Risk assessment of foods consumed by children – a case study

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Workshop on risk-benefit assessment of foods
21st May, 2018 | Lisbon
Children vulnerability to food contaminants

• Children are **constantly growing**!
  – They breathe more air, consume more food, and drink more water than adults do, in proportion to their weight.

• Children are **still developing**!
  – Exposure to toxicants (as mycotoxins) can lead to irreversible damage.
Children vulnerability to food contaminants

- A disproportionate burden of exposure from food contaminants (e.g. mycotoxins), is borne by children.
- In many parts of the world, children are routinely exposed to many mycotoxins via food chain.
Children vulnerability to food contaminants

- A disproportionate burden of exposure from food contaminants (e.g., mycotoxins) is borne by children.

...burden of exposure... to many mycotoxins...
Multiple chemicals → Multiple exposure
Food & Chemical contaminants

- **Ingestion of food** is considered a major route of exposure to many chemical contaminants.

- **Mycotoxins** → main reason to notify RASFF (Rapid Alert System for Food and Feed)
What are mycotoxins?

• **Mycotoxins** ("mykes" = fungus + "toxicum" = poison)
  – Secondary metabolites produced by fungi

• **Toxic effects** ➔ **Humans and animals**
  – Acute and chronic (e.g. cancer, kidney damage, immune suppression)

• **Main mycotoxins** (Public Health perspective):
  – Aflatoxins; Ochratoxin A; Fumonisins; Trichothecenes; Patulin

• **Discovered in the early 1960s** – veterinary crisis
  – Agent of the turkey X disease
Mycotoxins & Food

- Food products mainly contaminated with mycotoxins:
  - Contaminated agricultural products (e.g. cereal-based products, fruits)
  - Products of animal origin (e.g. milk, meat, eggs)

Usually consumed by children?
Multiple mycotoxins present in food

FAO estimated that approximately 25% of cereals produced in the world are contaminated with, at least, one mycotoxin

Natural co-occurrence of mycotoxins in foods → increasing concern
Why mycotoxins co-occur in food?

• Most fungi are able to produce several mycotoxins concurrently

• Food commodities can be contaminated by several fungi simultaneously or in quick succession

• Foodstuffs could be made up of multiple grain sources with different potential fungi contamination
Co-occurrence of mycotoxins

Main mycotoxin mixtures found by geographic origin reported by Smith et al. (2016), since 1987 to present.
What about Portugal?

• Growing concern relatively to mycotoxin involvement in human diseases

• Co-occurrence of mycotoxins in food products usually consumed by vulnerable populations as children

  – Portugal → previous studies: some foods intended for children consumption were contaminated with multiple mycotoxins (aflatoxins and ochratoxin A) (Alvito et al., 2010)
Imminent questions...

• Are Portuguese children exposed to multiple mycotoxins through food consumption?
• Are mycotoxin contents in foods for children above the legal limits? And is there a potential impact on children health?
CASE STUDY: PORTUGUESE CHILDREN EXPOSURE TO MULTIPLE MYCOTOXINS

Assunção et al. (In Press). Portuguese children dietary exposure to multiple mycotoxins - an overview of risk assessment under MYCOMIX project. Food and Chemical Toxicology
• “Exploring the toxic effects of MIXtures of MYCotoxins in infant food and potential health impact”

– Multidisciplinary team
– PI: Dr. Paula Alvito
– Funded by Fundação para a Ciência e Tecnologia (FCT, Portugal, PTDC/DTP-FTO/0417/2012)

https://youtu.be/CsKaz3mt2J4

Are children exposed to mycotoxins through diet?
Are there interactive effects in toxicity of mixtures of mycotoxins?

CHILDREN ARE EXPOSED TO MYCOTOXIN MIXTURES THROUGH THEIR DIET AND THIS CONSTITUTES A HEALTH THREAT

Could this exposure be a health threat to children?
Portuguese children exposure assessment to multiple mycotoxins

- Exposure assessment – 2 steps:
  - 1st step: children exposure through breakfast cereals
  - 2nd step: children exposure through breakfast cereals + processed cereal-based products (flours) + biscuits

Occurrence data
- Mycotoxin (14) contents
- Aflatoxins & OTA: HPLC-FD
- Trichothecenes: GC-MS
- Fumonisins and ZEA: UPLC-MS/MS
- PAT: HPLC-UV

Consumption data
- 3-days food diary
- Primary Health Care Unit near Lisbon
- Children from 0 to 3 years old (n=103)

Exposure assessment
(Deterministic & Probabilistic)
Co-occurrence of mycotoxins

- Results – positive samples:

Positive samples (%) for mycotoxins in all analysed samples (breakfast cereals, processed cereal-based products, biscuits, n=52)
Co-ocurrence of mycotoxins

- Results – mycotoxin contents:
  - 94% of products presented detected levels of mycotoxins (at least one mycotoxin)
  - 75% of analysed samples presented 2 or more mycotoxins
  - OTA & DON; OTA & fumonisins; aflatoxins, OTA & ZEA most common combinations
Mycotoxins contents & EU limits

• Results – mycotoxin contents:
  – Mycotoxin contents were below the maximum admissible levels (when available) (EU limits, Reg. 1881/2006)
  • Available regulatory limits → not cover all mycotoxins that can contaminate foods
  • Based on individual toxicities → not taken into account the risk of co-exposure
Food consumption & daily intake

- Results – food consumption & daily intake:

  - 92% of the children aged between 1 – 3 years old consumed one or more cereal-based products, at least one time in 3 days
  
  - **Estimated daily intake** (through consumption of three food products):

<table>
<thead>
<tr>
<th></th>
<th>Mean Estimated Daily Intake* ng/kg bw/day</th>
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<tbody>
<tr>
<td>AFB&lt;sub&gt;1&lt;/sub&gt;</td>
<td>0.013</td>
</tr>
<tr>
<td>AFM&lt;sub&gt;1&lt;/sub&gt;</td>
<td>0.058</td>
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<tr>
<td>AFB&lt;sub&gt;2&lt;/sub&gt;</td>
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<td>1.2</td>
</tr>
<tr>
<td>ZEA</td>
<td>0.89</td>
</tr>
</tbody>
</table>

Breakfast cereals group was the highest contributor for the EDI

*Probabilistic results
Portuguese children exposure assessment to multiple mycotoxins

- Risk characterization = Outputs of exposure compared with reference dose values
  - For **aflatoxins** (carcinogenic compounds) → Margin of Exposure (MoE)
    - MoE ≥ 10000 → low concern for public health (EFSA, 2013)
  - **Remaining mycotoxins** → Hazard Quotients (HQ)
    - HQ < 1 → tolerable exposure level

Cumulative risk assessment

Aflatoxins → Combined Margin of Exposure Index (MoET)

Remaining mycotoxins → Hazard Index (HI)
Risk characterization using MoE and MoET derived from estimates of aflatoxin exposure from different food products, performed by probabilistic approach (H1 scenario: < LOD = LOD).
Risk characterization using HQ and HI derived from estimates of OTA, FB\textsubscript{1}, FB\textsubscript{2}, DON, NIV and ZEA exposure from different food products, performed by probabilistic approach (H\textsubscript{1} scenario: < LOD = LOD).
Portuguese children exposure assessment to multiple mycotoxins

- To sum up...

<table>
<thead>
<tr>
<th>Portuguese children (1-3 years old)</th>
<th>Multiple mycotoxins occurrence data in cereals-based products:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption data:</td>
<td>Breakfast cereals, infant cereals &amp; biscuits</td>
</tr>
<tr>
<td>Pilot study through 3-days food diary</td>
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</table>

MYCOMIX

“Exploring the toxic effects of mixtures of mycotoxins in infant food and potential health impact”
National funded project

Risk assessment:
- 94% of analyzed products were contaminated with at least one mycotoxin and 75% with two or more mycotoxins
- Aflatoxins exposure suggested potential adverse health effect for P50 or higher
- Mycotoxins present in food usually consumed by young children could constitute a risk for children’s health
Strategies to reduce risk of aflatoxins exposure

- Risk associated with the children consumption of foods contaminated by mycotoxins dependent of:
  - Magnitude
  - Frequency of exposure
  - Hazard of each mycotoxin

It is possible to reduce Portuguese children exposure?
Strategies to reduce risk of aflatoxins exposure

Scenario \(\rightarrow\) a quarter (1/4) of the aflatoxins daily intake (previously estimated)

Improvement of the aflatoxins MoET:

- just percentiles of intake **above P90** could be under health concern
Strategies to reduce risk of aflatoxins exposure

• How to reduce?

i) improvement on the variety and diversity of cereal-based products consumed by children

ii) reduction on the amount of daily ingestion of these products

iii) reduction on mycotoxins contaminations of cereal-based raw materials used for food products

Benefits & Risks?

Risk-benefit assessment
Conclusions

1. Are Portuguese children exposed to multiple mycotoxins through food consumption?
   Yes
   Portuguese children included in the present study were exposed to multiple mycotoxins through food consumption

2. Are mycotoxin contents in foods for children above the legal limits? And is there a potential impact on children health?
   No/Yes
   None analysed samples presented contents above maximum limits
   Gathering consumption and occurrence data, mycotoxins present in food could constitute a risk for children’s health
Conclusions

Future studies considering the risk-benefit assessment are of utmost importance to establish recommendations based on scientific evidences to protect children’s health.
Thank you for your attention!