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AFLATOXINS AS NATURAL CONTAMINANTS OF IMPORTANT AGRICULTURAL COMMODITIES

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The article shows analyzes of the current scientific data that relate to the biological properties of aflatoxins as dangerous ecotoxicants, nature and patterns of distribution of the main producing mycotoxins fungi, toxic effects and action mechanisms of toxins on human and animal organisms. These data suggest that environmental contamination by these pollutants, their concentration in phytogenic foods and feed raw materials poses a potential hazard to human health, leading to the losses due to high morbidity and mortality of livestock animals. Therefore, the study of bioaccumulation process and further development of aflatoxins management system are urgent questions of modern science.

Key words: *aflatoxins, contamination, Aspergillus flavus, biological influence.*

Introduction. Mycotoxins are the most dangerous for human and animal health natural ecotoxicants. The results of the assessment carried out by the UN Commission on Nutrition (FAO), nearly 25 % of the world grain harvest annually contaminated by the mycotoxins – metabolic by-products of microscopic fungi [1]. They are ubiquitous, can contaminate food or feed at all stages of production, storage, transport and realization. According to present knowledge, it is allocated about 250 species of microscopic fungi that produce near 200 kinds of mycotoxins; a lot of them of them cause nutritional acute and chronicle toxicosis of animals and humans, lead to a reduction of livestock animals, cause harm to human health, as well as cause damage as a consequence of reduction of crops suitable for exports. However, mycological analysis shown that livestock feed from different regions of Ukraine infected by *Myxomycetes* different genera: *Fusarium* (26 %), *Aspergillus* (21,5 %), *Penicillium* (18 %), *Alternaria* (12 %) and others [2]. Such complex analysis of samples of feed raw materials, which was held at the Institute of Poultry NAAS for eight years, showed that from 399 samples 214 of them were contaminated by different types of mycotoxins [3].

The currently known microscopic fungi are fungi of the genus *Aspergillus* and they are of greatest biologist's interest, in particular *A. flavus*, which emit hazardous for animals and humans mycotoxins: aflatoxins B_1, B_2, G_1, G_2, M_1, etc. These natural ecotoxicants have immune suppressive, mutagenic, teratogenic effects, they reduce the total resistance of the organisms, encourage of severe liver diseases and kidney failure [4].

Natural expansion of microscopic fungi that produce aflatoxins in different regions of Ukraine, is not investigated enough and it makes difficult to forecast occurrence of acute and chronic aflatoxicosis in human and animal organisms. For the development of prophylactic and preventive measures for different agricultural zones of Ukraine, it is first necessary to note the relationships of toxigenic strains with living cycle of host plants, study the patterns of bioaccumulation and natural conditions that contribute to contamination.

Aflatoxins consist of a group of approximately 20 related fungal metabolites, although only aflatoxins B_1, B_2, G_2, G_2 and M_1 are normally found in foods. Aflatoxin B_2 is the dihydro derivative of the parent compound. Aflatoxins B_1 and B_2 are highly toxic secondary metabolites of microscopic fungi *A. flavus*, which formed on various food products, food raw material and feed almost universally, most often in large quantities in peanuts, corn, cotton seeds [5].

Aflatoxins B_1 and B_2 − lethally danger mycotoxins, that belong to class of polyketides. Their main wide-spread producer is the fungus *A. flavus*, which grows on grain, seeds and fruits of plants with high oil and other substrates. Of all the naturally produced toxins aflatoxin is the most hepatocancerogenic that found today. Proved that the maximum allowable safe levels of mycotoxins are not exist, even the smallest amount in their products have a negative effect and can gradually accumulate in living organisms.

Aflatoxins are possessed the high stability and retain their biological activity in contaminated substrate for a long time. These aflatoxins come with feed in animal organisms, cause severe disease mycotoxicosis, resulting in decline of productivity of livestock animals. Finished products contaminated with the toxin are also dangerous to humans. Therefore the problem of inactivation of aflatoxins and disinfection of food raw materials and food is one of the most urgent in Ukraine.

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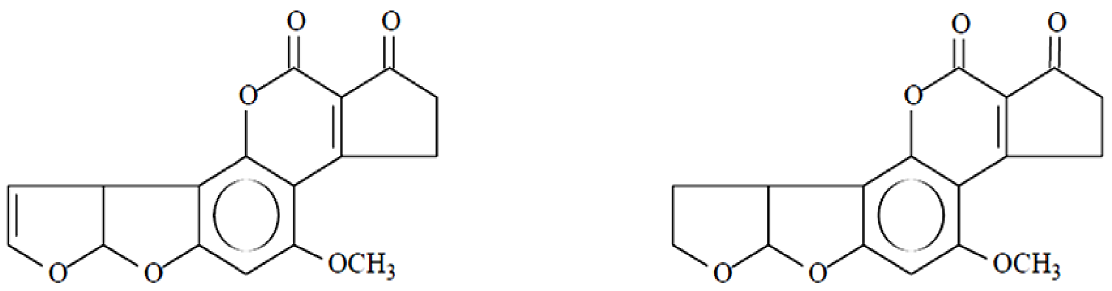
Elucidation of the biosynthesis of aflatoxins in *A. flavus* and related fungi, without doubt, represents an important (because of the practical significance of these toxins) and difficult problem, the difficulty is due to the structural features of aflatoxins as a highly modified derivatives of the precursors, as well as their toxicity. According to the chemical structure aflatoxins are coumarines (fig. 1) [4, 6].



B_1: $C_{17}H_{12}O$ Mol. wt: 312.3 B_2: $C_{17}H_{14}O_6$ Mol. wt: 314.3

Fig. 1. Structures of naturally occurring aflatoxins

Aflatoxins are crystalline substances, freely soluble in moderately polar solvents such as chloroform, methanol and dimethyl sulfoxide, and dissolve in water to the extent of 10–20 mg/litre. They fluoresce under UV radiation.

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. The lactone ring makes them susceptible to alkaline hydrolysis, and processes involving ammonia or hypochlorite have been investigated as means for their removal from food commodities, although questions concerning the toxicity of the breakdown products have restricted the use of this means of eradicating aflatoxins from food and animal feeds. If alkaline treatment is mild, acidification will reverse the reaction to reform the original aflatoxin. In acid, aflatoxin B_1 is converted to aflatoxin B_2 and G_2 by acid catalytic addition of water across the double bond of the furan ring. Oxidising reagents react and the molecules lose their fluorescence properties. Some important physical and properties of the aflatoxins are given in the table 1. [7].

Table 1

Physical properties of aflatoxins

Aflatoxin	Molecular formula	Molecular weight	Melting point, °C	UV absorbtion max (e), nm, methanol	
				265	360−362
B_1	$C_{17}H_{12}O_6$	312	268–269	12,400	21,800
B_2	$C_{17}H_{14}O_6$	314	286–289	12,100	24,000

They can be oxidized and gaseous chloride, chlorine dioxide, nitrogen dioxide. Major role in the oxidation of aflatoxins B_l, G_1, M_1 has a double bond in the terminal furan ring. Aflatoxins are destroyed by ionizing radiation.

Most susceptible to aflatoxin contamination of peanut, cotton seed and corn. In significant amounts, they accumulate in various nuts, especially in Brazilian and pistachio, oilseed, wheat, rice, in compound feed for farm animals. Contamination can occur not only during storage but also during the growing season.

Ecology of aflatoxin producing fungi

The aspergilli have always been a factor in the human environment. Micheli was the first to distinguish stalks and spore heads, but it was not until the middle of the 19th century that these fungi began to be recognized as active agents in decay processes, as causes of human and animal disease and as fermenting agents capable of producing valuable metabolic products [5, 7].

The genus *Aspergillus*, a member of the phylum *Ascomycota,* includes over 185 known species. To date, around 20 of them have been reported to cause harmful infections in humans and animals. Perhaps the most infamous species in this genus is *A. flavus*. Next to *Aspergillus fumigatus*, it is the second most common cause of invasive and non-invasive aspergillosis in humans and animals; and in some geographic areas it is the leading causative agent for aspergillosis. *A. flavus* produces many secondary metabolites including aflatoxins, the most toxic and most potent carcinogenic natural compounds that cause aflatoxicosis and induce cancers in mammals. In addition, it is a weak and opportunistic pathogen of many crops (corn, cotton, peanuts, and treenuts) and contaminates them with aflatoxins. This ubiquitous mold not only reduces yield of agricultural crops but decreases the quality of the harvested grains. Due to *A. flavus* infection to the crops and aflatoxin contamination in grains, hundreds of millions dollars are lost to the U.S. and world economy annually. In nature, *A. flavus* is one of the most abundant and widely distributed soil-borne molds and can be found anywhere on earth. It is a saprophytic fungus that is capable of surviving on many organic nutrient sources like plant debris, tree leaves, decaying wood, animal fodder, cotton, compost piles, dead insect and animal arcasses, outdoor and indoor air environment (air ventilation system), stored grains, and even human and animal patients. Its optimal range for growth is at 28 – 37 °C and can grow in a wide range of temperatures from 12 to 48 °C. The heat tolerance nature contributes to its pathogenicity on humans and other warm blooded animals. The fungus mostly exists in the form of mycelium or asexual conidia spores (fig. 2) [9]. Under adverse conditions such as dry and poor nutrition, the mycelium congregates to form resistant structures called sclerotia. The fungus over-winters either as spores or as sclerotia. The sclerotia germinate to form new colonies when growth conditions are favorable [8, 9].

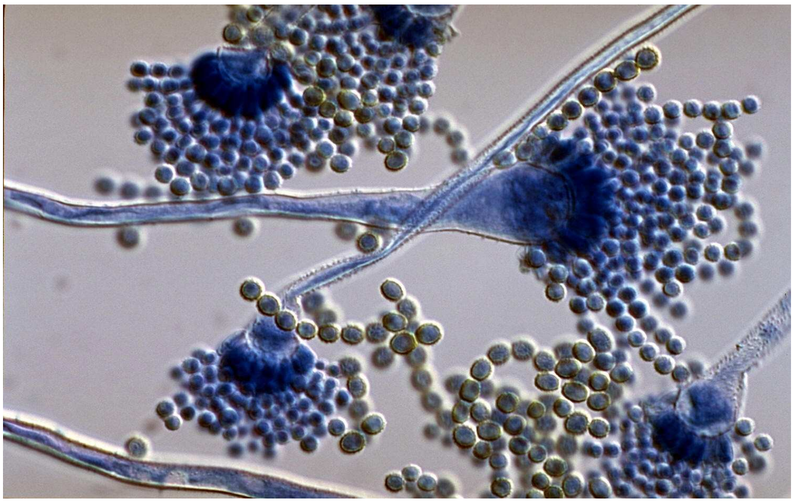


Fig. 2. Microscopical view of conidia of *A. flavus* mold, with the budding conidiospores and the releasing conidia (×400)

Like other *Aspergillus* species, *A. flavus* has a worldwide distribution. This probably results from the production of numerous airborne conidia, which easily disperse by air movements and possibly by insects (fig. 3) [8]. Atmosphere composition has a great impact on mould growth, with humidity being the most important variable. *A. flavus* grows better with water activity (aw) between 0.86 and 0.96. The optimum temperature for *A. flavus* to grow is 37 °C, but fungal growth can be observed at temperatures ranging from12 to 48 °C. Such a high optimum temperature contributes to its pathogenicity in humans [8, 10].

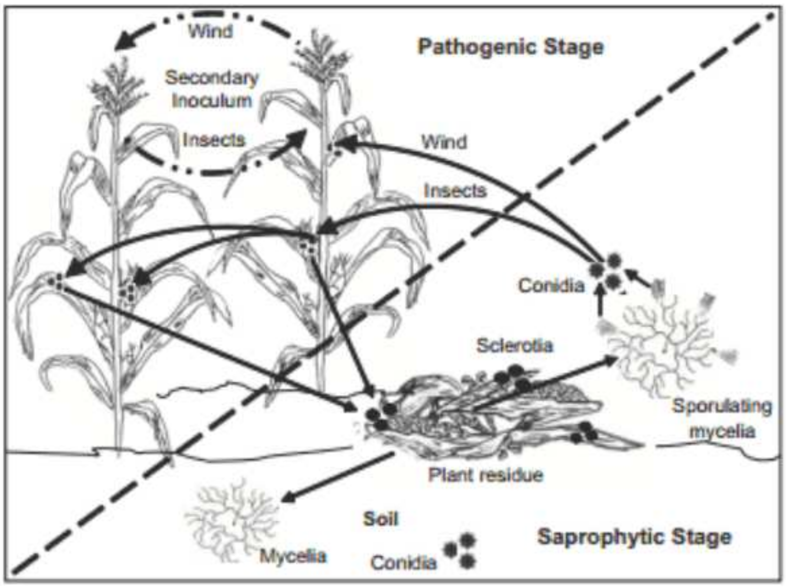


Fig. 3. Life cycle of *A. flavus*

Contamination of aflatoxins can occur during the pre- and post-harvest stages of food production when the environmental conditions are suitable for mould growth. The key environmental factors are temperature, water availability (a_w) and atmospheric composition such as presence of O_2 and CO_2, environmental temperature, moisture and humidity on the mold growth and subsequent production of aflatoxin and found that higher mold growth and aflatoxin contamination occurred at 90 % humidity with 32 °C temperature in wettest grains (12,3 % moisture) [10].

Temperature. Temperature is one of the key environmental factors that play a critical role in the growth of molds. Temperatures of 8, 11, 15, 28 and 32 °C were tested, and 28 °C was found the most favorable temperature for aflatoxin production. It is founded that the best temperature for aflatoxin production by *A. flavus* was 30 °C but no toxin production was observed at 10 °C. According to Sanchis and Magan, *A. flavus* germinates and grow over a wider range of temperature than that for growth, with the aflatoxin production range narrower than that for growth. The optimum condition for the growth of these species was found to be 35 ºC and 0.95 a_w while that for aflatoxin production was found to be 33 ºC and 0.99 a_w. Experimentally it is cultured three strains of aflatoxigenic fungi on rice and examined that all synthesized aflatoxin at 25 to 34 °C. Production of afltoxins by *A. flavus* was highest at 30 ° C. Four *Aspergillus* section *Flavi* isolates were reported to produce aflatoxins optimally at 20 to 35 °C but minimally at 10 or 40 °C on substrates of shelled peanuts, rice and cottonseed. Shih and Marth reported that maximum aflatoxins production took place at 25 °C, whereas 35 °C was observed most suitable for maximal fungal growth. Under high water activity, the best temperature for aflatoxin production by *A. flavus* varied from 13 to 31 °C. In a solid-state fermented cassava, *A. flavus* produced aflatoxin at 35 °C. High temperature or drought stress reduces phytoalexin production which result in the craking of pistachios hull or the maize kernel integrity is lost due enhanced “silk cut”. The naturally senescing crop parts such as blossoms, petioles or silks are very prone to fungal infection in such conditions [8, 9].

Water activity. Water activity (a_w) has a primordial influence on the fate of mycofloral population harbored by a food. The common methods for controlling water activity in food are sun or air drying, freezing and addition of salt or sugar. Water activity is defined as the ratio of the partial vapor pressure of water in equilibrium with a food to the partial saturation vapor pressure of water vapor in air at the same temperature. It is a measure of the energy state of H_2O in the commodity, and hence represents the potential of free water to act as a solvent, contribute in biochemical reactions and support the growth of microorganisms. This parameter plays a critical role in forecasting the safety and stability of food with respect to microbial growth, rates of deteriorative reactions and physico-chemical properties. The relationship between aw and moisture content of different cereals is given in Table 2 [11].

Table 2

Relationship between moisture content (wet weight basis, %) and water activity (a_w) for some key cereals at 25 ºC

a_w	Moisture content (%)				
	Maize	Wheat	Sorghum	Rice	Groundnuts
0,98	30,0–32,0	30,0–34,0	31,0–32,0	26,0–28,0	16,0–17,0
0,95	26,0–27,0	26,0–28,0	26,0–27,0	23,0–24,0	14,5–15,0
0,90	23,0–24,0	21,0–22,0	22,5–23,0	20,0–21,0	12,5–13,5
0,80	16,0–17,0	16,0–17,0	18,0–19,0	17,0–18,0	9,0–10,0
0,70	15,0–16,0	14,0–14,5	16,0–17,0	14,0–14,5	7,0–8,0

Optimum conditions for aflatoxins production are a water activity in excess of 0.85 aw and a temperature of 27 °C; conditions which are frequently encountered in the Mediterranean regions. In a study conducted by Koehler, *A. flavus* produced maximum aflatoxins at a_w of 0,95–0,96 a_w and temperatures of 21 and 30 °C. In another study, it is founded a direct relationship between moisture and aflatoxin contents in maize. *A. flavus* produced maximum amount of aflatoxin at 0,996 a_w. It can be concluded from the preceding discussion that production of afltoxin is generally highest at relatively high water activities. Under high humidity, initially dry seed absorbs moisture content and provide conditions favorable for fungal attack. Temperature and substrate moisture content are the key factors that dictate the extent of contamination. Conditions supporting the growth of aflatoxigenic fungi have been described repeatedly in literature [8, 11].

Atmospheric composition. The atmospheric composition particularly lower partial pressure of oxygen (O_2) and increased partial pressure of carbon dioxide (CO_2) have a critical role in the toxigenesis of fungi. Aflatoxin production by molds on peanut was moderately reduced between 21 and 5 % O_2, but was practically inhibited when the concentration was below 1 %. Elevated CO_2 of >75 % completely stopped the growth of mycotoxins producing molds in partially dried grain. It is founded that aflatoxin levels on peanut decreased with increasing concentration of CO_2 provided that if other conditions are kept constant. Epstein tested the effects of controlled atmosphere viz. 10 % CO_2, 1,8 % O_2 and 88,2 % N_2 on toxin production by *A. flavus* against air 0,0314 % CO_2, 20,94 % O_2 and 78,084 % N_2 in liquid medium and cracked corn. They observed that less toxin was produced in the controlled atmosphere i.e. lower O_2 and higher CO_2 content. Scientists examined the influence of CO_2 and ethylene on the aflatoxins production in Georgia Green peanuts. It was examined that CO_2 repressed aflatoxin synthesis over a narrow dose range. Modern methods for storing agricultural products are based on the principle of limited O_2 supply. A maximum of 212 mg liter-1 was produced at 9,000 ml min-1 aeration, but the yield decreased significantly at the lower aeration rates. In all cases where spore germination occurred, aflatoxin was formed in the cultures with air flow, but no production of aflatoxins took place in the absence of air [11]. Supply of traces of O_2 and addition of vitamin B gave an approximately fifteen-fold increase in the amount of aflatoxin in two days. CO_2 delayed aflatoxin production on the medium even when vitamin B was present [8].

Effects of aflatoxins on human and animal health

Effect on human health. Humans are exposed to aflatoxins by consuming foods contaminated with products of fungal growth. Such exposure is difficult to avoid because fungal growth in foods is not easy to prevent. Even though heavily contaminated food supplies are not permitted in the market place in developed countries, concern still remains for the possible adverse effects resulting from long-term exposure to low levels of aflatoxins in the food supply [12]. Evidence of acute aflatoxicosis in humans has been reported from many parts of the world, namely countries, like Taiwan, Ouganda, India, and many others. The syndrome is characterized by vomiting, abdominal pain, pulmonary edema, convulsions, coma, and death with cerebral edema and fatty involvement of the liver, kidney, and heart. Conditions increasing the likelihood of acute aflatoxicosis in humans include limited availability of food, environmental conditions that favour fungal development in crops and commodities, and lack of regulatory systems for aflatoxin monitoring and control [5, 12].

The expression of aflatoxin related diseases in humans may be influenced by factors such as age, sex, nutritional status, and/or concurrent exposure to other causative agents such as viral hepatitis (HBV) or parasite infestation. Ingestion of aflatoxin, viral diseases, and hereditary factors have been suggested as possible aetiological agents of childhood cirrhosis. There are evidences to indicate that children exposed to aflatoxin breast milk and dietary items such as unrefined groundnut oil, may develop cirrhosis [7]. Malnourished children are also prone to childhood cirrhosis on consumption of contaminated food. Several investigators have suggested aflatoxin as an etiological agent of Reye’s syndrome in children in Thailand, New Zealand etc. Though there is no conclusive evidence as yet. Epidemiological studies have shown the involvement of aflatoxins in Kwashiorkor mainly in malnourished children. The diagnostic features of Kwashiorkor are edema, damage to liver etc. These out breaks of aflatoxicosis in man have been attributed to ingestion of contaminated food such as maize, groundnut etc. Hence it is very important to reduce the dietary intake of aflatoxins by following the procedures for monitoring levels of aflatoxins in foodstuffs [13].

Effects on animals. There are differences in species with respect to their susceptibility to aflatoxins, but in general, most animals, including humans, are affected in the same manner.

Acute toxicity is less likely than chronic toxicity. Studies have shown that ducklings are the species most susceptible to acute poisoning by aflatoxins. The LD50 of a day old duckling is 0,3 mg/kg bodyweight [7]. The principal target organ for aflatoxins is the liver. After the invasion of aflatoxins into the liver, lipids infiltrate hepatocytes and leads to necrosis or liver cell death. The main reason for this is that aflatoxin metabolites react negatively with different cell proteins, which leads to inhibition of carbohydrate and lipid metabolism and protein synthesis. In correlation with the decrease in liver function, there is a derangement of the blood clotting mechanism, icterus (jaundice), and a decrease in essential serum proteins synthesized by the liver. Other general signs of aflatoxicosis are edema of the lower extremities, abdominal pain, and vomiting [12, 14].

Animals which consume sub-lethal quantities of aflatoxin for several days or weeks develop a sub acute toxicity syndrome which commonly includes moderate to severe liver damage. Even with low levels of aflatoxins in the diet, there will be a decrease in growth rate, lowered milk or egg production, and immunosuppression. There is some observed carcinogenicity, mainly related to aflatoxin B_1. Liver damage is apparent due to the yellow color that is characteristic of jaundice, and the gall bladder will become swollen. Immunosuppression is due to the reactivity of aflatoxins with T-cells, decrease in Vitamin K activities, and a decrease in phagocytic activity in macrophages [14].

Aflatoxins are inhibitors of nucleic acid synthesis because they have a high affinity for nucleic acids and polynucleotides. They attach to guanine residues and for nucleic acid adducts. Aflatoxins also have been shown to decrease protein synthesis, lipid metabolism, and mitochondrial respiration [7]. They also cause an accumulation of lipids in the liver, causing a fatty liver. This is due to impaired transport of lipids out of the liver after they are synthesized. This leads to high fecal fat content. Carcinogenisis has been observed in rats, ducks, mice, trout, and subhuman primates, and it is rarely seen in poultry or ruminants. Trout are the most susceptible. In fact, 1ppb of aflatoxin B_1 will cause liver cancer in trout. Carcinogenisis occurs due to the formation of –8,9-epoxide, which binds to DNA and alters gene expression. There is a correlation with the presence of aflatoxins and increased liver cancer in individuals that are hepatitis B carriers [14].

Aflatoxins management problem

It is clear, that problem of aflatoxins is paid great attention of specialists of the whole world. In the U.S.A, European Union and other countries stringent sanitary rules of governing the permissible levels of mycotoxins are introduced, and held tight control of food and feed (although it is difficult to say whether there is actually permissible limits of aflatoxins in food). To reduce the risk of contamination of agricultural products subject to different mycotoxins agricultural practices, the whole strategy for the integrated control and elimination of aflatoxin contamination of the results are developed. The use of such a policy helps protect people from diseases caused by mycotoxins, to minimize losses in livestock sector and improve the quality of products intended for human consumption within the country and exports.

In Ukraine there are also standards governing the permissible limits of detention aflatoxins B_1 and B_2 in feed and food products. However, there are a number of problems that increase the risk of mycotoxin consumption of contaminated food for the inhabitants of our country:

I. The existing Ukrainian standards regarding acceptable levels of aflatoxins in raw materials are not harmonized with EU Regulation. That is why, levels of mycotoxins in Ukrainian products higher than in European countries.

II. Existing base of equipment is not possible to determine the content of mycotoxins fast enough and at the appropriate level sensitivity. State laboratories usually use obsolete equipment and unmodern methods of analysis.

III. In Ukraine there is no statistical data on the number of contaminated raw materials, not identified losses in livestock related to exposure of aflatoxin in animal organism, and no biomedical research aimed at identifying the harmful effects of mycotoxins on humans.

IV. A significant mass of agricultural products sold through markets or in the form of payment (for example, grain often paid rent land shares). This product does not pass the necessary tests. For example, while subsistence farmers consume their own grain, they also sell part of their harvest to local markets. They may later themselves purchase grain from these markets when their own supplies are depleted. Food commodities within these local markets are not tested for aflatoxins in Ukraine. This is the one of problems, which increase risk of aflatoxins contamination in country, because of significant percent of agricultural production realized as form of work payments, and grain that does not pass quality control are commonly used for animal feeding and proper storage conditions did not adhere. While general principles of HACCP and other commercial practices may be applicable at the individual farmer level, appropriate adaptation of these principles into effective and sustainable strategies is essential and currently missing.

An intervention to reduce exposure to aflatoxins can occur at various stages of food production and preparation. Before crops are planted, efforts can be made to reduce the future burden of aflatoxins. Interventions can also occur before harvest, during harvest, and after harvest. The appropriate intervention or combination of interventions may differ depending on the crop and the country. Therefore further therefore further development of the strategy should take into account an assessment of the effectiveness and economic feasibility.

First of all, for solving the aflatoxins problem it is needed to investigate the consistent patterns of mycotoxin bioaccumulation as an ecological aspect. It is also important to pay attention to the problem of mycotoxins in the public level and the develop the recommendations for reducing the risk of their use by humans or animals, it is relevant on a global scale, and especially important for the conditions of our country.

CONCLUSIONS

Aflatoxins consist of a big group of related fungal metabolites belong to class polyketides, that possessed the high stability under different physical and chemical conditions (temperature, UV light) and retain their biological activity in contaminated substrate for a long time. There is main widespread producer of aflatoxins – *A. flavus.* It is microscopic fungi that has worldwide distribution and infects different agricultural plants: wheat, barley, corn, groundnut and others.

Ideal conditions for the growth of *A. flavus* are ambient conditions and the moisture content affects the production of mycotoxins. Formation of toxins increases with levels of free water more than 0.90; *A. flavus* can begin to produce aflatoxin at 0,83 A_w; at a temperature near 25 ºC it is begin active accumulation of aflatoxins, at 10ºC the toxin is not mentioned (the ideal temperature from 12 ºC to 40 ºC); development of fungal colonies occur at pH values of from 4 to 8; oxygen concentration and acidity of the substrate are not essential factors for the production of mycotoxins; vegetable substrates enhances the formation of mycotoxins more than animal origin media.

Aflatoxins are dangerous for its carcinogenic properties. They can be accumulated in the liver and kidney and promote the occurrence of tumor cells to induce mutations (cancer). They adversely affect the immune system of the body (lower overall body's defenses), cause teratogenic and mutagenic effects. One intaking of excessive contaminated food or feed can induce hard liver damage even death. Under the action of very low doses of aflatoxin poisoning insufficient, but entering the body repeatedly or continuously, develop cirrhosis or liver cancer (chronicle aflatoxicosis). Aflatoxins virtually are not destroyed during normal processing and cooking contaminated food. Development of different strategies to control the level of aflatoxins in agricultural commodities, preventing the occurrence of aflatoxicosis in human and animals is an urgent problem for our country.

REFERENCES

1. Ames I. A. Mycotoxins: economic and Health Risks. Task force Report / I. A. Ames // CAST (Council for Agriculture Science and Technology). — 1989. — № 116. — P. 21—43.

2. Васянович О. М. Біотехнологія Т-2 токсину та обґрунтування максимально допустимого рівня його в кормах для молодняку великої рогатої

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3. Ефективність препарату "Мікосорб" (Alltech) в умовах періодичної контамінації кормів мікотоксинами / [Котик А. М., Труфанова В. О., Леднева О. Л., Андрієнко О. М.] // Ефективне тваринництво і птахівництво. — 2004. — № 1. — С. 46—49.

4. Зайченко А. М. Макроциклические микотоксины: продуценты, распространение, определение, физиология токсинообразования, токсигенный потенцил / Зайченко А. М., Рубежняк И. Г., Кобзистая О. П. // Современные проблемы токсикологии. — 2001. — № 2. — С. 25—34.

5. Rai M. Mycotoxins in food, feed and bioweapons / M. Rai, A. Varma. — New York : Springer, 2009. — 405 p.

6. Стожаров А. Н. Медицинская экология: учебное пособие / А. Н. Стожаров. — Минск: Высшая школа, 2007. — 368 с.

7. Bruegel P. Mycotoxins: risk in plant, animal and human systems / P. Bruegel, G. Stewart. — Ames: Iowa State University, 2003. — 217 p.

8. Hedayati M. T. *Aspergillua flavus*: mycotoxin producer and human allergen / Hedayati M. T., Pasqualotto A. C., Warn P. A. // Microbiology. — 2007. — № 153. — P. 50—68.

9. Bock C.H. Wheat seed colonized with atoxigenic *Aspergillus flavus*: characterization and biopesticide for aflatoxin control / C.H. Bock, P. J. Cotty // Biocontrol science and technology. — 2009. — V. 9. — P. 109—128.

10. Dictionary of the fungi: glossary / [ed. P. Kirk, P. Cannon, D. Minter] — 10-th ed. — UK: CABI Europe, 2008. — 771 p.

11. Hammed K. A. Aflatoxin and food safety / K. A. Hammed. — Boca Raton: CRC Press, 2005. — 565 p.

12. Paterson M. Molecular, clinical and environmental toxicology. V. 2. / M. Paterson, N. Lima. — Bern: Birkhuser Verlag, 2010. — 245 p.

13. Bennett W. Mycotoxins / W. Bennett, M. Klich // Clinical microbiology review. — 2003. — V. 16, № 3. — P. 497—516.

14. Weidenborner M. Mycotoxins and their metabolites in humans and animals / M. Weidenborner. — New York: Springer, 2009. — 461 p.

15. Barkai-Golan R. Mycotoxins in fruits and vegetables / R. Barkai-Golan, N. Paster. — London : Academic Press, 2008. — 408 p.

АФЛАТОКСИНЫ КАК ЕСТЕСТВЕННЫЕ КОНТАМИНАНТЫ ВАЖНЫХ СЕЛЬСКОХОЗЯЙСТВЕННЫХ КУЛЬТУР

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В статье проанализировано современные научные данные, что касаются биологических свойств афлатоксинов как опасных экотоксикантов, характер и закономерности распространения главного продуцента микотоксинов, токсические эффекты и механизмы влияния токсинов на организм животных и человека. Приведенные данные говорят о том, что загрязнение окружающей среды этими контаминантами, накопление их в продуктах растительного происхождения и кормовом сырье создает потенциальную угрозу для здоровья человека, приводит к убытку вследствие заболеваемости и смертности сельскохозяйственных животных. Поэтому изучение процесса биоакумуляции и дальнейшие разработки системы менеджмента афлатоксинов являются актуальными вопросами современной науки.

Ключевые слова: *афлатоксины, контаминация, Aspergillus flavus, биологическое влияние.*

АФЛАТОКСИНИ ЯК ПРИРОДНІ КОНТАМІНАНТИ ВАЖЛИВИХ СІЛЬСЬКОГОСПОДАРСЬКИХ КУЛЬТУР

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У статті проаналізовано сучасні наукові дані, що стосуються біологічних властивостей афлатоксинів як небезпечних екотоксикантів, характер та закономірності поширення головного продуцента мікотоксинів, токсичні ефекти та механізми впливу токсинів на організм тварин і людини. Наведені дані говорять про те, що забруднення навколишнього середовища цими контамінантами, накопичення їх в продуктах рослинного походження і кормовій сировині створює потенційну загрозу для здоров'я людини, призводить до значних збитків внаслідок захворюваності та смертності сільськогосподарських тварин. Тому вивчення процесів біоакумуляціі та подальші розробки системи менеджменту афлатоксинів є актуальними питаннями сучасної науки.

***Ключові слова**: афлатоксини, контамінація, Aspergillus flavus, біологічний вплив.*