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28 – 30 SEPTEMBER 2021, Parma

Food Safety Aspects of Integrated Food Systems

Chemical mixture in the crop production chain: a focus on mycotoxins

efsa European Food Safety Authority

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CENTRE OF BIOLOGICAL ENGINEERING

Linking life and technology to shape the future

Chemical mixture in the crop production chain: a focus on mycotoxins

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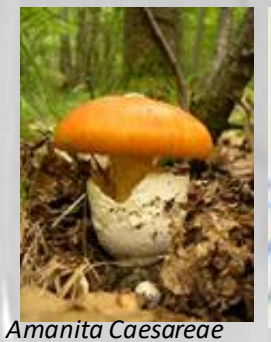
OUTLINE (& BACKGROUND)

- Fungi are a huge group of heterotrophic organisms organized in a kingdom, including
  - yeast
  - filamentous fungi
  - mushrooms


Amanita Caesareae


Alternaria sp.

- The filamentous fungi are widespread in nature and are usually present in natural products
  - The scientific community estimates that less than 10 % of the species are known
  - Same commodity, many *fungi*
  - Same *fungus*, many commodities
  - In ***any crop ...*** they may occur

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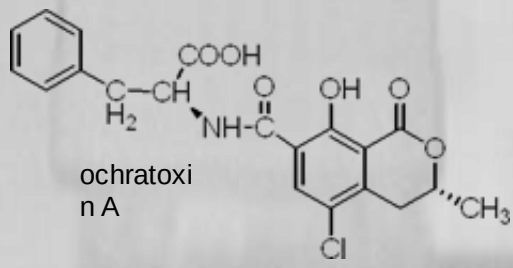
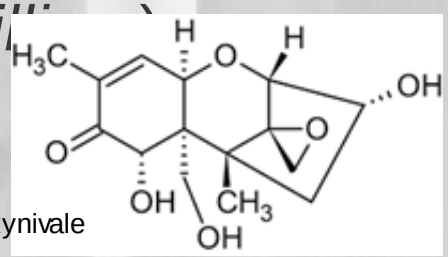
OUTLINE (& BACKGROUND)

- Mycotoxins are toxic compounds mainly produced by fungi of the genera *Aspergillus*, *Fusarium* and *Penicillium*
  - aflatoxins (from *Aspergillus*)
  - ochratoxin A (from *Aspergillus* and *Penicil*
  - trichotecenes (from *Fusarium*)



ochratoxin A



deoxynivalenol

- As fungi, **undesirable compounds** should be regarded as common contaminants in commodities
  - not being natural, are *naturally* present
  - in ***any crop ...*** they may occur
  - the key issue is to determine if they occur at levels that deteriorate or present an hazard to health

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OUTLINE (& BACKGROUND)

- Mycotoxins are often present as mixtures
  - in many feed and food commodities including cereals, fruits and vegetables
- Their ubiquitous presence represents a major challenge to the health and well being of humans and animals
- Hundreds of compounds are listed as possible mycotoxins occurring in raw and processed materials destined for human food and animal feed
- … so far, I have just mention mycotoxins … now, imagine the potential of toxic chemical mixtures in the food chain, if I had included
  - heavy metals
  - pesticides, …

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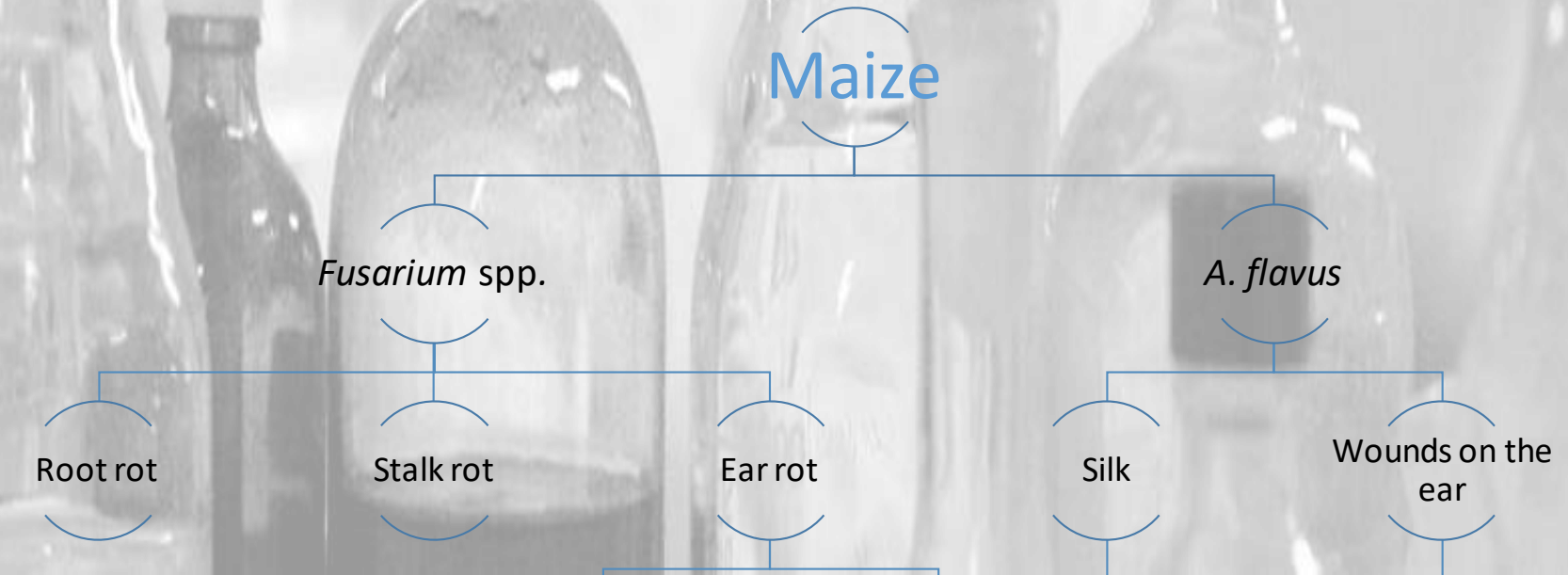
MAIZE

- Maize is susceptible to mycotoxin-producing fungi from flowering
- The dynamics of a_w in grains during the growing season and the ability to use the carbon sources at different *T* and aw determines the competitiveness of the different fungal species, and the dynamics of mycotoxin accumulation



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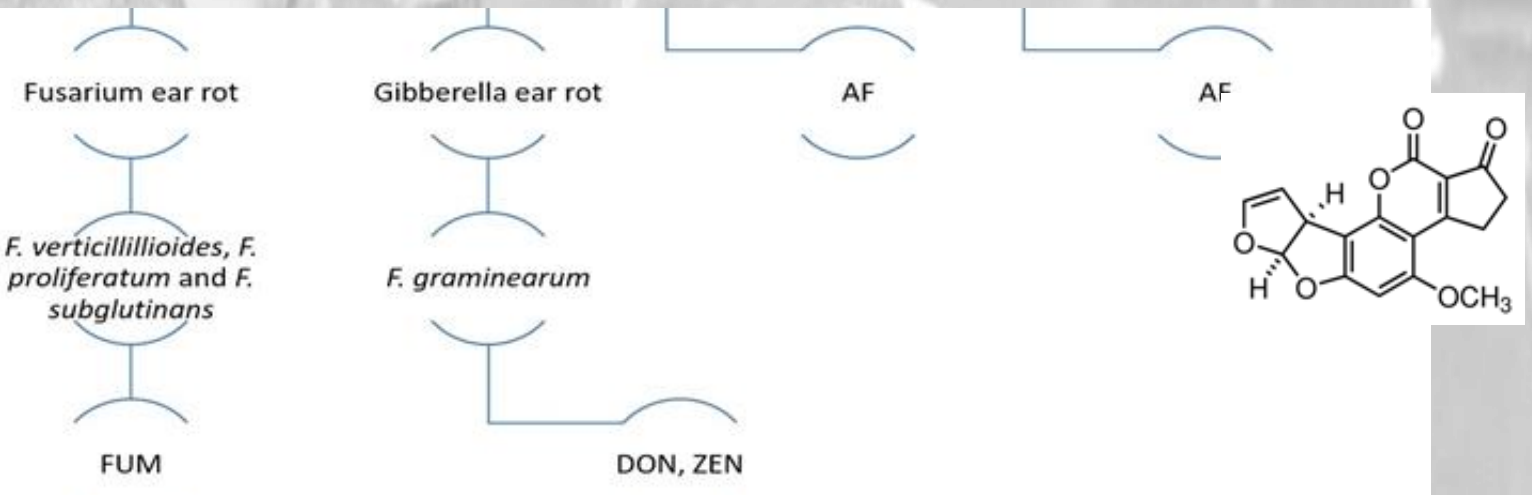
MAIZE

- Due to the prevalence of fungi, co-occurrence of mycotoxins in maize is highly possible
  - A survey in 2013 indicated that, on a global scale, 84 % of maize was contaminated with at least one mycotoxin, and 46 % was co-contaminated with multiple mycotoxins
  - Other study indicated that DON and FB have the highest probability of co-occurrence (74 %), whereas the probability of DON, FB, and AF is rather low (1 %)



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MAIZE

- Apart from the occurrence of parent forms, modified mycotoxins have been frequently reported to co-occur in cereals, including maize
  - glucosides of DON, ZEN, and other minor trichothecenes are frequently reported in other cereals (mainly wheat)
  - **in maize**,
    - conjugation of FBs with fatty acids (oleic and linoleic acids) through the formation of ester bonds has been described
    - modified FBs (*hidden FB*)
    - complexation of FBs with maize macro-constituents, the main one being starch
    - the latter complexation may significantly affect the quantification of FBs under routine conditions
    - The ratio between free and total FBs has been reported at between **0.4 to 0.7**

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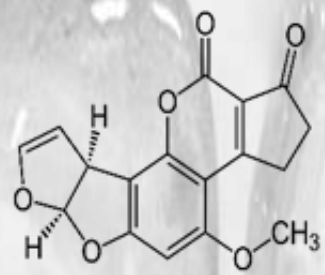
MAIZE

- But, we still may be exposed to mycotoxins indirectly by the consumption of animal products
- More than 80 % of maize grain is used for feed
  - Dairy cattle consume AFB1 contaminated feed, and secrete a AFM1 in milk

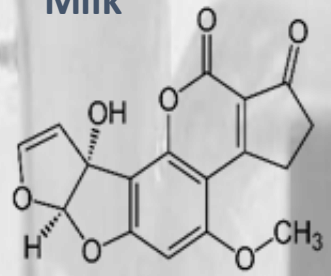
Crops-Feed

Toxigenic fungal strains



AFB1

Milk



AFM1

Human Consumer

Dairy products

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AFM1 IN DAIRY PRODUCTS

- Occurrence data for the last 30 years, shows a trend in mean AFM1 concentrations

	Decade	N	Mean of AFM1 concentration (ng/L)
World	1990	1882	20.1 ± 1.0
	2000	35591	39.4 ± 1.2
	2010	62930	85.4 ± 2.3
Europe	1990	1486	17.9 ± 0.8
	2000	23923	29.9 ± 1.2
	2010	36549	38.6 ± 0.6

Data not published

- Will CC be responsible for the latter finding?

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CLIMATE CHANGE

- Indeed, mycotoxins have been reported as one of the most important food safety hazards affected by climate change

- Projected climate change includes
  - an increase in average global air temperatures and changes in precipitation distribution
  - an increase in the variability of the weather with more extreme events, such as heat waves, droughts and extreme precipitation is expected, with a consequent strong increase of uncertainty
  - But, in an unpredictable way, making forecast more uncertain

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CLIMATE CHANGE

- In Europe, the increased occurrence of *A. flavus*, a fungus considered typical of tropical and subtropical areas, and **AF** contamination of maize have been observed since the 2000s, in regions with dry and warm summers
  - Climate change has been reported to be the key responsible
  - Possible corroborating previous finding on AFM1 trend

- Also in Europe, in events of mild and humid weather conditions, favouring *F. graminearum*, outbreaks of DON in maize have been reported

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CONCLUSION

- Looking just at one crop – maize – it is clear that
  - a community of fungi may infect the crop, and potentially produce different mycotoxins, including the most problematic ones
    - Aflatoxins (AF)
    - Deoxynivalenol (DON) and Zearalenone
    - Fumonisins B (FB)
  - contamination by mixtures of these mycotoxins is highly possible
    - … 46 % was co-contaminated with multiple mycotoxins
    - … DON and FB have the highest probability of co-occurrence (74 %), whereas the probability of DON, FB, and AF is rather low (1 %)

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CONCLUSION

- Looking just at one crop – maize – it is clear that
  - Toxins will persist in the food chain
  - Good agricultural practices may mitigate the problem, and
  - Climate change may boost the problem
  - It is not only a food safety, but also a food security issue
- *Weather and climate variability seem to be the most challenging conditions of this century (in:* Camardo Leggieri *et al*. , 2020)

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Thank you for your attention

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