Occurrence of *Fusarium* mycotoxins in food and feed

Hans van Egmond & Ronald Schothorst  
Beijing, 11 December 2006

Toxic effects of mycotoxins at a glance
JECFA and EFSA: risk assessment

JECFA: Fusarium toxin evaluations in food

- JECFA: FAO/WHO Joint Expert Committee on Food Additives
- Risk assessment: data needed on hazard and exposure
- *Fusarium* toxins evaluated:
  - zearalenone (2000)
  - DON (2001)
  - T-2 and HT-2 toxins (2001)
  - fumonisins B₁, B₂ & B₃ (2001)
EFSA: *Fusarium* toxin evaluations in feed

**Scientific panel**: Contaminants in the Food and Feed Chain
- W.G. undesirable substances in animal feed - mycotoxins
- Tasks: preparing scientific opinions (assessments) on a.o. ZEA, DON, FUM in feed (all published).
- Contents of scientific opinions: introduction, analysis, legislation, occurrence, intake, effects, kinetics, metabolism, carry-over, human dietary exposure
- Data used in decision-making process of setting limits

---

**Outline of presentation**

- Introduction
- About trichothecenes, zearalenone and fumonisins, and their occurrence in food and feed
- Stability and carry-over
- SCOOP: focus on trichothecenes
- Summary
• Introduction
• About trichotheccenes, zearalenone and fumonisins, and their occurrence in food and feed
• Stability and carry-over
• SCOOP: focus on trichotheccenes
• Summary

deoxynivalenol
Effects deoxynivalenol

- Acute/subacute toxicity in animals
- Immunotoxic in mice
- Teratogenic and reproductive effects
- Nausea, vomiting, diarrhoea
- Growth retardation in children

Trichotheccenes: DON is most widespread

- Mg/kg levels of DON (often with NIV) are frequently detected, mainly in wheat, barley, maize and oats in North America, Japan and Europe
vrijdag 25 juni 1999

Giftige schimmel in graan
Van onze parlementaire redactie

DEN HAAG, vrijdag
Na de schandalen met Belgische kippen en Coca Cola is nu in ons land verdacht graan aangetroffen.

Minister Borst (Volksgezondheid) en staatssecretaris Faber hebben gisteravond laat bekendgemaakt dat bij drie monsters van partijen graan onlangs overmatig veel giftige DON-schimmels zijn ontdekt.

Wie langdurig te veel van deze stof binnenkrijgt, loopt het risico op vermindering van voedselopname, groei en afweer.
Trichothecenes: DON is most widespread

- Mg/kg levels of DON (often with NIV) are frequently detected, mainly in wheat, barley, maize and oats as data show from North America, Japan and Europe.
- Information on occurrence of trichothecenes is limited mainly to nivalenol, deoxynivalenol, T-2 toxin, diacetoxysscirpenol, fusarenon-X, HT-2 toxin, neosolaniol and 3- & 15-acetyl deoxynivalenol.
- Prevention difficult, fungicide treatment problematic.

Trichothecenes in animal feed

- DON in cereal grains and animal feeds: ranging from a few μg/kg to hundreds of mg/kg.
- Levels in feed tend to be higher than in food.
- DON found in corn cob mix, maize silage, maize gluten feed, straw bedding.
- Feeds and feed ingredients can be co-contaminated with zearalenone, fumonisins and moniliformin.
Effects zearalenone

- Most toxic effect on the reproductive system (reduced fertility)
- Swine particularly sensitive to ZEN, males less sensitive than females
- Other species susceptible to ZEN include sheep and, to a lesser extent, cattle and poultry
- Limited evidence for carcinogenicity of ZEN in experimental animals and not classifiable according to human carcinogenicity (IARC)
Zearalenone: associated with cereals

- Particularly occurring in maize at levels of the order of tens to hundreds of μg/kg upwards
- Found in many agricultural products: breakfast cereals, corn beer, wheat flour, bread, walnuts
- Zearalenone often co-occurs with DON
- Seasonal variations significantly influence the extent of *Fusarium* infections; ZEN levels vary from year-to-year: difficult to generalize typical occurrence levels
- Information on EU exposure: SCOOP 2003

Zearalenone in animal feed

- Worldwide occurrence in feed ingredients (from Argentina, Canada, China, Germany, Italy, Japan, Korea, India, Poland and UK)
- Occurs in particular in feed maize, bran, germ, gluten and maize silage, corn cob mix and forage maize
- Can also occur in wheat, barley, oats, rye, sorghum
- Evidence of occasional contamination of wheat straw, hay, pasture grass and grass silage
- EFSA (2004) for further details (www.efsa.eu.nl)
fumonisin B₁

Effects fumonisin B₁

• Tumor promoter in rats
• Toxic effects in horses (ELEM), pigs (PPE) and poultry
• Possible role in human oesophageal cancer in Africa and Asia
• Possible influence on neural tube defects
Fumonisins: typical maize contaminants

• Incidentally found in wheat, asparagus, tea, cowpea
• Commercially available refined maize products for human consumption usually contain < 1mg/kg
• Excessive levels detected in polenta in northern Italy, but possible correlation with oesophageal cancer unlikely
• Information on EU exposure: SCOOP 2003
Fumonisins in animal feeds

• Levels in feed tend to be higher than in food, vast majority of feed maize is contaminated
• Fumonisins found in maize meal, germ, germ bran, gluten, screenings and silage
• Levels in animal feeds implicated in ELEM and PPE may be very high, up to hundreds of mg/kg
• EFSA (2004) for further details (www.efsa.eu.int)

Outline of presentation

• Introduction
• About trichothecenes, zearalenone and fumonisins, and their occurrence in food and feed
• Stability and carry-over
• SCOOP: focus on trichothecenes
• Summary
**Fusarium toxins: effects of processing and carry-over**

- Various studies undertaken on carry over to animal products such as edible tissues, milk, eggs
- Information exists about stability and persistence
- Data reviewed recently by EFSA

**Stability of Fusarium toxins and carry-over into animal products: trichothecenes**

- Trichothecenes structures quite stable, most compounds largely survive processing
- When flour with DON was used to make bread, maximum reductions in concentration approx. 50 %
- Residues of DON in animal tissues (pig, cattle, poultry) insignificant; no carry-over seen into eggs
- Carry-over of DON to milk: only trace amounts including metabolites (conjugates and DOM) found
Stability of *Fusarium* toxins and carry-over into animal products: fumonisins

- Maize processing: high levels of fumonisins in maize screenings, removal reduces concentrations
- Fate of fumonisins during dry milling: higher concentrations in bran, germ, animal feed flour
- Fumonisins stable with moderate heat treatment, but degraded with CaOH (tortilla production)
- Food processing may lead to breakdown products about as toxic as the parent compound
- Limited transmission to meat and other edible tissues, low transmission rate into milk and eggs

Stability of *Fusarium* toxins and carry-over into animal products: zearalenone

- Zearalenone partly decomposed by heat: 60% remains in bread, 50% survives noodle production
- Dry milling of maize: lower concentrations in flour and grits, higher concentrations in bran and germ
- Limited tissue deposition in meat and other edible tissues, low transmission rate into milk and eggs
- Metabolism of zearalenone to related oestrogenic compounds can take place within livestock
**Fusarium toxins: effects of processing and carry-over**

- Various studies undertaken on carry over to animal products such as edible tissues, milk, eggs
- Some information about stability and persistence
- Data reviewed recently by EFSA

- Conclusion: *Fusarium* toxins rather stable and carry-over into animal products insignificant!

---

**Outline of presentation**

- Introduction
- About trichotheccenes, zearalenone and fumonisins, and their occurrence in food and feed
- Stability and carry-over
- SCOOP: focus on trichotheccenes
- Summary
SCOOP: Scientific Cooperation on Problems relating to Food

SCOOP TASK 3.2.10
"COLLECTION OF OCCURRENCE DATA OF FUSARIUM TOXINS IN FOOD AND ASSESSMENT OF DIETARY INTAKE BY THE POPULATION OF EU MEMBER STATES"

Final Report

Activity 1: instruction of participants and exchange of views
- Production of questionnaire
  - Mailing of questionnaire to participants

Activity 2: collection, selection and classification of data
- Completion of questionnaires
  - Completed questionnaires to co-ordinators

Activity 3: digestion, consultations, corrections
- Production of first overviews by co-ordinators
  - Get-together of co-ordinators to discuss

Activity 4: meeting with participants to discuss and correct
- Production of final report by co-ordinators
  - Completion of the task and publication

Target month
- 2
- 13
- 15
- 16
SCOOP subtask trichothecenes

12 participating Countries

- Austria
- Belgium
- Denmark
- Finland
- France
- Germany
- Italy
- The Netherlands
- Norway
- Portugal
- Sweden
- United Kingdom

Number of samples and positives per country (N=34823)
SCOOP subtask trichothecenes
Number of samples and positives per country (N=34823)

SCOOP subtask trichothecenes
Number of samples for each trichothecene in each country
SCOOP subtask trichothecenes: occurrence

12 countries provided occurrence data

TABLES for type A - trichothecenes (example)

Table 1A1: Summary of individual occurrence data by food group (Food Categorisation System as in Annex 2)

<table>
<thead>
<tr>
<th>Trichothecene type A</th>
<th>Country</th>
<th>Method</th>
<th>Analyte</th>
<th>Assay</th>
<th>STAMP</th>
<th>ICP-MS</th>
<th>MS/MS</th>
<th>LOD</th>
<th>LOQ</th>
<th>Data coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SCOOP subtask trichothecenes; occurrence
Food categorisation system

<table>
<thead>
<tr>
<th>Type</th>
<th>Group-No.</th>
<th>Group-Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>04</td>
<td>01</td>
<td>TN</td>
<td>Tree nuts</td>
</tr>
<tr>
<td>04</td>
<td>02</td>
<td>SO</td>
<td>Oilseed</td>
</tr>
<tr>
<td>04</td>
<td>03</td>
<td>SB</td>
<td>Seed for beverages and sweets</td>
</tr>
<tr>
<td>04</td>
<td>03 A</td>
<td>SB1</td>
<td>Green coffee</td>
</tr>
<tr>
<td>04</td>
<td>03 B</td>
<td>SB2</td>
<td>Cocoa beans</td>
</tr>
<tr>
<td>04</td>
<td>03 C</td>
<td>SB3</td>
<td>(Others)</td>
</tr>
</tbody>
</table>

SCOOP subtask trichothecenes; occurrence
DON: Number of samples (11022) and positive samples (57%)
SCOOP subtask trichothecenes; occurrence
DON occurrence in cereal grains

Number of samples and positive samples for different cereal grains:
- Wheat: 6000
- Barley: 2000
- Oats: 3000
- Rye: 5000
- Corn: 4000

T-2: Number of samples (3490) and positive samples (20%)

Number of samples and positive samples for different countries:
- Australia
- Belgium
- Denmark
- Finland
- France
- Germany
- Italy
- The Netherlands
- Norway
- Portugal
- Sweden
- UK

Total number of samples: 1200
Number of positive samples: 240
SCOOP subtask trichothecenes; occurrence
T-2 occurrence in cereal grains

<table>
<thead>
<tr>
<th>Cereal grain</th>
<th>Number of samples</th>
<th>Number of positive samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1600</td>
<td>200</td>
</tr>
<tr>
<td>Barley</td>
<td>400</td>
<td>50</td>
</tr>
<tr>
<td>Oats</td>
<td>600</td>
<td>100</td>
</tr>
<tr>
<td>Rye</td>
<td>800</td>
<td>15</td>
</tr>
<tr>
<td>Corn</td>
<td>1000</td>
<td>20</td>
</tr>
</tbody>
</table>

SCOOP subtask trichothecenes; consumption
11 countries provided consumption data
Table 2A1, 2A2, 2A3 etc.: Estimate of food consumption for an average person belonging to the group using Food Categorisation System as in Annex 2

<table>
<thead>
<tr>
<th>Country</th>
<th>Method used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Dietary survey (1 d. diary). N=2580</td>
</tr>
<tr>
<td>Belgium</td>
<td>Dietary survey (7 d. diary). N=341 (13-18 y)</td>
</tr>
<tr>
<td>Denmark</td>
<td>Personal interview and self-administrated diet record (7 d. survey). N=1837</td>
</tr>
<tr>
<td>Finland</td>
<td>Dietary survey (1 d. recall). N=2007</td>
</tr>
<tr>
<td>France</td>
<td>Dietary survey (7 d. diary). N=3003</td>
</tr>
<tr>
<td>Germany</td>
<td>German Food Survey</td>
</tr>
</tbody>
</table>
**SCOOP subtask trichothecenes; consumption**

Food consumption methodologies

<table>
<thead>
<tr>
<th>Member State</th>
<th>Method used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>Household individual data (diary). N=1978</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Dietary survey (2 d. diary). N=6250</td>
</tr>
<tr>
<td>Norway</td>
<td>-Adult: dietary survey (FFQ). N=2672</td>
</tr>
<tr>
<td></td>
<td>-Child (0.5y): Precoded 4d. records. N=2383</td>
</tr>
<tr>
<td>Portugal</td>
<td>Food Balance Sheets</td>
</tr>
<tr>
<td>Sweden</td>
<td>Dietary survey (diary). N=1200</td>
</tr>
<tr>
<td>UK</td>
<td>Dietary record (7 d. diary).</td>
</tr>
</tbody>
</table>

**SCOOP subtask trichothecenes; dietary intake**

12 countries provided intake data
SCOOP subtask trichothecenes; dietary intake

Table

Mean intake:
Mean food consumption X mean 1 occurrence

High level intake:
High level food consumption X mean 1 occurrence
SCOOP subtask trichothecenes; dietary intake
DON: Intake data

SCOOP subtask trichothecenes; dietary intake
T-2 toxin: Intake data
SCOOP subtask trichothecenes; dietary intake
DON: Contribution of food commodities to the intake

SCOOP subtask trichothecenes; dietary intake
T-2 toxin: Contribution of food commodities to the intake
SCOOP subtask trichothecenes; conclusions

Occurrence

- Far most of the occurrence data available is on DON in wheat
- Among cereals, corn showed the highest level of contamination with trichothecenes
- EU regulatory limits:
  - DON (products) > 500 µg/kg = 6%
  - DON (cereals and flour) > 750 µg/kg = 7%

Consumption

- There is a significant lack of consumption data in some countries.
- Information on baby food is generally not available
**SCOOP subtask trichothecenes; conclusions**

**Dietary intake**

- Wheat and wheat containing products (bread and pasta) represent for DON and T-2 toxin the major source of intake.

**TDI DON = 1 µg/kg bw**

**DON mean intake:**
- Most of the intakes are below the TDI.
- For most young children groups the intakes are close to the TDI.

**DON high level intake:**
- For most young children groups the intakes are above the TDI.
- 13-18 years adolescents: the intake is close to the TDI.
SCOOP subtask trichothecenes; conclusions

**Dietary intake**

\[ t\text{-TDI sum HT-2 and T-2 toxin} = 0.06 \, \mu g/kg \, \text{bw} \]

HT-2 and T-2 toxin intake:
- Limited amount of data
- t-TDI is in most cases exceeded

---

**Future needs**

- Analytical methods with lower limits of detection should be developed.
- Consumption data for specific population groups should be collected (children and consumers).
- A common approach to assess the dietary intake in the EU should be elaborated.
**SCOOP subtask trichothecenes; conclusions**

Spin-off

- New legislation (Baby food)
- New analytical methods with LODs according to the (new) legislation
- Development of reference materials
- Collection of intake data for young population groups

---

**SCOOP tasks; conclusions**

- Lack of harmonization in sampling procedures, analytical methods and quality assurance
- Reliability of occurrence data
- Different approaches for consumption methodologies
- Lack of consumption data for specific groups.
- Intake estimates realistic/not realistic
- Effect of processing and storage at home
Introduction
About trichothecenes, zearalenone and fumonisins, and their occurrence in food and feed
Stability and carry-over
SCOOP: focus on trichothecenes
Summary

Summary
Fusarium toxins occur in various foods and feeds; cereals (e.g. maize) particularly susceptible
These toxins relatively stable during processing
Carry-over to animal products is insignificant
Occurrence data published e.g. by EFSA and SCOOP
Most occurrence data exist for DON in wheat
For young children DON levels close or > TDI
Limited SCOOP data for T-2/HT-2 suggest t-TDI often exceeded
Occurrence of *Fusarium* mycotoxins in food and feed

Hans van Egmond & Ronald Schothorst Beijing, 11 December 2006

Thank you for your attention!