Mycotoxins

Hazards by
QAssurance

Mycotoxins

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Mycotoxins are metabolic products of fungi, which can be harmful if ingested by humans. Separate documents are available for the aflatoxins, ochratoxin, deoxynivalenol (DON), fumonisins, zearalenone and patulin.

Aflatoxin

Aflatoxin (AFs) are toxins produced by fungi that may cause severe sickness in both animals and humans. AFB1, AFB2, AFG1, and AFG2 are the four main aflatoxins. These toxins are produced primarily by specific strains of *Aspergillus flavus* and *A. parasiticus* in a variety of agricultural commodities, such as grains and nuts, under adverse weather or under poor storage circumstances.

Parameter	*Characteristics*
Fungus	*Aspergillus flavus, Aspergillus parasiticus, Aspergillus nomius*
Agricultural raw materials	Cereals, buckwheat, maize and maize products, cottonseed, peanuts, other types of nuts (pistachio-nuts, walnuts), spices, dried figs, milk (products), semsame seed soy and soy products.
Symptoms	Acute toxic; degradation of liver and kidneys. Chronic: carcinogenic (cancer forming) especially in the liver.
Legislation	Warenwet (milk, earth nuts). Dutch legislation: EEG-diervoederrichtlijn
Comments	Aflatoxin B 1 is the most common and toxic carcinogen. In milk (products) is the most common aflatoxin M 1 formed after that B 1 is broken down. Around 1-3% B 1 is processed in milk to M 1. M 1 is not as poisonous and carcinogenic as B 1. Next to M 1 are other break down products of B 1 present in milk. Fungus mostly grow during the transport and storage in the tropics, mostly characterised by high temperatures (optimum 25 °C: range 8-37) and or high humidity (>83%). In developed countries (VS) are aflatoxins mainly caused during difficult growth seasons (growth-stress).

Symptoms

Aflatoxins can cause bleeding, jaundice, early cell death, and liver tissue necrosis and perhaps other organs due to disruption and suppression of glucose and lipid metabolism and protein synthesis. Other common symptom include lower extremity edema, stomach discomfort, and vomiting.

Ergot alkaloids

Cereals and grasses can be infected during cultivation by the fungus *Claviceps purpurea*. This fungus can form so-called sclerotia (mycelium consisting of 2 - 4 cm large black seeds) in which mycotoxins (the ergot alkaloids) are present. During the harvest, the sclerotia can end up between the grains and be ground in the mill. The most well-known is rye contamination with Claviceps purpurea. Wheat contains ergot alkaloids as well. Ergot alkaloids are mostly formed before to harvest under relatively high humidity and temperatures ranging from 10 to 30 degrees Celsius. The concentration of ergot alkaloids reduces after washing and grinding.

Parameter	Characteristics
Fungus	*Claviceps purpurea; Claviceps paspali*
Agricultural raw materials	Rye (mainly), wheat, barley and oats.
ADI of AWI (ug/kg body weight)	ADI: 0,001 mg/kg (human) {2}, Medicines: 0,125 mg/kg
Symptoms	Hallucinations, gangrene. Carcinogenicity is not demonstrated.
Comments	Europe: last case in humans was in 1951. In the middle ages was it a very common disease (St. Anthoniusvuur). Toxins are present in firm, purple granules. Toxin forming takes place in the field.

Symptoms

Ergot alkaloids could result in the narrowing of blood vessels. Ergotism can manifest itself in two ways: a gangrene-like type, in which body parts die due to insufficient blood flow, and a type in which symptoms occur that indicate impairment of the central nervous system, such as vomiting, headaches, muscle cramps and seizures. Severe poisonings are manifested by blood vessel constrictions, followed by the dying of tissue parts and neurological abnormalities. With less severe poisoning with ergot alkaloids, impaired kidney function can be observed and there are effects on the endocrine system; thyroid gland and especially the part involved in the regulation of carbohydrates in the mechanism.

Fumonisin

Parameter	Characteristics
Fungus	Fusarium verticillioides
Agricultural raw materials	Maize and maize products
Symptoms	Possible carcinogenic for oesophagus and lever.

Symptoms & Toxicity

It was concluded from the available studies that chronic exposure to fumonisin B1 leads to kidney damage and an increased risk of developing tumors in this organ. At higher concentrations of fumonisin B1, toxicity was observed in the liver and immune system. The tolerable daily intake (TDI) was set at 0.2 micrograms per kilogram of body weight. The previous TDI for fumonisin B1 was equated to that for the sum of fumonisins B1, B2, and B3.

Fusarium verticillioides which is also known as Fusarium moniliforme, a fungi, is frequently seen in maize. Fumonisin has the potential to cause a wide range of biological symptoms, including pulmonary edema in pigs, brain softening in horses, and liver cancer in rats. The most relevant and well-studied Fusarium toxins are fumonisins B1 (FB1), B2 (FB2), and B3 (FB3). Fumonisins are resistant to heat, acids, drought and salt and will therefore survive normal process conditions in food preparation. In the production of maize starch, fumonisins are largely removed during milling, which uses water, because fumonisins are water-soluble.

Ochratoxin A

Parameter	Characteristics
Fungus	*Aspergillus Penicillium* species
Agricultural raw materials	Barley, rye, wheat, rice, corn, peanuts, Brazilian nuts, peppers, Cotton seed, Cheese.
ADI of AWI (ug/kg body weight)	AWI of toxin A: 0,112 limit: 10 ug/kg food product. LD 50 (rat, oral) van toxin A: 20 mg/kg
Symptoms	Acute: damage to kidney and liver; possible kidney-carcinogenic (already proved in rats), teratogenic.
Comments	Toxin A is more toxic than B. In the Netherlands are such low amounts found that the risk is perceived very low and therefore is there no norm. Growth fungus is possible in a temperate climate. Toxin A is inactivated at > 221 °C

Ochratoxin A is a mycotoxin produced by several Aspergillus and Penicillium genera that is one of the most common food-contaminating toxins. This is also a common pollutant in moisture damage and heating ducts. Consumption of infected products, notably infected grains and , as well as coffee beans, wine grapes, and dried fruit, can result in human contamination. Ochratoxin A has been demonstrated in animal studies to be toxic and carcinogenic. The kidney is ochratoxin A's primary target organ. Other negative effects include liver toxicity, immunosuppression, cell damage, and suppression of mitochondrial ATP generation, effecting the production of energy.

Patulin

Patulin is a metabolic product of fungi. It can be harmful if ingested by humans. The substance is formed by fungi at temperatures between 5 and 25 ºC, a high moisture content and a relatively low pH (3 - 5).Patulin is a toxic fungi metabolite made by a plethora of fungi, including certain Penicilllium, Aspergillus, and Byssochlamys species. Patulin may be found in tainted fruit, cereals, and other foods. Apples and apple products seem to be the most major sources.

Parameter	Characteristics
Fungus	Apergillus clavatus; Penicillium; roqueforti Penicillium expansum; Penicillium patulum
Agricultural raw materials / Food products	Apple, apple juice, contaminated fruits, grains, cheese and sausage.
ADI of AWI (ug/kg body weight)	AWI: 7 (JECFA, 1989)
Symptoms	Acute toxic (damage to lungs, brains, liver, kidneys); carcinogenicity is not proved yet (IARC, 1985)

Symptoms

Only in high doses did internal bleeding, oedema, intestinal strictures and damage to the immune system develop in laboratory animals.

Sterigmatocystin

Parameter	Characteristics
Fungus	Aspergillus versicolor; Aspergillus rubber; Aspergillus flavus; Penicillium luteum A. nidulans, Bipolaris
Agricultural raw materials / Food products	Grain, buckwheat, wheat, rice, peanut, soy, cheese, green coffee beans and melting cheese.
ADI of AWI (ug/kg body weight)	No ADI
Symptoms	Acute: Damage on liver, teratogen. Chronic: mutagenic, carcinogenic
Parameter	Characteristics

The presence of Sterigmatocystin toxins in grain, buckwheat, and soy products is being investigated in the Netherlands. Because no toxins are detected, management is deemed unnecessary. Aspergillus versicolor and Aspergillus nidulans, for example, produce sterigmatocystin. In test animals, this toxin causes cancer, but at a lesser rate than aflatoxin B1.

Trichothecenes

Trichothecenes are mycotoxins caused by fungi, such as Fusarium species that contaminate cereal grains. Deoxynivalenol (DON), nivalinol (NIV), fusarenon X (FUSX), T2 tocine (T2), HT2 toxin (HT2), Zearalenone, diacetoxyscripenol (DAS), and neosolaniol are the most significant trichothicenes (NEO).

Deoxynivalenol (DON) is a toxin produced by the fungus part of the genus Fusarium. These fungus are naturally present in cereals. Chronical exposure to DON, through consumption of bread and other products containing cereals, could negatively influence the food intake, the growth and immune system. Vomiting is an acute symptom of consumption contaminated with too high DON-concentrations. ADI adults: 3, ADI children: 1,5, ADI children: 1,5

Parameter	Deoxynivalenol	T2	Zearalenone
Fungus	Fusarium spp., Fusarium graminearum	Fusarium spp.	Fusarium spp. among others: Fusarium graminaerum Fusarium roseum, Fusarium culmorum, Fusarium moniliforme
Agricultural raw materials	Wheat, barley, maize, oats, rye, rice, cereal flakes and bran products	Millet, wheat, oats, barley, rye, buckwheat, peanuts, maize, sorghum.	Maize, sorghum, wheat, barley
Symptoms	Acute toxic: several symptoms (s.a. vomiting, degradation of immune system). Possible teratogenic. Carcinogenicity is not proved.	Acute toxic: alimentary toxic aleukia (ATA) 80% death. Possibly also mutagenic and teratogenic.	Oestrogenic effects have negative effects on fertility. Probably mutagenic, teratogenic and carcinogenic.
Comments	The functioning and toxicity is quite unknown, and more research is preferred. The toxin is mainly produced in the field. Fusarium spp. is present in cereals growing in temperate regions.	Growth of fungus is stimulated by low temperatures, especially around the freezing point. Hibernating of grains on the field is not recommended. Inactivation of toxins happens at temperatures higher than 200 °C.	Forming of toxins is stimulated by temperatures for a long time around freezing point and temperature changes from low to moderate temperatures. Fungal growth happens mainly on the field but it is also possible during storage. Inactivation of the toxins happen at temperatures higher than 165 °C.

Other Mycotoxins

Parameter	Rubratoxin A and B
Agricultural raw materials / Food products	Algae, fish products (as consequence of food supply) mainly in shellfish naturally living in plants.
ADI of AWI (ug/kg body weight)	Toxic and/or unfavourable effects on the bioavailability of nutrients
Legislation	Resistant to normal heat treatments, common toxins: solanum-alkaloids in potatoes, glucosinolates in cabbage, agaritine in champignons

Parameter	Fycotoxins
Agricultural raw materials / Food products	Algae, fishery products (as consequence of food supply) especially shell fish. naturally found in plants.
Symptoms	Toxic and/or undesirable effect on the bioavailability of the nutrients.
Comments	Resistant to normal heat treatment. Present toxins: solanum-alkaloids in potatoes, glycosylates in cabbage species, agaritine in mushrooms.

Parameter	Yellow Rice Toxin
Fungus	Penicillium spp. sometimes Aspergillus spp. Penicillium citrinum Penicillium veridicatum.
Agricultural raw materials / Food products	Rice, wheat, barley, peanuts.
ADI of AWI (ug/kg body weight)	Citrinin: LD 50 in rats, oral = 50 mg/kg.
Symptoms	Acute toxic, different symptoms (such as kidney- and liver damage).
Comments	Citrinin is inactivated at T > 172 o C; citreoviridin at T > 110 o C. P.Citrinum produces except Citrinin a yellow pigment fluorescent under UV-light.

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