FRONT OFFICE FOOD AND PRODUCT SAFETY

Transfer of chemicals from feed to food

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Subject

During inspections by the Netherlands Food and Consumer Product Safety Authority (NVWA) for chemical contaminants in food, the measurement uncertainty of the chemical analysis is taken into account when assessing compliance with maximum limits. Food products are considered compliant if the analysis result minus the measurement uncertainty falls below the maximum limit. Until recently, companies were not allowed to include this measurement uncertainty when comparing their own analysis results to legal limits. For food products, this has been changed by the NVWA as of April 1, 2026, following an amendment of EU Regulation 333/2007 on 9 April 2024. Since April 1, 2026, the industry is also allowed to take measurement uncertainty into account during their own internal controls (Controles op contaminanten in levensmiddelen | NVWA).

The Office of Risk assessment & Research (BuRO) requests the Front Office Food and Product Safety to determine the transfer of several contaminants from animal feed to animal products by using existing models for this purpose, such as the feed-food transfer models (www.feedfoodtransfer.nl) and/or other available models.

[1] A few minor corrections have been made in this version.

This transfer should be determined for:

- Concentrations in the animal feed equal to the maximum limit (ML or MRL) of the substance in feed.
- Concentrations in the animal feed equal to the maximum limit (ML or MRL) of the substance in feed plus the measurement uncertainty.

In the table below, selected substances and animal products are shown for which the transfer must be determined.

Chemical (group)	**Animal feed**	**Animal product**
Aflatoxin*	Maize and compound feed	Milk (dairy cow)
Dioxins and PCBs** (total TEQ)	Compound feed	Eggs (laying hen) Milk (dairy cow) Meat fat or body fat (cattle****)
Ndl-PCBs***	Compound feed	Meat fat and egg yolk fat (laying hen)
Cadmium	Compound feed	Kidney and liver (pig)

* Includes both Aflatoxin B_1 (AFB_1) and its main metabolite Aflatoxin M_1 (AFM_1).
** PCB: Polychlorinated biphenyls
*** Ndl-PCB: Non-dioxin-like polychlorinated biphenyls
**** if possible, also for laying hen and pig

Model input:

- Use the legally established maximum limits (ML) from Directive 2002/32/EC.
- For measurement uncertainty, use 20%, 30%, and 50%.
- Use the WFSR database for feed intake quantities.
- Assume a post-exposure of zero.

Assume prolonged (weeks to months) exposure to the feed.

Questions:

1. What are the contaminant concentrations in the animal product if the substance concentration in the feed is at the level of the ML?
2. What are the contaminant concentrations in the animal product if the substance concentration in the feed is at the level of the ML plus measurement uncertainty?

Conclusions

1. An overview of the estimated contaminant concentrations in animal products is provided is the table below.

Overview of the estimated contaminant concentrations in the food products following exposure via feed at the ML level of contamination with 0% measurement uncertainty.

Chemical	Animal	Feed type	Product	Concentration
Aflatoxin M_1	Dairy cow	Maize	Milk	0.050 µg/L
Aflatoxin M_1	Dairy cow	Compound	Milk	0.020 µg/L
Dioxins and PCBs (total TEQ)	Dairy cow	Compound	Milk fat	2.58 pg/g
Dioxins and PCBs (total TEQ)	Dairy cow	Compound	Meat fat	1.36 pg/g
Dioxins and PCBs (total TEQ)	Laying hen	Compound	Egg yolk fat	21.1 pg/g
Dioxins and PCBs (total TEQ)	Laying hen	Compound	Body fat	23.4 pg/g
Dioxins and PCBs (total TEQ)	Pig	Compound	Body fat	3.18 pg/g
PCB28	Laying hen	Compound	Meat fat	90.5 ng/g
PCB28	Laying hen	Compound	Egg yolk fat	152 ng/g
PCB52	Laying hen	Compound	Meat fat	27.5 ng/g
PCB52	Laying hen	Compound	Egg yolk fat	12.1 ng/g
PCB101	Laying hen	Compound	Meat fat	37.3 ng/g
PCB101	Laying hen	Compound	Egg yolk fat	13.9 ng/g
PCB138	Laying hen	Compound	Meat fat	98.8 ng/g
PCB138	Laying hen	Compound	Egg yolk fat	148 ng/g
PCB153	Laying hen	Compound	Meat fat	97.2 ng/g
PCB153	Laying hen	Compound	Egg yolk fat	169 ng/g
PCB180	Laying hen	Compound	Meat fat	99.8 ng/g
PCB180	Laying hen	Compound	Egg yolk fat	181 ng/g
Cadmium	Pig	Compound	Kidney	0.69 mg/kg
Cadmium	Pig	Compound	Liver	0.17 mg/kg

2. Contaminant concentrations in animal products increase if measurement uncertainty is added to the maximum concentrations in animal feed. Based on the transfer models used in this assessment, the contaminant concentrations in animal products are expected to increase linearly with the measurement uncertainty. Thus, a measurement uncertainty of e.g. 20% is expected to lead to a 20% increase of the estimated contaminant concentration in the food product.

1. Introduction

Animal feed may contain undesirable substances, i.e. contaminants, which can endanger animal health. In addition, human health may be at risk due to the transfer of the contaminants into animal products intended for human consumption (e.g. meat, milk and eggs). Therefore, specific rules on animal feed have been established by the European Commission to ensure agricultural productivity and sustainability and to protect human and animal health, as well as the environment. The presence of certain contaminants in animal feed is thus limited by appropriate maximum levels (MLs) (Directive 2002/32/EC).

In order to protect human health, the European commission also set appropriate MLs for undesirable substances in animal products intended for human consumption (Commission Regulation (EU) 2023/915). Maximum levels are set at a strict level that is considered reasonably achievable by following good agricultural and manufacturing practices and taking into account the risk related to the consumption of the animal product.

To estimate the transfer of undesirable substances from feed into animal products intended for human consumption, specific feed-food transfer models can be used. These models allow the prediction of levels of undesirable substances in animal products for human consumption following prolonged exposure to contaminated feed, which can be compared to their respective MLs.

2. Methods

To estimate whether maximum limits of the included chemicals in relevant animal products are exceeded due to the correction for measurement uncertainties in feed concentrations, transfer models were applied that are publicly available.

For all chemicals, four feed concentration levels were assumed. The first feed concentration level is equal to the maximum limit in the corresponding feed type, whereas the other feed concentration levels are equal to the maximum limit plus measurement uncertainties of 20%, 30% and 50%, respectively. Although it should be noted that 50% measurement uncertainty is fairly high, especially for dioxins and PCBs, it was still included in this assessment to provide a fair comparison between chemicals. An overview of the feed concentrations applied in this assessment is provided in Table 1. More details on the transfer modelling are provided in the subsections below.

Table 1. Overview of the maximum feed concentrations of chemicals as indicated in EU directive 2002/32/EC, including concentrations corrected for 20%, 30% and 50% measurement uncertainties.

Chemical	**Feed type**[a]	**Feed concentration**[b]			
		0% uncertainty	20% uncertainty	30% uncertainty	50% uncertainty
Aflatoxin B_1	Feed materials[c]	20.0 µg/kg	24.0 µg/kg	26.0 µg/kg	30.0 µg/kg
Aflatoxin B_1	Compound feed for dairy cattle	5.0 µg/kg	6.0 µg/kg	6.5 µg/kg	7.5 µg/kg
Dioxins and PCBs (total TEQ)	Compound feed	1.5 ng/kg	1.8 ng/kg	1.95 ng/kg	2.25 ng/kg
ndl-PCBs	Compound feed	10 µg/kg	12 µg/kg	13 µg/kg	15 µg/kg
Cadmium	Complete feed	0.5 mg/kg	0.6 mg/kg	0.65 mg/kg	0.75 mg/kg

[a] As referred to in the directive 2002/32/EC

[b] Feed concentration is expressed per kg relative to a feed with a moisture content of 12%

[c] Maize is considered to be a feed material

Aflatoxin - Cow
Aflatoxin B_1 is a chemical that is metabolized to aflatoxin M_1. In this assessment, the excretion of aflatoxin M_1 via cow milk was studied. Note that aflatoxin B_1 is not excreted via milk and was thus not assessed. To model the concentration of aflatoxin M_1 in milk after exposure to aflatoxin B_1, the transfer model described by van Eijkeren, Bakker, and Zeilmaker (2006) was used, which is currently also available as a webtool on www.feedfoodtransfer.nl (Transfer model aflatoxin B1 - dairy cow, version 1.1). Two types of feed were considered, i.e., maize and compound feed. For maize, we assumed an intake of 4.4 kg dry matter per day, whereas an intake of 7 kg dry matter per day was assumed for compound feed (WFSR feed database). These feed intakes are default values in the webtool for winter. As the default feed intakes for winter are higher, and thus more conservative than for the summer, the winter feed intakes were applied in this assessment. An exposure duration of 90 days was selected. This was sufficiently long to ensure that a steady state was reached, based on a visual assessment of the concentration-time curve.

Dioxins and PCBs - Cow, laying hen and pig
Dioxins and PCBs can be expressed as the weighted sum of the toxic equivalent factors (TEFs), which are also known as the total toxic equivalents (total-TEQ). The distribution of dioxins and PCBs expressed as total-TEQ was modelled in cows, laying hens and pigs. To model total-TEQ concentrations in milk fat and meat fat of cows, a transfer model was used that is available on www.feedfoodtransfer.nl (Transfer model dioxins (total TEQ) – dairy cow, version 1.2), which is adapted from the models published by Hoogenboom et al.

(2010) and Derks et al. (1994). To model the total-TEQ concentration in egg yolk fat and body fat of laying hens, a transfer model was used that is available on www.feedfoodtransfer.nl (Transfer model dioxins (total TEQ) - laying hen, version1.1), and has been described by Notenboom et al. (2023). To model the total-TEQ concentration in body fat of pigs, a transfer model was used that is available on www.feedfoodtransfer.nl (Transfer model dioxins (total TEQ) - pig, version 2.0), which is adapted from the model published by Hoogenboom et al. (2007).
For all models, compound feed was considered. For cows, similar to the aflatoxin model, an intake of 7 kg dry matter per day was assumed for compound feed based on the default values for winter intake. For laying hens, a default feed intake of 0.113 kg dry matter per day was assumed. For pigs, the model represents a growing pig with varying feed intake (WFSR feed database). For this, the default feed intake values were used in the model, which are summarized in Table 2.

Table 2. Age-dependent feed intake of pigs used in this study.

Age (day)	**Feed intake (kg 88% dry matter per day)**
0 – 28	0
29 – 75	1.0
76 – 125	1.6
126 – 175	2.1
> 175	2.6

For the cow and laying hen models, an exposure duration of 180 days was assumed, which was sufficient to reach steady state concentrations. For the pig model, the exposure scenario that was used included animals that were 91 days of age and were exposed to contaminated feed for 91 days. This scenario corresponds with the controlled animal experiment that was performed to develop this model (Hoogenboom et al. 2004).

Cadmium – Pig
Cadmium is an accumulating chemical that is hardly excreted from the body. To model this accumulation, the model described by Hoogenboom et al. (2015) was used. This model is available as a webtool via www.feedfoodtransfer.nl (Transfer model cadmium - pig, version 2.0). For this model, compound feed was considered. Since this model represents a growing pig, a varying feed intake was modelled. For this, the default feed intake values were used in the model, which are summarized in Table 2.

The exposure scenario that was used for this model included animals that were 12 weeks (=84 days) of age and were exposed to contaminated feed for 105 days. This scenario corresponds with the controlled animal experiment that was performed to develop this model (Hoogenboom et al. 2015).

Ndl-PCBs – Laying hens
For the modelling of ndl-PCBs in meat fat of laying hens, a transfer model was used that is available on https://contrans.bfr.bund.de/models/chicken/ndl_pcb_Meat (accessed June 2026). This model is described in detail by Ohlhoff et al. (2021), and is applicable for six ndl-PCBs: PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180. Although the model can be applied to estimate the ndl-PCB sum, mixtures are not considered in this assessment. Since estimated ndl-PCB sum in meat fat highly depends on the mixture composition, all ndl-PCBs are considered separately. A default exposure scenario was applied, which consisted of 37 days of exposure starting at the age of 1 day.

For the modelling of ndl-PCBs in egg yolk fat produced by laying hens, a transfer model was applied that is available on https://contrans.bfr.bund.de/models/chicken/ndl_pcb_Egg (accessed June 2026). This model is described in detail by Ohlhoff et al. (2022) and Savvateeva et al. (2022), and is applicable for six ndl-PCBs: PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180. Although the model can be applied to estimate the ndl-PCB sum, mixtures are not considered in this assessment. Since estimated ndl-PCB sum in egg yolk fat highly depends on the mixture composition, all ndl-PCBs are considered separately. A default exposure duration of 200 days was applied, which was sufficient to reach steady state in eggs.

In contrast to the models available on https://www.feedfoodtransfer.nl/en, the feed intake amount is not an input parameter in the applied transfer models on https://con-trans.bfr.bund.de/. Instead, a fixed, age-dependent daily intake of feed is assumed for modelling ndl-PCBs in meat fat, according to the equation $Feed = \frac{239.14}{1+e^{-0.104\cdot(t-23.75)}}$ (Ohlhoff et al., 2021). Here, *Feed* represents the daily feed intake in gram per day and *t* the age of the chicks in days. For modelling ndl-PCBs in egg yolk fat a fixed daily intake of 0.109 kg dry matter (0.124 kg feed with 88% dry matter) by grown laying hens is assumed (Savvateeva et al., 2022).

Other considerations
For all models, a post-exposure period of zero days was chosen in the calculations, meaning that any potential clearance or depletion phase after exposure to contaminated feed was not considered in the modelled scenarios.

It is important to note that the legally established maximum limits for contaminants in animal feed and food products are defined on a 88% dry matter basis.

3. Results

Table 3 provides an overview of the maximum concentration simulated for each chemical and measurement uncertainty. In addition to this overview, Figures S1-S18 in Annex I show the contaminant concentrations estimated in this assessment. In these figures, the effect of including various levels of measurement uncertainties on the tissue concentrations is visualized.

Table 3. Maximum concentrations and maximum limits of the studied chemicals in various animal food products simulated with the available transfer models using feed MLs including uncertainties. Concentrations were expressed in µg/L for aflatoxin M_1 in milk, pg TEQ's/g for dioxins and PCBs in meat fat, body fat, milk fat and egg yolk fat, ng/g for ndl-PCBs in meat fat and egg yolk fat, and mg/kg for Cadmium in kidney and liver. Maximum simulated concentrations that exceed the corresponding ML are marked in red. All concentrations are given on a 88% dry matter basis.

Chemical	**Species**	**Food**	**ML**	**Maximum simulated concentration plus uncertainty**			
				0%	**20%**	**30%**	**50%**
Aflatoxin M_1 *Maize*	Cow	Milk	0.05	0.050	0.060	0.065	0.075
Aflatoxin M_1 *Compound feed for dairy cattle*	Cow	Milk	0.05	0.020	0.024	0.026	0.030
Dioxins and DL-PCBs (total TEQ)	Cow	Milk fat	4.0	2.58	3.09	3.35	3.87
Dioxins and DL-PCBs (total TEQ)	Cow	Meat fat	4.0	1.36	1.63	1.76	2.03
Dioxins and DL-PCBs (total TEQ)	Laying hen	Egg yolk fat	5.0	21.1	25.3	27.4	31.6
Dioxins and DL-PCBs (total TEQ)	Laying hen	Body fat	3.0	23.4	28.1	30.5	35.1
Dioxins and DL-PCBs (total TEQ)	Pig	Body fat	1.25	3.18	3.82	4.14	4.77
Ndl-PCB PCB28	Chicken	Meat fat	40	90.5	109	118	136
Ndl-PCB PCB52	Chicken	Meat fat	40	27.5	32.9	35.7	41.2
Ndl-PCB PCB101	Chicken	Meat fat	40	37.3	44.8	48.5	56.0
Ndl-PCB PCB138	Chicken	Meat fat	40	98.8	119	128	148
Ndl-PCB PCB153	Chicken	Meat fat	40	97.2	117	126	146
Ndl-PCB PCB180	Chicken	Meat fat	40	99.8	120	130	150
Ndl-PCB PCB28	Laying hen	Egg yolk fat	40	152	183	198	228
Ndl-PCB PCB52	Laying hen	Egg yolk fat	40	12.1	14.6	15.8	18.2
Ndl-PCB PCB101	Laying hen	Egg yolk fat	40	13.9	16.7	18.1	20.8

Ndl-PCB PCB138	Laying hen	Egg yolk fat	40	148	178	193	222
Ndl-PCB PCB153	Laying hen	Egg yolk fat	40	169	202	219	253
Ndl-PCB PCB180	Laying hen	Egg yolk fat	40	181	217	235	271
Cadmium	Pig	Kidney	1.0	0.69	0.82	0.88	1.0
Cadmium	Pig	Liver	0.5	0.17	0.21	0.23	0.26

For some of the chemicals and food products studied, the inclusion of measurement uncertainty in feed concentrations did not result in exceedance of the maximum limit in the final food product. For example, for dioxins and PCBs in cow milk fat and meat fat, as well as for cadmium in pig liver and kidney, the simulated concentrations remained below the ML for all tested uncertainty levels. However, several exceptions were observed.

For aflatoxin M_1 in cow's milk, the simulation using maize as feed ingredient resulted in concentrations (0.050 µg/L at 0% uncertainty) that were equal to or above the maximum limit (0.05 µg/L). This exceedance increased with higher uncertainty, reaching 0.075 µg/L at 50% uncertainty. In contrast, when compound feed was used, the simulated concentrations remained below the ML, even when measurement uncertainty was included.
For PCB101 and PCB52 in chicken meat fat, the maximum limit is exceeded when including measurement uncertainties of 20% and higher and 50%, respectively.

For dioxins and PCBs in egg yolk fat and body fat of laying hens and pigs and for the majority of studied ndl-PCBs in meat fat and egg yolk fat, the maximum limits are estimated to be already exceeded without including measurement uncertainties.

4. Discussion

This assessment examined the impact of measurement uncertainty on the estimated concentrations of chemical contaminants in animal-derived food products, using transfer models aligned with regulatory limits. The results demonstrate that, for some chemical–food product combinations, the inclusion of measurement uncertainty (up to 50%) in feed concentrations does not lead to exceedance of the maximum legal limits in animal products. This suggests that, in these cases, the current regulatory framework provides a sufficient margin of safety, even when measurement uncertainty is taken into account. For instance, simulated concentrations of dioxins and PCBs in cow milk fat and meat fat, as well as cadmium in pig liver and kidney, remained below the respective maximum limits across all levels of measurement uncertainty.

Nevertheless, the findings also highlight several critical exceptions. For certain contaminants, particularly those where estimated concentrations are already close to the maximum limits, the inclusion of measurement uncertainty can have significant regulatory implications. This was evident for aflatoxin M_1 in milk where the maximum limit was exceeded when using maize as feed source when applying a measurement uncertainty of 20%. Also, for PCB101 and PCB52 in chicken meat fat, the maximum limit was exceeded when applying a measurement uncertainty of 20% and 50%, respectively. Similarly, for dioxins and PCBs in egg yolk fat and body fat of laying hens and pigs and the majority of ndl-PCBs in egg yolk fat and for the majority of ndl-PCBs in chicken meat fat, the simulated concentrations exceeded the maximum limit even without considering measurement uncertainties.

It must be noted, that for most chemicals included in this assessment, the actual measurement uncertainty associated with routine chemical analyses is typically around 20–30%. Therefore, the 50% uncertainty scenario that was included in the simulations likely represents a conservative overestimation of real-world measurement uncertainty. In fact, for dioxins and PCBs, the maximum allowed measurement uncertainty is far below this 50%, as specified in article 5.6 of Commission Regulation (EU) 2017/644.

In conclusion, while measurement uncertainty has a limited impact for most chemical–food product pairs, it can be decisive in cases where contaminant concentrations are close to regulatory thresholds.

Assumptions and uncertainties
In this assessment, the impact of including measurement uncertainties in substance concentration in feed on the concentrations in food products was estimated. However, for this estimation various assumptions were made that could lead to uncertainties in the results.

In this section, the assumptions and uncertainties of this assessment are discussed.

First, the duration of exposure is an important factor that influences estimated concentrations in food products. In this assessment, a prolonged exposure duration was used such that a steady state concentration was reached in the food product. In real-world settings, shorter exposure durations or the inclusion of withdrawal periods could result in lower contaminant levels, potentially affecting compliance outcomes. On the other hand, a steady state concentration was not always reached (i.e., cadmium in pigs and ndl-PCBs in laying hens). For those cases, longer exposure durations may lead to higher concentrations in food products.

Another consideration is the treatment of ndl-PCBs in this study. Here, ndl-PCBs were assessed individually, as the available transfer models are only suited for individual congeners, and not for their sum. However, regulatory maximum limits apply to the sum of all ndl-PCBs. As a result, simulating the transfer of ndl-PCB mixtures, rather than individual congeners, will yield different results.

Finally, it is important to acknowledge that the findings of this assessment are based on model simulations. While transfer models are valuable tools for estimating contaminant levels and informing risk management, they inherently carry uncertainties and assumptions. The actual concentrations in animal products may differ due to factors not captured by the models, such as intra-animal variability. Thus, analytical measurements remain indispensable for verifying compliance and protecting food safety. Additionally, the applicability of the models is limited by the available data and their relevance to specific feed-product combinations. The exposure durations and concentration ranges tested in the animal studies used to fit the models heavily influence the applicability of the transfer models. In the transfer models used in this assessment, the contaminant concentrations in animal products increased linearly with the measurement uncertainty. This linear correlation may not be present in other transfer models.

5. Conclusions

1. An overview of the estimated contaminant concentrations in animal products when the contaminant concentration in feed is at the ML level is provided is the table below.

Overview of the estimated contaminant concentrations in the food products following exposure via feed at the ML level of contamination with 0% measurement uncertainty.

Chemical	Animal	Feed type	Product	Concentration
Aflatoxin M_1	Dairy cow	Maize	Milk	0.050 µg/L
Aflatoxin M_1	Dairy cow	Compound	Milk	0.020 µg/L
Dioxins and PCBs (total TEQ)	Dairy cow	Compound	Milk fat	2.58 pg/g
Dioxins and PCBs (total TEQ)	Dairy cow	Compound	Meat fat	1.36 pg/g
Dioxins and PCBs (total TEQ)	Laying hen	Compound	Egg yolk fat	21.1 pg/g
Dioxins and PCBs (total TEQ)	Laying hen	Compound	Body fat	23.4 pg/g
Dioxins and PCBs (total TEQ)	Pig	Compound	Body fat	3.18 pg/g
PCB28	Laying hen	Compound	Meat fat	90.5 ng/g
PCB28	Laying hen	Compound	Egg yolk fat	152 ng/g
PCB52	Laying hen	Compound	Meat fat	27.5 ng/g
PCB52	Laying hen	Compound	Egg yolk fat	12.1 ng/g
PCB101	Laying hen	Compound	Meat fat	37.3 ng/g
PCB101	Laying hen	Compound	Egg yolk fat	13.9 ng/g
PCB138	Laying hen	Compound	Meat fat	98.8 ng/g
PCB138	Laying hen	Compound	Egg yolk fat	148 ng/g
PCB153	Laying hen	Compound	Meat fat	97.2 ng/g
PCB153	Laying hen	Compound	Egg yolk fat	169 ng/g
PCB180	Laying hen	Compound	Meat fat	99.8 ng/g
PCB180	Laying hen	Compound	Egg yolk fat	181 ng/g
Cadmium	Pig	Compound	Kidney	0.69 mg/kg
Cadmium	Pig	Compound	Liver	0.17 mg/kg

2. Contaminant concentrations in animal products increase if measurement uncertainty is added to the maximum concentrations in animal feed. Based on the transfer models used in this assessment, the contaminant concentrations in animal products are expected to increase linearly with the measurement uncertainty. Thus, a measurement uncertainty of e.g. 20% is expected to lead to a 20% increase of the estimated contaminant concentration in the food product.

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Annex I – Simulated contaminant concentrations

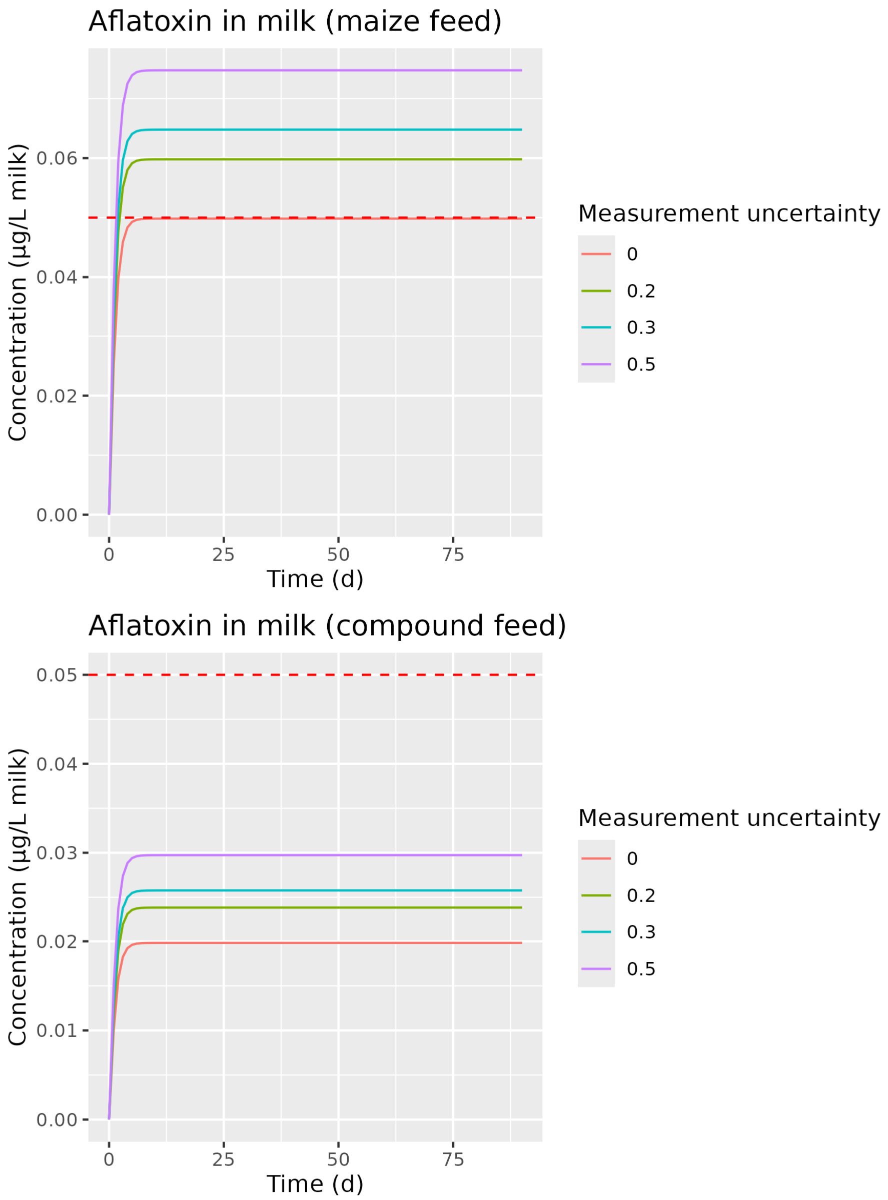
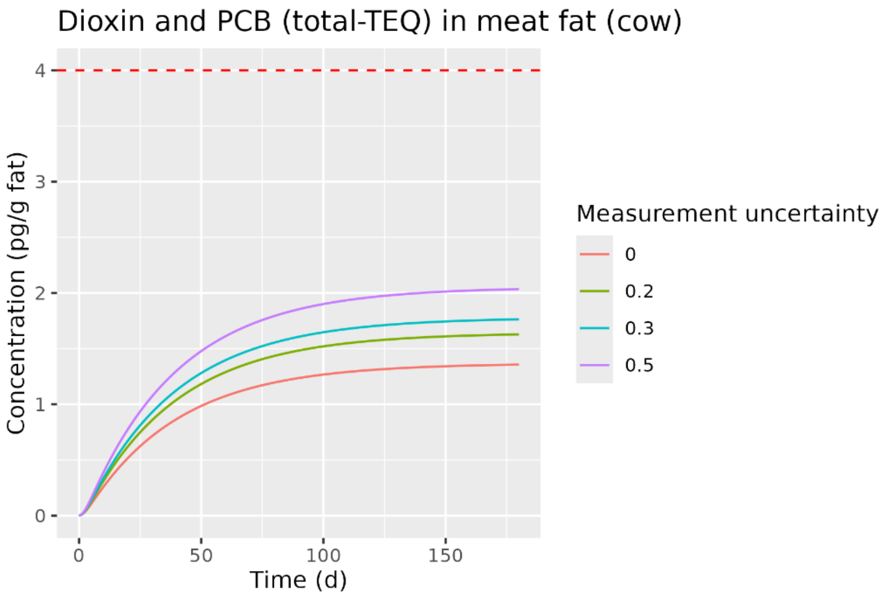


Figure S1. Simulated aflatoxin M_1 concentrations in milk (µg/L) based on maximum levels in maize feed and compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 90 days. The red dashed line represents the ML of aflatoxin M_1 in cow milk (0.05 µg/L).



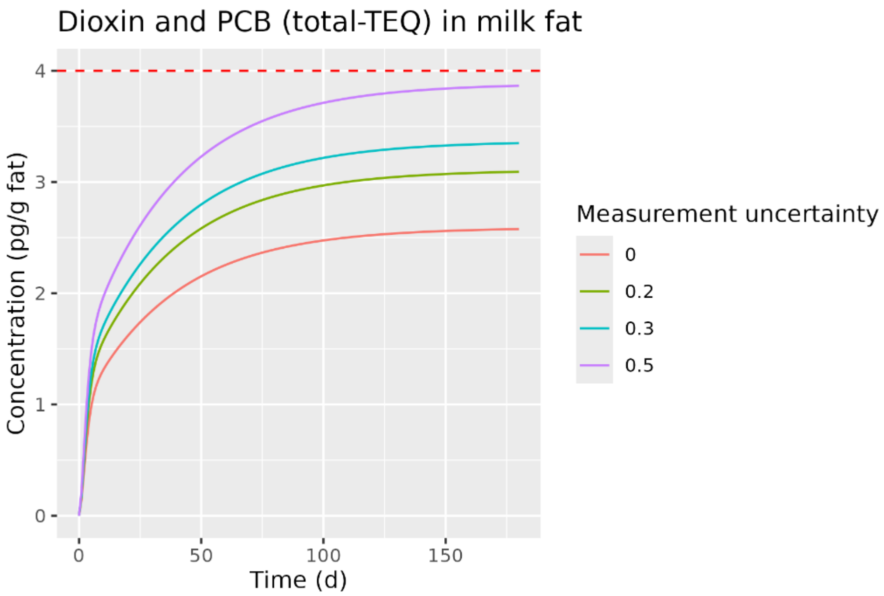


Figure S2 Simulated dioxin and PCB (total-TEQ) concentrations in meat (pg/g meat fat) and milk (pg/g milk fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 180 days. The red dashed line represents the ML of total-TEQ in meat fat and milk fat (4.0 pg/g).

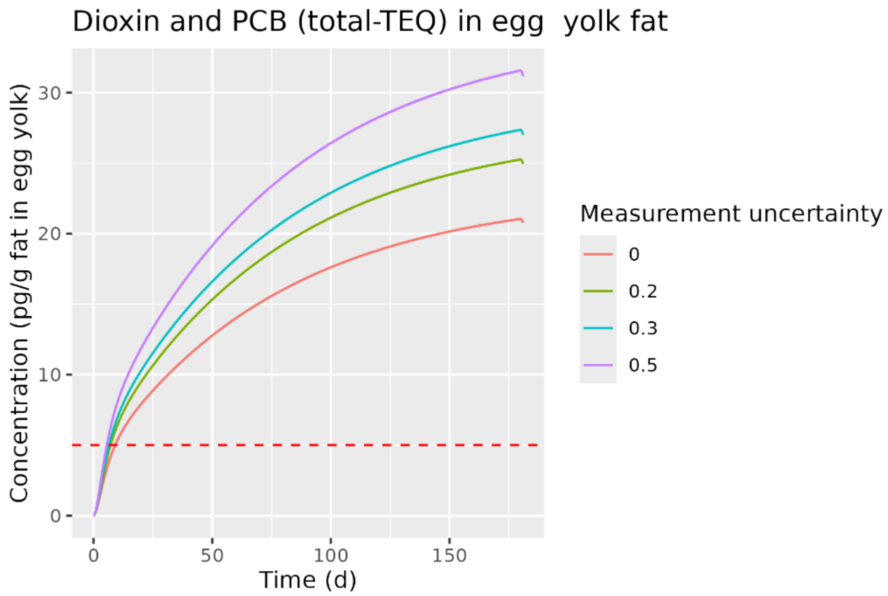


Figure S3 Simulated dioxin and PCB (total-TEQ) concentrations in egg yolk fat (pg/g) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 180 days. The red dashed line represents the ML of total-TEQ in egg yolk fat (5.0 pg/g).

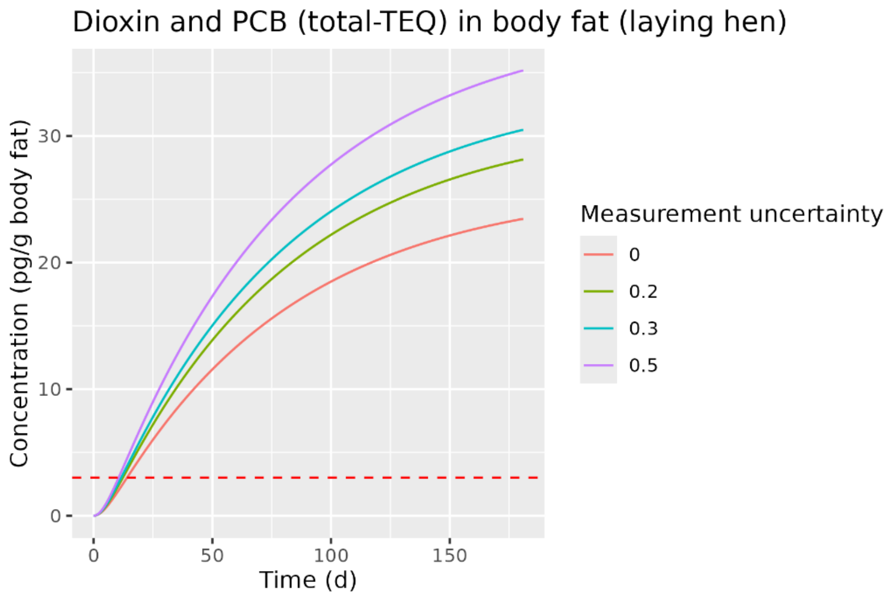


Figure S4 Simulated dioxin and PCB (total-TEQ) concentrations in body fat of laying hens (pg/g) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 180 days. The red dashed line represents the ML of total-TEQ in body fat of laying hens (3.0 pg/g).

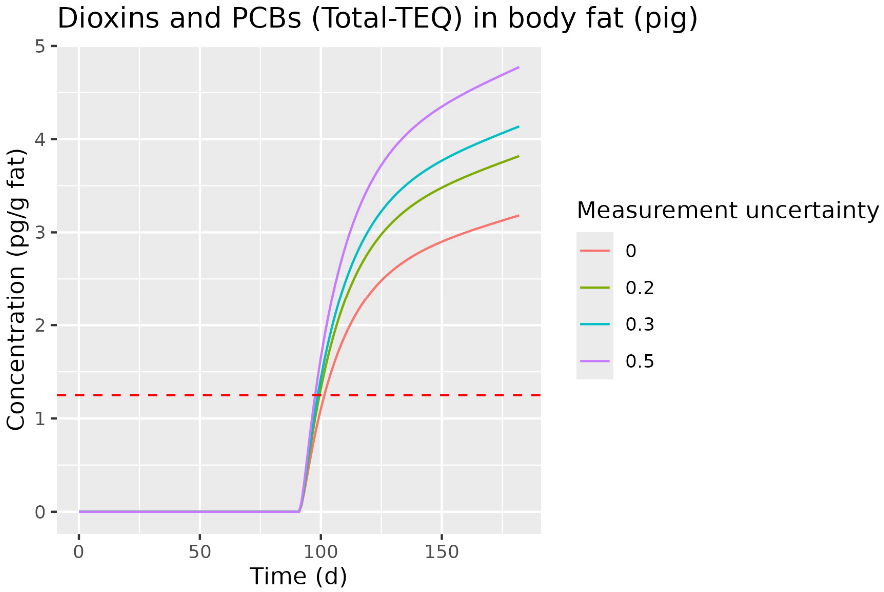


Figure S5 Simulated dioxin and PCB (total-TEQ) concentrations in body fat of pigs (pg/g) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. Also note that the time on the x-axis represents the age of the animal, with exposure starting on day 91. The exposure duration was 91 days. The red dashed line represents the ML of total-TEQ in body fat of pigs (1.25 pg/g).

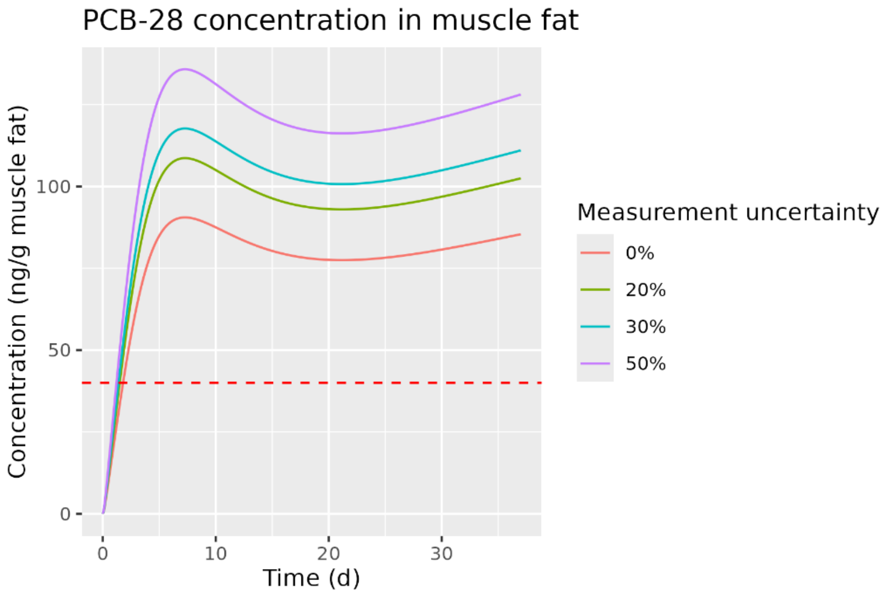


Figure S6 Simulated PCB28 concentrations in chicken muscle fat (ng/g muscle fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 37 days. The red dashed line represents the ML of PCB-28 in muscle (40 ng/g).

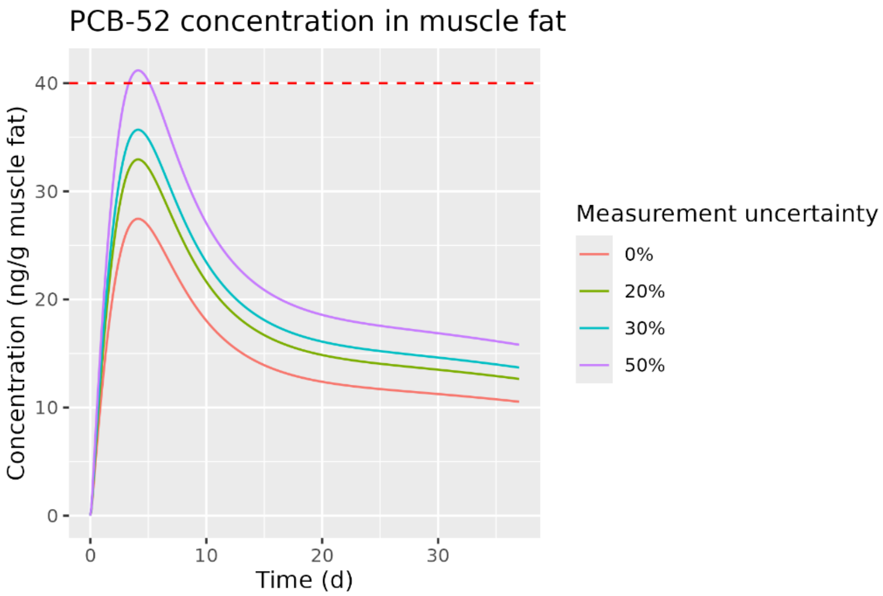


Figure S7 Simulated PCB52 concentrations in chicken muscle fat (ng/g muscle fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 37 days. The red dashed line represents the ML of PCB-52 in muscle (40 ng/g).

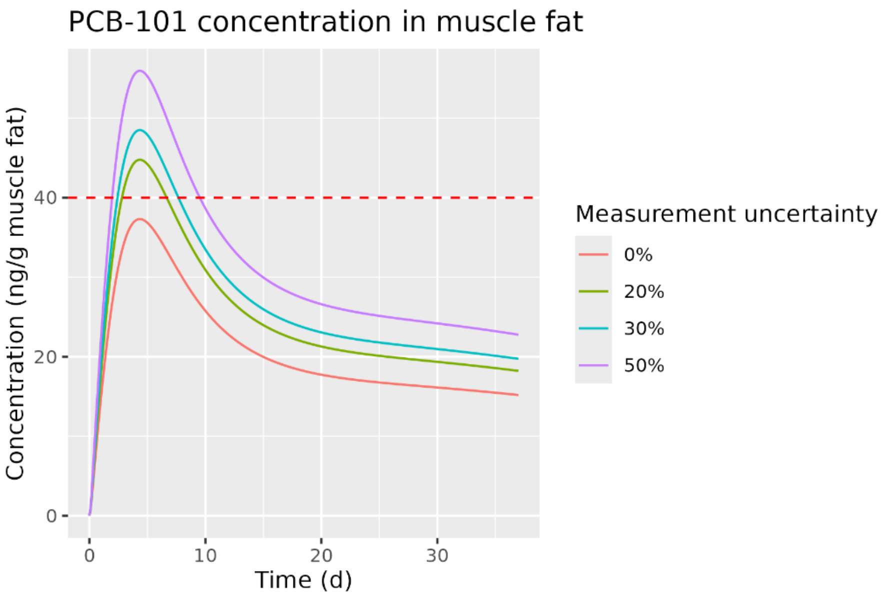


Figure S8 Simulated PCB101 concentrations in chicken muscle fat (ng/g muscle fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 37 days. The red dashed line represents the ML of PCB-101 in muscle (40 ng/g).

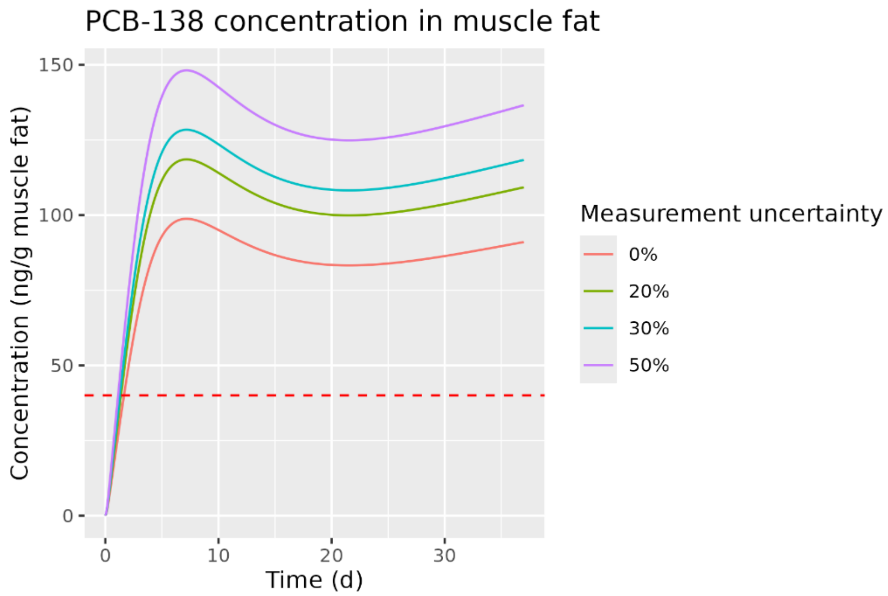


Figure S9 Simulated PCB138 concentrations in chicken muscle fat (ng/g muscle fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 37 days. The red dashed line represents the ML of PCB-138 in muscle (40 ng/g).

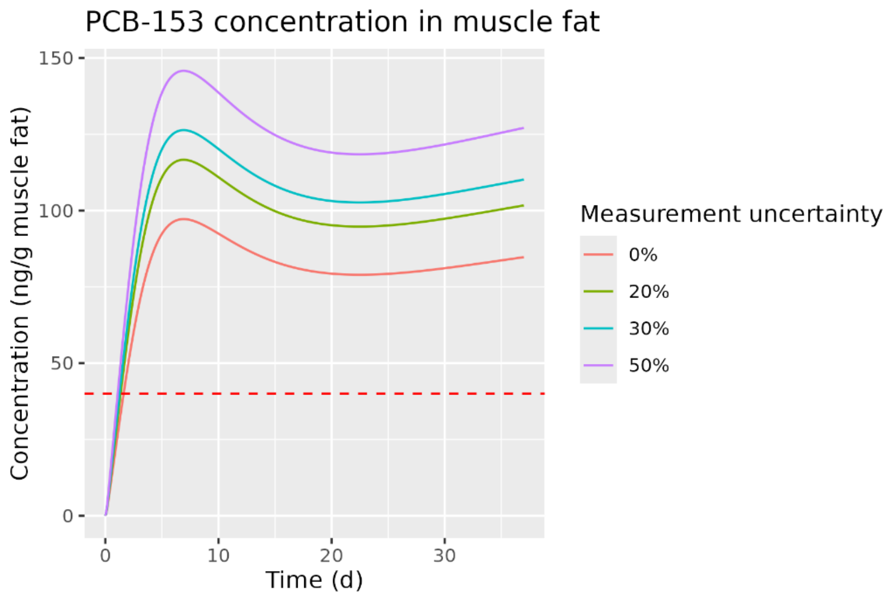


Figure S10 Simulated PCB153 concentrations in chicken muscle fat (ng/g muscle fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 37 days. The red dashed line represents the ML of PCB-153 in muscle (40 ng/g).

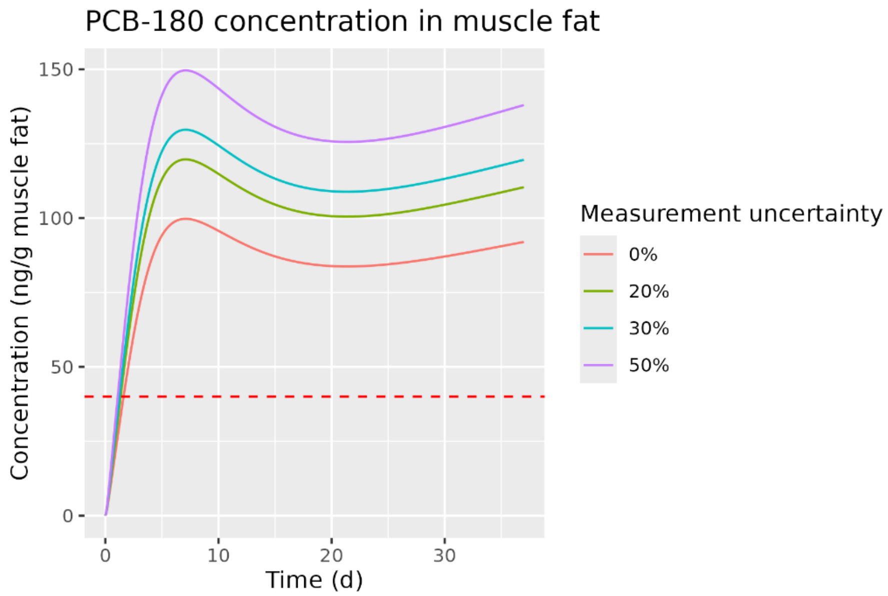


Figure S11 Simulated PCB180 concentrations in chicken muscle fat (ng/g muscle fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 37 days. The red dashed line represents the ML of PCB-180 in muscle (40 ng/g).

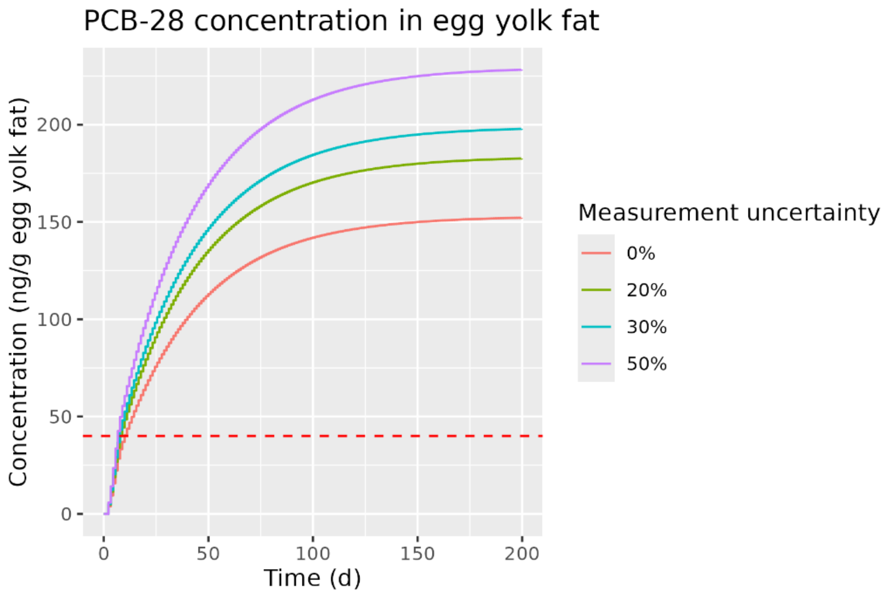


Figure S12 Simulated PCB28 concentrations in egg (ng/g egg yolk fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 200 days. The red dashed line represents the ML of PCB-28 in egg yolk fat (40 ng/g).

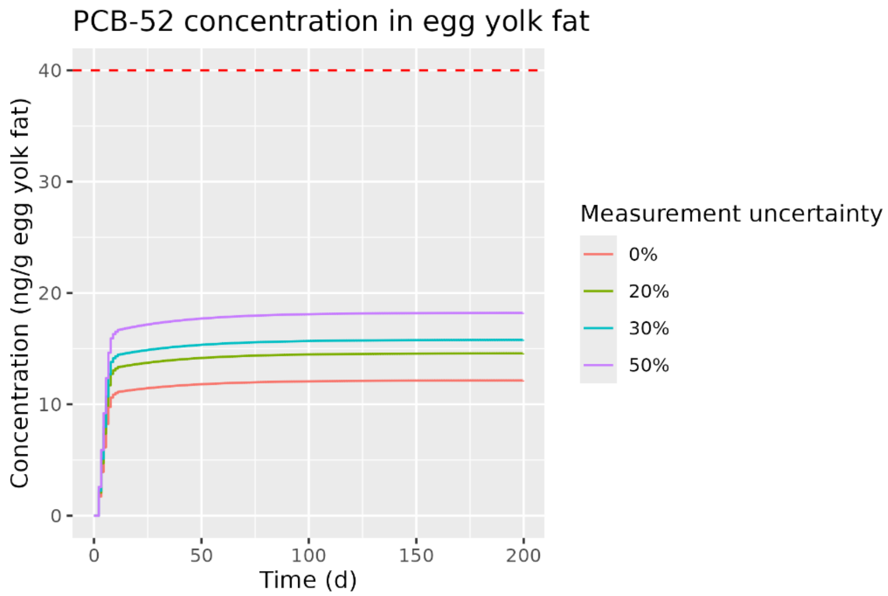


Figure S13 Simulated PCB52 concentrations in egg (ng/g egg yolk fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 200 days. The red dashed line represents the ML of PCB-52 in egg yolk fat (40 ng/g).

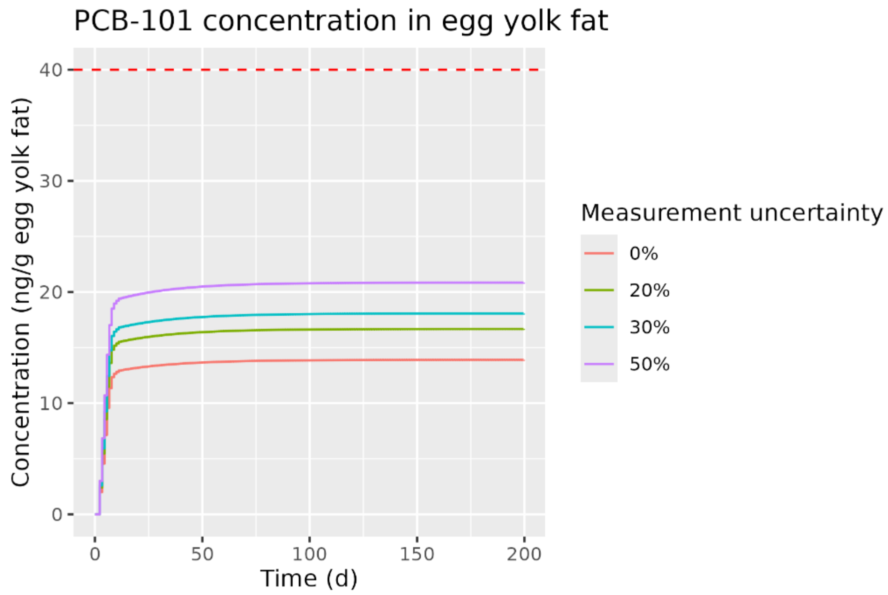


Figure S14 Simulated PCB101 concentrations in egg (ng/g egg yolk fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 200 days. The red dashed line represents the ML of PCB-101 in egg yolk fat (40 ng/g).

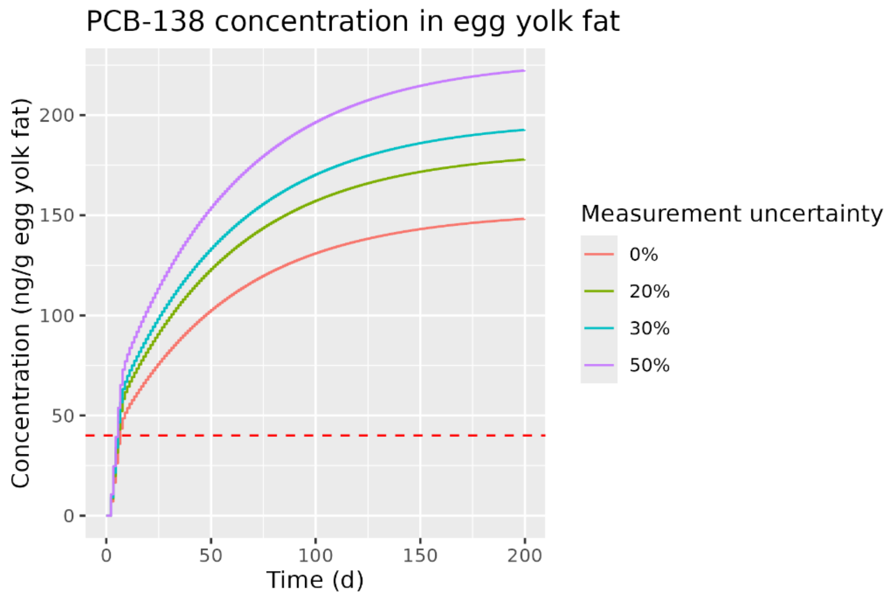


Figure S15 Simulated PCB138 concentrations in egg (ng/g egg yolk fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 200 days. The red dashed line represents the ML of PCB-138 in egg yolk fat (40 ng/g).

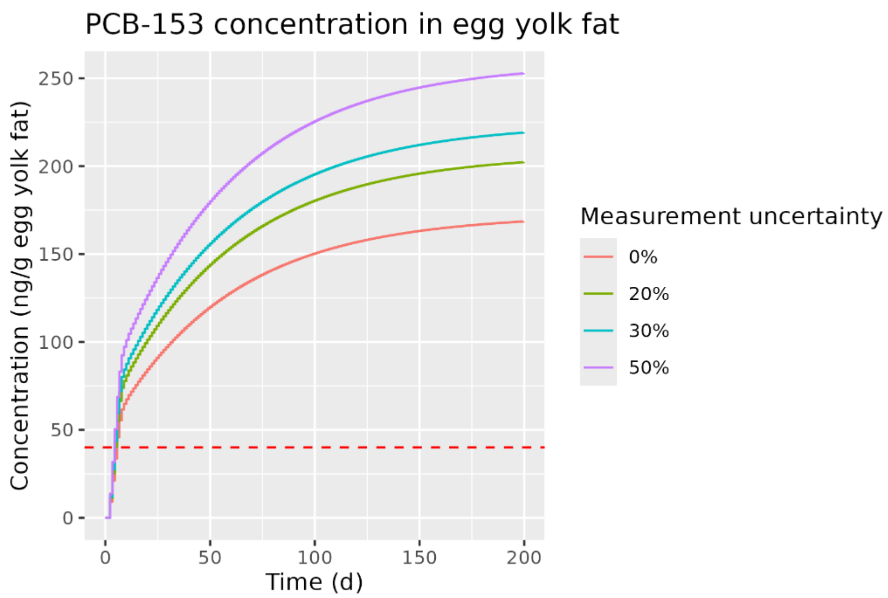


Figure S16 Simulated PCB153 concentrations in egg (ng/g egg yolk fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 200 days. The red dashed line represents the ML of PCB-153 in egg yolk fat (40 ng/g).

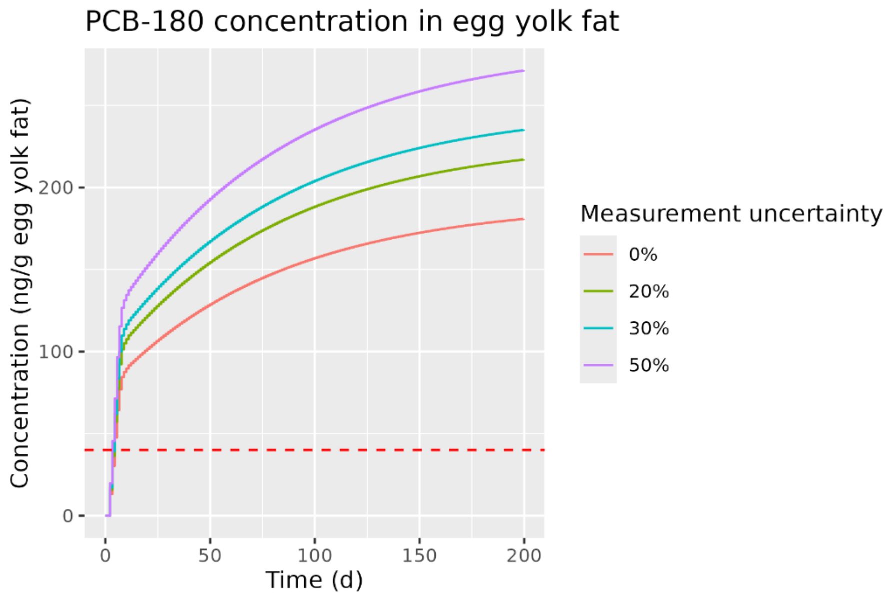
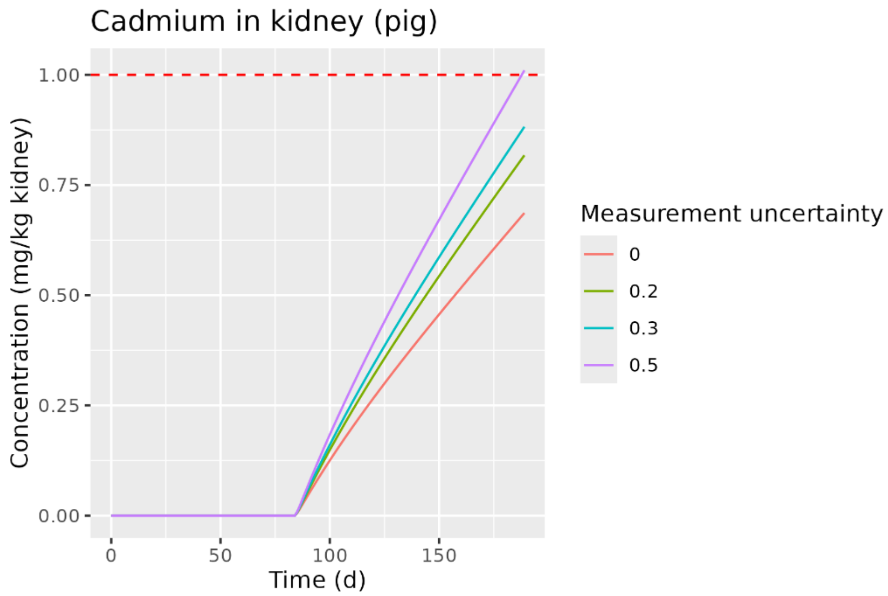


Figure S17 Simulated PCB180 concentrations in egg (ng/g egg yolk fat) based on maximum levels in compound feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. The exposure duration was 200 days. The red dashed line represents the ML of PCB-180 in egg yolk fat (40 ng/g).



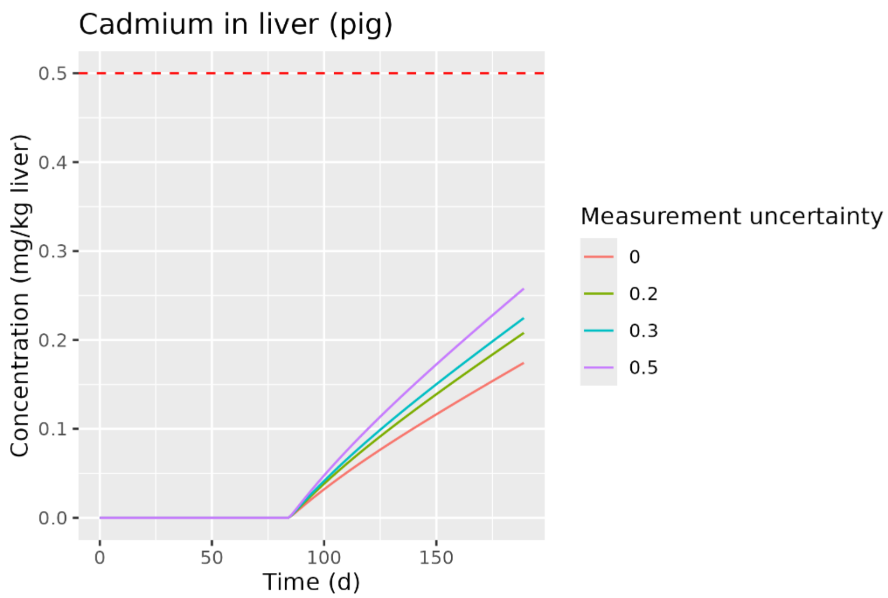


Figure S18 Simulated Cadmium concentrations in pig kidney and liver based on maximum levels in complete feed, including several levels of measurement uncertainty. Note that the measurement uncertainty is denoted as a fraction of the maximum level, instead of a percentage. Also note that the time on the x-axis represents the age of the animal, with exposure starting on day 84. The exposure duration was 180 days. The red dashed line represents the ML of Cadmium in kidney (1.0 mg/kg) and liver (0.5 mg/kg).