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Assessment of deoxynivalenol (DON) contamination of cereal grain and cereals collected from organic and conventional cultivations

Ocena poziomu zanieczyszczeń deoksyniwalenolem (DON) produktów zbożowych i zbóż z upraw ekologicznych i konwencjonalych

Abstract:

Introduction
The production volume of ecological food in Lubuskie Province tripled between 2007-2010. A majority of organic products on the market are cereal products, which constitute one of the sources of mycotoxins in both human and animal diets. The aim of the study was to compare the content of deoxynivalenol (DON) in cereals and in cereal grain derived from organic and conventional cultivations marketed in Lubuskie Province.

Materials and methods
The material tested consisted of samples of cereal grain (wheat, rye, barley, oats) and cereals products (flour, groats, pasta). The concentration of deoxynivalenol (DON) in the items tested was determined by high performance liquid chromatography.

Results
The study, which used product samples (cereals, grain, flour), targeted the presence of deoxynivalenol (DON). One case revealed that the highest permissible level (MRL) of the mycotoxins as determined by relevant regulations in force was exceeded. It also revealed a similar content of deoxynivalenol (DON) in grain and in cereals obtained from organic and conventional cultivations. Flour differentiated significantly as regards organic and conventional products, although unfavourably for the latter which were 80 per cent contaminated as compared to a 60% contamination prevalent in the organic ones. Deoxynivalenol (DON) was found in both types of products, yet it was the conventional products that showed the highest concentrations.

Conclusion
Of the studied samples, those that were obtained from organic cultivations showed lower contamination levels as compared to conventional products. An increase in deoxynivalenol (DON) contamination occurs during the processing phase, the more processed the raw product, the higher the number of samples containing mycotoxin.

Streszczenie:

Wstęp
Produkcja żywności ekologicznej w województwie lubuskim zwiększyła się ponad trzykrotnie w latach 2007-2010. Zdecydowana większość produktów ekologicznych na rynku to produkty zbożowe, które są jednym z głównych źródeł mikotoksyn zarówno w diecie człowieka i zwierząt. Celem pracy było porównanie zawartości deoksyniwalenolu (DON) w zbożach i przetworach zbożowych pochodzących z upraw ekologicznych i konwencjonalnych, znajdujących się w obrocie handlowym na terenie województwa lubuskiego.

Materiał i metody
Badaniami objęto próbki zbóż (pszenicy, żyta, jęczmienia, owsa) i przetworów zbożowych (mąki, kasze, makarony) pod kątem obecności w nich deoksyniwalenolu (DON). Stężenie deoksyniwalenolu (DON) w badanych produktach określano metodą wysokosprawnej chromatografii cieczowej (HPLC).

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Wyniki
W jednym przypadku stwierdzono przekroczenia najwyższego dopuszczalnego poziomu (NDP) badanej mikotoksyny, określonego w obowiązującym rozporządzeniu. Badania wykazały podobną zawartość deoksyniwalenolu (DON) w zbożu i przetworach zbożowych pochodzących z produkcji zarówno ekologicznej, jak i konwencjonalnej. W przypadku mąki zaistniała istotna różnica pomiędzy produktami ekologicznymi i konwencjonalnymi na niekorzyść tych drugich, gdzie skażonych było 60% próbek z produkcji ekologicznej i 80% konwencjonalnej. Deoksyniwalenol (DON) odnotowano w obu rodzajach produktów, przy czym największe jego stężenie wystąpiło w produktach konwencjonalnych.

Wnioski
W badanych próbkach, produkty z upraw ekologicznych wykazują mniejsze skażenie deoksyniwalenolem (DON) niż produkty z upraw konwencjonalnych. Odnotowano wzrost skażenia deoksyniwalenolem (DON) badanych produktów w fazie przetwórstwa (im bardziej przetworzony surowiec, tym więcej odnotowano próbek z zawartością mikotoksyny).

Słowa kluczowe: *deoksyniwalenol, mikotoksyny, zboża, produkty zbożowe*
Keywords: *deoxynivalenol, mycotoxins, cereals, cereal products*

Introduction

Mycotoxins are low molecular weight compounds produced by secondary fungus metabolites that chiefly affect grain crops such as wheat, maize, barley, oats and rye. They may induce toxic and/or carcinogenic changes in animals and in humans, even at low concentrations in some cases [2,12,25].

Fungi from the kingdom of *Fusarium* may produce mycotoxins belonging to three groups of toxins: trichothecenes (deoxynivalenol, nivalenol), fuminosines and zearalenons [1]. In Poland, those which belong to trichothecenes are particularly dangerous [11]. These mycotoxins attack ears and panicles across all climatic spheres. [4]. According to Golińskiet al., if the ear does not show a sizeable intensity of fusariosis, then the amount of coccidia fusarosis mycotoxins is low [8, 9].

Undoubtedly, it is high moisture levels during vegetation, especially prior to harvesting, that fosters the development of *Fusarium* genus. This also poses a threat to the storage of crops and their products [14, 24]. *Fusarium* toxins are generally fairly stable during processing and cannot be thoroughly removed, which, in later processing stages, may lead to potential contamination of marketable cereals.

Deoxynivalenol (DON) is the most serious toxin prevalent in wheat and its products owing it to its occurrence in the world and its potential toxic impact on human and animal health. Research confirms the widespread distribution of deoxynivalenol in cereals and feed [3]. Deoxynivalenol is accountable for impeding protein synthesis, reducing enzyme activity, disturbing the division of citoplasmatic membranes, and disturbing cell division and cell processes [10, 13, 16]. In December 1999, the Foodstuff Scientific Committee determined the Tolerated Daily Intake (TDI) of deoxynivalenol to be 1 μg/kg of body weight [18]. In order to minimise the contamination of grain crops and cereals with mycotoxins and to protect consumer health the highest permissible levels of deoxynivalenol (1250 μg/kg) in cereals, 750 μg/kg in cereals were established [20].

Organic cultivations are thought to produce crops free of mycotoxins. Plant production in that system consists of controlling or limiting the unwholesome impact of agrofags through preventive measures and the application of methods other than chemical agents [17]. Nonetheless, the unavailability of fungicides in crop protection against fusarosis may lead to an increase in the content of mycotoxins produced by *Fusarium* fungi.

The objective of the study was to compare the content of deoxynivalenol (DON) in grain crops and in cereals derived from organic and conventional cultivations marketed in the Province of Lubuskie.

Material and research method

The material used in the study was sampled from foodstuffs collected from shops in Lubuskie Province. The following were subject to analysis for the presence of deoxynivalenol (DON): cereal grain (wheat, rye, barley, oats) and cereals products (flour, groats, pasta). The samples tested to determine deoxynivalenol were prepared in accordance with the methodological publication of the National Institute of Hygiene: "Determination of *Fusarium* toxins – deoxynivalenol (DON) in grain crops and cereals by means of high proficiency gas liquid chromatography with purification by means of immunologic affinity" [26].

Deoxynivalenol (DON) was isolated from the products by means of Donprep® (R-Biopharm Rhône) immunological affinity columns to isolate deoxynivalenol (DON) in compliance with the procedures established by the manufacturer of columns.

Results and discussion

As many authors point out, deoxynivalenol (DON), on account of its frequent occurrence and toxic character, is believed to be the most serious mycotoxin to contaminate cereals intended for consumption and as fodder [7, 13]. The obtained results revealed a widespread distribution of deoxynivalenol (DON) in grain crops and in organic and conventional cereals.

The average content of deoxynivalenol was found to be highest in samples of conventional cereals and in conventional flour and equalled 387.67 and 279.00 µg/kg respectively (Table 1). It has to be emphasised that the highest permissible level of the tested mycotoxin in the case of a single pasta sample (792 µg/kg) exceeded the permissible level described in the regulation in force [20]. Scholleberger et al. found deoxynivalenol in conventional flour to be at the level of 394 µg/kg [21]. The studies carried out by Stanisławczyk et al. revealed the average content of deoxynivalenol was highest in samples of grain crops and flour, and equalled 127.95 µg/kg and 127.36 µg/kg respectively [23].

Tab. 1. Content of deoxynivalenol (DON in cereals and cereal products [µg/kg]

Tab. 1. Zawartość deoksyniwalenolu (DON) w zbożach i przetworach zbożowych [µg/kg]

Food products (name)	Type of product	Content of deoxynivalenol [µg/kg]			
			minimum	maximum	MRL
Cereal grain	ecological	178.00	130.00	226.00	1250
	conventional	343.67	137.00	529.00	
Flour	ecological	201.50	104.00	459.00	750
	conventional	279.00	159.00	486.00	
Cereal products	ecological	199.60	102.00	465.00	750
	conventional	387.67	137.00	792.00	

The chromatographic analysis revealed the presence of deoxynivalenol (DON) in wheat obtained from the two types of cultivation – organic and conventional. The organic wheat showed 178 µg/kg of mycotoxin and it was discovered in 37.5% of samples while the variation was between 130 to 226 µg/kg. Deoxynivalenol (DON) was also found in 62.5% of the tested samples of conventionally grown crops where the average content was 343.67 µg/kg while the variation ranged between 137 and 529 µg/kg (Fig. 1). According to Chełkowski, the content of DON in attacked wheat and triticale coccidia is on the average 30 µg/kg [6]. Whereas sound grain shows a low DON content and equals less than 0.05 µg/kg. Coccidia fusarosis can be seen in all grain species, both in spring and winter crops [19]. Other research carried out by Birzele showed that a majority of green and conventional crops were contaminated with deoxynivalenol (DON) at a comparable level [3]. Yet Malmuret et al. in their studies noticed that conventional grain crops showed more frequent cases of contamination at lower levels, while organic grain crops have yet a rarer prevalence of higher content [15].

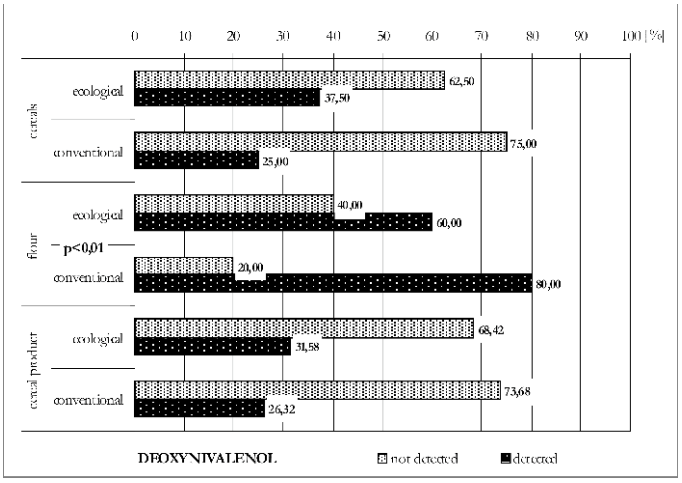

Fig. 1. The content of deoxynivalenol (DON) in products from organic (n = 32) and conventional (n = 32) cultivations

Ryc. 1. Zawartość deoksyniwalenolu (DON) w produktach pochodzących z ekologicznych (n=32) i konwencjonalnych (n=32) upraw

Organic flour DON averaged 201.50 µg/kg and was found in 60% of samples varying from 104 to 459 µg/kg, whereas conventional flour DON was 279.00 µg/kg at the minimal value of 159 µg/kg, and the maximal one of 486 µg/kg; 80% of the samples were contaminated with mycotoxin (Fig. 2).

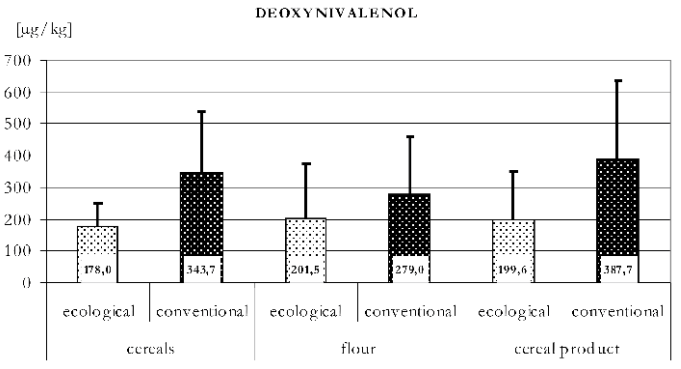

Fig. 2. Compare the contents of deoxynivalenol (DON) in the tested product samples

Ryc. 2. Porównanie zawartości deoksyniwalenolu (DON) w badanych próbkach produktów

Cereals obtained from organic cultivations showed an average content of the mycotoxin to be 199.6 µg/kg which was confirmed in 31.5% of the samples with variations

ranging from 102 to 465 μg/kg. The percentage of contaminated cereal samples was 26.32%, while the average DON content was 387.67 μg/kg varying between 137 and 792 μg/kg. The frequency of contamination with deoxynivalenol (DON) in conventional flakes served for breakfast was 64% [5]. Schollenberger et al. [22] in their studies showed that 67% of the breakfast flakes tested were contaminated with mycotoxin.

Conclusion

1. Out of the studied samples those that were obtained from organic cultivations showed lower contamination levels as compared to conventional products.
2. An increase in deoxynivalenol (DON) contamination during the processing phase (the more processed the raw product, the higher the number of samples containing mycotoxin).
3. Deoxynivalenol (DON) was also found in cereals, flour as well as in grain crops.
4. Inasmuch as flour is concerned, a significant difference disfavoured conventional products when compared to organic ones; the former revealed 80% of samples contaminated in contrast with 60% of organic samples.

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