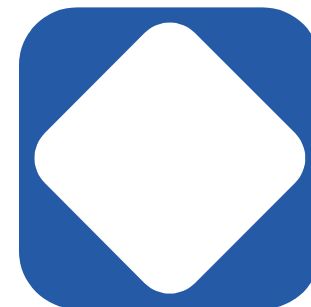
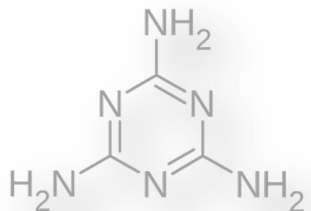


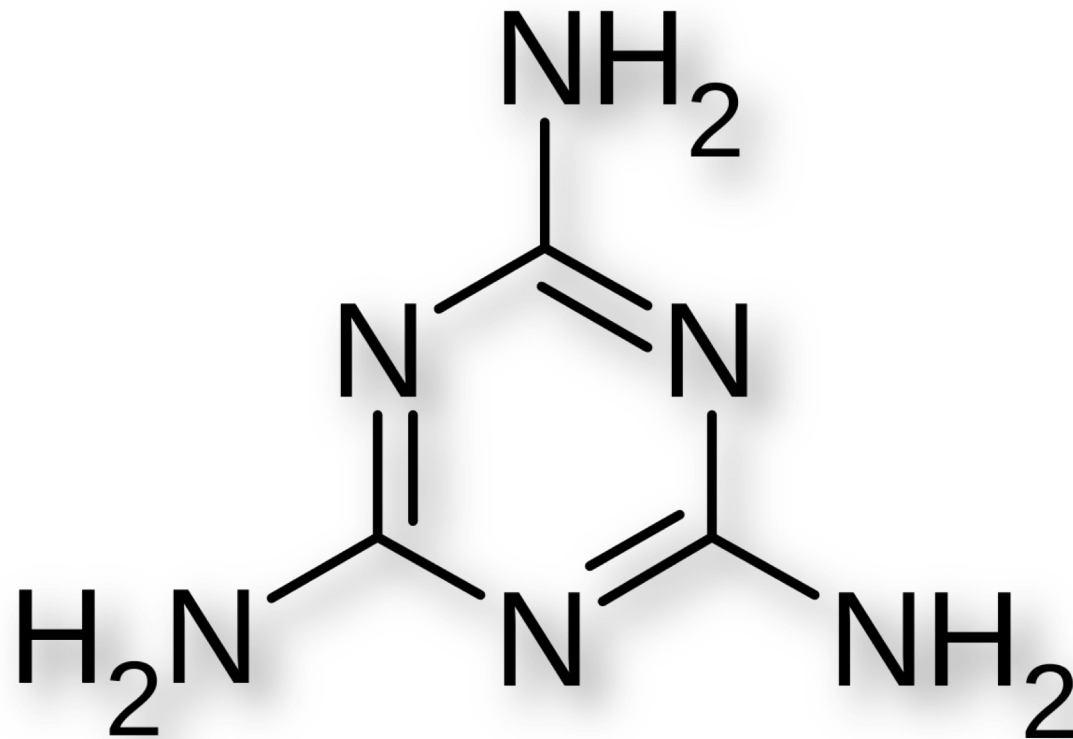
# Melamine in food contact materials: What you need to know

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Collaborative for Health and the Environment CHE webinar 14 October 2021



Food  
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# 1. What is *Melamine*?



- **Melamine**
- 1,3,5-Triazine-2,4,6-triamine
- CAS 108-78-1
- synthetic chemical (“man-made”)
- first made in 1834
- by German chemist **Justus von Liebig** (1803 – 1873)

# Production volume (US), US EPA comptox

Domestic production 141372900 lb (= 64 mio t/16k elephants)

Imported 52960433 lb (= 24 mio t)

Exported 63393900 lb (= 29 mio t)

TOTAL in US: 59 mio t 14k elephants / 130 million lb



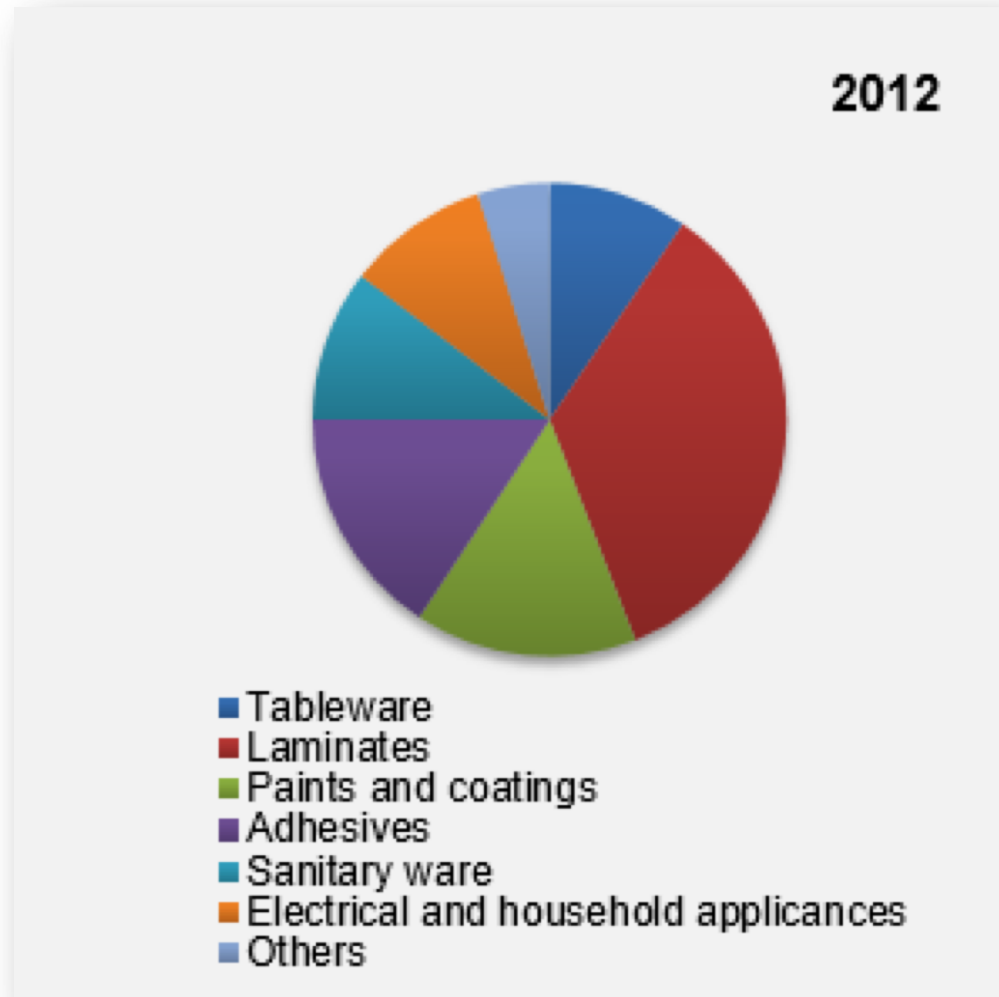
<https://comptox.epa.gov/dashboard/dsstoxdb/results?search=DTXSID6020802#production-volume>

# Uses of Melamine

The background of the slide features a close-up, slightly blurred view of several stacks of colorful plastic plates. The plates are in various colors including yellow, light blue, and light green. They are stacked on shelves within a pinkish-purple kitchen cabinet. The lighting is soft, highlighting the smooth texture of the plates.

- Polymerization with Formaldehyde, e.g. laminates for flooring, reusable plastics table ware, “bamboo” plastics, coatings, adhesives, composites (plywood)

# Global Melamine Formaldehyde Market (2019): 21 Bn US\$



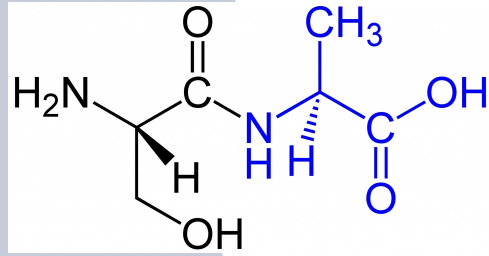
# Uses of Melamine

- Polymerization with Formaldehyde, e.g. laminates for flooring, reusable plastics table ware, “bamboo” plastics, coatings, adhesives, composites (plywood)
- Pigment Yellow 150 (inks, plastics)
- Melamine foam, e.g. polymeric cleaning products, building materials
- Fire-retardant additive in plastics, paper (reacted w/polyphosphate, cyanuric acid)
- Metabolite of Cyromazine (Insecticide, authorized US, not EU)
- Non-protein nitrogen, e.g. food adulteration to increase apparent protein content

## 2. Why is there *concern* about Melamine?



# Infant formula adulteration in China, 2008



**Tania Branigan,**  
*China correspondent*

Thu 18 Sep 2008 00.01  
BST



## Three die in tainted baby milk scandal in China

- Thousands ill after banned chemical found in formula
- Authorities not alerted for more than a month



▲ Two Chinese babies suffering from kidney stones after drinking contaminated formula. Photograph: Reuters  
More than 6,000 Chinese babies have been taken ill and three have died after being fed contaminated milk formula, with the scandal deepening as it was revealed that a fifth of China's infant formula producers have made tainted powder.

- Protein content measurement is based on N (nitrogen) content
- Melamine has a high N content

# Hazard profile

- Kidney toxicity (increased w/ cyanuric acid, CAS 108-80-5)<sup>1</sup>
- Suspected of damaging fertility of the unborn child (GHS warning)<sup>4</sup>
- Possibly **carcinogenic** / suspected carcinogen (IARC group 2B / ECHA category 2)<sup>5</sup>
- Neurotoxicity<sup>6</sup>
- Gut microbiome<sup>7</sup>
- Suspected PBT (persistent, bioaccumulative, toxic)<sup>2</sup>
- PMT (persistent, mobile, toxic)<sup>3</sup>

# References “Hazard profile”

1. Dalal, R., Goldfarb, D. Melamine-related kidney stones and renal toxicity. *Nat Rev Nephrol* 7, 267–274 (2011). <https://doi.org/10.1038/nrneph.2011.24>
2. European Chemicals Agency. Substance Infocard Melamine. <https://echa.europa.eu/substance-information/-/substanceinfo/100.003.288>
3. ChemSec: Melamine key PMT chemical of concern. <https://www.foodpackagingforum.org/news/chemsec-melamine-key-pmt-chemical-of-concern>
4. US EPA. Comptox. Safety—GHS data. <https://comptox.epa.gov/dashboard/dsstoxdb/results?search=DTXSID6020802#safety>
5. IARC: Melamine possibly carcinogenic. <https://www.foodpackagingforum.org/news/iarc-melamine-possibly-carcinogenic>
6. An, L. et al. (2014). “Prenatal melamine exposure induces impairments of spatial cognition and hippocampal synaptic plasticity in male adolescent rats.” *Reproductive Toxicology* <http://www.sciencedirect.com/science/article/pii/S0890623814002020>  
Bolden, A., et al. (2017). “Melamine, beyond the kidney: A ubiquitous endocrine disruptor and neurotoxicant?” *Toxicology Letters*. <http://www.sciencedirect.com/science/article/pii/S0378427417311396>
7. Zheng, X., et al. (2013). “Melamine-Induced Renal Toxicity Is Mediated by the Gut Microbiota.” *Science Translational Medicine* 5(172): 172ra122. <http://stm.sciencemag.org/content/5/172/172ra22.abstract>

3. Are *food contact articles* a  
(relevant) source of Melamine?

# Food Contact Terms

## food contact article (FCA):

- yoghurt cup



## food contact materials (FCMs):

- plastic(s)
- aluminum
- coating
- adhesives
- printing inks
- ...

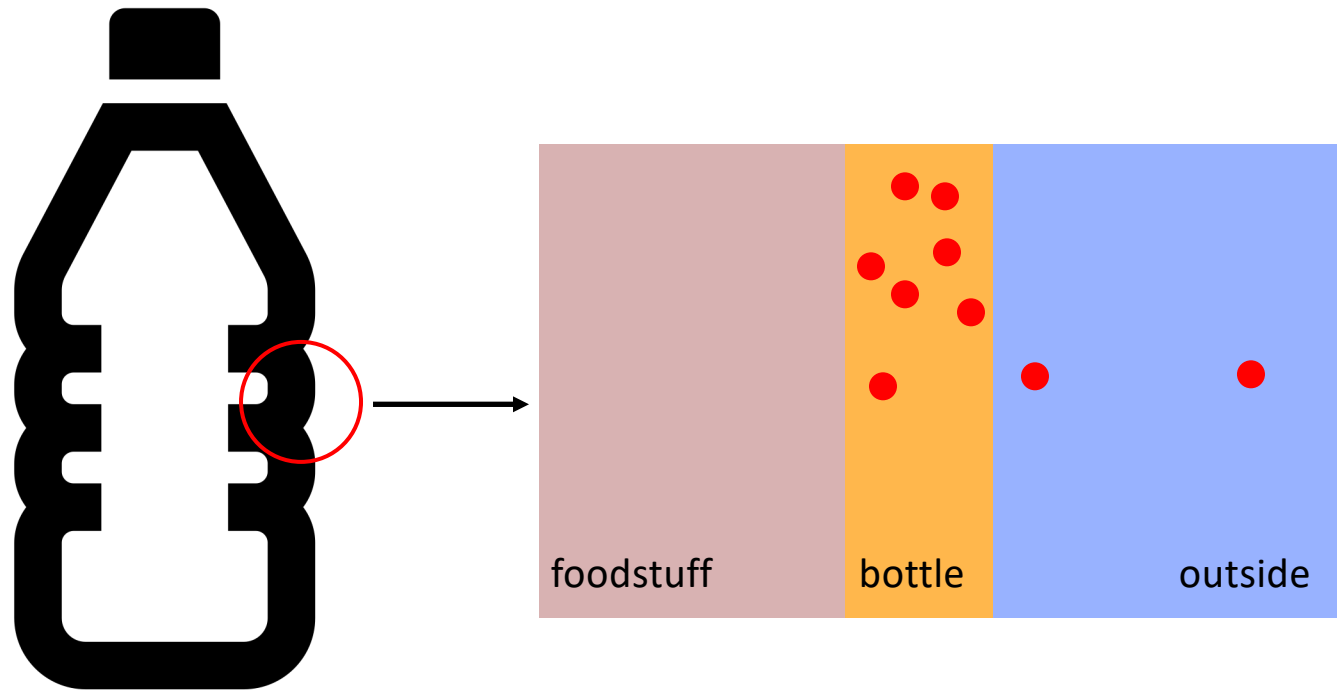
## food contact chemicals (FCCs):

- monomers
- polymers
- oligomers
- additives
- pigments
- metals
- impurities
- reaction by-products
- degradation products
- ...



Muncke et al. 2017 EHP <https://doi.org/10.1289/EHP644>

# Migration: Food Contact Chemicals transfer into food



● small molecule food contact chemical

# WHAT INFLUENCES MIGRATION OF CHEMICALS INTO FOOD?



...at high temperature



...when using small portion sizes



...after long contact times



...of fat-soluble chemicals into fatty foods



Find out more: [bit.ly/fpf-factsheet](https://bit.ly/fpf-factsheet)



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4. How (& how often) is melamine measured in *food contact articles*?



Real World

## Migration experiment

FCCs measured in:

- food
- food simulants  
e.g., distilled water, ethanol, isooctane, acetic acid 3%, Tenax, Miglyol 812, HB 307

vs.

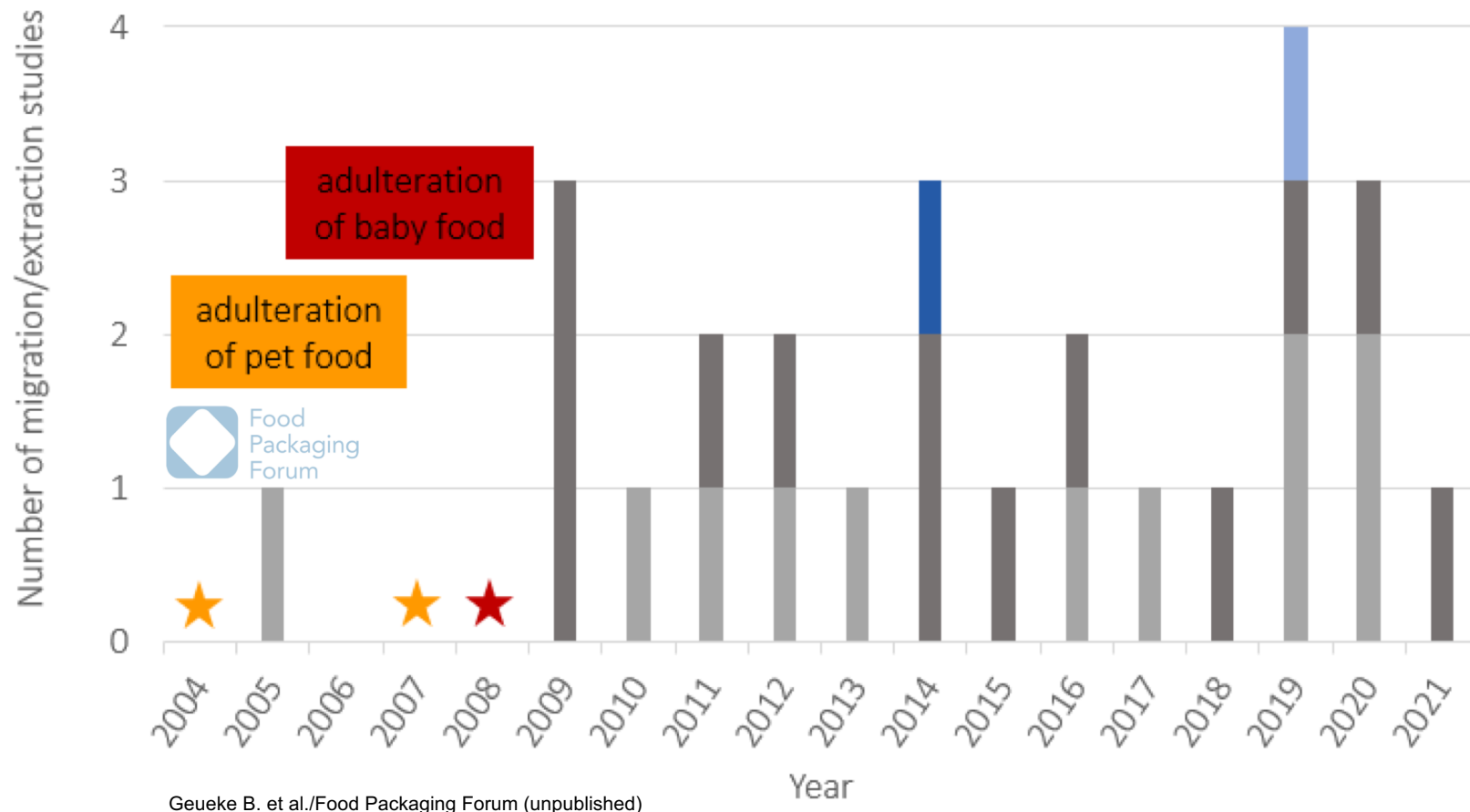
## Extraction experiment

FCCs measured in/by:

- non-food, non-food simulants
- organic solvents  
e.g., hexane, heptane, ethyl acetate, isopropanol
- material dissolution
- thermal desorption

Worst Case

# 26 migration / extraction studies on melamine in food contact articles



# Migration and extraction from FCAs

- **Melamine** and **formaldehyde** are the most frequently found migrants from melamine-formaldehyde resin
- Melamine is usually not detected in migrates/extracts of other plastic types (e.g. PE, PP, PS), but **coatings of metal cans are a source of melamine**
- In 2020, untargeted migration studies from **bamboo-melamine tableware** showed dozens of FCCs to migrate into food simulants (Osorio et al. 2020; [10.1016/j.jhazmat.2020.122891](https://doi.org/10.1016/j.jhazmat.2020.122891))
- Melamine degradation products could be extracted from food packaging: **ammeline, ammelide, cyanuric acid** (Zhu and Kannan 2019; [10.1016/j.envint.2019.104950](https://doi.org/10.1016/j.envint.2019.104950))
- UV sterilization of kitchenware made of melamine-formaldehyde resin increased migration of plastic additives and NIAS (Kim et al. 2021; [10.1016/j.foodcont.2021.107981](https://doi.org/10.1016/j.foodcont.2021.107981))
- **Repeated use** of melamine-formaldehyde table ware with **hot foods leads to increased migration of melamine, formaldehyde** (Merkel 2020; [https://www.foodpackagingforum.org/fpf-2016/wp-content/uploads/2020/03/Merkel\\_FPF2020Workshop.pdf](https://www.foodpackagingforum.org/fpf-2016/wp-content/uploads/2020/03/Merkel_FPF2020Workshop.pdf) / German BfR; <https://www.bfr.bund.de/cm/349/fillable-articles-made-from-melamine-formaldehyde-resin.pdf> )

# 5. What is known about *levels of melamine*?

# Migration levels: *safe vs. measured*

- **EU Specific Migration Limit: 2.5 mg/kg foodstuff** (corresponds to 0.17 mg/dm<sup>2</sup>) <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02011R0010-20200923&from=EN>
- EFSA (European Food Safety Authority): *“the appropriate level to distinguish between the unavoidable background presence of melamine (from food contact materials, pesticide use) and unacceptable adulteration”*  
<https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/j.efsa.2010.1573>
- FDA has same acceptable level (except for infant formula)
- **Tolerable Daily Intake (EFSA)** currently is **0.2 mg/kg bw** (since 2010) <https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/j.efsa.2010.1573>
- Daily intake from food would correspond to 40 µg/kg bw → other exposure sources than food are considered
- Bradley et al. (2005) measured **migration**: [10.1080/02652030500135243](https://doi.org/10.1080/02652030500135243)
  - 3% acetic acid, 2h, 70°C: 47/50 samples detected melamine, **0.05-3.8 mg melamine/dm<sup>2</sup>**
  - water, up to 100°C: 1 sample, no migration detected
- Poovarodom et al. (2014) measured **migration after microwaving**: [10.1080/19440049.2014.947638](https://doi.org/10.1080/19440049.2014.947638)
  - 3% acetic acid, 1 min repeated heating: microwave heating affects melamine migration differently than other heating



# Migration: *summary of evidence*

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3% acetic acid > approximately 2x higher migration than in water:  
good food simulant for acidic beverages (juices, fruit tea, sodas)

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lower migration into olive oil (log P: -1.37)

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high temperatures cause degradation of the polymer, leading to  
increased migration rates with repeat use

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microwave heating: very high migration despite short contact  
times, material is degraded by microwaves

# 5. What do the *authorities* recommend?



# FDA recommendation, 2017

“when highly acidic foods are heated to extreme temperatures (e.g., 160 ° F or higher), the amount of melamine that migrates out of the plastic can increase. Foods and drinks **should not be heated on melamine-based dinnerware in microwave ovens.**”

<https://www.fda.gov/food/chemical-contaminants-food/melamine-tableware-questions-and-answers>

# German BfR warning, 2019

“infants who often consume hot food/drinks from this type of tableware were found to potentially absorb tolerable daily intake (TDI) for melamine up to three times the TDI. The BfR concluded that there was a **possible increase in health risk for consumers drinking hot liquid foods from melamine-type tableware.**”

<https://www.foodpackagingforum.org/news/bfr-statement-on-bamboo-cups-and-tableware>

# Conclusions

- Melamine is a widely used man-made chemical
- Melamine is a chemical of concern
- There is increasing concern about its human toxicity and persistence/mobility in the aquatic environment
- Migration from food contact materials (FCM) has been detected, often exceeding safe levels
- Melamine table ware should not be used for contact with hot foods or acidic foods
- Other sources of melamine (than FCM) may be significant (flooring, cleaning products, insecticides, pigment, etc)

# Food Packaging Forum (FPF) Foundation



Science communication & scientific research (desk-based)



Food contact materials, chemicals, migration, human health



2012 in Zurich



Scientists & science communication experts



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