

## Mould fungi

Moulds are omnipresent in nature. It is estimated that there are around 140,000 species worldwide, of which around 25-50% can produce one or more toxins, known as mycotoxins. Mycotoxins are secondary metabolic products and serve to protect the mould from competition by inhibiting the growth of other microorganisms or as a defence against predators. They can also be produced in response to environmental stress, such as a lack of nutrients or temperature fluctuations.

## Aflatoxins

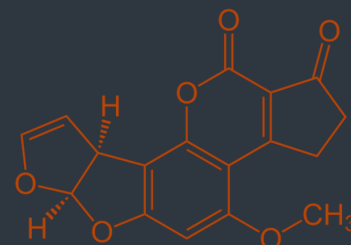
Chemically, aflatoxins are condensed dihydrofuran or furan rings that are linked to a coumarin backbone. Depending on the aflatoxin variant, hydroxy, methoxy or epoxy groups may be present as functional groups.

Aflatoxins fluoresce, are poorly soluble in water but heat-stable and therefore survive common cooking and pasteurization processes. Most aflatoxins are metabolized in the liver by cytochrome P450 enzymes. Aflatoxin B1 is metabolized to aflatoxin-8,9-epoxide. This epoxide is highly reactive and forms DNA adducts (e.g. with guanine bases), which can lead to mutagenic and carcinogenic effects.

Other aflatoxins (B2, G1, G2, M1) are also metabolized, but with less toxicity. However, aflatoxins can also be detoxified during their degradation in the body. This is primarily carried out by glutathione S-transferases and epoxide hydrolases.

## AI-supported aflatoxin detection

Detecting and sorting out contaminated food is a major challenge along the entire supply chain. New, AI-based approaches that combine spectroscopic methods with machine learning (ML) to reliably determine aflatoxin levels are promising. Hyperspectral imaging analyzes spectral signatures and detects contaminated samples. In addition, AI algorithms optimize biosensors and immunological tests, improving sensitivity and accuracy. Drones with multispectral sensors are



Aflatoxin B1

## Aflatoxins - A creeping risk in our food chain

Aflatoxins occupy a special position among moulds, because although these colourless and tasteless mycotoxins have little sensory impact on food, they can have devastating effects on health.

To date, 6 different aflatoxins are known: B1, B2, G1, G2, M1 and M2. Aflatoxins, especially aflatoxin B1, are highly toxic and highly carcinogenic. They preferentially attack the liver and lead to aflatoxinosis in acute poisoning, which is characterized by liver failure, jaundice, vomiting and abdominal pain. However, chronic exposure in low doses can also have serious health consequences. These include growth retardation in children as well as immunodeficiency and metabolic damage. Furthermore, the risk of developing liver cancer (hepatocellular carcinoma) increases.

However, chronic exposure to low doses can also have serious health consequences. These include growth retardation in children as well as immunodeficiency and metabolic damage. Their accumulation in food is particularly dangerous in combination with malnutrition, which is common in developing countries.

The World Health Organisation (WHO) has classified aflatoxins in Group 1 of carcinogenic substances, which means that their carcinogenic effect in humans is well documented.

Aflatoxins are not only one of the most toxic, but also one of the most widespread mycotoxin groups worldwide. While many mycotoxins can be formed by various moulds, aflatoxins are only formed as toxic metabolic products by fungi of the *genus Aspergillus*, more precisely by the species *Aspergillus flavus*, *Aspergillus parasiticus* and *Aspergillus nomius*.

Spores, which can travel relatively long distances through the air, reach various surfaces and begin to grow under suitable conditions. Aflatoxins

also increasingly being used to identify fungal infestations in fields at an early stage.

Future developments such as edge AI, with improved real-time analysis of aflatoxin concentrations in products and blockchain technologies for more transparent and tamper-proof supply chains, could further optimize food monitoring.

### Aflatoxin contamination in almond drinks

The Max Rubner Institute (MRI), a German research institution specializing in food and nutrition science, analysed 2023 almond drinks available on the market for their mycotoxin content, among other things. The MRI detected levels of aflatoxin B1 in 23 of the 24 samples analysed. Based on this data, the Federal Institute for Risk Assessment (BfR) calculated the health risk using the margin-of-exposure (MoE) concept, as aflatoxin B1 is a genotoxic carcinogen for which no safe intake level can be derived. Results from a 2-year carcinogenicity study in rats were used as a toxicological reference value, resulting in a BMDL10 value of 400 ng/kg bw\*d. The BMDL10 indicates the dose at which the number of additional cancer cases in the animal experiment increases by 10 %.

If a MoE calculation results in a value of  $\geq 10,000$ , this is considered to be of little concern. The calculations for the content of aflatoxin B1 in almond milk resulted in MoE values between 79 and 3,496, depending on the age group and scenario, which is why the BfR concludes that long-term consumption could lead to adverse health effects, especially in children aged 0.5 to <6 years. This is also due to the fact that this age group is more exposed due to their higher relative consumption. The BfR draws attention to the fact that the consumption of plant-based drinks is increasing, which is why current consumption data is required in order to be able to assess the health risks more precisely.

those with a high starch or fat content, such as cereals (maize, wheat, rice, barley, millet), nuts (peanuts, pistachios, almonds, hazelnuts, Brazil nuts, walnuts), oilseeds (soya beans, sunflower seeds, cotton seeds), spices (paprika, chilli, nutmeg), ginger and dried fruit (figs, dates, sultanas).

Aflatoxins can also be found in milk and dairy products through so-called 'carry over' if cows have been fed with aflatoxin-contaminated feed.

However, aflatoxins are not only a problem in tropical and subtropical regions, but also in global retail chains that spread the contaminated food worldwide.

In addition, aflatoxins are a growing problem. The climate crisis is increasingly creating ideal conditions for the responsible fungi to multiply. Rising temperatures and higher humidity are favouring the contamination of grain fields, warehouses and transport chains. Regions that were previously hardly affected, such as southern and central Europe, are facing an increasing risk.

One example of the increasing threat is maize crops in Italy, Spain and Poland, which have been more frequently contaminated with aflatoxins in recent years. The increased infestation not only poses a health risk in these regions, but also results in economic losses as the grain can no longer be brought to market.

The European Union has introduced strict limits for aflatoxins in food in order to protect consumers. These regulations require extensive testing and controls along the entire food chain, especially for imported products from countries with less stringent regulations.

*By Ute Haßmann*

#### Literature and links:

- [Comparative metabolism of aflatoxin B1 in mouse, rat and human primary hepatocytes using HPLC-MS/MS | Archives of Toxicology](#)
- [schimmelpilze-in-lebensmitteln-gesundheitliche-risiken-und-wie-sie-sich-vermeiden-lassen.pdf](#)
- [Eröffnung Hesse](#)
- <https://efsa.onlinelibrary.wiley.com/doi/abs/10.2903/sp.efsa.2020.EN-179>
- [https://www.mri.bund.de/fileadmin/MRI/Institute/OG/MRI-Pflanzendrinks.pdf?utm\\_source=chatgpt.com](https://www.mri.bund.de/fileadmin/MRI/Institute/OG/MRI-Pflanzendrinks.pdf?utm_source=chatgpt.com)
- <https://www.bfr.bund.de/cm/343/mykotoxine-in-pflanzendrinks-mehr-daten-erforderlich.pdf>
- [Peter F auf Unsplash](#)