Hazard identification and Risk characterization – micro and nano plastics in food and feed (draft)

6th May 2021, Ron Hoogenboom
Hazards of micro- and nanoplastics

- Exposure via food and drinking water?
- Effects in gastrointestinal tract?
  - Including microflora?
- Uptake of particles resulting in systemic exposure?
- Effects in tissues and organs?
- Carriers of contaminants?
  - Which ones?
  - Relevant in comparison to other sources?
Presence of microplastics and nanoplastics in food, with particular focus on seafood

EFSA Panel on Contaminants in the Food Chain (CONTAM)
Absorption data not available

- MPs <150 μm may be absorbed

- Absorption of MPs is likely limited, data indicate <0.3%.
  - Nanoparticle bioavailability in vivo <10%
  - Nanoparticle uptake in vitro <10%
  - Uptake size dependent, no simple correlation, different mechanisms

- Only MPs <1.5 μm may penetrate deeply into organs
EFSA statement 2016

Toxicity data

MPs could interact with the immune system, but not reported yet

➢ MP T-cell activation and uptake by macrophages
  (inhalation, injection) in vivo/in vitro

Data gaps

• Absorption and distribution data
• Metabolism and excretion data
• Tox data on effects of MPs
• Tox data on local effects of MPs on GI tract including microbiota
Current Insights into Monitoring, Bioaccumulation, and Potential Health Effects of Microplastics Present in the Food Chain

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- Various aspects on analysis, occurrence, uptake and toxicity

**Study design**

Oral gavage daily for 28 days.
2 sizes MPs: 5 and 20 µm (fluorescently labeled)

Bioavailability:
0.1 mg/day  
(1.46 *10^6 MPs; 5 µm)  
(2.27 *10^4 MPs; 20 µm)

Effects:
0.01 mg/day  
(1 *10^5 MPs; 5 µm)  
(2 *10^3 MPs; 20 µm)
0.1 mg/day  
(1 *10^6 MPs; 5 µm)  
(2 *10^4 MPs; 20 µm)
0.5 mg/day  
(5 *10^6 MPs; 5 µm)  
(1 *10^5 MPs; 20 µm)

Organs evaluated: liver, kidney, gut
- Inflammation
- Lipid droplets
- Various blood parameters affected
Major results

- **Bioavailability**
  - High accumulation (71% in gut, liver, kidney at day 4)

- **Effects**
  - Histology: liver inflammation and lipid droplets
  - Plasma markers:
    - ATP down, LDH up (energy disturbance)
    - Cholesterol and triglycerides down (lipid disturbance)
    - GSH and SOD up, CAD down (oxidative stress)
    - AChE up (neurotoxic responses)
Discussion in the literature by BfR

- **Bioavailability**
  - High accumulation (71% in gut, liver, kidney at day 4)

- **Response to study:**
  - BfR calculated clearance half life t1/2 = ~3 days
  - Would lead to ~100% bioavailability (highly unlikely)
  - EFSA report: Absorption is likely limited, data indicates <0.3%
  - EFSA report: Only MP <1.5 µm may penetrate deeply into organs
Discussion in the literature by BfR

- **Effects**

- **Histology: liver inflammation and lipid droplets**
  - BfR: no description of scoring (qualitative evaluation at best)

- **Plasma markers**
  - BfR points out that the SDs are very minor (unusual for serum data)
Alternative explanations

- Fluorescent label released from the particles?
  - But also particles observed

- Calculated concentrations in tissues not correct?
  - So time related increase
  - But lower levels that may still be relevant
Other studies (same group)

- Lu et al., 2018. Polystyrene microplastics induce gut microbiota dysbiosis and hepatic lipid metabolism disorder in mice. Science of the Total Environment
- Luo et al., 2019. Maternal exposure to different sizes of polystyrene microplastics during gestation causes metabolic disorders in their offspring. Environ poll.
Lu et al. (2018)

- Mice
  - Two sizes: 0.5 and 50 µm polystyrene MPs
  - Concentrations of 100 and 1000 µg/L ($1.456 \times 10^{10}$ and $1.456 \times 10^{4}$ particles/L)
  - Exposure via drinking water for 5 weeks (how much water consumed?)

- Effects
  - Reduction in body, liver, and fat weight for high dose
  - Reduction in mucus production colon
  - Reduced liver and serum triglycerides and cholesterol
Lu et al. (2018)

- Composition microbiome changed at phylum and genus levels

- Effect on liver via effect on gut microbiota?
Stock et al., 2019. Uptake and effects of orally ingested polystyrene microplastic particles in vitro and in vivo. Archives of Toxicology.

- Male Hmox1 reporter mice (lacZ reporter gene under the control of the inflammation- and redox stress-sensitive heme oxygenase 1 promoter)
- Oral gavage for 28 days, 3x per week
- Fluorescently labeled MPs, 3 sizes: 1. 4 and 10 µm
  - 1 µm (4.55 × 10^7 particles)
  - 4 µm (4.55 × 10^7 particles)
  - 10 µm (1.49 × 10^6 particles)
- Duodenum, ileum and jejunum, testes, large intestine, lung, heart, spleen and kidneys
Some particles detected in the intestinal wall (not quantitative, concentration too low)

- No particles detected in lung, heart spleen or kidneys
- Data corroborate with EFSA report

No inflammation and/or oxidative stress (histology and mouse model; fluorescence)

Mice examined \( x \) days after last dosing: effect?
Other recent studies (not in review 2020)

- .........
Conclusions

- Absorption and effects of larger particles reported
  - Several studies
  - Results questioned
  - Data require thorough investigation
  - Repeat of studies?
- Unclear if high doses are relevant for humans
  - Need for more data on exposure
- Primarily polystyrene tested; studies with other types of plastics?
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Thank you for your attention

Questions?