Opinion of the Panel on Contaminants of the Norwegian Scientific Committee for Food Safety

22 November 2007

Risk assessment of dioxins and dioxin-like PCBs in fish liver

SUMMARY

The Norwegian Food Safety Authority has asked the Norwegian Scientific Committee for Food Safety (Vitenskapskomiteen for mattrygghet, VKM) to do a risk assessment of dioxins and dioxin-like PCBs (dl-PCBs) in fish liver. Given the different levels of dioxins and dl-PCBs found in fish liver from different areas, the assessment will consider - what are the general risks to consumers, and with respect to vulnerable groups.
The request has been answered by the Panel on Contaminants (Panel 5) of VKM.
Concentrations of dioxins and dl-PCBs in cod liver vary and are dependent on the place where the fish is caught. Results from available analyzes indicate that liver from cod caught close to cities and/or industrial zones, small towns and villages contain from 30 to 740 pg TEQ/g. Concentration in liver from cod caught in open coastline, varied from 40 to130 pg TEQ/g. The levels of dioxins and dl-PCBs in fish liver samples from the Barents Sea, ranged from 3 to 66 pg TEQ/g, with a median and mean concentration of 13.0 pg TEQ/g and 16.7 pg TEQ/g, respectively. The mean concentration in roe-liver pâté, which is a bread spread, was 7 pg TEQ/g.

In Norway, approximately 30% of the population consumes oily liver from lean fish species like cod and saithe. The consumption of fish liver is unevenly distributed throughout the adult population. The median consumption among fish liver consumers only corresponds to one meal containing 30 g fish liver every second month. High consumption of fish liver, the 95th percenile, corresponds to nearly 3 meals of fish liver every month. To the knowledge of Panel 5 nothing is known about fish liver consumption among children. Approximately 2% of pregnant women in a cohort were consumers of roe-liver pâté.

Panel 5 is of the opinion that the exposure of dioxins and dl-PCBs among children and in women that are in child-bearing age preferably should be below the TWI for dioxins and dl-PCBs at 14 pg TEQ/kg body weight. Women above fertile age and men are believed to be less sensitive to exposure to dioxins and dl-PCBs, and for these groups of the population, exposure

moderately above the TWI is not believed to be connected to increased risk of negative health effects.

Since relatively few people eat fish liver, the median total TEQ intake among all Norwegians is hardly affected by fish liver consumption. However, fish liver consumption may have pronounced impact on total TEQ intake on an individual basis, depending on the contamination levels found. Exposure calculations indicate that a level of 60 pg TEQ/g in fish liver would for individuals with median fish liver consumption (six meals of 30 g fish liver per year) lead to an intake which is 20% of the TWI from fish liver alone. Those with median exposure to dioxins and dl-PCBs from fish and other seafood, including fish liver, could eat fish liver containing up to 60 pg TEQ/g without exceeding the TWI from the total diet.

High consumption of fish liver with a level of 30 pg TEQ/g would singly contribute with nearly 60% of the TWI. At a contamination level of 30 pg TEQ/g in fish liver, 75% of the cod liver consumers will have exposures below the TWI.

The 95th percentile exposure from total diet at a contamination level of up to 100 pg TEQ/g in fish liver would not exceed the highest TDI for non-developmental health effects suggested by Swedish experts, which corresponds to a weekly intake of 70 pg TEQ/kg body weight.

Available analytical results indicate that liver from cod caught in the Barents Sea contains less dioxins and dl-PCBs than liver from fish caught near cities and/or industrial zones, small towns and villages in Norway, which appears to have median levels above 60 pg TEQ/g. Only one of the 53 samples from the Barents Sea contained more than 60 pg TEQ/g. Over time, the liver consumed from fish caught in the Barents Sea would tend to contain the average concentration of approximately 15 pg TEQ/g liver. The four analyses on liver from fish caught at the open coastline are not sufficient to conclude about the contamination level.

Panel 5 is of the opinion that roe-liver pâté used as bread spread could be a significant source for dioxins and dl-PCBs. People that consume this bread spread regularly increase the probability of exceeding the TWI for dioxins and dl-PCBs.

Fish liver is a rich source for several nutrients, like marine n-3 fatty acids and vitamins A and D. However, the possible nutritional benefits of eating fish liver have not been taken into consideration.

SAMMENDRAG

Mattilsynet har bedt Vitenskapskomiteen for mattrygghet (VKM) om en risikovurdering av dioksiner og dioksinliknende PCB (dl-PCB) i fiskelever. Hva er risikoen for konsumentene, både i den generelle befolkningen og for følsomme grupper, gitt de forkjellige nivåene av dioksiner og dl-PCB som er funnet i fiskelever fra forskjellige geografiske områder?

Oppdraget er besvart av VKMs Faggruppe for forurensninger, naturlige gifter og medisinrester (Faggruppe 5).

Konsentrasjoner av dioksiner og dl-PCB i torskelever er varierende og avhenger av hvor fisken er fanget. Resultater fra tilgjengelige analyser indikerer at lever fra torsk fanget i nærheten av byer, tettsteder og/eller områder der det er industriell aktivitet innholdt fra 30 til 740 pg toksiske ekvivalenter (TE)/g. Konsentrasjoner i lever fra torsk fanget ved åpen kyst varierte fra 40 til 130 pg TE/g. Konsentrasjonen av dioksiner og dl-PCB i torskeleverprøver fra Barentshavet varierte fra 3 til 66 pg TE/g, med median og gjennomsnittlig konsentrasjon på henholdsvis 13,0 pg TE/g og 16,7 pg TE/g. Gjennomsnittskonsentrasjonen av dioksiner og dl-PCB i rognleverpostei, som er et pålegg, var 7 pg TE/g.

I Norge konsumerer omtrent 30 % av befolkningen lever fra mager fisk, slik som torsk og sei. Konsumet av fiskelever er skjevfordelt i den voksne populasjonen. Mediankonsumet av fiskelever blant de som spiser slik mat tilsvarer ett måltid på 30 g fiskelever annenhver måned. Høyt konsum av fiskelever, 95-persentilen, tilsvarer nesten 3 måltider med fiskelever hver måned. Faggruppe 5 har ikke kunnskap om fiskeleverkonsum blant barn. Omtrent 2 % av gravide kvinner i en kohortstudie spiste rognleverpostei.

Faggruppe 5 er av den oppfatning at eksponering for dioksiner og dl-PCB blant barn og kvinner som kan få barn, fortrinnsvis bør være lavere enn tolerabelt ukentlig inntak (TWI) for dioksiner og dl-PCB, som er 14 pg TE/kg kroppsvekt. Kvinner som ikke lenger kan få barn og menn antas å være mindre følsomme for eksponering av dioksiner og dl-PCB. For disse gruppene av befolkningen vil en moderat overskridelse av TWI sannsynligvis ikke være forbundet med økt risiko for helseskade.

Siden det er relativt få fiskeleverkonsumenter, er medianinntaket av dioksiner og dl-PCB i den norske befolkningen lite påvirket av fiskeleverkonsum. Avhengig av hvor forurenset fiskeleveren er, kan imidlertid konsum av fiskelever ha stor betydning for totalinntaket av dioksiner og dl-PCB hos enkeltindivider. Dersom fiskeleveren inneholder 60 pg TE/g vil de som har et mediant fiskeleverkonsum (seks måltider av 30 g fiskelever per år) ha et inntak av dioksiner og dl-PCB fra fiskelevere alene som tilsvarer 20 % av TWI. Blant de med et mediant inntak av dioksiner og dl-PCB fra fisk og annen sjømat, inkludert fiskelever, kan fiskelever inneholde opp til 60 pg TE/g uten at TWI overskrides når hele kostholdet tas i betraktning.

Høyt konsum av fiskelever som inneholder 30 pg TE/g vil gi et inntak av dioksiner og dl-PCB som tilsvarer nesten 60 % av TWI fra fiskelever alene. Når fiskeleveren inneholder 30 pg TE/g vil 75 % av torskeleverkonsumentene ha eksponering som er lavere enn TWI.

Ved en konsentrasjon på 100 pg TE/g i fiskelever, vil heller ikke de med høyt inntak av dioksiner og dl-PCB (95-persentil) fra hele kostholdet overskride det høyeste tolerable daglige

inntaket (TDI) som er foreslått av svenske eksperter for andre helseeffekter enn de utviklingsmessige. Denne TDI tilsvarer et ukentlig inntak på 70 pg TE/g kroppsvekt.

De tilgjengelige analyseresultater tyder på at lever fra torsk fanget i Barentshavet inneholder mindre dioksiner og dl-PCB enn lever fra fisk fanget i nærheten av industriområder, byer og tettsteder. Fiskelever fra slike områder ser ut til å ha et mediant nivå som er høyere enn 60 pg TE/g. Bare en av de 53 prøvene fra Barentshavet innehold mer enn 60 pg TE/g. Over tid vil nivået i det som er konsumert av fiskeleveren fra Barentshavet nærme seg gjennomsnittsnivået for dette området, som er ca 15 pg TE/g. De fire prøvene av fiskelever fra åpen kyst er ikke tilstrekkelig for å konkludere hvilke nivåer av dioksiner og dl-PCB som er vanlig i disse områdene langs kysten av Norge.

Faggruppe 5 er av den oppfatning at rognleverpostei brukt som pålegg kan være en betydelig kilde til dioksiner og dl-PCB. De som spiser slikt pålegg regelmessig øker sannsynligheten for å overskride TWI for dioksiner og dl-PCB.

Fiskelever er en rik kilde for flere næringsstoffer, slik som marine n-3 fettsyrer og vitaminene A og D. Mulige ernæringsmessige fordeler av å spise fiskelever er imidlertid ikke tatt med i betraktning.

CONTRIBUTORS

Persons working for VKM, either as appointed members of the Committee or as *ad hoc* experts, do this by virtue of their scientific expertise, not as representatives for his/her employers. The Civil Services Act instructions on legal competence apply for all work prepared by VKM.

Assessed by

Panel on Contaminants (Panel 5): Janneche Utne Skåre (Chair), Jan Alexander, Augustine Arukwe, Trine Eggen, Gunnar Sundstøl Eriksen, Christiane Kruse Fæste, Kari Grave, Helle Katrine Knutsen, Amund Måge, Anders Ruus

Scientific coordinator from the secretariat: Marie Louise Wiborg

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BACKGROUND

The Norwegian Food Safety Authority (Mattilsynet) and the former Norwegian Food Control Authority (SNT) have for several years advised the consumers not to eat fish liver from certain fjords and harbours, since they can contain high levels of contaminants (Økland, 2005). The consumption advice has been based on environmental surveys and risk assessment from scientific committees. In 2002 SNT gave general consumption recommendation for fish liver due to high levels of dioxins and dioxin-like PCBs (dl-PCBs). The advice was later extended to include products from fish liver:

- Children, women of child bearing-age and pregnant women should not eat fish liver or fish liver spread.
- Other groups in the population should restrict their consumption of fish liver and fish liver spread.

The occurrence and levels of dioxins and dl-PCBs in fish liver have been monitored in fish living in fjords and harbours a long the coastline of Norway for several years. In 2005 all the data were collected in one report (Økland, 2005). To get an overall view of the dioxins and dl-PCBs levels in fish liver caught at different sites, VKM asked Bergfald & Co to describe the available data on occurrence and levels in fish liver in detail. The results are available in the report "Nivåer av dioksiner og PCB i torskelever" (Økland, 2006). One of the conclusions in the report was that there were very few analytical data on dioxins and PCBs in liver from fish living in open sea. Recent data indicate lower levels of dioxins and dl-PCBs in liver from fish living in areas which are less influenced by local contamination, such as the Barents Sea, than in liver from fish living closer to the coast.

So far, fish liver has not been included in the EU/EEA regulation setting maximum levels for certain contaminants in foodstuffs, and therefore no maximum level for dioxins and dioxin-like PCBs is set for this food group. However, EU has started their work on setting maximum levels for dioxins and dl-PCBs in fish liver.

TERMS OF REFERENCE

The Norwegian Food Safety Authority has requested VKM to do a risk assessment of dioxins and dl-PCBs in fish liver. Given the different levels of dioxins and dl-PCBs found in fish liver from different areas, the assessment will consider - what are the general risks to consumers, and with respect to vulnerable groups.

The opinion is going to be used as a basis for suggesting maximum levels for dioxins and dioxin-like PCBs in the ongoing negotiations in the EU.

ASSESSMENT

Introduction

Dioxins and dl-PCBs are persistent organochlorine compounds that are globally dispersed environmental contaminants which accumulate in oily foods. Exposure of the general population to dioxins and dl-PCBs is primarily from food (> 90%), and oily fish is an important source. Dioxins and dl-PCBs exhibit a broad range of toxic and biological effects. The level of toxic equivalency (TEQ) in a food sample is a measure of the total dioxin toxicity and simplifies risk assessment of complex mixtures of dioxins and dl-PCBs. Expert groups in SCF (SCF, 2001) and JECFA (JECFA, 2001) have assessed health risk of intake of dioxins and dl-PCBs from food. They based their updated assessments on rodent studies providing a NOAEL and LOAELs for the most sensitive effects of 2,3,7,8-TCDD (the most potent dioxin compound) exposure, i.e. developmental effects in rat male offspring. The tolerable weekly intake (TWI) for dioxins and dl-PCBs is 14 pg TEQ/kg body weight (SCF, 2001).

A new Swedish risk assessment was recently performed to estimate the tolerable intake of dioxins and dl-PCBs among humans that will not undergo a pregnancy, i.e. boys, men and post-menopausal women (Hanberg *et al.*, 2007). The Swedish experts concluded that cancer is the most sensitive adverse effect of chronic exposure for these groups. Using different assessment factors (x3.2, x10, x50), three scenarios with different safety margins were calculated. The report concludes that based on current scientific knowledge, a tolerable daily intake (TDI) range of 2-10 pg TEQ/kg body weight (b.w.)/day represents exposure levels where human cancer risks are very low or non-existing. Due to time limitations, Panel 5 of VKM has not had the opportunity to fully evaluate the Swedish assessment. The results, however, support opinions held by VKM in the report “A comprehensive assessment of fish and other seafood in the Norwegian diet”:

”The TWI has been established to protect the most sensitive life stage, i.e. the foetal stage. However, dioxins and dioxin-like PCBs have such a long half-life in the body that the body burden during pregnancy is not a result of the diet during pregnancy but of the diet during the many years prior to pregnancy. Women who are pregnant or who will become pregnant, and the foetuses, are therefore the most vulnerable group. It is the total accumulated amount of dioxins and dioxin-like PCBs ingested throughout life and throughout the fertile period that is of significance. Women above fertile age and men are believed to be less sensitive to exposure to dioxins” (VKM, 2007a).

Fish liver is a rich source for several nutrients, like marine n-3 fatty acids (EPA, DPA and DHA) and vitamin A and D. The Scientific Steering Committee of VKM conducted a comprehensive review of fish and other seafood in 2006. More information about nutritional benefits of consuming fish and other seafood compared with the health risk associated with the intake of contaminants can be read in the above mention report (VKM, 2007a).

In this opinion the Panel 5 of VKM has been asked to do a risk assessment of dioxins and dl-PCBs in fish liver for regulatory purposes and thus, the nutritional benefits of eating fish liver will not be further discussed.

Levels of dioxins and dl-PCBs in fish liver

In Norway it is common to eat fish liver from Atlantic cod, (*Gadus morhua*) saithe (*Pollachius virens*) and haddock (*Melanogrammus aeglefinus*). These fish species have lean fillets and most energy storage is in the liver. The liver is very oily, and a fat content up to about 70% is common, ω-3 fatty acids counting up to 30%. Quite extensive volumes of fish liver from the three common codfishes are produced as a side product during fishing. This is about 13 000 tons from cod, 23 000 tons from saithe and 5000 tons from haddock. Some of this volume is used for processing cod liver oil following extensive clean-up to minimize the content of dioxins and PCBs, while the major part is discarded. A minor part is used for direct human consumption.

Analytical data on dioxins and dl-PCBs in fish liver are from cod only. In terms of management it is usual to think of three different stocks of cod. It is the southern stock in the North Sea, the coastal stock and the North Eastern Atlantic stock which grows up in the Barents Sea and comes into the Lofoten area to spawn. As cod stocks are distributed in different areas, like open sea, coastline and in the many fjords and harbours, it is assumed that the content of organic pollutants may vary.

Levels of dioxins and dl-PCBs in liver from fish caught in fjords, harbours and open coastline

For several years fish liver samples from different marine environments along the Norwegian coast line have been collected in various environmental monitoring programmes. In 2005, VKM in collaboration with The Norwegian Food Safety Authority and the Norwegian Pollution Control Agency, collected environmental monitoring data on fish and seafood in a report (Økland, 2005). To get a better detailed overview data on fish liver were systematized according to where the fish had been caught; harbours and fjords close to big cities and/or industrial zones, harbours and fjords close to small towns and villages and/or small industrial zones, open coastline and open oceans (Økland, 2006). Results on dioxins, dl-PCBs and other PCBs (Sum PCB_7) in fish liver from fish caught at different sites are summarised in Tables 1-3. More details about the different samples included are given in the Appendix.

Levels of dioxins and dl-PCBs in liver from fish living in contaminated marine environments vary from 30-740 pg TEQ/g (Table 1). Levels of dioxins and dl-PCBs in fish liver from fish caught in harbours and fjords close to small towns and villages and/or small industrial zones vary from 36-420 pg TEQ/g (Table 2). Levels of dioxins and dl-PCBs in fish liver from fish caught in open coastline vary from 40-130 pg TEQ/g (Table 3).

Table 1. Mean, median, minimum and maximum concentrations of different dioxins and PCBs parameters in fish liver samples from fish caught in a marine environment near cities and/or industrial zones. Toxic equivalence (TEQ) is given in ng/kg fresh weight. PCB_7 is given in microgram/kg fresh weight.

Parameter	No. of samples	Mean	Median	Minimum	Maximum
TEQ PCDD/F	26	57,5	5,8	1,8	587
TEQ n-o PCB	41	93,6	67,2	14,9	255
TEQ m-o PCB	51	75,3	54	8,9	355
Sum TEQ PCB	35	181,1	128	24,3	610,4
Sum TEQ PCB+PCDD/F	20	220,8	172,5	28,8	738,7
Sum PCB_7	61	1736,8	1208,1	166,9	6584,6

Table 2. Mean, median, minimum and maximum concentrations of different dioxins and PCBs parameters in fish liver samples from fish caught in a marine environment near small towns and villages and/or small industrial zones. Toxic equivalence (TEQ) is given in ng/kg fresh weight. PCB_7 is given in microgram/kg fresh weight.

Parameter	No. of samples	Mean	Median	Minimum	Maximum
TEQ PCDD/F	19	6,8	6,3	2	25,5
TEQ n-o PCB	40	87,3	48,9	11,3	745,3
TEQ m-o PCB	34	47,8	32,2	5	260
Sum TEQ PCB	27	111,6	72	16,6	393,8
Sum TEQ PCB+PCDD/F	6	139,5	84,6	35,8	419,3
Sum PCB_7	66	1161,3	689,4	67,8	8030,8

Table 3. Mean, median, minimum and maximum concentrations of different dioxins and PCBs parameters in fish liver samples from fish caught in open coastline. Toxic equivalence (TEQ) is given in ng/kg fresh weight. PCB_7 is given in microgram/kg fresh weight.

Parameter	No. of samples	Mean	Median	Minimum	Maximum
TEQ PCDD/F	8	29,6	27,1	6,1	56,7
TEQ n-o PCB	9	29,5	31,8	5,1	38,1
TEQ m-o PCB	5	18,8	10,7	8,2	48
Sum TEQ PCB	5	47,4	46,3	14,4	83
Sum TEQ PCB+PCDD/F	4	76,2	78,4	45	103
Sum PCB_7	10	292,1	239,4	110	825

Levels of dioxins and dl-PCBs in liver from cod caught in the Barents Sea

Just a few analytical data on dioxins and PCBs in fish liver from open sea were reported in the report from Bergfald & Co, and most of them were quite old (from 1995). Panel 5 of VKM has chosen not to include them in this opinion.

In 2007 several data on dioxins and dioxin-like PCBs in cod liver from the Northern stock (fish from Lofoten/Barents Sea) have been made available from The National Institute of Nutrition and Seafood Research (NIFES). These are presented in Figure 1. More details are found in the Appendix.

Levels of dioxins and dl-PCBs in fish liver from open sea range from 3-66 pg TEQ/g (Figure 1). All samples from 2002 and 2003 contain less than 20 pg TEQ/g, whereas 11 samples from 2006 contain more than 20 pg TEQ/g. The reason for this variability is not known. The median value for the individual samples presented is 13.0 pg TEQ/g and the mean value is 16.7 pg TEQ/g.

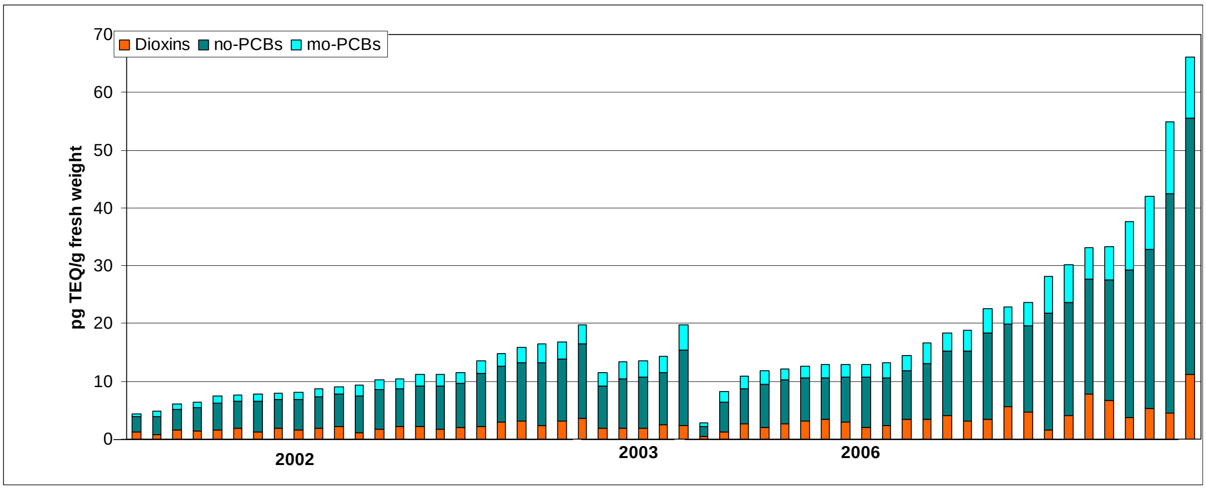


Figure 1. Dioxins and dl-PCBs in cod liver samples (pg TEQ (WHO 1998)/g fresh weight, upper bound[1]) from Lofoten/Barents Sea. The 48 samples from 2002 and 2006 are individual samples whereas the five samples from 2003 are pooled from five livers. The samples are arranged with increasing total TEQ for each sampling year.

Recently the Panel 5 of VKM has given an opinion on the revised TEF-values from WHO in 2005 (VKM, 2007b). In order to evaluate the impact of the revised TEF-values on total TEQ in cod liver, the Panel 5 has calculated total TEQ with the TEFs from 1998 and the revised TEFs from 2005 in the individual cod liver samples presented in Figure 1 and in the Appendix.

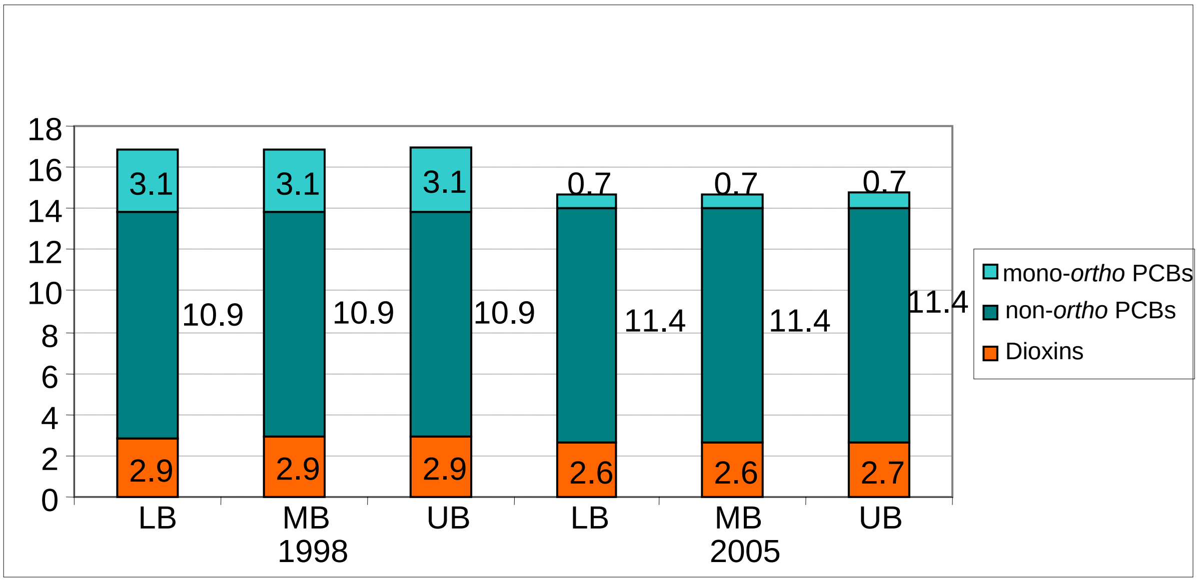


Figure 2. Average TEQ levels (pg/g) in cod liver samples calculated with TEFs from 1998 and 2005. The results are presented for lower bound (LB), medium bound (MB) and upper bound (UB) concentrations.

[1] TEQ can be calculated as lower bound, medium bound or upper bound levels. Using lower bound levels, the concentrations of all non-detected congeners in a sample are set to 0. For medium bound calculations, the concentrations of non-detected congeners are set to ½ the level of quantification. Using upper bound calculations, the concentrations of non-detected congeners are set equal to the level of quantification.

The results presented in Figure 2 indicate that TEQ levels calculated with the revised TEFs from 2005 would be approximately 13-14% lower. As shown in Figure 2 the TEQ levels are not influenced by lower bound, medium bound and upper bound concentrations, since practically all the different congeners of dioxins and dl-PCBs are detected in the fish liver samples.

<u>Levels of dioxins and dl-PCBs in roe-liver pâté</u>

The levels of dioxins and dl-PCBs in four samples of fish liver spread containing cod liver and roe range from 4.9-8.7 pg TEQ/g fresh weight (Table 4). The results are from The Norwegian Food Safety Authority's monitoring programme for dioxins and dl-PCBs and samples have been analysed by the Norwegian Institute for Air Research (NILU).

Table 4. Levels of dioxins and dl-PCBs (pg TEQ/g fresh weight, upper bound) in 4 samples of roe-liver pâté.

Fish liver spread	Sample no	Dioxins/Furans pg TEQ/g	dl-PCBs TEQ pg TEQ/g	Total TEQ pg TEQ/g
Lofotpostei	2005-1741	1.2	7.5	**8.7**
Lofotpostei	2006-0012	0.80	6.5	**7.3**
Svolværpostei	2005-1740	0.68	4.2	**4.9**
Svolværpostei	2006-0011	0.81	6.5	**7.3**

Exposure characterisation

<u>Dietary exposure to dioxins and dl-PCBs</u>

The intake of dl-PCBs and dioxins in the Norwegian population from fish and other seafood has been estimated on the basis of the Fish and Game Study, Part A. The median intake of dioxins and dl-PCBs from fish and other seafood is 4.7 pg TEQ/kg body weight/week. Fatty fish is an important source of dioxins and dioxin-like PCBs, while lean fish contribute little to the exposure (VKM, 2007a).

There is no single dietary survey in Norway that is suitable for investigating the impact of various contamination levels in different types of fish and other seafood, because the Norkost 1997 survey (Johansson & Solvoll, 1999), which covers the entire diet, did not include detailed questions on these foods. Panel 5 has chosen to add an estimated median intake (4 pg TE/kg body weight/week) from other foods than fish based on the Norkost 1997 survey (VKM, 2007a) on top on the estimated intake based on fish and other seafood from the Fish and Game Study, Part A (Meltzer *et al.*, 2002). There are several uncertainties connected to this approach, but this is the best estimate for total TEQ exposure from the entire diet that is available in Norway at present. More information on dietary surveys can be found in the report "A comprehensive assessment of fish and other seafood in the Norwegian diet" (VKM, 2007a).

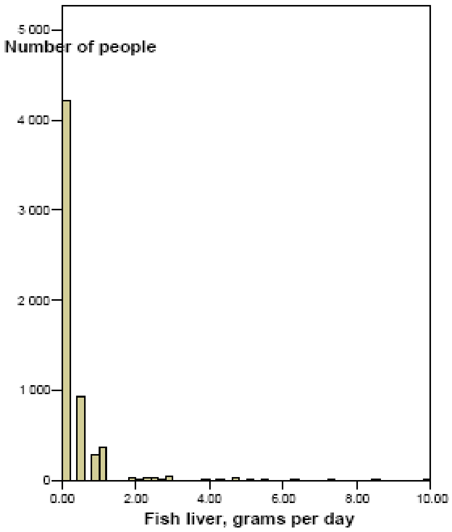
A preliminary assessment of dietary TEQ exposure among children is available (VKM, 2007a). It indicates that the median weekly exposure among 2, 4, 9 and 13 years old children is 18.5 pg TEQ/kg b.w., 13.0 pg TEQ/kg b.w., 8.8 pg TEQ/ kg b.w., and 5.6 pg TEQ/ kg b.w., respectively. The 95th percentile weekly TEQ exposure has been calculated to be 37.9 pg

TEQ/ kg b.w. (2 years old), 32.6 pg TEQ/kg b.w. (4 years old), 23.8 pg TEQ/kg b.w. (9 years old) and 14.7 pg TEQ/kg b.w. (13 years old). Fish consumption is higher for younger children than for older children, but the proportion of fish consumers is low among children compared with adults.

Consumption of fish liver

The consumption of liver from cod and saithe is very unevenly distributed throughout the adult population (Figure 3). Seventy per cent never eat fish liver, and the 95th percentile for consumption (among those who eat fish liver) is also low, i.e. approximately 3 grams/day. These figures do not include fish liver used in various types of spread, such as pâtés made of fish roe and fish liver. Based on sales figures, it is estimated that such pâtés account for approximately 2% of the fish spreads consumed (VKM, 2007a).

There are considerable regional differences in the consumption of fish liver. In the three northernmost counties of Norway, fish liver is eaten 2-3 times more often than in the rest of the country (VKM, 2007a). The regional differences are also found in another study (Brustad *et al.*, 2007).



	All participants (n = 6015)	Consumers only (n = 1803)
10th percentile	0	0.45
25th percentile	0	0.45
50th percentile	0	0.53
75th percentile	0.45	1.05
90th percentile	0.9	2.3
95th percentile	1.05	2.8
Average – SD	0.3 ± 0.7	1 ± 1
Min. – Max.	0 – 10	0.45 - 10

Figure 3. Consumption of fish liver in the Fish and Game Study, Part A. Fish liver refers to cod liver and saithe liver. This figure is from the report "A comprehensive assessment of fish and other seafood in the Norwegian diet" (VKM, 2007a).

Fish liver is commonly eaten together with cod in a Norwegian traditional dish, and 30 g has been stipulated as an average amount of fish liver consumed per meal (Meltzer *et al.*, 2002). The median consumption of 0.5 gram/day among fish liver consumers only corresponds to a consumption of one fish liver meal every second month. High consumption of fish liver, the 95th percentile, corresponds to nearly 3 meals of fish liver every month.

To the knowledge of Panel 5 nothing is known about fish liver consumption among children.

Intake of dioxins and dl-PCBs from fish liver

Since relatively few people eat fish liver, the median total TEQ intake among all Norwegians is hardly affected by fish liver consumption. However, fish liver consumption may have a pronounced impact on total TEQ intake on an individual basis. In the following, the exposure assessment will be done for the adult consumers of fish liver (30% of the total Norwegian population). Panel 5 has made a theoretical calculation (Figure 4), where different levels of dioxins and dl-PCBs in fish liver (10, 20, 30, 60, 100 and 200 pg TEQ/g) are combined with the consumption rates among those who eat fish liver in the Fish and Game Study, Part A (Figure 3). The different TEQ levels in fish liver are reflecting the different levels found in liver from cod in Norway, in the lack of analytical data in liver from saithe. The figure illustrates that the fish liver alone could be a significant source to the TEQ intake, especially for the high consumers of fish liver (90th and 95th percentile).

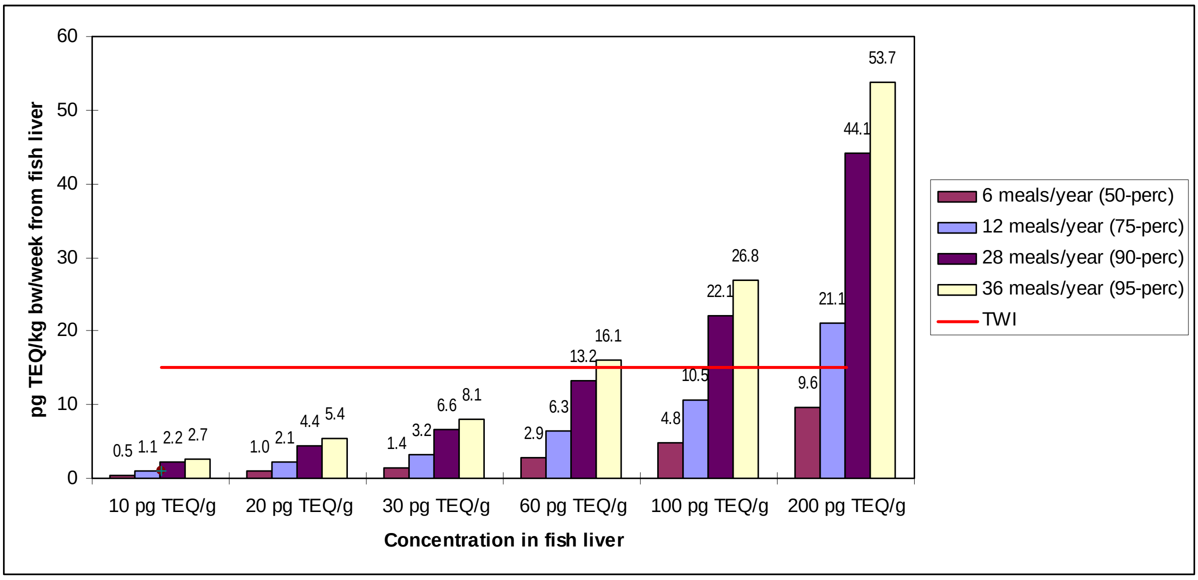


Figure 4. Theoretical calculated intake of dioxins and dl-PCBs from fish liver containing different levels of dioxins and dl-PCBs. Intakes are shown as pg TEQ/kg body weight/week, assuming a body weight of 70 kg. Consumption data are from the Fish and Game Study, Part A, consumers of fish liver only. The numbers of fish liver meals per year reflect the consumption percentiles among fish liver consumers only, presented in figure 3. The g/days have been translated into meals per year, assuming a portion size of 30 g fish liver/meal. The numbers above the bars show the calculated intake from fish liver.

The theoretical intake calculations (Figure 4) indicate that if fish liver contains more than 60 pg TEQ/g, those with a high consumption of fish liver (95th percentile, nearly 3 meals of 30 g fish liver per month) will exceed SCF's TWI for dioxins and dl-PCBs (14 pg TEQ/kg body weight) from fish liver consumption alone. A level of 20 pg TEQ/g fish liver would for high consumers correspond to a similar intake of dioxins and dl-PCBs as the Norwegian median intake. Eating fish liver with a content of 10 pg TEQ/g fish liver would for the high consumers lead to an intake which contributes with less than 20% of the TWI for dioxins and dl-PCBs. For median consumers of fish liver (one meal of 30 g fish liver every second month), contamination levels between 10 and 30 pg TEQ/g would lead to low intakes of dioxins and dl-PCBs from fish liver alone. A level of 60 pg TEQ/g would for a median consumer lead to an intake which is 20% of TWI, while levels of 100 and 200 pg TEQ/g would for the median fish liver consumer correspond to intakes which are 34% and 69% of the TWI respectively.

Impact of fish liver consumption on total dietary TEQ exposure

As Figure 4 shows the TEQ intake from fish liver only, it does not give a picture of intake of dioxins and dl-PCBs from the total diet. Figure 5 shows the calculated intakes of dioxins and dl-PCBs from fish and other seafood with various TEQ levels in fish liver (10, 30, 60, 100 and 200 pg TEQ/g) (VKM, 2007a). The percentiles show total TEQ intake per kg body weight per week from all fish and other seafood consumed, with varying contamination level in fish liver. Consumption data are from the Fish and Game Study, Part A, for fish liver consumers only. The results indicate that if fish liver contains 60 pg TEQ/g, 25% of the consumers will exceed the TWI for dioxins and dl-PCBs from their consumption of fish and other seafood only. The exposure from the rest of the diet would come in addition. The remaining foods in the Norwegian diet (all food except fish and other seafood) has been estimated to contribute approximately 4 pg TEQ/kg body weight/week (median value, data based on Norkost 1997 (VKM, 2007a)). When this is added to the contribution from fish and other seafood, it can be interpreted from Figure 5 that at a contamination level of 30 pg TEQ/g in fish liver, 75% of the cod liver consumers will have exposures below the TWI. However, even at the lowest concentration in fish liver (10 pg TEQ/g) used in the calculations, those with highest TEQ exposure from fish and other seafood will exceed TWI. This illustrates the high contribution from fish and other seafood in addition to fish liver.

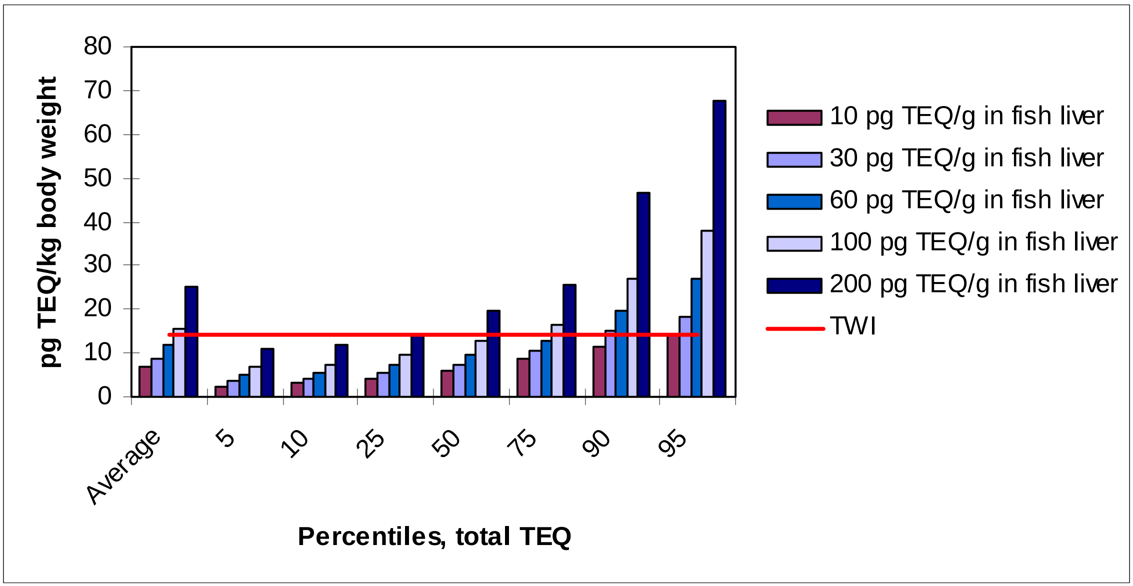


Figure 5. Theoretical calculated intake of dioxins and dl-PCBs (pg TEQ/kg body weight/week) from fish and other seafood with different levels of dioxins and dl-PCBs in fish liver. Consumption data are from the Fish and Game Study, Part A, fish liver consumers only. The results are presented as the average and percentiles for total TEQ intake. The red line indicates TWI at 14 pg TEQ/kg bw/week.

Intake of dioxins and dl-PCBs from roe-liver pâté

Consumption of roe-liver pâté as bread spread is not well characterised in the general population. However, The Norwegian Mother and Child Cohort Study[2] included specific questions about pâtés made of fish roe and fish liver in the questionnaire answered by the pregnant women. From 2002 to 2006, data from approximately 60 000 pregnant women have been collected. Of these, approximately 3.4% were consumers of such bread spread, and approximately 2% (1216 of the participants) were consumers on a weekly or daily basis. Since 2002, children, women of child bearing-age and pregnant women have been advised not to eat fish liver or roe-liver pâté. The proportions of pregnant women eating roe-liver pâté on a weekly or daily basis seem to be declining from 2002 to 2006 (table 5). This could indicate that the consumption advices are followed by pregnant women.

In total, 2502 questionnaires were registered before the Norwegian Food Safety Authority gave consumption advice for fish liver spread to children, women of child bearing-age and pregnant women, and 218 (8.2%) pregnant woman answered that they consumed fish liver spread. This may be more representative for the consumption in the general populations.

Table 5. Consumers (% of total participants) of roe-liver pâté in The Norwegian Mother and Child Cohort Study (Personal communication, Margaretha Haugen, Norwegian Institute of Public Health)

Year	Daily consumers	Weekly consumers
2002-2006	0.5%	1.5%
2002	1%	2.6%
2003	0.6%	1.5%
2004	0.6%	1.2%
2005	0.2%	0.7%
2006	0.2%	0.5%

Table 6 shows a theoretical intake calculation of dioxins and dl-PCBs exposure from roe-liver pâté with a mean value (7 pg TEQ/g) on slices of bread. In this calculation it is assumed that 25 g roe-liver pâté is used on each slice of bread (standard portion size, The Norwegian Mother and Child Cohort). One tin of roe-liver pâté contains 100 g. Intake of dioxins and dl-PCBs from one slice of bread is 2.5 pg TEQ/kg b.w., while the calculated intake from 7 slices of bread is 18 pg TEQ/kg b.w.

[2] **The Norwegian Mother and Child Cohort Study** (www.fhi.no)

Objective: The main objective of this study is to promote better prevention and treatment of serious diseases and greater knowledge about causal connections. The study will form the basis of a number of research projects that aim to understand the significance of various factors in pregnancy for the subsequent development of health and disease in the mother and child. Number of participants/ages: Nationwide study that recruits women in approximately their fourth month of pregnancy. The goal is to obtain a total of 100 000 participating mothers. Methodology: Semi-quantitative food frequency questionnaire.

Table 6. Theoretical intake of dioxins and dl-PCBs from roe-liver pâté expressed as pg TEQ/kg body weight.

	Slices of bred with roe-liver pâté containing average level of dioxins and dl-PCBs (7 pg TEQ/g)							
	1 slice (25 g)	**2 slices** (50 g)	**3 slices** (75 g)	**4 slices** (100 g)	**5 slices** (125 g)	**6 slices** (150 g)	**7 slices** (175 g)	**8 slices** (200 g)
Intake adult (70 kg) pg TEQ/kg bw	2.5	5	7.5	10	12.5	15	17.5	20
Intake children (20 kg) pg TEQ/kg bw	9	18	26	35	44	53	61	70

Eating between 5-6 slices of bread regularly on a weekly basis with roe-liver pâté containing mean levels of dioxins and dl-PCBs would alone reach the TWI. For children, the exposure would be higher per kg body weight, and they will exceed the TWI from the roe-liver pâté only if they consume two slices of bread with roe-liver pâté weekly.

Risk characterisation

The TWI for dioxins and dl-PCBs (SCF, 2001) has been established to protect the most sensitive life stage, i.e. the foetal stage against reproductive and developmental toxicity. However, dioxins and dioxin-like PCBs have such a long half-life in the body that the body burden during pregnancy is not a result of the diet during pregnancy but of the diet during the many years prior to pregnancy. Women who are pregnant or who will become pregnant, and the foetuses, are therefore the most vulnerable group. It is the total accumulated amount of dioxins and dioxin-like PCBs ingested throughout life and throughout the fertile period that is of significance. Women above fertile age and men are believed to be less sensitive to exposure to dioxins and dl-PCB. Swedish experts have suggested that cancer is the most sensitive adverse effect of chronic exposure for other groups than children and women that are in child-bearing age (Hanberg *et al.*, 2007). They concluded that based on current scientific knowledge, a TDI range of 2-10 pg TEQ/kg body weight represents exposure levels where human cancer risks are very low or non-existing. This corresponds to a weekly intake of 14-70 pg TEQ/kg body weight.

Higher exposure than the TWI will reduce the safety margins in the risk assessment of dioxins and dl-PCBs. The risk connected to this can not be quantified.

Fish liver

Dietary exposure assessments indicate that Norwegians with high exposure to dioxins and dl-PCBs (95th percentile), will exceed the TWI for dioxins and dl-PCBs when contribution from other food is added, even when the lowest level (10 pg TEQ/g) in fish liver were used in the calculations. However, when fish liver contains between 60 and 200 pg TEQ/g, the exposure assessments from the total diet indicate that those at the 95th percentile exposure would be exceeding the TWI from two to more than five times. However, the exposure from the total diet at a contamination level of 100 pg TEQ/g in fish liver would not exceed the highest TDI for non-developmental health effects suggested by Swedish experts, which corresponds to a weekly intake of 70 pg TEQ/kg body weight.

If fish liver contains 60 pg TEQ/g, those with a high consumption of fish liver (95th percentile, nearly 3 meals of 30 g fish liver per month) will exceed TWI from fish liver consumption alone. High consumption of fish liver with a level of 30 pg TEQ/g would alone contribute with nearly 60% of TWI.

Those with median exposure (50th percentile) to dioxins and dl-PCBs from fish and other seafood, including fish liver, could eat fish liver containing up to 60 pg TEQ/g without exceeding TWI from the total diet. A level of 60 pg TEQ/g in fish liver will for those with a median fish liver consumption (six meals of 30 g fish liver per year) lead to an intake which is 20% of TWI from fish liver alone.

Cod liver consumption among children is not known. Due to children's higher energy requirements per kg body weight than adults, their dietary exposure to dioxins and PCBs is higher. Regular consumption of cod liver at any contamination level could be a major exposure source among children.

Bread spread containing fish liver

Consumption of 5 to 6 slices of bread with roe-liver pâté containing mean levels of dioxins and dl-PCBs (7 pg TEQ/g) regularly on a weekly basis would alone fill up the TWI. One slice of bread with roe-liver pâté every week would contribute to 20% of TWI among adults.

Consumption of roe-liver pâté among children is not known. Because of their low body weight, regular consumption of such bread spread could be a significant source to dioxins and dl-PCBs exposure among children. One weekly slice of bread with roe-liver pâté would alone contribute to 70% of the TWI for a child with a body weight of 20 kg.

Uncertainties

There are several uncertainties connected to the dietary surveys. In lack of suitable dietary surveys which cover all foods know to be important sources for dioxins and dl-PCBs, intake calculations have been performed with a combination of two surveys. There are several uncertainties connected to this approach, but Panel 5 is of the opinion that this is the best estimate for total TEQ exposure from the entire diet that is available in Norway at present. Further, the consumption surveys are quite old since data were collected in 1997 and 1999, and the consumption patterns among Norwegians may have changed. Intake calculation of dioxins and dl-PCBs among children are preliminary, and there is no information available on fish liver consumption, including roe-liver pâté in children. There are also uncertainties connected to the portion sizes used in the intake estimates.

Panel 5 is of the opinion that there are sufficient data on levels of dioxins and dl-PCBs in cod liver from the Barents Sea to get a picture of the contamination levels in fish liver from that region. However, there are variabilities between data from 2002 and 2006 from the Barents Sea and the reason for this is not known. There are very few data available on dioxins and dl-PCBs in fish liver from fish caught in open coastline, and therefore it is not possible to assess average levels in fish liver from such areas in Norway. There are no data from saithe liver available which is also known to be consumed.

CONCLUSION

Panel 5 is of the opinion that the exposure of dioxins and dl-PCBs among children and in women that are in child-bearing age preferably should be below the TWI for dioxins and dl-PCBs at 14 pg TEQ/kg body weight. Women above fertile age and men are believed to be less sensitive to exposure to dioxins and dl-PCBs, and for these groups of the population, exposure moderately above the TWI is not believed to be connected to increased risk of negative health effects.

Fish liver could be a significant source of dioxins and dl-PCBs depending on the contamination levels found. A level of 60 pg TEQ/g in fish liver would for those with median fish liver consumption (six meals of 30 g fish liver per year) lead to an intake which is 20% of the TWI from fish liver alone. Those with median exposure to dioxins and dl-PCBs from fish and other seafood, including fish liver, could eat fish liver containing up to 60 pg TEQ/g without exceeding the TWI from the total diet.

High consumption of fish liver with a level of 30 pg TEQ/g would singly contribute with nearly 60% of the TWI. At a contamination level of 30 pg TEQ/g in fish liver, 75% of the cod liver consumers will have exposures below the TWI.

The 95th percentile exposure from total diet at a contamination level of up to 100 pg TEQ/g in fish liver would not exceed the highest TDI for non-developmental health effects suggested by Swedish experts, which corresponds to a weekly intake of 70 pg TEQ/kg body weight.

Available analytical results indicate that liver from cod caught in the Barents Sea contains less dioxins and dl-PCBs than liver from fish caught near cities and/or industrial zones, small towns and villages in Norway, which appears to have median levels above 60 pg TEQ/g. Only one of the 53 samples from the Barents Sea contained more than 60 pg TEQ/g. Over time, the liver consumed from fish caught in the Barents Sea would tend to contain the average concentration of approximately 15 pg TEQ/g liver. The four analyses on liver from fish caught at the open coastline are not sufficient to conclude about the contamination level.

Panel 5 is of the opinion that roe-liver pâté used as bread spread could be a significant source for dioxins and dl-PCBs. People that consume this bread spread regularly increase the probability of exceeding the TWI for dioxins and dl-PCBs.

Fish liver is a rich source for several nutrients, like marine n-3 fatty acids and vitamins A and D. However, the possible nutritional benefits of eating fish liver have not been taken into consideration.

REFERENCES

Brustad M, Sandanger TM, Andersen V & Lund E (2007) POP exposure from fish liver consumption and risk of cancer - the Norwegian Women and Cancer Study. *Journal of Environmental Monitoring* **9**, 682-686.

Hanberg A, Öberg M, Sand S, Darnerud PO & Glynn A (2007) *Risk assessment of non-developmental health effects of polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans and dioxin-like polychlorinated biphenyls in food* no. Rapport 11 - 2007: Livsmedelsverket.

JECFA (2001) *Joint FAO/WHO Expert Committee on Food Additives, Summary and conclusions. Fifty-seventh meeting, Rome, 5-14 June 2001. Summary and conclusions* no. Fifty-seventh meeting, Rome, 2001.

Johansson L & Solvoll K (1999) *NORKOST 1997. Landsomfattende kostholdsundersøkelse blant menn og kvinner i alder 16-79 år* no. 2/1999: Statens råd for ernæring og fysisk aktivitet.

Meltzer H, Bergsten C & Stigum H (2002) *Fisk og viltundersøkelsen. Konsum av matvarer som kan ha betydning for inntaket av kvikksølv, kadmium og PCB/dioksin i norsk kosthold* no. SNT-rapport 6, 2002.

Økland TE (2005) *Kostholdsråd i norske havner og fjorder. En gjennomgang av kostholdsråd i norske havner og fjorder fra 1960-tallet til i dag.*: [VKM, SFT og Mattilsynet, editors], Bergfald & Co as.

Økland TE (2006) *Nivåer av PCB og dioxiner i torskelever*: [VKM, editor], Bergfald & Co as.

SCF (2001) *Opinion of the Scientific Committee on Food on the Risk assessment of dioxins and dioxin-like PCBs in food*.

VKM (2007a) *A comprehensive assessment of fish and other seafood in the Norwegian diet*: Norwegian Scientific Committee of Food Safety, English translation published 2007. ISBN: 978-82-8082-207-9.

VKM (2007b) *New WHO TEFs for dioxins and dioxin-like PCBs:*
Assessment of consequence of altered TEF values for dioxins and dioxin-like PCBs on current exposure in the Norwegian population.

APPENDIX

Area: Close to cities and/or industrial zones

Dioxins and dioxin-like PCBs are given in TEQ, ng/kg fresh weight
Data for PCB7 and the different PCB congeners are given in microgram/kg fresh weight.

Place	Year	EQ PCDF/D	EQ n-o PCB	EQ m-o PCB	EQ PCB	um TEQ	Sum PCB7	PCB28	PCB52	PCB101	PCB118	PCB138	PCB153	PCB180	TEF	Kilde
Oslo, Bunnefjorden	1997/1998	6,9	133,6	112,7	246,3	251,8	2958	39	115	405	576	749	872	202	i-TEF og WHO. **)	TA-1694/1999
Oslo, Bekkelagsbassenget	1997/1998	11,2	181,8	93,1	274,9	286,1	3087	45	112	451	258	916	1047	258	i-TEF og WHO. **)	TA-1694/1999
Oslo, Hovedøya	1997/1998	8,2	209,1	185	394,1	402,3	4862	43	201	767	854	1221	1385	391	i-TEF og WHO. **)	TA-1694/1999
Oslo, Lysakerfjorden	1997/1998	11,5	203,8	151,6	355,4	366,9	3941	46	147	632	750	974	1108	284	i-TEF og WHO. **)	TA-1694/1999
Hurumlandet, VEAS	1997/1998	10,2	162,3	119,2	281,5	291,7	2928	34	78	329	605	751	909	222	i-TEF og WHO. **)	TA-1694/1999
Bærumsbassenget	1997/1998						2938	45	157	437	603	718	802	176		TA-1694/1999
Oslofjorden (JAMP 30B)	2003						2140									TA-2072/2004
Mossesundet	1999		57,4	43,7	101,1		1266	13	23	90	200	360	430	150	WHO	TA-1885/2002
Horten indre havn	2000/2002		182	156	338		4671,6	45,6	128	430	763	1126	1711	468	WHO	TA-1885/2002
Horten ytre havn	2000/2002		50	30	80		1058,8	13	26,7	77,1	129	259	406	148	WHO	TA-1885/2002
Vrengen st. C	1999		67,2	47,3	114,5		1359	13	41	120	250	360	500	75	WHO	TA-1885/2002
Vrengen st. D	1999		214,6	144	358,6		3588	19	59	250	720	1000	1300	240	WHO	TA-1885/2002
Vrengen St. E	1999		60,4	36,6	97		905,5	7,5	21	50	180	230	340	77	WHO	TA-1885/2002
Tønsberg havn	1999		71,3	48,8	120,1		1399	15	57	170	260	360	460	77	WHO	TA-1885/2002
Fredrikstad	1999		26,5	51,7	78,2		1435	28	47	150	250	380	450	130	WHO	TA-1885/2002
Sandefjordsfjorden, indre	2005	2,3	38,3				607,7	3,5	6,2	27	85	170	250	66	WHO	NIVA, notat
Grenland, Frier	2001	587	128	23,7	151,7	738,7	645,9	3,9	20	45	67	150	240	120	WHO	TA-1973/2003
Grenland, Brevik	2001	182	72,5	11,2	83,7	265,7	287,7	3,5	9,2	21	43	71	110	30	WHO	TA-1973/2003
Grenland, Frier	2004	339	122												WHO	TA-2125/2005
Grenland, Brevik	2004	228	47,1												WHO	TA-2125/2005
Arendal Galten	1997		53,4	35,9	89,3		587,9	7,3		36,8	95,7	153	211	84,1	Nord.	TA-1728/2000
Arendal Galten, dypvannstorsk	1997		96,1	39	135,1		662	5,3	9,6	34	118	172	246	77,1	Nord.	TA-1728/2000
Arendal Galten, rødtorsk	1997		24,3	8,9	33,2		166,9	3	2,7	14,3	28,2	45	59,6	14,1	Nord.	TA-1728/2000
Arendal Knubben	1997		165,1	63,7	228,8		1084,6	29,4	39,2	105	215	242	354	100	Nord.	TA-1728/2000
Arendal Kolbjørnsvik	1997		255	355	610,4		4784,1	14,9	79,2	452	1143	1193	1517	385	Nord.	TA-1728/2000
Arendal havn	1997		90,5	73,4	163,9		1299,9	21,2	72,7	103	211	438	302	152	Nord.	TA-1728/2000
Kristiansand, Dybingen	1996	30,2	153	20,8	173,8	204	456	4	8	27	60	123	176	58	i-TEF og WHO. **)	TA-1539/1998
Kristiansand, Bragdøya	1996	17,9	77,8	16,9	94,7	112,6	328	4	8	24	43	81	132	36	i-TEF og WHO. **)	TA-1539/1998
Kristiansand, Topdalsfjorden	1997		64,8	225,1	289,9		4400,8	16,6	23,2	236	441	1175	1769	740	Nord.	TA1728/2000

Area: Close to small towns and villages and/or small industrial zones

Dioxins and dioxin-like PCBs are given in TEQ, ng/kg fresh weight
Data for PCB7 and the different PCB congeners are given in microgram/kg fresh weight.

Hurumlandet, Dyno (Sætre)	1997/1998	25,5	275,6	118,2	393,8	419,3	2968	34	120	364	582	742	893	233	i-TEF og WHO. ***)	TA-1694/199
Hvitsten	1999		56,1	49,2	105,3		1629,9	7,9	22	100	170	450	610	270	WHO	TA1885/2002
Holmestrand	1999		65,6	69	134,6		1956	17	39	190	310	580	640	180	WHO	TA1885/2002
Tønsberg/Valløybukta	1999		51,7	32,8	84,5		689,4	8,4	31	48	160	160	220	62	WHO	TA1885/2002
Sandefjordsfjorden, ytre	2005	5	63,5				2069,5	5,5	14	100	200	570	880	300	WHO	NIVA, notat
Stavern	1999		35,5	31,5	65		820	13	18	62	150	220	280	77	WHO	TA1885/2002
Kragerø st. B	1999		36,3	15,8	52,1		422,9	5,9	14	36	77	110	141	39	WHO	TA-1885/200
Kragerø st. C	1999		32	16,9	48,9		492,1	5,1	12	26	74	130	183	62	WHO	TA1885/2002
Risør	1997			15,1			249,8	11,4	11,4	27,7	52,7	56,5	72,3	17,8	Nord.	TA1728/2000
Tvedestrand	1997		144,5	108,5	253		1549,2	36,4	20,8	102	394	404	479	113	Nord.	TA1728/2000
Grimstad havn	1997		43	24,6	67,6		395,3	5,7		25,2	73,2	99	146	46,2	Nord.	TA1728/2000
Grimstad Vikkilen	1997		15,2	55,5	70,7		1113	11	13	88	220	314	392	75	Nord.	TA1728/2000
Lillesand	1997			9,6			170,9	4,5		17,2	32,5	46	57,3	13,4	Nord.	TA1728/2000
Kristiansand, Dvergsøy	1996	10,5	45	23	68	78,5	366	3	6	23	56	90	148	40	i-TEF og WHO. ***)	TA-1539/199
Kristiansand, Kalvøy	1996	5,5	21,9	8,4	30,3	35,8	178	2	3	10	25	46	75	17	i-TEF og WHO. ***)	TA-1539/199
Farsund nord	1997		33,5	149,3	182,8		2846,3	8,1	8,2	192	371	715	1115	437	Nord.	TA1728/2000
Farsund Lundevågen	1997		98,5	70,7	169,2		1126,3	5,8	6,5	66	195	250	464	139	Nord.	TA1728/2000
Flekkefjord Tjørsvåg	1997		87,3	81,7	169		1618	20	36	120	228	384	623	207	Nord.	TA1728/2000
Flekkefjord Lafjorden	1997		83,8	48,5	132,3		909,2	6,7	8,6	57,9	123	220	376	117	Nord.	TA1728/2000
Egersund, bynær blandprøve	1999/2000	7,9	82	48	130	137,9	1258	15,4	19,2	97,9	210,9	312,7	498,9	103,1	WHO	TA-1843/200
Stavanger, Vassøy (ref.st.)	1999/2000			13			304,5		5,2	19	45,6	78,9	120,2	35,6	WHO	TA-1843/200
Stavanger, Dusavika	1999/2000			43			842	7,4	10,7	47,3	162,6	203,7	313,1	97,6	WHO	TA-1843/200
Sandnes, Hinnavågen	1999/2000			51			1261	5,2	15,4	78,4	170	314,3	491,7	186,1	WHO	TA-1843/200
Sandnes, Dale	1999/2000			34			846		11,1	55,4	125,5	214,2	328,8	111	WHO	TA-1843/200
Karmøya, Visnes	1999/2000			5			67,8					23,1	32,9	11,8	WHO	TA-1843/200
Karmøya, Vedavågen	1999/2000	4,6	40	46	86	90,6	927	4,1	16	62,5	167,1	222,6	332,9	121,4	WHO	TA-1843/200
Saudafjorden, ytre	2001	2,95	15,3				107,6	1,5	2,4	7,4	15,1	27,6	42,4	11,2	WHO	NIVA 4446-2
Sørfjorden, Strandebarm	2003						92,6									TA-2045/200
Bergen, Byfjorden Eidsvåg	2001						1262	14	55	160	214	324	290	205		NMT Bergen
Bergen, Koltveitosen	2001						1286	14	27	71	129	263	614	168		NMT Bergen
Bergen, Grimstadfjorden	2001						1932	42	176	283	449	358	501	123		NMT Bergen
Fanafjorden (sør for Bergen)	2001						182	10	22	26	25	33	58	8		NMT Bergen

Area: Open coastline

Dioxins and dioxin-like PCBs are given in TEQ, ng/kg fresh weight
Data for PCB7 and the different PCB congeners are given in microgram/kg fresh weight.

Place	Year	EQ PCDF/D	EQ n-o PCB	EQ m-o PCB	EQ PCB	Sum TEQ	Sum PCB7	PCB28	PCB52	PCB101	PCB118	PCB138	PCB153	PCB180	TEF	Kilde
Grenland, Såstein	2001	56,7	38,1	8,2	46,3	103	225,5	3,8	8,7	17	36	57	79	24	WHO	TA-1973/2003
Kragerø, Jomfruland	2001	53,6	31,8												WHO	TA-1973/2003
Grenland, Såstein	2004	50,1	29,2												WHO	TA-2125/2005
Kragerø, Jomfruland	2004	44,6	25,4												WHO	TA-2125/2005
Kristiansand, Flekkerøya	1996	9,4	35	48 *)	83	92,4	325								Nord.	SNT 4:1999
Kristiansandsfj., Vestergapet	1996	9,5	37,2	17,7	54,9	64,4	336	4	7	28	47	87	129	34	i-TEF og WHO. **)	TA-1539/1998
Ny Hellesund	1996	6,5	27,8	10,7	38,5	45	209	4	6	15	34	50	80	20	i-TEF og WHO. **)	TA-1539/1998
Lista (JAMP 15B)	2003						213									TA-2072/2004
Karihavet (JAMP 23B)	2003						114									TA-2072/2004
Herdlaflaket (Hordaland)	2001						825	7	35	100	156	237	243	47		NMT Bergen, 2
Sør av Ramsundet (ref. stasjon)	1997		5,1	9,3 *)	14,4		253,3	2,7	7,6	19,5	27,2	64,2	96	36,1	WHO	DNV 98-3455
Vestfjorden (JAMP 98B)	2003						110									TA-2072/2004
Henningsværstraumen	1994	6,1	36				310,4								Nord.	SNT 4:1997
Min. concentration		6,1	5,1	8,2	14,4	45	110									
Max. concentration		56,7	38,1	48	83	103	825									
Median		27,1	31,8	10,7	46,3	78,4	239,4									
Mean		**29,6**	**29,5**	**18,8**	**47,4**	**76,2**	**292,1**	**4,3**	**12,86**	**35,9**	**60,04**	**99,04**	**125,4**	**32,22**		

*) including also di-*ortho* PCBs
**) i-TEF for dioxins and furans, WHO for dioxin-like PCBs

I cells "TEF" is given an equivalency model for toxic equivalency (TEQ)
WHO: TEQ from WHO-1998
i-TEF: TEQ from International model
Nord: TEQ from Nordic model.

Dioxins and dioxin-like PCBs in 48 individual cod liver samples from the Northern stock (fish from Lofoten/Barents Sea). The samples are from The National Institute of Nutrition and Seafood Research (NIFES).

Cod liver 1998-TEF		UB			Cod liver 2005-TEF		UB		
Sample	**year**	Dioxins	sum dlPCBs	sum TEQ	**Sample**	**Year**	Dioxins	sum dlPCBs	sum TEQ
02_1800_1	2002	2.13	6.93	9.06	02_1800_1	2002	1.98	6.10	8.08
02_1800_2	2002	3.63	16.05	19.68	02_1800_2	2002	3.46	14.02	17.48
02_1800_3	2002	3.09	12.83	15.92	02_1800_3	2002	2.77	11.09	13.86
02_1800_4	2002	2.02	9.48	11.50	02_1800_4	2002	1.90	8.33	10.23
02_1800_5dny.xls	2002	0.83	3.93	4.76	02_1800_5dny.xls	2002	0.78	3.41	4.19
02_1800_6	2002	3.08	13.68	16.76	02_1800_6	2002	2.77	11.92	14.69
02_1800_7	2002	1.31	3.12	4.43	02_1800_7	2002	1.20	2.77	3.97
02_1800_8	2002	1.81	5.77	7.58	02_1800_8	2002	1.66	5.12	6.78
02_1800_9	2002	1.29	6.51	7.80	02_1800_9	2002	1.17	5.64	6.81
02_1800_10	2002	1.84	6.12	7.96	02_1800_10	2002	1.73	5.40	7.12
02_1800_11	2002	2.93	11.79	14.72	02_1800_11	2002	2.76	10.41	13.16
02_1800_12	2002	2.19	11.37	13.56	02_1800_12	2002	2.04	9.95	11.99
02_1800_13	2002	3.10	9.47	12.57	02_1800_13	2002	2.79	8.18	10.97
02_1800_14	2002	1.70	9.54	11.25	02_1800_14	2002	1.59	8.17	9.76
02_1800_15	2002	1.38	5.08	6.45	02_1800_15	2002	1.29	4.41	5.70
02_1800_16	2002	1.58	6.57	8.14	02_1800_16	2002	1.47	5.75	7.22
02_1800_17	2002	1.14	8.20	9.34	02_1800_17	2002	1.03	6.97	8.00
02_1800_18	2002	2.32	14.22	16.55	02_1800_18	2002	2.18	11.91	14.10
02_1800_19	2002	1.55	4.52	6.07	02_1800_19	2002	1.43	3.94	5.37
02_1800_20	2002	1.55	5.86	7.40	02_1800_20	2002	1.43	5.08	6.51
02_1800_21	2002	2.12	8.25	10.37	02_1800_21	2002	1.98	7.17	9.16
02_1800_23	2002	2.11	9.05	11.16	02_1800_23	2002	1.88	7.66	9.54
02_1800_24	2002	1.71	8.54	10.25	02_1800_24	2002	1.61	7.46	9.08
02_1800_25	2002	1.90	6.85	8.75	02_1800_25	2002	1.81	5.97	7.78
2006_245_2	2006	3.81	33.78	37.59	2006_245_2	2006	3.60	28.50	32.09
2006_245_4	2006	3.46	9.39	12.85	2006_245_4	2006	2.93	7.90	10.83
2006_245_6	2006	11.27	54.78	66.05	2006_245_6	2006	10.58	49.31	59.88
2006_245_8	2006	4.01	26.15	30.16	2006_245_8	2006	3.57	21.73	25.30
2006_245_10	2006	1.60	26.60	28.20	2006_245_10	2006	1.49	22.54	24.03
2006_245_12	2006	3.37	11.05	14.43	2006_245_12	2006	2.94	9.45	12.39
2006_245_14	2006	0.45	2.32	2.77	2006_245_14	2006	0.40	1.94	2.33
2006_245_18	2006	2.04	10.95	12.99	2006_245_18	2006	1.90	9.68	11.59
2006_245_20	2006	2.57	8.28	10.85	2006_245_20	2006	2.19	6.92	9.11
2006_245_22	2006	2.61	9.56	12.17	2006_245_22	2006	2.36	8.43	10.79
2006_245_24	2006	3.36	19.23	22.59	2006_245_24	2006	3.02	16.47	19.50
2006_245_26	2006	1.19	7.03	8.22	2006_245_26	2006	1.12	5.85	6.97
2006_245_28	2006	4.66	18.96	23.62	2006_245_28	2006	4.15	16.66	20.82
2006_245_30	2006	2.02	9.77	11.79	2006_245_30	2006	1.76	8.25	10.01
2006_245_32	2006	7.74	25.33	33.07	2006_245_32	2006	7.13	22.33	29.46
2006_245_34	2006	4.51	50.35	54.86	2006_245_34	2006	4.25	42.51	46.76
2006_245_36	2006	2.35	10.91	13.25	2006_245_36	2006	2.09	9.15	11.25
2006_245_38	2006	5.55	17.27	22.82	2006_245_38	2006	4.87	15.64	20.51
2006_245_40	2006	2.96	9.90	12.86	2006_245_40	2006	2.64	8.54	11.18
2006_245_42	2006	5.22	36.82	42.04	2006_245_42	2006	4.59	30.75	35.33
2006_245_44	2006	3.35	13.32	16.66	2006_245_44	2006	3.07	10.98	14.04
2006_245_46	2006	3.07	15.72	18.80	2006_245_46	2006	2.88	13.56	16.43
2006_245_48	2006	6.70	26.63	33.33	2006_245_48	2006	5.83	23.36	29.19
2006_245_50	2006	4.03	14.29	18.32	2006_245_50	2006	3.57	12.38	15.95

Dioxins and dioxin like PCBs in individual cod liver (ng TEQ/kg fresh weight, upper bound) from Lofoten/Barents Sea in 2003.
Each sample is a pooled sample of five cod livers.

Sample no.	Dioxins/Furans	dl-PCBs	Total TEQ
1. (N=5)	1.9	9.6	11.5
2. (N=5)	2.5	11.8	14.4
3. (N=5)	1.8	11.6	13.3
4. (N=5)	2.4	17.4	19.9
5. (N=5)	1.9	11.7	13.5