Available online at www.sciencedirect.com
ScienceDirect
International Journal of Food Microbiology 119 (2007) 59–66
INTERNATIONAL JOURNAL OF Food Microbiology
www.elsevier.com/locate/ijfoodmicro

Mycotoxins in rice

Kenji Tanaka [a,*], Yuki Sago [b], Yazhi Zheng [b], Hiroyuki Nakagawa [b], Masayo Kushiro [b]

[a] *Agriculture, Forestry and Fisheries Technical Information Society, Sixth Floor, Milling Building, 15-6, Kabuto-cho, Nihonbashi, Chuo-ku, Tokyo 103-0026 Japan*
[b] *National Food Research Institute, 2-1-12 Kannondai, Tsukuba, Ibaraki 305-8642 Japan*

Abstract

Mycotoxin contamination in rice is usually lower as in wheat or corn. However, there are some reports that rice has been contaminated with mycotoxins such as aflatoxin B_1, B_2, G_1, G_2 (AFS), citrinin, deoxynivalenol (DON), fumonisin B_1, B_2, B_3 (FMS), fusarenon-X (Fus.-X), nivalenol (NIV), ochratoxin A (OTA), sterigmatocystin (STE), and zearalenone. Rice in Japan is preserved in warehouses where moisture content and temperature are regulated. Therefore, mycotoxin contamination from post harvest fungal growth occurs very seldom. Trichothecenes, aflatoxins, and STE in rice were recently analyzed in our laboratory. In 1998, a typhoon struck before rice harvesting in Japan, and the unpolished rice was found to be stained brown. Samples were collected and analyzed for the presence of trichothecenes. Mycotoxins DON, Fus.-X, and NIV were detected and confirmed with GC-MS. The quantity of trichothecenes was determined using GC-ECD. STE is a carcinogenic mycotoxin produced by *Aspergillus versicolor* and some other fungi. STE contamination of rice was studied in our laboratory since 1973. GC-MS, LC-MS, LC-MS/MS, and LC-UV methods for STE determination were examined, giving good results for the LC-UV method using a photo diode array detector. Different techniques for the extraction of STE from rice were also studied. Finally, brown rice was ground, and the ground rice was extracted with acetonitrile-water. An Autoprep MF-A 1000 column was used to clean up AFS and STE. The cleaned-up extract was analyzed with HPLC-UV. Forty-eight brown rice samples were analyzed, and none of them were contaminated with STE. These rice samples were also analyzed for AFS and FMS, and none of the samples were contaminated. The Ministry of Agriculture, Forestry and Fisheries in Japan is making the appropriate Institutes develop analytical methods for mycotoxins and survey mycotoxin contamination on rice as well as wheat, corn, and some other cereals.

Keywords: Mycotoxins; Rice; Deoxynivalenol; Fusarenon-X; Nivalenol; Sterigmatocystin

1. Introduction

Mycotoxin contamination is less commonly reported for rice than for many other cereals. However, contamination by luteoskyrin (Shibata and Kitagawa, 1956), islanditoxin (Marumo and Sumiki, 1955), and cyclochlorotine (Sato and Tatsuno, 1968) has been reported on imported rice since the 2nd World War. There is also a report by Sugimoto et al. (1977) detailing the contamination of domestic rice with OTA, citrinin and sterigmatocystin. Norizuki et al. reported that commercial rice in Egypt was contaminated with aflatoxins (Norizuki et al., 1987). Weidenboerner also reported some mycotoxins were found in rice (Weidenboerner, 2000). This data are listed in Table 1. After the 2nd World War, rice was imported into Japan, as food was limited. Some rice was infected with fungi. The Japanese Government stopped the distribution of this rice. Japanese people were safe from these mycotoxins from that time on.

Sugita-Konishi et al. (2006) reported natural contamination of aflatoxins and ochratoxin A (OTA) in retail rice in 2004 and 2005. Aflatoxins were not detected in 53 samples. The limit of quantification was 0.1 μg/kg. No OTA was detected in 50 retail rice samples. The limit of quantification was 0.1 μg/kg. The Ministry of Agriculture, Forestry and Fisheries reported analytical results of mycotoxins contamination on several cereals on May 23, 2006 (Press release from MAFF in Japan, 2006). In this report, no OTA was detected in 98 rice samples. The limit of quantification was 0.0003 mg/kg.

* Corresponding author. Tel.: +81 3 3667 8931; fax: +81 3 3667 8933.
E-mail address: kjtanaka@afftis.or.jp (K. Tanaka).

0168-1605/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.ijfoodmicro.2007.08.002

1.1. Trichothecene determination

According to Manabe and Tsuruta (1991), the majority of fungal species are, mesophytes (optimal growth temperature: 22–35 °C) that are capable of growing temperatures between 5 and 45 °C, and therefore, in the temperate climate of Japan and in the tropical/subtropical climate, the prevailing temperature satisfy the growth conditions for a wide variety of mycelium

Table 1
Mycotoxin contamination in rice (Weidenboerner, 2000)

	Incidence	Conc. range	Mean conc. (μg/kg)	Conc. (μg/kg)	Contry	Condition
Afl. B_1	2/52*	26–38 μg/kg	32		Brasil	*Polished
	1/1			8	Egypt	
				28	Italy	
	6/8	<2.5–15 μg/kg			Nepal	
	4/4*	<2.5–12.5 μg/kg			Nepal	*Parboiled
	7/364	37 μg/kg	20		Thailand	
	9/9	≦600 μg/kg	<1–2		Thailand	
Total	1/182		98	5	USA	
Afl. B_2	1/52*			15	Brasil	*Polished
	1/1			2	Egypt	
	1/4*	1.8 μg/kg			Nepal	*Parboiled
Afl. G_1	1/52*			20	Brasil	*Polished
	2/84	73.1–77.5 μg/kg	75.3		Malaysia	
Afl. G_2	3/84	3.7–96.3 μg/kg	45.6		Malaysia	
Aflatoxin	3/15*	≦38 μg/kg	16		Philippines	*Rice brand
(no specification)	17/82*	≦43 μg/kg	12		Philippines	*Milled
	1/6*	≦3 μg/kg	3		Philippines	*Pop
	3/10*	≦18 μg/kg	15		Philippines	*Rough
Aflatoxin (AFB_1, AFB_2, AFG_1, AFG_2)	13/30	22–317 μg AFB_1/kg, 15–125 μg AFB_2/kg, 14–107 μg AFG_1/kg, 20–98 μg AFG_2/kg ,			India	
	Nc/4*	0.1–2.4 μg/kg			UK	*Basmati rice
Aflatoxin	14/20	2–19 μg/kg	7.9		Gambia	
(no specification)	12/80*	tr–430 μg/kg			India	*Cyclone-affected
	23/81*	30–1130 μg/kg			India	*Cyclone-affected
	32/43*	30–130 μg/kg			India	*Parboiled
	1/23			1000	Mozambique	
	16/72	≦33 μg/kg	16		Philippines	
Citrinin	4/30	49–92 μg/kg			India	
	2/2	700–1130 μg/kg			Japan	
Deoxynivalenol	1/1*			90	Papua New Guinea	*Imported
	Nc/4*	4–6 μg/kg			UK	*Basmati rice
	Nc/4*	4–7 μg/kg			UK	*Chinese rice
Fumonisin B_1	8/20	≦4300 μg/kg			USA	
Fumonisin B_2	6/20	≦1200 μg/kg			USA	
Fumonisin B_3	5/20	≦600 μg/kg			USA	
Fumonisins (FB_1, FB_2)	1/4*	28 μg/kg			UK	*Basmati rice
Nivalenol	2/9		22		Nepal	
	1/1*			63	Papua New Guinea	*Imported
	Nc/4*	4–11 μg/kg			UK	*Basmati rice
Ochratoxin A	1/3*			533	Egypt	*Rice germ
	2/36	≦0.3 μg/kg			Germany	
	2/32	8–25 μg/kg	16.5		India	
	2/15	1.7–2.4 μg/kg			Indonesia	
	8/15	≦1.0 μg/kg			Italy	
	1/various food samples			50	Japan	
	2/2*	230–430 μg/kg			Japan	*Deteriorated
Sterigmatocystin	3/30	108–157 μg/kg			India	
	2/nc	50–450 μg/kg			Japan	
	?/?*	3800–4300 μg/kg			Japan	*Moldy
	12/37	≦16,300 μg/kg			Japan	
	1/4*			49	UK	*Chinese rice
Zearalenone	1/9			8	Nepal	
	1/1*			3060	Papua New Guinea	*Imported
	3/42*	>200 μg/kg			Uruguay	*And by-products

Nc: not counted.