Mycotoxin Exposure Patterns in Africa: *single to multiple mycotoxin occurrences*

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Presented
@

TrainMic meets CroMycoScreen Workshop

University of Josip Juraj Strossmayer in Osijek, Faculty of Food Technology, 19-20th September 2016.

Chibundu Ezekiel | TrainMiC meets CroMycoScreen | 20.09.2016

Outline

- Background to mycotoxins and their impacts
- Exposure routes & effects
- Mycotoxin patterns in food, feed and products
  - West and Central Africa
  - Eastern Africa
  - Southern Africa
- Summary

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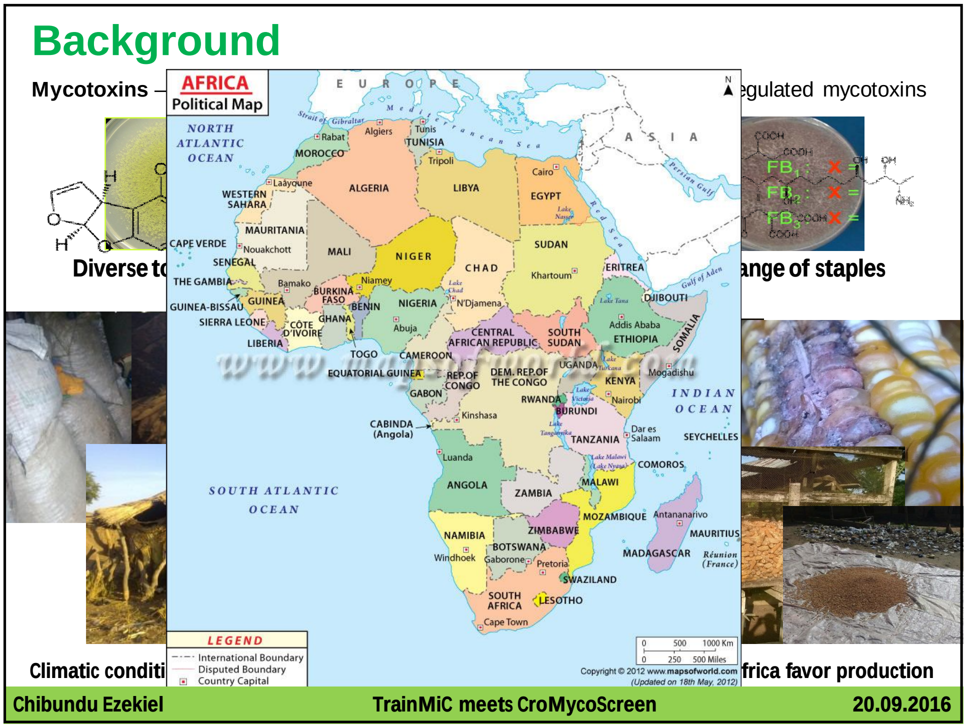
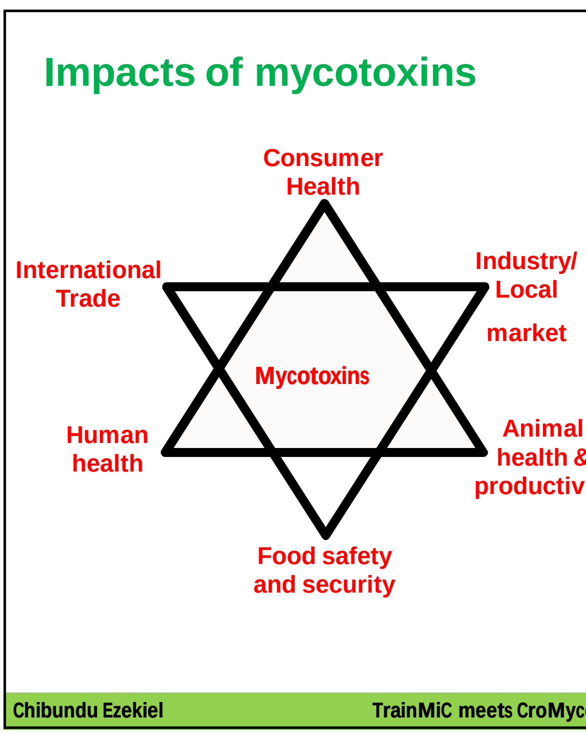




News 18 Apr 2012

Mycotoxins kill 7,000 chickens in Russia

PROCESS MANAGEMENT POULTRY PRODUCTION STATISTICS 2319× 0

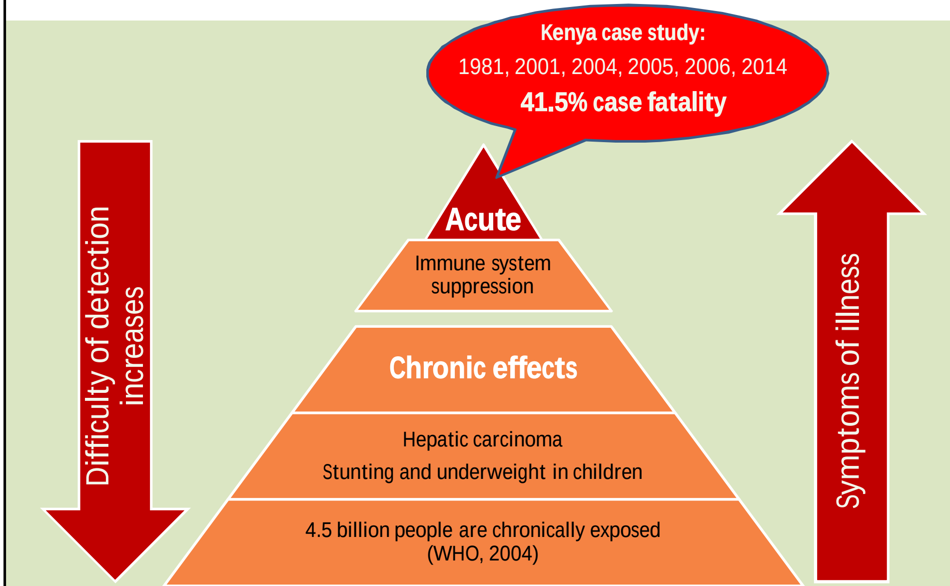
One of the largest poultry producers in Russia, 'Amur broiler' has reported a staggering number of chicken deaths.

Local media Amur Info reported that products from this poultry producers have disappeared from markets shelves. Representatives of Rosselkhoznadzor, which receive monthly reports from the company, believe that the chicken deaths were caused by poor-quality feed.

"At the end of the year the poultry received stale feed. Quite simply, Penicillium - fungi was prensent in the feed, which produces mycotoxins, and extremely dangerous for both animals and humans. This is a virulent poison, " explained Olga Atavina, deputy chief of management of Rosselkhoznadzor for the Zabaikalye Territory and Amur Oblast. "Perhaps these mycotoxins undermined the chicken immune system," she added.

According to experts, the feed killed about 7,000 of the company's poultry. Meat from the sick animals did not end up on shop-shelves, the officials added. However, the owners of the stricken poultry farms denied that the chickens died due to mycotoxin poisoning. According to them the underlying cause could be the new equipment

Health Impact: exposure routes/effects



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Variety of effects of exposure

Kwashiorkor /malnutrition symptoms due to aflatoxin exposure

Neural tube defects leading to fetal loss, stillbirth or neonatal death caused by fumonisins

Estrogenic effects in swine and other mammals caused by deoxynivalenol or zearalenone

Other effects: immunosuppression, growth faltering in children, hepatocarcinogenicity, oesophageal cancers, renal diseases

(Gong et al. 2002; Turner et al. 2003)

Synergistic interactions may lead to unknown but more severe effects

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Evidence on Association of Aflatoxin Exposure and Child Growth

Geography	Findings (correlation)	Reference
Ghana & The Gambia	Exposure during pregnancy and smaller babies during the first weeks of life	Barett (2005), Review
Ghana	Exposure and anemia in pregnancy	Shuaib et al. (2010a)
Ghana	Exposure and low-weight, still birth and pre-term babies	Shuaib et al. (2010b)
Tanzania	Exposure and reduced weight and height among breast fed infants under 6 months	Magoha et al. (2014)
Benin, Togo	Between higher levels of aflatoxins and lower growth rates	Gong et al. (2002)
Togo, Iran, Kenya, UAE	Exposure and stunting in children	Barett (2005), Review

There is possible association between aflatoxin exposure and micronutrient deficiencies (e.g. selenium, folate, zinc) and vitamin A and C (Turner et al. 2003; Obuseh et al. 2011; Liao et al. 2014).

Mycotoxin Contamination Patterns

Understanding the pattern of mycotoxins and fungal metabolites in food and feed chain can:

- ✓ give a clue to **the array of microbial contaminants** involved in a food/feed system
- ✓ help to **map and evaluate the incidence** of multi-mycotoxins in crops and suggest **high risk areas/regions**
- ✓ provide baseline data for **evaluating mycotoxin exposures** and **assessing risks**
- ✓ help identify **susceptible crops** to mycotoxins as well as **alternative crops** for human consumption
- ✓ aid in the selection of **potential mycotoxin management options** in crops
- ✓ identify **single or compound combinations** for future toxicological testing.

Contamination Patterns: *West Africa (NG)*

Findings

Food Additives and Contaminants
Vol. 29, No. 8, August 2012, 1288–1299
Taylor & Francis
Taylor & Francis Group

Fungal and bacterial metabolites in commercial poultry feed from Nigeria

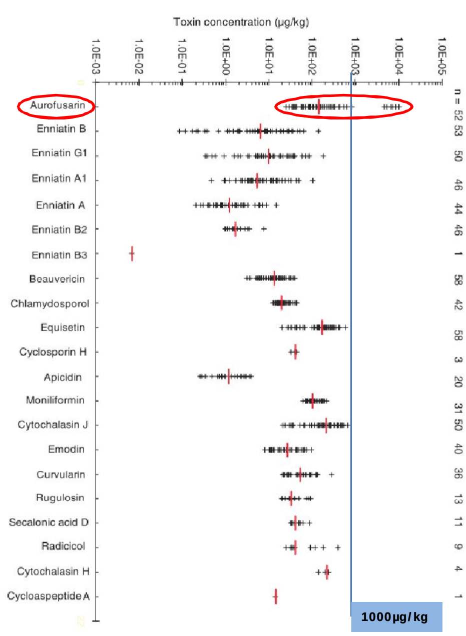
C.N. Ezekiel[ab], R. Bandyopadhyay[a*], M. Sulyok[c], B. Warth[c] and R. Krska[c]

✓63 microbial metabolites
- 56 are of fungal origin
- 7 are from bacteria
- 19 are novel in their occurrence

✓62% samples > 20µg/kg TAf limit

✓10.3% samples > 1mg/kg DON limit

		Concentration (µg kg^{-1})				Number of contaminated feed types				
Metabolite[a]	Incidence (%)	Mean	SD	Min	Max	Chick mash (n^b = 7)	Broiler finisher (n = 12)	Grower mash (n = 14)	Layer mash (n = 14)	Broiler starter (n = 11)
AFB1	76	198	246	6	1067	7	8	12	10	8
AFB2	50	34	23	10	114	7	7	4	3	8
AFG1	60	45	46	8	235	7	7	8	5	8
AFG2	10	13	4	10	20	3	2	0	0	1
DON	36	651	786	80	2336	1	5	5	5	5
DON-G	29	170	179	22	482	0	2	6	6	3



Concentration levels in poultry feed

✓Some known facts about ARF
- Feed ⟶ Egg yolk transfer.
- Impairs egg quality (induces colour change from golden orange to dark brown (Kotyk et al. 1995).
- Affects chicken meat quality by reducing amino acid and fat contents significantly (Dvorska 2000).
- Increases the susceptibility of the egg yolk to lipid peroxidation at >30µg/kg (Dvorska et al. 2001).

Food Control 27 (2012) 338–342

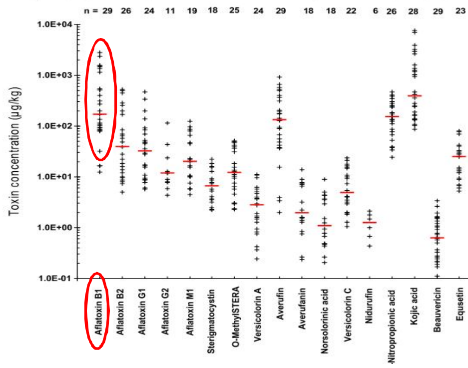
Contents lists available at SciVerse ScienceDirect

Food Control

journal homepage: www.elsevier.com/locate/foodcont

Natural occurrence of mycotoxins in peanut cake from Nigeria

C.N. Ezekiel [a,*], M. Sulyok [b], B. Warth [b], A.C. Odebode [c], R. Krska [b]



Aflatoxin B_1 concentrations in peanut cake samples from markets within five states in Nigeria.

State	N[a]	Concentrations (µg/kg)						
		Min	Max	Mean	% contaminated samples			
					<10	10–100	101–1000	>1000
Lagos	9	13	2824	385.1ab	0.0	55.6	33.3	11.1
Ogun	5	543	2335	1428.4a	0.0	0.0	20.0	80.0
Oyo	5	102	1487	588.4ab	0.0	0.0	80.0	20.0
Niger	3	32	1365	557.3ab	0.0	33.3	33.3	33.4
Kaduna	7	80	403	151.0b	0.0	57.1	42.9	0.0
Total	29	13	2824	–	0.0	34.5	41.4	24.1

Levels of metabolites in peanut cake

International Journal of Food Microbiology 162 (2013) 231–236

Contents lists available at SciVerse ScienceDirect

International Journal of Food Microbiology

journal homepage: www.elsevier.com/locate/ijfoodmicro

Fungal and mycotoxin assessment of dried edible mushroom in Nigeria

C.N. Ezekiel [a,*], M. Sulyok [b], J.C. Frisvad [c], Y.M. Somorin [d], B. Warth [b], J. Houbraken [e], R.A. Samson [e], R. Krska [b], A.C. Odebode [f]

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[b] Center for Analytical Chemistry, Department of Agrobiotechnology (IFA-Tulln), University of Natural Resources and Life Sciences Vienna, Konrad Lorenzstr, 20, A-3430 Tulln, Austria
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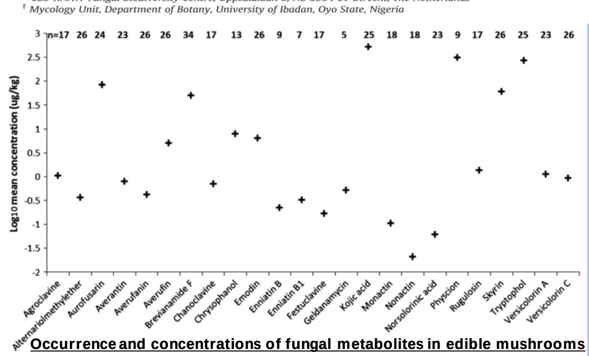

Occurrence and concentrations of fungal metabolites in edible mushrooms

- ✓ **24 fungal metabolites; none has been previously reported in mushrooms.**
- ✓ **No regulated toxin.**
- ✓ **Emerging *Fusarium* toxins were present at very low levels.**

Food Additives & Contaminants: Part B, 2013
Vol. 6, No. 4, 294–300, http://dx.doi.org/10.1080/19393210.2013.823626

Taylor & Francis
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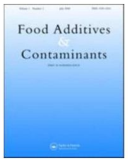
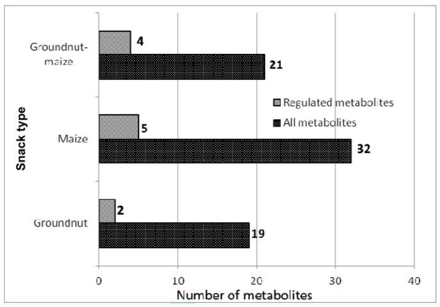


Food Additives & Contaminants: Part B: Surveillance

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tfab20

Mycotoxins and fungal metabolites in groundnut- and maize-based snacks from Nigeria

O.F. Kayode[a], M. Sulyok[b], S.O. Fapohunda[c], C.N. Ezekiel[c], R. Krska[b] & C.R.B. Oguntona[d]



Occurrence of fungal metabolites in snacks

- ✓32 fungal metabolites.
- ✓Aflatoxin levels reached 1,041µg/kg and **30% of the snacks had >20µg/kg**.
- ✓ Fumonisins levels were between **4.8 and 339µg/kg** in **maize**- and **maize-peanut-based snacks**.
- ✓ **>15 metabolite combinations** were found in samples.

Mycotoxin Res (2014) 30:89–102
DOI 10.1007/s12550-014-0194-2

MYCOTOXIN

ORIGINAL PAPER

Fungal and bacterial metabolites of stored maize (*Zea mays*, L.) from five agro-ecological zones of Nigeria

Modupeade Adetunji · Olusegun Atanda · Chibundu N. Ezekiel · Michael Sulyok · Benedikt Warth · Eduardo Beltrán · Rudolf Krska · Olusegun Obadina · Adegoke Bakare · Cynthia A. Chilaka

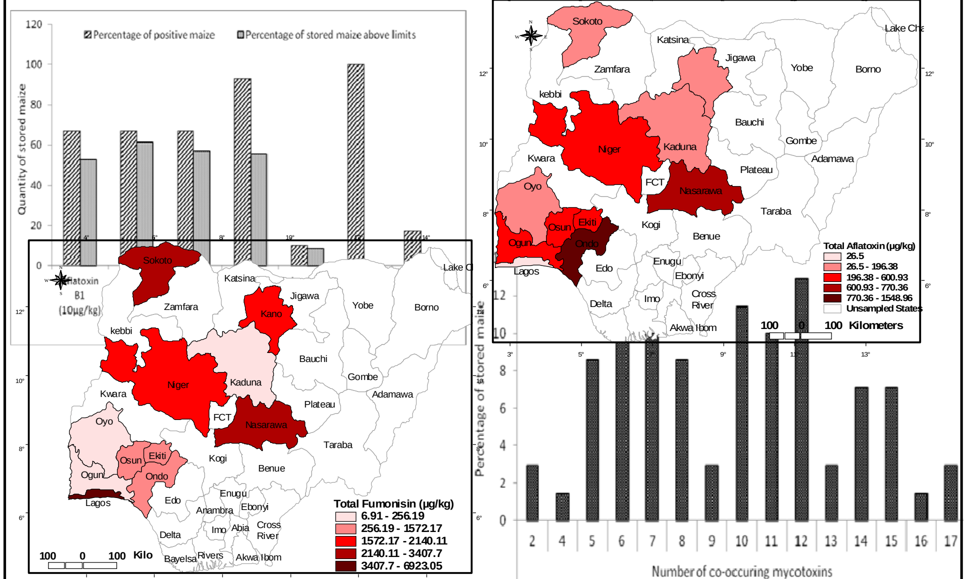
Occurrence and Concentration of Regulated and Non Regulated Mycotoxins in Stored Maize from Five AEZS[c] of Nigeria

Mycotoxin	N[a]	P[b]	Concentration (µg/kg) Min	Max	Median	Mean	SD
3-nitropropionic acid	59	84.3	6.5	2844	42.5	244	530
Aflatoxin B_1	47	67.1	0.4	6738	74	394	1033
Aflatoxin B_2	38	54.3	1	644	12	44	108
Aflatoxin G_1	11	15.7	1	264	16	47	83
Aflatoxin G_2	4	5.7	0.7	52	6	16	24
Aflatoxin M_1	34	48.6	1.2	120	5	14.5	23
Alternariolmethylether	20	28.6	0.04	21	0.6	3	6
Alternariol	13	18.6	0.8	57	4	10	16
Beauvericin	55	78.6	0.1	120	1	10	23
Deoxynivalenol	70	100.0	11	479	49	60	59
Deoxynivalenol-glucoside	7	10.0	0.1	76	0.4	11	29
Fumonisin B_1	65	92.9	1.8	10447	1064	1552	1934
Fumonisin B_2	59	84.3	12.8	3455	274	442	581
Fumonisin B_3	59	84.3	6.4	720	107	161	163
Hydrolysed fumonisin B_1	37	52.9	0.4	135	5	11	22
Fusaproliferin	3	4.3	57.4	263	243.5	188	114
Moniliformin	54	77.1	0.8	899	11	130	221
Nivalenol	38	54.3	0.7	164	6	14	28
Ochratoxin A	7	10.0	4	580	28	111	208
Ochratoxin-alpha	1	1.4	11	11	11	11	-
Ochratoxin B	5	7.1	2	26	2	7.5	11
Sterigmatocystin	26	37.1	0.4	17	0.9	3	5
Zearalenone	12	17.1	0.4	2044	4	174	589
Alpha-zearalenol	1	1.4	17	17	17	17	-
Beta-zearalenol	1	1.4	13	13	13	13	-

- ✓ 62 fungal and 4 bacterial metabolites; **54 first reports in Nigerian maize**.
- ✓ The incidence and levels of fumonisins were higher than those of aflatoxins.

Percentage of stored maize above set limits

Mapping aflatoxin levels in maize across Nigeria



Mapping fumonisin levels in maize across Nigeria

Co-occurrence of mycotoxins in Nigerian maize

Eur Food Res Technol (2012) 235:285–293
DOI 10.1007/s00217-012-1755-2

ORIGINAL PAPER

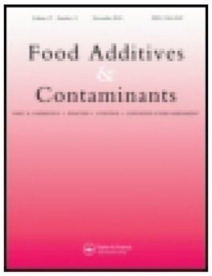
Multi-microbial metabolites in fonio millet (acha) and sesame seeds in Plateau State, Nigeria

C. N. Ezekiel · M. Sulyok · B. Warth ·
R. Krska

Occurrence and concentration levels of selected mycotoxins in fonio and sesame in Nigeria

Metabolite[a]	Fonio millet ($n^b = 16$)						Sesame ($n^b = 17$)					
	N^c	Concentration (µg/kg)					N^c	Concentration (µg/kg)				
		Min	Max	Median	Mean	SD		Min	Max	Median	Mean	SD
AFB1	13	0.08	1.4	0.2	0.4	0.4	0	<LOD	<LOD	<LOD	<LOD	<LOD
AFB2	4	0.07	0.1	0.08	0.08	0.02	0	<LOD	<LOD	<LOD	<LOD	<LOD
AFG1	4	0.2	2	0.4	0.6	0.6	0	<LOD	<LOD	<LOD	<LOD	<LOD
DON	14	3	14	10	9	3	15	8	76	21	28	22
FB1	3	5	43	9	19	21	0	<LOD	<LOD	<LOD	<LOD	<LOD
FB2	2	2	7	4	4	3	0	<LOD	<LOD	<LOD	<LOD	<LOD
ZEN	15	2	987	12	85	251	15	0.7	38	3	7	12
TEN-AC	16	14	1,049	123	235	274	16	2	40	11	16	13

- ✓**52 microbial metabolites in fonio while 30 in sesame.**
- ✓**Recent analysis of 35 sesame from another state in Nigeria showed 23 metabolites but no aflatoxins.**



Food Additives & Contaminants: Part A
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tfac20

Fungal and bacterial metabolites associated with natural contamination of locally processed rice (Oryza sativa L.) in Nigeria

Abdus-Salaam Rofiat[a], Francesca Fanelli[b], Olusegun Atanda[c], Michael Sulyok[d], Giuseppe Cozzi[b], Simona Bavaro[b], Rudolf Krska[d], Antonio F. Logrieco[b] & Chibundu N. Ezekiel[e]
[a] Department of Food Science and Technology, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria

Table 2. The incidence and concentration levels of metabolites in Nigerian rice.

Group	Metabolite	LOD[a]	Recovery ± SD %[b]	Concentration (µg/kg) Mean	Median	Maximum
Major mycotoxins and derivatives	Aflatoxin B_1	0.15	94.8 ± 4.1	5.1	3.7	20.2
	Aflatoxin B_2	0.2	91.4 ± 4.1	1.62	0.67	6.11
	Aflatoxin G_1	0.2	93.7 ± 3.8	3.76	3.76	7.21
	Ochratoxin A	0.5	101.3 ± 1.4	1.01	0.97	1.47
	Fumonisin B_1	3.0	100	18.52	7.22	60.72
	Fumonisin B_2	1.5	100	8.75	5.48	24.39
	Fumonisin B_3	2.0	100	5.54	6.97	8.79
	DON	0.5	99.4 ± 7.4	4.08	4.08	5.76
	Nivalenol	0.5	85.5 ± 12	17.1	10.86	42.18
	Zearalenon	0.3	106.4 ± 9.3	55.13	2.1	927.84
	Alpha-zearalenol	0.5	111 ± 7.8	2.54	2.08	7.53
	Beta-zearalenol	0.5	108.5 ± 3.7	3.9	2.84	14.2
	ZON-4-sulphate	0.03	103.8 ± 9.7	7.64	0.15	79.28

Table 3
Variation in mean concentrations of 14 mycotoxins in graded categories of melon and bush mango seeds sold in Lagos, Nigeria.

Mycotoxins	Melon (n^a = 16)		Bush mango (n^a = 40)	
	Mean ± SE concentrations (µg/kg)		Mean ± SE concentrations (µg/kg)	
	Hand-peeled	Machine-peeled	Discoloured	Non-discoloured
Aflatoxin B_1	50.4a ± 10.6	16.9b ± 2.7	95.4a ± 48.8	5.8b ± 0.9
Aflatoxin B_2	6.6a ± 1.8	1.8b ± 0.1	28.1a ± 14.0	1.6b ± 0.2
Aflatoxin G_1	8.4a ± 2.3	11.9a ± 0.4	3.8a ± 0.6	2.1b ± 0.4
Aflatoxin G_2	4.7 ± 0.9	–	–	–
Total aflatoxins[b]	62.9a ± 17.0	25.8b ± 5.6	111.9a ± 55.1	4.4b ± 0.9
Cyclopiazonic acid	26.9 ± 13.1	–	84.1a ± 31.6	24.9b ± 5.8
HT-2 toxin	–	–	24.5*	46.6 ± 21.1
Moniliformin	–	–	153.0a ± 133.6	10.2b ± 3.2
Mycophenolic acid	–	–	55.8a ± 30.0	8.2b ± 2.5
Nivalenol	–	–	3.8a ± 0.0	3.8a ± 0.0
Ochratoxin A	0.6[c]	–	68.1a ± 58.8	18.7b ± 11.3
Ochratoxin B	–	–	47.1a ± 41.4	5.9b ± 2.3
T-2 toxin	–	–	9.1b ± 2.0	40.1a ± 12.4
Tenuazonic acid	–	–	24.7a ± 6.1	19.1a ± 5.5

Mean values with different superscript alphabets in a row are significantly different ($p < 0.05$).

[a] Number of analyzed samples.
[b] Total aflatoxin is $\sum$ AFB_1, AFB_2, AFG_1 and AFG_2.
[c] Only one sample tested positive.

Risk Assessment/Exposures

Eur Food Res Technol (2014) 239:287–296
DOI 10.1007/s00217-014-2221-0

ORIGINAL PAPER

Distribution of mycotoxins and risk assessment of maize consumers in five agro-ecological zones of Nigeria

M. C. Adetuniji · O. O. Atanda · C. N. Ezekiel · A. O. Dipeolu · S. V. A. Uzochukwu · J. Oyedepo ·

Table 2 Risk assessment of aflatoxin exposure in Nigerian maize grains

AEZ	[a]Dietary AFB_1 exposure (ng/kg body weight/day)	[b]Annual HCC cases		[c]Estimated liver cancer risk (cases/100,000 population/year)	[d]Cancer incidence attributable to dietary aflatoxin (%)	[e]DALY
		HBsAg-negative	HBsAg-positive			
SS	0.91–465.32	0.0091–4.65	0.27–139.60	0.27–139.60	4.21–2,147.63	3.52–1,821.78
NGS	0.38–654.22	0.0038–6.54	0.11–196.26	0.11–196.26	1.75–3,019.46	1.44–2,561.19
SGS	2.43–1,869.35	0.024–18.69	0.73–560.80	0.73–560.80	11.22–8,627.78	9.53–7,318.44
DS	0.64–6,401.1	0.0064–64.01	0.20–1,920.33	0.02–1,920.33	2.93–29,543.54	2.61–25,060.31
HF	22.63–4,90.57	0.226–4.91	6.79–1,47.17	6.79–147.17	104.44–2,264.17	88.61–1,920.57
NATIONAL	26.99–9,880.56	0.2693–98.80	1.62–592.83	8.10–2,964.16	124.55–45,602.58	126.85–38,682.29

SS Sudan Savanna, *NGS* Northern Guinea Savanna, *SGS* Southern Guinea Savanna, *DS* derived Savanna, *HF* humid forest

[a] The value was calculated as reported by Liu and Wu [4]—the average maize consumed (57 g/person/day) in Nigeria as adapted from the WHO global environment monitoring system (GEMS)/food consumption cluster diets database [19] × concentration of aflatoxins in the stored grains in the various AEZs

[b] The value was calculated as reported by Abt Associates Incorporated [36]—dietary exposure × the HCC potency (0.01) for HBsAg-negative and (0.3) for HBsAg-positive

[c] Estimated liver cancer risk = HBsAg-positive

[d] The value was calculated as reported by Liu and Wu [4]—estimated liver cancer risk per 100,000 population/incidence rate of liver cancer in Nigeria (6.5 per 100,000) estimated for Nigeria by Global Burden of Disease Project [19] × 100 %

[e] DALYs–annual HCC cases (HBsAg-positive) per 100,000 population × sex-specific HCC DALY estimate (13.05) for both male and female population using the WHO's AFRD region data [36]

Chibundu Ezekiel TrainMiC meets CroMycoScreen 20.09.2016

Environment International 66 (2014) 138–145

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

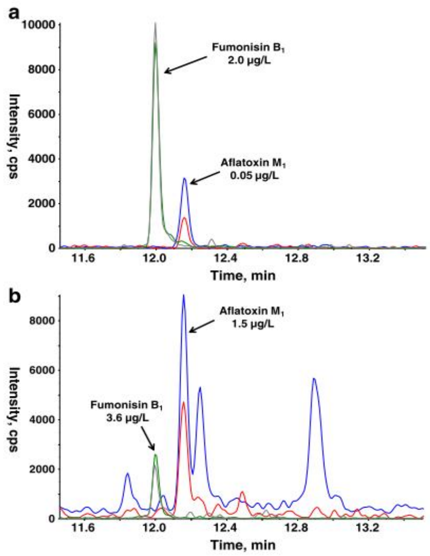
ELSEVIER

Mycotoxin exposure in rural residents in northern Nigeria: A pilot study using multi-urinary biomarkers

Chibundu N. Ezekiel [a,b,*], Benedikt Warth [c], Isaac M. Ogara [d], Wilfred A. Abia [e,f], Victoria C. Ezekiel [g], Joseph Atehnkeng [b], Michael Sulyok [c], Paul C. Turner [h], Grace O. Tayo [i], Rudolf Krska [c], Ranajit Bandyopadhyay [b]

- **8 mycotoxins/mycotoxin metabolites in 51% (61/120) samples**
  - -- exposure to 6 distinct mycotoxins (AFB_1, FB_1, FB_2, DON, OTA and ZEN)
  - -- 4 exposure biomarkers in addition to bio-measures
- **Significantly (p=0.03) higher exposure: Nasarawa (65%) > Kaduna (37%)**
- **Frequent exposures across age categories**
  - -- Children (47%), Adolescents (55%), Adults (51%)

Chibundu Ezekiel TrainMiC meets CroMycoScreen 20.09.2016



SRM-chromatogram of (a) standard, (b) a contaminated urine with AFM_1 & FB_1 from a breastfeeding mother in Nasarawa, Nigeria

- **25% of the contaminated urine contained mycotoxin species for more than one family**
  - **-- AFM_1/FB_1**
  - **-- AFM_1/OTA**
  - **-- $AFM_1/FB_1/FB_2$**
  - **-- AFM_1/FB_1/OTA**
  - **-- $AFM_1/FB_1/FB_2$/DON;**
- **Diverse mycotoxin combinations in consumed food**
  - **-- $AFM_1/FB_1/FB_2$/DON, NIV/ZEN**
- **Modest but significant correlations between food intake and**
  - **-- AFM_1 urinary data (r= 0.31; p=0.02)**
  - **-- FB_1 urinary data (r= 0.28; p=0.02)**

Processing to Reduce Mycotoxins


LWT - Food Science and Technology 60 (2015) 137–141
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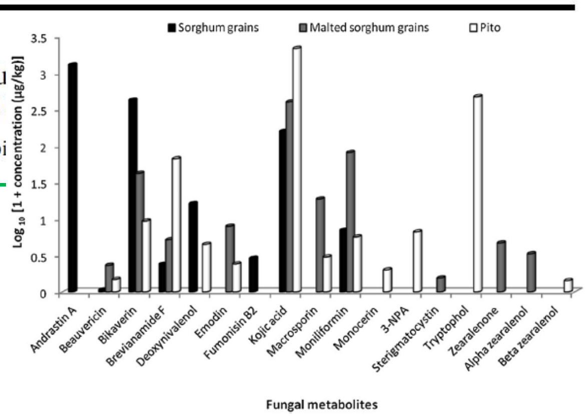
Fate of mycotoxins in two popu
(*kunu-zaki* and *pito*) from rural

Chibundu N. Ezekiel [a, b, *], Wilfred A. Abi
Benedikt Warth [f], Rudolf Krska [f]



Mycotoxins and metabolites in sorghum grains and traditional alcoholic drink (*pito*)

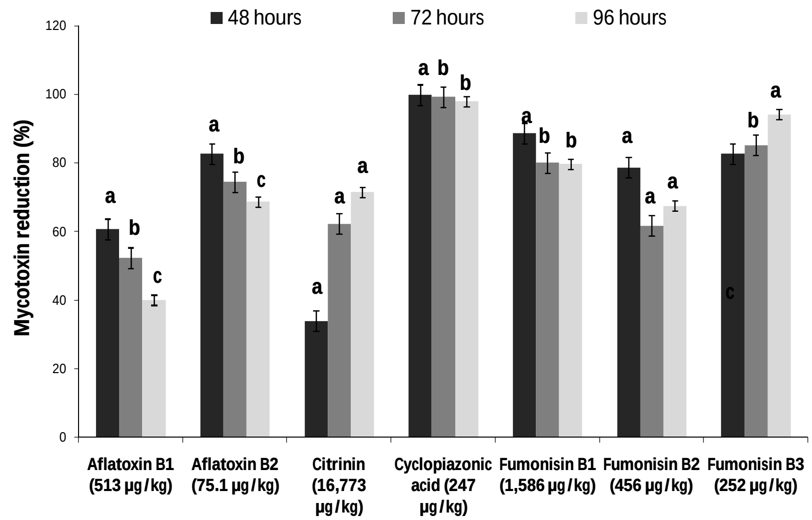


Figure 5. Reduction (%) of Mycotoxins in freshly fermented *ogi* due to fermentation during steeping of yellow maize grains. Vertical lines on bars indicate the standard error of mean (α= 0.05). Bars with different alphabets are significantly different by DMRT at α= 0.05.

Contamination Patterns: *Central Africa (CM)*

- **Simultaneous occurrence of mycotoxins in diverse staples**

Food Control 31 (2013) 438–453

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Food Control

journal homepage: www.elsevier.com/locate/foodcont

Determination of multi-mycotoxin occurrence in cereals, nuts and their products in Cameroon by liquid chromatography tandem mass spectrometry (LC-MS/MS)

Wilfred A. Abia[a,b], Benedikt Warth[b], Michael Sulyok[b], Rudolf Krska[b], Angele N. Tchana[a], Patrick B. Njobeh[c], Mike F. Dutton[c], Paul F. Moundipa[a,*]

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57% co-occurrence in staples from Cameroon

AFs–FBs–OTA
AFs–FBs–DON-ZEN
AFs–FBs–OTA–DON

Table 4. Mycotoxin Pattern in Cameroon from Three Agro-ecological Regions through Maize, Peanut, and Cassava Products

sample matrix/ mycotoxin[b]	mean concentration (CI, 95%) range (μg/kg) of mycotoxins detected in the different staples[a]							
	sampling period 1: 2009				sampling period 2: 2010–2011			
	HFM	HFB	WH	mean	HFM	HFB	WH	mean
maize								
DON	207 (27–2141)	60 (212–918)	275(27–2741)	181	612(27–2411)	161(27–1084)	452 (218–3842)	408
FB_1	1418 (75–3716)	468 (20–1418)	2102 (112–5412)	1329	2601 (20–4030)	665 (314–2841)	2949 (20–3212)	2072
FB_2	1157 (112–2268)	370 (50–843)	965 (75–2882)	831	2555 (10–2890)	663 (50–915)	1742 (112–1846)	1653
FB_3	398 (50–1442)	156 (75–482)	357 (65–412)	303	993 (112–2180)	604 (132–864)	376 (50–698)	657
AFB_1	22 (6–184)	59 (6–345)	26 (6–195)	35	100 (6–645)	96 (6–216)	47 (6–210)	81
AFB_2	7 (2–108)	8 (2–215)	6 (2–85)	7	23 (2–225)	14 (2–120)	29 (2–75)	22
ZEA	61 (75–279)	58 (27–228)	65 (85–262)	61	113 (35–334)	111 (27–242)	86 (55–286)	103
∑AcDON	44 (65–231)	36 (30–187)	47 (54–170)	42	71 (30–115)	62 (30–176)	46 (30–186)	60
ROQC	20 (1–94)	15 (1–137)	25 (1–145)	20	48 (1–84)	44 (1–118)	55 (1–181)	49
BEA	39 (15–412)	33 (15–384)	35 (15–264)	35	69 (15–312)	66 (15–284)	51 (15–385)	62
peanut								
OTA	ns	ns	ns	ns	5 (0.3–12)	3 (0.3–10)	4 (0.3–4)	4
AFB_1	ns	ns	ns	ns	26 (6–125)	22 (6–77)	22 (6–110)	23
cassava								
AFB_1	12 (6–194)	2 (6–95)	5 (6–193)	6	10 (6–125)	1 (6–32)	10 (6–141)	7
PA	7 (25–184)	3 (25–96)	3 (25–72)	4	4 (25–76)	2 (25–46)	4 (25–44)	4

[a]Samples < LOD were given the LOD/2 value. CI, confidence interval; HFM, humid forest region with monomodal rainfall; HFB, humid forest region with bimodal rainfall; WH, western highland; ns, no samples. [b]DON, deoxynivalenol; PA, penicillic acid; 3-AcDON, 3-acetyldeoxynivalenol; 15-AcDON, 15-acetyldeoxynivalenol; AFB_2, aflatoxin B_2; AFB_1, aflatoxin B_1; FB_1, fumonisin B_1.

Chibundu Ezekiel **TrainMiC meets CroMycoScreen** **20.09.2016**

Food and Chemical Toxicology 62 (2013) 927–934

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Food and Chemical Toxicology

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ELSEVIER

Bio-monitoring of mycotoxin exposure in Cameroon using a urinary multi-biomarker approach

CrossMark

- **11 mycotoxins/mycotoxin metabolites in 63% (110/175) samples**
  - **-- exposure to 7 distinct mycotoxins (AFB_1, FB_1, FB_2, DON, NIV, OTA and ZEN)**
- **Similar exposure in HIV infected sub-population (64%; 93/145) than in certified HIV negative participants (57%; 17/30)**
- **Typically greater exposure in Yaounde than Bamenda**
- **Co-exposure of up to five mycotoxins families in 18% (32/175) samples**
  - **-- most prevalent patterns AFM_1/DON; OTA/DON;** FB_1/DON; **NIV/DON,** ZEN/DON
  - **-- urinary patterns matched food occurrence data patterns**

Contamination Patterns: *East Africa (TZ)*

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ELSEVIER

Co-exposures of aflatoxins with deoxynivalenol and fumonisins from maize based complementary foods in Rombo, Northern Tanzania

CrossMark

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Table 1
Contamination levels and occurrences of mycotoxins in maize based flour.

Mycotoxin	Level (μg/kg)		Occurrence (%) at different ranges (μg/kg)	
	Median	Range	>LoD	>ML
Aflatoxin B1	1.27	0.53–364	24	5
Total aflatoxins	0.91	0.11–386	32	5
Deoxynivalenol	119	57–825	44	2
Fumonisins B1	329	57–1672	80	5
Total fumonisins	367	63–2284	83	12

LoD, Limit of detection, 0.53 for AFB1, 0.15 for AFB2, 0.24 for AFG1, 0.01 for AFG2, 52 μg/kg for DON, 53 μg/kg for FB1 and 47 μg/kg for FB2; Total aflatoxins, AFB1 + AFB2 + AFG1 + AFG2; Total fumonisins, FB1 + FB2; ML, Maximum limit, aflatoxins (5 μg/kg for AFB1, 10 μg/kg for total aflatoxins) or fumonisins (1000 μg/kg) or DON (750 μg/kg) in maize.

Table 3
Co-occurrence and levels of aflatoxins, deoxynivalenol and fumonsins in the co-contaminated flour.

Mycotoxins	Co-occurrence (%)	Range (μg/kg)		
		Total aflatoxins	Total fumonisins	Deoxynivalenol
Afaltoxins with both deoxynivalenol and fumonisins	10	0.12–0.63	94–702	57–459
Aflatoxins with fumonisins	29	0.12–0.63	85–1672	
Fumonisins with deoxynivalenol	41		94–2284	57–825

Aflatoxins, Total aflatoxins (AFB1 + AFB2 + AFG1 + AFG2); and Fumonisins, Total fumonisins (FB1 + FB2).

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Mol Nutr Food Res. 2013 October ; 57(10): 1874–1881. doi:10.1002/mnfr.201300116.

Dietary exposure to aflatoxin and fumonisin among Tanzanian children as determined using biomarkers of exposure

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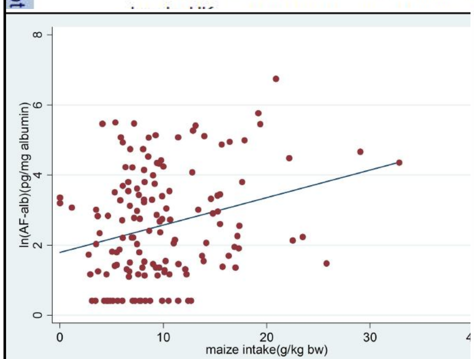
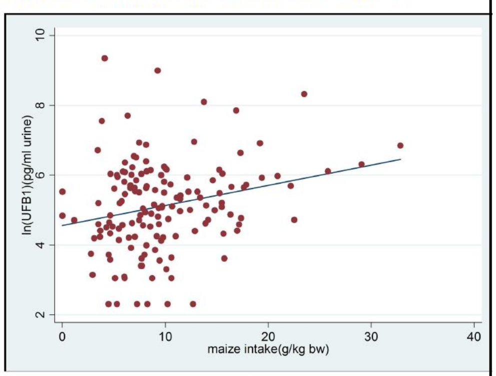
[1]Division of Epidemiology, Leeds Institute of Genetics, Health and Therapeutics, University of





THE CITIZEN

29 JULY 2016

Tanzania: Food Poisoning Linked to 14 Deaths in Two Regions

Tagged: Food and Agriculture • East Africa • Health • Tanzania

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Photo: Daily News

Aflatoxins are toxic, carcinogenic by-products of fungi that colonise maize and groundnuts, among other crops (file photo).

By Syriacus Buguzi

Dar es Salaam — Results of laboratory tests conducted on blood and urine samples of people who died or fell ill after eating food believed to have been contaminated in Dodoma and Manyara regions have revealed shocking levels of aflatoxins, The Citizen can report.

The US-based Centre for Disease Control (CDC), which carried out the tests on 19 urine and blood samples, has also isolated the most poisonous and cancer-causing substance known as Aflatoxin B1. Medical sources say this type of aflatoxin damages the liver.

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Contamination Patterns: *Southern Africa (MW)*

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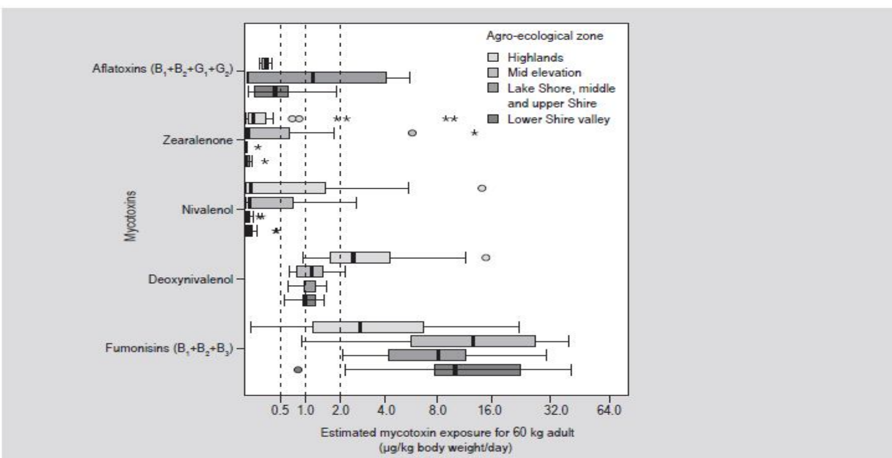

Figure 5. Box and whisker plot showing mycotoxin exposure estimates for a 60 kg adult (µg/kg body weight (bw)/day) assuming an ingestion of 382 g of maize flour made from the analysed samples. A vertical line within the box represents the median. The front and back ends of the box represent first and third quartiles, respectively. The front and back whiskers extend from the box to the smallest or largest non-outliers in the data set (relevant quartile ± 1.5×(interquartile range, IQR)). Circles depict mild outliers (1.5×IQR) and asterisks depict extreme outliers (3×IQR). Vertical dotted lines indicate JECFA's provisional maximum tolerable daily intake for zearalenone (0.5 µg/kg bw/day), deoxynivalenol (1.0 µg/kg bw/day) and FB (sum of fumonisin B_1 and

Contamination Patterns: *Southern Africa (SA)*

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Table 2. Contamination Levels of Agriculturally Important Mycotoxins in Good (n = 54) and Moldy (n = 38) Maize from Centane Region, Former Transkei

			good maize				moldy maize			
toxin	recovery (%)	LOD[a] (μg/kg)	% positive	mean[b] ± sd[c] (μg/kg)	median[b] (μg/kg)	range[b] (μg/kg)	% positive	mean[b] ± sd[c] (μg/kg)	median[b] (μg/kg)	range[b] (μg/kg)
				IAC Cleanup Method						
FB_1	93	3.9	100	2083 ± 3630	848	56−14990	100	27640 ± 38970	14940	514−190100
FB_2	95	3.7	100	927 ± 1565	299	38−6444	100	10580 ± 13810	5792	222−64840
DON	71	3.6	6	12 ± 2	12	10−14	11	14 ± 8	11	7.5−25
ZEN	60	1.5	32	108 ± 185	29	4.2−675	61	111 ± 167	23	1.6−614
OTA	79	3.6	0				0			
AFB_1	72	1.2	0				0			
				Dilute-and-Shoot Method						
FB_1	55	3	93	2764 ± 3584	1405	11−17120	100	35980 ± 41790	18330	927−178800
FB_2	58	1.5	93	1050 ± 1472	429	7.9−7680	100	14140 ± 17030	6810	314−74680
FB_3	66	1	93	192 ± 268	75	0.5−1312	100	2438 ± 2739	1355	90−11280
DON	125	0.8	100	4.7 ± 2.1	4.3	2.2−14	100	5.8 ± 2.6	5.2	1.1−12
ZEN	95	0.3	39	44 ± 88	4.1	0.6−329	74	184 ± 420	11	0.1−1648
OTA	92	0.4	0				0			
AFB_1	33	0.3	0				0			

[a]Limit of detection. [b]Mean/median/range of positive samples. [c]Standard deviation.

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Multiple mycotoxin exposure determined by urinary biomarkers in rural subsistence farmers in the former Transkei, South Africa

Gordon S. Shephard[a,*], Hester-Mari Burger[a], Lucia Gambacorta[b], Yun Yun Gong[c,1], Rudolf Krska[d], John P. Rheeder[a], Michele Solfrizzo[b], Chou Srey[c,1], Michael Sulyok[d], Angelo Visconti[b], Benedikt Warth[d],

Table 1
Urinary biomarkers determined by LC–MS/MS, normalised with urinary creatinine, conducted by University of Leeds and ISPA. Samples with no biomarker detected were assigned a level of the corresponding LOD. Values in parentheses are ng/mL.

	University of Leeds		ISPA						
	FB_1	DON	FB_1	DON	α-ZOL	β-ZOL	ZEA	OTA	AFM_1
Recovery (%)	n.a.[a]	n.a.	61	77	72	83	98	61	95
% Positive	87	100	96	87	92	75	100	98	0
Mean ± SD[b] (ng/mg creat)	0.342 ± 0.466 (0.185 ± 0.236)[c]	20.4 ± 49.4 (9.9 ± 15.1)	1.52 ± 2.17 (0.841 ± 1.06)	11.3 ± 27.1 (4.94 ± 7.60)	0.614 ± 1.91 (0.247 ± 0.590)	0.702 ± 2.95 (0.244 ± 0.820)	0.529 ± 1.60 (0.204 ± 0.456)	0.041 ± 0.086 (0.024 ± 0.058)	–
Median (ng/mg creat)	0.176 (0.103)[c]	8.95 (4.97)	0.689 (0.398)	5.97 (3.07)	0.063 (0.030)	0.161 (0.085)	0.118 (0.076)	0.024 (0.013)	–
Maximum (ng/mg creat)	2.27 (1.30)[c]	353 (99.2)	9.99 (4.94)	190 (53.4)	13.2 (3.72)	21.1 (5.94)	11.2 (3.15)	0.629 (0.432)	–
Minimum (ng/mg creat)[b]	0.007 (0.01)[c]	0.445 (0.3)	0.026 (0.04)	0.312 (0.45)	0.006 (0.009)	0.010 (0.016)	0.012 (0.012)	0.001 (0.002)	–
LOD (ng/mL)	0.01	0.25	0.04	0.45	0.009	0.016	0.002	0.002	0.01
LOQ (ng/mL)	0.02	0.50	0.12	1.51	0.029	0.054	0.007	0.007	0.02

[a] Not applicable – results are corrected by use of labelled internal standard.
[b] Not detected samples (minima) were assigned a value of LOD for calculation.
[c] ng/mL.

Country	Subject	Sample	Aflatoxin levels: Incidence (Mean)	Reference
Benin/Togo Benin	Children (n=480) Children (n=200)	Blood Blood	99% (32.8 pg/mg) 98-100% (37.4-86.8)	Gong et al. 2003 Gong et al. 2004
Cameroon	Infants (n=220) Adults (n=175)	Urine	*n/a* (0.33ng/mL) 9.1% (0.05µg/L)	Ediage et al. 2013 Abia et al. 2013
Egypt	Lact. mothers (n=46) Preg. women (n=98)	Blood Blood Urine	37% (50ppm) 35% (4.9 pg/mg) 48% (19.7 pg/mg)	Shouman et al. 2012 Piekkola et al. 2012 Piekkola et al. 2012
Ghana	Adults (n=314)	Blood	*n/a* (14.91 pg/mg)	Jolly et al. 2013
Kenya	Children (n=199)	Blood	*n/a* (110.5 pg/mg)	Castelino et al. 2015
Nigeria	Adults, adolescents & children (n=120)	Urine	14.2% (0.3µg/L)	Ezekiel et al. 2014
Senegal	Adults (n=168)	Blood	*n/a* (45.7 pg/mg)	Watson et al. 2015
The Gambia	Children (n=472) Preg. women Preg. women Children (n=138)	Blood Blood Cord blood Blood	93% (22.3 pg/mg) 100% (40.4 pg/mg) 48.5% (10.1 pg/mg) 11% (8.7 pg/mg)	Turner et al. 2003 Turner et al. 2007 Turner et al. 2007 Turner et al. 2007
Tanzania	Children (n=166) Children (n=166)	Blood Blood	84% (12.9 pg/mg) 99% (23.5 pg/mg)	Shirima et al. 2015
Uganda	Adults (n=100) Children (n=96)	Blood Blood	100% (11.5 pg/mg) 95.8% (9.7 pg/mg)	Asiki et al. 2014

Mycotoxin exposure is widespread in Africa due to underdeveloped food safety system which challenges supply of safe food, resulting in many unaccounted deaths

Summary

- ✓ **Diverse fungal and bacterial metabolites contaminate food and feed in Africa:**
  - Regulated toxins
  - *Fusarium* emerging toxins
  - Ergot alkaloids
  - *Alternaria* toxins

- ✓ **Aflatoxins and fumonisins seem to be the most prevalent mycotoxin in food and feed from West Africa/East Africa and Southern Africa, respectively.**

- ✓ **Fumonisins also dominate in maize (at harvest and in store).**

- ✓ **Exposure levels are consequently high in the African population.**

- ✓ **Processing has great potentials to reduce contamination levels thus minimize risk of exposure.**

Actors/Partners behind the scene

- ✓ Prof. Rudi Krska (BOKU, Austria)
- ✓ Dr. Michael Sulyok (BOKU, Austria)
- ✓ Dr. Benedikt Warth (BOKU, Austria)
- ✓ Dr. Ranajit Bandyopadhyay (IITA, Nigeria)
- ✓ Dr. Eduardo I. Beltrán (Univ. Jaume I, Spain)
- ✓ Dr. Wilfred A. Abia (Cameroon)
- ✓ Dr. Bojan Sarkanj (Croatia)
- ✓ Dr. Olusegun O. Atanda (McPherson Univ., Nigeria)
- ✓ Dr. Modupe Adetunji (McPherson University, Nigeria)
- ✓ Prof. Stephen Fapohunda (Babcock Univ., Nigeria)
- ✓ Foluke Olorunfemi (PhD Student, Univ. of Ibadan, Nigeria)
- ✓ Isaac M. Ogara (NSUK, Nigeria)
- ✓ Bola Akinmusiri (University of Maiduguri, Nigeria)
- ✓ Rofiat Abdul-Salaam (FUNAAB, Nigeria)
- ✓ All those who worked on the "scary Nigerian samples" @ IFA

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