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MYCOTOXINS IN POULTRY PRODUCTION

ABSTRACT: All poultry is sensitive to mycotoxins. This partly depends on the type, age and production categories of poultry, their living conditions and nutritive status and partly on the type, quantity and duration of mycotoxin ingestion. The presence of mycotoxins results in significant health disorders and a decrease in production performances. This leads to considerable economic loss for the poultry industry — either direct losses, i.e. death of the poultry or the indirect ones, i.e. the decrease in body mass, number and quality of eggs, greater food conversion, and immunosuppression. Immunosuppression results in increased sensitivity to infective agents and a bad vaccinal response. Morevover, mycotoxin residues in poultry meat, eggs and products derived from them pose a threat to human health.

In order to prevent and reduce the negative implications of mycotoxins in the poultry production, it is necessary to create both global and national strategies for combatting mycotoxins, advance diagnostic techniques and procedures, intensify the control of food quality, introduce new limits on the maximum amount of mycotoxins allowed in food and poultry feed used for certain species and categories of animals, and synchronise it with the European standards.

KEY WORDS: immune response, mycotoxins, mycotoxicoses, poultry, production results

INTRODUCTION

Safe food is an imperative in food production worldwide. Poultry meat, eggs, and products derived from them are crucial in the safe food chain. As far as safety is concerned, special attention is directed towards possible contamination of food and poultry feed with fungi and to the risk of mycotoxin contamination.

There are numerous mycotoxins in the food chain that cause unwanted biological effects inside human and animal organisms upon ingestion (B r y d e n, 2007). High level of mycotoxins in food and feed results in the appearance of acute mycotoxicoses and high mortality rate. Lower levels cause the occurrence of chronic mycotoxicoses with or without manifested clinical symp-

toms, but followed by a considerable decrease in production performance, immunosuppressive effects, and the occurrence of residues in poultry meat and eggs (S i n o v e c, 2006).

Due to the fact that mycotoxins have largely distinct structures, metabolisms, and consequently the level of toxicity, it is impossible to formulate a general attitude towards both the changes they cause in the organism and their influence on the poultry production parameters. This is why mycotoxins (ochratoxin, trichothecenes, aflatoxin, etc.) which are most frequently detected as food and poultry feed contaminants, will be discussed separately. Toxicity of mycotoxins primarily depends on the species of mycotoxins, quantity and duration of ingestion, type, sex and age of the animal, general health and immune status, as well as environmental factors (zoohygenic and zootechnological normatives) and nutritive status (B i n d e r, 2007). Since fungi frequently produce more than one mycotoxin, the animal simultaneously takes in more mycotoxins through ingestion. So far, any discussions about the interaction between two or more mycotoxins inside an organism, have most frequently been related to either their negative effects, or the way they can cause some other effects that have neither been fully explained, nor confirmed yet.

OCHRATOXIN

Ochratoxin is a relatively frequent cause of decrease in production results in poultry industry, whereas the degree of decrease depends on dosage and duration.

After resorption, the largest quantity of ochratoxin can be found inside kidneys and liver, and to a considerably smaller extent in the musculature. Inside the liver, ochratoxin A is hydrolysed to OTα and L-phenylalanine, and only an insignificant part of it to dp 4-hydroxy-OTA, whereby the newly formed metabolites are less toxic.

It is characteristic of poultry to possess a capacity for more efficient and faster excretion of this toxin than other animals, thus whithin 48 hours aproximately 90% of the ingested OTA is secreted and the semi-life of ochratoxin A in the serum is approximately 4 hours (G a l t i e r et al., 1981). It is considered that the toxic effect of ochratoxin A is based on numerous direct and several indirect effects. Primary effects are most probably connected with the influence of OTA on enzymes participating in the phenylalanine metabolism (phenylalanine-transferase, phenylalanine-hydroxylase, phenylalanine-lipoperoxide) and the functions of mitochondries.

Secondary mechanism of the toxic effect is based on increased lipid peroxidation in liver and kydney microsomes (F u c h s, 1988). Ochratoxin A stimulates NADPH-dependent microsomal and ascorbate-dependent lipid peroxidation with iron as an essential cofactor, i.e. it stimulates lipid peroxidation by complexing with iron and facilitates its reduction in this manner. The formed complex of OTA and iron produces highly toxic hydroxyl radicals in the presence of NADPH cytochrome of the P-450 reductase system.

The third mechanism of OTA's toxic effect is based on the inhibition of respiration in mitochondries (U r a g u c h i and Y a m a z a k i, 1978), where it acts as a competitive inhibitor of the carrier's proteins, localised on the inner membrane of mitochondries. Furthermore, it is considered that OTA represents a potent teratogenic agent for chickens, but not for other domestic animals (S i n g h and H o o d, 1985).

Ochratoxin A also manifests immunomodulator effects (M u l l e r at al., 1999; D w i v e d i and B u r n s, 1984). Reduction in the number of lymphoid cells was observed after OTA ingestion, especially in the thymus, bursa Fabricii and spleen of poultry. This indicates a potential suppression of cell-mediated immunity. The inhibitive effects are especially prominent in the number of T and B lymphocites, which confirms that OTA possesses immunosuppressive characteristics. Reduction in serum immunoglobulin and fagocyte capacity of leucocytes and neutrophyl (D w i v e d i and B u r n s, 1984) also occur, resulting, naturally, in reduced resistance to viral, bacterial, and parasitic infections.

The unspecific clinical image of chronic ochratoxicosis in poultry is followed by a decrease in egg production of laying hens and parent flocks, whereas, as far as broilers are concerned, their growth is hindered and conversion of food is weakened. The egg shell often becomes thin and fragile, with different discoloration appearing on the surface.

Growth inhibition is connected with malabsorption syndrome, as confirmed by the presence of hypocarotenoidemia. The minimum amount of ochratoxin leading to reduced growth also causes reduced bone firmness and poor pigmentation, whilst for the reduced bone diametar larger quantities of ochratoxin are necessary (D u f f at al., 1987).

Nephropathies need not be clinically manifested, although polydepsia accompanied by a substantial amount of moist excrement most frequently appears. Changes inside the kidneys are followed by the occurrence of glomerulonephritis with increased glomerules and dilated capillaries, with a decrease in the relative mass of kidneys. A decrease in the concentration of proteins, triglycerides, cholesterol, calcium, neorphanic phosphorus and potassium is followed by an increase in the level of uric acid and creatinine and a decrease in glomerular filtration (N e d e l j k o v i ć at al., 1999).

Turkey is somewhat more resistant to ochratoxin effects, but dosage and time-dependent effects can also be detected in them.

TRICHOTHECENES DEOXYNIVALENOL (DON), T-2 TOXINS, DIACETOXYSCIPRENOL (DAS) AND HT-2 TOXIN

Trichothecene poisoning in poultry manifests acutely or chronically. The acute form, unlike other mycotoxins, has a characteristic clinical picture and is easily diagnosed. However, the chronic form manifests unspecific clinical symptoms.

Upon peroral ingestion, T-2 toxin is very rapidly resorbed in the lower parts of the digestive tract (before jejunum), and only one hour after the inge-

stion it reaches maximum concentration in the blood (U r a g u c h i and Y a m a z a k i, 1978).

After this phase, a slower ensues one during which T-2 toxin and the formed metabolites are distributed to certain tissues. In comparison with trichothecenes, T-2 toxin is resorbed more rapidly. Resorption is performed by means of active transport, during which T-2 toxin is rapidly transported to ribosomes through the cell membrane of enterocytes.

After 3-4 hours, the biggest portion of T-2 toxin and its metabolites can be found in the majority of organs, whereas it takes then approximately 12 hours to reach the muscles, skin, and gall. After 24 hours, the largest portion of T-2 toxin is inside the excretion organs — the gall-bladder (gall), liver, kidneys, and intestines. In the liver, toxin T-2 is rapidly transformed into different metabolites (B a u e r, 1995), less toxic than the mother compound, and it is eliminated from the organism without accumulation.

The mechanism of T-2 toxin's agency has not yet been sufficiently explained. To become biolologically active, T-2 toxin does not demand biotransformation upon entering the organism. Primarily, T-2 toxin inhibits DNA replication (U e n o, 1983), whilst the degree of inhibition depends on the amount of mycotoxin and sensitivity of the species.

DNA synthesis is secondarily inhibited by disorders of protein synthesis, but certain disorders in cellular organisation can, under the influence of T-2 toxin, affect the synthesis of nucleic acids. Changes caused by T-2 toxin in DNA are of reversible nature. Nevertheless, it is considered that T-2 toxin, when its action is prolonged, can induce mutagenic, teratogenic, and carcinogenic effects (K r i v o b o k et al., 1987).

The inhibition of protein synthesis is observed in various tissues and it is characterised by either polysomic alterations and desegregation, or the induction of structural changes in chromosomes. Mycotoxins can cause both of these effects either simultaneously or successively. Numerous trichothecenes inhibit synthesis of proteins by blocking the elongation of the polypeptide chain, at the position of peptidyl-transferase on the 60S ribosomal subunit.

Accute intoxication of poultry with trichothecenes occurs as digestive and nervous system disorders, with hyperpnea accompanied by lethargy and loss of balance. Basic changes can be manifested as haemorrhages in the digestive tract and muscles. Local epithelial-necrotic effects in the form of stomatite, necrosis, and ulceration inside the mouth are very prominent (S i n o v e c et al., 2006).

One of the primary effects of T-2 toxin in poultry are weakened immunity and resistence of the organism. T-2 toxicosis is characterised by the decay of lymphoid cells inside the thymus, spleen, and bone marrow, which inhibits the cellular immune response. T-2 toxin has a distinctly negative effect on the immune system, which manifests itself as reduced resistence of poultry to infective deseases, especially to salmonelosis and E. coli infections (B o o n c h u v i t et al., 1975). The toxic effect also manifests itself as reduced proliferation of limphocites stimulated by phytohaemagglutin and lipopolysaccharide (R a f a i et al., 2000). Furthermore, T-2 toxin hinders the protective func-

tion of intestinal mucosis, which enables the penetration of bacteria and occurrence of secondary infections.

AFLATOXIN

Aflatoxin is the most studied mycotoxin, due to both its toxicity to animals and people and its rather high carcinogenic potential. Poultry is considerably resistant to aflatoxin, due to which the acute intoxication is relatively rare. Chronic intoxication with aflatoxin demands ingestion of aflatoxin for several weeks (one week minimum). The clinical picture is the consequence of the mechanism of aflatoxin effects in the organisms of poultry.

The toxic effect of aflatoxin manifests itself on the level of interaction with genetic material. The aflatoxin molecule penetrates the cell and the nucleus, subsequently placing itself between the base pairs of DNA. The inserted aflatoxin molecules decelerate to a great extent the process of DNA information transfer. Mistakes in DNA transcription are very frequent (R e s a n o v i ć, 2002), which result in the inhibition of protein synthesis, i.e. "wrong" proteins are synthesised. The immunosuppressive effect of aflatoxin has been proved, although the mechanism has not yet been fully explained. Negative effects of aflatoxin on complement, interferon, and serum proteins are probably the result of liver damages and the inhibition of protein synthesis. Aflatoxin performs suppression of nonspecific substances (complement and interferon) in charge of humoral immunity, as well as the suppression of fagocites through macrofagus.

Apart from this, aflatoxin also causes aplasia of the thymus, spleen, and bursa Fabricii in chicken, whereas larger quantities (0,6—10,0 ppm) cause the suppression of class G and A immunoglobulins during immunisation (K a r a m a n et al., 2005). It is interesting that doses of aflatoxin which do not affect the level of antibodies after vaccination have a strong effect on the cell-mediated immune response, which is manifested as a decrease in the total number of lymphocites and T effector cells, as well as a decrease in fagocite activity of monocytes (G h o s h et al., 1991).

Acute aflatoxin poisoning leads to impaired coordination of movement, vertigo, and paresis, followed by diarrhea with admixtures of blood, haemorrhages, tumescences, jaundice, coma, and death.

The clinical picture of chronic aflatoxicosis in poultry is dominated by a considerable decrease in body mass, reduced food consumption, bad conversion, decrease in egg-laying ability, reduced percentage of hatching, as well as disbalanced immunogenosis and exitus. Disruptions in blood coagulation occur and the prothrombic period is considerably elongated. Due to this occurrence, heamorrhages appear on the musculature, which in turn decreases the usability of such torsos. Poultry exposed to aflatoxins is pallid (its cockscombs, wattles, and legs), as a consequence of poor pigmentation, which is the result of reduced ingestion, resorption, and transport of carotenoid due to the presence of aflatoxin.

The disorder in metabolism of group B vitamins and amino acids manifests itself as a decrease of their concentration in the plasma, liver, and gall. In addition to this, aflatoxin affects bone mineralization by impairing the resorption of calcium and phosphorus inside kidneys, which leads to the metabolic vitamin D3 deficiency.

Steatorrhea is one of the cruicial symptoms of aflatoxicosis, caused by decreased concetration of gall, which leads to an increase in unabsorbed lipid content in the cecum. Thus in the case of chronic aflatoxicosis of poultry, food conversion is significantly increased.

ZEARALENON

Poultry is very resistent to zearalenon. Of all species of poultry, turkey is the most sensitive to the effects of zearalenon, which can cause a decrease in their egg-laying ability even up to 20% (Allen et al., 1983). The immunosuppressive effects of zearalenon in poultry have not been proved so far.

CYCLOPIAZONIC ACID

Cyclopiazonic acid is not a common contaminator of food and poultry feed. However, when detected, cyclopiazonic acid can, depending on the quantity and duration of ingestion, cause a very dramatic clinical picture of the central nervous system disorder — manifesting itself as ataxia, paresis, paralysis, and opisthotonus. Prominent cumulative toxicity of cyclopiazonic acid can be observed.

A decrease in the weight of bursa Fabricii followed by an incerease in the weight of liver, kidneys, and forestomach can also be detected. The decrease in the weight of bursa Fabricii leads to a weakened immune response after vaccination.

FINAL OBSERVATIONS

Mycotoxins have a very strong influence both on animal and human health. Total losses for the poultry industry caused by the presence of mycotoxins in food and the changes they cause on living material are very difficult to integrate and estimate. Numerous strategies for the prevention of harmful effects of mycotoxins in poultry farming have been applied, but none of these gave sufficiently good results.

In order to prevent and reduce the negative implications of mycotoxins in the poultry production, it is necessary to create both global and national strategies for combatting mycotoxins, advance diagnostic techniques and procedures, intensify the control of food quality, and introduce new limits on the maximum amount of mycotoxins allowed in food and poultry feed.

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МИКОТОКСИНИ У ЖИВИНАРСКОЈ ПРОИЗВОДЊИ

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Резиме

Сва живина је осетљива на микотоксине у зависности од врсте, старосне и производне категорије, услова амбијента и нутритивног статуса, са једне стране, и врсте, количине и дужине уношења микотоксина, са друге стране. Присуство микотоксина резултира значајним поремећајем здравља и падом производних перформанси, а самим тим и значајним економским губицима у живинарској индустрији, како директним, који се очитују угинућем живине, тако и индиректним, у виду пада телесне масе, броја и квалитета јаја, веће конверзије хране и имуносупресијом. Имуносупресија резултира повећаном осетљивошћу на инфективне агенсе и лошим вакциналним одговором. Опасност по људско здравље представљају резидуе микотоксина у живинском месу, јајима и производима добијеним од њих.

Да би се предупредиле и смањиле негативне импликације микотоксина у живинарској производњи потребно је формирати како глобалне тако и националне стратегије за борбу против микотоксина, унапредити дијагностичке технике и процедуре, пооштрити контролу квалитета хране, увести нове лимите за максималне количине микотоксина у храни и хранивима за поједине животињске врсте и категорије и ускладити их са европским стандардима.