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OCCURRENCE OF DEOXYNIVALENOLIN CEREALS AND CEREAL BASED PRODUCTS: A SHORT REVIEW

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ABSTRACT

During recent decades, the contamination of cereal grains with toxic metabolites of *Fusarium* species has been increasingly documented. Deoxynivalenol (DON) is one of the most common trichothecene toxins produced by *F. graminearum.* Wheat, rice, corn (maize),oats, barley and other grains used for human and animal consumption are frequently contaminated with DON. DON affects animal and human health causing vomiting, acute temporary nausea, diarrhea, abdominal pain, headache, dizziness, and fever. In this paper, we reviewedrecent studies in DON contamination incereals and cereal based products.

Key words: Deoxynivalenol, *Fusarium graminearum,* Mycotoxin, Trichothecenes.

INTRODUCTION

The presence of mycotoxins in agricultural products, mostly grains, has a potential hazard to the health of humans and animals. Cereal plants may be contaminated by mycotoxigenic fungal strains during anthesis that continue their proliferation during harvest and storage under favourable conditions [1]. Trichothecenes which are a large group of agriculturally important mycotoxins, are produced mainly by species belonging to the genus *Fusarium*. According to their chemical structure, they have been classified into four groups: types A–D, the most found in cereals are types A and B. The most prevalent B-trichothecenes are deoxynivalenol (DON), nivalenol (NIV), 15-acetyldeoxynivalenol (15-AcDON) and 3-acetyldeoxynivalenol (3-AcDON) [1, 2, 3]. Among the trichothecenes, DON is detected most frequently worldwide and in highest concentrations in cereal grains in Poland, Germany, Japan, New Zealand, and the Americas [4].DON is one of several mycotoxins produced by certain *Fusarium* species that frequently infect wheat, corn, rye, rice, oats, barley and other grains in the field or during storage [5, 6]. *F. graminearum*Schw. is one of the most frequently found *Fusarium* species on cereals. *F. graminearum* has a broad host range and can cause Fusarium head blight of wheat and barley often called FHB which has been reported in wheat growing areas worldwide but is especially prevalent in temperate climates when relatively cool temperatures and weather coincide during flowering stage [4, 7]. DON affects animal and human health causing vomiting, acute temporary nausea, diarrhea, abdominal pain, headache, dizziness, and fever [8]. It is also known as vomitoxin due to his strong emetic effects after consumption, because it is transported into the brain, where it runs dopaminergic receptors. The emetic effects of this mycotoxin were firstly described in Japanese men consuming mouldy barley containing *Fusarium* fungi in 1972[5, 8]. DON is reported to be a very stable compound, both during storage, milling and the processing, cooking of food and does not degrade at high temperatures and also bind to the ribosomal peptidyl-transferase site and inhibit protein and DNA synthesis, consequently exposure results in decreased cell proliferation [9, 10]. Physico-chemical properties of DON were shown in Table 1 [8].The limiting

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rates of DON in cereals and cereal products were shown in Table 2 [11]. In this paper, we reviewed recent studies in DON contamination in cereals and cereal based products.

Occurrence of DON in cereals and cereal based products

Cereals and cereal products are significant and important human food resources and livestock feeds worldwide. The main cereal grains used for foods include corn, wheat, barley, rice, oats, rye, millet, and sorghum. Examples of cereal products derived from cereal grains include wheat, rye, and oat flours and semolina, cornmeal, corn grits, breads, pasta, breakfast cereals, snack foods, cakes, dry mixes, pastries and tortillas [12,13]. Many researchers from different countries have carried out studies about the incidence of DON in cereals and cereal based products. Data from the studies on the occurrence of DON in cereals and cereal products are reported in Table 3.

Table 1.Physico-chemical properties of deoxynivalenol

Property	Information
Name	Deoxynivalenol (DON), vomitoxin
IUPAC name	12,13-epoxy-3α,7α,15-trihydroxytrichothec-9-en-8on
Molecular formula	$H_{15}O_{20}O_6$
Molar mass	296.32 g/mol
Physical state	Colourless fine needles
Boiling Point (°C)	543.9 ± 50.0 °C
Melting Point (°C)	151–153 °C
Flash Point (°C)	206.9 ± 2.5
Soluble in	polar organic solvents (*e.g*., methanol, ethanol, acetonitrile, chloroform, and ethyl acetate) and water

Table 2. Maximum limits for DON in cereals and cereal products

Deoxynivalenol	Maximum Limit (µg/kg)
Unprocessed cereals, other than durum wheat, oats and maize	1250
Unprocessed durum wheat and oats	1750
Cereals intended for direct human consumption, cereal flour, bran for direct human consumption and germ (with the exception of products for infants and young children listed below)	750
Processed cereal-based foods and baby foods for infants and young children	200
Bread, pastries, biscuits, cereal snacks and breakfast cereals	500

Table 3. Occurrence and content of DON in cereals and cereal based products

Year	Region	Technique	Sample	Positive samples	Range	Reference
1999	Germany	HPLC	60 Wheat flour	98.3%	15–1379 µg/kg	Schollenberger et al [14]
2002 - 2003	Turkey	HPLC	50 Beer	ND	ND	Omurtag and Beyoglu [15]
2004-2005	Iran	HPLC	60 Corn	76.7%	54.4-518.4 ng/g	Karami-Osboo et al [16]
2004-2005	Serbia	LC	76Maize 16Wheat 24Soybean 19 Sunflower 4Barley	Maize44.7% Wheat37.5% Sunflower47.4% Soybean8.3% Barley25%	Maize 0.040–2.460 Wheat 0.057- 1.840 Soybean 0.100 Sunflower 0.040-0.788 Barley 0.040-0.304 mg/kg	Jajic et al [17]
2005	Spain	GC	175Corn-based food products	26.8%	26.1–131.7 µg/kg	Castillo et al [18]

2006	Iran	ELISA	227 Wheat 154 Barley	Wheat 44.97 % Barley 78.36%	Wheat 18.53 to 192.81 Barley 15.19 to 280.6 ng/g	Mirabolfathy and Karami-Osboo [4]
2007	Tunisia	HPLC	65 Durum wheat	83%	12.8 - 30.5 µg/g	Bensassi et al [1]
2009	Spain	GC/MS	75 Bread 75 Pasta	Bread28% Pasta62.6%	Bread 12.2- 146.6 Pasta 10.9–623.3 µg/kg	Osnaya et al [19]
2009	Poland	ELISA	91 Beer	100%	6-70.2 µg/L	Kuzdralinski et al [20]
2010	Indonesian	HPLC	24 Maize kernels 26 Maize based food products	100%	47 - 348 µg/kg	Setyabudi et al [21]
2012	China	GC/MS	40 Soy sauces	97.5%	4.5-1245.6 µg /l	Zhao et al [22]
2011	Italy	ELISA	35 Maize 15 Barley 12 Oats 10 Rice bran	Maize 37.1% Barley73.3% Rice bran30%	Maize 0.3-1.9 Barley 0.2-0.9 Rice bran 0.4-1.2 mg/kg	Cortinovis et al [23]
2012	India	HPLC	50 Wheat 25 Maize 25 Barley	Wheat40% Maize24% Barley16%	Wheat 0.07-4.73 Maize 0.01-1.07 Barley 0.03-0.53 mg/kg	Mishra et al [24]
2012	Morocco	LC	81 Durum wheat	11.1%	65 - 1310 µg/kg	Ennouari et al [25]

CONCLUSION

DON is a damaging toxin produced by the fungus *Fusarium graminearum* in the heads of small grains. In addition to DON, *F. graminearum* strains may also produce modified forms of DON called 3-ADON and 15-ADON. DON intake causes immune suppression, emesis, and diarrhea in animals. In ruminants, DON is detoxified in the rumen by a transformation de-epoxygenation reaction. A DON metabolite, de-epoxy DON (DOM-1), has been detected in milk, urine, and feces. Therefore, DON contamination of feed is not only a problem for animal health but also poses a threat to human health through its accumulation in food products .Thus, many countries now have regulations for limiting DON contamination of both food and feed. In conclusion, According to results obtained, incidence and contamination levels of DON seem to be a serious problem for public health. Therefore, cereal and cereal based foods should be controlled for the presence of toxins, storage conditions and moisture content, which is considered a major factor in the growth of the fungi of the genus *Fusarium.*

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