European Food Safety Authority

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TECHNICAL REPORT

Aflatoxins (sum of B1, B2, G1, G2) in cereals and cereal-derived food products [1]

European Food Safety Authority[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

SUMMARY

An ad-hoc request was received from the European Commission to provide data on levels of aflatoxins (sum of aflatoxins B1, B2, G1, G2) in food samples of cereals and cereal-derived products from the EFSA chemical occurrence database.

A total of 2183 food samples collected between 2007 and 2012, and with analytical data on the four aflatoxins of interest, were available in the database. Among the samples, 1341 corresponded to cereals and their milling products and 842 to processed cereal products. Rice (636 samples) and breakfast cereals (346 samples) were the categories with the highest number of samples reported. Some 1964 samples (90%) did not report quantified values for any of the four aflatoxins.

For cereals and their milling products, the maximum mean value at Lower Bound (LB) was found in samples of unspecified grain milling products (2.21 µg/kg) while the maximum mean value at Upper Bound (UB) was found in oat milling products (2.60 µg/kg). For processed cereal products the maximum mean value at the LB was found in fine bakery wares (0.45 µg/kg), while the maximum mean value at the UB was found in raw pasta (1.87 µg/kg).

KEY WORDS

Aflatoxins, total sum (B1, B2, G1, G2), cereals, cereal-derived food products

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TABLE OF CONTENTS

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

Within the framework of the "Mandate for the continued data collection and data analysis for nitrates, mycotoxins and dioxins and PCBs in food and for undesirable substances in feed" (M-2010-0374) the European Commission sent an ad-hoc request to EFSA (Dietary and Chemical Monitoring Unit) to provide data on levels of aflatoxins (sum of aflatoxins B1, B2, G1, G2) in food samples of cereals and cereal derived products. Summary statistics of the occurrence values reported should be provided by cereal species and in cereal-derived products.

DATA ANALYSIS

1. Introduction

Aflatoxins are toxic secondary metabolites produced by two species of the genus *Aspergillus*, *Aspergillus flavus* and *Aspergillus parasiticus*. Aflatoxins are genotoxic and carcinogenic and can cause both acute and chronic toxicity in humans (EFSA, 2007). Therefore, exposure through food should be kept as low as possible. Aflatoxins are most commonly found in cereals.

Maximum levels of aflatoxins (aflatoxins B1, B2, G1, G2 and M1) in foodstuffs are laid down in Commission Regulation (EC) No 1881/2006[4] as amended by Commission Regulation (EU) No 165/2010[5] and Commission Regulation (EU) No 1058/2012[6]. Maximum levels in legislation are specified for aflatoxin B1, aflatoxin M1, and for the sum of aflatoxins B1, B2, G1 and G2.

Data providers can report aflatoxin levels to EFSA in different manners (i.e. as "Aflatoxins", as "Aflatoxin (sum of B1, B2, G1, G2)" or as levels of individual aflatoxins B1, B2, G1, G2, etc...). In this report only food samples of cereals and cereal-derived products that reported either the sum of aflatoxins B1, B2, G1 and G2 [Paramcode[7] = Aflatoxin (sum of B1, B2, G1, G2)] or the four individual aflatoxins were considered. For those samples reporting the four individual aflatoxins the sum was calculated. When a value for "Aflatoxin (sum of B1, B2, G1, G2)" was also reported by data providers this value was used. Therefore, all results shown in this report are presented as the sum of aflatoxins B1, B2, G1 and G2.

2. Occurrence data on cereals and cereal-derived products

Data were retrieved from the EFSA chemical occurrence database on 15 March 2013. A total of 2183 food samples collected between 2007 and 2012 were available in the database fulfilling the reporting conditions described above. For 1942 samples the final value was derived from the sum of the four aflatoxins while for 241 samples the value was reported directly as "Aflatoxin (sum of B1, B2, G1, G2)". Analytical results reported as "Grain as crops", for which their final use is unknown, were excluded from the final dataset (907 analytical results mainly on rice, reporting aflatoxin levels in different manners). The left-censored data were treated by the substitution method as indicated in the EFSA scientific report "Management of left-censored data in dietary exposure assessment of chemical substances" (EFSA, 2010). At the Lower Bound (LB) results below the Limit of Detection (LOD) or Limit of Quantification (LOQ) were replaced by zero; at the Upper Bound (UB) results

[4] Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. OJ L 364, 20.12.2006, p. 5-31.

[5] Commission Regulation (EU) No 165/2010 of 26 February 2010 amending Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs as regards aflatoxins. OJ L 50, 27. 2.2010, p. 8-12

[6] Commission Regulation (EU) No 1058/2012 of 12 November 2012 amending Regulation (EC) No 1881/2006 as regards maximum levels for aflatoxins in dried figs Text with EEA relevanceOJ L 313, 13.11.2012, p. 14-15

[7] Data element part of the Standard Sample Description (SSD) that describes the contaminants parameters under analysis.

below the limit of detection or limit of quantification were replaced by the value of the limit of detection or limit of quantification.

Most of the samples reported low LOD and LOQ for the individual aflatoxins B1, B2, G1 and G2, ranging from 0.01 to 0.7 µg/kg and from 0.01 µg/kg to 1.1 µg/kg for the LOD and LOQ, respectively. Maximum LOD and LOQ values reported for "Aflatoxin (sum of B1, B2, G1, G2)" were 1 µg/kg and 3 µg/kg, respectively. As shown in Table 1 90% of the samples (1964) were left-censored (i.e. samples for which none of the aflatoxins B1, B2, G1 and G2 was quantified).

Table 1 also shows the available samples of cereals and cereal-derived products (milling products and processed products) for which total aflatoxins (sum of B1, B2, G1, G2) was calculated/reported. They are classified at FoodEx Level 2 (EFSA, 2011) and divided by sampling year. The food category with the highest number of samples was "Grains for human consumption" with a total of 934 samples, followed by "Grain milling products" with 406 samples and "Breakfast cereals" with 346 samples. More than half of the samples were collected for analysis between 2010 and 2011. Sampling was carried out in 16 different European countries, with Germany being the most represented country followed by Austria and Slovenia (Figure 1).

Table 1: Number of samples (N) of cereals and cereal-derived products (milling products and processed products) for which total aflatoxins (sum of B1, B2, G1, G2) was calculated/reported.

		Year of sampling													
		2007		2008		2009		2010		2011		2012		Total (2007-2012)	
	FoodEx Level 2	N	LC[(a)]	N	LC	N	LC	N	LC	N	LC	N	LC	N	LC
Cereals and their milling products	Grains and grain-based products (unspecified)	.		.		1	100	.		.		.		*1*	*100*
	Grains for human consumption	88	81.8	194	92.8	113	70.8	229	81.7	310	84.2	.		*934*	*83.5*
	Grain milling products	15	93.3	80	96.3	35	97.1	99	93.9	165	98.2	12	100	*406*	*96.6*
Processed cereal products	Bread and rolls	1	100	.		3	66.7	8	100	16	100	.		*28*	*96.4*
	Pasta (Raw)	.		1	100	.		3	100	52	100	.		*56*	*100*
	Breakfast cereals	86	83.7	34	91.2	23	91.3	72	98.6	131	94.7	.		*346*	*92.2*
	Fine bakery wares	3	66.7	2	100	14	57.1	20	100	62	88.7	.		*101*	*86.1*
	Beer and beer-like beverage	.		1	100	.		.		.		.		*1*	*100*
	Cereal-based food for infants and young children	67	89.6	6	100	42	100	84	100	54	96.3	.		*253*	*96.4*
	Rice-based meals					2	100	2	100					*4*	*100*
	Cereal-based dishes	.		1	100	.		.		.		.		*1*	*100*
	Dietetic food for diabetics (labelled as such)	1	100	.		.		.		.		.		*1*	*100*
	Snack food	.		17	100	11	100	11	100	11	100	.		*50*	*100*
	Ready-to-eat meals for infants and young	.		.		.		.		1	100	.		*1*	*100*
	Total	*261*	*85.1*	*336*	*94*	*244*	*82*	*528*	*91*	*802*	*92*	*12*	*100*	**2183**	**90.0**

[(a)] % of left-censored data

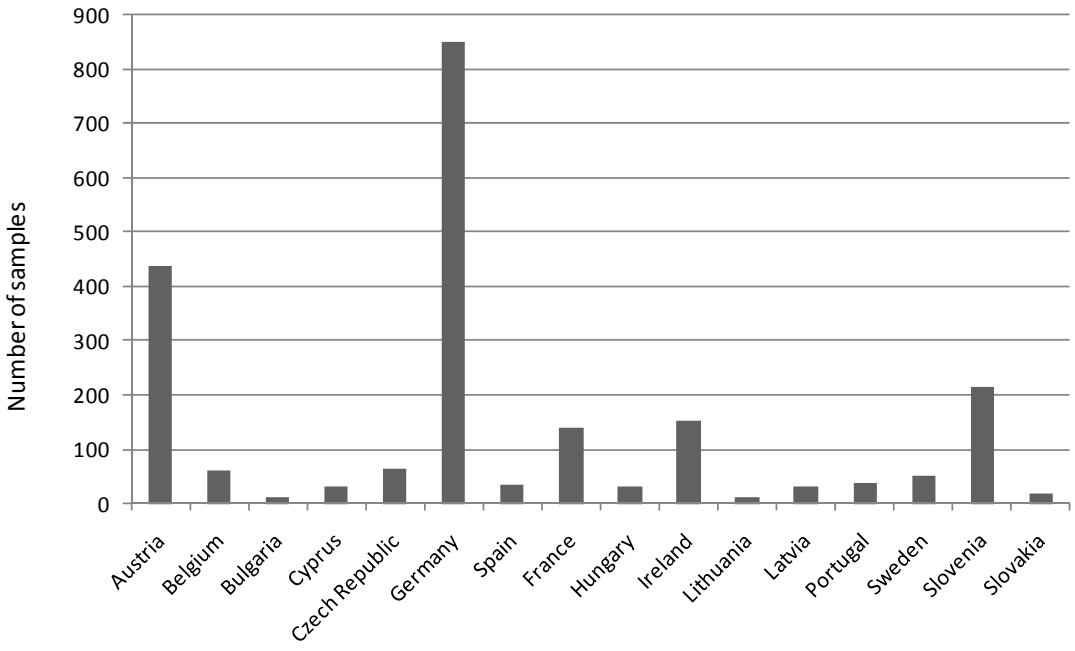

Figure 1: Distribution across European countries of the available samples of cereals and cereal-derived products (milling products and processed products) for which total aflatoxins (sum of B1, B2, G1, G2) was calculated/reported.

3. Occurrence data on cereals and their milling products

The distribution of total aflatoxins (sum of B1, B2, G1, G2) in cereals and their milling products is presented in Table 2. The mean is shown for the different food samples at FoodEx level 3 by sampling year. For the total number of samples collected between 2007 and 2012, the 95th percentile (P95) is also described (when n≥60). A total of 1341 samples were available (1173 left-censored, 87.4 %).

The maximum mean value at LB was found in samples of unspecified grain milling products (2.21 µg/kg) while the maximum mean value at UB was calculated for oat milling products (2.60 µg/kg). Rice was the most represented food commodity with a total of 630 samples (47% of the total), followed by wheat milling products (176 samples) and corn milling products (119 samples). Mean occurrence values for rice were 0.37 µg/kg at the LB and 0.87 µg/kg at the UB.

Total aflatoxins levels in six samples were above the maximum levels specified in the legislation (4 µg/kg for cereals and cereal-derived products except for rice and maize for which maximum levels are 10 µg/kg). They were three samples of rice, two of buckwheat grain and one sample of corn milling products. In general, only 70 samples of cereals and their milling products reported values above 1 µg/kg for the sum of aflatoxins B1, B2, G1 and G2 (61 samples of rice).

Table 2: Distribution of total aflatoxins (sum of B1, B2, G1 and G2) by sampling year in cereals and their milling products at FoodEx Level 3. Mean and 95th Percentile (P95) are expressed as µg/kg.

		Year of sampling												
		2007		2008		2009		2010		2011		TOTAL (2007-2011)		
		N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	P95
Barley grain	**Lower bound** [a]	1	0.00	5	0.03	1	0.00	4	0.00	5	0.00	16	0.01	.
	Upper bound [b]	1	0.40	5	0.69	1	0.64	4	0.58	5	1.00	16	0.74	.
Buckwheat grain	**Lower bound**	4	0.00	9	0.00	12	0.00	3	0.00	28	1.12	56	0.56	.
	Upper bound	4	0.12	9	0.64	12	0.64	3	0.40	28	2.43	56	1.48	.
Buckwheat milling products	**Lower bound**	.	.	.	.	1	0.00	10	0.00	2	0.00	13	0.00	.
	Upper bound	.	.	.	.	1	0.40	10	2.56	2	0.50	13	2.08	.
Corn grain	**Lower bound**	.	.	1	0.00	3	0.00	8	0.00	38	0.07	50	0.06	.
	Upper bound	.	.	1	0.80	3	0.35	8	0.39	38	1.48	50	1.21	.
Corn milling products	**Lower bound**	3	0.00	35	0.16	18	0.00	34	0.56	29	0.01	119	0.21	0.00
	Upper bound	3	0.09	35	0.52	18	0.34	34	1.21	29	0.59	119	0.69	0.99
Millet grain	**Lower bound**	.	.	.	.	.	.	1	0.00	2	0.00	3	0.00	.
	Upper bound	.	.	.	.	.	.	1	0.08	2	0.70	3	0.49	.
Oats, grain	**Lower bound**	1	0.00	2	0.00	.	.	4	0.00	.	.	7	0.00	.
	Upper bound	1	0.40	2	0.70	.	.	4	0.52	.	.	7	0.55	.
Oat milling products	**Lower bound**	.	.	1	0.00	.	.	2	0.00	3	0.00	6	0.00	.
	Upper bound	.	.	1	0.64	.	.	2	0.80	3	2.60	6	0.89	.
Rice	**Lower bound**	57	0.16	118	0.15	88	0.39	167	0.40	200	0.53	630	0.37	1.74
	Upper bound	57	0.38	118	0.43	88	0.65	167	0.84	200	1.38	630	0.87	2.60
Rice milling products	**Lower bound**	.	.	.	.	2	0.41	4	0.00	4	0.23	10	0.17	.
	Upper bound	.	.	.	.	2	0.66	4	0.40	4	0.65	10	0.55	.

Table 2: (Continuation)

		Year of sampling														
		2007		2008		2009		2010		2011		2012		TOTAL (2007-2012)		
		N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	P95
Rye grain	**Lower bound** [(a)]	10	0.00	28	0.00	4	0.13	11	0.00	4	0.00	.	.	57	0.01	.
	Upper bound [(b)]	10	0.70	28	0.70	4	0.76	11	0.91	4	0.63	.	.	57	0.74	.
Rye milling products	**Lower bound**	6	0.00	18	0.00	3	0.00	4	0.00	12	0.00	.	.	43	0.00	.
	Upper bound	6	0.70	18	0.52	3	0.39	4	0.70	12	0.11	.	.	43	0.44	.
Spelt grain	**Lower bound**	.	.	2	0.00	.	.	1	0.00	5	0.00	.	.	8	0.00	.
	Upper bound	.	.	2	0.70	.	.	1	0.80	5	1.09	.	.	8	0.96	.
Spelt milling products	**Lower bound**	.	.	3	0.00	3	0.00	1	0.00	8	0.00	.	.	15	0.00	.
	Upper bound	.	.	3	0.49	3	0.08	1	0.80	8	0.08	.	.	15	0.21	.
Wheat grain	**Lower bound**	14	0.00	27	0.00	4	0.00	23	0.00	8	0.00	.	.	76	0.00	0.00
	Upper bound	14	0.70	27	0.70	4	1.00	23	0.80	8	0.89	.	.	76	0.76	1.00
Wheat milling products	**Lower bound**	3	0.06	22	0.01	6	0.00	35	0.00	98	0.00	12	0.00	176	0.00	0.00
	Upper bound	3	0.72	22	0.20	6	0.32	35	0.84	98	0.42		.	176	0.48	1.30
Grain milling products (unspecified)	**Lower bound**	3	0.00	1	0.00	2	0.00	9	2.21	9	0.07	.	.	24	0.86	.
	Upper bound	3	0.29	1	0.70	2	0.33	9	2.51	9	0.35	.	.	24	1.17	.
Grains for human consumption (unspecified)	**Lower bound**	1	0.00	2	0.07	1	0.00	7	0.00	20	0.04	.	.	31	0.03	.
	Upper bound	1	0.08	2	0.72	1	0.33	7	0.53	20	0.71	.	.	31	0.62	.
Grains and grain-based products (unspecified)	**Lower bound**	.	.	.	.	1	0.00	.	.	.	.	.	.	1	0.00	.
	Upper bound	.	.	.	.	1	0.80	.	.	.	.	.	.	1	0.20	.

(a): Lower bound: results below the limit of detection or limit of quantification were replaced by zero.
(b): Upper bound: results below the limit of detection or limit of quantification were replaced the value of the limit of detection or limit of quantification (EFSA, 2010).

4. Occurrence data on processed cereal products

The distribution of total aflatoxins (sum of B1, B2, G1, G2) in processed cereal products is presented in Table 3. The mean is shown for the different food samples at FoodEx level 2 by sampling year. For the total number of samples collected between 2007 and 2011, the 95th Percentile (P95) is also described (when n≥60). A total of 842 samples of processed cereal products were available with data reported/calculated on the four aflatoxins (791 left-censored, 93.9%).

Data on eleven different food categories (FoodEx level 2) were reported. The three categories with the highest number of samples reported were "Breakfast cereals" 346 samples, "Cereal-based food for infants and young children" 253 samples and "Fine bakery wares" 101 samples. For processed cereal foods the maximum mean value at the LB was found in fine bakery wares (0.45 µg/kg) while the maximum mean value at the UB was found in raw pasta (1.87 µg/kg). Breakfast cereals showed mean occurrence values of 0.05 µg/kg and 0.46 µg/kg at the LB and UB, respectively.

The same maximum limits specified above for cereals and milling products applies to processed cereal products. Among the quantified samples, two samples of breakfast cereals were above the maximum levels specified in the legislation (4 µg/kg). Out of the 51 quantified samples of processed cereal-products only seven showed values above 1 µg/kg for the sum of aflatoxins B1, B2, G1 and G2.

Table 3: Distribution of total aflatoxins (sum of B1, B2, G1 and G2) by sampling year in processed cereal products at FoodEx Level 2. Mean and 95th Percentile (P95) are expressed as µg/kg.

		Year of sampling												
		2007		2008		2009		2010		2011		TOTAL (2007-2011)		
		N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	P95
Beer and beer-like beverage	**Lower bound** [(a)]	.	.	1	0.00	.	.	.	.			1	0.00	.
	Upper bound [(b)]	.	.	1	0.40	.	.	.	.			1	0.40	.
Bread and rolls	**Lower bound**	1	0.00	.	.	3	0.09	8	0.00	16	0.00	28	0.01	.
	Upper bound	1	0.12	.	.	3	0.33	8	0.92	16	0.43	28	0.55	.
Breakfast cereals	**Lower bound**	86	0.12	34	0.04	23	0.06	72	0.00	131	0.04	346	0.05	0.11
	Upper bound	86	0.28	34	0.38	23	0.44	72	0.75	131	0.44	346	0.46	1.30
Fine bakery wares	**Lower bound**	3	0.15	2	0.00	14	0.45	20	0.00	62	0.08	101	0.11	0.46
	Upper bound	3	0.39	2	0.60	14	0.81	20	0.79	62	0.70	101	0.72	1.30
Pasta (Raw)	**Lower bound**	.	.	1	0.00	.	.	3	0.00	52	0.00	56	0.00	.
	Upper bound	.	.	1	0.70	.	.	3	1.87	52	0.29	56	0.38	.
Ready-to-eat meals for infants and young children	**Lower bound**	.	.	.	.	.	.	.	.	1	0.00	1	0.00	.
	Upper bound	.	.	.	.	.	.	.	.	1	0.08	1	0.08	.
Cereal-based food for infants and young children	**Lower bound**	67	0.04	6	0.00	42	0.00	84	0.00	54	0.01	253	0.01	0.00
	Upper bound	67	0.16	6	0.99	42	0.20	84	0.18	54	0.20	253	0.20	0.60
Rice-based meals	**Lower bound**	.	.	.	.	2	0.00	2	0.00	.	.	4	0.00	.
	Upper bound	.	.	.	.	2	0.08	2	0.08	.	.	4	0.08	.
Cereal-based dishes	**Lower bound**	.	.	1	0.00	.	.	.	.	.	.	1	0.00	.
	Upper bound	.	.	1	0.40	.	.	.	.	.	.	1	0.40	.
Dietetic food for diabetics (labelled as such)	**Lower bound**	1	0.00	.	.	.	.	.	.	.	.	1	0.00	.
	Upper bound	1	0.80	.	.	.	.	.	.	.	.	1	0.80	.
Snack food	**Lower bound**	.	.	17	0.00	11	0.00	11	0.00	11	0.00	50	0.00	.
	Upper bound	.	.	17	0.23	11	0.24	11	0.70	11	0.21	50	0.33	.

(a): Lower bound: results below the limit of detection or limit of quantification were replaced by zero. (b): Upper bound: results below the limit of detection or limit of quantification were replaced the value of the limit of detection or limit of quantification (EFSA, 2010).

RECOMMENDATIONS

Collection of analytical data on occurrence of aflatoxins in relevant food commodities should continue in order to have representative number of samples in different food categories. Harmonised reporting across the European countries is needed; submitting data on contaminants and residues to EFSA should follow the requirements of EFSA's Guidance on Standard Sample Description (SSD) for Food and Feed[8]

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[8] Available at http://www.efsa.europa.eu/en/datex/datexsubmitdata.htm

ABBREVIATIONS

EFSA	European Food Safety Authority
LB	Lower Bound
LOD	Limit of Detection
LOQ	Limit of Quantification
PCBs	Polychlorinated Biphenyls
SSD	Standard Sample Description
UB	Upper Bound