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Biological SciencesJournal homepage: www.Sjournals.com**Review article****Occurrence of deoxynivalenol in cereals and cereal based products: a short review****A.Tajehmiri^a, M.A. Aliabadi^b, R.K. Darsanaki^{b,*}**^aMedical Biology Research Center Kermanshah, University of Medical Sciences, Kermanshah, Iran.^bDepartment of Microbiology, College of Microbiology Science, Lahijan Branch, Islamic Azad University, Lahijan, Iran.

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ABSTRACT

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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 reviewed recent studies in DON contamination in cereals and cereal based products.

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1. 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 (Bensassi et al., 2010). 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) (Bensassi et

al., 2010; Bottalico, 1998; Hussein and Brasel, 2001). 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 (Mirabolfathy and Karami-osboo, 2013). 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 (Kushiro, 2008; Ji et al., 2011). *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 (Mirabolfathy and Karami-osboo, 2013; Goswami and Corby kistler, 2004). DON affects animal and human health causing vomiting, acute temporary nausea, diarrhea, abdominal pain, headache, dizziness, and fever (Sobrova et al., 2010). It is also known as vomitoxin due to its 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 (Kushiro, 2008; Sobrova et al., 2010). 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 binds to the ribosomal peptidyl-transferase site and inhibits protein and DNA synthesis, consequently exposure results in decreased cell proliferation (Simsek et al., 2012; Shifrin and Anderson, 1999). Physico-chemical properties of DON were shown in Table 1 (Sobrova et al., 2010). The limiting rates of DON in cereals and cereal products were shown in Table 2 (Pestka et al., 2007). In this paper, we reviewed recent studies in DON contamination in cereals and cereal based products.

Table 1

Physico-chemical properties of deoxynivalenol.

Property	Information
Name	Deoxynivalenol (DON), vomitoxin
IUPAC name	12,13-epoxy-3 α ,7 α ,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 \pm 50.0 °C
Melting Point (°C)	151–153 °C
Flash Point (°C)	206.9 \pm 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 (μ g/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. (2002)
2002 -2003	Turkey	HPLC	50 Beer	ND	ND	Omurtag and Beyoglu (2007)
2004-2005	Iran	HPLC	60 Corn	76.7%	54.4-518.4 ng/g	Karami-Osboo et al. (2010)
			76 Maize	Maize44.7%	Maize0.040–2.460	
			16 Wheat	Wheat37.5%	Wheat0.057- 1.840	
2004-2005	Serbia	LC	24 Soybean	Sunflower47.4%	Soybean0.100	Jajic et al. (2008)
			19 Sunflower	Soybean8.3%	Sunflower0.040- 0.788	
			4 Barley	Barley25%	Barley0.040-0.304mg/kg	
2005	Spain	GC	175 Corn-based food products	26.8%	26.1–131.7µg/kg	Castillo et al. (2008)
			227 Wheat	Wheat44.97 %	Wheat18.53 to 192.81	Mirabolfathy and Karami-Osboo (2013)
2006	Iran	ELISA	154 Barley	Barley 78.36%	Barley15.19 to 280.6 ng/g	
2007	Tunisia	HPLC	65 Durum wheat	83%	12.8 - 30.5µg/g	Bensassi et al. (2010)
			75 Bread	Bread28%	Bread12.2- 146.6	Osnaya et al. (2011)
2009	Spain	GC/MS	75 Pasta	Pasta62.6%	Pasta10.9–623.3µg/kg	
2009	Poland	ELISA	91 Beer	100%	6-70.2 µg/L	Kuzdralinski et al. (2013)
			24 Maize kernels			
2010	Indonesian	HPLC	26 Maize based food products	100%	47 - 348 µg/kg	Setyabudi et al. (2013)
2012	China	GC/MS	40 Soy sauces	97.5%	4.5-1245.6 µg /l	Zhao et al. (2013)
			35 Maize	Maize 37.1%	Maize0.3-1.9	
2011	Italy	ELISA	15 Barley	Barley73.3%	Barley0.2-0.9	Cortinovic et al. (2012)
			12 Oats	Rice bran 30%	Rice bran0.4-1.2mg/kg	
			10 Rice bran			
2012	India	HPLC	50 Wheat	Wheat 40%	Wheat0.07-4.73	Mishra et al. (2013)
			25 Maize	Maize 24%	Maize0.01-1.07	
			25 Barley	Barley 16%	Barley0.03-0.53mg/kg	
2012	Morocco	LC	81 Durum wheat	11.1%	65 - 1310 µg/kg	Ennouari et al. (2013)

2. 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 (Yazar and Omurtag, 2008; Miller, 2003). 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.

3. 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*.

References

- Bensassi, F., Zaied, C., Abid, S., Hajlaoui, M.R., Bacha, H., 2010. Occurrence of deoxynivalenol in durum wheat in Tunisia. *Food Control.*, 21, 281–285.
- Bottalico, A., 1998. *Fusarium* disease of cereals: Species complex and related mycotoxin profiles, in Europe. *J. Plant Pathol.*, 80, 85–103.
- Castillo, M.A., Montes, R., Navarro, A., Segarra, R., Cuesta, G., Hernandez, E., 2008. Occurrence of deoxynivalenol and nivalenol in Spanish corn-based food products. *J. Food Comp. Analys.*, 21, 423–427.
- Cortinovis, C., Battini, M., Caloni, F., 2012. Deoxynivalenol and T-2 Toxin in Raw Feeds for Horses. *J. Equ. Veter. Sci.*, 32, 72-74.
- Ennouari, A., Sanchis, V., Marín, S., Rahouti, M., Zinedine, A., 2013. Occurrence of deoxynivalenol in durum wheat from Morocco. *Food Control.*, 32, 115-118.
- Goswami R.S., Corby kistler, H., 2004. Heading for disaster: *Fusarium graminearum* on cereal crops. *Mol. Plant Pathol.*, 5(6), 515–525.
- Hussein, H.S., Brasel, J.M., 2001. Toxicity, metabolism and impact of mycotoxins on humans and animals. *Toxicol.*, 167, 101–134.
- Jajic, I., Juric, V. Abramovic, B., 2008. First survey of deoxynivalenol occurrence in crops in Serbia. *Food Control.*, 19, 545–550.
- Ji, F., Li, H., Xu, J., Shi, J., 2011. Enzyme-Linked Immunosorbent-Assay for Deoxynivalenol (DON). *Toxins.*, 3, 968-978.
- Karami-Osboo, R., Mirabolfathy, M., Aliakbari, F., 2010. Natural Deoxynivalenol Contamination of Corn Produced in Golestan and Moqan Areas in Iran. *J. Agr. Sci. Tech.*, 12, 233-239.
- Kushiro, M., 2008. Effects of Milling and Cooking Processes on the Deoxynivalenol Content in Wheat. *Int. J. Mol. Sci.*, 9, 2127–2145.
- Kuzdralinski, A., Solarak, E., Muszynski, M., 2013. Deoxynivalenol and zearalenone occurrence in beers analysed by an enzyme-linked immunosorbent assay method. *Food Control.*, 29, 22-24.

- Miller, J.D., 2003. Aspects of the ecology of *Fusarium* toxins in cereals. In J. W. de Vries, M. W. Trucksess, & L. S. Jackson (Eds.), *Mycotoxins and food safety*. New York: Kluwer Academic/Plenum Publishers.
- Mirabolfathy, M., Karami-osboo, R., 2013. Deoxynivalenol and DON-Producing *Fusarium graminearum* isolates in wheat and barley crops in north and northwest areas of Iran. *Iran. J. Plant Path.*, 48(4), 197-210.
- Mishra, S., Ansari, K.M., Dwivedi, P.D., Pandey, H.P., Das, M., 2013. Occurrence of deoxynivalenol in cereals and exposure risk assessment in Indian population. *Food Control.*, 30, 549-555.
- Omurtag, G.Z., Beyoglu, D., 2007. Occurrence of deoxynivalenol (vomitoxin) in beer in Turkey detected by HPLC. *Food Control.*, 18, 163–166.
- Osnaya, L.G., Cortes, C., Soriano, J.M., Molto, J.C., Manes, J., 2011. Occurrence of deoxynivalenol and T-2 toxin in bread and pasta commercialised in Spain. *Food Chem.*, 124, 156–161.
- Pestka, J.J., 2007. Deoxynivalenol: Toxicity, mechanisms and animal health risks. *Anim. Feed Sci. Technol.*, 137, 283–298.
- Setyabudi, F.M.C.S., Nuryono, N., Wedhastri, S., Mayer, H.K., Razzazi-Fazeli, E., 2012. Limited survey of deoxynivalenol occurrence in maize kernels and maize-products collected from Indonesian retail market. *Food Control.*, 24, 123-127.
- Schollenberger, M., Terry Jara, H., Suchy, S., Drochner, W., Muller, H.M., 2002. *Fusarium* toxins in wheat flour collected in an area in southwest Germany. *Int. J. Food Microbiol.*, 72, 85– 89.
- Shifrin, V.I., Anderson, P., 1999. Trichothecene mycotoxins trigger a ribotoxic stress response that activates c-Jun N-terminal kinase and p38 mitogen-activated protein kinase and induces apoptosis . *J. Biol. Chem.*, 274, 13985–13992.
- Simsek, S., Burgess, K., Whitney, K.L., Gu, Y., Qian, S.Y., 2012. Analysis of Deoxynivalenol and Deoxynivalenol-3-glucoside in wheat. *Food Control.*, 26, 287-292.
- Sobrova, P., Adam, V., Vasatkova, A., Beklova, M., Zeman, L., Kizek, R., 2010. Deoxynivalenol and its toxicity. *Int. Toxicol.*, 3(3), 94–99.
- Yazar, S., Omurtag, G., 2008. Fumonisin, Trichothecenes and Zearalenone in Cereals. *Int. J. Mol. Sci.*, 9, 2062–2090.
- Zhao, H., Wang, Y., Zou, Y., Zhao, M., 2013. Natural occurrence of deoxynivalenol in soy sauces consumed in China. *Food Control.*, 29, 71-75.