

EFFECTS OF AFLATOXINS CONTAMINATING FOOD ON HUMAN HEALTH

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Keywords: Mycotoxins, aflatoxins, cancer, mutagenesis, food contamination, DNA adducts, biomarkers, hepatic diseases, cirrhosis, hepatitis, toxicology, chemical mutations.

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Summary

Aflatoxins (AF) are toxic metabolites of the moulds *Aspergillus flavus*, *A. parasiticus* and *A. nomius*. AF link to DNA, RNA and proteins and affect all the living kingdom, from viruses to man, causing acute or chronic symptoms, they are mutagens, hepatocarcinogens, and teratogens.

The impact of AF contamination on crops is estimated in hundreds of millions dollars. FAO declared that 25% of all crops in the world have AF, mainly cereals, oilseeds and spices. The responsible factors for AF production are temperature, grain and environmental humidity, damage by insects, rodents, genetic inheritance, etc. AF are economically important due to the damages to health, also because they act in traces and are accumulated in the nucleic acids of man and animals, and after years of consuming AF, they develop chronic illness such as cancer. When AF link to DNA they form adducts that are biomarkers of risk of disease.

The preventive measures to avoid the fungal production of AF is to dry, all stored food products and their derivates, to take crops or foods to a humidity level lower than the needed by the fungus, to use plant varieties resistant to insects and fungal attacks, extra crop irrigations, chemical products or fungicides. Decontaminate the affected crop with ammonium or other chemical, use of chemosorbents with feed.

In the Sections 1.0 to 4.0 of the present chapter all the main features of AF has been briefly developed, their definition, conditions for their production, occurrence, chemical structure, types, physicochemical and biological properties, their biosynthetic pathway, biotransformation, analytical methods, metabolism.

The Section 5.0 describes the toxic effects of AF in plants, animals and man, giving some details of their behavior as mutagens, AF-DNA adduct formation, proto-oncogene activation and carcinogenesis. Sections 6.0 to 8.0 deal with economic losses, control measures and legislation. The chapter ends with general conclusions and bibliography.

1. Aflatoxins, Production, Occurrence, Chemical Structure

1.1 Definition of Aflatoxins

The word “aflatoxin” comes from a = *Aspergillus*, fla = *flavus* and toxin = venom. Aflatoxins (AF) are fungal secondary metabolites that form a group of toxic compounds that chemically correspond to furan coumarins.

AF were discovered in Great Britain in 1960, after the death of one hundred thousand turkeys that were fed with AF contaminated peanuts from Brazil, the flour was contaminated with the mould *Aspergillus flavus*.

1.2. Aflatoxin Producing Fungi and Production Conditions

1.2.1. Aflatoxin Producing Fungi

Mainly three fungi *Aspergillus flavus* Link, *Aspergillus parasiticus* Speare and *Aspergillus nomius* Kurtzman synthesized AF by their metabolism. *A. bombycis*, *A. ochraceoroseus* and *A. nomius*, are also AF producing mould species, but they are not found frequently.

The morphological characteristics that are more upstanding in *Aspergillus* are globose or column heads with green yellowish or olive green color. Phyalids grow in one or two

series frequently from the same fungal strain or even in the same head. The fungal species lack a sexual reproductive stage, they do not reproduce by meiosis, and it is common the presence of brown reddish, purple brown or black sclerotia when they are mature, sclerotia can be globose, sub global or vertically elongated.

The fungi *Aspergillus flavus* produce only AFB₁ and AFB₂ with a higher proteolytic activity, and some strains can produce cyclopiazonic acid. *Aspergillus parasiticus* synthesize mainly AFB₁, that is the most toxic compound of the group, but it can also produce the four common aflatoxins B₁ (AFB₁), B₂ (AFB₂), G₁ (AFG₁) and G₂ (AFG₂) with more lipolytic activity. Not all the species of *Aspergillus spp.* are capable of producing AF.

These fungi contaminate seeds in the field, where they can grow as saprophytes in crop debris on the soil, and in warehouses. A source of primary contamination can be sclerotia formed in damaged grains and in healthy maize. During dry seasons the plants are more susceptible to insect invasions that carry spores, beginning the development of the fungi. Aflatoxins can remain longer time after the producing fungi die, therefore, grains can have dangerous levels of AF although they have not a moldy appearance.

Maize seeds can be invaded by fungi during plant formation, as well as in post harvest, transportation and storage periods. The fungi reduce viability, nutritional and sanitary qualities to seeds and grains.

1.2.2. Conditions for Aflatoxin Production

Aflatoxins appear when a **producing strain** of *A. flavus* or *A. parasiticus* grows in a substrate, where environmental conditions favor their development. The genotype of each species, some biological, environmental and chemical factors determine the amount of AF produced by aflatoxicogenic strains in the substrate.

The fungi *Aspergillus spp.* is stimulated by **physical factors** such as **temperature**, **relative humidity** of the atmosphere and **substrate**, or by biological, biochemical and environmental factors.

The principal factors for AF production are: the aflatoxicogenic fungus, the substrate, environmental and substrate humidity (an environmental relative humidity of 85% corresponds to a wetness content of 16.5-18% of the grain), temperature, associated mycoflora, oxygen of the storage atmosphere and time of storage.

The AF production in the substrate can happen in the field and in storage conditions between 20 and 40°C with a 10-20% of humidity, and 70-90% of relative humidity in the air. Aflatoxins can be formed in storage conditions or in the cereal fields before harvest. These fungi grow at temperatures from 8 to 55 °C being 36 to 38 °C the optimal ones, and 25 a 35 °C for AF production; beginning at 11 to 14 °C and stopping AF production below 10 °C or more than 45 °C. *A. parasiticus* grows mainly in tropical or subtropical areas; *A. flavus* develops in a wide range of temperatures in substrates with high hydrocarbon content, nevertheless many non aflatoxicogenic strains do the same, therefore the fungi presence do not indicate the existence of aflatoxins.

Mycotoxins are produced at the end of the exponential phase or at the beginning of the stationary phase of the mould growth. The development of the fungus is favored if the grains are damaged by insects or rodents. Some spores of the substrate bud and grow as mycelia generators of AF because, when breathing, they produce water increasing the humidity of the seeds or grains.

Aflatoxin production by *Aspergillus* reaches its maximum production rate at the fifth day, that is, when the mould comes up to the stationary growth phase. Its AF production diminishes from the sixth to the eighth days. After 24 hours, *Aspergillus* reaches the optimal conditions of temperature (27-30 °C) and relative humidity (85%) to produce aflatoxins, its rate of production increases as far as 12 days that is when it has its highest production, later this rate lowers progressively.

Aspergillus producer species require to be in pure culture to generate AF, because there are other species, such as *A. chevalieri*, *A. candidus* and *A. niger*, that compete with them at the same conditions of temperature and humidity and interfere the AF production. These facts have been applied in the biological control, where some other fungi and bacteria are used as contenders of the aflatoxicogenic strains.

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Biographical Sketches

Magda Carvajal is a Researcher Professor of Mycotoxins at the Institute of Biology of the Universidad Nacional Autónoma de México (National Autonomous University of Mexico) in Mexico City. She carried out his Postdoctoral work at the University of York, UK in the Cancer Research Unit, and also in the University of Bristol, UK in Long Ashton Research Station. Her present research interests are in aflatoxin biomarkers of human cancer, aflatoxins in maize products, in poultry tissues and in eggs, fumonisin in maize products. She has been tutor of 28 thesis, has presented around 250 papers in congresses and has more than 70 publications.

Pavel Castillo-Urueta Studied Food Chemistry (2002) with the thesis "Contamination of marine

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