Limits for contaminants in feed and food

Carry-over of contaminants in food producing animals

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Contaminants in feed

- Mycotoxins
- Plant toxins
- Heavy metals
- Persistent organic pollutants
- Pesticides
- Antibiotics
- Others

Contaminants

- Most compounds easily metabolized and/or excreted
- Some are persistent and excreted or accumulated in animal derived products
  - Certain dioxins and PCBs
  - Certain brominated flame retardants
  - Certain organochlorine pesticides
  - Perfluorinated alkanes (PFOS/PFOA)
  - Some heavy metals
- Sometimes toxic metabolites

Maximum limits

- Maximum limits set for certain contaminants
  - Directive EC 2002/32 (feed)
  - Regulation EC 1881/2006 (food)
- Regularly updated (look for consolidated version)
- Limits for food and feed not necessarily “harmonized”
  - Feed limit does not always ensure that food limit is not exceeded

Mycotoxins

- Aflatoxins (limits; 2002/32)
- Ergot alkaloids (limit rye ergot; 2002/32)
- Fusarium toxins (guidance values; 2006/576)
  - Deoxynivalenol
  - Zearalenone
  - Fumonisins
  - Ochratoxin A
  - T2/HT2 (since 2013)
- Others (sterigmatocystin, nivalenol, beauvarecin, enniatins, diacetoxyscirpenol, phomopsins cyclopiazonic acid, penicilllic acid, masked mycotoxins)?

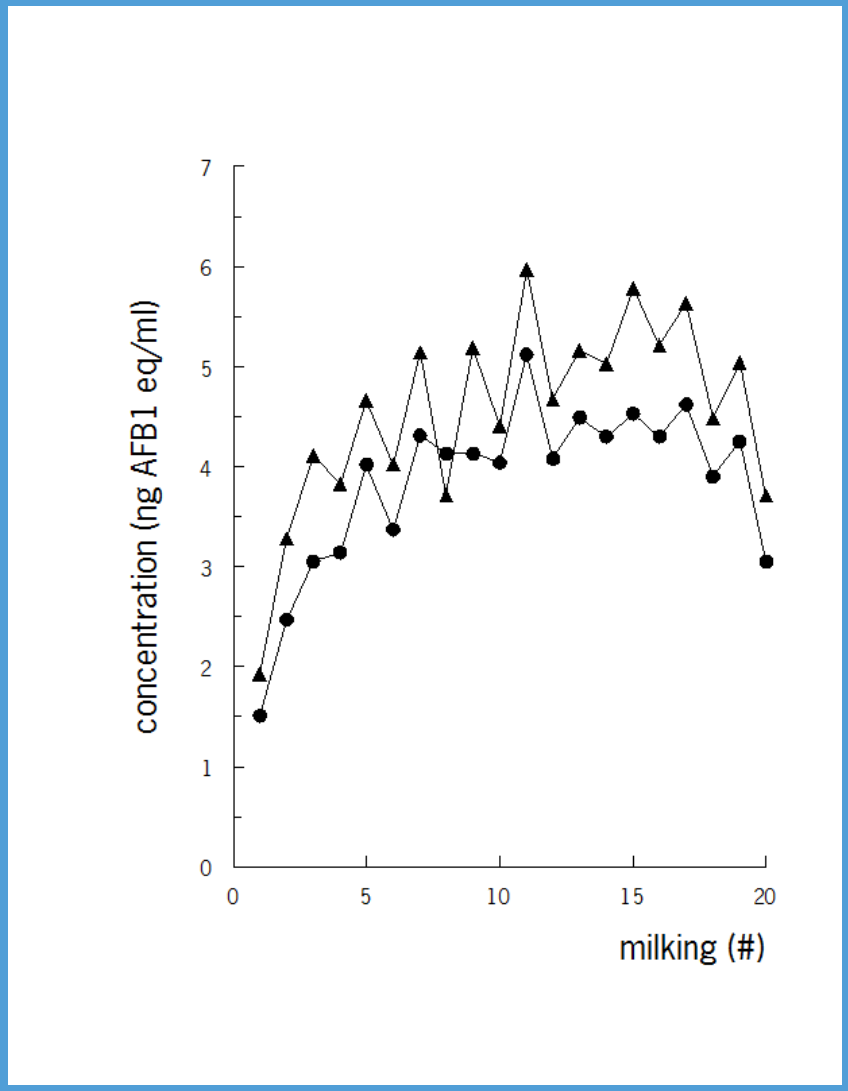
Aflatoxins

- Present in peanuts, corn, cotton seed, ...
  - Beginning of 2013 incident with corn Balkan
  - Both pre- and postharvest contamination
- Up to 4 compounds, B1, B2, G1 and G2
- Cause liver tumours in animals and humans
- In animals metabolized, so no clear residues of these compounds
- Animals do normally not seem to suffer from toxicity
  - Exception: turkey-X-disease due to high levels of aflatoxins and cyclopiazonic acid

Aflatoxins

- However, aflatoxin B1 partly metabolized to aflatoxin M1
  - AFM1 partly excreted in milk (up to 5-6% of ingested AFB1)
- Like AFB1, AFM1 is considered a genotoxic carcinogen
- Strict limits for both milk and feed, especially for dairy cows
  - Limits for feed based on data about carry-over to milk
  - Some doubt whether limit for feed low enough
- No similar examples in the case of mycotoxins

Study with peanut meal



3.5 mg/kg AFB1 in peanut meal;
50% of label AFM1
0.5% carry-over

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Deoxynivalenol/zearalenone

- Present in cereals
- DON causes growth retardation, ZEA is estrogenic and causes hormonal disruption
    - Pigs very sensitive to effects
- Therefore, species guidance levels for feed and feed ingredients
- No harmful residues for consumers in animal derived products
    - Grains much more important source for humans

Pyrrolizidine alkaloids, an increasing problem?

- Risk for animals
  - Direct consumption
  - Presence in feed
- Potential risk for consumers
  - Contamination of honey
  - Contamination of milk and meat
  - Presence in rucola
  - Herbs/tea
- No limits for feed

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Senecio jacobaea/inaequidens/*vulgaris*)

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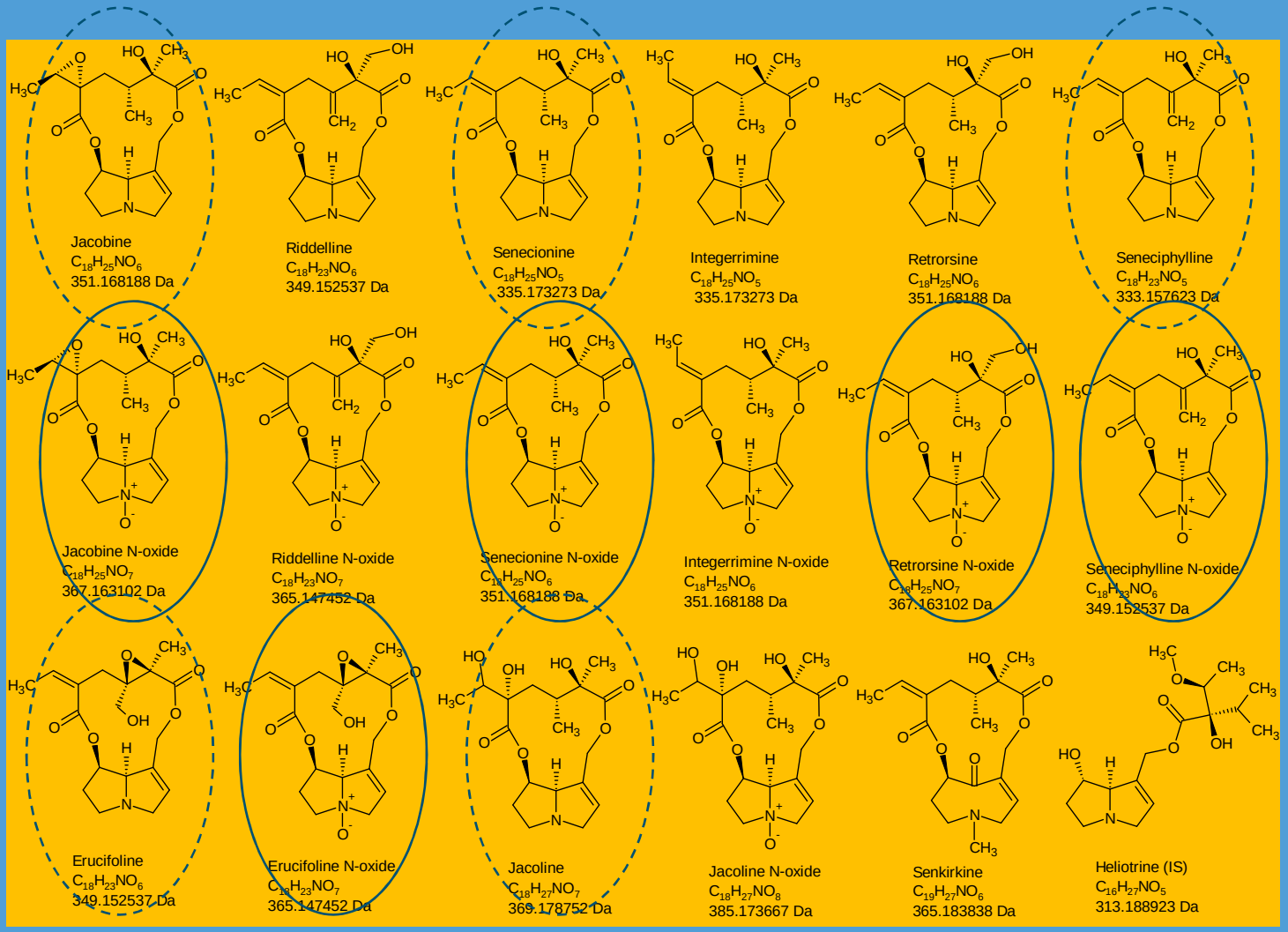
Structures of pyrrolizidine alkaloids



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Properties of PAs

- Effects on the livers (veno-occlusive disease)
- Causing liver tumours
  - Formation of DNA adducts
  - Genotoxic properties
- Therefore regarded as genotoxic carcinogens: no threshold
  - Low levels may cause effects
- May be present in honey
- But also feed: carry-over to edible products?

Animal feedstuffs: Alfalfa (lucerne)

	2006	2007	2008	2009	2010	2011	2012
No of samples	6	13	12	17	51	50	51
Positive	83%	85%	83%	88%	92%	86%	90%
Average content (µg/kg)	1440	225	716	621	225	265	356
Max (µg/kg)	3439	1409	6219	4507	2418	2027	4169
Samples >1000 µg/kg	3 (50%)	1 (8%)	1 (8%)	2 (12%)	4 (8%)	4 (8%)	6 (12%)

- In the Netherlands contamination of alfalfa with PAs remains high, notwithstanding the information provided to the industry

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PAs in milk – Experiment 1

- 3 cows fed (fistula) 2x/day with tansy ragwort (*Senecio jacobaea*)
  - Week 1: no ragwort
  - Week 2: 2x 25 g ragwort
  - Week 3: 2x 50 g ragwort
  - Week 4: 2x 100 g ragwort (1% of feed intake)
  - Week 5: no ragwort
- Morning and evening milk collected

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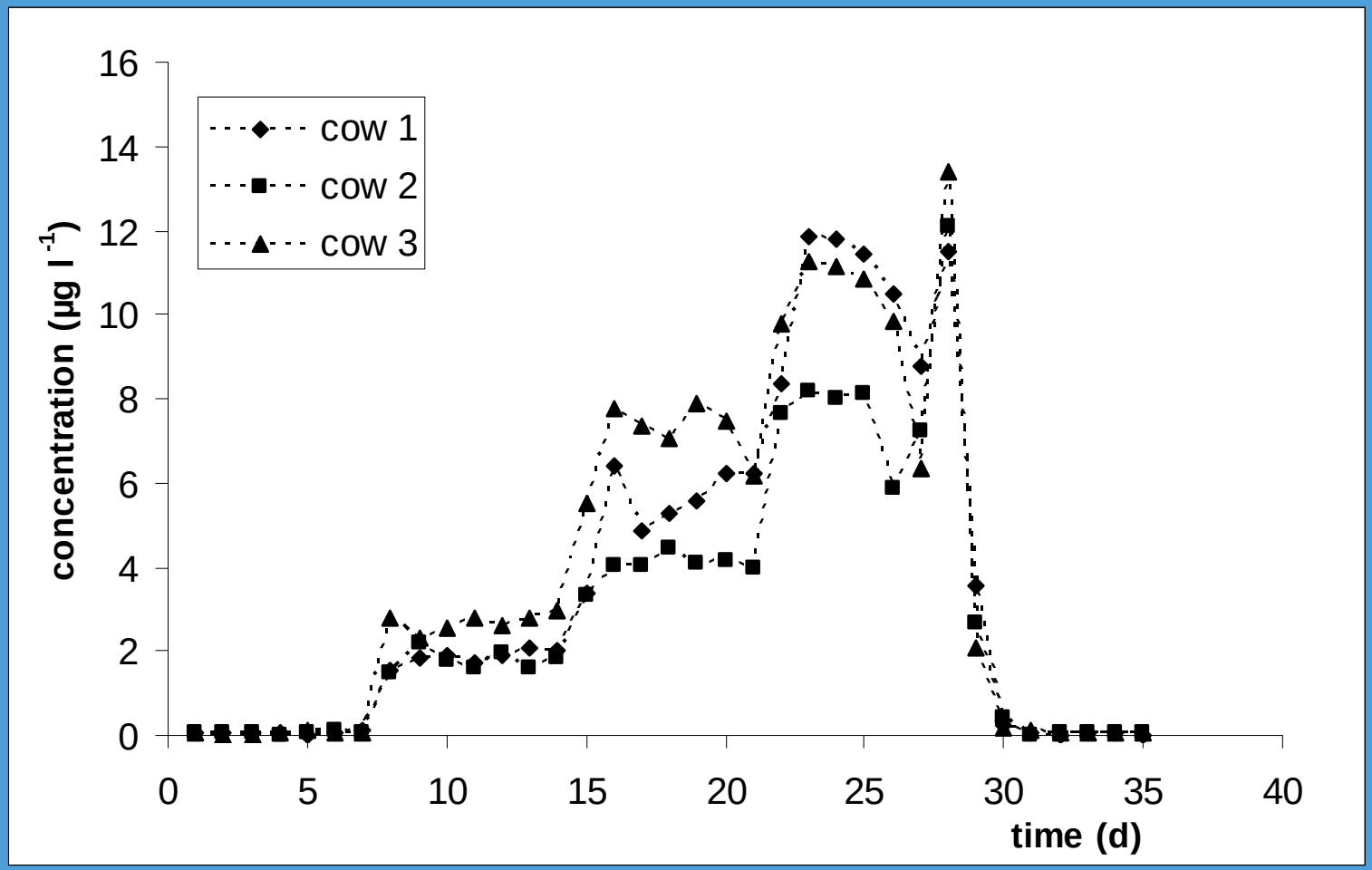
PAs in evening milk



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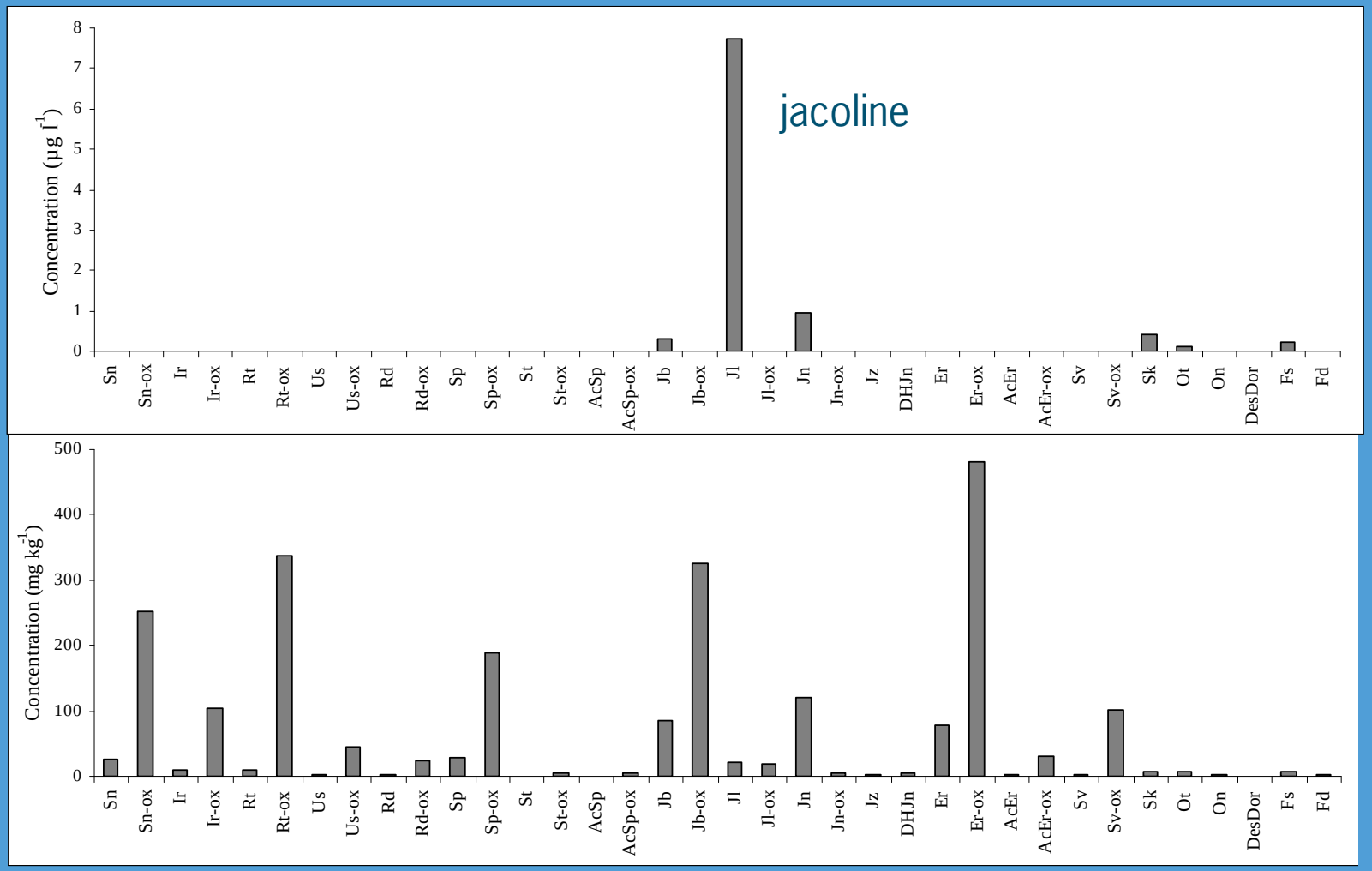
Milk versus plant material



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Conclusions and remaining questions

- Overall low carry-over: 0.1% but higher for eg jacoline
- Carcinogenic potency of jacoline unknown
- If similar to others, potential risk for the consumer
- Also: poor balance, meaning the formation of unknown metabolites
    - Additional risk, if transferred to milk?
- What about other plants?
    - Second study with S. vulgaris and E. vulgare
    - Carry-over seems lower but poor balance again

Heavy metals and toxic elements

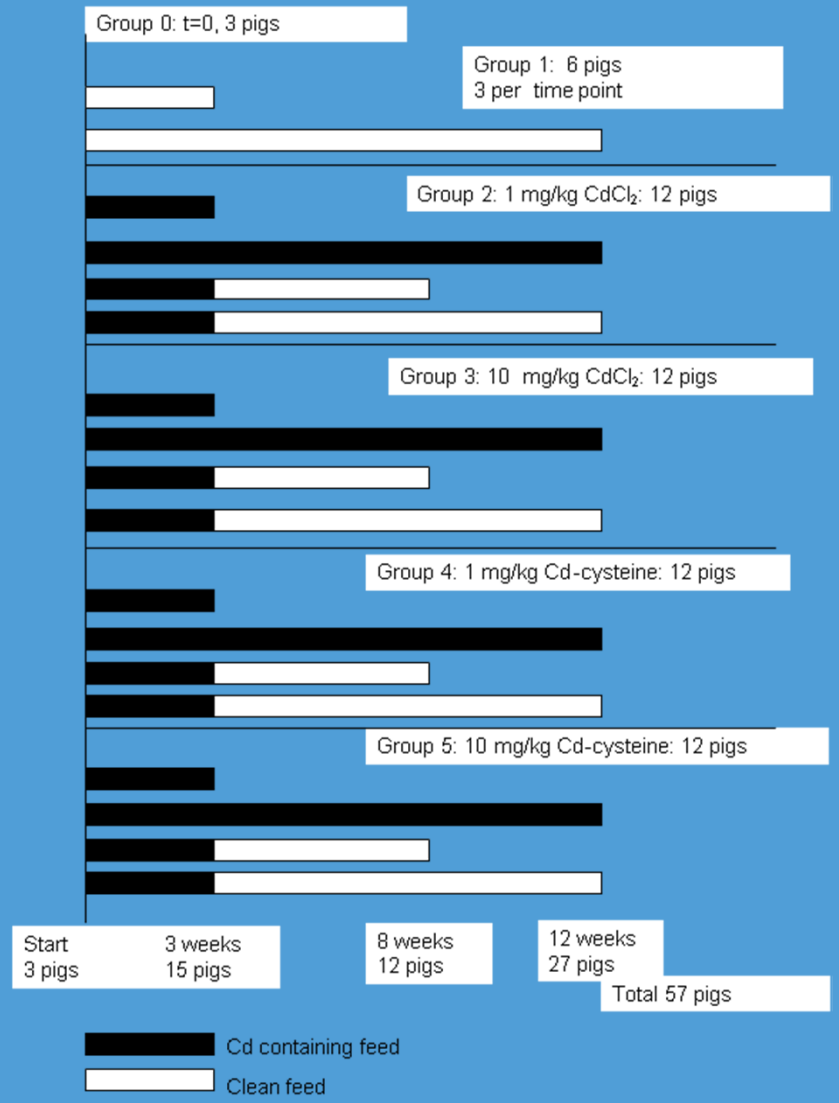
- Feed limits for lead, mercury, cadmium and arsenic
  - EC 2002/32
- Development towards speciation of elements
  - Inorganic arsenic more toxic than organic
  - Organic mercury more toxic than inorganic mercury
  - ICPMS
- Some accumulate in the animals
  - E.g. cadmium in livers and kidneys

Cadmium in cows and pigs

- In the South of the Netherlands problems with elevated levels in soil
- Results in non-compliant levels in kidneys of older cows
- Cadmium primarily stored in kidneys and livers
    - Bound to metallothioneins
- Carry-over study performed with pigs

Exposure scheme

- Levels of 0, 1 and 10 mg Cd/kg feed (ML 0.5)
- For 3 and 12 weeks
- Also put on clean feed after 3 weeks



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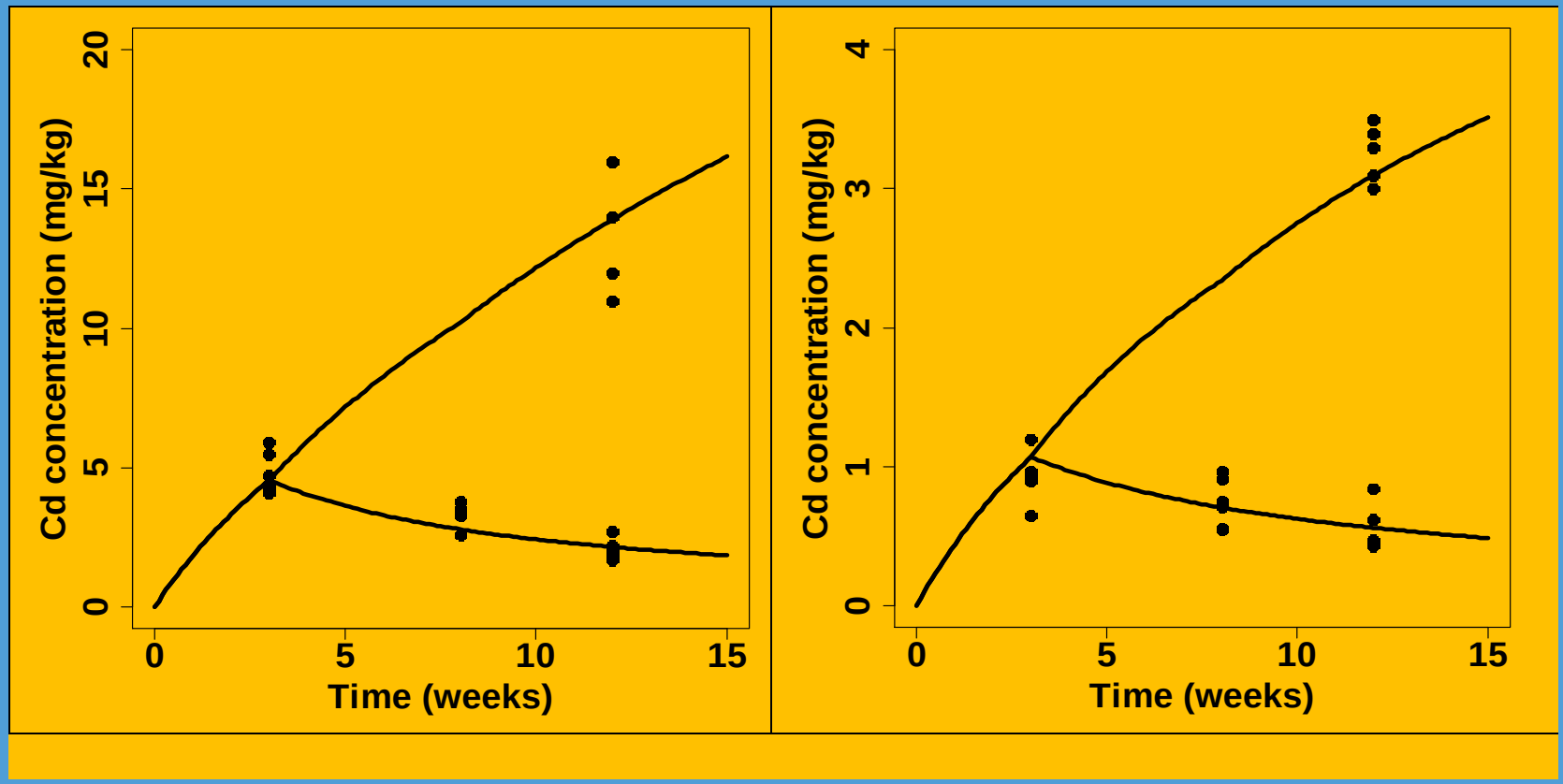
Cd levels in kidneys and livers (10 mg/kg feed)



MLs: 1.0 (kidneys) and 0.5 (livers) mg/kg

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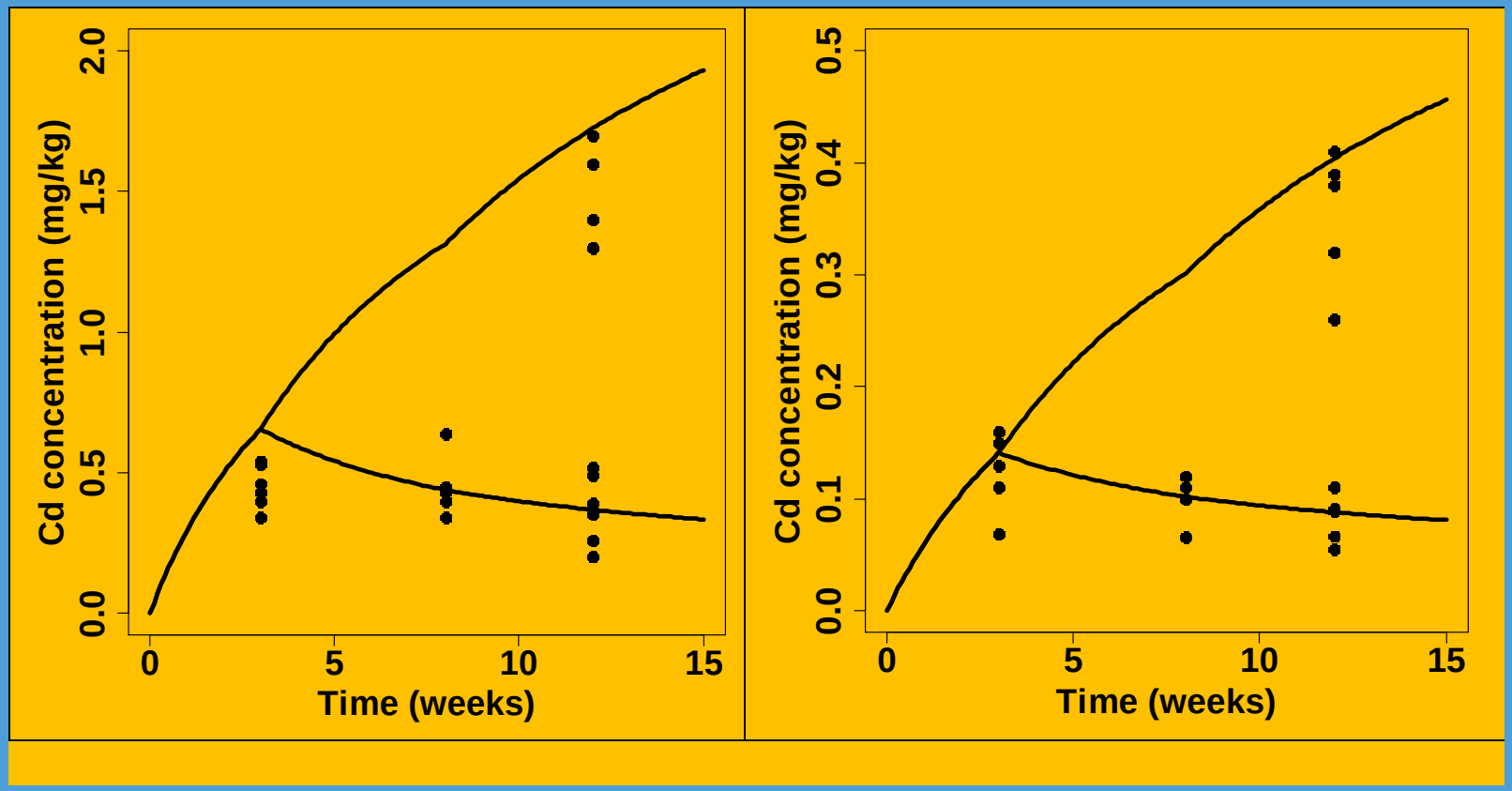
Cd levels in kidneys and livers (1 mg/kg feed)



MLs: 1.0 (kidneys) and 0.5 (livers) mg/kg

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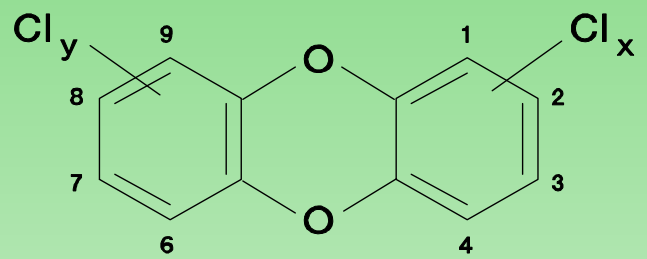
Conclusions

- In growing pigs limits for cadmium in feed seem to ensure that levels in kidneys and lives do not exceed the MLs
- Decrease in levels after ending exposure primarily due to increase in organ weights; no clear migration of cadmium from liver and kidney

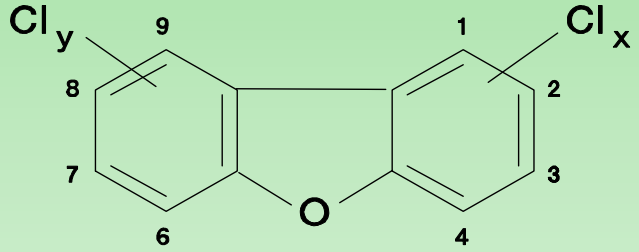
Dioxins and PCBs

PCDD



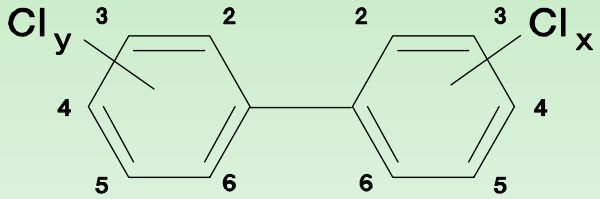
7 out of 75

PCDF



10 out of 135

PCB



12 out of 209

Since 2012 also harmonized limits for non dioxin-like PCBs (sum of six)

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Incidents with dioxins

- In some cases effects in animals: chickens sensitive
- At lower levels no clear effects in animals but
- elevated levels in products will cause accumulation in consumer to levels that may cause adverse effects

Feed related incidents

Ball clay US 1998

Brazilian citrus pulp 1998

Belgian PCB fat 1999

German kaolinic clay 1999

Belgian cholin chloride 2002

German bakery waste 2003

Potato peels/kaolinic clay 2004

Gelatin fat/Hydrochloric acid 2006

Minerals (Zinc) Chile 2008

Bakery waste Ireland 2008

Organic corn Ukraine 2010

Fatty acids Germany 2011

Sources of PCBs

- Used as technical mixtures and maybe still present in older equipment
  - Transformers
  - Heat exchange
  - Eg Arochlor, Kanechlor, Clophen
- Also used in certain paints and sealants
  - Flame retardent
- Destruction?

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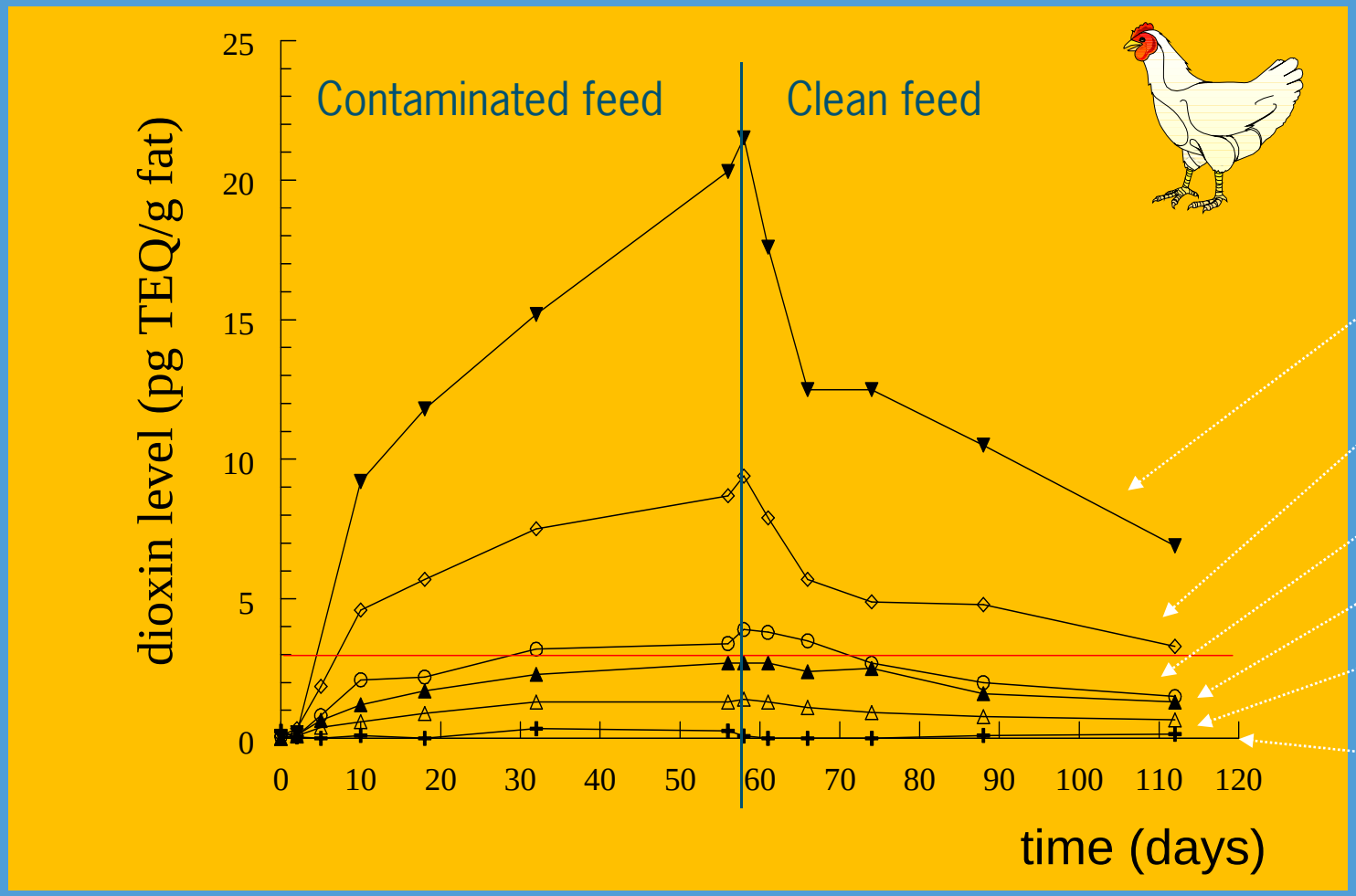
Sources of dioxins

- Present as contaminants in e.g.:
  - PCB mixtures
  - Pentachlorophenol
  - 2,4,5-T (agent Orange)
- Kaolinic clay and other clays (ball clay, Mabele clay)
- Formed during incineration of waste (fires)
- So contamination through feed but also environment

Carry-over dioxins from feed to eggs



ng TEQ/kg

2.04

0.97

0.40

0.30

0.20

0.04

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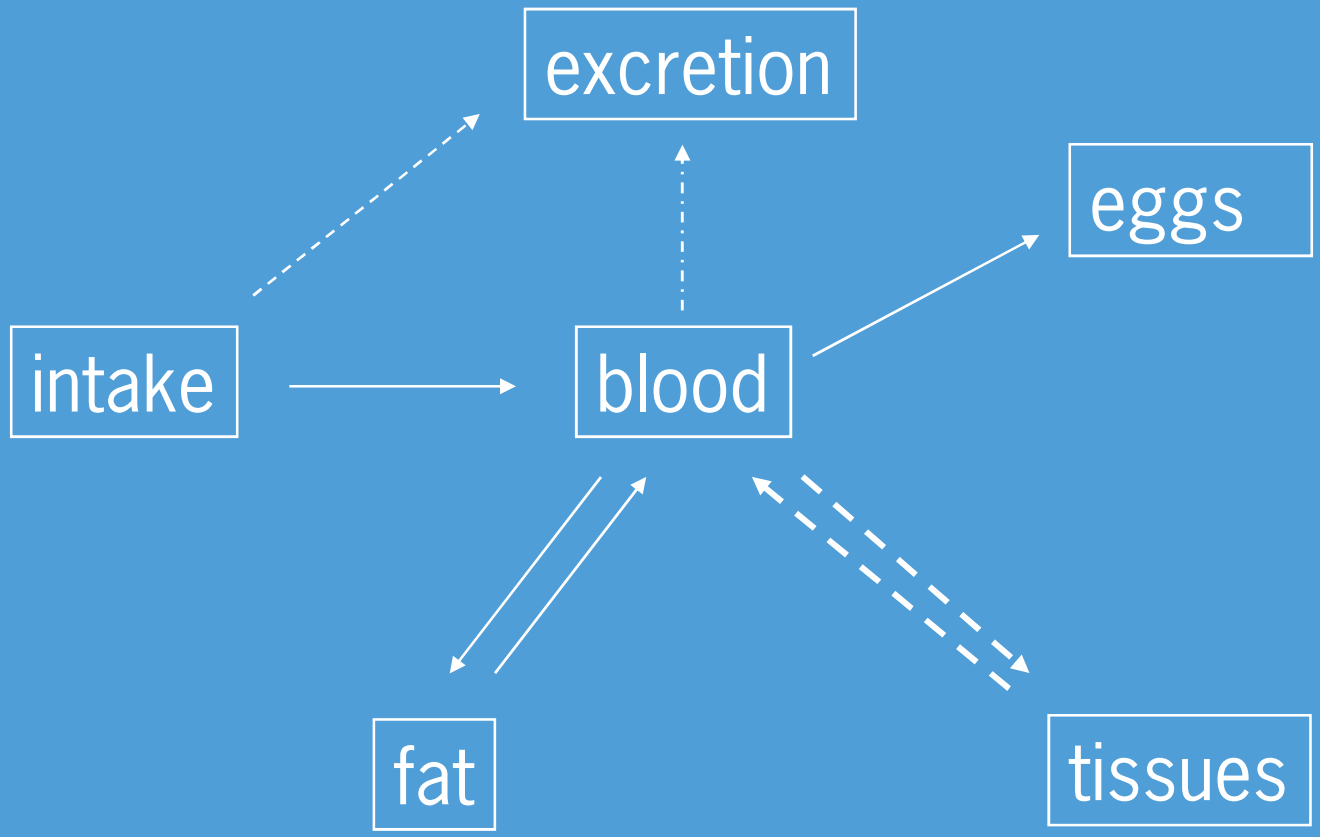
Adapted from Hoogenboom et al. 2006, Chemosphere 68, 814-823

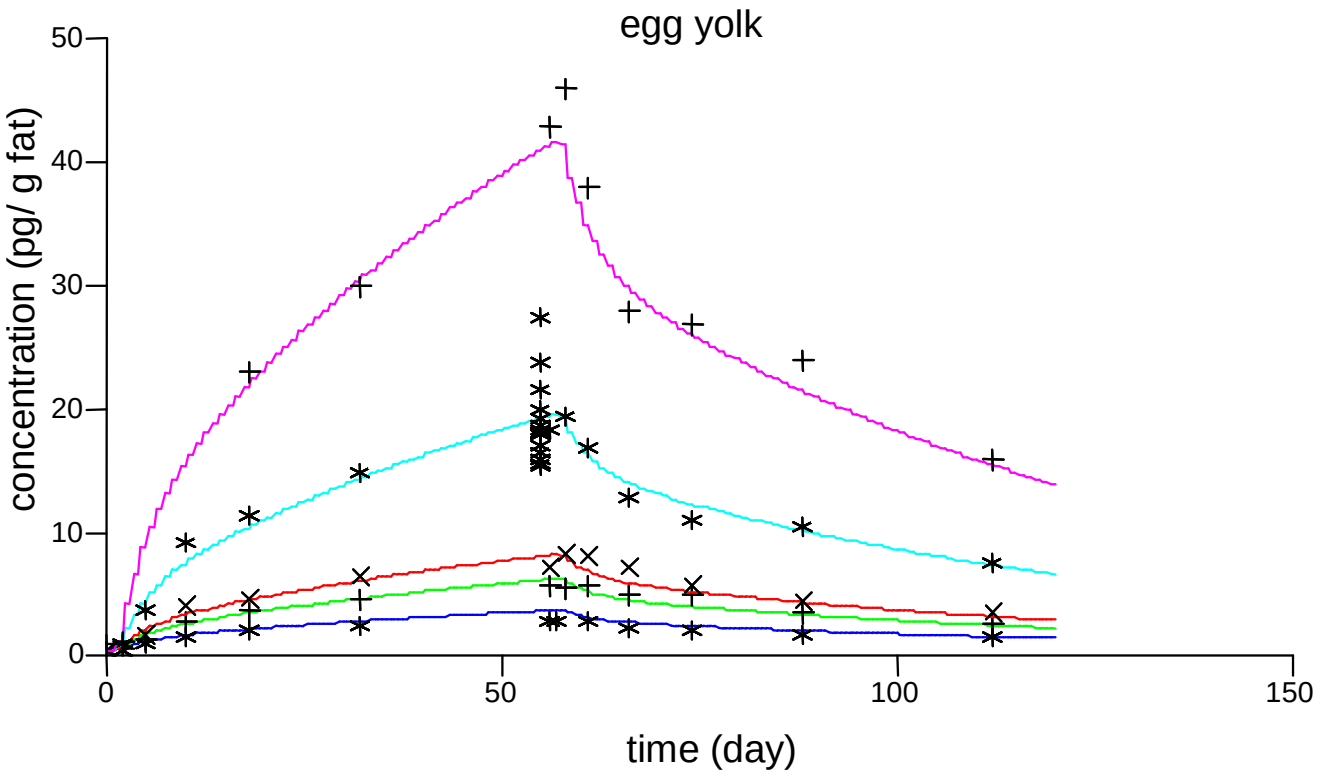
PBPK-modelling

- Based on physiology in the animal
  - Absorption, excretion
  - Exchange between blood and tissues
  - Excretion in eggs
  - Only relevant tissues modelled
- Normally modelled on TEQ (as if only one compound)

Kinetics in laying hens



TEQ-based modelling (sum dioxins, dl-PCBs)



Conclusions carry-over laying hens

- Low levels in feed cause eggs to exceed the MLs
  - At steady state COR around 0.4, meaning:
  - 40% of dioxins/PCBs in feed (100 g/day) go to eggs (5 g fat)
- Similar carry-over with dioxins and PCBs from soil
  - No solid information on soil intake
  - Based on 10 g soil and 40% carry-over, soil levels should be below 5 ng TEQ/kg (sum) or 2.5 ng TEQ/kg (dioxins)

Carry-over dioxins and PCBs in cows

- Various carry-over studies in lactating cows
  - Focus on dioxins
  - Some information on dl- and ndl-PCBs
- Few studies in meat cows
  - Again focus on dioxins

Impact of fires on grazing animals

- In some fires release of dioxins
- Carry-over from deposition on grass/feed materials to milk?
- Absorption low?

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GC-MS dioxins and dl-PCBs ng TEQ/kg: ML 1.25 ng TEQ/kg

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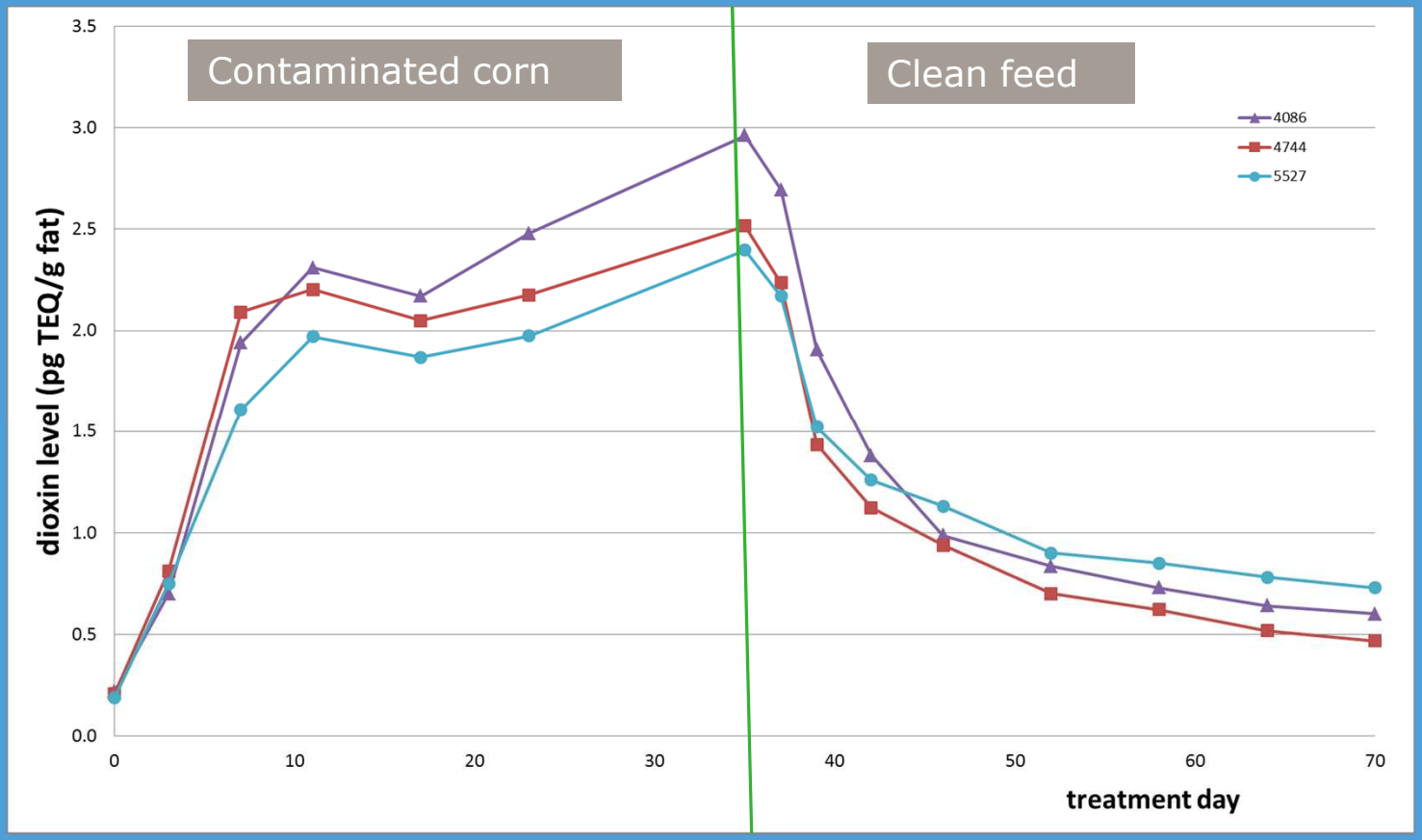
Carry-over of dioxins from contaminated corn in dairy cows

- Corn contaminated by smoke from PVC fire
  - Level of 0.8 ng TEQ/kg (ML 0.75)
- Study with 3 dairy cows
  - 5 weeks exposure
  - 5 weeks clean feed

Study dairy cows with contaminated corn silage

primarily dioxins due to fire



ML

AL

Cows fed 15 kg (dm) corn silage/day, 0.8 ng TEQ/kg (88% dm) for 5 weeks

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Elevated dioxins and PCBs in sheep livers

- More than half of the livers exceed the current ML in the EU
    - EFSA evaluated risks
- Levels in meat and fat normally OK
- Sheep normally forage outside, winter and summer
    - Although males often slaughtered in autumn
    - Little insight in relation dioxin intake vs levels in meat and liver

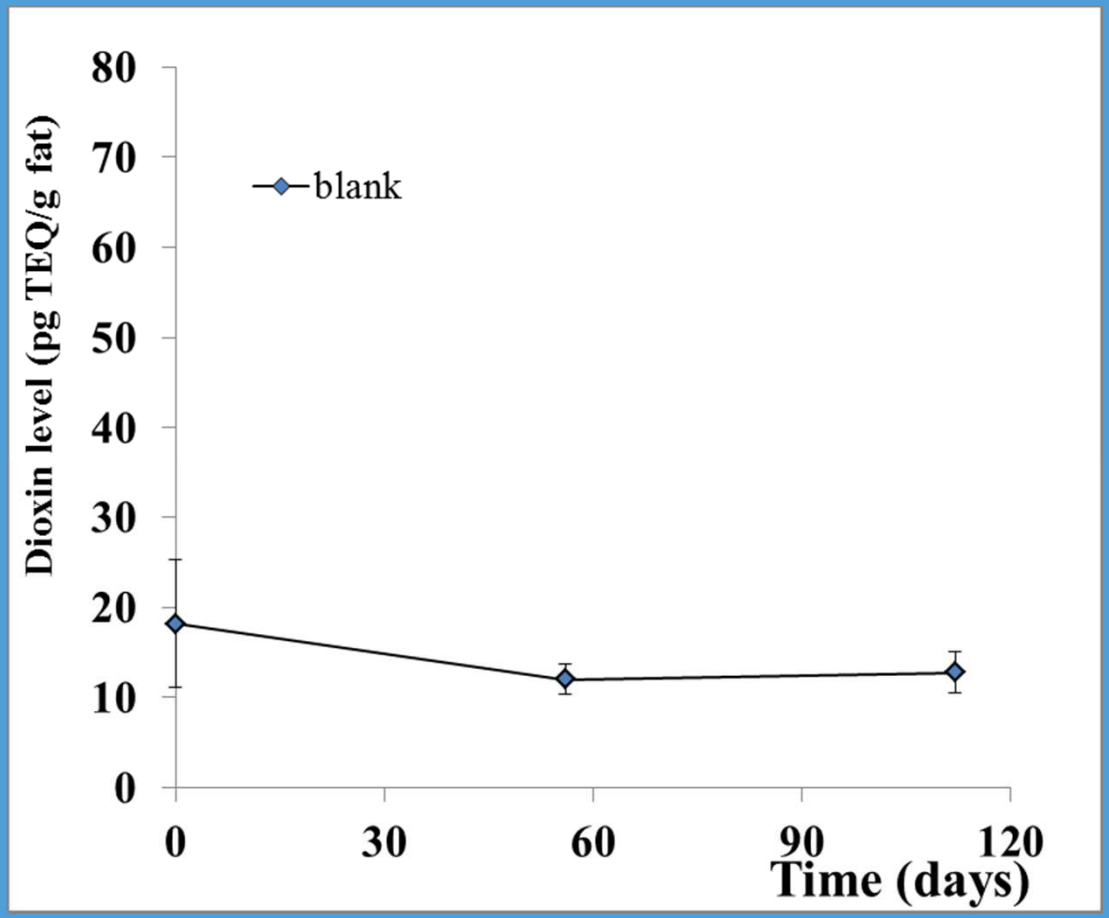
Carry-over study with sheep

- Study with blackhead lambs performed by BfR Berlin
- Sheep fed with contaminated grass followed by clean grass (both from NL; contaminated grass from flood plain)

Grass

	Dioxins pg TEQ/g dm	dl-PCBs pg TEQ/g dm	Sum pg TEQ/g dm	ndl-PCBs µg/kg dm
Clean	0.27 (0.26)	0.06 (0.06)	0.33 (0.32)	0.45 (0.45)
Contaminated	1.71 (1.71)	0.32 (0.32)	2.04 (2.02)	2.33 (2.33)

Dioxins in liver (blank)



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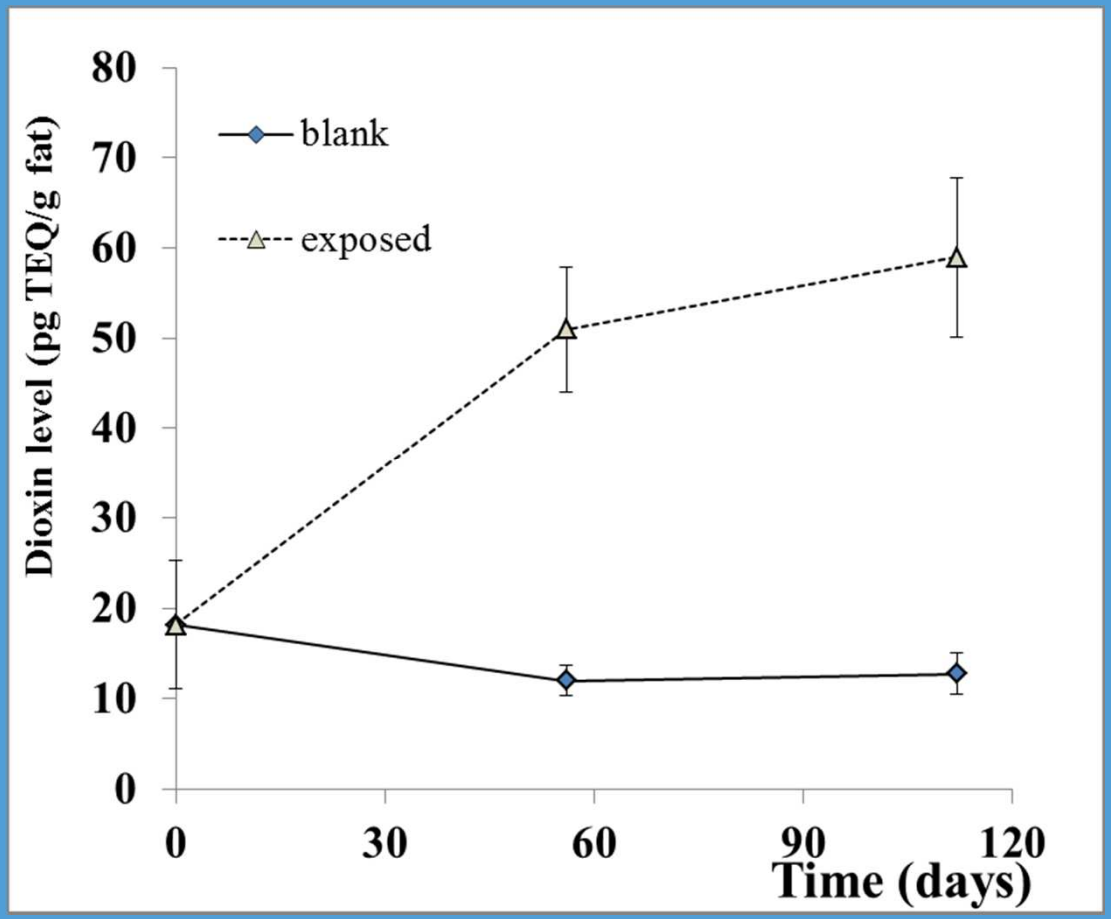
Dioxins in liver (exposed for 112 d)



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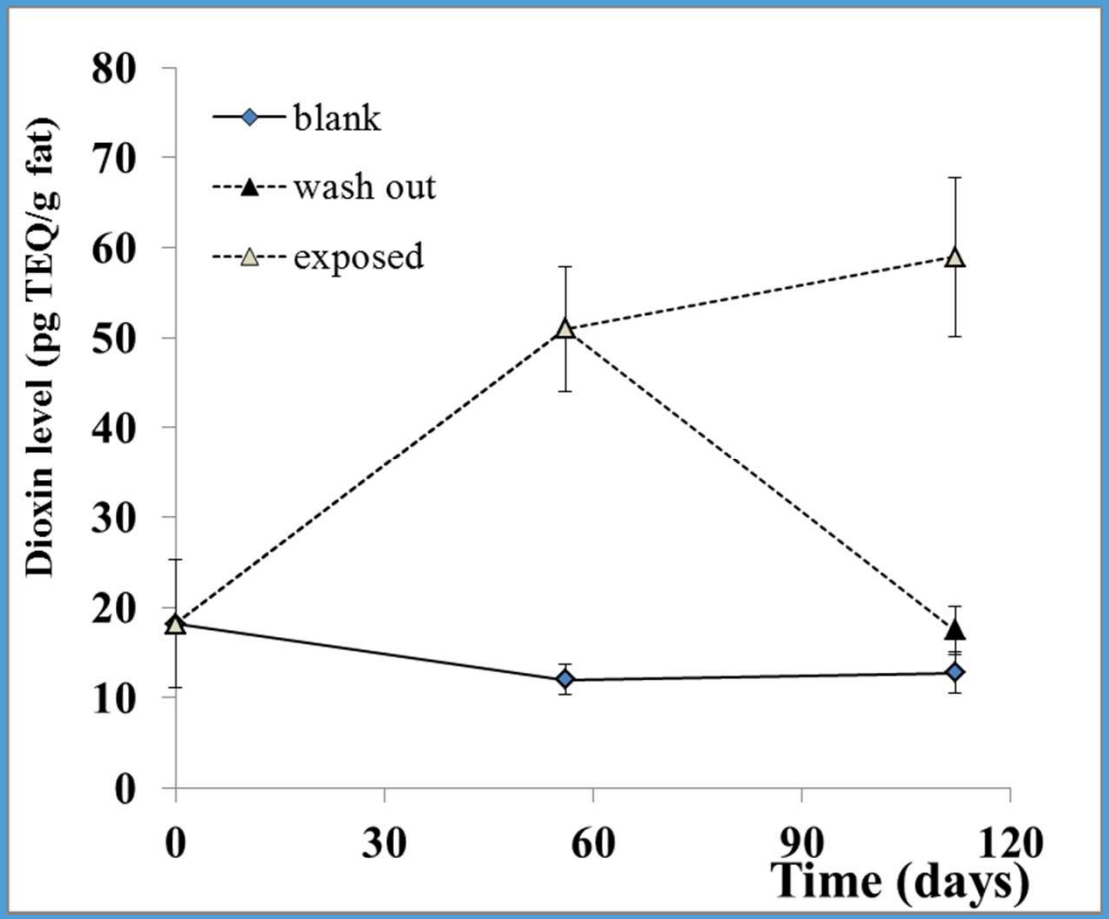
Dioxins in liver (wash-out after 56 days)



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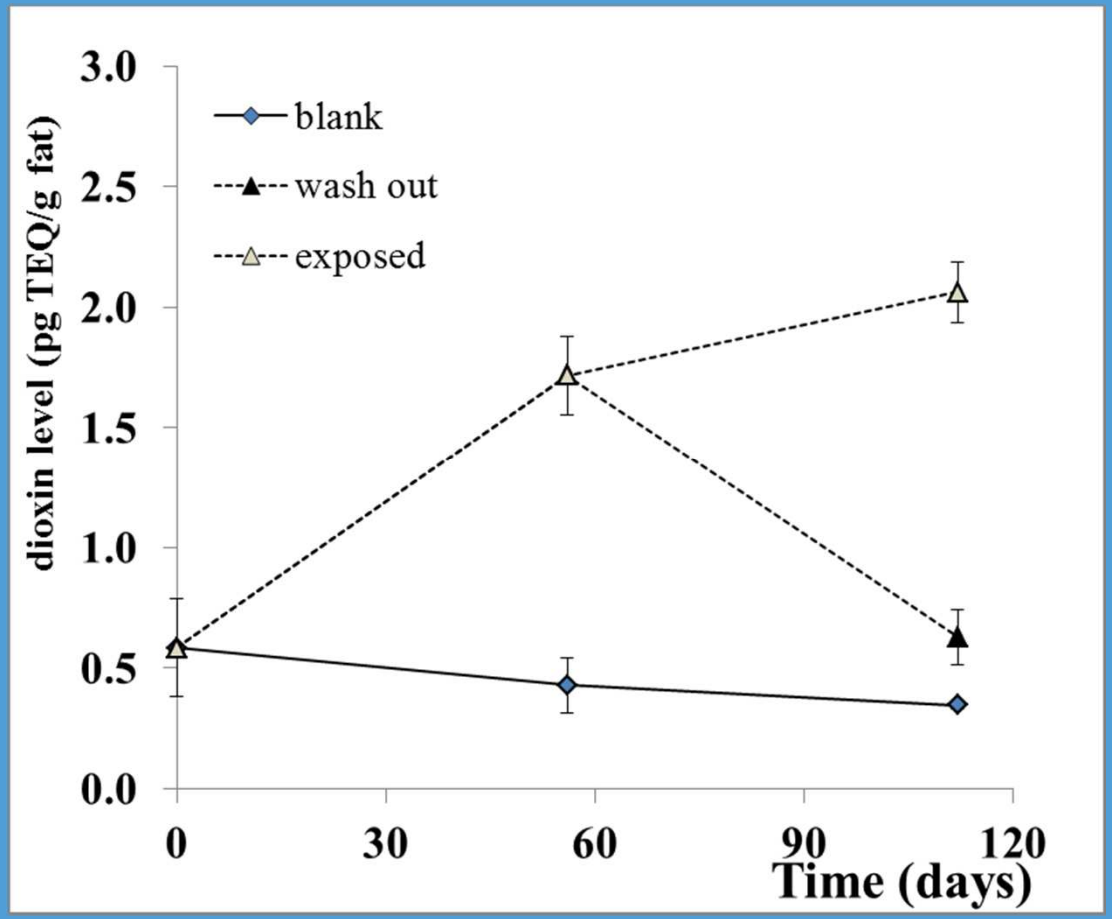
Dioxins in kidney fat



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Conclusions

- Current limits in feed too high to prevent non-compliant levels in eggs
  - Product Board eggs uses lower “guidance value”
- In lactating cows borderline
- Low levels in soil (few ng TEQ/kg) may cause problems in laying hens and maybe other species
  - Only estimates about soil intake
  - Current soil limits too high
- Also for fish some studies available
  - Modeling by RIVM (with NIFES)

Thank you for your attention

Questions?

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