BfR MEAL Study
First German Total Diet Study

Irmela Sarvan, Oliver Lindtner
Mahlzeiten für die Expositionsschätzung und Analytik von Lebensmitteln

[Meals for Exposure assessment and Analysis of foods]
Modular structure of the BfR MEAL Study

Substances to be analyzed were grouped into nine modules:

- Same pools for different modules were used (synergic effect)
Steps of the BfR MEAL Study

Step 1: Selection of foods
Step 2: Shopping on national level
Step 3: Preparation and processing
Step 4: Pooling and homogenisation
Step 5: Analysis
Step 6: Evaluation and exposure assessment
Step 1: Food selection

- Main Food Groups (FoodEx II-Codes, EFSA)

- Food Groups in BfR MEAL Food List

- Pools, division in:
  - Regionality
  - Seasonality
  - Organic / conventional

- Selected modules:
  + Browning degree
  + Type of packaging
Step 2: Shopping on national level

- Market data used, to represent consumer shopping behaviour
- Panel with 30,000 households over one year
- Parameters selected: brand, production method, type of packaging, origin...
- Expert consultation to decide on distinction of pools by season, region and production type
Step 3: Preparation of foods

Representative household behaviour due to:

- Market data on foods for origin, production method,
- Market data on recipe books and most visited cooking homepages
- Surveys on
  - kitchen utensils (N=1.008)
  - preparation of foods (N=1.008)
  - Degree of browning (N=2.003)
15-20 pooled samples homogenised
**Laboratories**
- Commercial laboratory
- Federal chemical investigations offices
- Only for very few selected substances: in-house

**Quality parameters in tender**
- Monitored cooled transport and storage till analysis
- Implemented quality concept with e.g.
  - Quality control cards with reference material
  - Analysis of blanc values
  - Registration for interlaboratory comparisons

Samples were sent to laboratories twice, to check precision of the measurement

Close communication with laboratories and audit of selected laboratories
## Schedule

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<tr>
<td>Planning</td>
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<tr>
<td>Sampling / Analysis</td>
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<td>Data evaluation / publishing</td>
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<tr>
<td>Expert groups / IAB MEAL</td>
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</table>

**Field phase 1**

**Field phase 2**

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Federal chemical investigations offices

Universities

Institutes
Outcome occurrence data so far

Public Use File: (URL wird später eingefügt)

Schendel, S. et al (accepted). Results of the BfR MEAL Study: Highest levels of retinol found in animal livers and of β-carotene in yellow-orange and green leafy vegetables.

Stadion, M. et al (accepted). The first German Total Diet Study (BfR MEAL Study) confirms highest levels of dioxins and dioxin-like polychlorinated biphenyls in foods of animal origin.

Fechner, C. et al (2022). Results of the BfR MEAL Study: In Germany, mercury is mostly contained in fish and seafood while cadmium, lead, and nickel are present in a broad spectrum of foods. Food Chemistry: X 14.

Schwerbel, K. et al. (2022). Results of the BfR MEAL Study: The food type has a stronger impact on calcium, potassium and phosphorus levels than factors such as seasonality, regionality and type of production. Food Chemistry: X 13.


Sarvan, I. et al. (2021). Exposure Assessment of methylmercury in samples of the BfR MEAL Study. Food and Chemical Toxicology 149.

Hackethal, C. et al. (2021): Total arsenic and water-soluble arsenic species in foods of the first German total diet study (BfR MEAL Study). Food Chemistry 346.

Report to the ministry (2001): „Bestimmung der Gehalte verschiedener Süßungsmittel in marktrelevanten Erfrischungsgetränken“ [Occurrence concentration of sweeteners in soft drinks relevant for the German market]
Substances with high concentrations near to MPLs

ndlPCB: Dog fish

Aflatoxins & OTA: Buck wheat

Chlorate: butter, meat and meat products, salad dressings, rice pudding, cakes

Chlorpyrifos: dates

Copper: beef liver, sheep liver, game meat, chia-seeds und honey

Benzoates: Fish products

Sulfites: Shrimps/ prawns

Soft drinks
- Acesulfam K, Cyclamat, Benzoate (MPL)
- Cyclamat, Saccharin, Aspartam/ Saccharin (not declared)
Mean levels of the sum of PCDD/Fs and DL-PCBs in the 15 MEAL foods (wet weight)

- Cod liver: 13.69 pg WHO\textsubscript{2005}-TEQ/g wet weight
- Spiny dogfish, smoked: 3.55 pg
- Eel: 1.60 pg
- Herring, pickled (Roll mops): 0.96 pg
- Herring, fried herring: 0.83 pg
- Herring, pickled, young salted herring, Bismarck…: 0.73 pg
- Mussels: 0.73 pg
- Herring, canned in sauce: 0.73 pg
- Sheep liver: 0.64 pg
- Herring, smoked: 0.60 pg
- Halibut, smoked: 0.55 pg
- Eel, smoked: 0.49 pg
- Plaice/sole: 0.43 pg
- Halibut: 0.41 pg
- Butter: 0.39 pg

Mean UB level (pg WHO\textsubscript{2005}-TEQ/g wet weight)

Adapted from Stadion et al., *Food Chem X.*, 2022.
Pools with highest levels of P, Ca, K

<table>
<thead>
<tr>
<th>Chewing gums</th>
<th>19.230</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emmental cheese</td>
<td>9.210</td>
</tr>
<tr>
<td>Firm/semi-hard cheese</td>
<td>8.010</td>
</tr>
<tr>
<td>Chia seeds</td>
<td>5.760</td>
</tr>
<tr>
<td>Soft-ripened cheese</td>
<td>4.515</td>
</tr>
</tbody>
</table>

mLb mean Ca levels [mg·kg⁻¹]

<table>
<thead>
<tr>
<th>Pumpkin seeds</th>
<th>11.385</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processed cheese</td>
<td>8.433</td>
</tr>
<tr>
<td>Chia seeds</td>
<td>7.701</td>
</tr>
<tr>
<td>Sunflower seeds</td>
<td>7.635</td>
</tr>
<tr>
<td>Cocoa powder</td>
<td>6.538</td>
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</tbody>
</table>

mLb mean P levels [mg·kg⁻¹]

<table>
<thead>
<tr>
<th>Cocoa powder</th>
<th>36.975</th>
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<tbody>
<tr>
<td>Spices</td>
<td>16.238</td>
</tr>
<tr>
<td>Vegetable crisps</td>
<td>15.030</td>
</tr>
<tr>
<td>Potato crisps</td>
<td>10.840</td>
</tr>
<tr>
<td>Pistachio nuts</td>
<td>9.750</td>
</tr>
</tbody>
</table>

mLb mean K levels [mg·kg⁻¹]

adapted from Schwerbel et al., Food Chem X., 2022
Analysis of methylmercury (MeHg) in fish, mushrooms and their products:
• Measurement of MeHg and not derivation of total Hg
• About a quarter of the adult German population ingests MeHg via fish and seafood
• pollock, tuna, ocean perch and herring are particular contributors to exposure

Figure 1: MeHg exposure in adults (all subjects, in %) with upper bound (UB) approach (green bars) and amount of consumption calculated in g/kg bw/d for consumers (in % of total consumption, yellow bars).

- exposure of pollack and herring is mainly due to high consumption
- exposure from tuna and ocean perch is mainly caused by high levels
Exposure estimation of methylmercury (MeHg) in fish and fish products.

- Exceedances of the health limit (TWI 1.3µg/kg bw) may occur especially in 14-25 year olds with high consumption (P95)
- Tuna plays an important role among 14-25 year olds
- Ocean perch and cod contribute more to exposure in 65-79 year olds

Irmela Sarvan & Oliver Lindtner, 10.10.2020, 6th International Workshop on TDS, Berlin

Table 3

<table>
<thead>
<tr>
<th>Exposure (UB)</th>
<th>Valid N</th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
<th>14&lt;18 Years</th>
<th>18&lt;25 Years</th>
<th>25&lt;35 Years</th>
<th>35&lt;45 Years</th>
<th>45&lt;55 Years</th>
<th>55&lt;65 Years</th>
<th>65&lt;80 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>P 50</td>
<td>0.185</td>
<td>0.194</td>
<td>0.177</td>
<td>0.180</td>
<td>0.201</td>
<td>0.154</td>
<td>0.159</td>
<td>0.207</td>
<td>0.186</td>
<td>0.187</td>
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<tr>
<td>Mean</td>
<td>0.339</td>
<td>0.335</td>
<td>0.343</td>
<td>0.473</td>
<td>0.398</td>
<td>0.334</td>
<td>0.308</td>
<td>0.324</td>
<td>0.352</td>
<td>0.338</td>
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<tr>
<td>P 95</td>
<td>1.059</td>
<td>1.027</td>
<td>1.059</td>
<td>2.175</td>
<td>1.330</td>
<td>1.037</td>
<td>0.999</td>
<td>0.944</td>
<td>1.114</td>
<td>1.030</td>
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<table>
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<tr>
<th>Exposure (LB)</th>
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<th>Total</th>
<th>Male</th>
<th>Female</th>
<th>14&lt;18 Years</th>
<th>18&lt;25 Years</th>
<th>25&lt;35 Years</th>
<th>35&lt;45 Years</th>
<th>45&lt;55 Years</th>
<th>55&lt;65 Years</th>
<th>65&lt;80 Years</th>
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<tbody>
<tr>
<td>P 50</td>
<td>0.184</td>
<td>0.193</td>
<td>0.176</td>
<td>0.180</td>
<td>0.201</td>
<td>0.154</td>
<td>0.159</td>
<td>0.207</td>
<td>0.186</td>
<td>0.187</td>
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<tr>
<td>Mean</td>
<td>0.335</td>
<td>0.330</td>
<td>0.340</td>
<td>0.461</td>
<td>0.386</td>
<td>0.328</td>
<td>0.303</td>
<td>0.322</td>
<td>0.350</td>
<td>0.336</td>
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<tr>
<td>P 95</td>
<td>1.059</td>
<td>1.027</td>
<td>1.059</td>
<td>2.175</td>
<td>1.330</td>
<td>1.037</td>
<td>0.999</td>
<td>0.944</td>
<td>1.114</td>
<td>1.030</td>
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</table>

Food and Chemical Toxicology 149 (2021) 112005
Contribution of food groups to the total iodine intake

The diagram shows the contribution of various food groups to iodine exposure in a scenario of conventional production. The largest contributors are Milk and dairy products (21%), Grains and grain-based products (15%), Meat and meat products (13%), Composite dishes (11%), and Water and water-based beverages (10%). Other Food Groups account for 20% of the contribution.

Pools with highest contribution to mean iodine intake:

- No use of iodized salt in the households

### Conventional production

<table>
<thead>
<tr>
<th>Anteil (%)</th>
<th>Food</th>
</tr>
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<tbody>
<tr>
<td>8,9</td>
<td>Cow milk, plain</td>
</tr>
<tr>
<td>6,2</td>
<td>Mineral water</td>
</tr>
<tr>
<td>3,7</td>
<td>Wheat bread and roll, white (refined flour)</td>
</tr>
<tr>
<td>3,7</td>
<td>Yoghurt/yoghurt drink, cow milk, flavored</td>
</tr>
<tr>
<td>3,0</td>
<td>Instant coffee, prepared with water</td>
</tr>
<tr>
<td>2,6</td>
<td>Coffee, prepared with water</td>
</tr>
<tr>
<td>2,6</td>
<td>Drinking water (tap water)</td>
</tr>
<tr>
<td>2,2</td>
<td>Salami-type sausage (pork, beef)</td>
</tr>
<tr>
<td>2,1</td>
<td>Henn eg</td>
</tr>
<tr>
<td>1,9</td>
<td>Appel</td>
</tr>
</tbody>
</table>
Lessons learned for iodine intake

- In comparison to requirements, part of the population ingests too little iodine via food.

- Daily consumption of milk and dairy products helps to reach an adequate iodine intake.

- Same for consumption of sea fish once or twice a week.

- Iodised table salt should be preferred in the kitchen and in pre-packaged foods.

- According to model scenarios based on BfR MEAL data, the currently discussed increase of iodine levels in salt of 5 mg/kg can be assumed to be safe.

- Moreover, the results show that also the level of industrially and handcrafted products containing iodised salt needs to be increased to around 40 percent, to reach an adequate intake also for women in childbearing age.
How does food monitoring and BfR-MEAL-Study complement each other?

* figures and tables at the next slides were taken from:
Example of one substance per category

<table>
<thead>
<tr>
<th>No.</th>
<th>Main Food Group</th>
<th>Cadmium</th>
<th></th>
<th>PCB 126</th>
<th></th>
<th>Iodine</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>BfR MEAL Study</td>
<td>National Monitoring</td>
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<tr>
<td></td>
<td></td>
<td>N foods</td>
<td>n samples*</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Grains and grain-based products</td>
<td>40</td>
<td>1540 (97)</td>
<td>38</td>
<td>1490 (94)</td>
<td>40</td>
<td>1540 (97)</td>
</tr>
<tr>
<td>2</td>
<td>Vegetables and vegetable products</td>
<td>34</td>
<td>2306 (152)</td>
<td>18</td>
<td>911 (60)</td>
<td>34</td>
<td>2306 (152)</td>
</tr>
<tr>
<td>3</td>
<td>Starchy roots or tubers and products thereof, sugar plants</td>
<td>8</td>
<td>410 (26)</td>
<td>7</td>
<td>245 (15)</td>
<td>8</td>
<td>410 (26)</td>
</tr>
<tr>
<td>4</td>
<td>Legumes, nuts, oilseeds and spices</td>
<td>20</td>
<td>440 (24)</td>
<td>20</td>
<td>440 (24)</td>
<td>20</td>
<td>440 (24)</td>
</tr>
<tr>
<td>5</td>
<td>Fruit and fruit products</td>
<td>22</td>
<td>1010 (64)</td>
<td>8</td>
<td>175 (10)</td>
<td>22</td>
<td>1010 (64)</td>
</tr>
<tr>
<td>6</td>
<td>Meat and meat products</td>
<td>35</td>
<td>1578 (101)</td>
<td>35</td>
<td>1578 (101)</td>
<td>35</td>
<td>1578 (101)</td>
</tr>
<tr>
<td>7</td>
<td>Fish, seafood, amphibians, reptiles and invertebrates</td>
<td>30</td>
<td>720 (39)</td>
<td>30</td>
<td>720 (39)</td>
<td>30</td>
<td>720 (39)</td>
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<tr>
<td>8</td>
<td>Milk and dairy products</td>
<td>23</td>
<td>635 (37)</td>
<td>23</td>
<td>635 (37)</td>
<td>23</td>
<td>640 (37)</td>
</tr>
<tr>
<td>9</td>
<td>Eggs and egg products</td>
<td>2</td>
<td>150 (10)</td>
<td>2</td>
<td>150 (10)</td>
<td>2</td>
<td>150 (10)</td>
</tr>
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Added value of BfR MEAL Study to number of substances with significant more information

Fig. 1. Distribution of substances grouped by the number of foods analysed within the National Monitoring (2011–2019) and the BfR MEAL Study (2016–2021)

(a) Number of substances allocated to categories A (> 100), B (25–100) and C (< 25)

(b) Portions of substances covered exclusively in datasets and respective allocation to categories among the groups (% of 512 substances)

MEAL adds > 100 substances not covered by German food monitoring

MEAL expands the list of investigated foods for many substances that are only analysed in a limited food list within the German food monitoring
Decision tree: How food monitoring and BfR-MEAL-Study will complement each other

DIETARY EXPOSURE ASSESSMENT

Short-term Exposure Assessment
- Yes: Is the type of risk acute?
  - No: Long-term Exposure Assessment
    - Total exposure across whole food basket required?
      - Yes: Are the numbers of foods analysed for the relevant substance comparable in both datasets?
        - No: Use dataset with more relevant foods available
        - Yes: Expert judgement of exposure to decide which dataset is more suitable for the specific case by checking criteria shown in Table 1
      - No: Is the relevant food/substance combination(s) available in both datasets?
        - Yes: Use dataset with required information
        - No: Use dataset with more relevant foods available
New monitoring projects to follow up on BfR MEAL results

Nickel in nuts

Elements in chia seeds

Quelle: wikimedia commons, public domain, Vicki Nunn

Quelle: wikimedia commons, Autor: formulatehealth.com
Do you want to know more about the BfR MEAL study?

Thank you for your attention!

Oliver Lindtner and Irmela Sarvan