Perspectives on Mycotoxins in South African maize

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FOOD SAFETY

Food safety (Food Security/Product Quality Assurance) is an issue that is becoming increasingly important in national and international debates about agriculture, nutrition and health

Dr J Diouf (FAO Director General / FAO 1988-2000)

"Food safety is not a luxury of the rich, but a right of all people"
Africa - 17/22 countries: ≥35% of population is undernourished

Economic losses

Food & feed losses: lower yields & foreign exchange earnings
Inspection, sampling & analyses of exports, imports, detoxification
- Research, training and extension programmes

MYCOTOXIGENIC FUNGI

Mycotoxigenic fungi - fungi capable of producing toxins

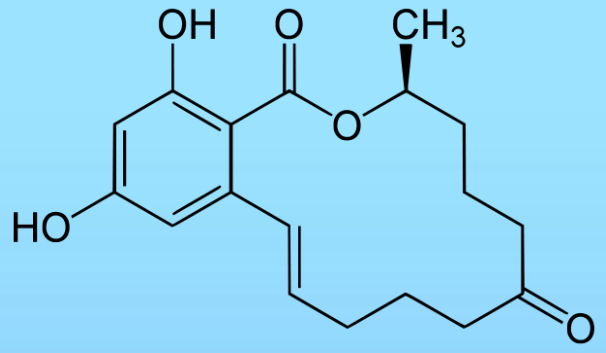
Mycotoxins – secondary fungal metabolites

Mycotoxicosis

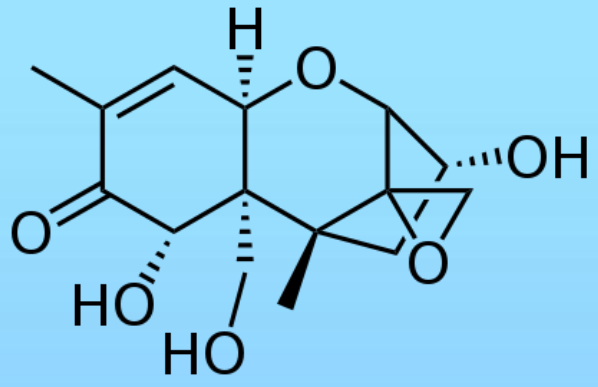
– diseases caused by ingestion of foods containing mycotoxins (acute vs sub chronic effects)

Important Mycotoxins and Mycotoxigenic Fungi Associated with Food

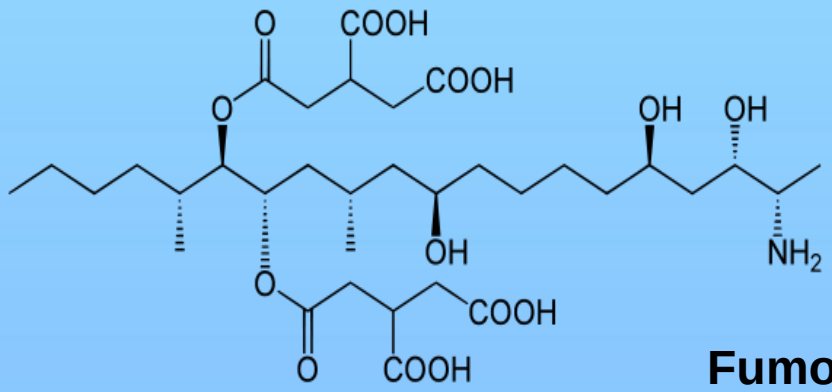
Aflatoxins	–	***Aspergillus flavus, A. parasiticus***
Fumonisins (FB)	–	***Fusarium verticillioides, F. proliferatum***
Deoxynivalenol	–	***Fusarium graminearum***
Zearalenone	–	***Fusarium graminearum***
Ochratoxin A	–	***Aspergillus ochraceus, Penicillium verrucosum***



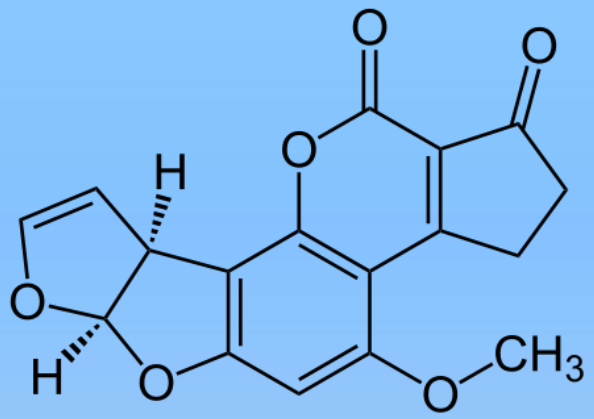
Zearalenone



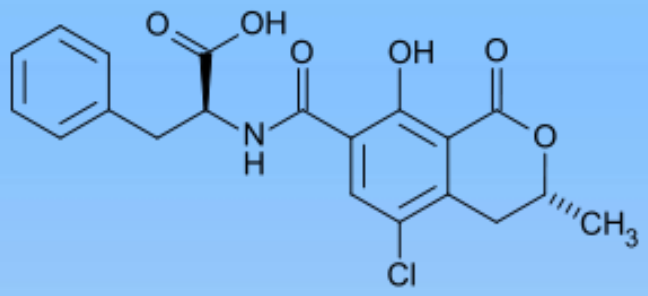
Deoxynivalenol



Fumonisin B_1



Aflatoxin B_1



Ochratoxin A

Deoxynivalenol

Feed refusal or reduced feed intake in pigs DON

Can cause acute poisoning in humans, where severe gastrointestinal toxicity is the primary symptom

Zearalenone

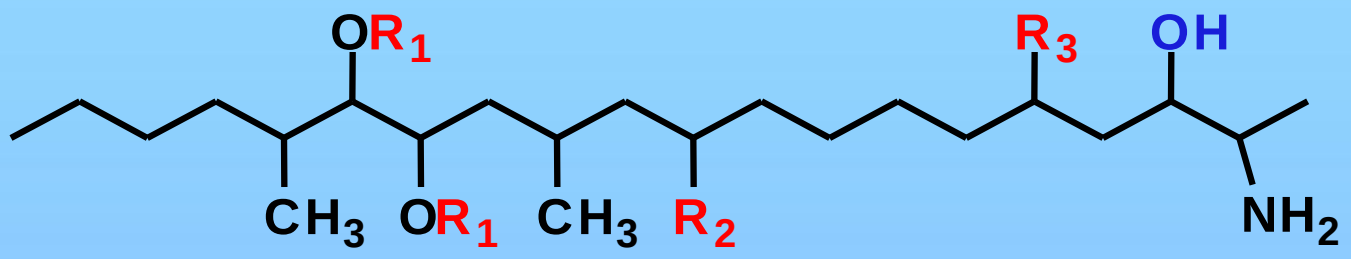
Nonsteroidal oestrogenic mycotoxin

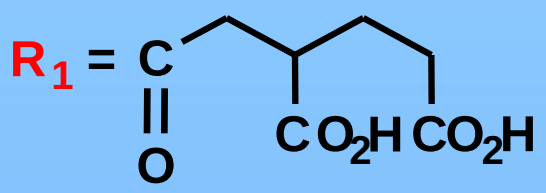
Greater relative oestrogencity of α-zearalenol

Potential to act as an endocrine disruptor

Early onset of puberty in Hungary and Italy

Fumonisins





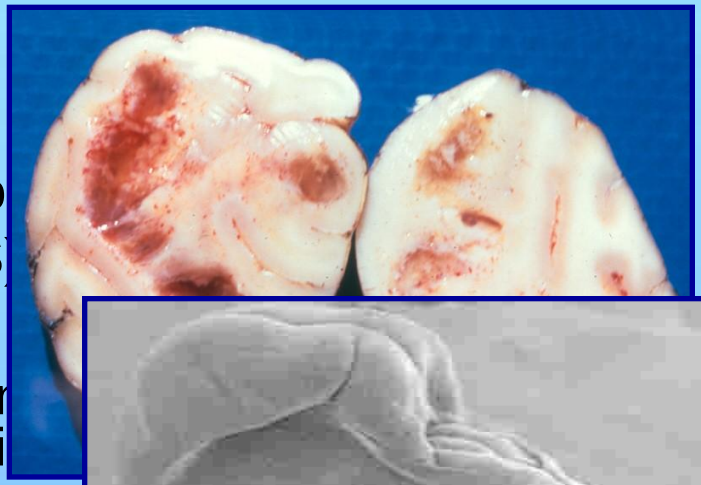
	R_2	R_3
Fumonisin B_1	OH	OH
Fumonisin B_2	H	OH
Fumonisin B_3	OH	H

Toxicology of Fumonisins

oencephalo
drome (PES)

mals

cardiotoxic in
rcinogenic i
TD) in mouse e



Toxicological of Fumonisins

In Humans associated with:

(i) Oesophageal cancer: mainly in former-Transkei region & China

(ii) Birth defects (spina bifida & anencephaly):

China, Texas-Mexico border, Guatemala, former-Transkei region

(iii) Hepatocellular carcinoma in China

(iv) Stunting ??? – gut function/immunity

Toxicological of Fumonisins

DNA damage ?
(Genotoxicity vs cytotoxic/proliferative)

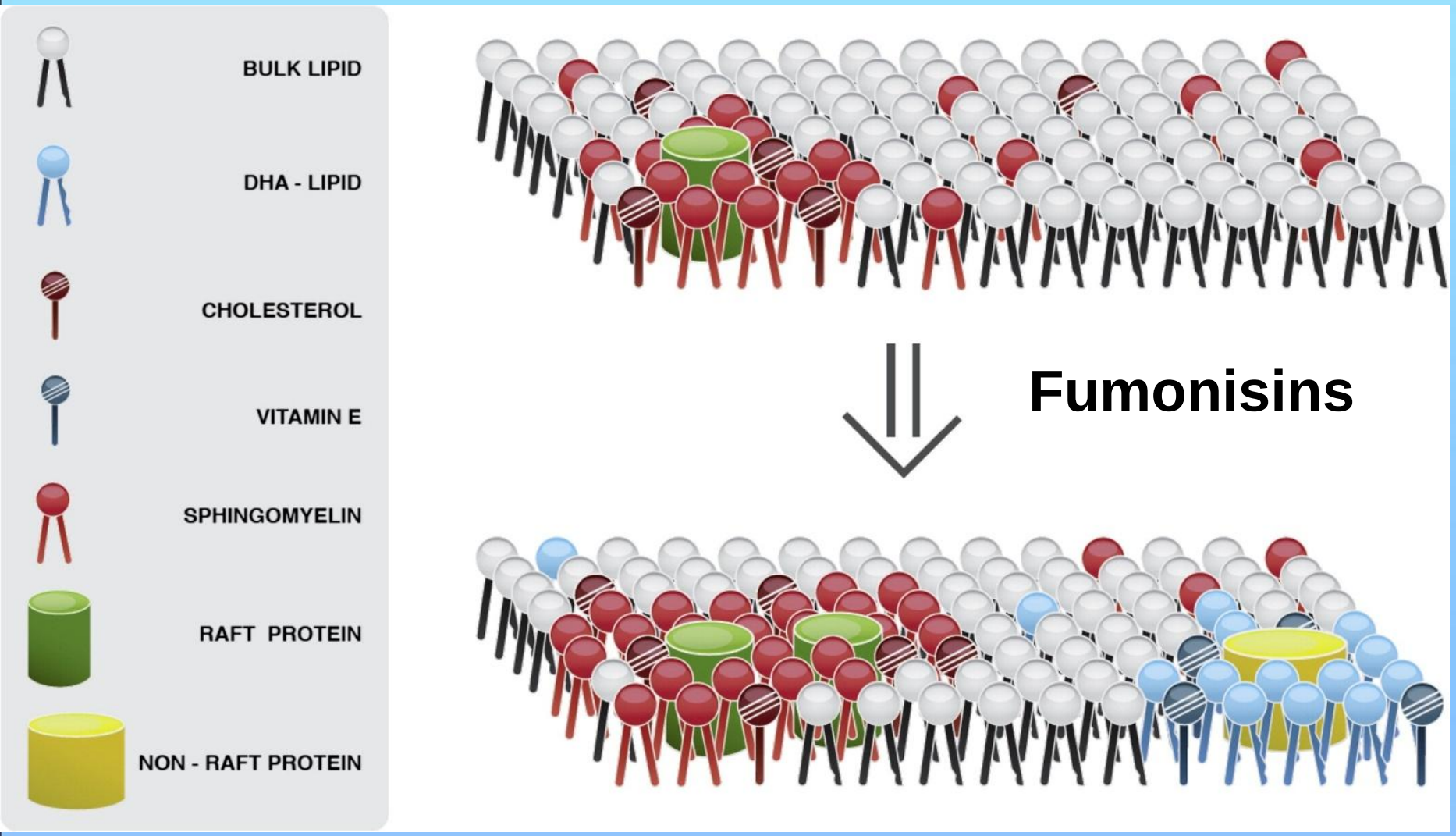
Genetic vs Epigenetic mechanisms

Threshold effects for toxicity and carcinogenicity

Disruption of membrane integrity (enzymes/receptors)

Modulation of signal transduction pathways related to apoptosis and cell proliferation

Lipid Rafts


BULK LIPID
DHA - LIPID
CHOLESTEROL
VITAMIN E
SPHINGOMYELIN
RAFT PROTEIN
NON - RAFT PROTEIN
Fumonisins

ARE HUMANS AT RISK ?

TYPE 2B CARCINOGEN – IARC MONOGRAPH VOL 56 (2001)

PMTDI for FBs of 2ug/kg bw/day - JECFA

PMTDI for DON of 1 µg/kg bw/day

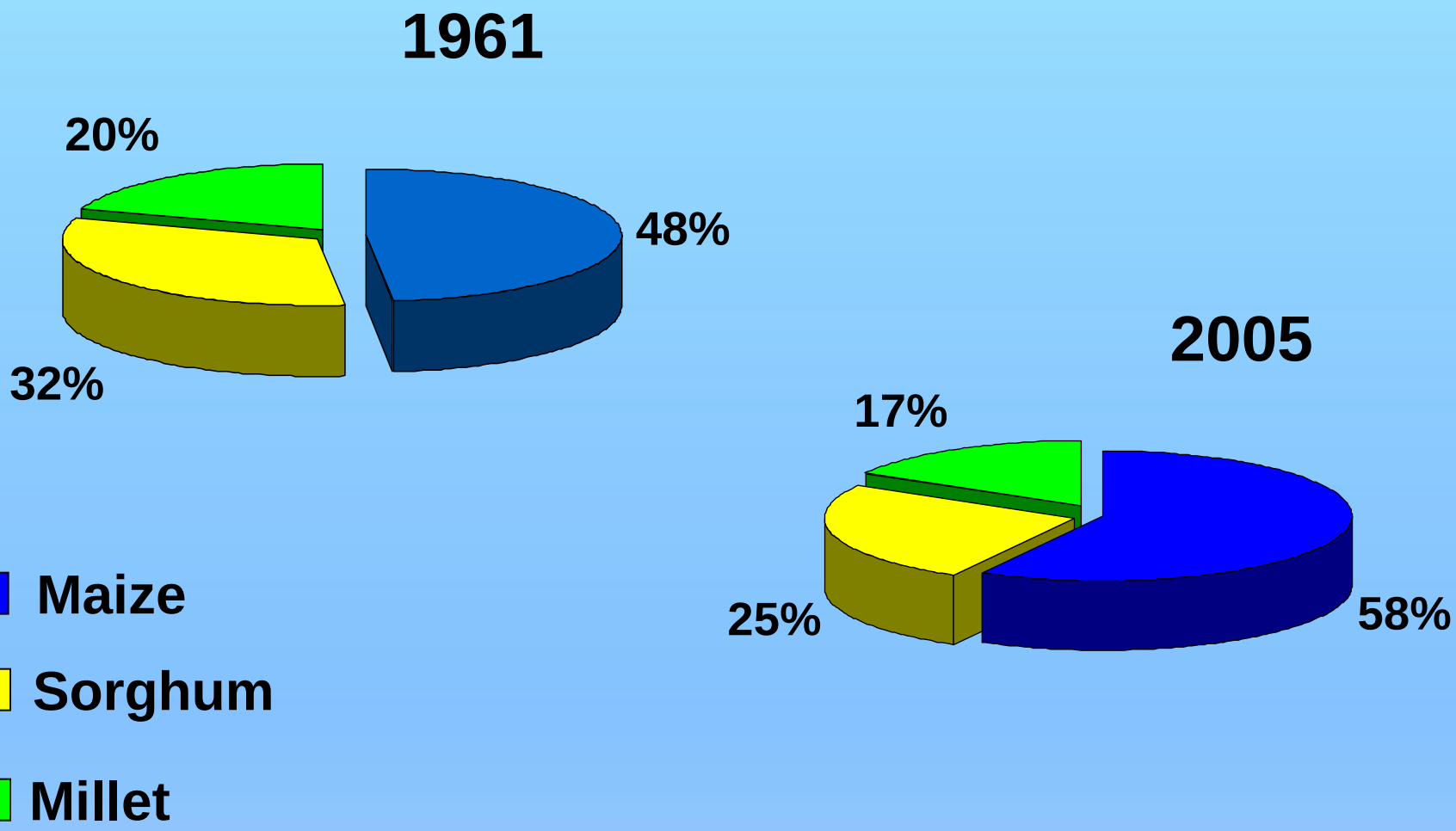
PMTDI for ZEA of 0.5 µg/kg bw/day

Maize

	Production	Utilisation [Food]
	2005 Metric tons	2002
USA	298 233 088	3 879 000
China	131 145 000	20 074 000
Brazil	34 859 600	3 701 000
Africa	41 610 637 (RSA - 8 311 000)	35 395 000

(HTTP://faostat.fao.org)

Grain production in Africa

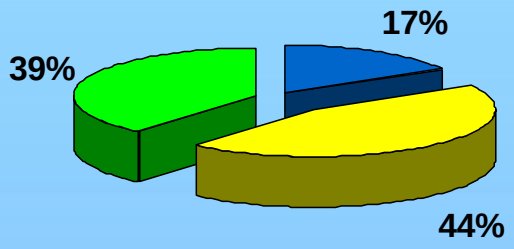


(HTTP://faostat.fao.org)

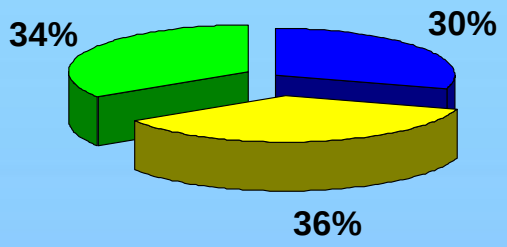
Grain production

West Africa

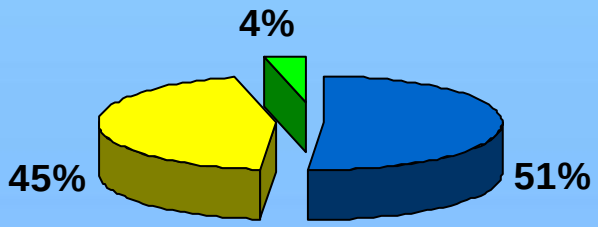
1961

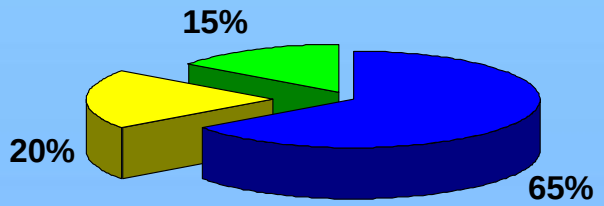


2005



Southern Africa





Millet Sorghum Maize

(HTTP://faostat.fao.org)

Fumonisins in maize (mg/kg)

	1990/91	1991/92	1994/95
Maize	0.33	0.25	0.40
Maize screenings	3.06	1.38	8.88
Maize bran	1.17	0.61	1.79
DFG	-	0.39	0.47
Unsifted mmeal	0.28	0.08	1.04
Sifted mmeal	0.28	0.40	0.67
Spes mmail	0.27	0.13	0.42
Superior mmeal	0.16	0.16	0.13
Germless products	0.10	0.13	0.43

Viljoen *et al*., 1993, 2002

FB_1 risk assessment

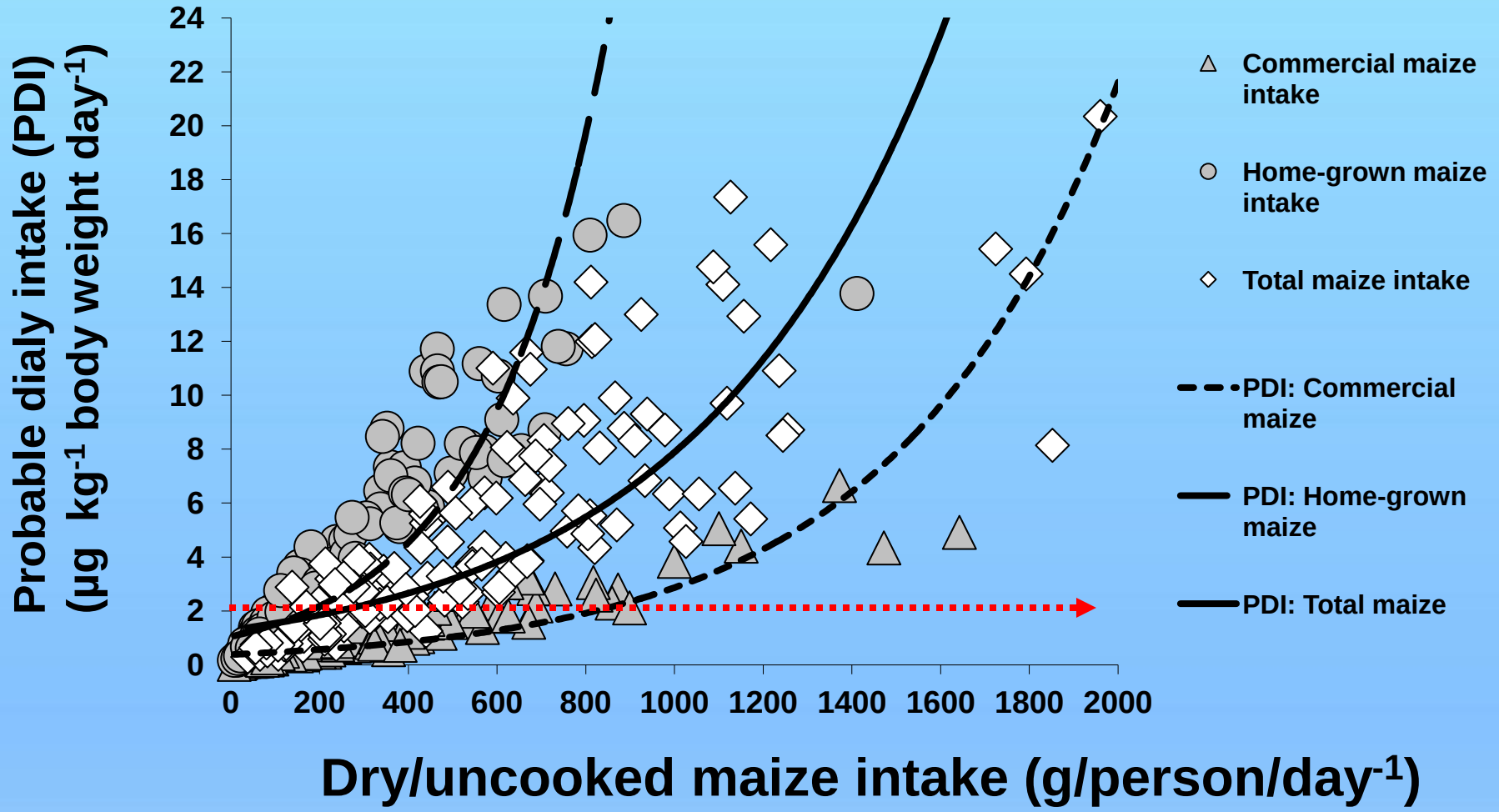
MAIZE INTAKE [g/person (60kg)/day]

FB (ppm)	10	50	100	150	200	400	500
0.2	0	0.2	0.3	0.5	**0.7**	**1.4**	**1.7**
0.5	0.1	0.4	**0.8**	**1.3**	**1.7**	***3.4***	***4.2***
1	0.2	**0.8**	**1.7**	***2.5***	***3.3***	***6.6***	***8.3***
2	0.3	**1.7**	***3.3***	***5.0***	***6.7***	***13.4***	***16.7***
3	0.5	***2.5***	***5.0***	***7.5***	***10.0***	***20.0***	***25.0***
4	**0.7**	***3.3***	***6.7***	***10.0***	***13.3***	***26.6***	***33.3***

PDI (µg/kg bw/day)

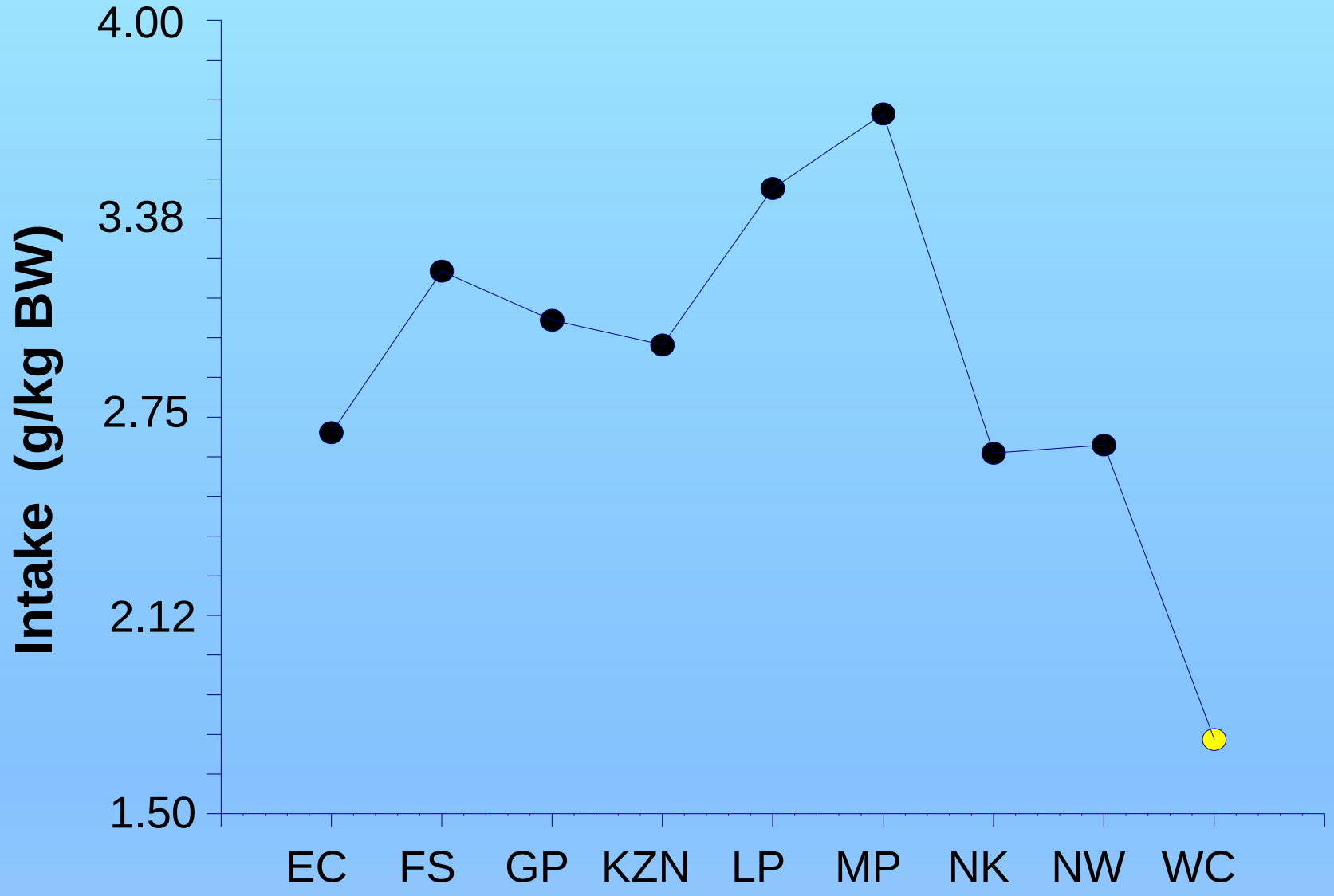
PMTDI = 2 µg/kg bw/day (nephrotoxicity)
PMTDI = 0.7/0.8 µg/kg bw/day (carcinogenicity)

Fumonisin exposure among people consuming both home-grown and commercial maize



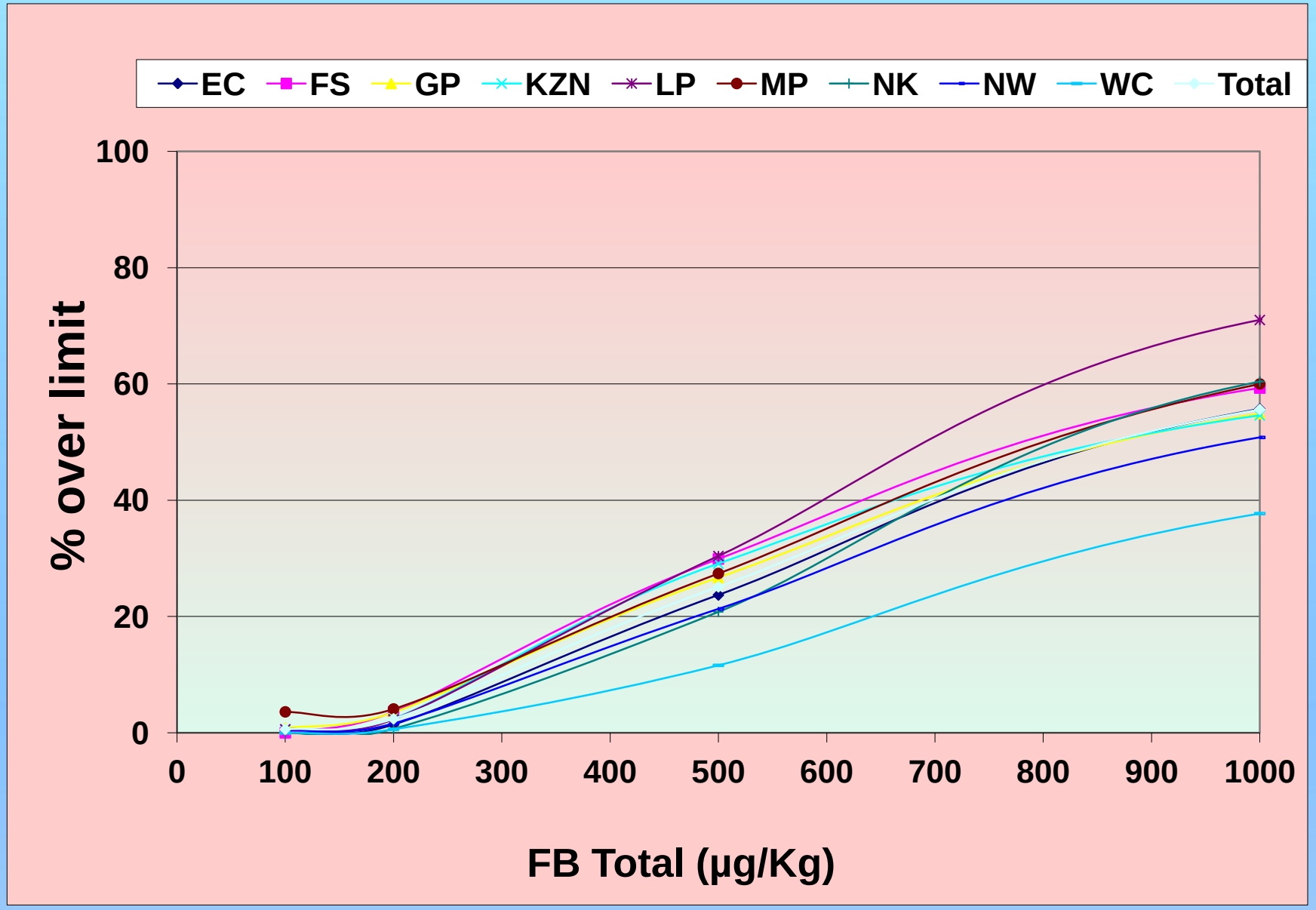
n=137

Means of Intake (g/kg BW)



EU – 10g/person/day

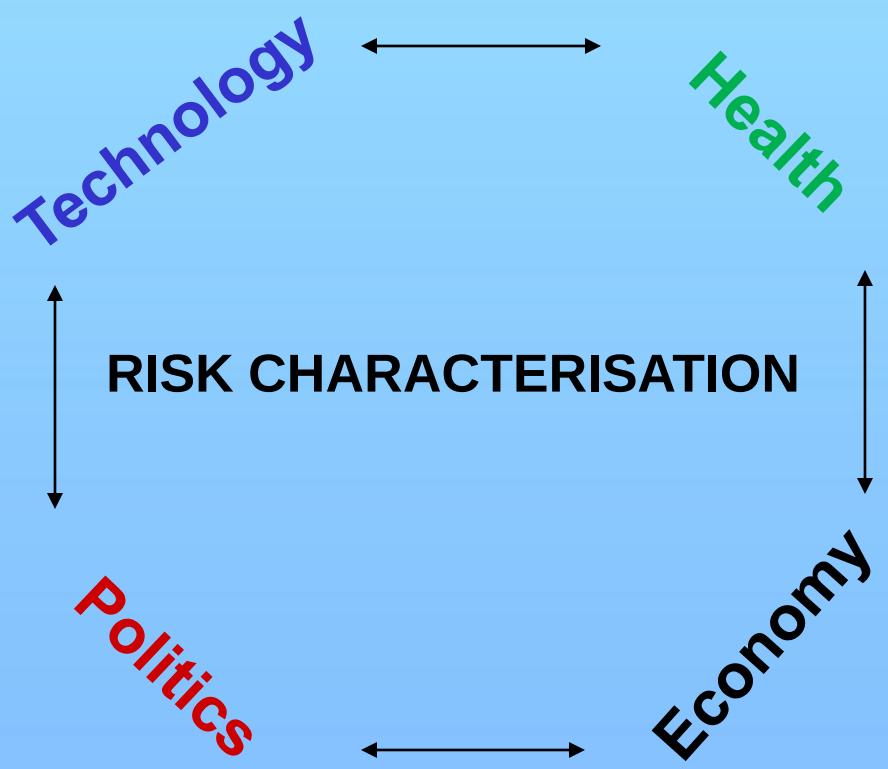
Percentages over for different FB Total Levels by Province with cut-off 2ug/Kg



Mycotoxins
Control / Regulatory Applications

Regulatory measures are appropriate for export crops, but has little relevance in developing countries agriculture – particularly in the case of small-scale & subsistence farmers

Mycotoxin risk management



??? UNCERTAINTIES ????

MYCOTOXINS

Crop Losses in USA

$1.4 billion annually
($1.4 to $2.4)

Exports from Africa

EU regulations on AFB will cost $670 million

(Wu, 2004)

MYCOTOXINS

Economic Impact

Peanuts

EU = 4 ug AFB/kg (20 ug/AFB/kg)	$1450 million

Maize

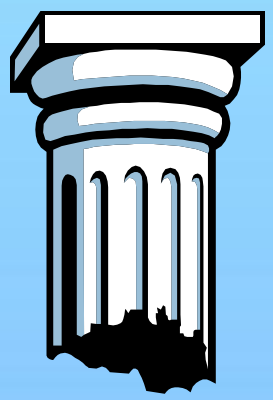
Worldwide = 0.5 mg/kg	$300 million
EU = 2 mg FB /kg	$100 million

Ethanol production

3x FB concentration in DDGS $216 million (pig industry)

(Wu, 2004)

Risk



Mycotoxin intervention studies

Pre harvest - Biocontrol
- BT maize
- Resistant cultivars

Post harvest - physical methods
eg. sorting and drying

Biomarker interventions

Fumonisin intervention study

	FB (food) exposure (µg/kg/day)	Urine (pg FB_1/ mg Creatinine)
Baseline	**13.19**	**775**
Intervention	**2.94**	**376**
Reduction	**78%**	**51%**

Acknowledgements

John Rheeder

Liana v/d Westhuizen

Gordon Shephard

Hester Burger

Hester Vismer

Hanneke Alberts

WFO Marasas

Sylvia Riedel

Funding: Maize Trust/MRC