Mycotoxins in high moisture grain silages and ensiled grain by-products

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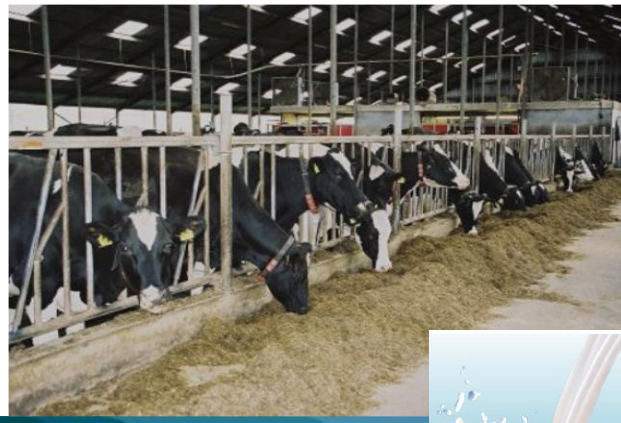

Together to the next level

Presentation outline

- High moisture grain & by-products
- Major classes of mycotoxins and toxigenic moulds
- Occurrence data mycotoxins in grains
- Development mycotoxins in high moisture grain silage
- Mycotoxins in by-products
- Conclusions

High moisture grain & by-products

Grain conservation methods (maize, wheat, barley)

- Air drying → dry storage
- No or partial drying → high moisture grain
  - Ensilage (e.g. crimped grain silage, CCM-silage)
  - Acid treatment
  - Modified atmosphere (oxygen-free)

Grain processing

- Starch, bio-ethanol, beer
- By-products → dried; e.g. DDGS, maize gluten
  → ensiled; e.g. ‘wet’ DGS, brewers grains

Moulds & mycotoxins

- Mycotoxins formed prior to harvesting : field mycotoxins

- Mycotoxins formed after harvesting : storage mycotoxins
  - Associated with dry/moist storage
  - Associated with silage

Major toxinogenic moulds and mycotoxins

Distinction between field-derived, storage-derived and ensilage-derived

Typical field-derived moulds/mycotoxins	
Fusarium species	DON, zearalenone, fumonisins, (H)T2-toxin, enniatins, beauvericin
Claviceps purpurea	Ergot alkaloids
Aspergillus flavus, A. parasiticus	Aflatoxins

Typical storage-derived moulds/mycotoxins	
Aspergillus flavus, A. parasiticus	Aflatoxins
A. ochraceus, P. verrucosum	Ochratoxin A

Typical ensilage-derived moulds/mycotoxins	
Penicillium roqueforti, P. paneum	Roquefortin C, mycophenolic acid
Aspergillus fumigatus	Fumigaclavines, gliotoxin
Monascus ruber	Monacolin K, citrinin

Metabolism & carry-over into milk

Mycotoxin	Detoxification in rumen	Carry-over into milk	Health risk
Aflatoxin B1	No	High (1 – 6%)	Human
Ochratoxin A	Yes	Low (< 0.03%)	Animal
DON	Yes	Low (< 0.02%)	Animal
T2-toxin	Yes	Low (< 0.02%)	Animal
Zearalenone	No	Low (< 0.03%)	Animal
Fumonisin B1	No	Low (< 0.001%)	Animal
Claviceps alkaloids	No	Low (< 0.01%)	Animal
Roquefortin C	No	Low (< 0.005%)	Animal
Mycophenolic acid	No	Low (< 0.005%)	Animal

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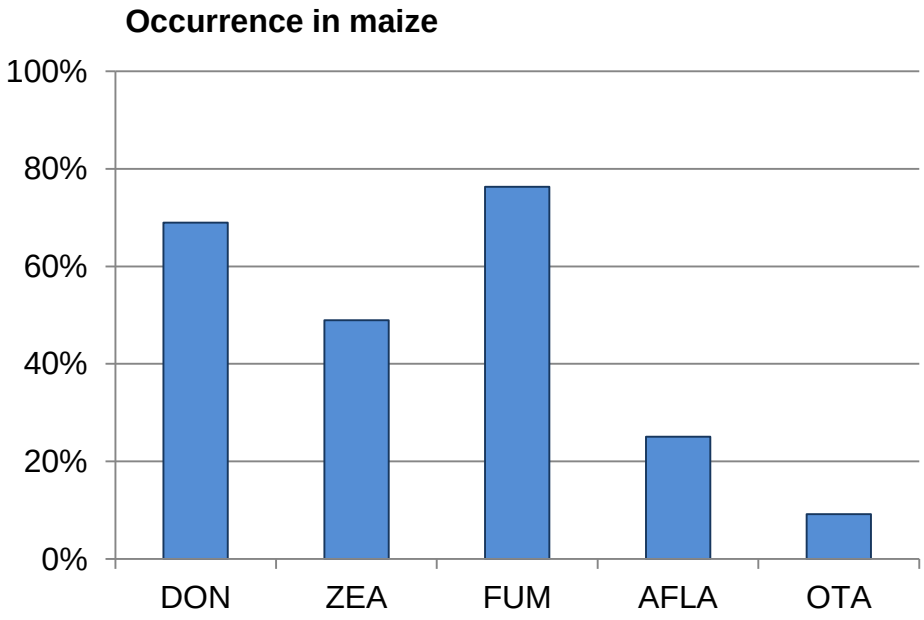
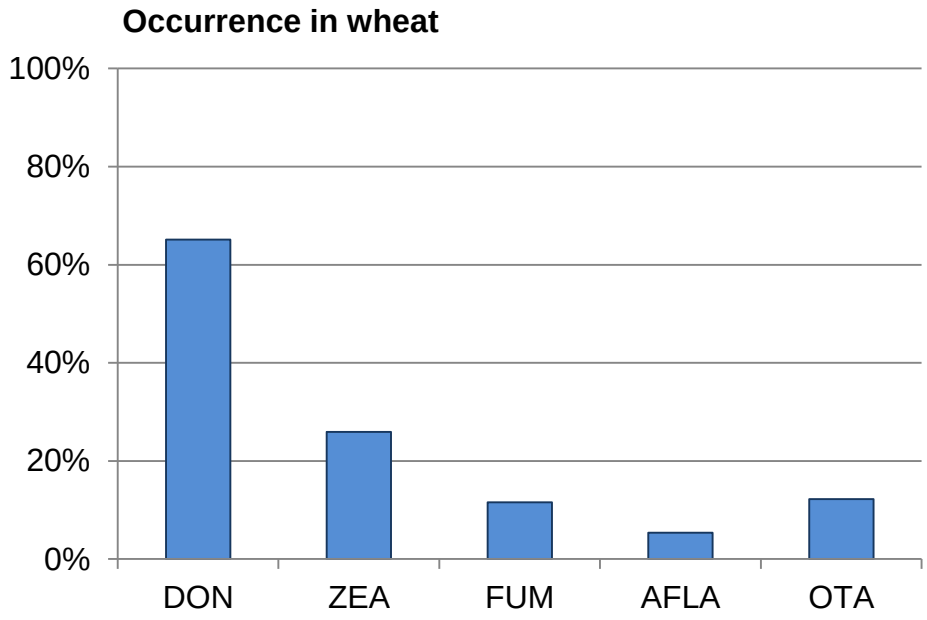
Mycotoxins in feed commodities

*Biomin global survey 2012-2014 **





*** Streit et al. 2013; Kovalsky et al. 2015**

Mycotoxins in feed commodities

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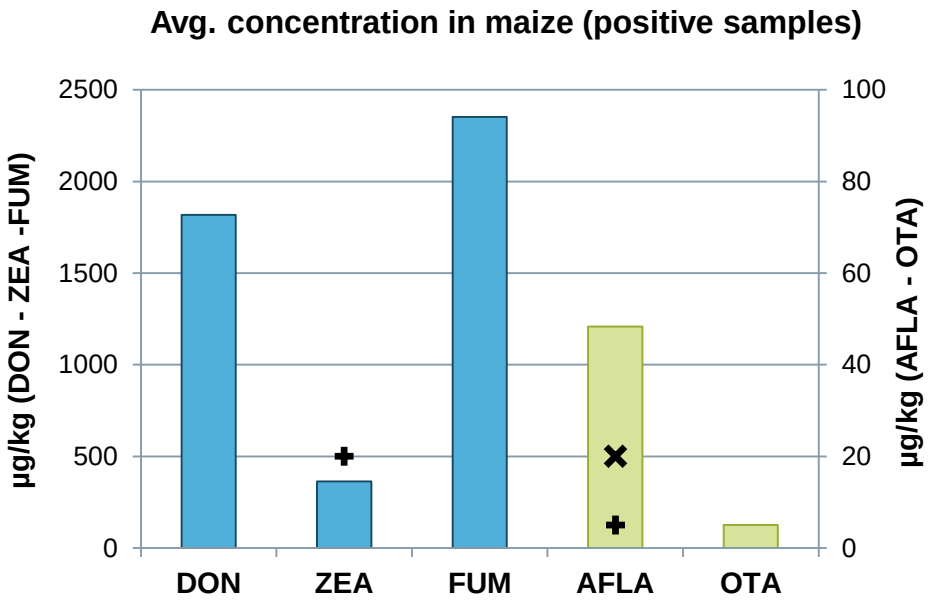

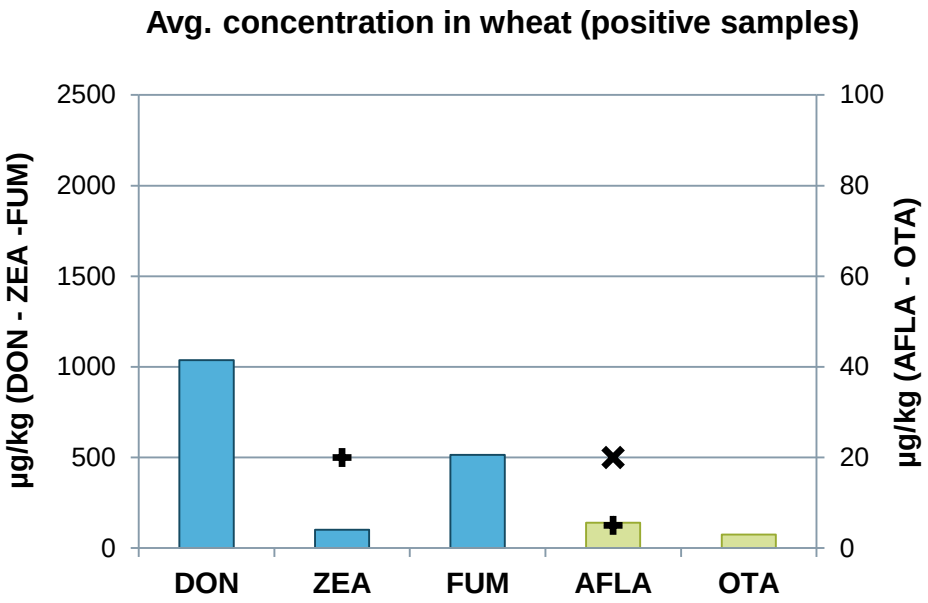

+ EU maximum (AFLA) or guidance concentration (ZEA) for dairy cattle feed

× US maximum (AFLA) for dairy cattle feed

*** Streit et al. 2013; Kovalsky et al. 2015**

Key factors ensilage high moisture grain

- Moisture content / water activity Aw
  - Aw high enough to support lactic acid fermentation by LAB
  - Guideline: Aw > 0.95 (cereal grain MC 30 – 45%)
- Availability of fermentable sugars
  - Grain processing: crimping, cracking, grinding
- Anoxic conditions
  - Prevents growth competing aerobic microorganisms, e.g. moulds
  - Important: adequate sealing, compaction
- No additives that inhibit growth of LAB
  - E.g. high levels of formic acid

Effect a_w on growth and mycotoxin formation*

a_w	Moisture content %		LAB	*A. flavus*		*P. verrucosum*	
	Maize	Wheat	growth	growth	AF1	growth	OTA
0.98	30-32	30-34	+	+	++	++	+
0.95	26-27	26-28	-	++	+	+	+
0.92	24-25	23-24	-	+	+	+	++
0.90	23-24	21-22	-	+	+	+	+
0.80	16-17	16-17	-	~	-	-	-
0.70	15-16	14-15	-	-	-	-	-

* **Sanchis & Magan 2004; Magan & Aldred 2007; Pahlow et al. 2003**

Mycotoxins in ensiled by-products

- Examples of ensiled by-products
  - Spent brewer's grains
  - Pressed sugar beet pulp
  - Pressed potato pulp

- Data on mycotoxins in ensiled by-products are largely lacking

- DGS/DDGS (Wu and Munkvold 2008)
  - 2/3 of dry mass converted to ethanol; 1/3 DDGS
  - 3 times higher AFLA and DON concentration in DDGS vs. grain
    → no degradation of AFLA and DON during ethanol fermentation
  - ZEA and FUM: 1,5 to 2 times higher in DDGS vs. grain

Conclusions

Prevention/control of mycotoxins in high moisture grain silage and ensiled by-products requires:

- Good agricultural practices in crop production; to prevent field-mycotoxins
- Good high moisture silage management, to prevent storage-/silage-mycotoxins
  - Sufficient moisture: 35% - 45%
  - Fermentable sugars
  - High degree of compaction
  - Prevention air infiltration

Thank you for your attention

Together to the next level