AFMA Workshop

Mycotoxins in Grains and Derived Products

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STATUS AND PREVALENCE OF MYCOTOXINS IN GRAIN-DERIVED PRODUCTS

A Case Study of Maize in South Africa

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MYCOTOXINS IN MAIZE

Major mycotoxins: AF, FB, DON, OTA, ZON

Other mycotoxins reported to occur on maize:

- Beauvericin
- Fusaproliferin
- Moniliformin
- Fusarin C (heat & light labile)
- Nivalenol
- Type A trichothecenes (T-2 Toxin, HT-2 Toxin, DAS)

SOURCE OF MYCOTOXINS IN FOOD AND FEED

Mostly, mycotoxins enter the mill / factory via the grain.

$$\text{GRAIN} \xrightarrow[\text{(Milling / Heating / Mixing)}]{\text{Processing}} \text{FOOD / FEED}$$

Varying degrees of reduction

RECOGNITION OF THIS REDUCTION IN EU LEGISLATION

Regulations for fumonisins:

➢ Unprocessed maize	4000 ppb
➢ various milling fractions not for direct human consumption	2000 – 1400 ppb
➢ Maize for direct human consumption	1000 ppb
➢ Maize-based breakfast cereals	800 ppb
➢ Maize-based infant and baby food	200 ppb

Off J EU 2007, L255: 14-17.

DISTRIBUTION OF MYCOTOXIN IN MAIZE KERNEL

- Mycotoxin not uniform in the maize kernel, but mostly in bran and the outer layers of the kernel, with reduced levels in the endosperm
- Milling causes distribution of the mycotoxin into different products
- Processed food and feed products with fibre and bran have greater mycotoxin levels

INDUSTRIAL MILLING OF MAIZE

Effect on Fumonisins

Wet milling

FB found in steep water

Decreasing levels in gluten, fiber and germ, none in starch

Dry milling

Decreasing levels in bran, germ, flour and flaking grits

WET MILLING OF MAIZE

Effect on FB_1 levels

Maize → Steep → Germ separation → Grind → Starch-gluten separation

Maize → 13.9 ppm

Steep → Steep water → 22%

Germ separation → Oil

Germ separation → Germ → 3.1 ppm

Grind → Fibre → 5.7 ppm

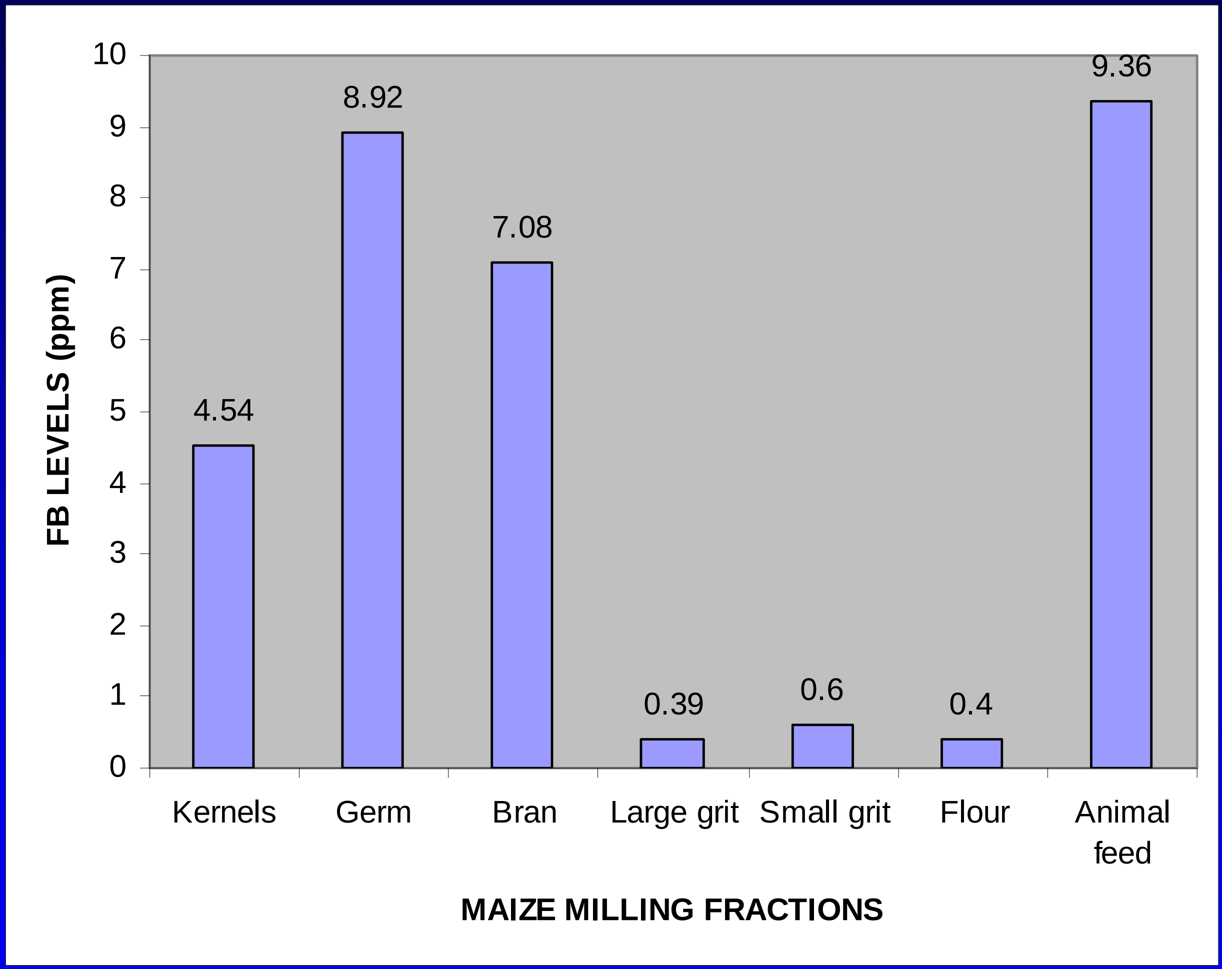
Starch-gluten separation → Gluten → 5.8 ppm

Starch-gluten separation → Starch → ND

Not all FB_1 recovered

Saunders *et al*., 2001; Bennett *et al*., 1996

DISTRIBUTION OF FB_1 CONTAMINATION LEVELS IN DRY MILLING



Industrial Italian mill processing 5 tons of maize per hour

Brera et al. 2007, J Food Protect 67: 1261-1266

SURVEYS OF MAIZE-BASED FOODS AND FEEDS IN SOUTH AFRICA

- Most data exist for maize grain (commercial and subsistence)
- Limited data available for processed products
- Some data is held unreported in laboratories

FAO / DoH TCP

Deoxynivalenol in Maize Meal

2006

N = 18

Mean = 0.26 ppm

Max = 0.96

LOD

PROMEC (HPLC-UV)	0.01 mg/kg
DoH (ELISA)	0.1 mg/kg

Sample description	Sample origin	Deoxynivalenol (mg/kg or ppm)	
		PROMEC	DOH
Maize meal	Free State	0.05	0.35
Maize meal	Free State	nd	0.32
Maize meal	Free State	0.30	0.56
Maize meal	Free State	0.03	0.36
Maize meal	Free State	0.14	1.48
Maize meal	Free State	0.04	nd
Maize meal	Free State	0.09	nd
Maize meal	Free State	0.04	nd
Maize meal	Western Cape	0.07	0.20
Maize meal	Limpopo	0.11	0.25
Maize meal	Limpopo	0.73	0.71
Maize meal	Free State	0.43	0.29
Maize meal	Free State	0.06	0.14
Maize meal	Free State	nd	nd
Maize meal	Free State	0.78 **	0.60
Maize meal	Western Cape	0.96 **	1.60
Maize meal	Western Cape	0.07	0.16
Maize meal	Western Cape	0.80 **	1.34

** Exceed EU limit of 0.75 mg/kg

FUMONISIN B_1 LEVELS IN HUMAN FOODSTUFFS

Samples bought in Cape Town & Bloemfontein 1990 / 91

Product	Positive/total	Maximum (ppb)	Mean (positives) (ppb)
Maize meal	46/52	475	138
Maize "grits"	10/18	190	125
Cornflakes	0/3	--	--
Miscellaneous	2/8	91	84
Maize meal (purchased 2000)	10/10	491	201

Sydenham et al., 1991, J Agric Food Chem 39: 2014-2018

MYCOTOXINS IN MAIZE PRODUCTS FOR HUMAN CONSUMPTION

1994/95 MAIZE BOARD MARKETING SEASON

Sampled at various mills across the country

	No.	FB_1 (ppb)	DON (ppb)	NIV (ppb)	ZON(ppb)
Samp	13	461 (1994)*	237 (630)	38 (300)	0 (0)
Maize rice	11	295 (991)	27 (300)	0 (0)	0 (0)
Maize grit	5	554 (1800)	0 (0)	0 (0)	0 (0)
Maize flour	2	532 (549)	0 (0)	0 (0)	0 (0)
Super maize meal	25	134 (871)	22 (400)	0 (0)	4 (100)
Special maize meal	36	378 (1400)	10 (200)	17 (300)	4 (100)
Sifted maize meal	47	562 (4482)	221 (850)	13 (250)	2 (110)
Unsifted maize meal	19	827 (3929)	179 (430)	16 (300)	0 (0)

*** Mean (maximum)**

No AF, OTA, T-2 Toxin, DAS and AME found in any sample.

Rava, 1996, Mycotoxin Res 12:25-30

MRC SOUTH AFRICA

MYCOTOXINS IN MAIZE PRODUCTS FOR ANIMAL CONSUMPTION

1994/95 MAIZE BOARD MARKETING SEASON

Sampled at various mills across the country

	No.	FB_1 (ppb)	DON (ppb)	NIV (ppb)	ZON(ppb)
No 1 straightrun YM* meal	8	1200 (2437)**	56 (300)	0 (0)	6 (50)
No 2 straightrun YM meal	2	506 (1011)	135 (270)	0 (0)	25 (50)
Unsifted crushed YM	2	857 (1311)	160 (200)	0 (0)	0 (0)
Sifted crushed YM	4	581 (1237)	55 (220)	0 (0)	0 (0)
Maize germ meal	8	437 (1288)	38 (150)	0 (0)	0 (0)
Maize bran	32	1324 (8180)	658 (5350)	89 (820)	7 (120)
Screenings	7	6651 (15716)	1114 (4820)	50 (200)	16 (60)

*** YM: yellow maize** **** Mean (maximum)**

No AF, T-2 Toxin, DAS and AME found in any sample. OTA (50 ppb in 1 sample)

Rava, 1996, Mycotoxin Res 12:25-30

MRC SOUTH AFRICA

South African National AF Monitoring Programme 2003/4

Total aflatoxin in peanut butter (µg/kg)

		n	<10	10-50	>50	Maximum
Big/medium processors	A	112	98%	2%	-	15
	B	185	96%	4%	-	22
	C	64	38%	34%	28%	550
Small processors		64	42%	36%	22%	232
School feeding scheme		235	58%			470

(South African MTL for total AF: 10 µg/kg)

HEAT PROCESSING OF FOODS - 1

In general, mycotoxins are heat stable compounds.

- FB & AF little affected by normal cooking
- Cooking of pasta in water causes DON to leach into the boiling water
- High temperature processing can reduce levels
- Thermal processes do not completely eliminate mycotoxins

HEAT PROCESSING OF FOODS - 2

- Roasting of peanuts can achieve 45 – 80 % loss of AF
- Roasting of coffee beans can achieve 30 – 90 % loss of OTA
- FB loss during high temperature maize processing (frying, roasting, extrusion) depends on temperature and time
- FB only significantly reduced above 150ºC
- DON stable at 120ºC, moderately stable at 180ºC and decomposes within 30-40 min at 210ºC

QUALITY OF IMPORTED MAIZE?

MAIZE IMPORTS: CAPE TOWN 1992

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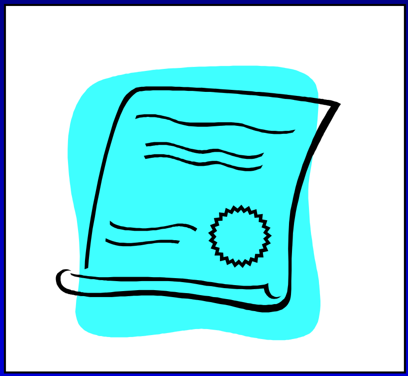
Sampling the holds

WHAT DOES THE LABORATORY RESULT MEAN?



Food store

Laboratory

Certified Result

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TYPES OF ERRORS IN MYCOTOXIN TESTING

Total error

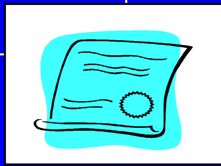
Sampling error

Sample preparation error

Analytical error

Lot

→ Sample → Sample preparation → Analysis



Withdraw random sample

Mill / grind & remove subsample (Test sample)

Specified analytical method

DISTRIBUTION OF ERRORS IN TESTING FARMERS' LOTS FOR MYCOTOXINS

- Individual contributions to total testing variability
- Under specified conditions

	Sampling	Sample Prep	Analysis
AF in peanuts	92.7	7.2	0.1
FB in maize	61.0	18.2	20.8
DON in wheat	22.0	56.0	22.0
OTA in coffee	72.6	26.4	1.0

Whitaker *et al*., 1994: J AOAC Int, 77, 107; 1998: J AOAC Int, 81, 1162; 2000: J AOAC Int, 83, 1285); Vargas *et al*., 2006: Food Addit Contam, 23, 62

MYCOTOXINS ASSOCIATED WITH MAIZE SILAGE

➢ **France**	**AFB_1, CIT, ZON, DON**
➢ **Mexico**	**AFB_1, FB, OTA, OTB, DON, ZON**
➢ **Denmark**	**BEA, enniatins**
➢ **Germany**	**Roquefortine**
➢ **USA**	**FB, PAT, mycophenolic acid, cyclopiazonic acid, roquefortine C, PR toxin**

More recent concerns on silage in Canada:

Penicillium roqueforti	**toxicosis in cows**	**roquefortine, PR toxin**
Penicillium paneum	**ill-thrift in cows**	**roquefortine, festuclavine**

Thank You for Your Attention