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Review

Fusarium spp. and fumonisin in feed for equine and its importance for occurrence of leukoencephalomalacia

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In the animal feed industry, an ever growing increase in quality has been observed, but the main feature of a food is related to its security because the contamination poses a risk to animal health. The problems caused by fungal colonization is the significant loss of food quality, because even those who do not produce mycotoxins cause losses in the nutritional quality. Researches show that the most important Fumonisins are the mycotoxins found in corn, particularly when cultivated in warmer regions, produced by the fungi *Fusarium verticillioides* and *F. proliferatum.* Equine leukoencephalomalacia is a disease caused by ingestion of mycotoxin produced by the fungus *F. verticillioides*. Those infective mycotoxins are fumonisin (B1, B2, A1 and A2), having the B1 type as the most common and the most severe. The animals contamination occurs by ingestion of corn and its by-products in food that are contaminated by the fungus. This review addresses the importance of fungal contamination of the genus *Fusarium* by the production of fumonisin in horse feed and its relation to leukoencephalomalacia.

Key words: Fungi, mycotoxins, corn, food.

INTRODUCTION

Horses are animals that have been historically used by humans, mainly as a means of transport and also as an instrument of war. Over the years, horses developed skills ranging from physiological and physical features, until achieving the current conformation presented nowadays (Santos et al., 2012).

The human's relationship with horses is reported since the beginning of domestication, involving various functions like riding cavalry, some work activities and also used for leisure (Vieira, 2012).

With the development of management, sought to increasingly attend the nutritional needs and the welfare of these animals, deploying horse breeding, which has conquered several other areas of horse action, which involves leisure activities, sports and therapy with these animals (Santos et al., 2012).

In Brazil, the horse breeding has been outstanding and has been developing research and practices in nutrition

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of these animals, which has been serving the needs and optimizing the functioning of the competitive market of sport horses in the country (SÁ, 2014). In Brazil its main functions still remain in the work of agricultural activities, which basically involve the management of cattle (MAPA, 2014).

The world population of horses is estimated in 59.8 million of heads, which is a stable number since 2010 (FAO, 2013). In Brazil, much of the herd is in the Southeast, then immediately appear the Northeast, Midwest, South and North. It can highlight the Northeast, because of having the largest concentration of horses, and more registration of asses and mules (MAPA, 2014).

Horses are animals with nutritional requirements that are basically determined by the maintenance of power-up and also for its energy that is used to perform physical activities, thereby determining the feeding of those animals must be balanced and must be a composition proper proportions of nutrients, which determine maintenance of your body condition. The amount of food that a horse can eat in your daily diet will depend on certain requirements, among them, the dry matter content of food relative to their body weight, their performance, and also relating to their physiological state and level of physical activity performed (Ribeiro et al., 2009).

Regarding its food habits and physiology, horses are classified as monogastric animals, vegetable grazing, and have the characteristic of food selection capability where they choose more often the leaves, stems and buds. They spend in grazing about 10 to 16 h a day, their meals are on average 2 to 3 h and in some cases have short rest intervals (Dittrich et al., 2010).

In the animal feed industry seeing an increasingly growing increase in quality, and it relates to various parameters relating to the constitution of food, the balance, palatability, digestibility and acceptability of such products for animals. However, the main feature of a food is linked to its security because the contamination poses a risk to animal health (Góes, 2011).

Equine leukoencephalomalacia (ELEM), also known as equine mycotoxic encephalomalacia or corn poisoning is a devastating neurologic diseases of equidae characterized by acute central neurological clinical signs associated with liquefactive necrosis of the cerebral sub-cortical white matter.The disease has been reported in several countries and it is caused by ingestion of one or more type of fumonisins (Kellerman et al. 1990), mycotoxins produced by several species of fungi of the genus *Fusarium*, including *F. proliferatum* and *F. verticillioides* (formerly *F. moniliforme).* Of these, fumonisins B1 (FB1), B2 (FB2) and B3 (FB3) are the most common in nature and FB1 is the most frequently detected in corn worldwide and the most commonly associated with ELEM outbreaks. Fumonisins are responsible for a variety of health problems in several animal species, including humans (Shephard et al., 1996; FDA 2001).

REVIEW

Fungi in animal feed

Fungi are characterized by being microorganisms that have wide distribution in the environment, with high geographic dispersion. They are important in several economic activities such as production of food, drugs, enzymes and organic acids. Other aspect of these organisms is that some fungi are pathogenic to plants and food spoilage, which may cause reduction in the nutritional value of food, the production of secondary metabolites and diseases in humans and animals (Silva et al., 2015).

The fungi naturally disperse through the atmospheric air. This is the way most used by fungi, by their spores and vegetative mycelium fragments that are released into viable portions of these organisms for air dissemination process. The fungal conidia are very important in this spreading segment, as the biological material suspended in the air often becomes imperceptible in an epidemiological analysis (Lobato, 2014).

The process of plant infection with the fungus is caused by the pathogen contact with the host root, so the plants can germinate resistance structures, stimulated by exudates produced by the plant and this determines a prominent infection. The penetration process occurs through the primary root or rhizoid and also absorbent structures. The infection process by the fungus, descriptively is performed through wounds or natural openings in the cell wall of roots, the effectiveness of this infection and subsequent development in the host includes the production of enzymes, toxins and virulence factors (Gawehns et al., 2014).

The colonization occurs with the intercellular growth hyphal toward the xylem vessels. As a result, the development of the fungus will lead to the obstruction of vessels due to the accumulation of structures and substances formed by the pathogen. In this intrinsic process, some mycotoxins can be produced by the fungus, and can naturally also block the vessels, and its damaging effects can destroy surrounding cells, causing accumulated material reaching the leaves. It also reduces the synthesis of chlorophyll, decreased movement of water and nutrients rate, which results in further decrease in cellular respiration as a result harmful effects on the production of the fruit (Takken and Rep, 2010).

It occurs a blackening of the vessels caused by substances that result from oxidation and polymerization of phenolic compounds. The symptoms spread throughout the plant leaves and, depending on the aggressiveness of some isolated, they can quickly become necrotic (Ma et al., 2013).

After infection by pathogenic fungi, some forage grasses show biochemical changes that lead to a loss of nutritional quality, and consequently also the food palatability for animals due to the reduction in the concentration of proteins, amino acids, sugars, soluble carbohydrates and digestibility of the dried matter, and increased phenolic compounds and lignin in the infected plants (Martinez et al., 2010).

The problem caused by fungi colonization is the significant loss of food quality, even those who do not produce mycotoxins can cause losses in nutritional quality for being heterotrophic and they are not able to produce their own food, needing of nutrients present in the substrate inhabited (Gimeno and Martins, 2011). Fungi that produce mycotoxins include in the grain and make use of the substrate as a source of energy and nutrients and require a minimum moisture content of the substrate between 13 and 25%; relative humidity of the air greater than 70%; the presence of oxygen and the presence of appropriate temperatures to make their development in infested crops (Alfonzo et al., 2011). The fermentation, coloration changes, staining, changes in the odor and flavor, chemical changes, loss of dry matter, decreased germination and production of mycotoxins are the major damages to stored grain because of the fungi development (Ferrari Filho, 2011).

Contamination of raw materials directly affects livestock productivity and contributes to the loss of crops, which causes economic losses to the food industry and costs for control and analysis of mycotoxins (Cheli et al., 2013). In the infections caused by fungi in animals, pathogens establish infection opportunistically invading host tissue as soon invades the immune system, making survival mechanisms, then they can reproduce in this environment. To survive fungi go to nourish in infected tissues, and in cases of systemic infection, they spread to new tissues or organs (Negri et al., 2012).

Fusarium

The *Fusarium* is cosmopolitan fungi, which are largely inhabitants of the soil and is found in more favorable conditions in temperate and tropical regions. Many species are pathogens of cultivated plants, especially those that are important in the agricultural sector (Leslie; Summerel, 2006).

The genus *Fusarium* belongs to Nectriaceae family, Ascomycota phylum, and this fungal genus was described and classified for the first time in 1809 by the German mycologist Link (Maciel, 2012). Among the duties of the genus *Fusarium*, one is having wide geographical distribution, and its dispersion and development factor in the environment may be associated with the types of the climate, the vegetation, the microbiota, the type of soil and nutrients. It is also distinguished by having rapid growth, colonies with pale and colorful colorings and aerial and branched mycelium (Maciel, 2012; Frias, 2014).

Approximately about 1000 *Fusarium* species were described in 1900, based primarily on structure tests, including sporodochia in plant materials analyzed. These large number of species have been reduced by Wollenweber and Reinking (1935) in 65 species, 55 varieties, 22 forms, and arranged in 16 sections (Leslie et al., 2013).

The importance of this fungus is evidenced by most of these species are plant pathogens and widely inhabit the soil (Guarro, 2013).

In this genus the spores have two forms that are called microconidia and macroconidia. Microconidia are unicellular, uninucleate and fusiform. The macroconidia are multicellular, but each cell has only one core (Sandoval, 2010).

Pathologies triggered in cultures by the *Fusarium* species has as a imminent result the rotting of the roots, stems and fruits (Menezes et al., 2010). In corn culture, *F. verticillioides* and *F. graminearum* are the main pathogenic species of *Fusarium* that can cause various diseases associated with drastic reductions in productivity result in grain quality (Kuhnem Júnior et al., 2013).

In general aspects, the genus *Fusarium* is identified as a fungus that can be potentially pathogenic to plants, animals and humans and can also be a producer of secondary metabolites which cause poisoning by ingestion of food contaminated by humans and other animals (Leslie et al., 2013).

Mycotoxins

Mycotoxins are products that result from fungal metabolism. That is, they are secondary metabolites that can affect both human and animal health. Typically, mycotoxins are present in the environment in which they develop, such as grain-based food, cereals and feed. The environmental factors that contribute to the occurrence of mycotoxins are mainly ambient temperature, high humidity of the substrate associated with the processing, production or storage, and food type (Ferreira, 2012).
Mycotoxins cause pathological and functional changes in the animal body, which are called mycotoxicosis. One of the main damage caused by mycotoxins is its carcinogenic effect, which can affect animals and humans (Pereira; Santos, 2011).

The presence of fungi in agricultural products does not mean that the fungus produced mycotoxins. However, the detection of mycotoxins can occur with no presence of the fungus in food, since mycotoxins are highly resistant to adverse conditions such as industrial processes involving mechanical and thermal phases. In this way, the mycotoxins may remain in food even after the elimination of the fungus that produces them (Oliveira and Koller, 2011).

Mycotoxins can cause various harmful biological effects in the animal organism, including, hyperestrogenism, nephrotoxicity and hepatotoxicity (Rocha et al., 2014). The establishment of strict limitation and tolerance levels

Table 1. Permitted limits for mycotoxins in various species.

Mycotoxin	Feed stuff(s)	Limit (ppb)	Country / Authority
Aflatoxin B1	Maize	5	Turkey, Russia, Egypt.
	Maize	10	China, Korea, Japan
	Animal feed	10	Egypt
	Animal feed	50	Turkey
	All cereals except rice and maize	2	EU
	Unprocessed maize and rice	5	EU
	Animal feed ingredients	20	EU
	Feed stuffs for immature animal	20	FDA
Aflatoxin B1& G1	Maize	30	Brazil
Aflatoxin M1	Milk	0.5	U.S.A, Russia, Egypt
		0.05	Turkey
	Milk and milk products	0.05	EU
	Milk	0.5	FDA
Deoxynivalenol	Unprocessed cereals other than wheat, oats and maize	1250	EU
	Unprocessed wheat and oats, maize	1750	EU
	Cereal products	500	EU
	Cereals and cereal products for feed	8000	EU
	Maize by-products for feed	12000	EU
	Animal feed	100	FDA
Fumonisin B1, B2	Animal feeds except Equines	50	EU
	Animal feeds for Equines	5	EU
Fumonisin B1,	Animal feeds except Equines	30	FDA
B2, B3	Animal feeds for Equines	5	FDA
Fumonisins	Unprocessed maize	2000	EU
	Maize products for human	1000	EU
Ochratoxin A	Unprocessed cereals	5	EU
	Cereals and cereal products for feed	250	EU
	Cereal products for food	3	EU
T-2 and HT-2	All cereals grains	100	EU
Total aflatoxin	Animal feed ingredients	50	EU
	Animal feed	20	Canada, Egypt, Iran
		50	Brazil
	Maize	10	Turkey, Egypt
		30	India
	Cereals feedstuffs	200	Mexico
	Feedstuff (ingredient)s	20	Japan, U.S.A, Korea
	All cereals except rice and maize	4	EU
	Maize and rice	10	EU
	Feed stuffs for mature animal	100	FDA
Zearalenone	Unprocessed cereals other than maize	100	EU

EU: European Union. FDA: Food and Drug Administration. Source: Abdallah et al. (2015).

of mycotoxins is held by national and international authorities such as the European Commission (EC), US Food and Drug Administration (FDA) and World Health Organization (WHO) as shown in Table 1. FDA has established the maximum acceptable limits in food for sum of AFs (B1, B2, G1, and G2) at 20 μg/kg and AFM1 in milk at 0.5 μg/kg while the total Afs residue limit in feeds for mature and immature animals is 100 and 20 μg/kg, respectively (Womack et al., 2014). Up to date, the major source of food and feed all over the world is cereal grains.

As a result of their health implications and increasing knowledge of health hazards, regulations for major mycotoxins in commodities exist in at least 100

Table 2. Toxic effects of mycotoxins in different animals.

Mycotoxin	IARC† classification	Major effects	Clinical and pathological signs on most susceptible animals
Aflatoxins Aflatoxin M1	1 2B	Carcinogenic, hepatotoxic and impaired immune system	Reduced productivity; inferior egg shell and carcass quality; increased susceptibility to infectious disease.
Ochratoxin A	2B	Carcinogenic, nephrotoxic, hepatotoxic, neurotoxic and teratogenic	Kidneys are grossly enlarged and pale due to nephrotoxicity; fatty livers in poultry; shell decalcification/thinning.
Deoxynivalenol	3	Immunotoxic and ATA (alimentary toxic leukopenia)	Decreased feed intake and weight gain in pigs; feed refusal and vomiting at very high concentrations.
Other trichothecenes (T-2 toxin)	3	Immuno-depressants, gastrointestinal haemorrhaging and hematotoxicity	Reduced feed intake; vomiting, skin, and gastrointestinal irritation; neurotoxicity; abnormal offspring; increased sensitivity to infection; bleeding.
Zearalenone	3	Fertility and reproduction (estrogenic activity) and disrupts endocrine system	Swollen, reddened vulva, vulvovaginitis, anestrus vaginal prolapse and sometimes rectal prolapse in pigs; feminization and suppression of libido; suckling piglets may show enlargement of vulvae; fertility problems.
Fumonisins	2B	Carcinogenic, hepatotoxic, central nervous system damage and immuno-depressants	Equine leucoencephalomalacia (ELEM), porcine pulmonary edema, liver damage in poultry.

†International Agency for Research on Cancer. 1: carcinogenic to humans AFs; 2A: probably carcinogenic to humans; 2B: possibly carcinogenic to humans; 3: not classifiable as to its carcinogenicity to humans; 4: probably not carcinogenic to humans. Source: Abdallah et al. (2015).

countries (Oruc et al., 2006; Cheli et al., 2014). Because of the health risks of toxicity, Brazilian law establishes maximum levels for AFB1 (5 μg kg^{-1}) and OTA (10 μg kg^{-1}) in cereals and cereal products; and ZEA e in wheat flour and bakery products (200 μg kg^{-1} until December of 2015, and from January of 2016 this limit will be reduced to 100 μg kg^{-1}) (BRASIL, 2011).

The thresholds of toxicity of mycotoxins intake by equine species vary from animal to animal and depend on parameters such as their health status, level of work and the reproductive stage of this species. The mycotoxins sporadically occur in isolation and its effects are usually synergistic or cumulative. In the body of the equine species, the mycotoxins ingested in the feed are absorbed before occurs post-gastric fermentation. The metabolites reach the small intestine where they exert their effect on the intestinal wall. After, they are absorbed and distributed via the bloodstream (Knowmicotoxins, 2015).

The factors that provide or interfere with fungal growth and production of mycotoxins are physical, chemical and biological. Physical factors are moisture or free water, water activity, relative humidity, temperature, microflora zones, and physical integrity of grain. Chemical factors are the pH, substrate composition, minerals and nutrients, redox potential (O_2 / CO_2). Biological factors are characterized by the presence of invertebrates and specific strains with production ability (Gimeno and Martins, 2011).The mechanism of action of mycotoxins in the host involves the impairment of the animal's immune status that favors various infections, which will depend on the type of mycotoxin involved (Table 2). These attributes are a major reason for the difficulty of diagnosis of mycotoxicosis (Iheshiulor et al., 2011).

Six classes of mycotoxins are considered the most significant in agriculture and in the food industry: aflatoxins (AFs), ochratoxins (OTs), fumonisins (FBs), zearalenone (ZEN), deoxynivalenol (DON) and other trichothecenes, and Patulin (Figure 1). They are the most widespread mycotoxins in animal feed and human food (European Food Safety Authority, EFSA, 2010).

Fumonisin

The fumonisins had its first statements about 1988. They are produced by the gender *Fusarium*. The main species that produce fumonisins are: *F. verticillioides, F. proliferatum, F. nygamai, F. anthophilum, F. dlamini, F. napiforme, F. subglutinans, F. polyphialidicum* and *F. oxysporum* (Cruz, 2010; Mallmann et al., 2013).

There are several types of fumonisin due to the large amount of producing species. So far, it is known around 25 substances, which B1, B2 and B3 occur more frequently in food (Cruz, 2010; Pereira and Santos, 2011; Santana, 2012).

The climate in Brazil favors the contamination of grain by fungi. The conditions of high humidity and temperatures of about 20 to 26°C are optimal for the production of these metabolites (Cruz, 2010). In Brazil there is a high incidence of contamination

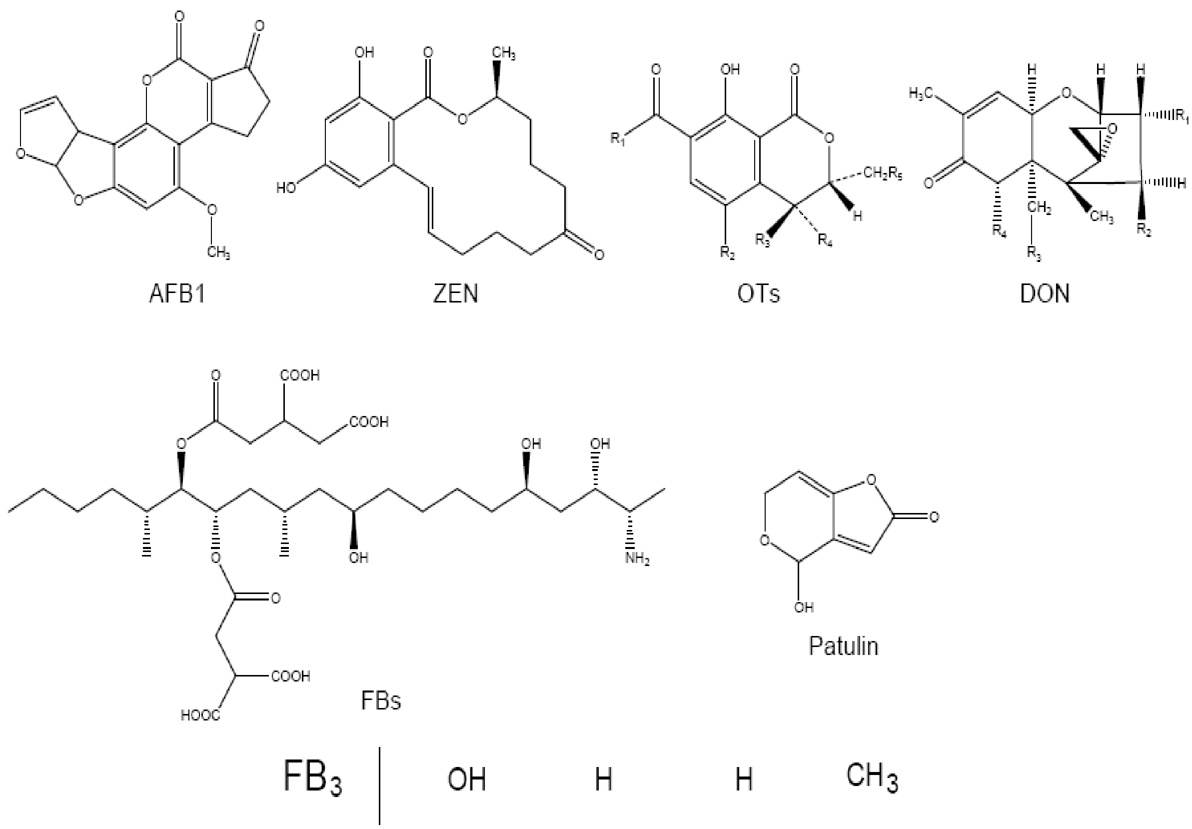

Figure 1. Chemical structures of some of the major mycotoxins produced by *Fusarium* spp.

by fumonisins in diets in general. The raw material of these feeds, especially corn and its derivatives, are naturally colonized by these fungi producing mycotoxins. This condition can lead to a high incidence of contamination in feed intended for animal consumption. (Souza et al., 2013; Cardoso Filho et al., 2015). This natural contaminant of cultures occurs worldwide and is of great importance for the economy and public health (Marin et al., 2013).

Studies report that diseases caused by fumonisin are quite frequent. The chronic use in animal of subclinical levels of toxin can degrade the function of the immune system (Grenier et al., 2011).

Fumonisin is highly toxic and is found not only in corn and its derivatives, but it can be found in many other types of foods such as beer, brewer's grains, wine, rice bran, sorghum, millet or folder. The metabolites may occur in low concentrations in a production. This metabolite often is linked to internal array of food, and it is not easily extracted due to its strong interaction, non-covalent, with macromolecules of food matrix (Scott, 2012).

The toxic mechanism of Fumonisin B1 in the animal organism is related to inhibition of biosynthesis of sphingolipid of cell membrane. Such inhibition can cause several cellular damages. Parallel pathways may be affected by the inhibition of ceramide synthase, as well as the bioactivity of sphingoid bases and their metabolites, and the multiple functions of more complex sphingolipids (Merrill Jr. et al., 2001; Soriano et al., 2005).

This is because fumonisins have similar structures to the precursors of sphingolipids, which allows change of important cellular functions, such as control of membrane integrity, cell proliferation, differentiation and apoptosis (Rocha, 2014).

Acute and chronic effects of toxicity of FB1 include diseases such as esophageal cancer and neural tube defects in humans. It can cause carcinogenicity, hepatotoxicity, nephrotoxicity and neurotoxicity in animals (Rocha et al, 2014).

Analytical methods for the determination of fumonisin are typically based on chromatography techniques (high-performance liquid chromatography) in combination with a variety of detection methods (molecular fluorescence or mass spectrometry) (Shephard et al., 2012).

Research has shown that the Fumonisins are the most important mycotoxins found on corn, especially when grown in warmer regions. The producing fungi, such as *F. verticillioides* and *Fusarium proliferatum*, can grow over a wide range of temperatures, but only with relatively high amounts of water. (Cao et al., 2013; Cardoso Filho et al., 2015).

Equine leukoencephalomalacia

Equine leukoencephalomalacia is a disease caused by ingestion of mycotoxin produced by the fungus *F. verticillioides*. The infective mycotoxins are fumonisins B1, B2 and B3. The mycotoxin B1 is more frequent and severe. Animal intoxication occurs by ingestion of corn and its sub-products contaminated by the fungus (Del Fava, 2010).

The use of corn and its derivatives in the feeding and supplementation of equine diet is needed during the shortage of pasture forage (Del Fava, 2010). In a retrospective study of equine diseases in Rio Grande do Sul-Brazil, leukoencephalomalacia was the nervous system disease most frequent (Pierezan, 2009).

Fumonisins (B1, B2, and B3), in the central nervous system equine, develop sudden neurological signs due to the liquefaction necrosis of the white matter. The animal's death may occur 4 to 72 h after the clinical course. However, depending on the amount of infective dose of mycotoxins, animal survival time can extend from one to two weeks (Méndez; Riet-Correa, 2007).

The use of corn-based supplementation in the diet of equine involves products such as natural corn, pollard, bran or corn xerém. Some regions make use of waste processing industries of this grain, particularly during the shortage of fodder in pastures, which favors the onset of disease (Ragsda and Debey, 2003).

Frequently detected in corn worldwide and the most commonly associated with leukoencephalomalacia outbreaks. Fumonisins are responsible for a variety of health problems in several animal species, including humans. These compounds are carcinogenic in laboratory rodents and the International Agency for Research on Cancer of the World Health Organization has included them in the list of probable carcinogenic substances for humans. Amongst the domestic animals, horses are the most sensitive to fumonisin intoxication, the toxic effects of FB1 in this species being dose-dependent. The clinical signs include decreased tongue tone and mobility, propioceptive deficit, ataxia, anorexia, lethargy, blindness, circling, aimless walking, head-pressing, hyperexcitability, diaphoresis and coma. Affected animals that develop clinical signs but survive usually show some degree of neurologic deficit for life (Maxie; Youssef 2007; Pacin et al., 2009).

The pathogenesis is not yet completely understood. The enzyme sphingosine-N-acyltransferase is structurally inhibited by fumonisins. This enzyme is involved in sphingolipids biosynthesis and it is hypothesized that the accumulation of the enzyme substrates as well as the depletion of complex sphingolipids, may account for the toxicity of these. The characteristic gross lesion is restricted to the white matter of the cerebral hemispheres and consists of softening, cavitation and yellow discoloration. The lesion may be focal or multifocal, uni or bilateral and mild cases may not show gross lesions at all. Histologically, the most characteristic lesions consist of areas of liquefactive necrosis, edema and hemorrhage affecting the encephalic white matter A presumptive diagnosis is established based on clinical signs and on gross and/or histological findings. Confirmation of the diagnosis relies on detection of toxic concentrations of fumonisins in feed (Beasley, 1999; Maxie and Youssef, 2007).

In horses, the signs are characterized by brain injuries, brain stem injury. In mules, the predominant signs are generally characterized by lesions of the brain stem (Riet-Correa et al., 2007).

PREVENTIVE ACTIONS

The use of pasture rotation in non-host plants and the elimination of crop residues are ways that favor the decrease in pathogenic strains. The increase in microbial activity is decreased by effective practices that increase soil supressiveness by the antagonist ability of these methods provide against potential pathogen (Zhao et al., 2013).

The use of integrated management in modern agriculture has contributed in order not only to increase production in less space, but also in significant improvement in the control of weeds, pests and diseases. The main advantages are increased productivity of crops, increased profitability, significant reduction in production costs, rational use of pesticides, reduced use of water and fuel, and less use of machines for cultivation which leads to lower release of greenhouse gases (Lerayer, 2010).

Advances in crop technologies have increased the productivity of maize. Examples of these new techniques are the direct planting, which uses correction and proper soil fertilization; extensive use of integrated management techniques of weeds, diseases and insect pests; and increased adoption of improved seeds with high production capacity. The most important contributions in the use of these new techniques are the use of simple hybrids and adoption of genetically modified seeds (Gravina; 2011).

Some *Fusarium* spp. tend to be less aggressive, which can be observed by analysis of visible symptoms in the host. Some of these strains can be represented by *F. verticillioides*, which nevertheless is an excellent pathogen in the production of mycotoxins. However, these pathogens should not be neglected since the resistance of a species cannot be extended to the others. That is, resistance to an isolated pure from one species can not result in cross-resistance to a *Fusarium* population in commercial corn fields (Reid et al., 2009). The conditions for fungal growth and therefore mycotoxin production depends on environmental factors and erroneous parameters, such as agricultural production without technical and preventive measures, inadequate drying, handling, packaging, storage, and transport conditions that may promote fungal growth (Marin et al., 2013).

In general, fungal infestations are difficult to be handled by conventional methods due to the ability of these pathogens to survive in different environments. Among these places, the soil and crop residues can be cited, which characterizes the persistence of these pathogens. An efficient and cost-effective control technique is the use of resistant cultivars. (Bakhsh et al., 2007).

The fungicides carbendazim, thiram + benomyl, and thiram + captan, are used for seed treatment (Nene et al., 2012). The systemic use of chemical fungicides on plants is considered costly because it may bring about damage to the environment. Another problem is that these fungicides cannot prevent infection and colonization of roots by the pathogen (Animisha et al., 2012).

The preventive measure against poisoning of equines is based on the recommendation of the use of corn and its sub-products in amounts lower than 20% of total of dry matter ingested by these equines. The corn used must be subjected to a correct drying process. However, the disease can occur in equines who eat corn dried previously with moisture within the standards required in Brazil, which is less than 15%. Thus, it is necessary to completely dry so that there is no possibility of fungal growth in the raw material (Méndez and Riet-Correa, 2007).

CONCLUSIONS

Thus, it can be noted that the equine feeding with the use of ration requires a lot of care. Such care may range from preparation of feed until the supply of the animals. The processes of production, storage and delivery when not held properly could favor the growth of fungi, such as those from the genus *Fusarium*. Fungi of this genus are producers of fumonisin, which can lead to leukoencephalomalacia outbreaks, among other pathologies. Therefore, it is emphasized the importance of control methods and awareness for the production of feed. These actions may help to minimize the contamination by fungi and reduce the risk of diseases to equines, what may lead to a better nutritional quality for the animals and less economic losses.

Conflict of Interests

The authors have not declared any conflict of interests.

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