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Analysis on contamination status and dietary exposure assessment of fumonisins in cereal and oil food samples of a coastal city in northern China

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Abstract

Fumonisin is a class 2B carcinogen, which can pollute many food varieties and has been proved to be carcinogenic and teratogenic. 258 pieces cereal and oil food samples were collected from 14 districts in Yantai city from farmers' homes, supermarkets and farmers' markets. The contamination level of fumonisins was detected by High-performance liquid chromatography-tandem mass spectrometry. The pollution level of fumonisin was determined by *CODEX STAN 193-1995 and EC No 1881/2006*. We conducted quantitative risk assessment of fumonisins through the Daily intake (EDI) and Hazard Quotient (HQ) by point assessment method. Corn and its products were multiple polluted by FBs, and the pollution degree of corn flour and corn-based cake were higher than that of corn kernels. The food exposure risk of FBs in 2-6 years old was higher than that of standard population, urban standard population and rural standard population. The exposure risk of fumonisins in high consumption group was higher than that in general consumption group. The food exposure risk of corn with average content of fumonisins was basically at an acceptable level, but corn and its products with high FBs content caused greater risk for children aged 2-6 years old and adults with high corn consumption.

Keywords: cereal and oil food; fumonisins; contamination status; exposure assessment.

Practical Application: We applied the model provided by the project results to fit and calculate the content , the pollution situation and the dietary exposure risk probability of fumonisins in cereal and oil food.It provided a scientific basis for understanding the pollution situation of fumonisins in cereal and oil food of a coastal city in northern China. At the same time, trace the pollution source of high concentration fumonisins, explore their pollution pathways and prevention and control measures.Based on residents' food consumption data, and based on the FAO/WHO recommended dietary exposure assessment method for chemical pollutants in food, a dietary exposure risk assessment was conducted to obtain the dietary risk values of fumonisins in specific populations, evaluate the potential risk of fumonisins pollution in food in Yantai City, and provide scientific theoretical basis for further constructing risk warning mechanisms and assessment models.

1 Introduction

Yantai is a typical coastal city in northern China, and its geographical location is shown in Figure 1. Previous studies found that its cereal food was contaminated by a variety of mycotoxins, including fumonisins (FBs) and aflatoxins (Gong et al., 2018). Its toxicity and harm have additive or synergistic effects, which seriously threaten human health, animal growth and reproduction, and pose a threat to food security and international trade (World Health Organization, 2021). It has important practical significance to investigate the contamination level of FBs in cereal and oil food and assess the dietary exposure risk of Yantai city residents for understanding the contamination level and dietary exposure risk of FBs of coastal residents in northern China.

FBs is a group of 28 structurally related mycotoxins produced by *F. verticillioides, F. proliferatum, F. nygamai, Alternaria alternata f. sp. Lycopersici and A. niger* and it is a Class 2B carcinogen (possibly carcinogen) (Coppa et al., 2019; Li et al., 2021), which has been proved to be carcinogenic and teratogenic. Dietary exposure of FBs can lead to several harmful outcomes in both farm and experimental laboratory animals. For example, these toxins are responsible for leukoencephalomalacia in horses (Ross et al., 1992), pulmonary edema syndrome in pigs (Harrison et al., 1990), hepatotoxicity and nephrotoxicity in rats (Voss et al., 1998), and apoptosis in many other types of cells (Jones et al., 2001). Although no direct evidence of FBs hazard is found, its prolonged exposure may lead to cancer and birth defects in human (Liverpool-Tasie et al., 2019). Studies have confirmed that it is positively related to the occurrence of esophageal cancer (Claeys et al., 2020), and can also cause neural tube defects in children (Eze et al., 2018).

FBs is widely distributed in many kinds of foods. The maize and maize-based products are most commonly infected with FBs. FBs is also present in several other grains, such as rice, wheat,

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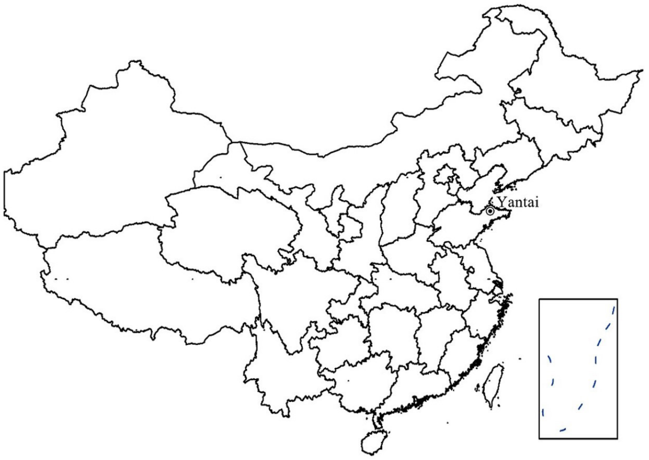


Figure 1. The location of Yantai city in China.

barley, maize, rye, oat, and millet, and grain products, such as tortillas, corn flask, chips (Petrarca et al., 2016; Cendoya et al., 2018; Shen et al., 2022; Dall'Asta & Battilani, 2016; Cendoya et al., 2018). Hidden FBs were found in raw and processed corn samples from Brazil, Poland and North America (Bryła et al., 2013). Studies carried out in the USA reported the presence of FB$_1$ and moniliformin in 34% of corn samples and 53% of corn-based food products, respectively (Gutema et al., 2000). A study in Brazil was conducted (during 2007-2010) to detect FBs in corn-based food products and reported that FB$_1$ and FB$_2$ were present in 82% and 51% of the examined products, respectively (Martins et al., 2012).

FBs are divided into four subtypes (Odjo et al., 2022). FB$_1$, FB$_2$, and FB$_3$ are most abundant with FB$_1$ being the most toxic form (Yu et al., 2018; Damiani et al., 2019). It has been found that FB$_1$ can cause systemic toxicity, including neurotoxicity, hepatotoxicity, nephrotoxicity and mammalian cytotoxicity (Chen et al., 2021). Besides this, FB$_1$ was found to be toxic to other cell lines. For example, FB$_1$ triggers dose-dependent apoptosis and necrosis in esophageal carcinoma (SNO) cell lines in humans. Similarly, FB$_1$ inhibited the activity of ceramide (CER) synthase, which is responsible for the acylation of sphinganine (Sa) and the recycling of sphingosine (So) (Solfrizzo et al., 2004). Further, Alizadeh et al. (2012) found a significant relationship between FB$_1$ contamination in rice and the risk of esophageal cancer.

Herein, the contamination level of FBs in cereal and oil food in Yantai city was monitored, and the exposure level of FBs from dietary sources of residents was evaluated. In combination with the dietary data of residents and the detection results of FBs contamination level in cereal and food in Yantai in the past decade, the spot assessment method was used to conduct the first evaluation of FBs contamination status and dietary exposure level analysis in cereal and oil food, in order to understand the FBs exposure status in Yantai residents, and to take effective regulatory measures for the government to control the harm of FBs of cereal and corn oil, reduce the loss in the planting process, improve consumer protection awareness, and ensure the healthy life of the people.

Figure 2. The fourteen administrative regions of Yantai city.

2 Materials and methods

2.1 Sample collection

258 pieces cereal and oil food samples were collected in Yantai. In order to ensure the dispersion and representativeness of sample collection, samples were distributed to 14 districts of Yantai city, as shown in Figure 2. The samples were collected from 2011 to 2022. All the samples were collected from farmers' homes, supermarkets and farmers' markets. They all had no abnormal appearance under naked-eyes examinations. Each sample was collected at least 0.5 kg, placed in air-tight sealed sterile plastic bags, encoded and stored at ambient temperature for not more than two days before being transported to CDC for analysis. Two identical samples were collected for each sample. For the grain in the household, samples are collected from different parts of storage containers to obtain representative samples. For the samples in circulation, we choose supermarkets and farmers' markets with large circulation volume to collect samples. Cereal food included wheat grain, wheat flour, corn kernel, corn flour and corn-based cake, while oil food meant corn oil, as FBs in corn oil was seriously polluted than other kinds of oils. The following types of foods were collected: wheat and its products (wheat grain and wheat flour) (N = 90), corn and its products (corn kernel, corn flour, corn-based cake) (N = 146), corn oil (N = 22).

2.2 Methods

High-performance liquid chromatography-tandem mass spectrometry (HPLC-MS) was used to detect the FBs in samples (Yang & Li, 2013). Add an appropriate amount of isotope internal standard to the sample, soak it in acetonitrile water solution, extract it by ultrasonic vibration, centrifuge it, take the supernatant, purify it by solid phase extraction column, concentrate it to constant volume, analyze it by liquid chromatography mass spectrometry system, and quantify it by stable isotope dilution internal standard method.

2.3 Result evaluation

FBs have attracted increasing attention and have become another research hotspot after aflatoxins (Wan et al., 2020). Countries world-wide have researched pollution distribution, dietary exposure, and risk assessment. As there is relatively little research on FBs in China, at present, there is currently no limit standard for FBs in food in China. Therefore, we adopt FAO and EC standards to determine the contamination of FBs in food. According to the *CODEX STAN 193-1995 General Standard for Pollutants and Toxins in Food and Feed* (Food and Agriculture Organization of the United Nations, 2015), the limit of $FB_1 + FB_2$ in unprocessed corn kernels is 4000 $\mu g \cdot kg^{-1}$, while in corn flour and corn flour is 2000 $\mu g \cdot kg^{-1}$. Corn-based cake adopts the 400 $\mu g \cdot kg^{-1}$ standard specified in the *EU Commission Regulation (EC) No 1881/2006 Maximum Limit of Food Pollutants* (European Commission, 2006).

2.4 Calculation of dietary exposure

In this study, the exposure assessment method of point assessment was adopted. Four categories of population, including children aged 2 to 6 years old, standard population, urban standard population and rural standard population, were selected for exposure assessment. Each category of population was divided into two groups: general consumption group and high consumption group according to the amount of consumption (Guo et al., 2013). Specific information was shown in Table 1.

Risk exposure was calculated based on the daily intake of cereal and oil food and the concentration of pollutants of FBs found in the samples evaluated. In addition, the body weight (bw) of different consumer groups was determined according to Table 1. Exposure risk was estimated for each consumer groups, considering different amounts of daily corn intake esti-mated in this study. The calculation is shown in Formula 1 (Wokorach et al., 2021).

$$EDI = \frac{R \times F}{\text{bw}} \times 10^{-3} \tag{1}$$

Table 1. Corn consumption and demographic information of different consumer groups in China.

consumer groups	body weight/ kg	corn consumption/(g/d)	
		general consumption group	high consumption group
children aged 2-6 years old	15.18	7.70	83.50
standard population	62.57	11.53	116.90
urban standard population	66.57	6.02	66.70
rural standard population	61.13	14.12	150.00

EDI: Daily intake, μg/(kg·bw·d);

R: Residual concentration of a biological toxin, μg/kg;

F: amount of food consumption, g/standard person·d;

bw: body weight, kg.

2.5 Risk characteristics description

For the risk characterization, the outputs of exposure, namely the daily intake values, were compared with the reference dose values in order to calculate the Hazard Quotients (Assunção et al., 2015). Hazard Quotient (HQ) (Wokorach et al., 2021) is used to describe the FBs exposure risk value of cereal and oil food. HQ is a proportion of the probable exposure to a chemical and level at which no negative impacts are expected. An HQ with a value less or equal to one was interpreted as the dose intake level of the fumonisins that will probably not present any harmful effect to individuals in Yantai city. An HQ greater than one indicates that the average daily intake of the fumonisins exceeds the tolerable daily intake and could potentially present a health risk. The greater the HQ value, the greater the risk is (Kacholi & Sahu, 2018). HQ was calculated as follows (Formula 2):

$$HQ = \frac{EDI}{TDI} \times 100\% \tag{2}$$

Where EDI is the daily intake of cereal and oil intake per day (μg/(kg·bw·d)) and TDI is the tolerable daily intake dose of cereal and oil food (μg/(kg·bw·d)). The General Standard for Pollutants and Toxins in Food and Feed of *FAO/WHO Joint Expert Committee on Food Additives stipulates* that the PMTDI of FBs ($FB_1 + FB_2$) in food is 2 $\mu g \cdot kg^{-1}$bw/d (Food and Agriculture Organization of the United Nations, 2015).

2.6 Low level data processing and statistical analysis

According to the principles of the World Health Organization (WHO) for the processing of undetected data (Wang et al., 2002), when the proportion of undetected data is less than or equal to 60%, all undetected data are replaced by 1/2 detection limit; when the proportion of undetected data is more than 60%, all undetected data are replaced by detection limit. Excel is used for data import and sorting, and PASW Statistics 18 trial version statistical software is used for related statistical analysis. chi square test is used to compare the detection rate, and the test level is $\alpha = 0.01$.

3 Results and discussion

3.1 Pollution level of FBs in cereal and oil food

Table 2 showed the pollution level of FB_1, FB_2 and FB_3 in cereal and oil food of Yantai. The total detection rate of FB_1 was 44.19% (114/258), with the mean value of 128.6 μg/kg and max value of 5204 μg/kg; the total detection rate of FB_2 was 40.33% (96/238), with the mean value of 30.53 μg/kg and max value of 1582 μg/kg; the total detection rate of FB_3 was 48.32% (115/238), with the mean value of 29.29 μg/kg and max value of 937.0 μg/kg. FB_1, FB_2 and FB_3 were not detected in wheat kernels, wheat flour

Table 2. Determination of FBs pollution level in cereal and oil food in Yantai city by high-performance liquid chromatography-tandem mass spectrometry.

kinds of food	sample size	pollution level of FB_1				sample size	pollution level of FB_2			
		detection rate%	mean (μg/kg)	min (μg/kg)	max (μg/kg)		detection rate%	mean (μg/kg)	min (μg/kg)	max (μg/kg)
wheat and its products	90	0	ND	ND	ND	70	0	ND	ND	ND
wheat grain	70	0	ND	ND	ND	70	0	ND	ND	ND
wheat meal	20	0	ND	ND	ND	-	-	-	-	-
corn and its products	146	78.08	224.9	ND	5204	146	65.75	47.33	ND	1582
corn kernel	43	34.88	19.43	ND	195.0	43	27.91	2.86	ND	32.80
corn flour	63	96.83	426.6	ND	5204	63	88.89	91.25	ND	1582
corn-based cake	40	95	128.5	ND	451.0	40	70	26.44	ND	79.60
corn oil	22	0	ND	ND	ND	22	0	ND	ND	ND
total	258	44.19	128.6	ND	5204	238	40.33	30.53	ND	1582

kinds of food	sample size	pollution level of $FB_1 + FB_2$					sample size	pollution level of FB_3			
		detection rate%	exceedance rate%	mean (μg/kg)	min (μg/kg)	max (μg/kg)		detection rate%	mean (μg/kg)	min (μg/kg)	max (μg/kg)
wheat and its products	70	0	-	ND	ND	ND	70	0	ND	ND	ND
wheat grain	70	0	-	ND	ND	ND	70	0	ND	ND	ND
wheat meal	-	-	-	-	-	-	-	-	-	-	-
corn and its products	146	78.77	5.48	217.86	ND	6786	146	58.22	31.22	ND	937.0
corn kernel	43	34.88	0	21.4	ND	227.8	43	30.23	3.72	ND	23.80
corn flour	63	96.83	4.76	517.58	ND	6786	63	63.49	59.33	ND	937.0
corn-based cake	40	97.5	12.5	154.6	ND	499.5	40	80	16.99	ND	73.90
corn oil	22	0	0	ND	ND	ND	22	0	ND	ND	ND
total	238	35.71	3.36	168.3	ND	937.0	238	48.32	29.29	ND	6786

Note: ND means not detected.

and corn oil. There was triple pollution of FB_1, FB_2 and FB_3 in corn kernels, corn flour and corn-based cake, the detection rates and mean value of FB_1 were 34.88% (15/43), 19.43 μg/kg in corn kernel, 96.83% (61/63), 426.6 μg/kg in corn flour and 95% (38/40), 128.5 μg/kg in corn-based cake; the detection rates and mean value of FB_2 were 27.91% (12/43), 2.86 μg/kg in corn kernel, 88.89% (56/63), 91.25 μg/kg in corn flour and 70% (28/40), 26.44 μg/kg in corn-based cake; the detection rates and mean value of FB_3 were 30.23% (13/43), 3.72 μg/kg in corn kernel, 63.49% (40/63), 59.33 μg/kg in corn flour and 80% (32/40), 16.99 μg/kg in corn-based cake. The total unqualified rate of corn and its products was 5.48% (8/146). The unqualified rate of corn flour was 4.76% (3/63), and the $FB_1 + FB_2$ values of unqualified samples were 6786 μg/kg, 3179 μg/kg and 2186 μg/kg; The unqualified rate of corn-based cake was 12.5% (5/40), and the $FB_1 + FB_2$ values of unqualified samples were 499.5 μg/kg, 436.1 μg/kg, 426.7 μg/kg, 418.7 μg/kg, and 414.6 μg/kg, respectively; the qualified rate of corn kernel was 100%.

Figure 3 shows the contamination level of FBs in different kinds of cereal and oil food, and it can be seen that FBs in corn and its products was the most polluted.

The pollution of corn-based cake is lower than that of corn flour, which may be due to the decrease of FBs when heated above 150-200 °C during food processing techniques like baking, frying, roasting, or extrusion cooking, FBs may be reduced. The degree of reduction in their chemical structure and toxicity depends on the cooking conditions and the composition of the food matrix (Humpf & Voss, 2004). This reduction could be due to the structural modifications of FBs while interacting with other components of food that leads to the conjugate's formation (Falavigna et al., 2012).

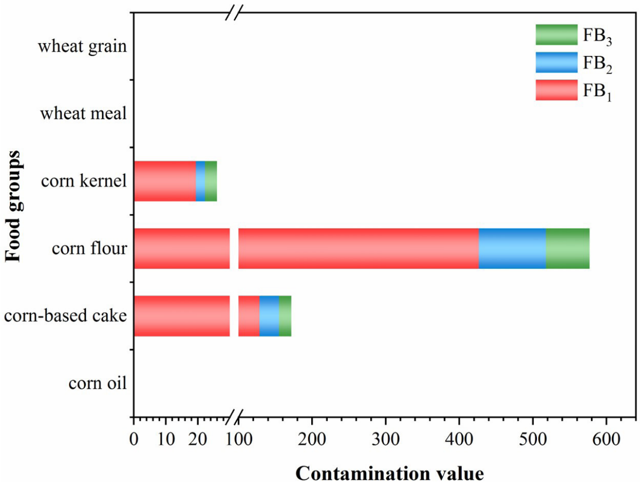


Figure 3. Cumulative contamination value of FB_1, FB_2 and FB_3 in cereal and oil food.

3.2 Comparison of FBs contamination in different kinds of food

FBs had different pollution status in different kinds of cereal and oil food, among which wheat and its products and corn oil were not detected. More FBs are detected in corn and its products. Corn flour had the highest frequency of contamination with FB_1 (96.83%), FB_2 (88.89%), and FB_3 (63.49%). For the other food types, the frequency of positive samples depends on the toxin type (Figure 4). This is related to the pollution characteristics of FBs, which mainly pollute corn and its products (Burger et al., 2010). In this study, the detection rates and detection mean values of FB_1 (78.08%, 224.9 μg/kg), FB_2 (65.75%, 47.33 μg/kg) and

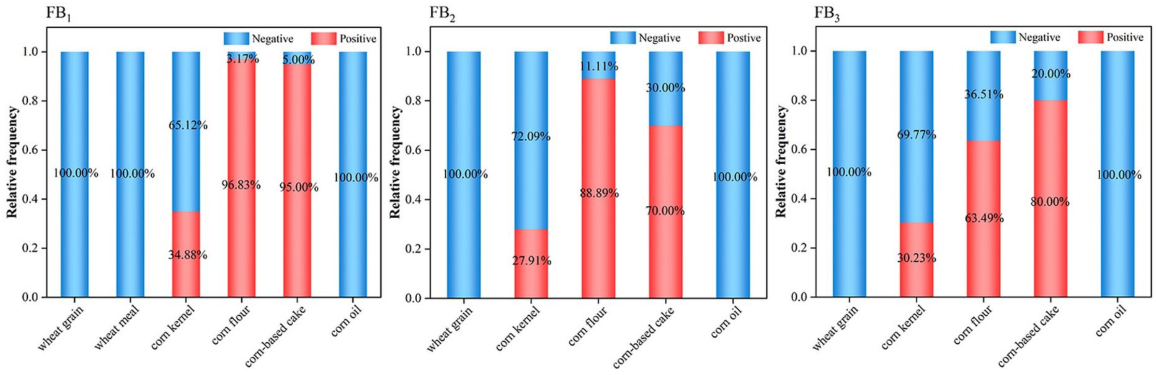


Figure 4. Detection of FB$_1$, FB$_2$ and FB$_3$ in cereal and oil food.

Table 3. Comparison of FBs pollution status of different kinds of corn and its products.

kinds of food	sample size	detection quantity of FB$_1$	detection rate%	χ^2	detection quantity of FB$_2$	detection rate%	χ^2	detection quantity of FB$_3$	detection rate%	χ^2
corn kernel	43	15	34.88	66.51	12	27.91	42.65	13	30.23	22.37
corn flour	63	61	96.83		56	88.89		40	63.49	
corn-based cake	40	38	95		28	70		32	80	

FB$_3$ (58.22%, 31.22 μg/kg) in corn and its products were lower than the detection rate of FB$_1$ (94.0%), FB$_2$ (90.0%) and FB$_3$ (88.0%) in Henan Province, China (Li et al., 2020). The detection rates and detection mean values were lower than FB$_1$ (97.9%, 832.6 μg/kg), FB$_2$ (88.2%, 294.5 μg/kg) and FB$_3$ (90.0%, 109.6 μg/kg) in Jilin Province, China (Meng et al., 2021) and Latin America (90%, 1390 μg/g~21883 μg/g), from 2017 to 2021 (Odjo et al., 2022). It proved that FBs in cereal and oil food in Yantai was less polluted.

Table 3 showed the detection of FBs in different kinds of corn and its products. The detection rate of FB$_1$, FB$_2$, and FB$_3$ in corn flour and corn-based cake was higher than that in corn kernels, the χ^2 value of FB$_1$, FB$_2$, FB$_3$ were 66.51, 42.65, 22.37, respectively, $P < 0.01$, the three kinds of food had significant statistically significant. But a study in Honduras found (Cabrera-Meraz et al., 2021) that among different types of products (corn kernel, masa and tortilla), corn kernel had the highest pollution, which was statistically different from masa and tortilla ($p < 0.05$). Different monitoring results may be related to different sampling methods. The research method of Honduras was to collect the same batch of corn kernels, masa and tortilla in the same household, but in this study, the corn kernels were newly dried corn kernels collected in harvest season of the year. Corn flour and corn-based cakes were collected from the planting and circulation links, not from the same batch of products. If the storage conditions of corn kernels are not suitable, the pollution of FBs from the subsequent products of corn flour and corn-based cake may increase.

3.3 Contamination levels of FB$_1$, FB$_2$ and FB$_3$ in corn and its products

The average value of FB$_1$, FB$_2$ and FB$_3$ in corn and its products is 224.9 μg/kg, 47.33 μg/kg and 31.22 μg/kg, respectively. As was shown in Figure 5, FB$_1$, FB$_2$ and FB$_3$ accounts for 74.11%, 15.60%, and 10.29% of the total FBs in corn and its products, 74.70%, 11.00%, and 14.30% of the total FBs in corn kernel, 73.91%, 15.81%, and 10.28% of the total FBs in corn flour, 74.74%, 15.38%, and 9.88% of the total FBs in corn-based cake, respectively. The results are similar to previous studies, which noted that FB$_1$ usually accounts for about 70% of the total FBs, while FB$_2$ usually makes up 15-25% and FB$_3$ usually makes up from 3 to 8% when cultured on corn or rice. FB$_1$ is often mixed with FB$_2$ and FB$_3$, which have similar toxicity and usually play similar toxic effects (Rheeder et al., 2002).

3.4 Daily dietary exposure of FBs in cereal and oil food

The dietary exposure of FBs in cereal and oil food of Yantai residents was shown in Table 4 and Figure 6. It can be seen that the EDI value of FBs exposure of children aged 2 to 6 years old by consuming corn and its products was 0.003~28.004 μg/kg bw/d, while the EDI value of standard human was 0.001~9.512 μg/kg bw/d, the EDI value of urban standard person and rural standard person was 0.001~5.101 μg/kg bw/d and 0.001~12.492 μg/kg bw/d, respectively. The dietary exposure of FBs was significantly lower than that of Honduras (Cabrera-Meraz et al., 2021), whose EDI value of FBs was 6.16~151.98 μg/kg bw/d. The dietary exposure caused by the average fumonisin content of corn and its products ingested by adults in Yantai is 0.040~0.407 μg/kg bw/d, while the value is 6.006 μg/kg bw/d in northern Uganda (Wokorach et al., 2021). It showed that FBs dietary exposure of Yantai residents was lower than others.

The risk of FBs dietary exposure in children aged 2-6 years old was higher than that in standard population, urban standard population and rural standard population. For the same consumer

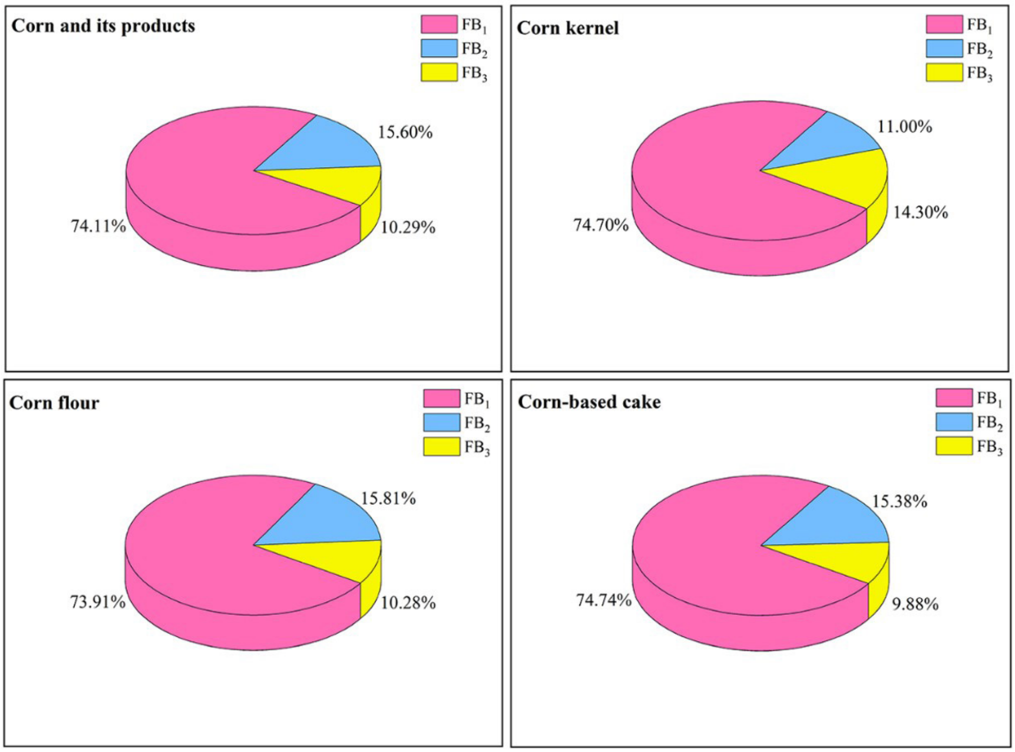
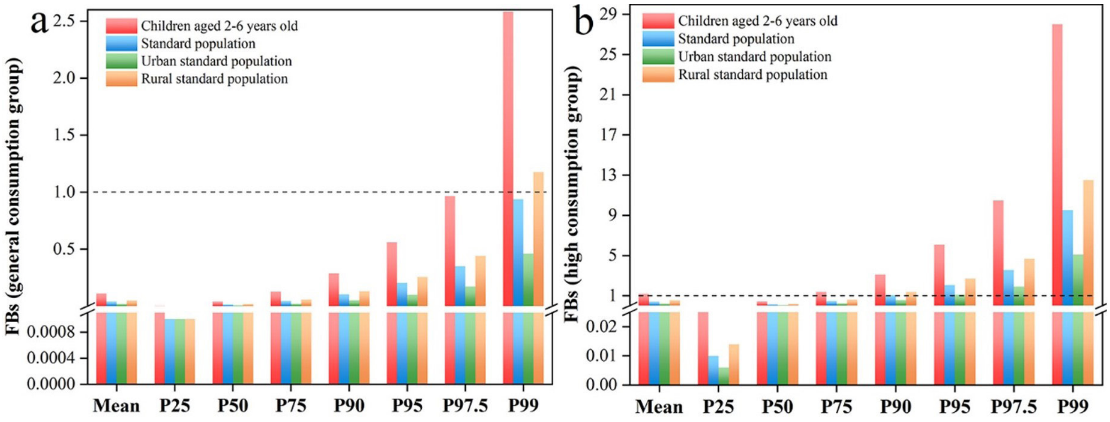


Figure 5. Contamination levels of FB_1, FB_2 and FB_3 in corn and its products.



Note: a: general intake population; b: high intake population

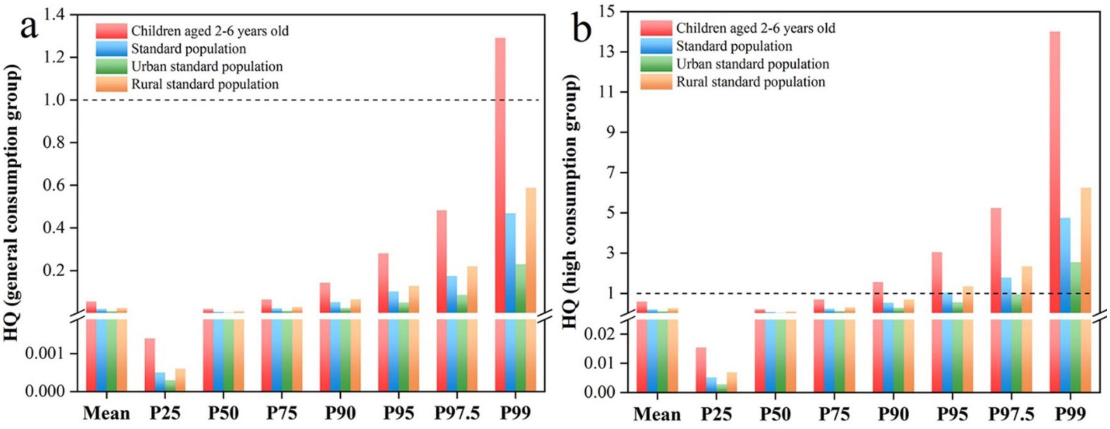
Figure 6. Dietary exposure (EDI) of FBs in corn and its products from different consumer groups.

Table 4. Dietary exposure (EDI) of FBs in corn and its products.

consumer groups	consumption level	percentage of FB_1 + FB_2 content in corn and its products							
		mean	P25	P50	P75	P90	P95	P97.5	P99
children aged 2-6 years old	general consumption group	0.111	0.003	0.040	0.128	0.287	0.561	0.966	2.582
	high consumption group	1.198	0.031	0.429	1.386	3.110	6.089	10.480	28.004
standard population	general consumption group	0.040	0.001	0.014	0.046	0.104	0.204	0.351	0.938
	high consumption group	0.407	0.010	0.146	0.471	1.056	2.068	3.559	9.512
urban standard population	general consumption group	0.020	0.001	0.007	0.023	0.051	0.100	0.172	0.460
	high consumption group	0.218	0.006	0.078	0.252	0.567	1.109	1.909	5.101
rural standard population	general consumption group	0.050	0.001	0.018	0.058	0.131	0.256	0.440	1.176
	high consumption group	0.535	0.014	0.191	0.618	1.387	2.716	4.675	12.492

Table 5. Risk characteristic value (HQ) of FBs in corn and its products.

consumer groups	consumption level	percentage of $FB_1 + FB_2$ content in corn and its products							
		mean	P25	P50	P75	P90	P95	P97.5	P99
children aged 2-6years old	general consumption group	0.055	0.001	0.020	0.064	0.143	0.281	0.483	1.291
	high consumption group	0.599	0.015	0.214	0.693	1.555	3.044	5.240	14.002
standard population	general consumption group	0.020	0.001	0.007	0.023	0.052	0.102	0.176	0.469
	high consumption group	0.204	0.005	0.073	0.235	0.528	1.034	1.780	4.756
urban standard population	general consumption group	0.010	0.000	0.004	0.011	0.026	0.050	0.086	0.230
	high consumption group	0.109	0.003	0.039	0.126	0.283	0.555	0.954	2.550
rural standard population	general consumption group	0.025	0.001	0.009	0.029	0.065	0.128	0.220	0.588
	high consumption group	0.267	0.007	0.096	0.309	0.694	1.358	2.337	6.246



Note: a: general intake population; b: high intake population

Figure 7. Risk characteristic value (HQ) of FBs in corn and its products from different consumer groups.

group, the EDI value of the high consumption group is higher than that of the general consumption group, which means that the FBs exposure risk of the high consumption group of corn and its products was higher than that of the general consumption group.

3.5 Risk characteristics of FBs in cereal and oil food

The risk characteristics of FBs taken by Yantai residents through cereal and oil food were described in Table 5 and Figure 7. It can be seen that the dietary exposure risk of corn and its products with average FBs pollution level of different consumption groups was basically at an acceptable level. No matter adults or children, both HQ of general consumption group and that of high consumption group with average FBs content were less than 1, which proved that the dietary exposure risk of corn and its products with average FBs content was acceptable.

However, the HQ value of P99 content percentile of general consumption group of children aged 2 to 6 years old and P90, P95, P97.5, P99 content percentile of high consumption group of children aged 2 to 6 years old were both greater than 1, which proved that corn and its products with high FBs content has a greater risk to children aged 2 to 6 years old, especially to the high consumption group of children, the HQ value was as high as 14.002.

Corn and its products with high FBs content also affected adults with high corn consumption, and its impact on rural standard population was higher than that on urban standard population. The P95, P97.5 and P99 content percentiles of high corn consumption among standard population, the P99 content percentiles of high corn consumption among urban standard population, and the P95, P97.5 and P99 content percentiles of high corn consumption among rural standard population were all greater than 1, which proved that corn and its products with high FBs content also had an impact on adults with high corn consumption (HQ = 4.756), and its impact on rural standard population (HQ = 6.246) was higher than that of urban standard population (HQ = 2.550), this may be related to the higher intake of corn for rural standard population.

4 Conclusion

The present study aimed, for the first time, to monitor the pollution level of fumonisins of Yantai City in different food types and assess the exposure risk of different populations to fumonisins in Yantai. Results indicate that the FBs were not detected in wheat kernels, wheat flour and corn oil. There was triple pollution of FB_1, FB_2 and FB_3 in corn and its products, and the pollution degree of corn flour and corn-based cake were higher than that of corn kernels.

Risk characterization revealed that the food exposure risk of FBs in 2-6 years old was higher than that of standard population, urban standard population and rural standard population. The exposure risk of fumonisins in high consumption group was higher than that in general consumption group. The food exposure risk of corn with average content of fumonisins was basically at an acceptable level, but corn and its products with high FBs content caused greater risk for children aged 2-6 years old and adults with high corn consumption.

Although still presenting some limitations, for example, this assessment does not cover all cereal and oil categories, which will lead to uncertainty in the FBs health risk assessment, the present work does shed a light on the presence of FBs levels in cereal and oil food in Yantai, which can help the city in developing public health strategies to prevent further hassle for their citizens.

We believe that it is of great significance to expand the monitoring variety, carry out more comprehensive food category samples and food consumption surveys in specific regions for conducting regional dietary exposure risk assessment. Next, we intend to study other in-depth aspects of the toxicity of FBs so we could link to the present work better. Another aspect that we consider to future work is the sampling methods and sampling processing methods that would help to give a technological boost to the work.

Conflict of interest

No conflict of interest associated with this work.

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