not destroy the very heat-resistant toxin. During the production of cheese, 60% of aflatoxin from the initial content accumulate in the whey, while 40% of the AFM1 remain in the curd or fresh cheese.

Contamination of milk may be reduced indirectly by decreasing the AFB1 content in feed or directly by decreasing the AFM1 content in milk. Current strategies for AFM1 mitigation include good agricultural practices in pre-harvest (e.g. crop rotation, fungal resistance, biocontrol), during harvest (e.g. ripening, dry matter) and post-harvest (e.g. storage, cooling, dryness) management of feed crops as well as physical or chemical decontamination of feed and milk. There are several possibilities to reduce aflatoxins in milk, e.g. with the use of certain microorganisms (e.g. lactic acid bacteria), purified microbial enzymes, dietary clay minerals and vaccinations; however, no single strategy offers a complete solution to the issue.

Despite decades of research, there is currently a lack of efficient strategies for a sustained reduction of contamination of the food- and feed-chain by fungi or their mycotoxins. In this issue, two papers contribute to this topic: A promising method of reducing the aflatoxin content when there are contaminated feed, is using binders. The possibilities with binders on basis of bentonite clay are shown by Ullah et al. On the other hand restrictions in plant protection in organic farming systems may pose new problems. The contribution by Santos et al. addresses the occurrence of aflatoxins in raw milk originating from organic and conventional production systems.

When looking at the aflatoxin problems in milk, the farm animal is the first consumer of possible mycotoxin containing feed. Therefore, the effort of consumer protection should focus on minimizing the exposition of milk cows to undesired components in the feed ratio and thus largely exclude also the prejudice to the animal's health and performance. A consequent use of pertinent minimization possibilities in the feed sector can lead to more or less aflatoxin-free milk.

The Max Rubner-Institute coordinates a project called AflaNet (Aflatoxin Networking on Aflatoxin

Reduction in the Food Value Chain) that has currently started. The goal of this project is to establish a long-term network between scientific and development partners in Kenya/East Africa and Germany to

address the reduction of aflatoxins in the food value chain. It is funded by German Ministry for Food and Agriculture (BMEL).