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Occurrence of four mycotoxins in cereal and oil products in Yangtze Delta region of China and their food safety risks

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ABSTRACT

A total of 76 cereal and oil products collected from Yangtze Delta region of China were analyzed for occurrences of aflatoxins (AFs), aflatoxin B_1 (AFB_1), ochratoxin A (OTA), deoxynivalenol (DON) and zearalenone (ZEN). The mycotoxins were determined by the standard detection procedures using immunoaffinity column clean-up coupled with fluorometer (or HPLC-UV). ZEN was the most prevalent toxin, with the incidence of 27.6% (range = 10.0–440.0 μg kg^{-1}), and 9.2% of the evaluated samples were contaminated with a concentration higher than that of the legislation limit of China (60 μg kg^{-1}). AFs and AFB_1 were detected in 14.5% of the samples analyzed, the concentrations ranging 1.1–35.0 μg kg^{-1} for AFs, and 1.0–32.2 μg kg^{-1} for AFB_1; 4.0% of the samples had the concentrations of AFs and AFB_1 higher than that of the corresponding legislation limits of China (5.0, 10.0 and 20.0 μg kg^{-1} for different products). OTA was detected in 14.5% of the cereal and oil products collected; the concentrations ranged 0.51–16.2 μg kg^{-1}. Only 2 samples showed OTA levels higher than that of the legislation limit of China (5.0 μg kg^{-1}). DON was detected in 7.9% of the samples; the concentrations ranged 100–700 μg kg^{-1}, and none of the samples showed DON concentration higher than that of the legislation limit of China (1.0 mg kg^{-1}). A total of 15.8% cereal and oil products were contaminated with at least two mycotoxins (multiple contaminations with different combinations including AFs-ZEN, AFs-OTA-ZEN, OTA-ZEN, ZEN-DON, OTA-ZEN-DON). The dietary exposure assessment results indicated that AFs (AFB_1), OTA, DON and ZEN from cereal-based products represented a series health risk to both adults and children in Yangtze Delta region of China. This is the first report of safety evaluation associated with major mycotoxins for the area.

1. Introduction

Mycotoxins are secondary metabolites mainly produced by specific filamentous fungi such as *Aspergillus*, *Penicillium* and *Fusarium* under appropriate conditions of temperature and humidity (Nielsen, Mogensen, Johansen, Larsen, & Frisvad, 2009). Mycotoxins contamination occurs frequently in various food commodities worldwide, leading to serious risks in animal and human health by following ingestion of the contaminated products (Njobeh et al., 2009). Previous study estimated that about 25% crop and oil products were contaminated with different kinds of mycotoxins in various degrees (Fink-Gremmels, 2009). Up to date, over four hundred mycotoxins have been indentified, the important groups of them, including aflatoxins (AFs), ochratoxin A (OTA) deoxynivalenol (DON) and zearalenone (ZEN), have received great attentions and strict regulatory controls under the government legislations for agro-products safety (Binder, Tan, Chin, Handl, & Richard, 2007). AFs and OTA were classified as group 1 and 2B carcinogen, respectively, by the International Agency for Research on Cancer in 1993 (IARC, 1993, pp. 489–521). Among aflatoxins, aflatoxin B_1 is the most toxic form for mammals and causes damages such as toxic hepatitis, hemorrhage, edema, immunosuppression and hepatic carcinoma (Speijers & Speijers, 2004). DON and ZEN were classified as group 3 carcinogen in 1993 and 1999 by IARC, respectively. The toxic effects triggered by the ingestion of

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DON and ZEN vary from compound to compound. However, a chronic activity (e.g., carcinogenicity, teratogenicity or mutagenicity) is a common characteristic in most cases (Coppock & Jacobsen, 2009; Wild & Gong, 2010). Currently, the four major groups of mycotoxins discussed above are widely found in a variety of cereal and oil products (e.g., rice, maize, oil, barley and wheat). For example, AFs and OTA were the most prevalent toxins in retail cereal products in Turkey, with the incidence of 24.5% and 43.5%, respectively (Baydar, Engin, Girgin, Aydin, & Sahin, 2005). DON was detected in 83.7% of corn samples collected from Ontario, Canada in 2008 (Tran, Smith, & Girgis, 2011). ZEN was detected in around 15.0% of cereals including wheat, barley, maize, sorghum, rice and the derived products in Tunisia (Ghali, Hmaissia-khlifa, Ghorbel, Maaroufi, & Hedili, 2008).

As the staple food of Asian, cereal and oil products play an important role in a healthy diet in China. Under the unique climatic conditions of Yangtze Delta region (especially in rainy season), large amounts of mycotoxins are easily produced by mycotoxigenic fungi in cereal and oil products. The contaminated mycotoxins in cereal and oil products could be the potential hazards to consumers, especially for the susceptible groups (e.g., children, oldie and gravida). The Chinese government renewed the maximum residue limits (MRLs) and standard detection methods for major mycotoxins in foods in 2011 (China's Ministry of Health, 2011). Mycotoxins can be detected by various analysis methods including thin layer chromatography (TLC), liquid chromatography (LC), high-performance liquid chromatography (HPLC) and ELISA according to the specific detection requirements, and each method with its merits and faults (Zheng, Richard, & Binder, 2006). Although a number of surveys and monitoring projects had been carried out in several countries attempting to determine occurrence of mycotoxins in agro-products, and assess their potential risk to human health (Cabañas, Bragulat, Abarca, Castellá, & Cabañes, 2008; Zhang & Caupert, 2012), the food safety risks associated with the multiple mycotoxins (AFs, OTA, DON, and ZEN) in cereal and oil products in the Yangtze Delta region has never been performed. The Yangtze Delta region is one of the most developed and major agro-products consuming regions in China; knowledge on mycotoxins in staple food of the area is significantly needed for mitigating food safety risks in China. The aim of this work was to determine the prevalence of the four mycotoxin groups in cereal and oil products in this area; and to assess the safety risk of the human diet based on the obtained results.

2. Materials and methods

2.1. Sample collection

A total of 76 cereal and oil products were randomly purchased from supermarkets and wholesale markets of agro-products in the Yangtze Delta region of China during April 2010 (Fig. 1). The samples were collected from the most important cities in the region, including Hangzhou, Ningbo, Shanghai, Suzhou and Wuxi, and the details of the samples were presented in Table 1. The samples were transported to the laboratory within 24 h, and stored at 4 °C in the refrigerator until being analyzed. All of the samples were ground with a Waring blender (Waring products Co., Connecticut, USA) to produce homogeneous particle size, and analyzed within the shelf life of the product.

2.2. Verification of detection methods

The Immunoaffinity chromatography- (IAC-) fluorometer rapid analytical methods in this study were all compared and evaluated with the AOAC standard detection methods for individual

Fig. 1. A map that shows sample locations in Yangtze Delta region of China.