Levels and pattern of contamination with trichothecenes in cereal grains and their risk assessment

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Trichothecenes are commonly found in cereal grains such as wheat, barley, and maize, and less often in oat, rice, rye, sorghum, and triticale. The occurrence of trichothecenes is mainly associated with *Fusarium* species which are important plant pathogenic fungi, causing several crop diseases such as head blight in wheat and ear rot in maize. After consumption of *Fusarium*-infected grains, the emetic effect occurs in humans as one of earliest symptoms of trichothecenes. Deoxynivalenol (DON) and nivalenol (NIV) are major trichothecenes, and had caused animal and human intoxication in Japan.

Occurrence of DON in wheat and barley is associated primarily with *Fusarium graminearum* (teleomorph; *Gibberella zeae*) in Japan, and also with *F. culmorum* in foreign countries. *F. graminearum* is divided into two populations; DON-producing *F. graminearum* and NIV-producing *F. graminearum*. Interestingly, their distribution has geographical difference in local fields of Japan, and their niches are closely related to the proportion of DON/NIV in wheat and barley grains harvested. In Hokkaido and Tohoku districts, DON-producing *F. graminearum* exists predominantly whereas, NIV and DON-producing *F. graminearum* are widely distributed south of the Tohoku district¹⁾. Hence, co-occurrence of DON and NIV in wheat and barley is commonly found as reported earlier. In Hokkaido, the levels and frequency of DON is prevailing to those of NIV^{2,3)}. However, the levels and frequency of NIV has gradually increased south of the Tohoku district. The proportion of DON/NIV in wheat and barley ranges from 30 to 80 %. As other NIV-producing *Fusarium* species, *F. poae* and *F. crookwellense* distribute widely in the crop fields of Hokkaido, and they are responsible for NIV contamination in wheat and barley cultivated in Hokkaido¹⁾. On the other hand, the surveys in Korea suggest that NIV occurs mainly in cereals due to prevailing NIV-producing *F. graminearum*⁴⁾. Further, surveys have indicated that co-contamination of DON and NIV was common in cereal grains harvested from 21 countries in the world although, the level and frequency of DON/NIV was different⁵⁾.

In 2001, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) established 1 µg/kg of body weight per day as a provisional maximum tolerable daily intake (PMTDI) for DON based on the results of a 2-years feeding study in mice. In Japan, the Ministry of Health, Labor and Welfare recommended 1.1 mg/kg of DON levels as provisional standard for local governments in unpolished

wheat on May 21, 2002, because it requires further investigations to establish the administrative guideline based on Article 7 of Food Sanitation Law in Japan⁶⁾.

The year before last, the contamination of domestic and imported wheat with DON and NIV was examined. The data revealed that 33 out of 36 domestic wheat samples tested were positive for DON, and the mean concentrations and range were 388 µg/kg and 0-2,248 µg/kg, respectively. In addition, 4 samples were in excess of the allowable limits. In imported wheat, 75 % of 20 samples were positive for DON, and the mean concentrations and range were 100 µg/kg and 0-740 µg/kg, respectively. Based on 89.9 g of Japanese prospective intake of wheat and assuming 50 % reduction of DON at manufacturing process, the corresponding limit of tolerable daily intake (TDI) was made by the following formula; mean concentrations (µg/kg) x 0.5 x 89.9 g ÷ 50 µg (TDI per 50 kg body weight) x 100 (%). Since, the European Scientific Committee on Food in 2002 assigned 0.7 µg/kg body weight per day as temporary TDI (t-TDI) for NIV⁷⁾, 35 µg (t-TDI per 50 kg body weight) was applied instead of 50 µg for DON.

As summarized in Table 1, the data were obtained from domestic and imported samples harvested in 1984 and 2001, and from the references of Lee, *et al.*⁴⁾, Tanaka, *et al.*⁵⁾, and Yoshizawa, *et al.*⁸⁾. Co-contamination of DON and NIV was common, and the mean concentrations of DON ranged from 23-1,550 and 110-300 µg/kg for wheat and barley, respectively, corresponding to the TDI as 2.1-139 %. Those of NIV were 1.3-669 and 296-920 µg/kg for wheat and barley, respectively, corresponding to the t-TDI as 0.1-118 %.

To prevent the risks from DON and NIV exposure, the following proposals should be considered to guarantee food safety in wheat and barley products. 1) adequate control of disease pathogens in wheat and barley fields, 2) cultivation of *Fusarium* tolerant wheat and barley varieties, 3) rapid monitoring system for scab disease (Akakabi-byo). Taking into account the above proposals, the inspection and monitoring systems for grains in the fields should be established to ensure the safety

Table 1. Contamination of deoxynivalenol and nivalenol in wheat and barley grains, and ratios to TDI

Source	Wheat and barley grains		Deoxynivalenol (DON)			Nivalenol (NIV)		
	No. tested	Year of yield	Mean conc. (µg/kg)	(Frequency) (%)	Ratio ^{*1} to TDI(%)	Mean conc. (µg/kg)	(Frequency) (%)	Ratio ^{*2} to t-TDI(%)
Domestic wheat	36	2001	388	(92)	34.9	8.2	(94)	1.0
Imported wheat	20	2001	100	(75)	9.0	1.3	(45)	0.1
Domestic wheat ^{*3}	3	1984	270	(67)	24.3	633	(67)	81.3
Domestic barley ^{*3}	2	1984	303	(100)	27.2	920	(100)	118
Korean wheat ^{*4}	9	1984	23	(56)	2.1	535	(100)	68.7
Korean barley ^{*4}	31	1984	124	(100)	11.1	489	(100)	62.9
Wheat from foreign countries ^{*5}	222	1983-85	188	(43)	16.9	59	(50)	7.6
Barley from foreign countries ^{*5}	139	1983-85	109	(75)	9.8	296	(76)	38.0
Domestic wheat ^{*6}	17	1976-91	1,545	(100)	139	669	(100)	85.9

^{*1} Mean concentrations x 0.5 x 89.9 g (prospective intake of wheat per day) / TDI (50 µg/50 kg body weight per day) x 100

^{*2} Mean concentrations x 0.5 x 89.9 g (prospective intake of wheat per day) / t-TDI (35 µg/50 kg body weight per day) x 100

^{*3} Harvested from Kinki region

^{*4} Reference 4)

^{*5} Reference 5)

^{*6} Reference 8)

of all products derived from cereals. Furthermore, additional research will be required to estimate DON and NIV in rice grains. Because, daily intake of rice grains in Japanese peoples is about twice as much as that of wheat grains. Atmospheric temperature and environmental conditions are closely connected to the mycotoxins production by toxigenic fungi, and that is why the concentrations of mycotoxins in grains are variable from year to year. Therefore, continuous monitoring of DON and NIV is the best way for maintaining food safety in cereals.

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トリコテセンの穀類中の汚染実態とそのリスク

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2001 年 FAO/WHO 合同食品添加物専門家会議（JECFA）はデオキシニバレノール（DON）の暫定最大 1 日耐容量（PMTDI）を 1 $\mu\text{g}/\text{kg}$ （体重）に評定した。厚生労働省は食品衛生法第 7 条に基づく規格基準設定に向けた小麦に含有する DON の暫定的な基準値を 1.1 mg/kg に定め、行政上の指導指針とした。昨年度に実施した麦類の汚染調査の結果、国内産小麦 36 試料中 33（92%）に DON の汚染が認められ、その平均濃度は 388 $\mu\text{g}/\text{kg}$ （濃度範囲 0 ~ 2,248 $\mu\text{g}/\text{kg}$ ）で、4 試料が暫定基準を超えていた。輸入小麦では 75% に汚染が認められ、平均濃度は 100 $\mu\text{g}/\text{kg}$ （濃度範囲 0 ~ 740 $\mu\text{g}/\text{kg}$ ）であった。日本人の小麦の平均摂取量 89.8 g、加工による DON の減衰率を 50% と仮定した場合、TDI 比率は国産、輸入小麦でそれぞれ 34.8%、9% となる。なお、供試試料の多くはニバレノールとの複合汚染が認められた。今後継続した汚染実態の究明と圃場での汚染防止対策、人の健康への影響評価が講じられる必要がある。

キーワード：デオキシニバレノール，ニバレノール，汚染，穀類