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IMPORTANCE OF TOXIGENIC *Fusarium* SPECIES IN ANIMAL FOOD

V. Krnjaja[1], J. Lević[2], S. Stanković[2]

[1]Institute for Animal Husbandry, Autoput 16, P. Box 23, 11080 Belgrade-Zemun, Republic of Serbia
[2]Maize Research Institute „Zemun Polje", Slobodana Bajića 1, 11185 Belgrade-Zemun, Republic of Serbia
Corresponding author: vesnakrnjaja.izs@gmail.com
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Abstract: Numerous plant species, which are main components of various mixtures used in animal nutrition, can be contaminated by mycotoxins created by large number of pathogenic and toxigenic fungi (moulds). From the aspect of animal nutrition, most important are cereals and oil crops (in form of meals) because they constitute the highest share in preparation of animal food, and on the other hand, they are especially sensitive to toxigenic fungi and can contain mycotoxins above maximum allowed quantity. Contamination of plants or certain plant parts, of which the grain is of major importance, occurs in the field or during storage, as consequence of growth of toxigenic fungi. Numerous factors favour and contribute to growth of moulds, such as environment conditions, stress, sensitivity of genotype to fungi and insects, moisture content, etc. Species of the *Fusarium, Aspergillus* and *Penicillium* genera, from the mycotoxicological aspect, are the most important pathogens isolated in livestock feed in Serbia. However, the most studied plant pathogenic fungi are *Fusarium* species, and there are several reasons for this. Firstly, each year, in higher or lower percentage, they cause diseases on maize, wheat, barley and other cereal species, which are major component of animal and human nutriiton. Secondly, they have cause in certain years mass incidence of mycotoxicosis in animals, esepcially in pigs. *F. graminearum* is the most important pathogenic species for wheat, barley and maize, *F. poae* for wheat and barley, whereas species from the section *Liseola* (*F. verticillioides*, *F. subglutinans* and *F. proliferatum*) are more significant for maize and sorghum. In addition to above mentioned, the presence of other *Fusarium* species was determined, although in small percentage, but very toxigenic and cannot be neglected as potential animal food contaminants. Considering the prevelance of certain toxigenic species in Serbia, three groups of mycotixins produced by *Fusarium* fungi species can be considered as the most important from the aspect of animal health. Within the group of trichothecenes, deoxynivalenol (DON) is associated with situations when pigs refuse to eat, whereas toxin T-2 can cause reproduction disorders in sows. Other group includes zearalenone (ZON) and its derivatives which cause estrogenism. Third group includes fumonisins which are associated with specific syndroms of toxicity such as equine leukoencephalomalacia (ELEM) and porcine pulmonary oedema (PPE). Growth and presence of *Fusarium* species in grains and animal food, becuase of the production of mycotoxins, has been current topic in many researches world wide.

Key words: toxigenic *Fusarium* species, mycotoxins, animal food

Introduction

Cereals and cereal mixtures are widely used as source of energy for farm animals. Unfortunately, numerous fungi species can develop on cereals in the field and during storage (warehouse) and contaminate the animal food by mycotoxins which exhibit toxic effects on animals and humans *(Biagi, 2009)*. Climatic conditions and growing of cereals on large areas in Republic of Serbia are conducive to the growth of toxigenic species, such as *Fusarium* spp., *Aspergillus* spp. and *Penicillium* spp., resulting in frequent contamination of animal food by their secondary metabolites. In Republic of Serbia, the most often isolated species in animal food are fungi of *Fusarium* species, as well as their mycotoxins *(Krnjaja et al., 2009b)*.

Species of the *Fusarium* are characterized by excellent interspecies and intraspecies variability in regard to morphological, physiological, genetic and ecological properties. Due to high variability of these properties, species of the *Fusarium* genus are wide spread, and mainly cosmopolitan, although certain number of species is dominant in the regions with tropical and sub-tropical or moderate climate *(Burgess et al., 1994; Leslie and Summerell, 2006)*.

Fusarium species are wide spread in the soil and organic substrates, and they are isolated everywhere *(Booth, 1971)*. They are the most often isolated plant pathogens among imperfect fungi *Deuteromycetes*. Genus *Fusarium* is divivded into several sections on the basis of anamorph characteristics. Telemorph of *F. avenaceum* (section *Artrosporiella*/*Roseum*), *F. graminearum* (section *Discolor*/*Fusarium*) and *F. equiseti* (section *Gibossum*) belong to genus *Gibberella (Booth, 1971; Gerlach and Nirenberg, 1982)*. Sex stadiums have not been detected in *F. culmorum* (section *Discolor*/*Fusarium*), *F. oxysporum* and *F. redolens* (section *Elegans*) *(Booth, 1971)*. During the evolution of species of *Fusarium* genus, the process of their adjustment (specialization) to certain plant species took place – hosts in different habitats (specialized forms, varieties) or even genotypes of the same plant species (breed). Certain species, especially those which cause conductive vessel wilt (*F. oxysporum*), are more specialized towards the plant host than other species which cause rot of roots and vegetative plant parts *(Burgess et al., 1994)*.

Many attempts have been made to create a uniform procedure for identification of species of *Fusarium* genus, but to date this has not yet been realized. Every approach developed so far based on morphological characteristics had positive aspects but also disadvantages. Therefore, resulting from various systems of taxonomy and nomencalture, there is a great confusion in regard to indentification of the species of *Fusarium* genus. Actual consideration of the number and taxonomy of species *Fusarium* genus will be possible after detailed phylogenetic studies at the molecular level. Recent studies of the basic organization of the genome of species of *Fusarium* genus and of their morphological and metabolic properties, presented at the 6th European *Fusarium* Seminar (Berlin), indicate that the phylogenetic tree of the *Fusarium* genus will be different from the tree presented for this genus by *Booth (1971) (Tančić, 2009)*. Taking into consideration the morphological, physiological, genetic/phylogenetic diversity of species of *Fusarium* genus, over 80 species have been determined within this genus so far *(Moretti, 2002)*.

Fusarium species form long, multicellular, spindle-shaped macroconidia. These macroconidia define the morphological characteristics of the genus. Many species will also form small, usually single-cell microconidia which vary in their shape from fusiform to oval to spherical. Also, some species form resistant chlamidospores which are important for longer survival. Microconidia and macroconidia are important for spreading of fungi by wind and splash. Conidia are, aslo, usually propagules which participate in the infection of host plant *(Glenn, 2007)*.

Fusarium species can cause vascular wilting, decay of seedlings, root rot, crown rot resulting in drying of leaves. Premature decay of forage plants in our country is significantly contributed to by some factors of the environment. Long dry periods during summer lead to weakining of the plant vitality and increase their sensitivity to species of the *Fusarium* genus. Strong winter frost, in periods without snow cover, damage the crown rot of plants making them more sensitive to weakness parasites *(Todorov et al., 1995)*. Many questions are focued on the ability of *Fusarium* species to penetrate the root directly, their compatibility to host and interaction with other plant stress factors. Some isolates of *Fusarium* species, joined within the complex of root rot of forage plants, penetrate the root directly. Injuries of the root lead to increased occupation by other isolated *(Leath and Kendall, 1978)*.

Because of exceptional diversity of species of *Fusarium* genus in regard to morphological, physiological, genetic and pathogenic properties, as well as mycotoxin spectrum which they produce, study of the presence and distribution of *Fusarium* species and their mycotoxins is very important, as well as risk assessment of the potential damage caused by these pathogen fungi and potentially toxigenic fungi species. In this paper the most important *Fusarium* species which are potentially toxigenic species in cereals as basis of animal food, are reviewed.

F. graminearum Schwabe

F. graminearum (teleomorph *Gibberella zeae* (Schw.) Petch.) is cosmopolitan, and most often it is present in areas with moderate and tropical climate, where it causes maize root rot, rot of stem and of the maize cob, as well as fusariosis of the wheat ear and other species of the family *Poaceae*. *F. graminearum* is very toxigenic species which synthesizes deoxynivalenol and zearalenone, mainly on maize and wheat *(Lević, 2008)*. In addition to primary hosts – wheat, maize and barley, it parasites also on other annual and perennial plants *(Leslie and Summerell, 2006)*.

For many years *F. graminearum* was divided into two taxons known as *F. graminearum* Group 1 and *F. graminearum* Group 2. Morphologically it is very difficult to distinguish these two groups, but there are important ecological and pathological differences *(Leslie and Summerell, 2006)*. Members of Group 1 rarely form perithecia in nature and are heterothallic. Contrary to this, members of Group 2 form abundantly perithecia in nature and are homotallic. Perithecia in both groups are similar and have teleomorph stage *Giberella zeae* (Schw.) Petch. *(Burgess et al., 1994)*. In recent years, by applying phylogenetic analyses based on comparisons of DNA sequences of various genetic loci several new species were established. In morphological and molecular analyses of isolates in Groups 1 and 2 it was established that isolates in Group 1 belonged to species *F. pseudograminearum*. *Gibberella coronicola* is name given to heterothallic teleomorph of *F. pseudograminearum*. Populations in Group 2 kept the original name *F. graminearum* and have teleomorph *Gibberella zeae (Aoki and O'Donnell, 1999)*. *O'Donnell et al. (2004),* based on extensive molecular phylogenetic analyses of 11 nuclear genes assumed additional revisions in taxonomy of homothallic population of *G. zeae*/*F. graminearum*. Nine phylogenetically different bio-geographical structural lines were identified, which have been formally considered as different species, including *F. graminearum sensu stricto* and *F. pseudograminearum (O'Donnell et al., 2004)*.

Isolates of *F. graminearum* produce trichothecenes deoxynivalenol (DON) (and its derivatives), as well as polyketide estrogenic metabolite zearalenone (ZON) *(Glenn, 2007)*. Based on production of different trichothecenes, *F. graminearum* can be divided into two chemotaxonomic groups - DON chemotype and nivalenol (NIV) chemotype. DON is the most present mycotoxin in cereals and DON chemotypes of *Fusarium* were detected worldwide. On the other hand, NIV chemotype has been detected more in limited regions, such as certain Asian *(Hsia et al., 2004)* and European countries *(Logrieco et al., 2002)*, and lately, it was also detected in North America *(Gale et al., 2011).* In some countries, there are legally regulated limits of DON concentration in cereals. So, more attention is focused on DON compared to NIV, of trichothecene mycotoxins *(Nakajima, 2007)*.

In agro-ecological conditions of Serbia, species *F. graminearum* has very often been identified on wheat and maize. According to results obtained by *Bočarov-Stančić (1996, 1998)* and *Bočarov-Stančić et al. (2000),* of *Fusarium* species determined in analyzed wheat garain, species *F. graminearum* was the most frequent. *Stojanović et al. (2005)* established 5.03% *F. graminearum* in investigated samples of wheat grain with content of ZON of up to 500 μg kg^{-1}. According to these authors, ZON concentration in samples of wheat flour ranged from 66.67 to 200 μg kg^{-1}.

In Serbia, ZON is one of the most important fusariotoxins causing mycotoxicosis in animals and one of the most common contaminants of livestock mixtures used in nutrition and of their components *(Bočarov-Stančić et al., 1995; Lević et al., 2004)*. In the analysis of the content of DON in maize samples which were artificially infected with *F. gramineraum, Abramović et al. (2005)* established DON concentrations which did not exceed maximum allowed values, regardless of the artificial inoculation with *F. graminearum*. These results were explained by authors as the consequence of absence of moisture and exceptionally high temperatures in the period of artificial inoculation of plants *(Abramović et al., 2005)*.

In the study of the incidence of toxigenic *Fusarium* species in wheat during 2005 and 2006, *Stanković et al. (2007)* identified 13 *Fusarium* species, of which *F. graminearum* was the most common with 35.2% (2005) and 12.5% (2006). In sampled maize kernels, post-harvest, among isolated *Fusarium* species the most common was species *F. graminearum* (17.8%) *(Krnjaja et al., 2006)*. Of six identified *Fusarium* species on maize kernels in warehouse, species *F. graminearum* was the third in regard to its incidence, and according to the mycotoxicological aspect it is very important in the period June-September when it was mainly identified in samples (5-11%) *(Krnjaja et al., 2007)*. *Krnjaja et al. (2008)*, in post-harvest wheat samples, identified eight species from *Fusarium* genus, of which *F. graminearum* was the most common with 63.5%. In the analysis of the presence of *F. graminearum* on different parts of the wheat ear, *Lević et al. (2008a)* established that this species was most common on the grain (55.5%) and whole rachis (34.7%). *Krnjaja et al. (2009a)* established also high incidence of *F. graminearum* (7.8-10.8%) in all studied treatments where wheat was fertilized with different types of fertilizer and in different times – first treatment was slurry before sowing and in plant feeding, the second treatment was manure before sowing and urea in plant feeding, and the third treatment urea in the plant feeding, compared to the control treatment without application of fertilizer (3.5%).

In the analysis of the content of DON mycotoxins in wheat ear, *Balaž et al. (2007)* established 353.4 μg g^{-1} of this toxin in grain samples with exhibited symptoms of fusariosis (*F. graminearum*) on the ear, 0.225 µg g^{-1} in grain samples above the infected part of the ear, and 0.125 µg g^{-1} in grain samples below the infected part of the ear. Presence of ZON in concentration of 2.1 µg g^{-1} was determined in grain samples from the wheat ear with symptoms of fusariosis *(Balaž et al., 2007)*.

In wheat samples collected from different locations in Serbia prior to harvest in 2005 and 2006, in which the *F. graminearum* had been identified as the most common species, the concentrations of ZON of 37 to 331 µg kg^{-1} and of DAS and T-2 toxin from 31 to 125 µg kg^{-1} were determined *(Stanković et al., 2007)*. In the analysis of samples of wheat collected during 2004 and 2005 in Vojvodina, it was established that 41.6% of samples were contaminated by DON with concentrations ranging from 57 to 1840 µg kg^{-1} *(Jurić et al., 2007)*. In the analysis of 14 isolates of *F. graminearum* isolated in wheat, as producers of DON, concentrations in the range from 160 to 45.260 µg kg^{-1} were established *(Stanković et al., 2008a)*.

F. sporotrichioides Sherbakoff and *F. poae* (Peck) Wollenweber

F. sporotrichioides was determined in regions with cold and moderate climate, most often in plant species of the family *Poaceae*. It is especially significant as pathogen of wheat and maize. One of the first species of *Fusarium* genus which was determined as toxigenic and that mycotoxins produced by it can cause alimentary toxic aleukia in humans and animals. It synthesizes T-2 toxin, diacetoxyscirpenol, butenolide, fusarin C, moniliformin, zearalenone, etc. *(Lević, 2008)*. *F. sporotrichioides* can develop even in very low temperatures sand can be isolated from seeds which survived the winter under snow. It can also be isolated from different substrates such as grasses, small grains and alfalfa, but in general it is weak pathogen *(Leslie and Summerell, 2006)*.

F. poae is cosmopolitan, determined in regions with moderate and tropical climate, it parasites on numerous hosts: seedlings of herbaceous plants, species of the family *Poaceae*, sugar cane, rice, citrus fruits, carnation and other plant species. It synthesizes fusarenone-X, nivalenol, diacetoxyscirpenol, T-2 toxin, beauvericin, fusarin C, etc. *(Lević, 2008)*.

Stojanović et al. (2005) established significant presence of *F. poae* (8.80%) in studied grains of three wheat cultivars in grain fractions with dark germ category. In the analysis of 57 samples of poultry feed in the period from 1998 to 2002, *Živković et al. (2005)* established significant presence of T-2 toxin in concentrations from < 300 µg kg^{-1} (19 samples of food), 500 µg kg^{-1} (18 samples of food) and 1,000 µg kg^{-1} (3 samples of food). In six samples of food, in addition to T-2 toxin, also DAS was present. Clinical picture and damages varied depending on the concentration of mycotoxins and age of chickens *(Živković et. al., 2005)*. In the post-harvest wheat grain, *Krnjaja et al. (2008)* established high presence of *F. sporotrichioides* (20.9%) and low presence of *F. poae* (0.9%). Potential of Serbian isolates of *F. poae* for bio-synthesis of trichothecenes from the group A was low, because concentration of DAS did not exceed 80 µg L^{-1}, i.e. concentration of T-2 toxin did not exceed 240 µg L^{-1} *(Bočarov et al., 2007)*. In the study of the effect of various types of fertilizer on infection of wheat grain with *Fusarium* species, that low presence of *F. sporotrichioides* was established in all studied treatments with fertilizer (0.3-0.6%) and of *F. poae* in treatments where manure was used before sowing and urea in plant nutrition (0.3%) *(Krnjaja et al., 2009a)*.

F. verticillioides (Saccardo) Nirenberg, *F. proliferatum* (Matsushima) Nirenberg and *F. subglutinans* (Wollenweber & Reinking) Nelson, Toussoun & Marasas

Species *F. verticillioides* (syn *F. moniliforme* Sheldon), *F. proliferatum* and *F. subglutinans* belong to the section *Liseola (Nelson et al., 1983)*. *F. verticillioides* (teleomorph *Gibberella moniliformis* Wineland, mating population A) is cosmopolitan, maize and sorghum pathogen, causes seedlings and root rot in rice, sugar cane, cotton, small grains, banana, pineapple and tomato fruit, and many other plants. It synthesized fumonisins, fusaric acid, fusarin C and trichothecenes *(Lević, 2008)*. Fumonisins are the most important mycotoxins produced by *F. verticillioides*. Fumonisin B_1 (FB_1) is the best known and studied of all fumonisins. They can be isolated in different types of food, but maize and maize products are with the highest risk of contamination *(Leslie and Summerell, 2006)*. There were some significantly dissenting opinions in regard to the name of this *Fusarium* species, some taxonomists called it *F. moniliforme* and some used the name *F. verticillioides*. The name *F. verticillioides* is now used more *(Leslie and Summerell, 2006)*. Many taxonomic concerns were associated with identification of the species *F. verticillioides*, and eventually several species were separated, including species *F. proliferatum* and *F. subglutinans* which are commonly joined with maize *(Nelson et al., 1983; Marasas, 1984)*. In regard to morphological criteria, precision in identification of species was based on application of the biological species concept in relation to different mating populations *(Leslie, 1991, 1995)*, same as later application of the biological species concept based on analysis of DNA sequences *(Nirenberg and O'Donnell, 1998)*. Detection of mating populations and application of the biological species concept were possible because perithecia formed in heterothallic form in the culture when isolate strains belonging to different mating types were grown together *(Leslie, 1991, 1995)*. It was recorded that *F. moniliforme sensu* Snyder & Hansen included isolates of some other species and not *F. verticillioides*. The name *F. verticillioides* should only be used for isolates which have teleomorph *Gibberella moniliformis* (*G. fujikuroi* mating population A) and not as replacement for *F. moniliforme sensu (Leslie and Summerell, 2006)*.

F. proliferatum is cosmopolitan, determined as pathogen of many different plant species, including maize, orchids, asparagus, etc. It synthesizes beauvericin, fusaproliferin, fusaric acid, fusarins, moniliformin, etc. *(Lević, 2008)*. In high concentrations it produces fumonisins *(Leslie and Summerell, 2006)*. *F. proliferatum* was first described as *Cephalosporium* species and then as *Fusarium* species. Telemorph of this species is *G. intermedia* (Kuhlman) Samuels, Nirenberg & Seifert (*G. fujikuroi* mating population D) *(Leslie and Summerell, 2006)*.

F. subglutinans is cosmopolitan, it prevails in regions with moderate climate where it causes maize disease, as well as disease in other species of the family *Poaceae*. It synthesizes moniliformin, beauvericin, fusaric acid, fusaproliferin etc. *(Lević, 2008)*. It produces in small concentrations, or not at all, fumonisins. The telemorph of this species is *Gibberella subglutinans* Nelson, Toussoun & Marasas (*G. fujikuroi* mating population E) *(Leslie and Summerell, 2006)*.

Stojanović et al. (2005) established significant presence of *F. subglutinans* (17.61%) in investigated grains of three wheat cultivars in fractions healthy, dark germ and slightly fusarious contaminated grains. In the study of the presence of *Fusarium* spp. and fumonisin in grain of three wheat cultivars (PKB Lepoklasa, Jugoslavija and Francuska) *Protić and Protić (2005)* established the presence of infection with *Fusarium* spp. In all studied wheat cultivars. The most common was species *F. graminearum*, whereas *F. moniliforme* and *F. proliferatum* were determined in lower percentage. Average concentration of fumonisins in wheat grain samples was 0.62 mg kg^{-1} *(Protić and Protić, 2005)*. In the study of the toxigenic potential for bio-synthesis of ZON and trichothecenes from group A (T-2 and DAS) in the most common species *F. verticillioides* isolated in the maize kernel harvested in 2005, *Jajić et al. (2007)* established that the studied isolates of *F. verticillioides* did not bio-synthesize ZON, and of trichothecenes of group A, T-2 toxin was synthesized in concentration of 80-240 μg L^{-1}, and DAS toxin was not synthesized. In post-harvest wheat grain, *Krnjaja et al. (2008)* established relatively high presence of *F. proliferatum* (5.2%), *F. subglutinans* (3.5%) and *F. verticillioides* (1.7%). In the study of the toxicological profile and fertility of 24 isolates of *F. proliferatum* isolated from maize plants on different locations in Serbia, *Stanković et al. (2008b)* established that all studied isolates produced relatively high level of fumonisin B_1 (FB_1) (to 3950 μg g-1). Seven studied isolates belonged to *MATD-1* and 17 isolates belonged to *MATD-2* mating type *(Stanković et al., 2008b)*. In the study of the effect of different fertilizer types on infection of wheat grain with *Fusarium* species, low presence of *F. subglutinans* (0.2%) was established in treatment with fertilizer compared to control treatment without fertilizer *(Krnjaja et al., 2009a)*.

Strategies of control of toxigenic fungi

Strategy which includes application of good agricultural practice and good storage practice with reduced effect of mycotoxins, with implementation of all regulations and other measures, can provide production of safe food for humans and animals *(Lević et al., 2008b)*.

In general, good practice that reduces the grain contamination by toxigenic fungi species in the field and in warehouses (*Fusarium* spp., *Penicillium* spp. and *Aspergillus* spp.) is at the same time good practice to reduce contamination of grain with mycotoxins *(Stack, 2000)*. The risk of mycotoxins does not exist if in the animal and human nutrition maize is used from fields free of cob fusariosis, which is subsequently dried and stored in standard way. Incidence of fusariosis of cob in the fields or in storage opens the issue to which extent such maize can be used in animal and human nutrition, without causing the mycotoxicosis. Similar is situation with fusariosis of ear and kernel of small grains.

When fungicides are used in control of cereal fusariosis, this reduces the risk of contamination. However, resistance of *Fusarium* species to certain fungicides has been registered. Selection of cereal cultivars resistant to *Fusarium* species is also one option to reduce the mycotoxins in cereals *(Placinta et al., 1999)*.

If the infection by toxigenic fungi species and mycotoxin contamination occur, chemical treatments which include calcium hydroxide monomethylamine, sodium bisulphite or ammonia are recommended as measures to reduce the level of fusariotoxins *(Placinta et al., 1999)*. Dilution of contaminated cereals with other components of livestock food is another option which enables establishing of control before cereals are incorporated in livestock feeds.

Based on all presented in the paper, it is apparent that prevention strategies are probably more efficient compared to remedial action in reduction of risk to animal health. Many countries are attempting to define in the legislation and regulations maximum allowed quantities of certain mycotoxins in plant products intended for nutrition of certain categories of domestic animals. According to Regulation on maximum quantities of harmful substances and ingredients in animal feed *(Službeni list SFRJ, 1990)* in Serbia, maximum allowed quantities of aflatoxin, ochratoxin, zearalenonae and total trichothecenes (T-2 toxin and DAS) are determined, as well as criteria for determination of the hygiene quality of mixture and of raw material used for production of animal feeds. These regulations have to be harmonized with EU recommendations, and supplemented with new mycotoxins (DON, FB_1).

Conclusion

Animal food may be contaminated with *Fusarium* species and fusariotoxins. A number of compounds within fusariotoxins have been implicated in spontaneous worldwide cases of mycotoxicoses in livestock. Knowledge of the taxonomic identity and mycotoxigenic potential of the various *Fusarium* species are important for development of strategies for monitoring and managing mycotoxin contamination of grain. Analysis of animal food gives the farmers information about the optimum utilization of nutrients in animal food; to producers, information about components which are included in feed mixtures and that they are suitable for different processes in livestock production; to scientists and researchers to be able to evaluate animal performance based on characteristics of animal food; to selection plant breeders it provides information on nutritional value of new cultivars/hybrids; and the most important information on undesirable contaminants in animal food which directly influence the safety of food of animal origin. Annual results and results obtained in studies lasting several years of presence and frequency of incidence of *Fusarium* species and their mycotoxins in animal food are very important because of application of preventive measures, as well as raising of the public awareness of consequences of the adverse effect of these contaminants in the food chain. However, in future studies, it remains to be determined how temperature, moisture and host genotype influence the geographical distribution of *Fusarium* species, their interaction and development of cereal diseases and production of mycotoxins.

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Značaj toksigenih *Fusarium* vrsta u hrani za životinje

V. Krnjaja, J. Lević, S. Stanković

Rezime

Brojne biljne vrste, koje čine sastavni deo različitih smeša hrane za životinje, mogu biti kontaminirane mikotoksinima koje stvara veliki broj patogenih i toksigenih gljiva (plesni). Sa stanovišta ishrane životinja najznačajnija su žita i uljane kulture (u vidu brašna) jer čine najveći udeo prilikom pripreme hrane, a s druge strane, posebno su osetljive prema toksigenim gljivama i mogu da sadrže

mikotoksine iznad maksimalne dozvoljene količine. Do kontaminacije biljaka ili pojedinih njenih delova, od kojih je zrno najznačajnije, dolazi u polju ili tokom skladištenja kao posledica razvoja toksigenih gljiva. Brojni su činioci koji pogoduju razvoju plesni, kao što su uslovi spoljašnje sredine, stres, osetljivost genotipa prema gljivama i insektima, sadržaj vlage i drugo.

U Srbiji vrste iz rodova *Fusarium, Aspergillus* i *Penicillium* su sa mikotoksikološkog aspekta najznačajniji patogeni izolovani iz hrane za životinje. Međutim, među najproučavanijim biljnim patogenim gljivama su *Fusarium* vrste, i to iz više razloga. Prvo, one svake godine u većem ili manjem procentu prouzrokuju bolesti na kukuruzu, pšenici, ječmu i drugim vrstama žita, koje su glavne komponente hrane za ljude i životinje. Drugo, one su u nekim godinama prouzrokovale masovnu pojavu mikotoksikoza životinja, posebno svinja. *F. graminearum* je najznačajnija patogena vrsta za pšenicu, ječam i kukuruz, *F. poae* za pšenicu i ječam, dok su vrste iz sekcije *Liseola* (*F. verticillioides*, *F. subglutinans* i *F. proliferatum*) značajnije za kukuruz i sirak. Osim ovih, utvrđeno je prisustvo i drugih *Fusarium* vrsta, koje su, iako prisutne u malom procentu, veoma toksigene i ne mogu se zanemariti kao potencijalni kontaminatni hrane za životinje.

S obzirom na rasprostranjenost pojedinih toksigenih vrsta gljiva u Srbiji, od posebne važnosti za zdravlje životinja mogu se razmatrati tri grupe mikotoksina koje proizvode *Fusarium* vrste gljiva. Unutar grupe trihotecena, deoksinivalenol (DON) je povezan sa odbijanjem hrane kod svinja, dok T-2 toksin može prouzrokovati poremećaje u reprodukciji kod krmača. Druga grupa obuhvata zearalenon (ZON) i njegove derivate koji prouzrokuju estrogenizam. Treća grupa uključuje fumonizine koji su povezani sa specifičnim sindromima toksičnosti kao što su leukoencefalomalacija i edem pluća. Razvoj i prisustvo *Fusarium* vrsta u žitima i hrani za životinje zbog produkcije mikotoksina, poslednjih godina je veoma aktuelna tema u brojnim istraživanjima širom sveta.

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