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Multiannual mycotoxin survey in feed materials and feedingstuffs

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ABSTRACT

Mycotoxins are compounds that can be formed in many raw materials and agricultural products under very different conditions. The study aimed at evaluation of the level of raw materials and products for animal nutrition contamination due to mycotoxins in Poland in 2011–2014. A total of 1384 samples (295 maize samples, 143 maize silage samples, 466 small grain cereal samples and 480 complete feed samples) were analyzed for the occurrence of deoxynivalenol, nivalenol, T-2 toxin, HT-2 toxin, zearalenone, fumonisins, ochratoxin A, and aflatoxins. Deoxynivalenol as well as zearalenone were the most frequently occurring mycotoxins, present in 89% and 92% of maize samples, respectively. They were also the most common mycotoxins in maize silages—86% and 88% of the samples, respectively. Deoxynivalenol and zearalenone were present in 456 (98%) and 450 (97%) small grains samples. Additionally, in 24 samples the content of mycotoxins exceeded the EU recommendation. Regarding the complete feed, trichothecenes and zearalenone were found in more than 90% of the samples. A moderate to strong positive correlation between DON and ZEN, as well as T-2 toxin and HT-2 toxin contents was observed for all matrices. The four-year survey indicated again that both feed materials and feeding stuffs are contaminated with mycotoxins, and in most cases the samples contained several compounds of interest.

1. Introduction

Both man and animals are exposed to undesirable substances that are harmful to their health. These include compounds naturally produced by plants, pollution emitted to the environment from industry, plant protection means or residues of veterinary drugs, that enter both animal and human organism most often through digestive tract. Nowadays, due to introduction of new cultivation techniques (e.g. intensive maize-wheat rotations, higher levels of nitrogen fertilizers) and climate changes, mainly in temperature and precipitation patterns, that have impact on the persistence and occurrence patterns of molds and thus their secondary metabolites—mycotoxins, the latter have become a problem of interest (Tirado et al., 2010; Landschoot et al., 2012).

Abbreviations: AF, aflatoxins; OTA, ochratoxin A; FUM, fumonisins; DON, deoxynivalenol; NIV, nivalenol; T2, T-2 toxin; HT2, HT-2 toxin; ZEN, zearalenone; ZAN, zearalanone; MeOH, methanol; ACN, acetonitrile; HPLC, high-performance liquid chromatography; MS/MS, tandem mass spectrometry; LOD, limit of detection; LOQ, limit of quantitation.

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Table 1
Feed samples exceeding recommended acceptable level of mycotoxins.

Mycotoxin	Feedingstuff	Concentration (μg/kg)
DON	Maize silage	7860 (17830)[a]
	Maize silage	7844 (18260)[a]
	Maize silage	7167 (15930)[a]
	Maize silage	7016 (17440)[a]
	Wheat	8187
	Complete feed (cattle)	5487
T2 + HT2	Maize	2133
	Maize	756
	Maize	563
	Oat	635
	Barley	514
	Complete feed (swine)	459
	Complete feed (swine)	440
	Complete feed (swine)	373
	Complete feed (swine)	314
	Complete feed (swine)	304
	Complete feed (poultry)	279
ZEN	Complete feed (swine)	349
	Complete feed (swine)	339
	Complete feed (poultry)	294
	Complete feed (poultry)	264
	Complete feed (poultry)	252
OTA	Complete feed (swine)	88.0
	Complete feed (cattle)	50.6

[a] Values calculated for a moisture content of 12%.

Mycotoxins are secondary metabolites of molds belonging mainly to the following genera: *Aspergillus*, *Penicillium*, and *Fusarium*. They may show acute toxic action, mutagenic (aflatoxins, fumonisins, ochratoxin A, T-2 toxin), teratogenic (ochratoxin A, patulin, aflatoxin B_1, T-2 toxin), and estrogenic properties (zearalenone). From the health and economic point of view, the most important include, among others, aflatoxins, ochratoxin A, fumonisins, zearalenone, and trichothecenes (Richard and Payne, 2003). Factors affecting molds growth and/or mycotoxins production, and thus contamination of raw materials and feed are associated with field conditions (i.e. temperature and humidity around harvest). Especially the development of fusaria and their metabolites in cereal crops is strongly influenced by weather conditions. Mycotoxins production in the field is also dependent on crop susceptibility, insect or bird damages and mechanical injuries. The temperature and moisture as well as microbial and insect growth are also the main factors influencing the molds and mycotoxins infestation during storage. So, it is very important to apply the pre-harvest control strategies, appropriate harvest management as well as storage conditions to reduce at least the molds growth and mycotoxin production. The way of raw material processing (e.g. ensiling process in case of silages) is not meaningless and may influence the mold and mycotoxins occurrence as well, when its parameters, i.a. the raw material quality, the use of silage additives, silo filling rate or packing tightness are chosen improperly (Milićević et al., 2010; Cheli et al., 2013).

Aflatoxins (AF) are synthetized primarily by *Aspergillus flavus* and *Aspergillus parasiticus* strains, particularly in warm climate. The four main compounds are B_1, B_2, G_1, and G_2. The plant-origin products most often contain larger quantities of metabolites B_1 and G_2. Aflatoxins can be produced by molds, both during storage and in the field, and the main factors that promote contamination are drought stress in plants and wet weather conditions in combination with high temperature during harvest. Ochratoxin A (OTA) is produced by *Penicillium verrucosum* and some *Aspergillus* species: *Aspergillus ochraceus* and *Aspergillus carbonarius*, particularly in north temperate growing areas. The greatest danger of the ochratoxin A formation occurs during storage of a grain characterized by excessive humidity, which favors the growth of *Aspergillus* and *Penicillium* fungi. Fumonisins (FUM) are a group of mycotoxins often contaminating maize, frequently accompanied by other mycotoxins. The B_1 form is most common. These toxins are usually produced by fungi of *Fusarium* genus with the most important species: *Fusarium verticilioides* and *Fusarium proliferatum*. The contamination by fumonisins may occur worldwide but higher content in commodities may be present in warm, dry climate areas. Deoxynivalenol (DON) belongs to a group of trichothecenes produced mainly by fungi such as: *Fusarium graminearum*, *Fusarium culmorum*, and *Fusarium nivale*. In addition to DON, other naturally occurring trichothecenes include, among others, nivalenol (NIV), T-2 toxin (T2), HT-2 toxin (HT2), and diacetoxyscirpenol. These compounds are produced most frequently during prolonged periods of cold, during the growing season and harvesting under conditions of high humidity, when the infected grains allow *Fusarium* spores to develop. Zearalenone (ZEN) is produced by: *Fusarium sporotrichoides*, *Fusarium oxysporum*, *Fusarium moniliforme*, and *Fusarium crookwellence*. Like trichothecenes, it is produced mainly during the growth of plants in the field (Weidenbörner, 2001; Richard, 2007).

Mycotoxins are compounds that can be formed in many raw materials and agricultural products under very different conditions. They are resistant to high and low temperatures, even after prolonged storage, they do not degrade being very