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 B1 (AFB1), ochratoxin A (OTA), deoxynivalenol (DON) and zearalenone (ZEN). The mycotoxins were determined by the standard detection procedures using immunofinity 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 AFB1 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 AFB1; 4.0% of the samples had the concentrations of AFs and AFB1; 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 (AFB1), 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.

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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 (Njoh 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, HandI, & Richard, 2007). AFs and OTA were classified as group 1 and 2B carcinogenic, respectively, by the International Agency for Research on Cancer in 1993 (IARC, 1993, pp. 489–521). Among aflatoxins, aflatoxin B1 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
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, & Cabañas, 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
A 50 g sample was homogenized with 200 ml purified water and 10 g polyethylene glycol 8000 (PEG 8000) at the high speed for 1 min. After filtration through a filtered filter paper, the filtrate was filtered again through a microfilter paper before 1 ml filtrate passing through a DONtest™ IAC column (Vicam USA). The IAC column was washed twice with 5 ml purified water for each time, and then was eluted with 1.0 ml methanol (HPLC grade, sigma). All of the eluate was collected in a glass cuvette and evaporated to dryness using N2 stream. The dried sample was reconstituted with 300 μl of HPLC mobile phase. Chromatographic separations were performed on a reversed phase Xterra C18 analytical column (250 × 4.6 mm, 5 μm, Waters Inc, USA), with an injection volume at 50 μl for both standards and analytical samples. Acetonitrile-water (10:90, v/v) was used as the mobile phase with the flow rate of 0.8 ml/min. Detection was made with deuterium detector at the wavelength of 218 nm.

Table 2
Verification for IAC-fluorometric inspection technology.

<table>
<thead>
<tr>
<th>Mycotoxins</th>
<th>QC samples</th>
<th>Assigned value* (μg kg⁻¹)</th>
<th>Method 1b</th>
<th>Method 2c</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFs</td>
<td>Peanut</td>
<td>3.69 ± 9.48</td>
<td>8.80 ± 0.54</td>
<td>8.22 ± 0.63</td>
</tr>
<tr>
<td>AFB1</td>
<td>Peanut</td>
<td>3.65 ± 9.39</td>
<td>5.54 ± 0.58</td>
<td>6.09 ± 0.91</td>
</tr>
<tr>
<td>OTA</td>
<td>Baby food</td>
<td>11.90 ± 30.70</td>
<td>19.20 ± 1.85</td>
<td>21.34 ± 2.22</td>
</tr>
<tr>
<td>ZEN</td>
<td>Baby food</td>
<td>Lower than 2.0</td>
<td>1.30 ± 0.06</td>
<td>1.65 ± 0.13</td>
</tr>
</tbody>
</table>

* The mycotoxin concentration of the QC samples is within the scope of the assigned value, but the exact concentration is uncertain.

b IAC-fluorometric.
c AOAC standard methods.
The detection limits for AFs (AFB1), OTA, ZEN by IAC-fluorometric method are 1.0, 0.47 and 10 μg kg⁻¹, respectively, and for DON by HPLC-UV is 40 μg kg⁻¹. The current AFB1 MRLs set by the Chinese government are 20.0 μg kg⁻¹ for primary agro-products, and 5.0–10.0 μg kg⁻¹ for processed foods. MRLs for OTA, ZEN and DON set by the Chinese government are 5.0, 60 and 1000 μg kg⁻¹, respectively, in cereal and oil products. Thus, the IAC-fluorometric method for AFs (AFB1), OTA, ZEN and HPLC-UV method for DON meet the requirements of Chinese MRLs (Table 3).

3.2. Mycotoxins in cereal and oil products

The incidence and concentration of the four mycotoxins in samples of cereal and oil products in Yangtze Delta region of China were presented in Table 4. Cereal and oil products are susceptible to aflatoxins producing fungi under the high moisture/humid storage (Cotty & Jaime-Garcia, 2007), thus aflatoxins contamination usually considered as one of the most important hazards in foodstuff in Yangtze Delta region of China. The incidence of AFs and AFB1 in the present investigation was 14.5% (11/76) of the analyzed samples, which is similar to those reported from German and Sweden (Fredlund et al., 2009; Reinhold & Reinhardt, 2011). The maximum contamination of AFs was found at the concentration of 35.0 μg kg⁻¹ in peanut butter and the mean value of the positive samples was 6.9 μg kg⁻¹. The peanut butter sample with the maximum contamination of AFs also contained the highest concentration of AFB1 (32.2 μg kg⁻¹) and the mean value of AFB1 for positive samples was 6.6 μg kg⁻¹.

Trade barriers often occurred due to different acceptable MRLs established between importing and exporting countries. There was 6.6% of cereal and oil samples with AFs higher than the MRL of European Union (EU, 4.0 μg kg⁻¹), and 9.2% of the samples showed AFB1 concentrations higher than the aflatoxin B1 MRL of EU (2.0 μg kg⁻¹). Compared to rigorous MRLs of EU, only 4.0% samples were estimated as the unacceptable products based on the AFB1 limits set by the governments of China and USA. For rice samples, the occurrence of AFs contamination (4.8%) was lower than other developing countries, such as India (67.8%) and Pakistan (25.0%) (Lutfullah & Hussain, 2012; Reddy, Reddy, & Muralidharan, 2009). Two maize flour samples were contaminated with AFB1 at the concentrations of 1.1 and 1.0 μg kg⁻¹, and those contaminations were much lower than the limitation established by the Chinese government (20.0 μg kg⁻¹). The AFB1 levels in maize flour sampled in this study was much lower than that in the previous study by Shah, Simpson, Alam, Khattak and Perveen (2010), which showed the 77.8% maize samples were contaminated with AFB1 higher than 5.0 μg kg⁻¹. Present investigation showed that peanut and peanut byproducts were the most susceptible agro-products to AFs contamination in this area (the occurrence is 80.0%). The contamination levels of AFs in peanut and peanut byproducts were 2.3–35.0 μg kg⁻¹ with the average value of 12.8 μg kg⁻¹ in positive samples. AFs contaminations in peanut and peanut byproducts of this study was much severer than that of previous investigation in Morocco, which showed only 5.0% of peanut products contaminated with AFs (Juan, Zinedine, Moltó, Idrissi, & Mañes, 2008). There were 44.4% of edible oils and rapeseed samples with AFs contamination, which was significantly higher than 14.3%, obtained from oil samples collected in Sudan (Idris, Mariod, Elnour, & Mohamed, 2010).

The incidence of ZEN was 27.6% which was significantly higher than that of the other mycotoxins in this investigation. The ZEN concentrations of the positive samples ranged from 10 to 440 μg kg⁻¹. The highest level of 440 μg kg⁻¹ was detected in a maize flour sample; the mean value of the positive samples was 76.5 μg kg⁻¹. The occurrence of ZEN in this study was lower than that of a previous report based on investigation in North Asia (Binder et al., 2007). In that report, ZEN occurrence was detected in 47.0% for different commodities, feeds and feed ingredients with a much higher average concentration of 494.0 μg kg⁻¹ (Binder et al., 2007). Of the samples analyzed in this study, there was 9.2% samples with ZEN concentration higher than 60 μg kg⁻¹, the MRL of China. The incidence of ZEN obtained in this study was significantly higher than that found in grain-based products from Finnish and Italian markets, where no corn and cereal samples exceeded the MRLs of EU (Jestoi et al., 2004). Edible oils and maize products had the highest incidences of ZEN contaminations, with the incidences at 44.4% and 35.7%, respectively, which are obviously higher than that of soybean oil in Germany (21.4%) and maize in Tunisian (9.0%) (Chali, Hmaissia-khlifa, Chorbel, Maaroufi, & Hedili, 2008; Schollenberger, Müller, Rüfle, & Drochner, 2008). The results showed that ZEN has become a serious safety problem in cereal and oil products in Yangtze Delta region of China.

In generally, oat, barley, gypsophila and wheat-based cereals are not inclined to be contaminated with aflatoxins, but often contaminated by OTA and DON. The occurrence of OTA in this study was 14.5% of 76 samples tested, which was slightly lower than that of 21.7% of samples analyzed in the zone of Portugal study, in which, 18 positive samples were detected from 83 cereal products with contamination levels ranging from 0.2 to 27.1 μg kg⁻¹ (Juan, Pena, Lino, Moltó, & Mañes, 2008). OTA was not detected in edible oils for this work. The incidence of OTA in peanut and byproduct was 20%, and in oats and other coarse grains was 27.3%, both were higher than the other samples collected in this study.

DON was detected in 7.9% of the analyzed samples with the highest concentration of 0.70 mg kg⁻¹ in pulled noodle. DON concentrations of the contaminated samples ranged from 0.1 to 0.7 mg kg⁻¹, none of them exceeded the limit (MRL = 1.0 mg kg⁻¹) permitted by the Chinese government for human consumption. DON was not detected in rice, edible oils, rapeseed, peanut, soybean and their byproducts. Occurrence of DON in this study was obviously lower than the other three groups of mycotoxins, especially lower than ZEN. These results suggested that DON contamination may not be a serious problem for cereal and oil products in Yangtze Delta region of China. Perhaps, the climates of high-temperature and humidity in

### Table 3
Detection limits of the analysis methods and Maximum Residue Limits (MRLs) for the four groups of mycotoxins in cereal and oil products in China.

<table>
<thead>
<tr>
<th>Mycotoxins</th>
<th>AFs</th>
<th>AFB1</th>
<th>OTA</th>
<th>ZEN</th>
<th>DON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection limits (μg kg⁻¹)</td>
<td>1.0</td>
<td>1.0</td>
<td>0.47</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>MRLs</td>
<td>20/10/5</td>
<td>20/10/5</td>
<td>5</td>
<td>60</td>
<td>1000</td>
</tr>
</tbody>
</table>

*The MRL of maize, peanut and their derived products is 20 μg kg⁻¹. The MRL of rice and derived products, vegetable oils (arachis oils and maize oils are not included) is 10 μg kg⁻¹. The MRL of wheat, barley, soybean and their derived products is 5 μg kg⁻¹.

### Table 4
Four mycotoxins investigation results in cereal and oil products.

<table>
<thead>
<tr>
<th>Mycotoxins</th>
<th>Positive samples (n)</th>
<th>Contamination incidence (%)</th>
<th>Mean value of positive samples (μg kg⁻¹⁻¹)</th>
<th>Range of contamination (μg kg⁻¹⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFs</td>
<td>11</td>
<td>14.5</td>
<td>6.9</td>
<td>1.1 – 35.0</td>
</tr>
<tr>
<td>AFB1</td>
<td>11</td>
<td>14.5</td>
<td>6.6</td>
<td>10 – 32.2</td>
</tr>
<tr>
<td>OTA</td>
<td>11</td>
<td>14.5</td>
<td>3.5</td>
<td>0.51 – 16.2</td>
</tr>
<tr>
<td>ZEN</td>
<td>21</td>
<td>27.6</td>
<td>76.5</td>
<td>10.0 – 440.0</td>
</tr>
<tr>
<td>DON</td>
<td>6</td>
<td>7.9</td>
<td>380.0</td>
<td>100.0 – 700.0</td>
</tr>
</tbody>
</table>
3.3. Multiple contaminations of cereal and oil samples

Contaminations with multiple mycotoxins are common in agro-products (Ibáñez-Vea, Martínez, González-Peñas, Lizarra, & López de Cerain, 2011). Multiple contaminations of mycotoxins can lead to combined additive or synergistic toxic effects; therefore, this work specially analyzed the co-occurrence of the multiple mycotoxins in the cereal and oil products in Yangtze Delta region of China. Co-occurrence of AFs and ZEN was detected at 6.6% in 76 cereal and oil samples, which was lower than the 12.4% in Tunisian food (Ghali, Hmaissia-Khlifa, Ghorbel, Maaroufi, & Hedili, 2008). Particularly, the co-occurrences of AFs and ZEN were 22.2%, 7.1% and 27.3% in the samples of edible oils, maize products, and peanut-soybean products (including peanut and soybean oil), respectively (Table 5). Co-occurrence of AFs-OTA-ZEN was not detected in rice, wheat, maize, oats products and edible oils, and this frequency was lower than the report of co-occurrence of AFs-OTA-ZEN in Tunisian food (7.2%) (Ghali et al., 2008). Co-occurrence of OTA-ZEN was also detected in 6.6% of all samples collected, and observed in 14.3% of the samples of rice and rice products, 7.1% of the samples of maize and maize products, and 9.1% of other coarse grains (including oats), and these co-occurrence rates were slightly higher than that from the investigation in Morocco, in which 5.0% corn samples were contaminated with both OTA and ZEN (Zinedine et al., 2006). Co-occurrence of ZEN and DON was detected in 7.6% of wheat and wheat products, and 7.1% of maize and maize products. Co-occurrence of OTA and DON was detected in 9.1% of oats and other coarse grains, 7.1% of maize and maize products, but not detected in wheat and wheat products. As a comparison, the co-occurrence of OTA-DON was recorded in 41.5% of the beer produced samples in several European countries (Bertuzzia, Rastellia, Mulazzia, Donadinib, & Pietri, 2011). Co-occurrence of OTA-ZEN-DON was detected in 71% for maize and maize products. Contaminations with four groups of mycotoxins (AFs, OTA, DON, and ZEN) was not found in this study although a total of 12 samples were contaminated with two or three groups of mycotoxins and the occurrence of multiple contaminations was 15.8%.

3.4. Dietary exposure assessment

Based on data of cereal and oil products from Yangtze Delta region of China, a theoretical exposure scenario for adults and children could be developed. Previous report estimated that the average annual per capita consumption of cereal-based products is about 146.73 kg in China, equivalent to an average daily per capita consumption of 0.402 kg (Jin, 2008). Although there was no indication of the upper intake amount for the cereal-based products in the report, the amount may be daily consumption of 0.804 kg estimated based on the Concise European Food Consumption Database, which indicated that the heavy consumers (the 95th percentile) had a consumption close to double that of average consumers. The targeted mycotoxins are very stable under high temperatures and other several manufacturing processes (e.g., baking, extrusion cooking and roasting), thus, processing factor was supposed to be 1.0 for the four groups of mycotoxins, that equivalent to 100% mycotoxins content for intake in the human body (Gajecjki, 2002). According to the above evaluation method, the estimated dietary intakes of AFs, OTA, DON and ZEN from the consumption of cereal-based products by the average and heavy consumers were shown in Table 6. Calculations are presented for adults at 60 kg b.w. and children at 20 kg b.w.

The estimated mean AFs intake from cereal-based foods is 8.3 ng kg⁻¹ b.w. day⁻¹ for adults and 24.9 ng kg⁻¹ b.w. day⁻¹ for children. The heavy consumer exposure is 16.6 ng kg⁻¹ b.w. day⁻¹ for adults and 49.8 ng kg⁻¹ b.w. day⁻¹ for children. Due to the high toxic property, there is no specific numerical tolerable daily intake (TDI) for AFs specified by International expert committees. These exposure values of AFs are much higher than 1.0 ng kg⁻¹ b.w. day⁻¹ which contributed to the risk of liver (JECFA, 2001).

The mean OTA intake exposure is 4.62 ng kg⁻¹ b.w. day⁻¹ for adults and 13.9 ng kg⁻¹ b.w. day⁻¹ for children, and the heavy consumer OTA intake is 9.23 ng kg⁻¹ b.w. day⁻¹ for adults and 27.7 ng kg⁻¹ b.w. day⁻¹ for children. The heavy consumer OTA exposure of children is higher than the TDI (14 ng kg⁻¹ b.w. day⁻¹) established by FAO/WHO Joint Expert Committee on Food Additives (JECFA, 2001). The mean ZEN intake exposure is 155 ng kg⁻¹ b.w. day⁻¹ for adults and 464 ng kg⁻¹ b.w. day⁻¹ for children, and the heavy consumer exposure is 310 ng kg⁻¹ b.w. day⁻¹ for adults and 929 ng kg⁻¹ b.w. day⁻¹ for children. The heavy consumer ZEN exposure for all population and the mean ZEN intake exposure for children are higher than the TDI (200 ng kg⁻¹ b.w. day⁻¹) established by JECFA. The mean DON intake exposure is 309 ng kg⁻¹ b.w. day⁻¹ for adults and 927 ng kg⁻¹ b.w. day⁻¹ for children, and the heavy consumer exposure is 618 ng kg⁻¹ b.w. day⁻¹ for adults and 1853 ng kg⁻¹ b.w. day⁻¹ for children. The heavy consumer exposure for children was higher than the TDI (1000 ng kg⁻¹ b.w. day⁻¹) established by JECFA.

### Table 6

Estimated daily intakes of four mycotoxins from consumption of contaminated cereal-based products.

<table>
<thead>
<tr>
<th>Mycotoxins</th>
<th>TDI (ng kg⁻¹ b.w. day⁻¹)</th>
<th>Mean concentration* (µg kg⁻¹)</th>
<th>Dietary exposure* (ng kg⁻¹ b.w. day⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>Children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean⁴</td>
<td>Mean⁴</td>
<td>Mean⁴</td>
<td></td>
</tr>
<tr>
<td>AFs ALARA³</td>
<td>1.24</td>
<td>8.31</td>
<td>24.9</td>
</tr>
<tr>
<td>OTA</td>
<td>14</td>
<td>0.69</td>
<td>13.9</td>
</tr>
<tr>
<td>ZEN</td>
<td>200</td>
<td>23.1</td>
<td>49.8</td>
</tr>
<tr>
<td>DON</td>
<td>1000</td>
<td>46.1</td>
<td>1853</td>
</tr>
</tbody>
</table>

⁴ Samples below the LOD were taken as LOD/2.

The estimated dietary intake was 8.31 ng kg⁻¹ b.w. day⁻¹ for adults and 24.9 ng kg⁻¹ b.w. day⁻¹ for children. The heavy consumer OTA intake is 9.23 ng kg⁻¹ b.w. day⁻¹ for adults and 27.7 ng kg⁻¹ b.w. day⁻¹ for children. The heavy consumer OTA exposure of children is higher than the TDI (14 ng kg⁻¹ b.w. day⁻¹) established by FAO/WHO Joint Expert Committee on Food Additives (JECFA, 2001). The mean ZEN intake exposure is 155 ng kg⁻¹ b.w. day⁻¹ for adults and 464 ng kg⁻¹ b.w. day⁻¹ for children, and the heavy consumer exposure is 310 ng kg⁻¹ b.w. day⁻¹ for adults and 929 ng kg⁻¹ b.w. day⁻¹ for children. The heavy consumer ZEN exposure for all population and the mean ZEN intake exposure for children are higher than the TDI (200 ng kg⁻¹ b.w. day⁻¹) established by JECFA. The mean DON intake exposure is 309 ng kg⁻¹ b.w. day⁻¹ for adults and 927 ng kg⁻¹ b.w. day⁻¹ for children, and the heavy consumer exposure is 618 ng kg⁻¹ b.w. day⁻¹ for adults and 1853 ng kg⁻¹ b.w. day⁻¹ for children. The heavy consumer exposure for children was higher than the TDI (1000 ng kg⁻¹ b.w. day⁻¹) established by JECFA.
According to the results discussed above, AFs, OTA, ZEN and DON from cereal-based products have represented a series health risk for both adults and children in the area of China. The high dietary exposure values obtained in this study was mainly due to a few heavily contaminated samples, and the evaluation results provide a theoretical exposure, and may be considered as reference indicator for the food safety associated with mycotoxins in this area. On the other hand, the occurrences of samples with high contamination levels of mycotoxins (e.g., AFs and ZEN) imply that these mycotoxins posed a high diet risk for people in the Yangtze Delta region.

In conclusion, AFs and ZEN were the major contaminants in the Yangtze Delta region of China, while the contaminations of DON and OTA were relatively lower for cereal and oil products in the region. Contamination with multiple mycotoxins was also a serious issue for cereal and oil products. The results have indicated that the mycotoxins’ contaminations have become a serious health hazard of human diet in this area. Mycotoxins evaluation for food safety should be monitored routinely and continuously, since the occurrences of mycotoxins may be different year to year under different environmental conditions, such as moisture, climatic, temperature changes, plant diseases and insect pests. Furthermore, effective managements are needed to mitigate food safety risks associated with mycotoxins.

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