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Protocol for the risk assessment of polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans and dioxin-like polychlorinated biphenyls in foods and food supplements

from the Panel on Contaminants of the Norwegian Scientific Committee for Food and Environment

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Protocol for the risk assessment of polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans and dioxin-like polychlorinated biphenyls in foods and food supplements

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Abbreviations and/or glossary

Abbreviations

dl-PCB	Dioxin-like PCB
HpCDD	Heptachlorodibenzo-p-dioxin
HpCDF	Heptachlorodibenzofuran
HxCDD	Hexachlorodibenzo-p-dioxin
HxCDF	Hexachlorodibenzofuran
OCDD	Octachlorodibenzodioxin
OCDF	Octachlorodibenzofuran
PCDD	Polychlorinated dibenzo-p-dioxins
PCDF	Polychlorinated dibenzofurans
PeCDD	Pentachlorodibenzo-p-dioxin
PeCDF	Pentachlorodibenzofuran
TCDD	Tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzofuran
TEF	Toxic equivalency factor
TEQ	Toxic equivalent
TWI	Tolerable weekly intake

Glossary

Congener
One of two or more substances related to each other by origin, structure or function. For dioxins and dioxin-like PCBs, they have the same molecular backbone but with varying numbers and/or positions of chlorines.

Tolerable weekly intake (TWI)
The maximum intake of contaminants in food that can be consumed weekly over a lifetime without risking adverse health effects.

Toxic equivalency factor (TEF)
The toxicity of the congener is expressed as a fraction of the toxicity of the reference compound in terms of potency, which is a pharmacological parameter that defines the amount of compound required for a certain effect. For dioxin/dl-PCB, this is the ratio of the toxicity of a congener divided to the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), the most toxic congener.

Toxic equivalent (TEQ)

A TEQ is calculated by multiplying the actual grams weight of each dioxin and dioxin-like compound by its corresponding TEF (e.g., 10 picograms X 0.1 TEF = 1 picogram TEQ) and then summing the results. The number that results from this calculation is referred to as picograms TEQ.

1 Introduction

Dioxins and dioxin-like polychlorinated biphenyls (dl-PCBs) are lipophilic chemicals with long half-lives in the environment. Dioxins include both polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF). Several congeners of PCDDs and PCDFs may occur, with varying number and positions of chlorine atoms in the molecules. Seventeen of these congeners are relatively persistent in animals and humans and exert similar toxicity. A subgroup of 12 out of 209 possible polychlorinated biphenyl (PCB) congeners show toxicological properties similar to PCDDs/PCDFs, and this subgroup is termed dl-PCBs (EFSA et al., 2018).

1.1 Terms of Reference from the Norwegian Food Safety Authority

The Norwegian Food Safety Authority (NFSA) requests VKM to

- Perform exposure assessments of dioxins and dl-PCBs for the total Norwegian diet and assess if the Norwegian population or sub-groups of the population have dietary intakes leading to different dietary dioxin and dl-PCB exposures compared to what EFSA reported for the European population. NFSA asks VKM to assess if separate calculations are needed for sub-groups of the population or for certain food categories (beyond those already mentioned in 2. and 3. below). If yes, NFSA asks VKM to perform the necessary assessments and calculations.
- Perform a risk assessment of dioxins and dl-PCBs in marine oils taken as food supplements.
- Calculate how much reindeer meat (with the reported dioxin and dl-PCB values) can be consumed before the TWI of dioxins and dl-PCBs will be exceeded. Alternatively, what is the additional contribution of dioxins and dl-PCBs from reindeer meat compared to an average diet?
- Assess health consequences of exceeding the TWI, both related to duration and degree of TWI exceedances.
- Identify risk-reducing factors, which can reduce dioxin and dl-PCB exposure in the population. If possible, present the risk reducing effects quantitatively.

1.2 Objectives of the risk assessment

The overall aim is to estimate the exposure to dioxins and dl-PCBs from foods and marine oils taken as food supplements, assess possible health consequences, and identify risk-reducing factors.

The sub-objectives:

1. Estimate the dietary exposure to dioxins and dl-PCBs for the Norwegian population.
2. Identify sub-groups with dietary intakes resulting in dietary dioxin and dl-PCB exposures different from the European population (as reported in EFSA et al., 2018).
3. Perform separate exposure estimations for the sub-groups identified in point 2.
4. Estimate the exposure to dioxins and dl-PCBs from marine oils taken as food supplements.
5. Estimate the exposure to dioxins and dl-PCBs from reindeer meat.
6. Identify factors reducing dioxin and dl-PCB exposure in the Norwegian population, and if possible, give a quantitative estimate of the effect.
7. Identify and describe possible health consequences resulting from an exposure exceeding the TWI, both related to duration and the degree of exceedance.

1.3 Target population

The target population is the Norwegian population.

1.4 Chemicals of concern

Seventeen PCDD and PCDF congeners will be included in the assessment. In addition, 12 dl-PCB congeners showing toxicological properties similar to the 17 PCDD/PCDF congeners will be included.

The PCDD congeners included are 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,4,7,8-HxCDD, 1,2,3,6,7,8-HxCDD, 1,2,3,7,8,9-HxCDD, 1,2,3,4,6,7,8-HpCDD and 1,2,3,4,6,7,8,9-OCDD.

The PCDF congeners included are 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF, 1,2,3,6,7,8-HxCDF, 2,3,4,6,7,8-HxCDF, 1,2,3,7,8,9-HxCDF, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF and 1,2,3,4,6,7,8,9-OCDF.

The dl-PCB congeners included are four non-ortho PCBs and eight mono-ortho PCBs. These are PCB-77, PCB-81, PCB-126, PCB-169, PCB-105, PCB-114, PCB-118, PCB-123, PCB-156, PCB-157, PCB-167 and PCB-189.

2 Exposure assessment

2.1 Sources and route of exposure

Dietary intake of dioxins and dl-PCBs from foods and marine oils taken as food supplements.

2.2 Exposure assessment questions

Questions addressed in the exposure assessment are shown in table 2.2-1.

Table 2.2-1. Exposure assessment questions.

	Exposure assessment questions
Occurrence	What is the concentration of dioxins and dl-PCBs in foods?
	What is the concentration of dioxins and dl-PCBs in marine oils taken as food supplements?
	What do we do if there is a lack occurrence data for foods/food groups?
	Norwegian occurrence data versus occurrence data from EFSA, which data should be used, and when?
	How old occurrence data can be used?
	Which food supplements contain marine oils, and what is the concentration of dioxins and dl-PCBs?
Intake	What is the food intake? What is the intake of marine oils taken as food supplements?
	Which exposure scenarios should be included when there is a lack of data on intake?
	How will we adjust for over- and underestimation of foods that are not consumed daily?
Exposure	How should the exposure calculations be performed?
	What is the dietary exposure to dioxins and dl-PCBs for the Norwegian population?
	For which sub-groups of the population should separate exposure estimations be performed?

2.3 Occurrence data for dioxins and dl-PCBs in foods and food supplements

Dioxin and dl-PCB occurrence data will be compiled in a database. Criteria for inclusion of occurrence data in the database:

- The samples were taken during year 2010 or later.
- The samples were analysed by gas chromatography/high-resolution mass spectrometry (GC-HRMS) or gas chromatography–tandem mass spectrometry (GC–MS/MS). Data obtained with other analytical methods or without information on the analytical method will be excluded.

- Samples with a LOQ higher than one fifth of the corresponding maximum levels for the sum of PCDD/Fs or higher than one third of the corresponding action level for the sum of DL-PCBs will be excluded.

Occurrence data that will be considered for inclusion in the database:

- Data on different fish species analysed by the Institute of Marine Research (IMR).
- Data on eggs and milk analysed by the Food and Environment Research Agency (FERA) for NFSA.
- Data on sushi analysed by the National Institute of Nutrition and Seafood Research (NIFES), now IMR.
- Data on meat analysed by FERA for NFSA.
- Data on reindeer analysed by the Norwegian Institute for Air Research (NILU).
- Data on different foods with Norwegian origin from interlaboratory comparisons in the period 2010 – 2019 in Norwegian Institute of Public Health reports (NIPH).
- Data on marine oil supplements analysed by NIFES, now IMR (NIFES et al., 2017).
- Data on crab meat used in the VKM report «Scenariofremstilling: inntak av dioksiner og PCB fra krabbe» (VKM, 2010), analysed by NIFES, now IMR.
- Data on crab meat analysed by NIFES, now IMR (NIFES et al., 2008).
- Data available in the EFSA (2018) report «Risk for animal and human health related to the presence of dioxins and dioxin-like PCBs in feed and food» (https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2018.5333).
- Other available data, including data provided by the industry.

The data for use in the compilation of the dioxin database will be prioritised as follows: 1) Norwegian occurrence data for foods most likely eaten in Norway, 2) Norwegian data and European data from EFSA will be compared if available Norwegian data are scarce, and 3) European data from EFSA will be used when Norwegian data are lacking.

Occurrence data will be given in lower and upper bound values. Lower bound estimates will be calculated by substituting values below the limit of detection (LOD) or limit of quantification (LOQ) for an analytical method with the number zero. Upper bound estimates will be calculated by substituting values below the LOQ, or LOD if LOQ is missing, with values set to equal to the LOD or LOQ.

2.4 Intake data for foods and food supplements

To get the best possible picture of the intake of foods and the intake of marine oils as food supplements for different population groups, intake data from several dietary surveys and studies will be used. The surveys/studies using short term recall/record methods like 24-hour recalls and 4 days food records give detailed information of food intake over a few days, whereas food frequency methods give less detailed information for a longer period like a month or a year.

The Norwegian national food consumption surveys will be used as the basis for the exposure calculations. These includes:

- Norkost 3 (2011) (Totland et al., 2012)
- Ungkost 3 (2015) (Hansen et al., 2015)
- Småbarnkost 3 (datacollection 2019, data ready for use 2019/2020)
- Spedkost 3 (datacollection 2018/2019, data ready for use 2019/2020)

Norkost 3 and Ungkost 3 are surveys that give detailed information of food intake at an individual level. The dietary methods used are 24-hour recalls and 4-days web record, respectively. For Spedkost 3 and Småbarnskost 3 the dietary assessment method used are food frequency questionnaires.

Data from other surveys and studies, all addressing food frequency, will also be considered used for the exposure calculations or as background for exposure scenarios, especially for more information on long-term fish intake, and seldom eaten foods:

- Tromsø 7; The seventh survey of the Tromsø study was carried out in 2015-16. The questionnaires include data on diet.
- HUNT4; The HUNT Study includes large total population-based cohorts covering 125,000 Norwegian participants, and spans from 1984 until today. The HUNT Study includes data from questionnaires (including food habits), interviews, clinical measurements and biological samples (blood and urine).
- SAMINOR; A population-based study on health and living conditions in regions with Sami and Norwegian populations. Two surveys have been completed.
- HUSK; Part of the Hordaland Health Studies and was conducted in 1997/99 as a joint project between the University of Bergen, the Norwegian Health Screening Service (now part of the National Institute of Public Health) and the Municipal Health Service in Hordaland.
- The Norwegian Mother, Father and Child Cohort (MoBa), food intake in 13-15-year-olds.
- The Norwegian Fish and Game Study (initiated 1999); The aim was to obtain more information about the consumption of specific kinds of fish, shellfish and game in order to obtain information about exposure to environmental contaminants.

2.5 Estimation of exposure to dioxins and dl-PCBs from foods and food supplements

The toxic equivalent (TEQ) concept is used to estimate the combined toxicity of mixtures of dioxins and dl-PCBs through the toxic equivalency factors (TEFs) methodology. TEF is the ratio of the toxicity of a dioxin/dl-PCB to the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), the most toxic dioxin congener. The TEQ is calculated by multiplying the amount of each dioxin and dl-PCB by its corresponding TEF and then summing the results. The TEF values published in 2005 by the World Health Organization (WHO) will be used (Van den Berg et al., 2006). It can be expected that the WHO2005 TEFs for dioxins and dl-PCBs will be revised, S the exposure calculations will be performed using congener specific values of dioxins and dl-PCBs, which will enable an update of the exposure assessments if new TEF-values are available.

The exposure estimations will be performed for chronic exposure only. For the occurrence, mean values will be used. The consumption estimates will be made using the Observed Individual Means method (OIM; semi-deterministic), and custom-made scripts in *R* (probabilistic).

Probabilistic estimates rely on distributions as inputs in place of single values for key parameters. This results in a distribution of possible exposure estimates and greater ability to characterise variability and uncertainty. Occurrence data and consumption data are needed to calculate the exposure. How to handle any lack of occurrence data (e.g. use the most comparable value, or set the occurrence to 0) cannot be clarified until a complete overview of all available data has been created. If data on consumption is lacking for specific foods with high content of dioxins and dl-PCBs, scenarios will be made.

For exposure calculations of marine oils taken as food supplements, the population will be divided in users and non-users of marine oils. For users of marine oils taken as food supplements, exposure to dioxins and dl-PCBs will be calculated both with and without the contribution from food supplements.

To answer the question regarding reindeer meat, different scenarios will be used.

Person-specific body weights will be used where possible, otherwise Norwegian age- and gender-specific body weights will be used.

2.6 Uncertainty in the exposure assessment

Factors introducing uncertainty in the exposure assessment may be e.g. model uncertainty, lack of occurrence data for dioxins and dl-PCBs in foods/food supplements, uncertainty in compiling the dioxin and dl-PCB database and use of intake scenarios due to lack of food/food supplement consumption data. Key uncertainty factors will be identified and described narratively.

3 Risk characterisation

A tolerable weekly intake for the sum in TEQ of dioxins and dl-PCBs (TWI) of 2 pg/kg bw was established by EFSA (EFSA et al., 2018). This TWI will be used to evaluate whether the estimated exposures to dioxins and dl-PCBs are likely to cause adverse health effects.

The identification and description of possible health consequences resulting from an exposure exceeding the TWI, both related to duration and the degree of exceedance, will be based on the EFSA opinion “Risk for animal and human health related to the presence of dioxins and dioxin-like PCBs in feed and food” (EFSA et al., 2018).

Factors that may reduce the dioxin and dl-PCB exposure in the Norwegian population will be identified. If possible, the effect size of different risk reducing factors will be quantified.

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