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Aflatoxins – Threat to Food Safety and Food Security

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Fungal secondary metabolites that are usually produced during the growth of the *Aspergillus flavus*, *Aspergillus parasitcus* and *Aspergillus nominus* on certain foods and feedstuffs under favourable conditions of moisture, temperature and aeration, have toxigenic effects to reduce the quality and quantity of food products. Aflatoxin may play role in a number of diseases, including Reye's syndrome, Kwashiorkor disease, etc.

Introduction

Aflatoxins are a group of fungal secondary metabolites that are stable and fairly resistant compounds to degradation. These metabolites are usually produced during the growth of the *Aspergillus flavus*, *Aspergillus parasitcus* and *Aspergillus nominus* on certain foods and feedstuffs under favourable conditions of moisture, temperature and aeration. Although aflatoxins B1, B2, G1 and G2 might be found in foods, AFB1 is considered as one of the most potent hepato-carcinogens. Upon a long term exposure to low levels in the diet could lead to carcinogenic, mutagenic, teratogenic, neurotoxic or immunotoxic effects. Aflatoxin B1 may also play a role in a number of diseases, including Reye's syndrome, Kwashiorkor disease. As these toxigenic fungus directly or indirectly by producing the aflatoxins reduce the quality and quantity of food products. These toxigenic food and feeds are chronic lethal to animals and human beings also. The aflatoxin B1 contaminated diet when ingested by the animals, bio transformed into Aflatoxin M1 in milk. That will be readily toxic to youngsters.

History

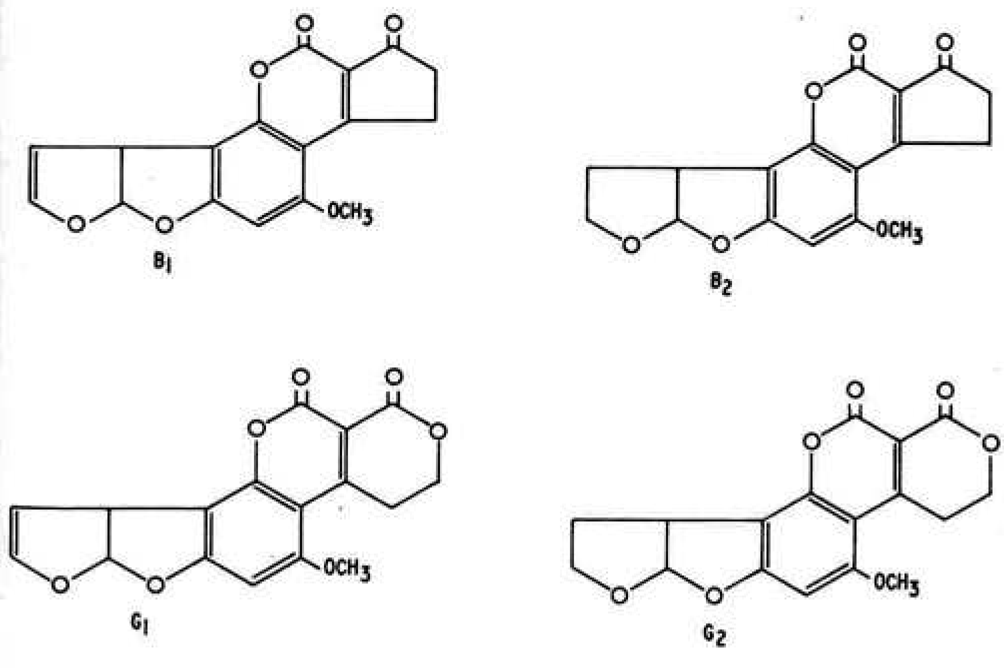
The aflatoxins were discovered in the late 1950s and early 1960s, when they were identified as causative agents of "turkey X" disease, an epidemic involving deaths of numerous turkey poults, ducklings, and chicks fed diets containing certain lots of peanut meal originating in South America. Investigations revealed that toxicity was associated with the presence of *Aspergillus flavus*, and further that extracts of cultures of the fungus isolated from the meal were capable of inducing the "turkey X" syndrome. The name "aflatoxin" (*A. flavus* toxin) was accordingly assigned to the toxic agents.

Favorable Conditions

The two most important environmental components favouring mould growth and aflatoxins production are hot and humid conditions. Although the optimum temperature and moisture content for the growth and toxin production for the various aflatoxigenic fungi varies, many of them achieve best growth and toxin synthesis between 24^{O} C and 28 ^{O} C and seed moisture content of at least 17.5%. Soil is another natural factor that exerts a powerful influence on the incidence of aflatoxic fungi. Crops grown in different soil types may have significantly different levels of Aflatoxin contamination. For example, peanuts grown in light sandy soils support rapid growth of the fungi, particularly under dry conditions, while heavier soils result in less contamination of peanuts due to their high water holding capacity which helps the plant to prevent drought stress. The storage atmosphere deficient in oxygen would lead to reduced metabolism and consequently mycotoxin production.

Properties of Aflatoxins

Aflatoxins are crystalline substances, freely soluble in chloroform, methanol and dimethyl sulfoxide and dissolve in water to the extent of 10-20 mg/litre. They fluoresce under UV radiation. The B series (Aflatoxin B1, B2) were named because of their strong blue fluorescence under UV light, whereas the G series (Aflatoxin G1, G2) fluoresced greenish-yellow.



Crystalline aflatoxins are extremely stable in the absence of light and particularly UV radiation, even at temperatures in excess of 100 ºC. A solution prepared in chloroform or benzene is stable for years if kept cold and in the dark.

Effect of Aflatoxins on Plants

Infection of these toxigenic fungi to the crops starts from the growing field itself. They 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 aflatoxins although they have not a moldy appearance. These fungi reduce viability, nutritional and sanitary qualities to seeds and grains.

Aflatoxin in Animal Feeds

Aflatoxins are more prevalent metabolites in feedstuffs worldwide produced by toxigenic strains of the genus *Aspergillus*. Factors such as high humidity, storage conditions, improper temperature levels and kernel damage contribute to more amount of aflatoxin formation. Biological effects of toxicity include reduced productivity, decline in reproductive capabilities, organ damage, and death. Extent of damage depends on the amount of toxin consumed, duration of exposure and animal susceptibility. State of diseased condition of animals after the intake of aflatoxins called as "aflatoxicosis". These aflatoxins reduce the feed intake, feed conversion ratio and body weight gain in broilers, where as in case of layers reduced egg laying capacity, weight of the eggs, strength of the egg shell. This toxin specifically targets the liver and kidney causing cancer. AFB1 is Metabolized in the liver to form AFM1 and excreted into milk associated with its protein fraction. Thus, Aflatoxin is present not only in milk but also in products made from contaminated milk and therefore a problem of major concern in all over the world .

Management

The fungus invade the crops in the field itself, once the mold start to infect and grow on the plants, then the aflatoxin contamination to the plants, plant products and consuming animals as well as human beings is unavoidable. So the prevention strategies are to be followed starting from the crop cultivation to processing**.** Here some of the important strategies to avoid aflatoxin contamination are explained. Prevention strategies grouped under two broad categories

1. Pre harvest strategies
2. Post harvest strategies

A. Pre-Harvest Management Strategies to Avoid Aflatoxin Contamination

The presence and growth of *Aspergillus* on pre-harvested crops is dependent on the environment. Agricultural practices including proper irrigation and pest management can reduce aflatoxin contamination. Pre-harvest interventions include choosing crops with resistance to drought, pest and diseases and choosing strains of that crop which are genetically more resistant to the growth of the fungus and the production of aflatoxins. Elimination of inoculum sources such as infected debris from the previous harvest may prevent infection of the crops

Crop Varieties Selection**:** Seeds must be free of pests and disease before planting, to ensure healthy, vigorous plants capable of withstanding attack during the growing season. A possible strategy is also to select crop varieties on their ability to resist mould attack.

Avoiding Insect Attack**:** It is known that the incidence of infection from *Aspergillus flavus* and *A. parasiticus* is significantly higher in damaged than healthy kernels. Insects can act as a vectors of fungal spores or create critical points within the commodity mass that favour fungal growth and toxin production. Furthermore, they attack external teguments of kernel and facilitate entry and colonization of aflatoxigenic fungi. Therefore, treatments with insecticides are advisable when the crops in the field to reduce these attacks.

Biological Control: Another potential means for toxin control is the biocontrol of fungal growth in the field. Numerous organisms have been tested for biological control of aflatoxin contamination including bacteria, yeasts and nontoxigenic (atoxigenic) strains of the causal organisms, of which only atoxigenic strains have reached the commercial stage. Biological control of aflatoxin production in crops in the US has been approved by Environmental Protection Agency and a commercial product based on atoxigenic *Aspergillus flavus* strains is being marketed as Afla-Guard®. In Africa, two isolates of *A. flavus* have been identified as atoxigenic strains to competitively exclude toxigenic fungi in the maize fields. These strains have been shown to reduce aflatoxin concentrations in both laboratory and field trials. A mixture of four atoxigenic strains of *A. flavus* in the name of AlfaSafe is very popular in Kenya and Senegal.

Post-Harvest Strategies

Drying & Storage*:* Before storage, crops should be properly dried to prevent the development of aflatoxins. Sorting and disposing of moldy or damaged kernels before storage has proven to be an effective method for reducing, but not eliminating the development of aflatoxins. During storage, moisture, insect, and rodent control can prevent damage to the crop and reduce aflatoxin development. Moisture and temperature influence the growth of toxigenic fungi in stored commodities. Aflatoxin contamination can increase 10 fold in a 3-d period, when field harvested maize is stored with high moisture content. The general recommendation is that harvested commodities should be dried as quickly as possible to safe moisture levels of 10 – 13 % for cereals. The product should be stored in well-ventilated, cleaned storehouses. The bag of the commodities should be stored on wood or stone bases, in order to avoid direct contact to the floor or soil.

Physical Separation and Hygiene: This step is critical in preventing mould growth and mycotoxin production in harvested feedstuffs. Sorting out of physically damaged and infected grains (known from colorations, odd shapes and size) from the intact commodity can result in the reduction of aflatoxin levels. The advantage of this method is that it reduces toxin concentrations to safe levels without the production of toxin degradation products or any reduction in the nutritional value of the food. This could be done manually or by using electronic sorters. Clearing the remains of previous harvests and destroying infested crop residues are basic sanitary measures that are also effective against storage deterioration.

Decreasing Bioavailability of Mycotoxins by Adsorption**:** Since there is no methods to decrease or detoxify the aflatoxin present in the poultry feeds without affecting the nutritive value of the products compared to clay binders. For many years sodium calcium alumina silicate marketed as NovaSil (NS) clay, a common anticaking agent in animal feeds, has worked to adsorb aflatoxins in the gastrointestinal tract of animals and diminish the bioavailability of aflatoxin from the feed to animals and reduce the adverse effects of the toxins.

Conclusion

The most potent carcinogenic aflatoxins in the plants, plant product, food and feeds will surely a hurdle to the world food security in future. To attain self-sustainability in food production and security without aflatoxin contaminations, an integrated approach should be followed in the entire commodity flow starting from sowing to consumption.