Chemical contaminants 2004-2011





DTU Food
National Food Institute

Chemical contaminants

Food monitoring 2004-2011

National Food Institute
Technical University of Denmark
Division of Food Chemistry

Chemical contaminants 2004-2011
Food monitoring 2004-2011

1. edition, July 2013

Photo: Colourbox
ISBN: 978-87-92763-77-8

This report is available at
www.food.dtu.dk

National Food Institute
Technical University of Denmark
Mørkhøj Bygade 19
DK-2860 Søborg

Tel: +45 35 88 70 00
Fax: +45 35 88 70 01

The parts concerning levels in food and exposure assessments were prepared by:
Annette Petersen
Arvid Fromberg
Jens Hinge Andersen
Jens J. Sloth
Kit Granby
Lene Duedahl-Olesen
Peter Have Rasmussen
Sisse Fagt
Tommy Licht Cederberg
Tue Christensen

The parts concerning the toxicological evaluation were prepared by:
Anne Marie Vinggaard
Charlotte B. Madsen
Elsa Nielsen
Julie Boberg
Max Hansen
Mona-Lise Binderup
Pelle Thonning Olesen
Stine Kroghsbo
Torben Hallas-Møller

Acknowledgement:

Julie Aagaard for reading and commenting on the report

Table of levels

1 Preface

Contaminants in food have been analysed in Denmark since 1983. This report presents the results of the analysis for contaminants the period 2004-2011. This report includes results for the following substances:

- Toxic trace elements as cadmium, mercury, arsenic, lead, manganese, nickel, and aluminium. Also selenium is included in this report since it is analysed in the same analytical method as the toxic substances
- Nitrate
- Mycotoxins as ochratoxin A (OTA), deoxynivalenole (DON), T-2 and HT-2
- Chlorinated environmental contaminants as PCBs, dioxins and chlorinated pesticides
- Other environmental contaminants as brominated flame retardants and perfluorinated compounds,
- Contaminants formed during preparation as acrylamide, furan, 3-MPCD, and polycyclic aromatic hydrocarbons (PAH)

Based on the analyses the dietary exposure (dietary intake) or just general exposure is calculated for most of the substances and compared with the relevant toxicological values or evaluated using the Margin of Exposure concept.

The food monitoring programme has been running since 1983, and the results for the period 1983-1987, 1988-1992, 1993-1997 and 1998-2003 have been reported (National Food Agency of Denmark 1990 and 1995; Danish Veterinary and Food Administration 2001 and 2005). In the period 1983-2003 foods were analysed in a systematic and regular way so that data could be compared from period to period. For the period 2004-2011 sampling was not planned in the same systematic way as in the previous periods, so the data cannot always be compared with data from previous periods. For some of the substances, supplementary data from other sources were needed to perform the exposure calculations. Moreover, some substances such as PAHs, acrylamide, brominated flame retardants, perfluorinated compounds, 3-MCPD, furan, DON, T-2 and HT-2 were not reported in the previous monitoring reports. Exposure from other sources than food is not taken into account.

The National Food Institute, Technical University of Denmark, and the Danish Veterinary and Food Administration (DFVA) collaborated on the sampling. Most of the samples were taken by authorised people from the regional authorities at DVFA. Samples of fish from Danish waters were taken by the Fisheries Inspection under the Danish Directorate of Fisheries. Analyses were carried out by the regional laboratories in Ringsted and Aarhus with the exception of except for some analyses for acrylamide that were carried out at the National Food Institute. Almost all the analyses were carried out by accredited methods.

2 Sammenfatning og konklusion

Denne rapport giver en oversigt over indholdet af udvalgte kemiske forureninger i fødevarer, der er analyseret som led i de nationale undersøgelser i perioden 2004-2011. Resultaterne for en del af disse forureninger kan man finde på Fødevarestyrelsens hjemmeside. Der har tidligere været analyseret for en del af de nævnte forureninger i forbindelse med det danske overvågningssystem (National Food Agency of Denmark 1990 og 1995; Danish Veterinary and Food Administration 2001 og 2005). I årene 1994-2011 er der analyseret for et øget antal forureninger, og i denne rapport er inkluderet resultater for uorganisk arsen, polycykliske aromatiske hydracarboner (PAH), acrylamid, bromerede flammehæmmere, perfluorerede stoffer, furan, 3-MCPD, deoxynivalenol (DON), HT-2 og T-2. Analyserne er udført på Fødevarestyrelsens regionale laboratorier i Ringsted og Aarhus på nær enkelte resultater for akrylamid, som er foretaget på DTU Fødevareinstituttet.

Resultaterne er sammen med oplysninger om danskernes kostindtag brugt til at estimere indtag eller eksponeringen fra fødevarer for de forskellige forureninger. Der er enten foretaget en sundhedsmæssig vurdering på basis af de estimerede indtag i forhold til de fastsatte sundhedsbaserede indtagsgrænser eller der er beregnet en Margin of Exposure (MOE). De sundhedsbaserede indtagsgrænser omfatter Acceptabelt Dagligt Indtag (ADI), Tolerabelt Dagligt Indtag (TDI), Tolerabelt Ugentlig Indtag (TWI) og Provisorisk Tolerabelt Ugentlig Indtag (PTWI). Disse værdier angiver den mængde mennesker kan indtage gennem et helt liv uden nævneværdig sundhedsrisiko. De forskellige toksikologiske begreber er nærmere defineret i kapitel 4.

Sporelementer

I årene 2004-2011 er der analyseret for de toksiske sporelementer bly, cadmium, kviksølv, uorganisk arsen og total arsen samt det essentielle sporelement selen. Selen er inkluderet i denne rapport, fordi det analyseres i samme metode som de toksiske elementer.

Resultaterne fra 2004-2011 viser, at indholdet af bly, cadmium og kviksølv i fødevarer fra det danske marked er forblevet på samme niveau som tidligere (Danish Veterinary and Food Administration, 2005). Forekomsten af disse tre stoffer skyldes hovedsageligt atmosfærisk nedfald og optag gennem rødderne fra opdyrket jord. For selen og arsen kan naturlige geokemiske processer i jorden eller i det marine miljø primært forklare tilstedeværelsen af disse stoffer.

Det gennemsnitlige indtag af cadmium for voksne (15-75 år) er estimeret til at være 0,15 µg/kg kropsvægt/dag svarende til ca. 10,8 µg/dag. Det gennemsnitlige indtag for voksne udgør 42 % af TWI på 2,5 µg/kg kropsvægt/uge, og der er ca. 5 %, som overskrider TWI af de voksne.. Indtaget i % af TWI er betydeligt højere i perioden 2004-2011 end i perioden 1998-2003. Det skyldes ikke at indtaget er steget, men at TWI er sat ned fra 7 µg/kg kropsvægt/uge til 2,5 µg/kg kropsvægt/uge (EFSA, 2009b). De største bidragsydere til indtaget af cadmium gennem fødevarer er korn og kornprodukter samt grøntsager og de udgør henholdsvis ca. 50 % og 35 % af indtaget. Da der med det nuværende indtag er grupper, hvor indtaget overskrider TWI, bør indtaget af cadmium sænkes.

Arsen har en kompleks kemi og kan findes i både organiske og uorganiske kemiske former, hvor uorganisk arsen evalueres som mest kritisk for fødevaresikkerheden. Uorganisk arsen er kræftfremkaldende hos mennesker i flere organer og dette betragtes som den kritiske effekt sammen med hudlæsioner efter lang-tids eksponering. På baggrund af epidemiologiske undersøgelser har EFSA modelleret, hvilke indtag af uorganisk arsen der øger incidensen af kræft i lunger, blære og hud med 1 % og fundet $BMDL_{01}$ værdier i intervallet 0,3 til 8 µg/kg kropvægt/dag. Da mekanismen for den kræftfremkaldende effekt ikke er fastslået med sikkerhed, kan der ikke fastsættes en lavest acceptabel MOE, og dermed kan der ikke sættes en sundhedsbaseret grænse for indtaget. Det gennemsnitlige indtag af uorganisk arsen i den danske befolkning er estimeret til at være 0,12 µg/kg kropsvægt/dag. Den beregnede MOE bliver derfor meget lav, og det må konkluderes, at indtaget af uorganisk arsen set fra et sundhedsmæssigt synspunkt bør sænkes væsentligt. Drikkevarer og kornprodukter er de fødevaregrupper som bidrager mest til eksponeringen for uorganisk arsen.

For det totale indhold af arsen indeholder fisk de største mængder, men stort set al arsen i fisk findes som organisk bundet arsen i forbindelser, der har meget lavere giftighed.

For kviksølv er fisk langt den største bidragsyder til indtaget, og det bidrager med ca. 68 % af det samlede indtag. Det gennemsnitlige indtag af methylkviksølv, som er den mest giftige af de kviksølvforbindelser, der forekommer i fødevarer, er beregnet til at være 0,018 µg/kg kropsvægt/dag for danskere i alderen 4-74 år. For total kviksølv er det tilsvarende gennemsnit på 0,03 µg/kg kropsvægt/dag Disse indtag svarer til dem, som blev beregnet i sidste overvågningsperiode. JECFA har fastsat en PTWI på 1,6 µg/kg kropsvægt/uge for methylkviksølv, mens EFSA i slutningen af 2012 fastsatte en TWI på 1,3 µg/kg kropsvægt/uge (ca. 0,22 µg/kg kropsvægt/dag) for methylkviksølv. Som det fremgår ligger indtaget generelt under de fastsatte sundhedsmæssige reference værdier.

For bly er det estimerede gennemsnitlige indtag 0,25 µg/kg kropsvægt/dag, og dette er lidt lavere end indtaget estimeret i perioden 1998-2003. Drikkevarer giver langt det største bidrag til indtaget (ca. 47 %). Den kritiske effekt af bly er påvirkning af centralnervesystemet under udvikling. EFSA har i 2010 vurderet, at det ikke er muligt at fastsætte en tærskelværdi, og dermed heller ikke en sundhedsmæssig grænse for indtaget, for denne effekt. EFSA har gennemført benchmark dose modellering for hvilket indtag af bly, der vil medfører 1 % fald i børns IQ, 1 % forøgelse af systolisk blodtryk hos voksne eller 10 % forøgelse af en tidlig biomarkør nyreskader. De modellerede BMDL værdier for disse effekter var henholdsvis 0,50 µg/kg kropsvægt/dag, 0,63 µg/kg kropsvægt/dag og 1,5 µg/kg kropsvægtdag (se kapitel 6). Den beregnede MOE bliver derfor meget lav, og det er derfor ønskeligt ud fra et sundhedsmæssigt synspunkt, at indtaget af bly sænkes.

Selen er i modsætning til de andre sporelementer et essentielt næringsstof. Det gennemsnitlige indtag for danskere (4-75 år) er beregnet til at være 35 µg/dag. De Nordiske Næringsstofanbefalinger er på nuværende tidspunkt på henholdsvis 40 µg/dag og 50 µg/dag for mænd og kvinder. Der er forslag om at sætte disse op til henholdsvis 50 og 60 µg/dag. Der er dog også en øvre grænse for indtaget af selen og Scientific Committee on Food (SCF, 2006) har fastsat et tolerabelt øvre indtag på 300 µg/dag for voksne og 90-250 µg/dag for børn (4-17 år). Cerealier bidrager mest til indtag af selen, men også mælk og mælkeprodukter, kød og kødprodukter samt æg giver et stort bidrag. Generelt er danskernes indtag af selen mindre end de anbefalede mængder og betydelig mindre end det tolerable øvre indtag.

Nitrat

Hvad angår nitrat er grøntsager den største kilde til danskernes indtag. I årene 2004-2011 er nitrat undersøgt i forskellige grøntsager og krydderier. I en gruppe der dækker de 4-75 årige er det gennemsnitlige nitrat indtagen fra de undersøgte grøntsager er beregnet til 33 mg/dag og til 75 mg/dag for folk der har et højt indtag af grøntsager. Med en kropsvægt på 60 kg svarer det til et gennemsnitsindtag på 0,6 mg/kg kropsvægt/dag. ADI for nitrat er 3,7 mg/kg kropsvægt/dag, så gennemsnitsindtagen er langt mindre end ADI. De største bidragsydere til indtaget af nitrat er kartofler og salat. Beregning af bidraget fra drikkevand er behæftet med betydelig usikkerhed, da der kan være store variationer mellem forskellige lokaliteter. Anvendes grænseværdien for nitrat i drikkevand på 50 mg/l, og man forudsætter at man drikker 2 l vand/dag, kan indtaget fra vand beregnes til 100 mg/dag eller 1,7 mg/kg kropsvægt/dag, Lægges hertil bidraget fra et højt indtag af grøntsager fås et dagligt indtag på 2,9 mg/kg kropsvægt/dag for en person på 60 kg, hvilket stadig er under ADI´en for nitrat, og der er derfor ikke noget indtagsproblem.

Mykotoksiner

Myktoksiner er stoffer som bliver dannet af svampe. I årerne 2004-2011 er der foruden ochratoksin A også foretaget analyser af fusarium toksinerne deoxynivalenol (DON), T-2 og HT-2. Disse toksiners toksiske effekter hænger primært sammen med deres evne til at inhibere protein-syntesen. Dette giver i grise symptomer som bl.a. reduceret vægt, diarre og hudlæsioner. Ochratoksin A (OTA) er klassificeret som et muligt kræftfremkaldende stof.

For alle mykotoksinerne gælder, at de primært er blevet undersøgt i korn og kornprodukter, da disse fødevarer er den primære kilde til indtaget. For fusarium toksinerne afhænger indholdet af vejrforholdene. OTA er en lagersvamp, og for at forhindre at svampen gror og danner OTA , gælder det om at få tørret afgrøderne efter høst.

For DON er det gennemsnitlige indtag beregnet til at være 12,6 µg/dag svarende til 0,215 µg/kg kropsvægt/dag. TDI er fastsat til 1 µg/kg kropsvægt/dag, og personer med en høj indtag er tæt på denne værdi.

Indholdet af HT-2 og T-2 er lave, og et samlet indtag er derfor ikke beregnet for disse to stoffer.

Det gennemsnitlige indtag for OTA er beregnet til at være 0,4 ng/kg kropsvægt /dag svarende til 2,8 ng/kg kropsvægt/uge. EFSA har fastsat en TWI for OTA på 120 ng/kg kropsvægt/uge, så det estimerede indtag er langt under TWI.

Chlorerede organiske miljøforureninger
I overvågningsperioden er der undersøgt en række forskellige organiske miljøforureninger, inklusiv dioxin, PCB (polychlorerede biphenyler), en række chlorpesticider og deres omdannelsesprodukter.

Dioxiner og PCB
Dioxin omfatter en gruppe på 210 forbindelser, mens PCB omfatter 209 forskellige forbindelser også kaldet congener. . Disse forbindelser rne er fedtopløselige og nedbrydes langsomt, og derfor akkumuleres de i fedtvæv hos dyr og mennesker. Det er beregnet at indtaget gennem fødevarer fra dioxiner og dioxin-lignende PCB er 0,55 pg WHO-TEQ^{2005}/kg kropsvægt/dag for den danske befolkning (4-75 år). I afsnit 9.1 er det nærmere forklaret, hvordan indtaget beregnes. SFC (SCF, 2001) har sat en TWI på 14 pg WHO-TEQ^{2005}/kg kropsvægt/uge for alle 2,3,7,8-substituterede PCDD'er og PCDF'er og dioxin-lignende PCB'er. Dette svarer til 2 pg WHO-TEQ^{2005}/kg kropsvægt/dag. Det gennemsnitlige indtag for børn i alderen 4-14 år er 0,87 pg WHO-TEQ^{2005}/kg kropsvægt/dag. Beregningerne viser, at ca. 1 % voksne og 5 % børn overskrider TWI.

For ikke-dioxinlignende PCB er der foreslået en TDI på 10 ng/kg kropsvægt/dag for summen af 6 PCB forbindelser (PCB-6) og 20 ng/kg kropsvægt per dag for total PCB (Afssa, 2007). Det gennemsnitlige indtag for PCB-6 er beregnet til 1,8 ng/kg kropsvægt/dag for den danske befolkning (4-75 år) og 2,7 ng/kg kropsvægt/dag for børn i alderen 4-14 år. For indikator PCB målt som en sum af 10 PCB forbindelser er indtaget estimeret til 5,7 ng/kropsvægt/dag for den danske befolkning (4-75 år) og 8,9 ng/kg kropsvægt/dag for børn i alderen 4-14 år. En del af befolkningen (1 til 5 %) overskrider de foreslåede TDI værdier for ikke-dioxinlignende PCB.

Fisk og fiskeprodukter bidrager mest til indtaget med ca. 32 % efterfulgt af mejeriprodukter med ca. 25 %, fedt og fedtprodukter med ca. 22 % og kød og kødprodukter med ca. 18 % af indtaget.

Chlorpesticider
Disse stoffer er svært nedbrydelige i miljøet, og da de er fedtopløselige, kan de finde vej til vore fødevarer. De akkumulere i fedt hos dyr, herunder husdyr, der bliver brugt som fødevare for mennesker. Derved vil der være et indtag af disse stoffer, og da mange af stofferne kan forårsage kræft hos dyr og mennesker, er dette uønsket, hvilket er grundlaget for at niveauerne følges i overvågningssystemet.

Tilstedeværelsen af de organiske miljøforureninger er blevet undersøgt i kød, fisk og mejeriprodukter. Historisk set har der tidligere været et fald af niveauerne af disse stoffer i fisk fra de danske farvande, men niveauerne har nu i en årrække været nogenlunde konstante. For andre produkter af animalsk oprindelse kan der ikke ses nogen klar udvikling i koncentrationsniveauerne, men en tendens til at niveauerne bliver lavere.

Ved beregning af danskernes gennemsnitlige daglige indtag af de organiske chlorpesticider er der fundet værdier mellem 1 og 10 ng/kg kropsvægt/dag. Estimatet for personer der har et relativt højt indtag af stofferne (95-percentilen) viser, at de får cirka dobbelt så meget som gennemsnittet. Det højeste bidrag til indtaget af chlorpesticider er fra fisk, fedt, kød og mejeriprodukter, hvor børn har et højere indtag fra mælk og mælkeprodukter og et lavere indtag fra fisk end voksne har. Da børn har et relativt højt fødevareindtag i forhold til deres kropsvægt, er børns daglige indtag pr. kg bw ca. dobbelt så højt som for voksne. Når man sammenligner de estimerede indtag med ADI eller TDI, ligger værdierne dog stadig langt under disse.

Polycykliske Aromatiske Hydrocarboner (PAH)
PAHr omfatter en stor gruppe af aromatiske forbindelser som består af to eller flere aromatiske ringe. PAH dannes ved ufuldstændig forbrænding. De har den sammekemiske opbygning. Flere af dem er genotoksiske og/eller kræftfremkaldende. Stoffer forekommer i fødevarer fra flere forskellige kilder, herunder atmosfærisk nedfald, ved forarbejdning i industrien (f.eks. røgning) og ved forarbejdning i hjemmet (f.eks. grillstegning). Der er analyseret 970 prøver i 57 forskellige fødevarer både friske og tilberedte. Indholdet i forarbejdede fødevarer afhænger af tilberedningsmetode, tid og temperatur.

Nogle PAH'er er vurderet at være både genotoksiske og kræftfremkaldende, og derfor har EFSA også anbefalet, at anvende Margin of Exposure (se afsnit 4.3) til at vurdere den sundhedsmæssige risiko af et estimeret indtag. (EFSA, 2008). EFSA har vurderet, at det bedste udtryk for det totale indhold af kræftfremkaldende PAH er summen af 4 PAH forbindelser, nemlig benzo[*a*]pyren, benzo[*a*]anthracen, benzo[*b*]fluoroanthen og chrysen (EFSA 2008), og der fra 2012 sat grænseværdier for denne sum i visse fødevarer (EC 2011c).

Indtaget for danskere i alderen 4-75 år er i gennemsnit estimeret til at være 4,5 ng/kg kropsvægt/dag for benzo[*a*]pyren og 19 ng/kg kropsvægt/dag for PAH4. De tilsvarende tal for børn (4-14 år) er henholdsvis 6,9 ng/kg kropsvægt/dag og 31 ng/kg kropsvægt/dag. De største bidragsydere til indtaget er grøntsager, cerealier, drikkevarer og mælk og mælkeprodukter for både benzo[*a*]pyren og PAH4.

Til beregning af MOE har EFSA anbefalet, at man skal anvende $BMDL_{10}$, svarende til en 10 % forøgelse af antal dyr med tumorer. a EFSA har beregnet en $BMDL_{10}$ på 70 og 340 µg/kg kropsvægt/dag for henholdsvis benzo[*a*]pyren og PAH4 (EFSA 2008). Ud fra det estimerede indtag af PAH er MOE derfor beregnet til at være mellem 5400 og 17.900, med de laveste værdier for børn. EFSA har vurderet, at en MOE større end 10.000 for genotoksiske og kræftfremkaldende stoffer ikke umiddelbart giver grund til en sundhedsmæssig bekymring (EFSA 2005a), men at man stadig skal tilstræbe, at indtaget er så lavt som praktisk muligt.

Akrylamid

Akrylamid dannes i fødevarer ved tilberedning (opvarmning), primært når reducerende sukkerforbindelser og asparaginsyre reagerer med hindanden. I perioden 2004-2011 er der udtaget og analyseret i 597 prøver fordelt på 34 tilberedte fødevarer, f.eks. kaffe, chokolade og kartoffelprodukter. Det gennemsnitlige indtag for danskere i alderen 15-75 år er estimeret til 0,19 µg/kg kropsvægt/dag mens den for børn (4-14 år) er beregnet til 0,33 µg/kg kropsvægt/dag. For voksne bidrager kartofler, kaffe/kakao og brød i den nævnte rækkefølge mest til indtaget. Akrylamid er genotoksisk, og man bruger MOE (se afsnit 4.3) til at vurdere indtaget. Bruger man en $BMDL_{10}$ (se afsnit 4.3) på 310 µg/kg kropsvægt/dag giver det en MOE på 1630 for voksne og 941 for børn. $BMDL_{10}$ er bestemt ud fra en forøgelse på 10 % i antal dyr med tumorer. Så lave MOE værdier for et kræftfremkaldende og genotoksisk stof udgør en bekymring for fødevaresikkerheden. Det laveste end-point bestemt ved dyreforsøg er en morfologisk ændring i nerverne, der ikke er en kræftfremkaldende effekt. Undersøgelser af denne effektgiver en NOAEL på 200 µg/kg kropsvægt/dag (WHO Technical Report 930), hvilket resulterer i MOE værdier på henholdsvis 1052 og 607 for voksne og børn. For en effekt, der ikke er kræftfremkaldende udgør disse MOE værdier ikke en bekymring for fødevaresikkerheden.

Bromerede flammehæmmere

Bromerede flammehæmmere bliver brugt i mange produkter for at gøre dem mindre brandbare. De findes derfor i miljøet og dermed ogås i fødevarer.. Stofferne er bio-akkumulerbare. En gruppe af bromerede flammehæmmere kaldes HBCDD'er. Det er disse forbindelser, der er analyseret men kun i fisk. EFSA har modelleret en $BMDL_{10}$ på 0,79 mg/kg kropsvægt/dag (790.000 ng/kg kropsvægt/dag). Den beregnede gennemsnitlige indtag fra fisk er for dansekere (4-75 år) beregnet til at være 0.19 ng/kg kropsvægt/dag. Den laveste beregnede MOE er på 617.000 for personer, som spiser mange fisk. De beregnende MOE'er er vurderet til ikke at udgøre en bekymring for fødevaresikkerheden.

Perfluorerede forbindelser

Perfluorerede forbindelser er blevet analyseret i fisk og kød. De bliver brugt i mange produkter og findes derfor i både luft, fødevarer og vand. Stofferne er bio-akkumulerbare. Der blev ikke fundet indhold i kød, så indtaget er kun beregnet for fisk. For gruppen i alderen 4-75 år er indtaget beregnet til at være 0,45 ng/kg bw/day. Dette er betydeligt mindre end den af EFSA fastsatte TDI på 150 ng/kg bw/day. Da stofferne er bio-akkumulerbare, er det dog ønskeligt, at indtaget nedsættes

Furan og 3-MCPD

Der er i rapporten vist resultater for furan og 3-MCPD. Begge stoffer dannes ved forarbejdning af fødevarer. For begge stoffer er et mindre udvalg af tilberedte fødevarer analyseret, og da der samtidigt kun i mindre udstrækning er oplysninger om konsum, er indtaget ikke beregnet for de to stoffer.

Konklusion

Fra et sundhedsmæssigt synspunkt viser rapporten, at man med fordel kunne fokusere indsatsen på at nedsætte danskernes indtag af uorganisk arsen, bly, cadmium, dioxin, PCB og akrylamid. For disse stoffer er indtaget højere end de sundhedsmæssige fastsatte reference værdier eller de beregnede MOE er meget lave (se kapitel 4). Et lavere indtag af PAH vil også være ønskeligt, da den beregnede MOE er meget tæt på eller under en MOE på 10.000, og EFSA har vurderet at en en MOE omkring eller mindre end 10.000 for genotoksiske og kræftfremkaldende stoffer som f.eks. PAH at være sundhedsmæssige betænkelige. For perfluorerede stoffer er det beregnede indtag betydeligt mindre end den sundhedsmæssige fastsatte reference værdi (TDI), men da disse stoffer akkumulerer i kroppen, er det også ønskeligt, at indtaget af disse stoffer nedsættes.

For 3-MCPD og furan er der ikke beregnet et indtag, idet der kun er analyseret få typer af fødevarer, og det har ikke umiddelbart været muligt at kombinere det med tilsvarende tal for konsum. Der er heller ikke beregnet indtag for nikkel, aluminium og mangan, da disse stoffer kun er analyseret i et begrænset antal fødevarer. For mykotoksiner, nitrat, bromerede flammehæmmere og chlorerede pesticider er indtaget mindre end de sundhedsmæssige fastsatte referenceværdier. Det vil dog altid være ønskeligt, at indholdet og dermed indtaget af forureninger i fødevarer er så lavt som muligt.

3 Summary and conclusion

This report presents the results of analysis for various chemical contaminants in foods on the Danish market. The time period covers the years 2004-2011. Included in this report are results from trace elements (e.g. mercury, inorganic arsenic, and cadmium), nitrate, environmental contaminants (including dioxin, PCB and brominated flame retardants), mycotoxins (ochratoxin A, deoxynivalenole, T-2, and HT-2), and substances formed during processing (polycyclic aromatic hydrocarbons, acrylamide and furan). Results for some of the contaminants were also reported for the periods 1983-1987, 1988-1993, 1993-1997, and 1998-2003 ((National Food Agency of Denmark 1990 and 1995; Danish Veterinary and Food Administration 2001 and 2005). Compared to these previous periods, the number of contaminants investigated increased to include inorganic arsenic, deoxynivalenole (DON), T-2, HT-2, polycyclic aromatic hydrocarbons (PAH), acrylamide, furan, 3-MCPD, fluorinated compounds, and brominated flame retardants. The analyses were carried out at the regional laboratories in Ringsted and Aarhus, except for some the analyses for acrylamide, which were carried out at the National Food Institute.

Results from the chemical analyses are combined with data on the consumption of the food items concerned to calculate the overall exposure for the Danish population, adults or children. The exposure was then compared to the health based toxicological values or evaluated by using the Margin of Exposure concept. The values as well as the MOE concept are described below further in Section 4.3.

Trace elements

The monitoring programme includes the toxic trace elements such as lead, cadmium, mercury, inorganic arsenic and total arsenic as well as the essential element selenium. Selenium is a nutrient, but is included in this and the earlier reports on contaminants because it is identified in the same analysis. It can however also be toxic if it is ingested in high amounts.

The results of the monitoring programme 2004-2011 show that the concentrations levels of lead, cadmium and mercury in foods marketed in Denmark remain at a stable concentration level in comparison with the previous monitoring periods. The occurrence of these three contaminants in foods is mainly caused by atmospheric deposition or by root uptake from arable soil. In contrast, the presence of arsenic and selenium in food is mainly due natural biogeochemical processes in the terrestrial or marine environments. .

For cadmium the average dietary exposure for adults (aged 15-75) is estimated to be 0.15 µg/kg bodyweight (bw)/day which correspond to about 10.8 µg/day. In the previous period the exposure was estimated to be about 10 µg/day. The average exposure for adult's amount to 42% of the Tolerable Weekly Intake (TWI) or 2.5 µg/kg bw/week and it is estimated that about 5% of the Danish adults exceed the TWI. The exposure as a percentage of TWI is higher in this than in the previous period, But this is due to the TWI being decreased from 7 µg/kg bw day to 2.5 µg/kg bw/week in 2009 (EFSA, 2009b). The main contributors to the dietary exposure of cadmium are cereals and vegetables and they contribute with respectively about 50% and 35% of the exposure.

Arsenic has a complex chemistry and can be found in both organic and inorganic compounds, where the inorganic form is considered most toxic. Inorganic arsenic is carcinogenic in humans in several organs and this is considered as the critical effect in addition to skin lesions. Based on epidemiological studies, EFSA modelled the exposure of inorganic arsenic that increases the incidence of cancers of the lung, bladder and skin at 1% and found $BMDL_{01}$ values in the range of 0.3 to 8 µg/kg body weight /day. Since the mechanism of the carcinogenic effect has not been established with certainty, it is not possible to set a lowest acceptable MOE, so a health-based exposure limit cannot be set. The average exposure to inorganic arsenic in the Danish population is estimated to be 0.12 µg/kg bw/day. The calculated MOE is therefore very low, and it must be concluded that the exposure of inorganic arsenic should be lowered significantly. Beverages and cereals are the food groups with the largest contribution to inorganic arsenic in the diet. Which regards to total levels of arsenic in fish contain the largest quantities, but virtually all arsenic in fish is present as organic arsenic compounds that have much lower toxicity than inorganic arsenic.

Fish are the main contributor to the dietary exposure of mercury and contribute almost to 68% of the total exposure. The average exposure for the Danish population (aged 4-75) is 0.018 µg/kg bw/day for methyl mercury and 0.03 µg/kg bw/day for total mercury. Methyl mercury is the most toxic species of mercury and the estimated exposure for the present period is similar to the previous period. The EFSA and JECFA have set a TWI for methyl mercury at 1.3 µg/kg bw/week and 1.6 µg/kg bw/week, respectively. These values correspond to about 0.22 µg/kg bw/day. The estimated average exposure is well below this value and the exposure is of no major health concern.

The estimated average exposure of lead is 0.25 mg/kg bw/day for the Danish population (aged 4-75) and this is slightly lower than the exposure estimated for the period 1998-2003. Beverages are the greatest contributor to lead exposure (approximately 47%). The critical effect of lead is effects on the developing central nervous system. In 2010 the EFSA concluded that it is not possible to set a threshold for this effect and it was therefore not possible to establish a health-based exposure limit. The EFSA has completed a benchmark dose modelling for which exposure will give either a 1% decrease in children's IQ, a 1% increase in systolic blood pressure in adults, or a 10% increase in early biomarker kidney damage in adults. The modelling gave values at 0.50 mg/kg bw/day, 0.63 mg/kg bw/day and 1.5 mg/kg bw/day, respectively (see Chapter 6). The MOEs for the Danish population are therefore very low, so from at health point of view it is desirable that the intake of lead should be decreased.

Selenium is an essential nutrient but at high doses it can also be toxic. The Nordic Recommended Intake for selenium is currently at 40 µg/day for women and 50 µg/day for men. The average dietary exposure is estimated to be 35 µg/day. It has been discussed whether the recommendation should be raised to 50 µg/day for women and 60 µg/day for men. The Scientific Committee (SCF) has set an tolerable upper limit for adults to 300 µg/day and for children (aged 4-17) to 90-250 µg/day. Cereals are the main contributor to the exposure but also milk and other dairy products, meat and meat products as well as egg contribute in a high degree. As can be seen the exposure in Denmark is estimated to be lower than the recommended exposure and also the upper tolerable limit.

Nitrate

Vegetables contribute the most to the dietary exposure of nitrate, and here lettuce and potatoes contribute the most. Exposure from the analysed vegetables is estimated to be 33 mg/day on average for the total Danish population (aged 4-75) and 75 mg/day for high consumers of vegetables. Using a bodyweight of 60 kg this corresponds to 0.6 mg/kg bw/day for the average consumer. The ADI for nitrate is 3.7 mg/kg bw/day. The concentration of nitrate in drinking water varies considerable between different localities and no average concentration is known. If however, the maximum level for nitrate in drinking water of 50 mg/l is used and you drink 2 l/day, the estimated exposure from drinking water is 100 mg/day (1.7 mg/kg bw/day). If you add the exposure from a high intake of vegetables the total exposure would be 175 mg/day or 2.9 mg/ kg bw/day for a 60 kg person. This value is below the ADI so nitrate is of no immediate consumer concern.

Mycotoxins

Mycotoxins are secondary metabolites formed by various kinds of fungi. The levels of ochratoxin A (OTA), deoxynivalenole (DON), T-2 and HT-2 were analysed in the period 2004-2011. The mycotoxins were only analysed in cereals since they are the main contributors to the exposure in Denmark.

OTA is produced by various *Penicillium* and *Aspergillus* species and represents a well-known hazard to human and animal health, because it is classified as a possible carcinogen. The EFSA has set a TWI of 120 ng/kg bw/week for OTA. A mean exposure of 0.4 ng OTA/kg bw/day was estimated and this is l well below the TWI; however exposure was only estimated for cereals.

The toxicity of trichothecenes (DON; T-2, HT-2) is largely due to their ability to inhibit protein synthesis, and common symptoms in pigs are feed refusal, reduced weight gain, diarrhoea, haemorrhaging, skin lesions and immunosuppression. For DON, a mean exposure of 12.6 µg/day was estimated for the total population. This corresponds to 0.215 µg/kg bw/day. For the high consumers of cereal and cereal products the daily exposure will approach the Tolerable Daily Intake (TDI) value of 1 µg/kg bw/day.

The levels of T-2 and HT-2 in cereals were generally low, and therefore the exposure was not estimated except for oats, which showed a low exposure.

Dioxins and PCB

Dioxins cover a group of 210 compounds including 75 polychlorinated dibenzo-*p*-dioxins (PCDD) and 135 polychlorinated dibenzofuranes (PCDF). PCB is a group of 209 organochlorine compounds that are synthesised by catalysed chlorination of biphenyl. Due to their lipophilic properties they accumulate in the food chain and are stored in the fatty tissues of animals and humans. For the general population, the main pathway of exposure to dioxins and PCB is food. The most sensitive effects for dioxins in animal studies are on the reproductive, immune, and central nervous system.

The Scientific Committee on Food (SCF) has established a TWI of 14 pg WHO-TEQ/kg bw for 2,3,7,8-substituted PCDDs and PCDFs and the dioxin-like PCB (SCF, 2001). This corresponds to 2 pg WHO-TEQ/kg bw/day. The mean dietary exposure of dioxins and DL-PCB (dioxin-like PCB) is 0.55 pg WHO-TEQ^{2005}/kg bw/day for the total Danish population (aged 4-75). For children (aged 4-14) the mean exposure is estimated to be 0.87 pg WHO-TEQ^{2005}/kg bw/day. However, it is also estimated that about 1% of adults and 5% of children exceed the TWI set by the SCF.

For non dioxin-like PCB a TDI of 10 ng/kg bw/day has been proposed for the sum of 6 PCB congeners (PCB-6) and a TDI of 20 ng/kg bw/day has been proposed for total PCB (AFSSA, 2007). The mean dietary exposure of PCB-6 was estimated to 1.8 ng/kg bw/day for the total Danish population (aged 4-75). For children (aged 4-14) the mean exposure is estimated to be 2.7 ng/kg bw/day. For indicator PCB measured as a sum of 10 PCB congeners the exposure is estimated to be 5.7 ng/kg bw/day for the total Danish population (aged 4-75) and 8.9 ng/kg bw/day for children (aged 4-14). Less than 1 % to 5 % of the population groups exceed the proposed TDI for non dioxin-like PCB.

For the Danish population, fish and fish products are the main contributors to the exposure (about 32 %) followed by dairy products (about 25 %), fat and fat products (about 22 %) and meat and meat products (about 18 %).

Organochlorine pesticides and level of indicator PCB

The monitoring programme includes a number of organochlorine pesticides, including metabolites, as well as indicator PCB. They are slowly degradable and persist for long periods in the environment, where they accumulate in the fatty tissues of animals and humans. Many of the substances cause the development of cancer in the liver of animals. Some have also shown a potential to affect hormone systems *in vitro*.

Organochlorine pesticides and PCB were analysed in samples of meat, fish, and dairy products. In a large number of samples no level were detected because they were below the limit of detection.. The highest average level was found in cod liver and fatty fish.

The levels in fish in the years 2004-2011 were compared with the results for the previous years. It seems that since the period 1998-2003 the levels have reached a more or less steady state.

The mean exposure of organochlorine pesticides for adults is between 0.2 and 5.5 ng/kg bw/day while the 95th percentile is between 0.4 and 11 ng/kg bw/day. For children, the average exposure is between 0.3 and 10 ng/kg bw/day while the 95th percentile is between 0.9 and 22 ng/kg bw/day. The estimated exposures are well below the ADIs or TDIs set for these substances, which are between 0.100 and 10 µg/kg bw/day.

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are a group of substances with a common structure and several of them are classified as possible genotoxic and/or carcinogenic substances. They occur in foods from several sources including deposits from the atmosphere, and the preparation of food both commercial and at home. The level in prepared foods depends on the preparation method, time and temperature.

Due to the classification as possible genotoxic or carcinogenic substances, no TDI, TWI etc. have been set for PAHs. Instead, the concept of Margin of Exposure (MOE – see paragraph 4.3) is applied. EFSA has evaluated that the most appropriate expression for the total exposure to carcinogenic PAHs is the sum of 4 PAHs, namely benzo[*a*]pyrene, benzo[*a*]anthracene, benzo[*b*]fluoranthene and chrysene (EFSA 2008). The mean exposure for the Danish population has been calculated to be 4.5 ng/kg bw/day for benzo[*a*]pyrene and 19 ng/kg bw/day for PAH4. For children the exposure is calculated to be 6.9 ng/kg bw/day for benzo[a]pyrene and 31 ng/kg bw/day for PAH4. The greatest contributors to the exposure in both cases are vegetables, cereals, beverages as well as milk and milk products.

For the calculation of MOE the EFSA modelled the benchmark dose lower confidence limit $BMDL_{10}$ (10 % increase in the number tumour bearing animals) to be 70 µg/kg bw/day for benzo[*a*]pyrene and 340 µg/kg bw/day PAH4. The MOE is therefore estimated to be between 5400 and 17900. According to the EFSA a MOE for genotoxic substances above 10,000 is of low health concern (see Section 4.3).

Acrylamide

Acrylamide is a process contaminant which is formed as part of the Maillard reactions when carbohydrate rich food is heat treated. It is a genotoxic compound and classified as a possible carcinogen. This is why the ALARA (As Low As Reasonable Achievable) principle should be followed with regard to levels of acrylamide in food. To evaluate the exposure to acrylamide, the MOE principle is applied.

The mean exposure for the total population is 0.19 µg/kg body weight per day and the 95th percentile is 0.46 µg/kg bw/day. The mean exposure for children aged 4-14 is 0.33µg/kg bw/day and the exposure for high consumers estimated as the 95th percentile is 0.89 µg/kg bw/day. .

For adults, the food category that gives the highest exposure to acrylamide is potato products, which constitutes 36% followed by coffee and cocoa at 30 % of which coffee contributes the most. Bread is the third largest contributor with 13 %. Children also have the highest acrylamide exposure from potato products but in addition to this the contribution from crisps, chocolate, and bread to children's acrylamide exposure is more than 10%.

The MOEs have been calculated to be between 348 and 1630 for the most sensitive carcinogenic effect, and all values are much below 10,000, thus indicating a health concern. The lowest MOE is calculated for the 95th percentile exposure of children while the highest is for the mean exposure of the adult population.

Brominated flame retardants
Brominated flame retardants (BFRs) are mixtures of man-made chemicals that are added to a wide variety of industrial and household products to make them less flammable. They are therefore widely spread in the environment and therefore also in food. They are fat-soluble and bio-accumulate for example in fish and meat. The substances have only been analysed in fish.

One group is the HBCD's. The ΣHBCD exposure for children aged 4-14 is estimated to be 0.23 ng/kg bw/day and the exposure of high consumers estimated as the 95th percentile is 1.28 ng/kg bw/day. The ΣHBCD exposure mainly derives from eating salmon and herring. EFSA identified neurodevelopmental effects on behaviour in mice, as the critical end-point and derived a benchmark dose lower confidence limit for a benchmark response of 10 % ($BMDL_{10}$) of 0.79 mg/kg bw (790,000 ng/kg bw/day). The lowest estimated MOE was 617,000 for the 95th percentile for the exposure of children. The estimated MOEs are of no food safety concern.

Perfluorinated compounds
Perfluorinated chemicals can be found in a wide variety of industrial and household products. They are therefore widely spread in the environment and therefore also in food. They are fat-soluble and bio-accumulate for example fish and meat. They have been only been analysed in a few samples of fish and meat. No levels were found in meat, so the exposure is only calculated for fish. For the group aged 4-74 the exposure was estimated to be 0.45 ng/kg bw/day. This is much less than the TDI of 150 ng/kg bw/day set by EFSA. Due to their bio-accumulating properties it is however desirable that the exposure is lowered.

Furan and 3-MPCD

Both substances are formed during processing. This report gives levels of the two substances in prepared food, but due to difficulties with alignment of consumption data the exposure has not been calculated for either of the two substances.

Conclusion

From a health-based point of view the exposure to lead, cadmium, inorganic arsenic, dioxin, PCB and acrylamide should preferably be lowered as the exposures to these substances exceed the health-based toxicological reference values or the calculated MOE (see Section 4) are very low. Also for PAH it would be desirably if the exposure is lowered as the MOE is very close to or lower than 10,000 which according to EFSA could give rise to health concern for genotoxic and carcinogenic compounds. For perfluorinated compounds the exposure is low compared to the health-based toxicological reference value but because they bio-accumulate it would be desirable that the exposure is lowered.

For 3-MCPD and furan the exposure has not been calculated due to a limited number of food items analysed and because it has not been possible to combine the concentrations in the analysed food items with consumption data. For aluminium, nickel, and manganese the exposure has not been calculated since these substances were only analysed in a limited number of food items.

The calculated exposure to nitrate, mycotoxins, brominated flame retardants, and organochlorine compounds are below the health-based toxicological reference values. However, it is always desirably if the concentrations and consequently the exposures to contaminants in foods are as low as possible.

4 Introduction

4.1 Data on levels of contamination

The data on levels of contamination are described in detail in Chapters 6 to 15, and the appendices give an overview of the results.

In general, the analytical work was carried out at the regional laboratories in Aarhus and Ringsted and primarily with accredited methods in accordance with EN 45000 or ISO17025. Various procedures for quality assurance were carried out in connection with the analyses, including recovery tests, the use of reference materials, and participation in proficiency tests.

The abbreviations LOD and LOQ have been used in the text and they are explained below.

LOD: The limit of detection of an analytical procedure is the smallest amount of an analyte in a sample that can be detected though not necessarily quantified as an exact value. At the limit of detection, a positive identification can be achieved with reasonable and/or previously determined confidence in a defined matrix using a specific analytical method (IUPAC, 2010).

LOQ: The limit of quantitation is defined as the lowest concentration at which an unambiguous identification and quantitative measurement of the analyte can be proven (IUPAC, 2010).

4.2 Exposure calculations

The exposure estimates are based on the dietary exposure data collected for DANSDA (Danish National Survey of Diet and Physical Activity) in 2005-2008. Chapter 5 describes the survey in more detail, as well as how concentration data and food consumption data were correlated. For some substances, concentration data from other sources, e.g. for the previous period (1998-2003), have been used, because some of these food items were not analysed, or very few samples were analysed, in the period 2004-2011.

On the other hand, some analytical data were not included in the exposure calculations because there were no consumption data for the foods analysed. The appendices indicate whether or not the data were used in the exposure calculation.

The exposure was calculated for each individual person in the food survey. The individual level of consumption for each of the food items was multiplied by a qualified estimate of the contaminant level in the particular food item. This yields a distribution of the contaminant exposure across the population. The exposure is described for various population groups, e.g. children, adults, total population, using both average and a high percentile. The bodyweight of the individual respondents was used in those cases where the results of the exposure calculation are stated as exposure per kg bodyweight.

4.3 Risk assessment

The risk assessment of chemicals was carried out by comparing the exposure with a health based guidance value e.g. ADI or TDI or by using the Margin of Exposure (MOE) concept.

NOAEL: No Observable Adverse Effect Level. This is the highest dose or concentration of a substance, found by experiment or observation, that causes no detectable adverse alteration of morphology, functional capacity, growth, development, or life span of the target organism under defined conditions of exposure (IUPAC 2007).

ADI: Acceptable Daily Intake. Estimated maximum amount of an agent, expressed on a body mass basis, to which an individual in a (sub) population may be exposed daily over its lifetime without appreciable health risk (WHO, publication year unknown). Used for food additives, pesticides, and residues of veterinary drugs. Are not used for contaminants.

TDI: Tolerable Daily Intake. Analogous to Acceptable Daily intake. The term Tolerable is commonly used in relation to food contaminants (WHO, publication year unknown).

TWI: Tolerable Weekly Intake. Estimate of the amount of a potentially harmful substance (e.g. a contaminant) in food or drinking water that can be ingested weekly over a lifetime without appreciable health risk (IUPAC 2007). TWI is used for substances which accumulate in the body.

PTWI: Provisional Tolerable Weekly Exposure. For regulation of substances that cannot easily be avoided, a provisionally tolerable weekly exposure (PTWI) may be applied as a temporary limit (IUPAC 2007). Usually used by JECFA

BMD: Benchmark Dose. A calculated dose which is expected to result in a specified response. For example is BMD_{10} the calculated dose which will result in a 10 % increase in the response compared to the d response in the control subjects.
The benchmark dose is a standardised reference point or point of departure derived from the animal data or human data (EFSA 2005a).

BMDL: Benchmark dose lower confidence limit; the lower confidence limit (usually 95 %) of the estimated dose with a specific response (BMD).

MOE: Margin of Exposure. The MOE approach uses a reference point usually a $BMDL_{xx}$ value. This reference point is then divided by various dietary exposure estimates in humans, taking into account differences in consumption pattern. If the exposure is estimated to be 0.0015 µg/kg bw/day and the $BMDL_{10}$ is 1 µg/kg bw/day the MOE is 1/0.0015 = 667.

No general values have been set for the lowest acceptable MOE. For substances which are both genotoxic and carcinogenic a MOE of 10,000 or higher based on the $BMDL_{10}$ for cancer development in an animal study would be of low concern from a public health point of view and might be viewed as low priority for risk management actions. (EFSA 2005a).

Except for the value of 10,000 mentioned above no fixed value can be established for MOE because it depends on the BMDL; e.g. if a $BMDL_{10}$ is estimated it will normally be desirable to have a higher MOE than with a $BMDL_{01}$.

5 Consumption data

5.1 Method

The data were collected as a part of DANSDA (DAnish National Survey of Diet and physical Activity) in 2005-2008 and are a subset of the data reported in “Danskernes kostvaner 2003-08” (Dietary Habits in Denmark 2003-2008). The subset was chosen because it matches the period for chemical analysis best and is the most recently reported dataset. The dataset covers consumption of food and drink recorded for 7 consecutive days collected from a representative sample of 2700 Danes aged 4 to 75. The individuals were drawn in a simple random sample from the civil population registration system. DANSDA uses a 7-day pre-coded (semi-closed) food diary with answering categories for the most commonly consumed foods and dishes in the Danish diet. The questionnaire is organised in accordance with the typical daily meal pattern. For food items not found in the pre-coded categories, it is possible to note the type and amount eaten. The amounts of food eaten were given in household measures and estimated from photos of various portion sizes. The information collected represents the current dietary consumption in the population. The Danish National Centre for Social Research carried out the interviews and the instruction of participants in the registration of the dietary consumption.

5.2 Data processing

Dietary records were processed in-house by scanning with ReadSoft Forms and post-processed using in-house-developed software (Scan2005). The consumption data were then processed by the in-house-developed GIES (General Exposure Estimation System) that interpret the recorded consumption into the ingredients that form the basis for the further calculations and estimations of the intake of nutrients and contaminants. The individual’s consumption of food was used for modelling in Excel, in which the actual exposures could be estimated.

To enable better alignment between registered consumption and the actual analysed level in food groups, special recipe collections, comparable to those normally used for nutritional analysis, were developed and deployed in GIES for some contaminant groups.

6 Trace elements

6.1 Introduction

Since it initiation in 1983 the level and the dietary exposure of trace elements in foods sold on the Danish market have been repeatedly investigated in the Danish Food Monitoring Programme since its initiation in 1983. The present report compiles the results from the analysis of trace elements in a range of food items on the Danish market in the period 2004-2011. The results were combined with food consumption data to estimate the Danish dietary exposure of trace elements. The dietary exposures of the following trace elements were estimated:

- Cadmium (Cd)
- Lead (Pb)
- Mercury (Hg)
- Arsenic, inorganic (iAs)
- Selenium (Se)

In addition some other trace elements, including aluminium (Al), Manganese (Mn) and Nickel (Ni) have also been analysed in certain projects, and the results on the levels of these elements are also presented in the report as well.

6.2 Methods of sampling, analysis and quality assurance

6.2.1 Sampling

The samples were taken in the period 2004-2011. The sampling and analysis was organised in various projects, each covering a certain food-group or –subgroup. In contrast to the previous monitoring periods, there was no stratified sampling, with the same type of samples being analysed consecutively, was conducted. The projects were defined with respect to the types of foods and trace elements that were to be included on a project-by-project basis by the Danish Food Administration in collaboration with the National Food Institute. The sampling was conducted by local food inspectors from the Danish Food Administration in various parts of Denmark. The types and numbers of various foods included in the projects and the results of the analysis are given in Appendices 16.1.1 to 16.1.11.

6.2.2 Chemical analyses and quality assurance

The level of trace elements was analysed by the regional laboratory of the Danish Food Administration in Aarhus. The samples were prepared in accordance with common household practices, but none of the foods were cooked prior to analysis. Only the edible parts of the foods were used and adhered soil was removed by brushing under clean water. The sample preparation involved isolation of the relevant tissue or part of the sample by utensils, which would not contaminate the samples. To determine the total level of trace elements, representative subsamples of the homogenised food samples were digested by microwave-assisted wet-ashing in quartz vessels with concentrated nitric acid. Following this process the trace element level was determined by using inductively coupled plasma- mass spectrometry (ICP-MS). External calibration with internal standardisation was used for the quantification of trace elements. For the selective determination of inorganic arsenic the samples were extracted with dilute acid at 90°C and the level of inorganic arsenic was determined by using anion-exchange HPLC-ICP-MS. The analytical work was generally organised and run in batches comprising up to 15-20 unknown samples, minimum one blank, minimum one double determination for approximately each 10 unknown samples and one or more certified reference material(s). In the event of deviations from a set of criteria for tolerable variations of blanks, for values obtained for CRMs (x-charts) and for double determinations (R-charts), all the analyses in that batch were repeated. The LODs, which were calculated in accordance with the three-sigma criterion, were estimated from the variance of the analytical blank values. Results indicated by ”<” in Appendices 16.1.1 to 16.1.11 were below the LOD value for the analytical survey in which the result was produced.

The results for the analysis of the levels of the trace elements in the food items sampled and analysed during the period 2004-2011 are summarised in Appendices 16.1.1 to 16.1.11.

6.2.3 Handling of low results and data analysis

Analytical results close to the limit of detection (LOD) are associated with a larger relative standard deviation and for values below the LOD the confidence interval may exceed 100% of the value. For those trace elements present at concentrations below the LOD, the values obtained were still collated. Their mean values were evaluated as the best approximation to the true concentration and were therefore used for the estimation of the mean concentration (see Appendix 16.1) and total dietary trace element exposure, as described in the next section. Using zero for these low concentrations would lead to an under estimation of the trace element exposure, and using the LOQ value would lead to its overestimation.

The samples included organically grown foods, but since the concentrations were similar to those for the non-organic foods, the results were merged

6.3 Dietary exposure to trace elements

The dietary exposure to trace elements was estimated by combining data on contamination level with data and data on food consumption. In the period 2004-2011 the monitoring system only provided data for the trace element level in some of the food items included in the exposure calculations. When no data were available, the corresponding data from the previous period (Danish Veterinary and Food Administration, 2005) were used in the exposure calculation. On the other hand, some projects provided data for food items that were not used in the exposure calculations. In Appendices 16.1.1 to 16.1.11, the food items for which the data has been used in the latest exposure calculations are marked. Furthermore, where the food consumption data includes food items that were not included in the analytical surveys, contamination level data from similar foods were used. This was particularly the case for several dairy products and types of bread. No corrections for losses and gains during food preparation were applied, because the current knowledge about these processes is insufficient. The mean values for trace element levels in the foods were used, because they were assumed to reflect the consumer’s average exposure to a trace element in marketed foods. For the purpose of comparing the exposure estimates (µg/day) with the health-based guidance values (e.g. TWI, PTWI) or calculating a MOE on the basis of a BMDL, the exposure was also expressed as µg/kg bw. Table 6.1 provides an overview of the BMDLs and health-based guidance values for the toxicological tolerable exposure established by JECFA and EFSA. Further information can be found in the various sections on the different elements.

***Table 6.1** Overview of health-based guidance values for the tolerable exposure established by JECFA and EFSA for the various elements and element species*

Element/species	Body	Year	Type	Value
Mercury, inorganic	JECFA	2011a	PTWI	4 µg/kg bw/week
	EFSA	2012a	TWI	4 µg/kg bw/week
Methylmercury	JECFA	2004	PTWI	1.6 µg/kg bw/week
	EFSA	2012a	TWI	1.3 µg/kg bw/week
Lead	JECFA	2011b	PTWI	Withdrawn, no no-effect level identified
	EFSA	2010	PTWI	Withdrawn, no no-effect level identified
			$BMDL_{01}$	0.50 µg/kg bw/day (developmental neurotoxicity)
			$BMDL_{01}$	1.50 µg/kg bw/day (effects on systolic blood pressure)
			$BMDL_{10}$	0.63 µg/kg bw/day (chronic kidney disease)
Cadmium	JECFA	2011b	PTMI	25 µg/kg bw/month
	EFSA	2009b	TWI	2.5 µg/kg bw/week
Arsenic, inorganic	JECFA	2011a	$BMDL_{0.5}$	3 µg/kg bw/day (2-7 µg/kg bw/day) with an average of 11.5 year follow up)
	EFSA	2009a	$BMDL_{01}$	0.3-8 µg/kg bw/day (lifetime risk)
Aluminium	JECFA	2006	PTWI	1 mg/kg bw/week
	EFSA	2008a	PTWI	1 mg/kg bw/week
Nickel	WHO	2005	TDI	22 µg/kg bw/day
	EFSA	2005c	-	No upper tolerable limit established
Manganese	WHO	-	-	No upper tolerable limit established
	EFSA	-	-	No upper tolerable limit established

6.4 Mercury

6.4.1 Introduction

Mercury (Hg) is naturally present in the Earth's crust usually at concentrations around 0.02 mg/kg. Elemental mercury is liquid at room temperature and in standard pressure conditions. The element can be found in various chemical forms, both inorganic and organic. It is used in various industrial applications, including products such as batteries, cables, electrical switches, dental amalgams and lamps. The main anthropological source of mercury is the incineration of waste.

Ingested mercury accumulates in the body, and the most toxic species is methyl-mercury, which is the predominant chemical form of mercury in marine fish. The central nervous system is the target organ of methyl-mercury, particularly during foetal development, and the toxic effects include alteration of sensory functions, motor coordination, memory, attention and learning ability. For inorganic mercury the adverse effects include renal lesions, neurotoxicity and cardiovascular disorders.

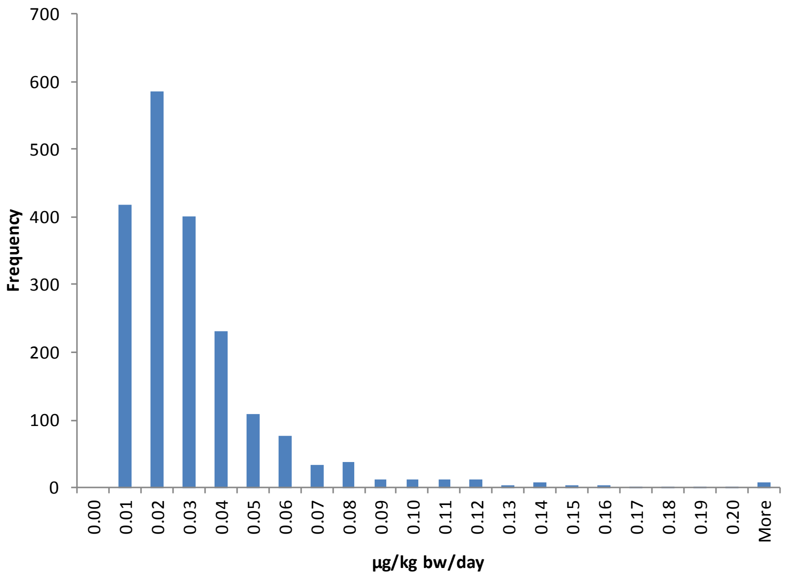
The risk to public health in relation to dietary exposure to inorganic mercury and methyl-mercury has recently been evaluated by JECFA (2011a) and EFSA (2012a). In line with JECFA, the CONTAM Panel of EFSA established a TWI for inorganic mercury at 4 µg/kg bw/week, expressed as mercury. JECFA has set a PTWI value for methyl-mercury exposure at 1.6 µg/kg bw/week. This applies to methyl-mercury exposure through the consumption of fish and seafood products (JECFA 2004, 2011a). The current EFSA opinion (2012a), took into account recent developments in epidemiological studies from the Seychelles Child Developmental Study Nutrition Cohort.. These studies indicate that n-3 long-chain polyunsaturated fatty acids in fish may counteract negative effects from methyl-mercury exposure. Taken together with the information that beneficial nutrients in fish may have confounded previous adverse outcomes in child cohort studies from the Faroe Islands, the CONTAM Panel established a TWI for methyl-mercury of 1.3 µg/kg bw/week, expressed as mercury.

6.4.2 Development over time

The level of mercury was, as in the previous periods, analysed in cod and plaice as marker foods (see Appendix 16.1.1). The concentration levels stable compared to previous monitoring periods. This indicates that the environmental levels of mercury have been stable in recent decades.

6.4.3 Exposure and risk assessment

Figure 6.1 shows the distribution in mercury exposure for the Danish population (aged 4-75) in µg/kg bw/day. The mean exposure was estimated at 1.7 µg/day, which is slightly lower than the estimated exposure from the previous monitoring period of 1.9 µg/day for adults (Danish Veterinary Food Administration, 2005). On the other hand, the exposure for high consumers has increased, as indicated by the increase for the 95^{th} percentile to 4.3 µg/day compared to 4.1 µg/day in the previous period.



		µg/kg bw/day
Mean		0.03
sd		0.03
N		1974
Percentiles	1	0.003
	5	0.005
	25	0.01
(median)	50	0.02
	75	0.03
	95	0.07
	99	0.14
Minimum		0.02
Maximum		0.97

Figure 6.1. *Distribution of mercury exposure in the Danish population (aged 4-75) in µg/kg bw/day*

Figure 6.2 shows the contribution to the exposure from various food groups. Fish and fish products constitute the food group with the largest contribution to mercury exposure comprising 68.1% of the total exposure. Fruits and fruit products (9.5%) and cereals (5.9%) are other food groups with some significant contribution, whereas the other food groups only provide low contributions to the overall dietary exposure.

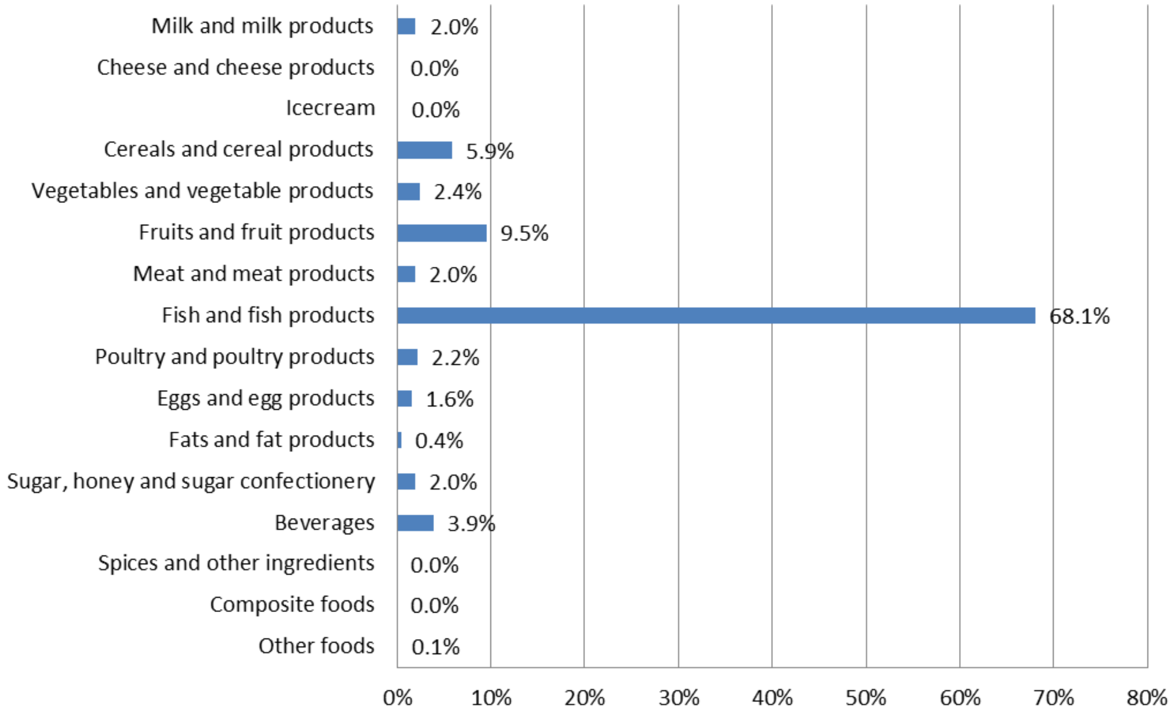


Figure 6.2 *Exposure of mercury from main food groups in the Danish population (aged 4-75)*

The data obtained during the monitoring projects were only determined as total mercury. However, the recent toxicological evaluations by EFSA and JECFA have established specific TWI values for both inorganic mercury and methyl-mercury.. To evaluate the species-specific dietary exposure and compare it with the established TWI values, the dietary exposure to the individual mercury species was calculated following the assumptions on mercury species distribution for different food groups used by EFSA (2012a). For fish and fish products a conversion factor of 1.0 was used for methyl-mercury and 0.2 for inorganic mercury. For all other food groups, apart from fish and fish products, the total mercury concentration was regarded as inorganic mercury.

Following the above assumption for methyl-mercury the mean and 95th percentile exposures were calculated to be at 0.018 and 0.051 µg/kg bw/day, respectively. This corresponds to 10% (mean) and 27% (95th percentile) of the EFSA TWI value for methyl-mercury. Similarly, mean and 95th percentile exposures of 0.012 and 0.034 µg/kg bw/day, respectively, were calculated for in-organic mercury. These values correspond to 2.2% (mean) and 6.0% (95th percentile), respectively, of the EFSA TWI value for inorganic mercury.

The estimated mean exposure of methyl-mercury (1.1 µg/day), in the present monitoring period is at the same level as estimated in the previous monitoring period. The exposure is at the same level as the methyl-mercury exposure reported in the French adult population (0.017 µg/kg bw/day) (ANSES, 2012a) but slightly lower compared to the EFSA evaluation for Denmark (0.17 µg/kg bw/week = 0.024 µg/kg bw/day) (EFSA, 2012). Based on this it can be concluded that the intake of methyl mercury is not of major health concern in the Danish population

6.5 Lead

6.5.1 Introduction

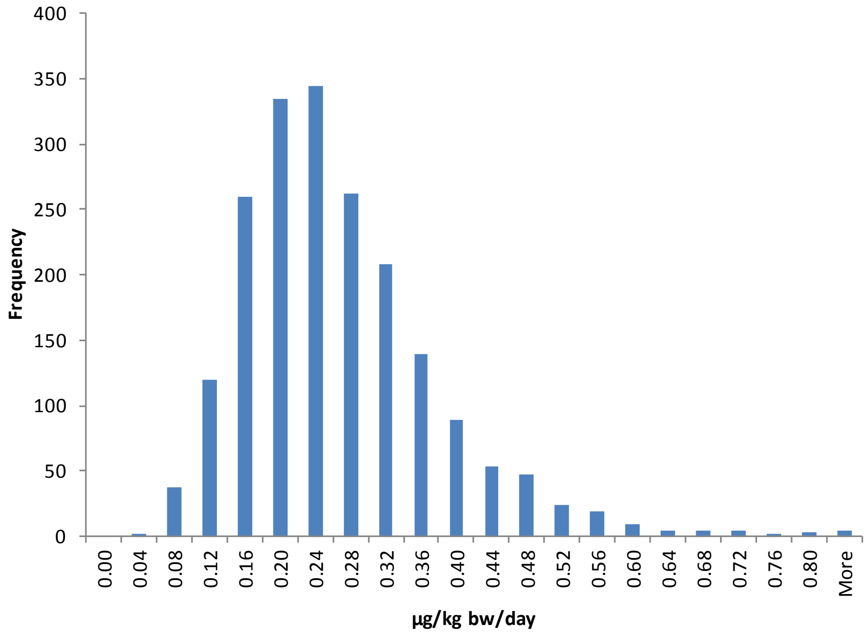
Lead is a ubiquitous element, found naturally in the Earth's crust at an average concentration of 10 mg/kg. It is widespread in the environment due to its use in various applications, including mining and industrial activities, accumulators, pigments, alloys, and ammunition. Exposure levels have decreased since the banning of lead additives to car fuel.. Ingested lead accumulates in the body, and its most adverse effect is associated with the development of the central nervous system in children and probably also in the foetus. In adults, lead affects the kidneys (increased prevalence of chronic kidney disease) and the cardiovascular system (high systolic blood pressure). Protecting children against the potential risk of neurodevelopmental effects would be protective against all other adverse effects of lead, in all populations (EFSA, 2010) In 1986 JECFA established a PTWI value at 25 µg/kg bw/week, but recently both JECFA (2011b) and EFSA (2010) acknowledged that this PTWI value was not sufficiently protective. They were, however, not able to establish a new health-based guideline value because it was considered likely that there is no threshold for neurodevelopmental effect in children. EFSA performed a benchmark dose modelling of the effects mentioned as shown above in Table 6.1.

6.5.2 Development over time

The mean level of lead was, as in previous periods, analysed in ox kidneys as a marker food (72 µg/kg; see Appendix 16.1.2) and the concentration level is stable compared to the previous monitoring periods from 1992 and onwards (mean levels below 100 µg/kg). This indicates that the environmental levels of lead have been stable in recent decades.

6.5.3 Exposure and risk assessment

Figure 6.3.shows the distribution of lead exposure to the Danish population (aged 4-75) in µg/kg bw/day. The estimated mean exposure of 15 µg/day (0.25 µg/kg bw/day) is slightly lower than the previously reported mean exposure of Danish adults of 19 µg/day for the time period 1998-2003 (Danish Veterinary and Food Administration, 2003).



		µg/kg bw/day
Mean		0.25
sd		0.11
N		1974
Percentile	1	0.069
	5	0.102
	25	0.17
(median)	50	0.23
	75	0.30
	95	0.46
	99	0.62
Minimum		0.03
Maximum		1.05

Figure 6.3. *Distribution of lead exposure in the Danish population (aged 4-75 in µg/kg bw/day*

Figure 6.4 shows the contribution to lead exposure of lead from different food groups. Beverages are the food group with the largest contribution to lead exposure comprising 46.6 % of the total exposure. Fruits and fruit products (17.6 %), sugar, honey and sugar confectionary (11.6 %), vegetables (9.1%) and cereals (8.4 %) are other food groups with significant contributions, while other food groups only make low contributions to the overall dietary exposure of lead.

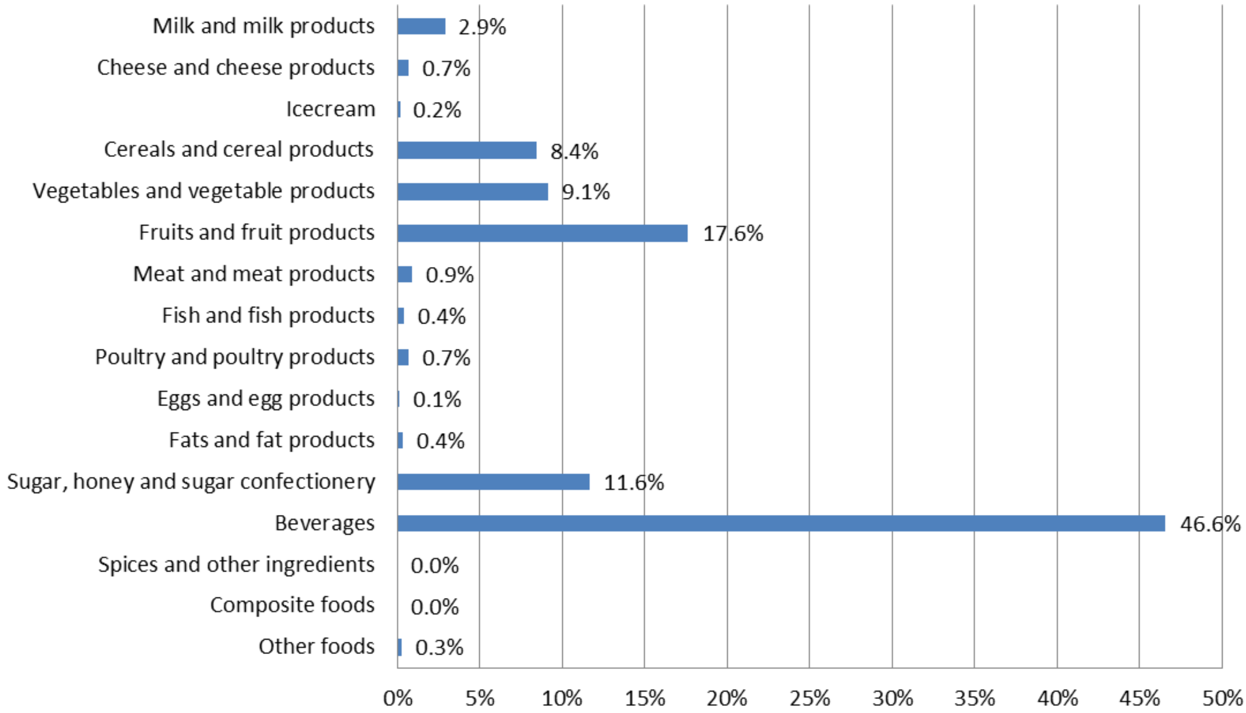


Figure 6.4. *Exposure of lead from main food groups in the Danish population (aged 4-75)*

For children (aged 4-14) the mean and 95th percentile exposure were estimated at 0.30 and 0.56 µg/kg bw/day), respectively. The values are at the same level as the exposure estimated for French children of 0.27 µg/kg bw/day (mean) and 0.57 µg/kg bw/day (95th percentile) (ANSES, 2012a), but lower than the estimates in the recent EFSA evaluation on dietary exposure to lead in the European population, where a mean exposure for Danish children at 1.07 µg/kg bw/day was reported (EFSA, 2012b). The exposure is near the $BMDL_{01}$ (0.5 µg/kg bw/day) for developmental neurotoxicity so the MOE is close to 1. It is therefore desirable that children decrease their exposure of lead.

For adults (aged 15-75) the mean and 95th percentile exposures were estimated at 0.23 and 0.41 µg/kg bw/day), respectively. The values are at the same level as estimated for French adults at 0.20 µg/kg bw/day (mean) and 0.35 µg/kg bw/day (95th percentile) (ANSES, 2012a), but lower than the estimates in the EFSA evaluation, where the mean exposure for Danish adults was reported as 0.58 µg/kg bw/day (LB-UB) (EFSA, 2012b). The MOE is also low for adults and it is therefore desirable that the exposure is lowered.

6.6 Cadmium

6.6.1 Introduction

Cadmium (Cd) is a heavy metal found as an environmental contaminant, both through natural occurrence and from industrial and agricultural sources. Foods are the main source of cadmium exposure for the non-smoking population. Tobacco smoking and work place air have also been identified as major contributors to cadmium exposure.

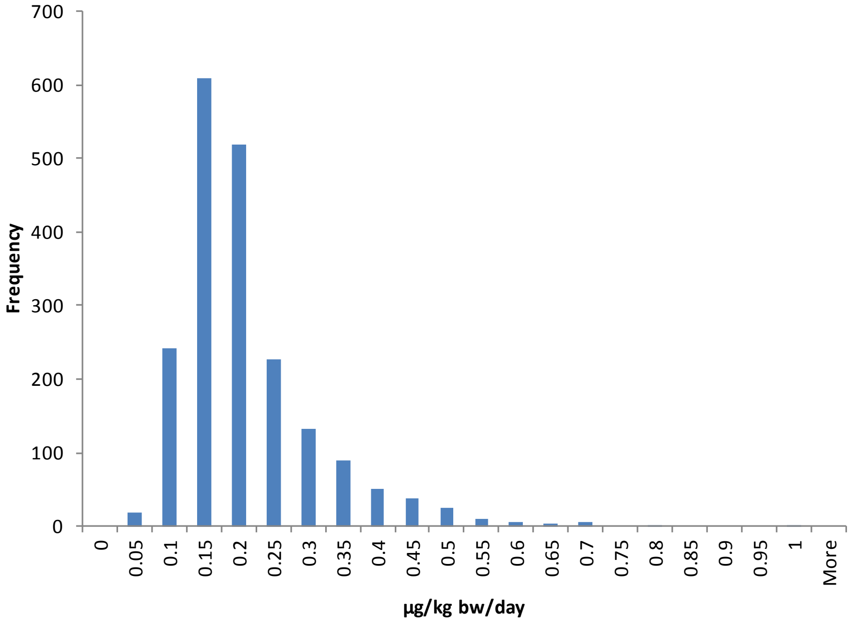
Upon exposure, cadmium is efficiently retained in the kidney and liver in the human body, with a very long biological half-life ranging from 10 to 30 years. Cadmium is primarily toxic to the kidneys and may cause renal dysfunction. Cadmium can also cause bone demineralisation, either through direct bone damage or indirectly as a result of renal dysfunction. There is limited evidence for the carcinogenicity of cadmium following oral administration. In 2009 the CONTAM Panel of EFSA evaluated the dietary exposure to cadmium in the European population. A tolerable weekly exposure (TWI) value of 2.5 µg/kg bw/week was established, based on human studies on kidney effects (EFSA, 2009a). This value was maintained in a statement from 2011 (EFSA, 2011a) following a renewed evaluation after a provisional tolerable monthly exposure (PTMI) of 25 µg/kg bw/month was established by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) in 2010.

6.6.2 Development over time

The level of cadmium (see Appendix 16.1.3) was analysed in potatoes, which can be used as a marker food for the body burden of cadmium. The mean concentration of cadmium in potatoes at 0.02 mg/kg indicate a stabilisation of the cadmium body burden because this value is at the same level as the values recorded in 1995 (0.02 mg/kg) and 2003 (0.025 mg/kg), whereas in the 1980's values at 0.040-0.055 mg/kg, were recorded.

6.6.3 Exposure and risk assessment

Figure 6.5 shows the distribution of cadmium exposure in the Danish population in µg/kg bw/day. The mean exposure was calculated to be 10.8 µg/day which is similar to the previously reported exposure of Danish adults at 10 µg/day for the time period 1998-2003 (Danish Food Administration, 2003). However, in the meantime the TWI value has been lowered from 7 µg/kg bw/week (JECFA, 1988) to 2.5 µg/kg bw/week (=0.36 µg/kg bw/day) (EFSA, 2009a) and consequently, the margin of exposure compared to the new TWI value has decreased. The mean exposure at 0.18 µg/kg bw/day corresponds to 50% of the TWI value. The data show that about 5% of the Danish population has an exposure, which exceeds the TWI value. It is therefore desirable that the exposure is lowered.



		µg/kg bw/day
Mean		0.18
sd		0.10
N		1974
Percentiles	1	0.05
	5	0.08
	25	0.12
(median)	50	0.16
	75	0.22
	95	0.38
	99	0.52
Minimum		0.02
Maximum		0.97

Figure 6.5. *Distribution of cadmium exposure in the Danish population (aged 4-75) in µg/kg bw/day*

The majority of those exceeding the TWI value are children, who have a relatively high exposure per kg bodyweight, mainly due to their lower bodyweight compared to adults. For children (aged 4-14) the mean exposure is 31 µg/kg bw/day (86 % of TWI) and approximately a quarter of this group exceed the TWI value. For adults (aged 15-75) the mean exposure is 0.15 µg/kg bw/day (42 % of TWI) and less than 1% exceed the TWI value. This is lower than the estimated cadmium exposure in Danish adults reported by EFSA in 2009 at 2.26 µg/kg bw/day (=0.32 µg/kg bw/day). On the other hand it is consistent with the cadmium exposure estimated in the French adult population (0.16 µg/kg bw/day) (ANSES, 2012a). It is noteworthy that EFSA also estimated an exposure at 2.27 µg/kg bw/day for France, which is the same level as for Denmark as but higher than the French evaluation.

Figure 6.6 shows the contribution to the exposure from various food groups. The food groups, that contribute the most to cadmium exposure are cereals and starch products (49%) and vegetables (34%). This is in accordance with the previous reporting period of 1998-2003.

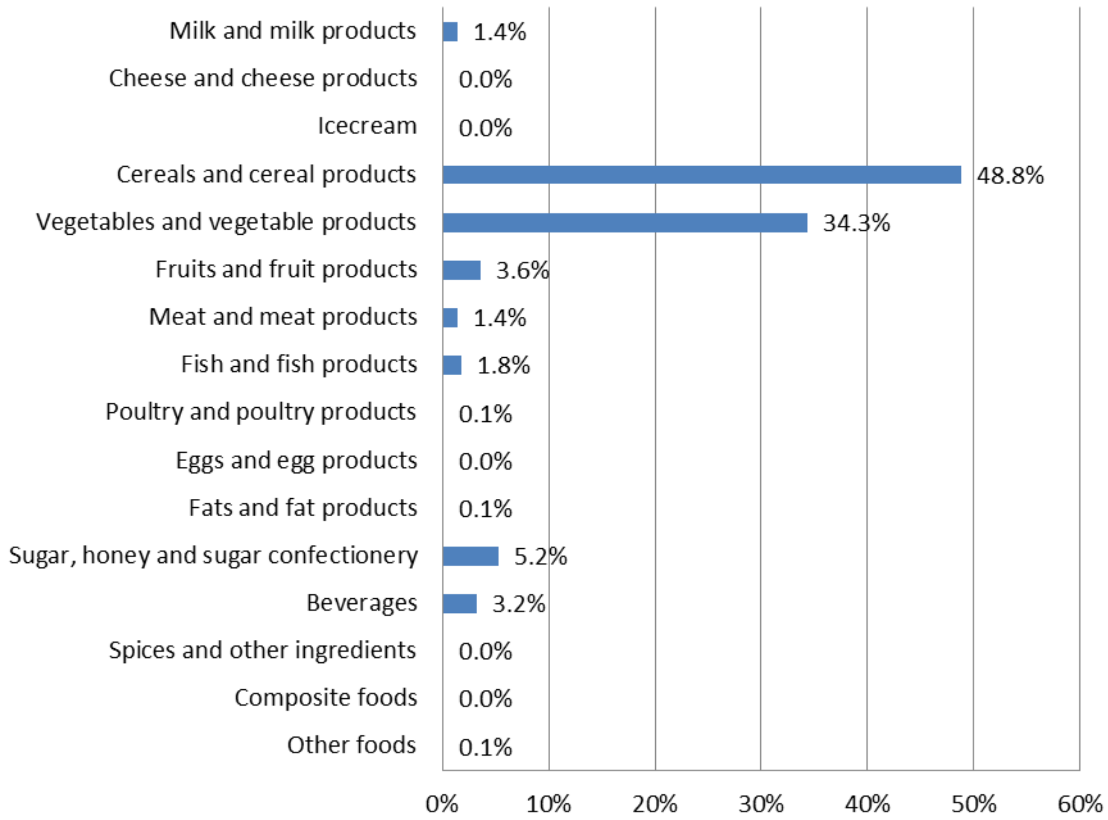


Figure 6.6. *Exposure of cadmium from main food groups in the Danish population (aged 4-75)*

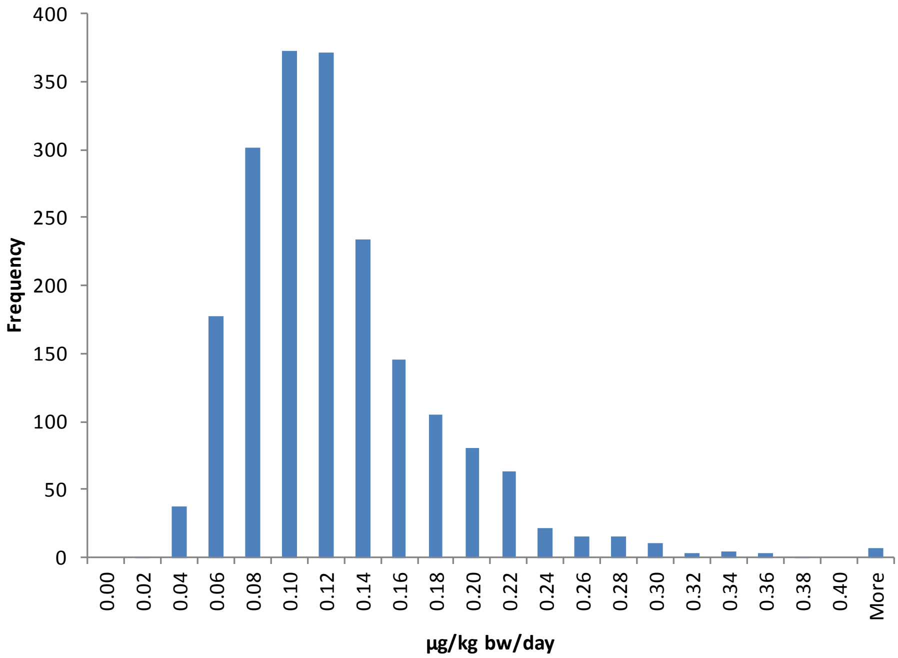
6.7 Arsenic

6.7.1 Introduction

Arsenic is a ubiquitous element, which is introduced to the environment from both natural and anthropogenic sources. The crust of the Earth contains arsenic, which is released through weathering of rocks and volcanic activity. The anthropogenic contribution originates primarily from mining and smelting industry, the burning of fossil fuels and from use of arsenic containing pesticides, growth-promoters and wood-preservation agents. Arsenic has a very complex chemistry and natural metabolic processes in the biosphere have resulted in the existence of a large number of arsenic compounds. The toxicity of arsenic compounds strongly depends on their chemical forms (speciation). Inorganic arsenic is considered the most toxic of the species present in food. There is good evidence for the carcinogenicity of inorganic arsenic and IARC consider it as carcinogenic to human (group 1) (IARC). Organoarsenic compounds are generally considered to have intermediate to low toxicity, although our understanding of the potential toxicity of all arsenic compounds is not fully elucidated. However, in the recent scientific evaluations on arsenic by EFSA (2009b) and JECFA (2011a) emphasis was on inorganic arsenic exposure. Therefore, the emphasis in this report has been on inorganic arsenic exposure and not total arsenic exposure, so the present evaluation also focuses on inorganic arsenic exposure and not the total arsenic exposure.

6.7.2 Exposure and risk assessment

In the present period, the specific determination of inorganic arsenic in a range of foods, including rice and seafood, has been included for the first time in the history of the monitoring programme (see Appendix 16.1.4). For the foods, where no specific data on inorganic arsenic were available (all foods except rice and seafood) a conversion factor of 1.0 from total arsenic has been applied in the exposure calculations (see Appendix 16.1.5). For rice and seafood specific results for inorganic arsenic were obtained and these results were used in the exposure estimation. Figure 6.7 shows the exposure of the Danish population to inorganic arsenic in µg/kg bw/day in . The mean exposure of inorganic arsenic was calculated to be 7.0 µg/day or 0.12 µg/kg bw/day. The mean exposure is at 40% of the lower value of the EFSA $BMDL_{01}$ range (0.3-8 µg/kg bw/day) and approximately 1% of the population has an exposure, which is within the $BMDL_{01}$ range. The estimated mean exposure is lower than the mean exposure for the French population, which was estimated at 0.24-0.28 µg/kg bw/day (ANSES, 2012a). These figures indicate that it is very important to reduce the exposure of inorganic arsenic.



		µg/kg bw/day
Mean		0.12
sd		0.06
N		1974
Percentiles	1	0.034
	5	0.049
	25	0.08
(median)	50	0.11
	75	0.14
	95	0.21
	99	0.30
Minimum		0.02
Maximum		0.81

Figure 6.7. *Distribution of inorganic arsenic exposure in the Danish population (aged 4-75) in µg/kg bw/day*

Figure 6.8 shows the contribution to inorganic arsenic exposure from different food groups. The food groups, that contribute the most to the exposure of inorganic arsenic, are beverages (45.8%) and cereals (26.2%). This is in accordance with the recent French total diet study (TDS), where drinking water and non-alcoholic beverages were reported as the main contributors to inorganic arsenic exposure in the French population (ANSES, 2012a), but differs from the EFSA evaluation, where cereals were reported as the main contributor (EFSA, 2009a).

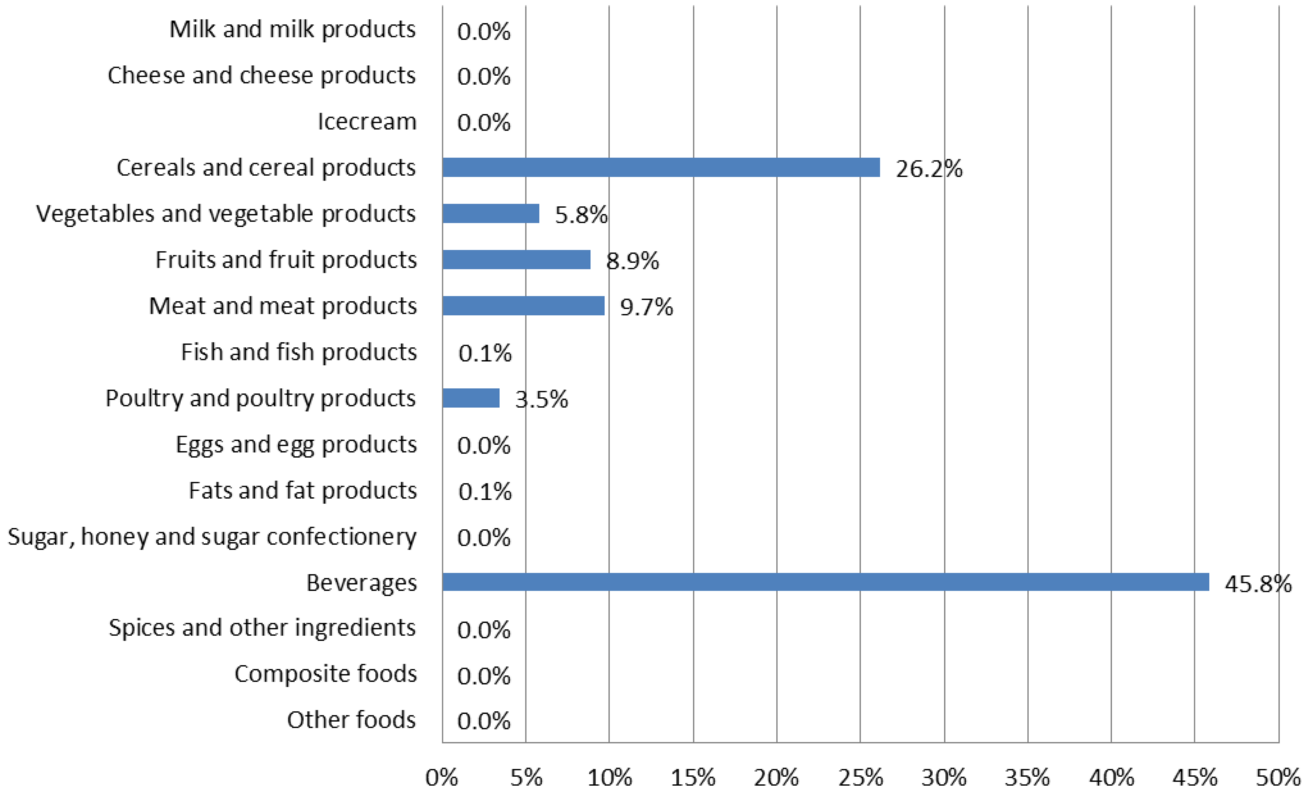


Figure 6.8. *Exposure of inorganic arsenic from main food groups in the Danish population (aged 4-75)*

6.8 Selenium

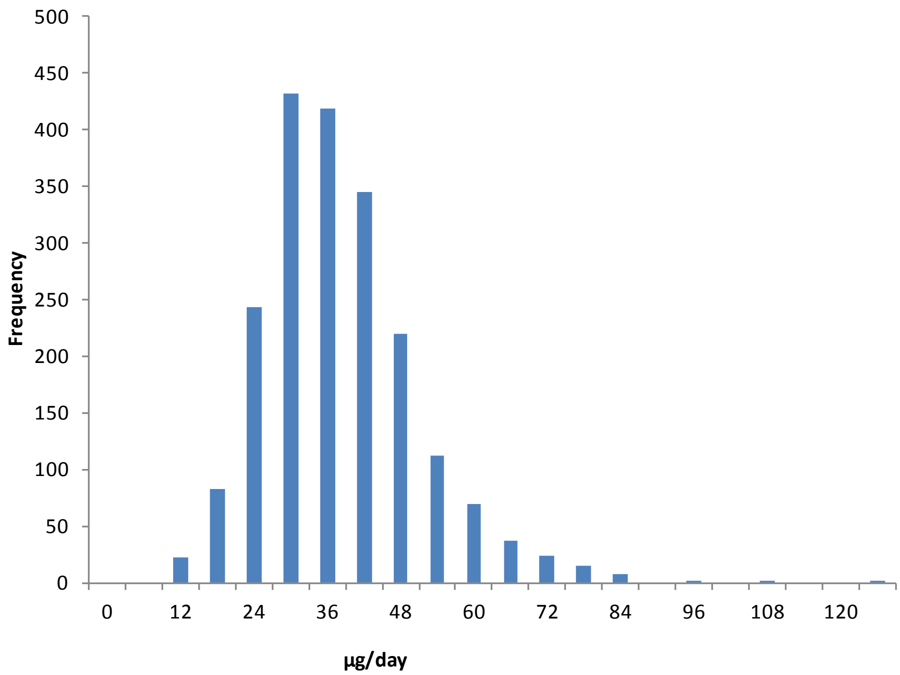
6.8.1 Introduction

Selenium is an element essential to humans and the main functions of selenium are performed through selenoproteins. Several selenoproteins have been identified, including glutathione peroxidases, deiodinases, selenoprotein P and thioredoxin. The deiodinases are involved in the thyroid hormone metabolism, while the other are antioxidant enzymes that act in the body's defence system against oxidative stress and the regulation of the redox status of vitamins C and E. Furthermore, selenium is believed to play an active role in the elimination of certain toxic molecules from the body (e.g. mercury). Selenium exposure is also linked to cancer-preventive effects in humans. A severely low exposure of selenium may lead to adverse effects like heart disease (Keshan's Disease), muscular degeneration, de-pigmentation of hair and nails, anaemia and increased occurrence of infections. Excessive exposure of selenium, though very seldom in human diets, may lead to selenosis, which causes gastrointestinal disorders, hair loss, fatigue and irritability (EFSA, 2009c).

The Scientific Committee on Food (SCF) has established a tolerable upper exposure level at 300 µg/day for adults and from 90-250 µg/day for children aged between 4 and 17 (SCF, 2006). The Nordic Nutrition Recommendations (NNR) working group estimated the recommended exposure (RI) of selenium at 40 µg/day for women and 50 µg/day for men(NNR, 2004). The recommendations are currently being re-evaluated and new values for the recommended exposure have been proposed (although not yet decided) at 50 µg/day for women, 60 µg/day for men, and between 25-40 µg/day for children of 2-13 (NNR, 2012). The NNR working group also estimated the average requirements (AR) for selenium at 35 µg/day (men) and 30 µg/day (women) (NNR, 2004). The AR value is primarily used to assess the risk of inadequate exposure of micronutrients in a group of individuals. The percentage of the group that has an exposure below the AR indicates the proportion that has an increased risk of inadequate exposure. NNR also established a lower limit of exposure value (LI) of 20 µg/day for both men and women. Long-term exposures below the LI value are associated with an increased risk of developing deficiency symptoms.

6.8.2 Exposure assessment

Figure 6.9 shows the distribution of selenium exposure in the Danish population (aged 4-75) in µg/day. A mean exposure of 35 µg/day was estimated for the whole population, which is slightly lower than to the estimated exposure from the previous monitoring period of 43 µg/day for adults (Danish Food Administration, 2003).



		µg/kg bw/day
Mean		35
sd		13
N		2033
Percentiles	1	12
	5	18
	25	26
(median)	50	33
	75	42
	95	58
	99	75
Minimum		7
Maximum		131

Figure 6.9. *Distribution of selenium exposure in the Danish population (aged 4-75) in µg/kg bw/day*

Figure 6.10 shows the contribution to the exposure of selenium from different food groups. The food group, that contributes most to the selenium exposure, are cereals, but also milk and milk products, fish and fish products, meat and meat products and eggs contribute with more than 10% of the overall exposure

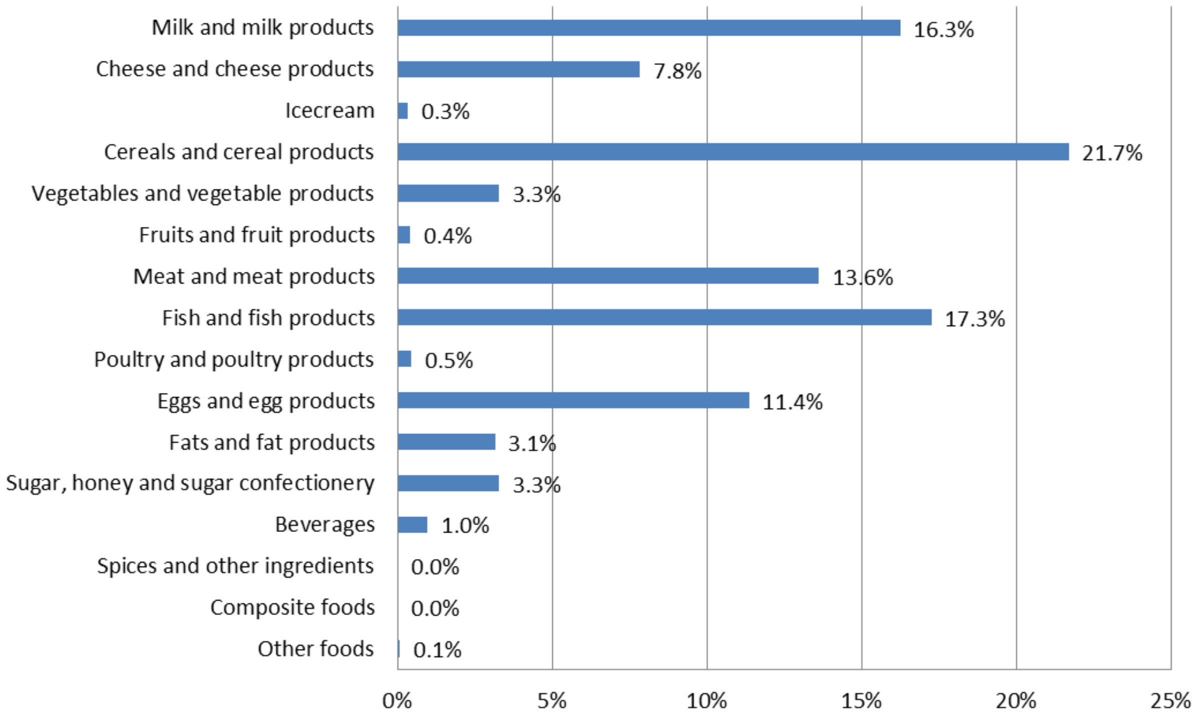


Fig 6.10. *Exposure of selenium from main food groups in the Danish population (aged 4-75)*

6.9 Other trace elements

During the monitoring period the elements nickel, aluminium and manganese were analysed in a limited number of projects. The amount of data was not sufficient to make exposure calculations. The levels can be found in Appendices 16.1.7 to Appendix 16.1.11.

6.9.1 Nickel

Nickel occurs naturally in the Earth's crust and is used in many industrial applications, e.g. in alloys (stainless steel), ships and aircraft manufacturing and electrical industries. Humans can be exposed to nickel through inhalation (occupational exposure), food and water and via skin contact. Dermal as well as oral exposure to nickel may cause allergic reactions like dermatitis in sensitized persons. Although it has been linked to the metabolism of methionine in animals, nickel is not considered to be an essential element to humans, so, no requirements or recommended dietary allowances have been established for nickel. WHO has established a TDI of nickel at 22 µg/kg bw/day (WHO, 2005). The mean and 95th percentile dietary exposures to nickel were estimated at 104 µg/day (~1.5

µg/kg bw/day) and 190 µg/day (~2.7 µg/kg bw/day), respectively, for the monitoring period 1998-2003. The new data in the present period are at the same levels as previously reported and the dietary exposure can be considered to be at the same level as previously. EFSA has estimated the exposure of nickel from an average diet at 150 µg/day (~2.5 µg/kg bw/day), but in high-consumers the exposure may reach 900 µg/day, when food items with high amounts of nickel are consumed (EFSA, 2005b). Moreover, first-run water, which can contain high levels of nickel (up to 1000 µg/L) and migration of nickel from kitchen utensils to foods may contribute to nickel exposure and could result in an exposure, which is higher than the critical dose. Foods with a high level of nickel include cocoa products (e.g. dark chocolate), where concentrations of up to 5.4 mg/kg have been found with a median of 3.3 mg/kg, and dried fruits, nuts and grains (see Appendix 16.1.8).

The present intake of nickel from food is not of health concern.

6.9.2 Aluminium

Aluminium is the most abundant element in the Earth's crust (8%). It is used in numerous industrial applications, including food processing, pharmaceuticals and drinking water treatment. Aluminium may be found in foods and drinking water in various chemical forms; but the chemical analysis only provides data on the total aluminium level. In the present monitoring period a project on baby food included the analysis of aluminium with 59 samples analysed. The level varied in the range from 0.2 to 4.4 mg/kg (see Appendix 16.1.7).

For the general population the main route of exposure to aluminium is through food. Aluminium in drinking water represents another, though less significant, source of exposure. Additional exposures may arise from the use of aluminium compounds in pharmaceuticals and consumer products. Various chemical forms of aluminium are used as food additives and are estimated to be the greatest contributors to the dietary exposure of aluminium. Other important sources are plant products and migration from food contact materials (especially from acidic foods). Bioavailability depends on the chemical form of aluminium, but is generally considered to be low (0.1-0.3%) (EFSA, 2008a). After absorption, aluminium distributes to all tissues in animals and humans and accumulates in particular in bone. The main carrier of the aluminium ion in plasma is the iron binding protein, transferrin. Aluminium can enter the brain and reach the placenta and foetus. , Neurotoxicity has been demonstrated in animal studies. Aluminium is not considered to be a human carcinogen following oral exposure. EFSA established a tolerable weekly exposure value (TWI) of 1 mg/kg bw/week based on neurotoxicity in experiments in animals (EFSA, 2008a – later confirmed in EFSA, 2011b).

The limited number of data on aluminium did not allow an estimation of the dietary exposure in the Danish population. EFSA reported the mean dietary exposure in a number of European countries to be in the range of 0.2 to 1.5 mg/kg bw/week and up to 2.3 mg/kg bw/week in high-consumers (EFSA, 2008). The recent TDS study in France estimated the exposure at 0.28 mg/kg bw/week for adults (ANSES, 2012a). Both EFSA and ANSES concluded that the TWI value is likely to be exceeded by some people. It is difficult to assess the health consequences of this because total aluminium is considered without taking the different species of aluminium into consideration. It is well known that there are large differences in the solubility, and therefore, the bioavailability of the different aluminium compounds. There are also large differences in the absorption of aluminium between l animals and humans.

6.9.3 Manganese

Manganese is a naturally occurring element and an essential nutrient, being a component of several enzyme systems (e.g. glycosyl transferases). Manganese is the twelfth most abundant element and the fifth most abundant metal comprising approximately 0.1 % of the earth's crust. Manganese exists in both inorganic and organic forms, with manganese dioxide (pyrolusite) being the most abundant naturally-occurring form of manganese. Its ubiquity in soils results in vegetable and animal foods readily containing varying amounts of this element. Food of plant origin, including cereal products and especially tea are main contributors to the dietary exposure.

Manganese deficiency may lead to skeletal disorders, alterations in the growth process and reproductive functions, skin appendages, and to a reduction in cholesterol levels. However, manganese deficiency has not been reported in humans. The nutritional need for manganese has been estimated at 1-2.5 mg/day in adults (Arnaud, 2001). The Scientific Committee on Food (SCF) concluded that, due to the lack of scientific evidence, it was not possible to establish an upper tolerable intake for manganese (SCF, 2006). In France a safety limit of 10 mg/day has been set (mg/day). Excessive exposure to manganese has been linked to neurotoxic effects in older people in particular. The French TDS study estimated the exposure to be 2.16 mg/day for adults and 1.46 mg/day for children, but this estimate was based on a limited amount of data. Results from the Danish analyses are shown in Appendix 16.1.9

7 Nitrate in vegetables

7.1 Introduction

Nitrate is a naturally occurring compound present in plants which may accumulate in different tissues of the plant. Vegetables are the main contributor of nitrate in the human diet, generally providing approximately 80 % of the total daily exposure (SFC, 1997). Some vegetables such as head lettuce, iceberg lettuce, rucola (salad rocket), and spinach have been shown to contain relatively high levels of nitrate. The level of nitrate varies between plant species, the extent of fertilisers use, humidity, temperature and amount of sunlight, e.g. the nitrate level in lettuce tends to be higher in samples from Northern Europe than from Mediterranean countries. The acute toxicity of nitrate is low, but in food and in the gastrointestinal tract nitrate can be reduced to nitrite, which has a higher acute toxicity.

Since 1984 the level of nitrate in various vegetables has been monitored (National Food Agency of Denmark 1990 and 1995, Danish Veterinary and Food Administration 2001 and 2005). The selection of crops in the present monitoring programme was based on these previous studies.

EU regulations have been adopted for nitrate levels in different vegetables (EC, 2006a) and in 2011, EU imposed maximum levels for nitrate in rucola (EC, 2011e). From April 2004 the nitrate levels in baby food and processed cereal based foods for infants and young children were regulated by the EU (EC, 2004)

7.2 Methods of sampling, analysis and quality assurance

The sampling was carried out on a nationwide basis by authorized personnel from local food control units. Samples were analysed for nitrate at the regional laboratory in Ringsted (Denmark). Samples were taken at vegetable markets all over Denmark. The analyses were performed in accordance with to the method for the determination of nitrate in fruits and vegetables of the Danish Veterinary and Food Administration (FIA-method, ANA-07.1481). The limit of quantification (LOQ) was 5 mg/kg for nitrate. The regional laboratories in Ringsted participate in inter calibrations and performance tests through the Food Analysis Performance Assessment Scheme (FAPAS), Central Science Laboratory, in the UK.

7.3 Data on levels of contamination

During the present monitoring period from 2004-2011 head lettuce, iceberg, spinach, potatoes, rucola, Chinese cabbage, dill and various spices were all analysed for nitrate. Babyfood based on both fruits and vegetables and cereals were also analysed. As in the three previous monitoring periods (1984 – 1988, 1993 – 1996 and 1998 – 2003), products of both Danish and foreign vegetables were collected. The results are shown in Appendix 16.2. In total 1071 samples were analysed for nitrate during the present monitoring period. The nitrate level varied widely depending on the crop. In general the highest levels were found in lettuce and spinach and the lowest levels in potatoes. However, as shown in the Appendix 16.2 there are considerable variations in the nitrate levels within the same crop were found, which is illustrated by the differences between minimum and maximum values.

Lettuce and potatoes

Lettuce in Denmark, as l in other countries is mostly grown under glass. However, due to collection problems, it was difficult to determine whether the samples were grown in the field or under glass so no distinction was made. As in the previous periods higher levels were observed in head lettuce from Denmark than in foreign samples (see Figure 7.1). On the other hand Danish, produced iceberg lettuce seems to contain lower nitrate levels than the foreign samples. Earlier monitoring periods have also shown lower nitrate levels in Danish produced iceberg lettuce than in foreign samples, but in this study only three Danish iceberg samples were analysed with a mean value of 720 mg/kg. The mean and median values in the 40 foreign samples were estimated to be 969 and 985 mg/kg, respectively.

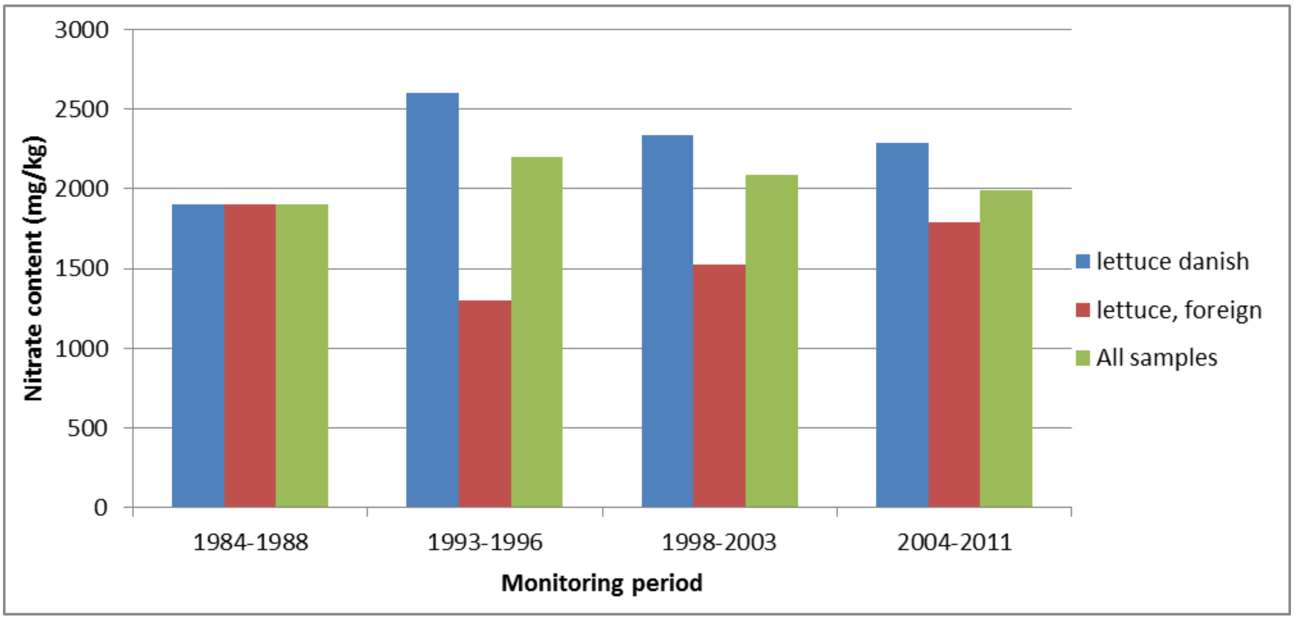


Figure 7.1*. Mean level of nitrate in lettuce (mg/kg) determined during the monitoring periods 1984 to 1988, 1993to 1996, 1998 to 2003, and 2004 to 2011*

The nitrate level in potatoes is significantly lower than for lettuce with mean levels varying between 148 and 274 mg/kg (Appendix 14.2). As in earlier monitoring periods significantly higher nitrate levels were found in foreign than in Danish potatoes (see Figure 7.2). New Danish potatoes seem to have less level of nitrate than common potatoes, whereas the opposite was found for foreign potato samples (Appendix 14.2). Both conventional and organic potatoes were analysed, but no significant differences were observed between the two groups. In total 23 samples of organic potatoes were investigated.

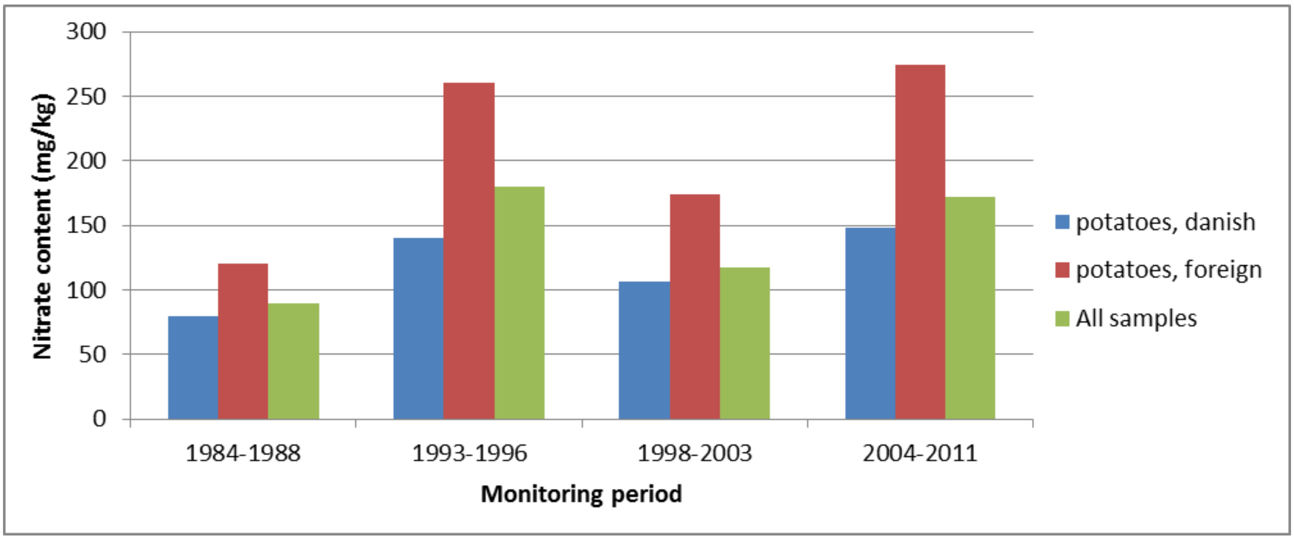


***Figure 7.2**. Mean level of nitrate in potatoes (mg/kg) determined during the monitoring periods 1984 to 1988, 1993to 1996, 1998 to 2003, and 2004 to 2011*

Other vegetables

High nitrate levels were found in samples of rucola with mean values of 4124 and 5578 mg/kg from Danish and foreign producers, respectively. In 2011, the EU commission introduced maximum levels for nitrate of 7000 mg/kg and 6000 mg/kg in rucola harvested from 1 October to 31 March and 1 April to 30 September, respectively. Of the number of samples analysed during the present monitoring period (n=73), 17 samples exceeded the level of 6000 mg/kg.

Spinach contains similar levels of nitrate to those as lettuce with a mean level of 2192 mg/kg when referred to both the Danish and the foreign collected samples (see Appendix 16.2). The level seems to be higher in foreign produced samples than in the Danish produced samples. In the present monitoring period various spices were also analysed and most of the samples contain relatively low nitrate levels. Dry dill was an exception with mean and median values above 10,000 mg/kg. However, only three samples were analysed and these results should be taken with reservation.

Baby Food

As shown in Appendix 14.2 the nitrate content in baby food is low with mean and median values below 20 mg/kg, where 36 of the analysed samples were of organic origin. In 2004 the European Union introduced a maximum level of 200 mg nitrate/kg for baby food as well as processed cereal-based foods for infants and young children. The 95th percentile is about 60 mg/kg and thus well below the EU maximum limit indicating that nitrate in baby food does not represent a food safety problem.

7.4 Development over time

In the present monitoring programme as in the three previous periods in addition to iceberg lettuce and head lettuce other kinds of lettuce were included in minor amounts. For all the 419 lettuce samples analysed the mean and median values were calculated to 1993 mg nitrate/kg and 2000 mg nitrate/kg, respectively. The corresponding 95th percentile was estimated to 3900 mg nitrate/kg. As shown in Figure 7.1, the mean value for nitrate was very similar to the values observed for the three previous monitoring periods of about 2000 mg/kg.

In the present as well as in the three previous monitoring programmes higher levels of nitrate were found in the foreign potatoes than in Danish potatoes. As shown in Figure 7.2 similar average levels were found for the years 1993-1996 and the present period. The lowest levels were observed for the monitoring period between 1984 and 1988. These differences may have several causes, such as different cultivars and different cultivation with respect to climate and soil, fertilization and dry matter content, etc.

7.5 Exposure and risk assessment

The mean values of nitrate level (Appendix 14.2) were used for the exposure calculations. The consumption surveys do not distinguish between Danish and foreign lettuce, potatoes, spinach and iceberg lettuce. Furthermore, dietary survey data was only available for the consumption of lettuce, so it was not possible to report the consumption of different types of lettuce. This means that head lettuce, iceberg, and other kinds of lettuce were pooled and treated as just lettuce. No specific consumption data were available for spices, but as shown in Appendix 16.2 the nitrate level in these samples were generally low. Furthermore, since the consumption of spices is low it is not believed to be of importance for the nitrate exposure.

Figure 7.3 shows a comparison of the average exposure of nitrate from potatoes and lettuces in the present period with the three previous periods. In the monitoring periods 1998-2003 and 1993-1996, spinach and Chinese cabbage contributed very little to the nitrate exposure compared to potatoes and lettuce. The consumption of spinach in the present period was only 0.75 g/day for the Danish population (aged 4-75) corresponding to an exposure of about 1.6 mg nitrate/day. For Chinese cabbage the contribution was even lower.

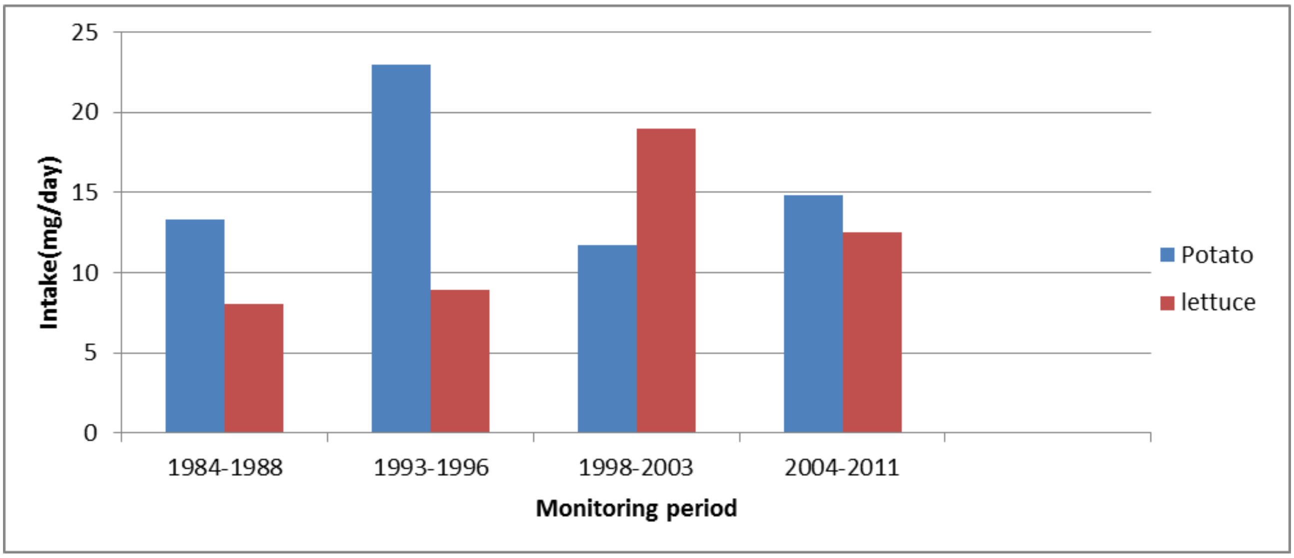


Figure 7.3. *Comparison of the nitrate exposure (mg/day) from vegetables included in the monitoring programmes from 1984 to 1988, 1993 to 1996, 1998 to 2003 and 2004 to 2011*

The exposure of nitrate was determined to 12.5 mg/day which is considerably lower than in the previous period (1998–2003) where the mean exposure was 19 mg/day. However, as shown in Figure 7.3 the nitrate exposure from lettuce was still significantly higher than in earlier periods. The mean consumption of lettuce in the Danish population in the present period has been determined to approximately 6 g/day, which is lower than for the 1998-2003 monitoring period, where it was about 9 g/day (Danish Veterinary and Food Administration, 1995). As already mentioned the nitrate level in lettuce was very similar for the two monitoring periods, and the differences in nitrate exposure is due to a lower consumption of lettuce in the present period than in the previous periods. The nitrate exposure from potatoes increased to 15 mg/day in the present period, which is significantly higher than for the previous period (12 mg/day) while it is lower than for the 1993-1997 period. This means that potatoes can now again be assumed to be the highest contributor to the nitrate exposure of the Danish population. The nitrate level in potatoes has increased significantly in the present period compared to the last monitoring period (Figure 7.2), which may explain the exposure differences between the two periods. As shown in Figure 7.3 the main exposure of nitrate for the monitoring periods 1984 to 1988 and from 1993 to 1997 was also from potatoes. The highest nitrate exposure was in the period 1993-1997, corresponding to approximately 23 mg/day.

Figure 7.4 shows the distribution in nitrate exposure from vegetables in the Danish population in the period 2004 to 2011. As already mentioned, specific consumption data was not available for every vegetable analysed for nitrate (Appendix 16.2). This applies for instance, to rucola, which might represent a potential safety problem for some consumers with a high exposure of rucola. With these limitations in mind, the mean exposure to nitrate from vegetables is determined to 33 mg/day, which is very similar to the value in the latest monitoring period from 1998 to 2003 and corresponds to 36 mg/day. The exposure of the high consumers of vegetables, estimated as the 95th percentile, was 75 mg/day.

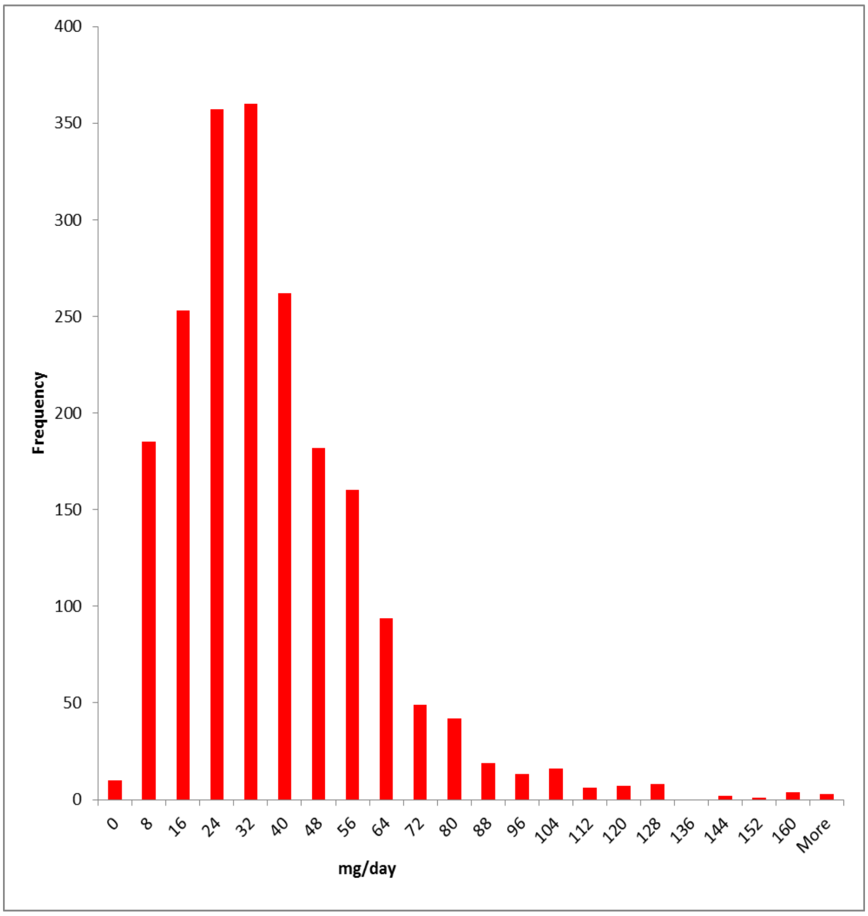


Figure 7.4. *Distribution of nitrate exposure in the Danish population (aged 4-75) in mg/day*

In addition to vegetables, drinking water is also an important contributor to the nitrate exposure by the Danish population. The maximum limit for nitrate in drinking water in Denmark is 50 mg/l. Most part of Danish drinking water corresponding to 77 % of the water supply contain less than 1 mg/l nitrate, and 18 % between 1 and 25 mg/l (GEUS, 2010). For the exposure assessments (EFSA 2012d) recommend a default value of 2 l of water from all beverages (water, tee, coffee, soda etc.) for all European adults. A person which consumes water with an average nitrate content of 1 mg/l would have an average daily exposure including both vegetables and water of 35 mg, and thus water will contribute only little to the average exposure. Using the values of 25 mg/l nitrate in the water, which would cover 95 % of the population, will give an average daily exposure from water and vegetables totalling 83 mg nitrate for an adult person. A high consumer of vegetables (95 percentile) drinking water containing the maximum allowed level of nitrate (50 mg/l) would be exposed to 175 mg nitrate pr. day.

The ADI for sodium nitrate is 5 mg per kg body weight (SFC, 1995), which after conversion to the anion gives a value of 3.7 mg nitrate/kg bw/day. A person weighing 60 kg would be exposed to 0.6, 1.4 and 2.9 mg nitrate/kg bw in the three listed scenarios, respectively, all below the ADI. Some concern remains considering people that, regularly consume large portions of vegetables high in nitrate level since they could potentially exceed the ADI. Though, in conclusion the vast majority of the Danish population is exposed to nitrate at levels well below the ADI.

8 Mycotoxins

8.1 Introduction

Mycotoxins are secondary fungal metabolites with diverse structures and toxicological properties that induce a variety of toxic effects in humans and animals. In particular, fungi of the genera *Aspergillus*, *Penicillium* and *Fusarium* are significant in foods and feed all over the world. The Food and Agricultural Organization of the United Nations (FAO) has estimated that up to 25% of the world's food crops are significantly contaminated with mycotoxins. In Denmark fungi of the genus *Fusarium* are probably the most important toxigenic fungi just as in other northern temperate regions. Many of the *Fusarium* species produce various trichothecenes including deoxynivalenole (DON, vomitoxin), HT-2 toxin (HT-2) and T-2 toxin (T-2) which might be present in cereal grain intended for human consumption. The toxicity of trichothecenes is largely due to their ability to inhibit protein synthesis, and common symptoms in pigs are feed refusal, reduced weight gain, diarrhoea, haemorrhaging, skin lesions and immunosuppression. Generally, T-2 and HT-2 exhibit the strongest activity, whereas DON is considered to be about ten times less toxic (Eriksen and Alexander, 1998). DON is the most prevalent of the toxins, and depending on the cereal it is generally found in more than 50% of the samples tested (Rasmussen et al, 2003 and 2007). The SCOOP report on Scientific Co-operation on Questions relating to Food from the European Commission (2003) shows that the main sources of dietary exposure of DON are products made from cereals, in particular wheat and maize, and that the dietary exposure of DON is often very close to the tolerable dairy exposure (TDI) of 1 µg/kg body weight/day (SFC 1999), especially in risk groups of infants and young children.

Increased levels of DON in cereal grains are often observed in harvest years with frequent rainfall and high humidity during the flowering period and timing, rather than the amount of rain is the most critical factor. In June 2005 the European Union introduced maximum levels of DON in various cereal and cereal products for human consumption. The maximum level permitted in cereal flour, including maize flour and maize grits is 750 µg/kg (Commission Regulation (EC) No. 1068/2005 of 6 July 2005). A separate lower maximum limit of 200µg/kg was introduced for baby food and processed cereal-based food for infants and young children, due to their higher consumption of cereal-based foods per kg body weight compared to adults. No EU maximum level exists for HT-2 and T-2.

OchratoxinA (OTA) is produced by various *Penicillium* and *Aspergillus* species and represents a well-known hazard to human and animal health. The European Union has set legal limits for OTA levels in grain (5 µg/ kg), flour (3 µg/kg) and cereals to be used for baby food and processed cereal-based food for infants and young children (0.5 µg/kg) (Commission Regulation (EC) No. 466/2001 of 8 march 2001; Commission Regulation (EC) No. 683/2004 of 13 April 2004). Analysis of OTA in cereal and cereal products has been a part of the Danish monitoring programme since 1986. After great problems with wet grain in the mid-1980s, Danish agricultural practices were improved with of better drying and storage conditions and improved self-imposed control at the mills. These efforts have improved the quality of the grain in relation to decreasing the level of OTA during recent years (Danish Veterinary and Food Administration, 2005). So, the number of samples analysed was decreased in both the previous monitoring programme (1998 to 2003) as in the present period.

8.2 Methods of sampling and analytical methods

Sampling was carried out on a nationwide basis by authorised personnel from local food control units. Samples were analysed for DON, HT-2, T-2 and OTA by the Danish Veterinary and Food Administration at the regional laboratory in Ringsted. Samples were taken at mills all over Denmark and could have either Danish or foreign origin. In Denmark most of the flour for human consumption is produced from domestic grain, and grain imported mainly from the southern part of Sweden and the northern part of Germany, where the climate and growing conditions for fungi are similar to Denmark. The analyses of DON, HT-2 and T-2 in cereal and cereal products were carried out by the regional laboratory in Ringsted using an accredited LC-MS/MS method (ANA-03.3050). OTA was also analysed at the regional laboratory in Ringsted by HPLC/FLD (ANA-03.3010). The limit of quantification (LOQ) for DON, HT-2, T-2 and OTA was 20, 2, 1.6 and 0.1µg/kg, respectively. Samples with levels lower than LOQ were assumed to have a concentration of half the value of LOQ. The regional laboratories in Ringsted participate in performance tests through FAPAS.

8.3 Data on levels of contamination

8.3.1 Trichothecenes (Deoxynivalenole, HT-2 and T-2 toxin)

Flour samples of common wheat and rye were analysed for DON in the present monitoring programme (2004 – 2011) and the results are shown in Appendices 16.3.1 to 16.3.3. As with other Danish studies (Rasmussen et al., 2003; Rasmussen et al 2007), the results show that the incidence and concentration levels of DON are considerably higher in flour from wheat than from in flour rye with mean values of 71 and 29 µg/kg, respectively. This indicates that wheat grain is more susceptible than rye to attacks from DON producing fungi. The highest levels were found in oat and various oat products. In oat kernels the respective mean and median values were 227 and 42 µg/kg with a corresponding 95th percentile of 820 µg/kg, which clearly exceeds the EU maximum limit of 750 µg/kg in these types of products. The mean value for oatmeal was 75 µg/kg with a maximum value of 1000 µg/kg. Wheat bran and some samples of wheat flour also showed relatively high concentrations of DON, where the 95th percentile exceeded the maximum limit of 750 µg/kg.

8.3.2 HT-2 and T-2

The levels of HT-2 toxin and T-2 toxin in samples of wheat and rye were generally low, and even in positive samples the levels were close to the detection limit of the methods used (see Appendix 16.3.2 and 16.3.3). The level of HT-2 toxin was generally higher than for T-2 toxin in the samples analysed. As for DON, the highest contamination levels were found in oat kernels with mean levels between 13 and 40 µg/kg for HT-2 and T-2 toxin, respectively. In Denmark most oat kernels for human consumption are used in the production of rolled oat. The significant higher concentration levels of HT-2 and T-2 found in oat kernels indicate that these toxins will be reduced during the manufacturing process to rolled oat.

8.3.3 Ochratoxin A (OTA)

The occurrence and concentrations of OTA were investigated in samples from rye, wheat, oat, spelt and baby food. As the results of for the previous monitoring period (1998-2003) the present data shows that the incidence and levels of OTA in rye flour has decreased significantly since the critical years in the mid-1980s, with mean and median levels of about 0.6 and 0.17 µg/kg (n=121), respectively. The highest value obtained was 12 µg/kg and the 95th percentile was 2.9 µg/kg (see Appendix 16.3.4) which is very close to the EU maximum limit of 3 µg/kg. In bran products of spelt and wheat the mean values were determined to approximately 0.2 and 0.4 µg/kg. Two samples exceeded the EU maximum level of OTA in rye flour.

8.4 Development over time

The level and occurrence of trichothecenes have not earlier been reported in the Danish monitoring system for foods. Some data has been reported on DON in wheat cereal products since 1998 in several scientific papers, but unfortunately not on HT-2 and T-2 toxins (Rasmussen et al., 2003 and 2007). The annual variation of DON level in Danish wheat flour between 1998 and 2012 is reported in Figure 8.1. The mean concentration values varied considerably from year to year with the highest overall contamination levels detected in 2002. All samples from that year were found to contain DON, an incidence of 100%. In the present monitoring period the highest DON concentration was observed for the 2008 harvest with mean and median values of respectively 149 and 51 µg/kg. Of the 43 analysed samples, 13 contain DON below LOQ. The highest concentration was 2600 µg/kg.

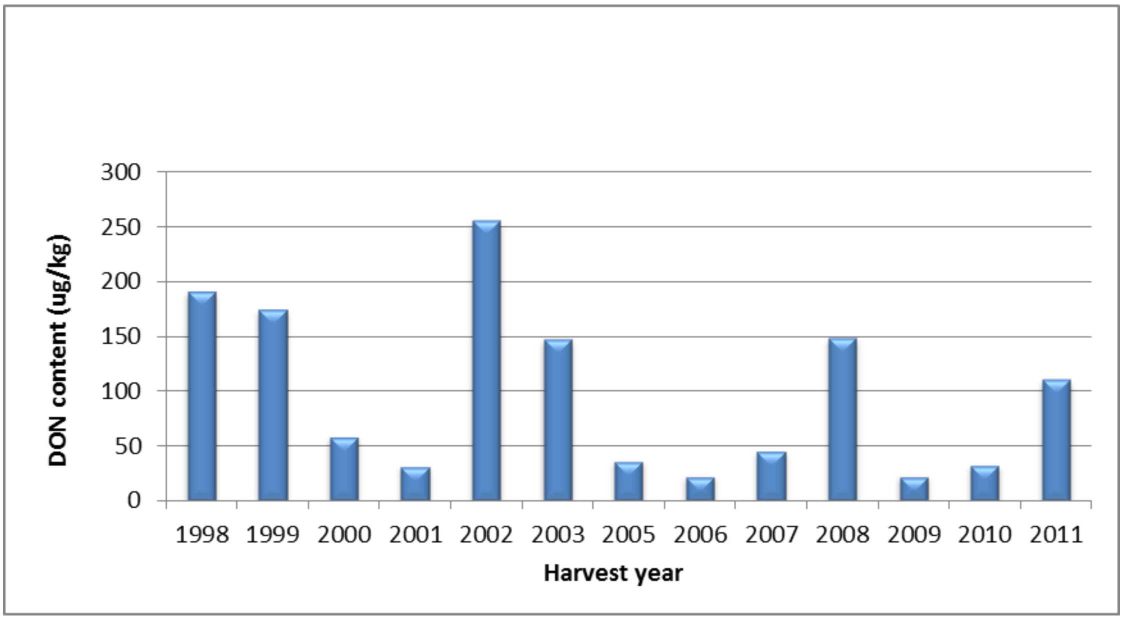


Figure 8.1. *Annual variation in the average concentration of DON in wheat flour samples collected in Denmark during the period 1998 to 2011*

As mentioned above levels of OTA in rye flour has decreased significantly since the critical years in the mid-1980s. The development over time has been described in detail in the reports from the previous periods and will not further be discussed in this report.

8.5 Exposure and risk assessment

Cereal and cereal products are considered to be the most important contributors to the exposure of trichothecenes in Denmark, as in other European countries (SCOOP, 2003). In the present study the mycotoxin level in flour were converted to levels in bread using a factor of 0.77 for wheat and 0.62 for rye, respectively (Rasmussen et al., 2007). The occurrence data shown in Appendix 16.3.1 were used to determine the exposure of DON from various wheat and oat containing cereals and cereal products including wheat and oat bread, rolled oat, cakes etc. No consumption data were available for oat kernel, oat bran, einkorn or spelt, in which the levels of DON have also determined.

In Figure 8.2 the distribution of DON exposure in the Danish population (aged 4-75) in µg/day is shown.

A mean exposure of 12.6 µg/day was estimated (median value 11.8 µg/day). The corresponding daily exposure in per kg body weight was calculated to be 0.215 µg/kg bw/day, which is higher than the estimated exposure found by Rasmussen et al (2007) at 0.17 µg/kg bw/day. However, Rasmussen et al. 2007 used only bread of rye and wheat for the exposure estimations and this may in part explain the lower values compared to the present findings. As shown in Figure 8.2 for high consumers of cereal and cereal products, the daily exposure approaches the TDI value of 1 µg/kg bw/day.

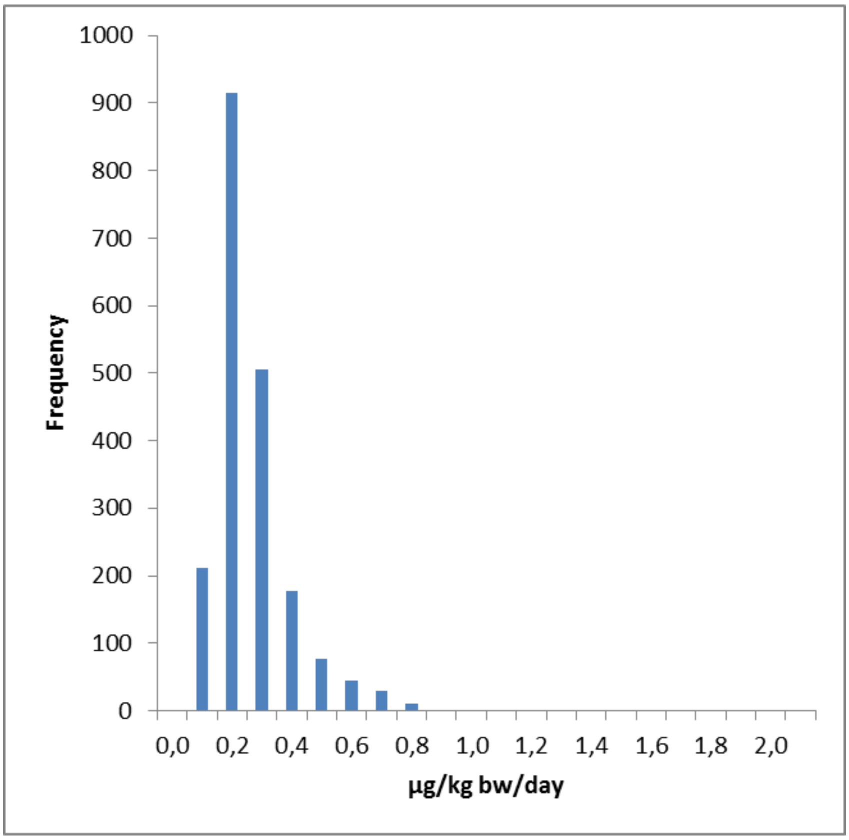


***Figure 8.2**. Distribution of DON exposure in µg/kg bw/day in the Danish population (aged 4-75)*

As already mentioned, the DON contamination level varied considerably from year to year, and in the present period the highest level was found in the 2008 harvest with a mean value of 149 µg/kg. This corresponds to an exposure of to 0.334 µg/kg bw/day. In the same way the, exposure for 2002 (see Figure 8.1) with the highest occurring DON level was 0.514 µg/kg bw/day. The large annual variation in DON levels therefore emphasises the importance of not using just a single year for the exposure calculations.

In view of the low levels of HT-2 and T-2 toxin determined in samples of wheat (Appendix 16.3.2 and 16.3.3), it makes no sense to calculate the exposure for these products. The daily exposure from oatmeal has been determined to be 0.042 µg HT-2/day corresponding to a daily exposure per kg body weight of 0.74 ng/kg bw/day. The daily exposure for T-2 is even lower and a mean exposure was estimated to be 0.015 ng/day. The EFSA Panel on Contaminants in the Food Chain recently (2012) established a group tolerable daily intake of 100 ng/kg bw for the sum of HT-2 and T-2 toxins. Based on the present data the estimated exposure is far below TDI, and thus HT-2 and T-2 do not represent an immediate health problem.

In reports from the 3rd and 4rd monitoring periods (Danish Veterinary and Food Administration, 2001 and 2005) comprehensive exposure calculations were performed for OTA and the main conclusion was, that cereal and cereal products especially from rye are the main sources of the Danish population's exposure of OTA. Figure 8.3 shows the distribution in OTA exposure in the Danish population (aged 4-75) in µg/kg bw/day.

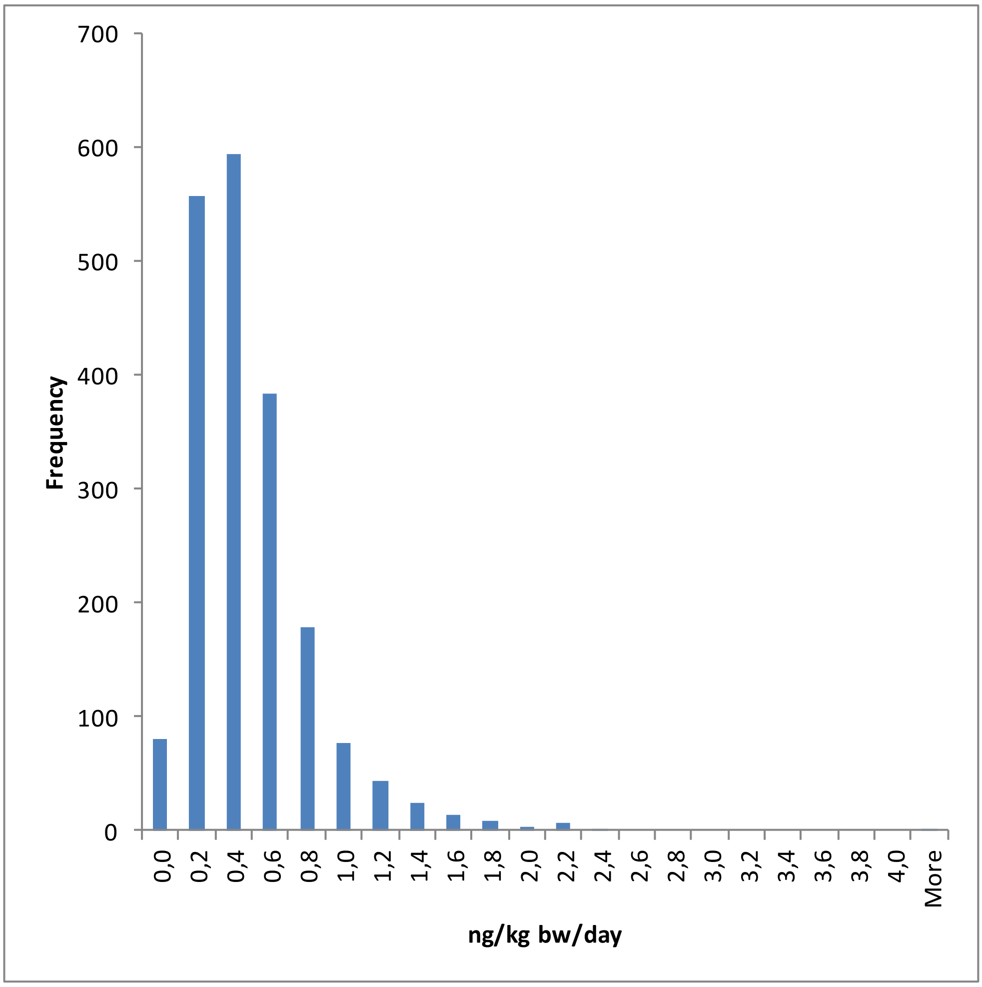


Figure 8.3. *Distribution of OTA exposure in ng/kg bw/day in the Danish population (aged 4-75)*

A mean exposure of 0.4 ng OTA/kg bw/day was estimated (median value 0.38 OTA ng/kg bw/day), which is lower than the estimated exposure from the previous monitoring period of approximately 1.8 ng OTA/kg bw/day (Danish Veterinary and Food Administration, 2005). Only cereals were used for the exposure calculations in the present study while also other contributors, such as coffee, red wine, and beer were included in the previous period which may in part explain some of the difference between the two monitoring periods. For high consumers (>95th percentile) the exposure was greater than 1 ng OTA /kg bw/day). Several risk assessments of OTA have been carried out internationally, and it has been proposed that the tolerable daily intake should be established "as low as possible''. The EU tolerable weekly exposure (TWI) for OTA is set to 120 ng/kg body weight (EFSA 2006). The mean exposure of OTA obtained for the present period is therefore below this value and there is therefore no immediate health concern.

The exposure for baby food has not been calculated, but as shown in Appendices 16.3.1 and 16.3.4 the mycotoxin levels in these samples are far below the EU maximum limit of 200 µg/kg for DON and 0.5 µg/kg of OTA indicating that baby food does not represent a food safety problem.

9 Chlorinated organic environmental contaminants

Dioxins (polychlorinated dibenzo-*p*-dioxins and dibenzofurans, also abbreviated as PCDD/F) and PCB (polychlorinated biphenyls) have regained attention as persistent organic contaminants in feed and food during the last decade. In the late 1990's several incidents of feed and food contamination occurred and this led to a more systematic monitoring of dioxins and PCB in many countries.

For the general population food is the main source of dioxins and PCB exposure and animal feed is an important contributor to the food contamination. In many industrialised countries human exposures to dioxins and PCB is higher than toxicologically tolerable levels so it is of interest to follow any trend in contamination of animal feed and food over the years.

PCB were included in the determination of dioxin, but also in the determinations of organochlorine pesticides, but using two different analytical methods with different characteristics and using separate samples. The results from the two studies are therefore presented separately in the next two sections.

9.1 Dioxins and PCB

9.1.1 Introduction

Dioxins are the short expression for a group of 210 compounds including 75 polychlorinated dibenzo-*p*-dioxins (PCDD) and 135 polychlorinated dibenzofuranes (PCDF). Dioxins have no technological use, but are generated in a number of thermal and industrial processes as unwanted, and often unavoidable, impurities or by-products. Important emission sources are metal production and processing, waste incineration and domestic furnaces. Dioxins are poorly soluble in water but highly soluble in lipids. Due to their lipophilic properties they accumulate in the food chain and are stored in the fatty tissues of animals and humans. Dioxins and dioxin-like PCBs can cause reproductive and developmental problems, damage the immune system, interfere with hormones and also cause cancer. Long-term exposure to low levels of dioxins and dioxin-like PCBs in food increases the risk of adverse effects on foetal development. A number of regulatory measures since the 1980s have considerably decreased the emission of dioxins into the environment. Consequently, human exposure to dioxins has decreased significantly over the recent decades.

PCB are a group of 209 organochlorine compounds that are synthesised by catalysed chlorination of biphenyl. Due to their physicochemical properties, such as non-flammability, chemical stability, high boiling point, low heat conductivity and high dielectric constants, technical PCB mixtures were widely used in a number of industrial and commercial closed and open applications. As a result of their widespread use, leakages and inappropriate disposal practices, PCB have, like dioxins, a global distribution in the environment. Restrictions on production and use of PCB have decreased the environmental pollution with PCB since a peak level in the 1970s. Many PCB congeners are persistent because they are degraded poorly and therefore can bio-accumulate in the food chain.

Based on their structural characteristics and toxicological effects, PCBs can be divided into two groups. One group consists of 12 congeners that can easily adopt a coplanar structure and show toxicological properties similar to the dioxins of concern. These are therefore called “dioxin-like PCBs” (DL-PCBs). The other PCBs do not show dioxin-like toxicity and have a different toxicological profile. These are called “non-dioxin like PCBs” (NDL-PCBs).

For the general population, the main pathway of exposure to dioxins and PCBs is food.

In general, environmental and biological samples contain complex mixtures of various dioxin congeners, so the concept of Toxic Equivalency Factors (TEFs) has been developed to facilitate risk assessment. TEFs have been established to express concentrations of mixtures of 2,3,7,8-substituted PCDDs and PCDFs, and some planar non-ortho and mono-ortho chlorine substituted DL-PCB in toxic equivalents (TEQs) of 2,3,7,8-TCDD. TEQ is calculated by multiplying the concentration of each congener with the assigned TEF. The weighted concentrations are summed to produce TEQ for dioxins, TEQ for DL-PCB and Total TEQ which is the sum of the TEQ for dioxins and DL-PCB.

In 1998, WHO adopted a set of TEF-values (Van den Berg, 1998) and they were revised in 2005 (Van den Berg, 2006) – see Table 9.1. Until the revision of the maximum levels in 2012, the TEF values from 1998 were used for the calculation of TEQs. Since 2012, the maximum levels have been expressed in TEQ using TEF-values from 2005. All TEQ data from 2004-2011 in this report are presented as WHO-TEQ^{2005} i.e. calculated by the use of TEF from 2005, and TEQ exposure calculations are conducted by the use of WHO-TEQ^{2005}. Table 9.1 and Appendices 16.4.10 and 16.4.11 show the ratio between WHO-TEQ^{2005} and WHO-TEQ^{1998} for the various foods monitored. The effect of the change from TEF^{1998} to TEF^{2005} is a decrease averaging 10% to 20% in the calculated TEQs. It is important to note that the actual concentration of the different congeners in the sample is the same whether TEF^{2005} or TEF^{1998} is used for TEQ calculations.

Table 9.1 *Dioxin Toxic Equivalency Factors (TEFs) for dioxins – PCDD/F and DL-PCB adopted by WHO in 1998 (Van den Berg, 1998) and in 2005 (Van den Berg, 2006)*

Congener	**TEF-1998**	**TEF-2005**	**Congener**	**TEF-1998**	**TEF-2005**
Dioxins			**Dioxin-like PCB**		
PCDD			**Non-ortho PCB**		
2,3,7,8-TCDD	1	1	PCB 77	0.0001	0.0001
1,2,3,7,8-PeCDD	1	1	PCB 81	0.0001	**0.0003**
1,2,3,4,7,8-HxCDD	0.1	0.1	PCB 126	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1	PCB 169	0.01	**0.03**
1,2,3,7,8,9-HxCDD	0.1	0.1			
1,2,3,4,6,7,8-HpCDD	0.01	0.01			
OCDD	0.0001	**0.0003**			
PCDF			**Mono-ortho PCB**		
2,3,7,8-TCDF	0.1	0.1	PCB 105	0.0001	**0.00003**
1,2,3,7,8-PeCDF	0.05	**0.03**	PCB 114	0.0005	**0.00003**
2,3,4,7,8-PeCDF	0.5	**0.3**	PCB 118	0.0001	**0.00003**
1,2,3,4,7,8-HxCDF	0.1	0.1	PCB 123	0.0001	**0.00003**
1,2,3,6,7,8-HxCDF	0.1	0.1	PCB 156	0.0005	**0.00003**
1,2,3,7,8,9-HxCDF	0.1	0.1	PCB 157	0.0005	**0.00003**
2,3,4,6,7,8-HxCDF	0.1	0.1	PCB 167	0.00001	**0.00003**
1,2,3,4,6,7,8-HpCDF	0.01	0.01	PCB 189	0.0001	**0.00003**
1,2,3,4,7,8,9-HpCDF	0.01	0.01			
OCDF	0.0001	**0.0003**			

Maximum levels for dioxins in food were introduced in the European Union (EU) on 1st July 2001 in Council Regulation 2375/2001 (EC, 2001a). A revision in 2006 (EC, 2006a) added maximum levels for DL-PCBs and on 1st January 2012 in Commission Regulation 1259/2011(EC, 2011f), the maximum levels were revised and maximum levels for the sum of six NDL-PCBs were established (PCB-6: PCB 28, 52, 101, 138, 153 and 180).

Moreover, action levels for dioxins, DL-PCBs and NDL-PCBs were introduced in Commission Regulations 201/2002, 88/2006 and 516/2012 (EC, 2002a; EC, 2006c and EC, 2011d). Foods with levels of dioxins and PCBs above the action levels but below the maximum levels can be marketed, but the EU member state must try to find the cause for the increased levels of dioxins and PCBs. The current maximum levels and action levels are listed in Tables 9.2 and 9.3.

__Table 9.2__. Maximum levels and actions levels for dioxins and PCB in fish and fish products established in 2012 (Commission Regulation 1259/2011 and Commission Recommendation 516/2011)

Food	**Action levels pg WHO-TEQ^{2005}/g wet weight**		**Maximum levels pg WHO-TEQ^{2005}/g wet weight**		**Maximum level ng/g wet weight**
	Dioxins	DL-PCB	Dioxins	Dioxins + DL-PCB	PCB-6
Muscle meat of fish	1.5*	2.5*	3.5	6.5	75
Muscle meat of wild fresh water fish	-	-	3.5	6.5	125
Muscle meat of wild caught ell	-	-	3.5	10	300
Marine oils	-	-	1.75	6.0	200
Fish liver	-	-	-	20	200

*: Action levels only apply for farmed fish.

Table 9.3. Maximum levels and action levels for dioxins and PCB in food other than fish and fish products as established in 2012 (EC, 2011d and 2011f)

Food	**Action levels pg WHO-TEQ^{2005}/g fat**		**Maximum levels pg WHO-TEQ^{2005}/g fat**		**Maximum level ng/g fat**
	Dioxins	DL-PCB	Dioxins	Dioxins + DL-PCB	PCB-6
Meat and fat of bovine animal and sheep	1.75	1.75	2.5	4.0	40
Meat and fat of pigs	0.75	0.5	1.0	1.25	40
Meat and fat of poultry	1.25	0.75	1.75	3.0	40
Mixed animal fat	1.0	0.75	1.5	2.5	40
Liver of terrestrial animals	-	-	4.5	10.0	40
Raw milk and dairy products	1.75	2.0	2.5	5.5	40
Hen eggs and egg products	1.75	1.75	2.5	5.0	40
Vegetable oils and fats	-	-	0.75	1.25	40
Foods for infants and young children	-	-	0.1*	0.2*	1.0*
Fruits, vegetables and cereals	0.3*	0.1*	-	-	-

*: on the basis of wet weight.

Before the EU established maximum levels for NDL-PCB in food in 2012, the Danish Veterinary and Food Administration operated with recommended values for acceptable levels of PCB (Danish Veterinary and Food Administration, 1999) as shown in Table 9.4.

Table 9.4. *Recommended values for acceptable levels of PCB (Danish Veterinary and Food Administration, 1999) used before 2012*

	Recommended value for acceptable level of PCB ng/g [(a)]
PCB 153	100
PCB in total [(b)]	400

(a) For fish the unit is by wet weight for other types of food the unit is by fat level.
(b) The sum of PCB 28, 52, 101, 105, 118, 138, 153, 156, 170 and 180.

9.1.2 Methods of sampling, analysis and quality assurance

The Danish monitoring of dioxins and PCB in food from 2004 to 2011 was a combination of official control analyses and a survey of the general background contamination with dioxins and PCB. Sampling was targeted at relevant matrices but samples were randomly selected. Follow up samples in case maximum levels were exceeded were not included in the monitoring results.

Chemical analyses were for the majority of the samples were carried out the Danish Veterinary and Food Administration, Region East. In 2004 the National Food Institute at the Technical University of Denmark analyses were carried out on samples of fish, fish oils, mussels, dairy products, vegetables oils, cereals, fruit and vegetables. The analytical methods at both laboratories were accredited. The requirements for the analysis of dioxins and PCB as stated in the EU legislation were followed (EC, 2002b, 2006b, 2012a. Congener specific determination was achieved for the seven 2,3,7,8-chloro substituted PCDDs, the ten 2,3,7,8-chloro substituted PCDFs, the four non-ortho PCB (PCB77, 81, 126 and 169), eight mono-ortho PCB (PCB105, 114, 118, 123, 156, 157, 167 and 189) and six marker PCB (PCB6: PCB28, 52, 101, 138, 153 and 180). After fat extraction, the fat was cleaned up on a multi-layer column containing sulphuric acid coated silica, and separated into two fractions (a) PCDD/F and non-ortho PCB and (b) di- and mono-ortho PCB (either manually or using a PowerPrep system from FMS). The instrumental detection and quantification was carried out by GC-HRMS using a 60 m DB5-column and at a mass resolution of 10,000.

9.1.3 Data on levels

The total number of samples analysed in the period 2004 to 2011 was 1765. Appendix 16.4.1 shows the sampling plan for each year. The measured levels of dioxins and PCB in the food samples are presented in Appendices 16.4.2 to 16.4.9. For each food the appendices show the total number of samples, the average, median, minimum, maximum and 95th percentile. The levels of dioxins, DL-PCB as well as the sum of the dioxins and DL-PCB are listed as WHO-TEQ^{2005}. The levels of NDL-PCB are listed as PCB-6.

The unit is per gram of fat except for fish, cereals, fruits and vegetables, where the unit is per gram of wet weight.

In general, a small number of the samples significantly exceed the maximum levels. An exception from this is the large salmons and the herrings from the eastern Baltic Sea, which exceed the maximum levels and cannot be sold commercially (Cederberg, 2010b). Sheep livers have increased levels of dioxins and DL-PCB and in many cases exceed the maximum levels (Lund, 2008). This is a general trend in many countries and the issue is under discussion in the EU. Eggs from free range hens can have elevated levels of dioxins and DL-PCB most likely due to the hen's intake of soil, which can be contaminated with dioxins and PCB for instance from air pollution.

It is difficult to evaluate trends over time in the concentration of dioxins and PCB in the various foods due to the limited and changing number of samples for each food category over time. In a study of two time periods, 2000-2004 and 2005-2009 of monitoring of dioxins and PCB in food a decrease was observed except for poultry (see Figure 9.1). The average levels of the sum of dioxins and DL-PCB in the various food categories decreased by between 9% and 40%. The tendency was that a few samples in the first years of the period, and before maximum levels were established, had elevated concentrations (Cederberg, 2010a). For dietary fish oils there was a decrease of 78%, but this is probably due to direct decontamination of the fish oil or the use of oils with lower contamination levels.

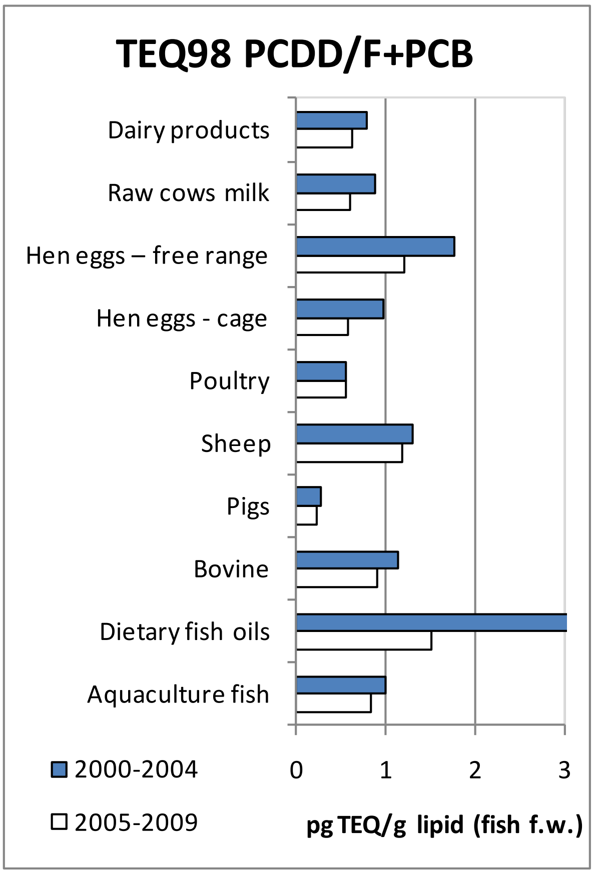


Figure 9.1. *Average levels of WHO-TEQ1998 (PCDD/F+DL-PCB) for selected food categories over two time periods: 2000-2004 and 2005-2009 (Figure from Cederberg, 2010a)*

9.1.4 Exposure and risk assessment

The exposure calculations were carried out as described in Chapter 4.2. Dioxins and DL- PCB accumulates in fatty tissue and this fact is the basis for the allocation of a level to the many types of food items in the consumption survey despite the relatively few categories of food analysed in the monitoring programme.

The Scientific Committee on Food (SCF) has established a tolerable weekly exposure (TWI) of 14 pg WHO-TEQ/kg body weight (bw) for 2,3,7,8-substituted PCDDs and PCDFs and the dioxin-like PCBs (SCF, 2001). Due to the very long half-lives in humans the tolerable exposure was expressed on a weekly basis rather than on a daily basis.

The French Food Safety Agency (AFSSA, 2007) has proposed a TDI of 10 ng/kg bw/day for NDL-PCB with regards to the group of 6 PCB congeners, most commonly found in food matrices (PCB-28, 52, 101, 138, 153 and 180). For total PCB the TDI proposed was 20 ng/kg bw/day used for comparison with PCB-10 (PCB28, 52, 101, 105, 118, 138, 153, 156, 170 and 180)

Figure 9.2 shows the distribution in the Danish population of exposure to the sum of dioxins and DL-PCBs based on consumption and occurrence data. The mean exposure to dioxins and DL-PCB is 0.55 pg WHO-TEQ^{2005}/kg bw/day.

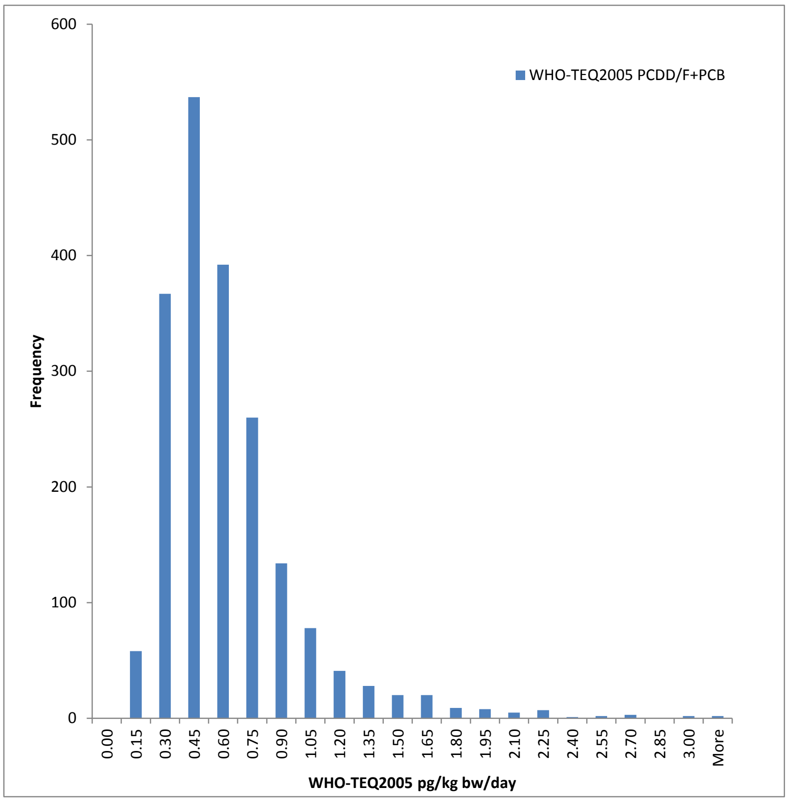


Figure 9.2. *Distribution of exposure to WHO-TEQ^{2005} PCDD/F+PCB in the Danish population (aged 4-75, 1974 individuals)in pg/kg bw/day*

The corresponding exposure distribution for children aged 4 to 14 is shown in Figure 9.3. The mean exposure to dioxins and DL-PCB is in this case 0.87 pg WHO-TEQ^{2005}/kg bw/day.

Figures 9.4 and 9.5 show the exposure distributions of NDL-PCB-6 for the same two population groups. The mean exposure to PCB-6 is 1.8 ng/kg bw/day for the total Danish population and 2.7 ng/kg bw/day for children aged 4 to 14.

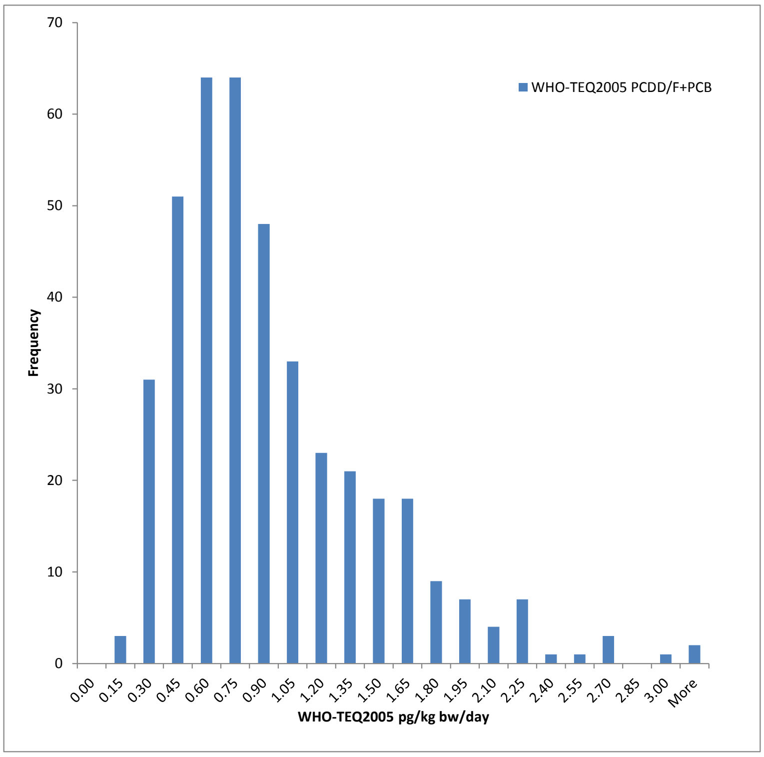


Figure 9.3. *Distribution of exposure to WHO-TEQ^{2005} PCDD/F+PCB for the Danish population (aged 4-14, 409 individuals) in pg/kg bw/day*

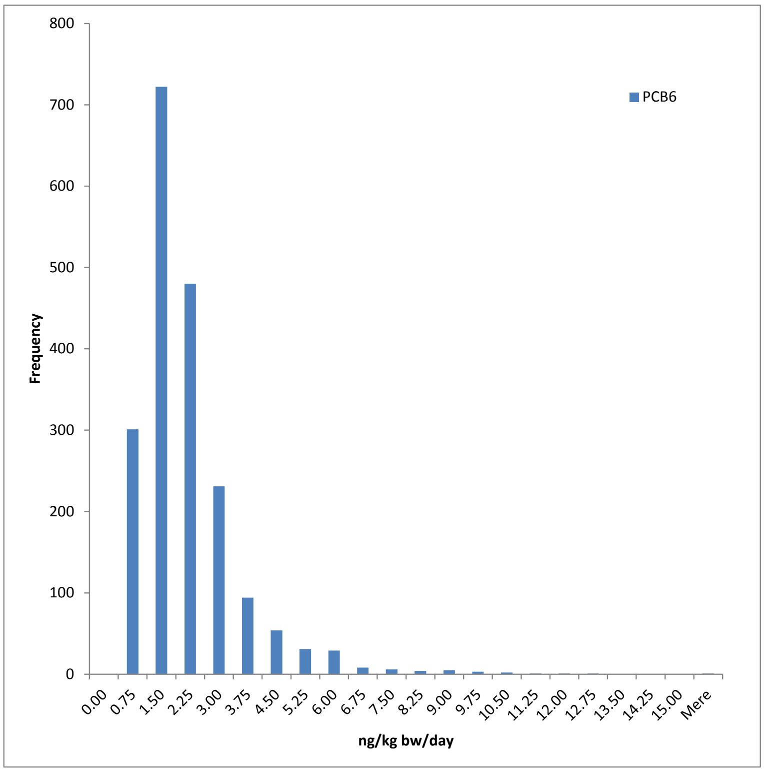


Figure 9.4*. Distribution of exposure to non dioxin-like PCB-6 in the Danish population (aged 4-75, 1974 individuals) in ng/kg bw/day*

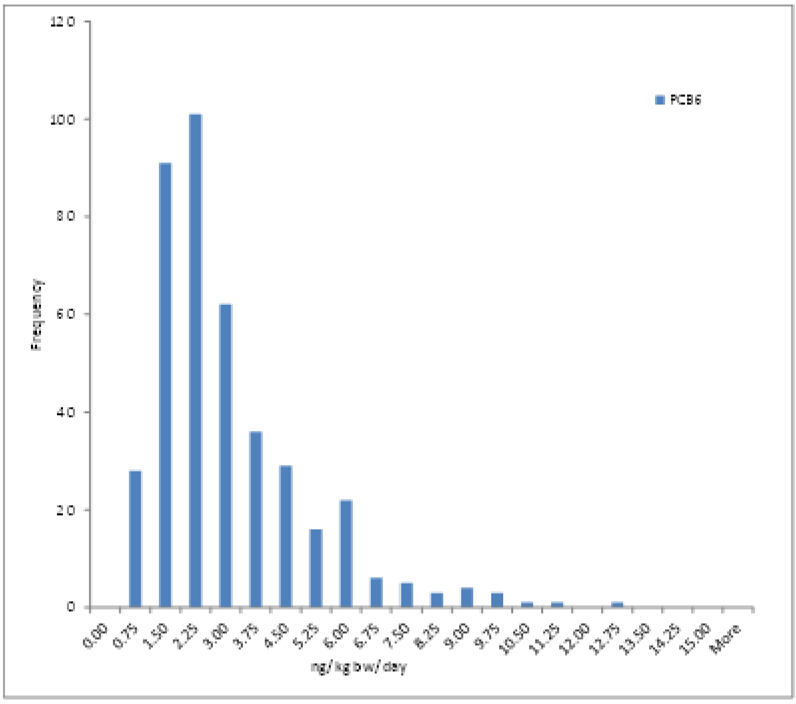


Figure 9.5*. Distribution of exposure to non dioxin-like PCB-6 in the Danish population (aged 4-14, 409 individuals in food exposure) in ng/kg bw/day*

Table 9.5 lists figures for the mean, percentiles and maximum for exposure of dioxins and DL-PCB as well as PCB-6 for the total Danish population.

The absolute exposure to dioxins and PCB is lower for children than for adults but the mean exposure per kg bodyweight is higher for children due to their higher consumption of food per kg bodyweight. In the case of dioxins and DL-PCB the mean exposure of dioxins and DL-PCB is higher compared to the TDI than in the case of NDL-PCB. However, all mean exposures are below the TDI. For the total population the mean exposure is a factor of 3.6 lower for dioxins and DL-PCB and a factor of 5.5 lower for NDL-PCB than the TDI. For children the factors are 2.3 and 3.7, respectively. However, for 1 % of the total population and 5% of the children the TDI of 2 pg WHO-TEQ/kg bw/day for dioxins and DL-PCB is exceeded. For NDL-PCB measured as PCB-6, the TDI of 10 ng/kg bw/day is not exceeded for 99% of the Danish population but for some people this value will probably be exceeded because maximal exposure estimates for PCB-6 are above this level.

The exposure calculations are based on the median value for the occurrence data for each food analysed. For eggs, the median level of dioxins and PCB is higher in free range eggs than in eggs from hens in cages. Here the average value for the two types of eggs is used. Fish from the Baltic Sea have a higher concentration of dioxin and PCB than fish sampled from other Danish catching areas and fish from retail. In the exposure calculations the data for fish from the Baltic Sea were not included because their market share is quite low. Frequent consumption of fish with a higher contamination level than used in the exposure calculations will lead to higher exposure than shown. This will be the case for the mean exposure and even more for consumers with a high consumption of fish.

Table 9.5. *Exposure estimates for WHO-TEQ^{2005} dioxins +DL-PCB and NDL-PCB measured as PCB-6 and PCB-10 listed as mean, percentiles and maximum for the total Danish population and for children aged 4-14. For comparison the relevant TDI is listed*

	WHO-TEQ^{2005} Dioxins+PCB pg/kg bw/day		**PCB-6** ng/kg bw/day		**PCB-10** ng/kg bw/day	
TDI	2		10		20	
Mean	0.55	0.87	1.8	2.7	5.7	8.9
Percentiles						
50	0.46	0.73	1.5	2.1	4.7	7.5
95	1.2	1.9	4.3	6.3	12.7	20.4
99	2.0	2.6	7.1	9.4	21.4	28.4
Max	3.4	3.4	16.4	12.5	41.0	41.0
Population (year)	4-75	4-14	4-75	4-14	4-75	4-14
Number of individuals	1974	409	1974	409	1974	409

Exposure calculations for indicator PCB measured as a sum of 10 PCB congeners (see Section 9.2) approaches the total PCB level and for this estimate the TDI of 20 ng/kg bw/day should be used. This means that exposure estimates for indicator PCB and PCB-6 correspond very well when compared relative to the appropriate TDI.

Figures 9.6 and 9.7 show the contributions of the main food groups to the mean exposure of dioxins and DL-PCB and NDL-PCB. Only the fatty food groups have been included in the exposure calculations and will contribute to the exposure. In the chosen main food groups, fish contribute the most with 31% for the sum of dioxins and DL-PCB and with 45 % for NDL PCB. Meat, dairy products and fats including, both animal and vegetable fat, contribute 10 % to 20 % while eggs and poultry contribute less than 5%.

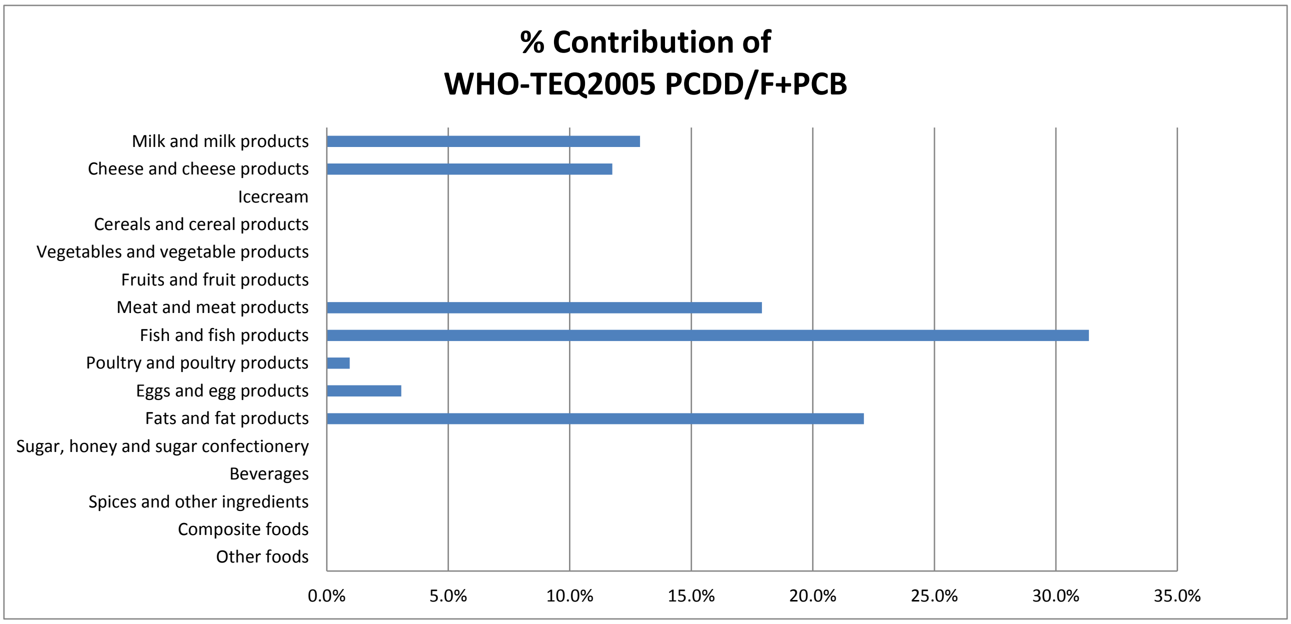


Figure 9.6. *Exposure of WHO-TEQ^{2005} PCDD/F+PCB from main food groups in the Danish population (aged 4-75, 1974 individuals)*

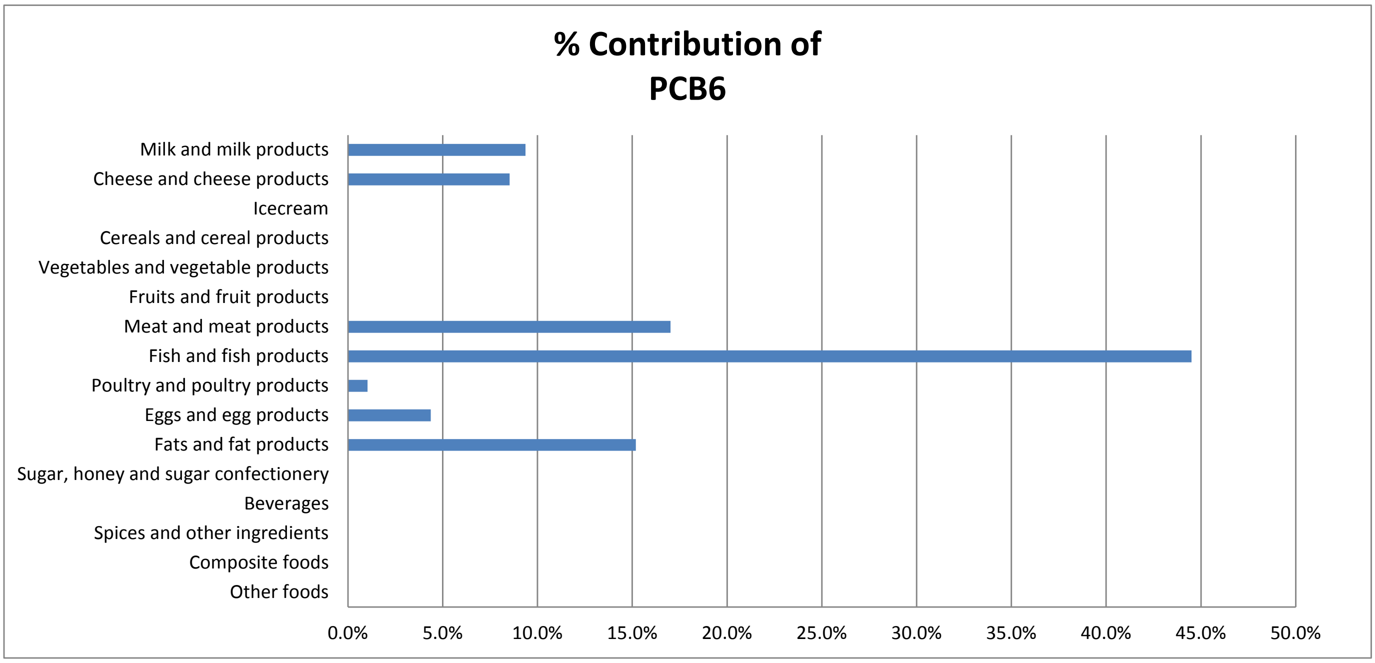


Figure 9.7. *Exposure of non dioxin-like PCB-6 from main food groups in the Danish population (aged 4-75, 1974 individuals)*

In summary, dietary exposure to dioxins and DL-PCB as well as to NDL-PCB exceeds the TDIs for a small fraction of the population, and mainly children. The dietary exposure is mainly from fish, dairy products and meat.

9.2 Organochlorine pesticides and level of indicator PCB

The occurrence of persistent organochlorine compounds in the environment has changed relatively slowly over a number of years; similar time trends are characteristic for levels in fish, meat, eggs, and dairy products, which are the foods with the greatest contributions to the exposure to organochlorine compounds. Contamination by organochlorine compounds may derive from pollution of the environment where the compounds, being fat-soluble and having apolar properties, accumulate through the food chain. In meat, eggs, and dairy products they may also derive from residual levels of the organochlorine pesticides in feedstuffs or from applications in the environment of the animals.

Analysed compounds

The analyses included a number of organochlorine pesticides: p,p'-DDT with its metabolites p,p'-DDE, p,p'-DDD and o,p'-DDT (the values for these four substances are reported here as the sum of the four, referred to as DDT sum), aldrin, isodrin, endrin, dieldrin, HCB (hexachlorobenzene), α- and β-HCH (hexachlorocyclohexane), lindane (γ-HCH), heptachlor and heptachlor epoxide, which is a metabolite of heptachlor, α-chlordane, γ-chlordane, oxychlordane, trans-nonachlor, α-endosulfan.. Furthermore ten indicator PCB congeners were measured: PCB28, PCB52, PCB101, PCB105, PCB118, PCB138, PCB153, PCB156, PCB170, and PCB180. Indicator PCB sum was calculated as the sum of the 10 congeners, which are a mixed group of NDL-PCBs and DL-PCBs. Some of the organochlorine pesticides were only detected in very few samples and their results are therefore not included in this report.

Maximum residue limits

The maximum residue limits for the organochlorine pesticides are continuously regulated under the pesticide MRL regulation (EC, 2005). The present maximum limits for relevant organochlorine pesticides in fat from meat, dairy products, and eggs are shown in Table 9.6, but more details can be found in the EU MRL database and regulation 396/2005.

For PCBs, nationally recommended values for acceptable levels were used until 2012, when EU maximum levels for NDL-PCBs came into force (see Section 9.1.1)

Table 9.6. *Maximum levels for selected organochlorine pesticides*

Substance	Maximum limit (mg/kg*)		
	Fat from meat	Milk, cheese, etc.	Eggs
Aldrin	0.2	0.006	0.02
Chlordane	0.05	0.002	0.005
DDT sum	1	0.05	0.05
Dieldrin	0.2	0.006	0.02
Endosulfan	0.05	0.05	0.05
Endrin	0.01	0.0008	0.005
Heptachlor	0.2	0.004	0.02
HCB	0.2	0.01	0.02
α-HCH	0.2	0.004	0.02
β-HCH	0.1	0.003	0.01
Lindane	0.01	0.001	0.01

* In mg/kg fat for meat and dairy products, and mg/kg fresh weight for eggs.

9.2.1 Methods of sampling, analysis and quality assurance

The environmental contaminants are unevenly distributed in the various foods. For example levels in fish depend on the type of fish, the area where the fish live and the age of the fish etc. Lean fish such as pollack or cod have appreciably lower levels of organochlorine pesticides and indicator PCB than fat fish such as salmon, herring or mackerel. The studies were planned with the intention of closely following all food items with either a high level of environmental pollution or a high consumption. Special samples for monitoring the contamination levels of the various Danish waters were taken from the Baltic Sea in the East to the North Sea in the West, distributed across six fishing waters. Furthermore, the following fish were investigated: trout from fish farms and sea farming and farmed eel, and fish from the retail trade, including herring, mackerel, salmon, Greenland halibut, cod and butterfish and finally wild fish collected by the Danish Directorate of Fisheries.
. For the analyses of meat, eggs, milk and farmed fish, sampling was performed in accordance with EU directive 96/23/EC (EC, 1996) on measures for monitoring certain substances in live animals and animal products. Surveys of imported dairy products, including imported milk, butter and cheese, were also made. A single survey looked at fish oil as a food supplement because the oil might contain the contaminants.

Samples of meat and farmed fish were taken at the slaughterhouses, eggs were taken at egg packing stations, and milk was taken either at the dairy works or directly from the livestock. When possible, samples of organically produced products were included. The substances monitored for are fat-soluble, and so they will be found in the lipid phase, i.e. the fat. Focus was put on dairy products with relatively high fatty levels, such as butter, milk fat and cheese. Kidney fat from cattle and pigs and subcutaneous fat from poultry were also analysed. Studies (Fries et al., 1978; Fries and Marrow, 1977; Lorber et at al., 1997; Rumsey et al., 1967) have shown that the levels of organochlorine pesticides and indicator PCB in such fatty tissues are representative of the levels in the market meat when measured on the basis of fat. Fillets of fish were analysed after removing the skin, because it is assumed that very few people eat the fish skin and that the migration of the substances from the skin to the rest of the fish during preparation is minimal.

The chemical analyses of organochlorine pesticides and indicator PCB were carried out at the Danish Veterinary and Food Administration regional laboratory in Aarhus in accordance with the quality assurance manual, including participation in international ring tests. The analytical procedure includes extraction using an organic solvent, after which the organochlorine contaminants are isolated from the fatty phase and detected by gas chromatography with EC detection. The results are calculated as mg/kg fish/cod liver (fresh weight), or as mg/kg fat for pigs, cattle, poultry, eggs, and dairy products.

9.2.2 Data on levels of contamination

The average levels of the substances found in the various foods are presented in Appendices 16.5.1 to 16.5.9. The appendices show the total number of samples for each of the foods analysed, the number of samples with levels above the detection limits, the average levels of the individual organochlorine compounds and the 95th percentile. The indicator PCB-sum was calculated as the sum of the averages for the 10 indicator congeners. The calculations of the average levels of the various organochlorine environmental contaminants in foods are briefly described below.

For the environmental contaminants PCB and organochlorine pesticides, it can be assumed that they are present in varying quantities everywhere in the environment, due to previous use of the compounds. To be able to follow the lower levels and to better estimate the dietary exposure of the population, all findings have been reported. When calculating the average levels of the various substances, the level in samples without positive findings had to be estimated because the level may be zero or it may be just below the limit of detection. As in the previous studies as well as the studies from 2004-2011 all values below the limit of detection were set to one-third of the limit of detection make it possible to use the historical data and compare results.

The levels of organochlorine pesticides and indicator PCB in fish depend on the fish species and the water where the fish was caught, among other things. The levels of these substances vary according to the fish species because the fatty level of different fish species varies. Differences in the organochlorine levels between different bodies of water may be explained by differences in the environmental pollution of the waters with organochlorine pesticides and indicator PCB. The data for the present period does not include other information on factors concerning the fish, such as their food basis, age and sex.

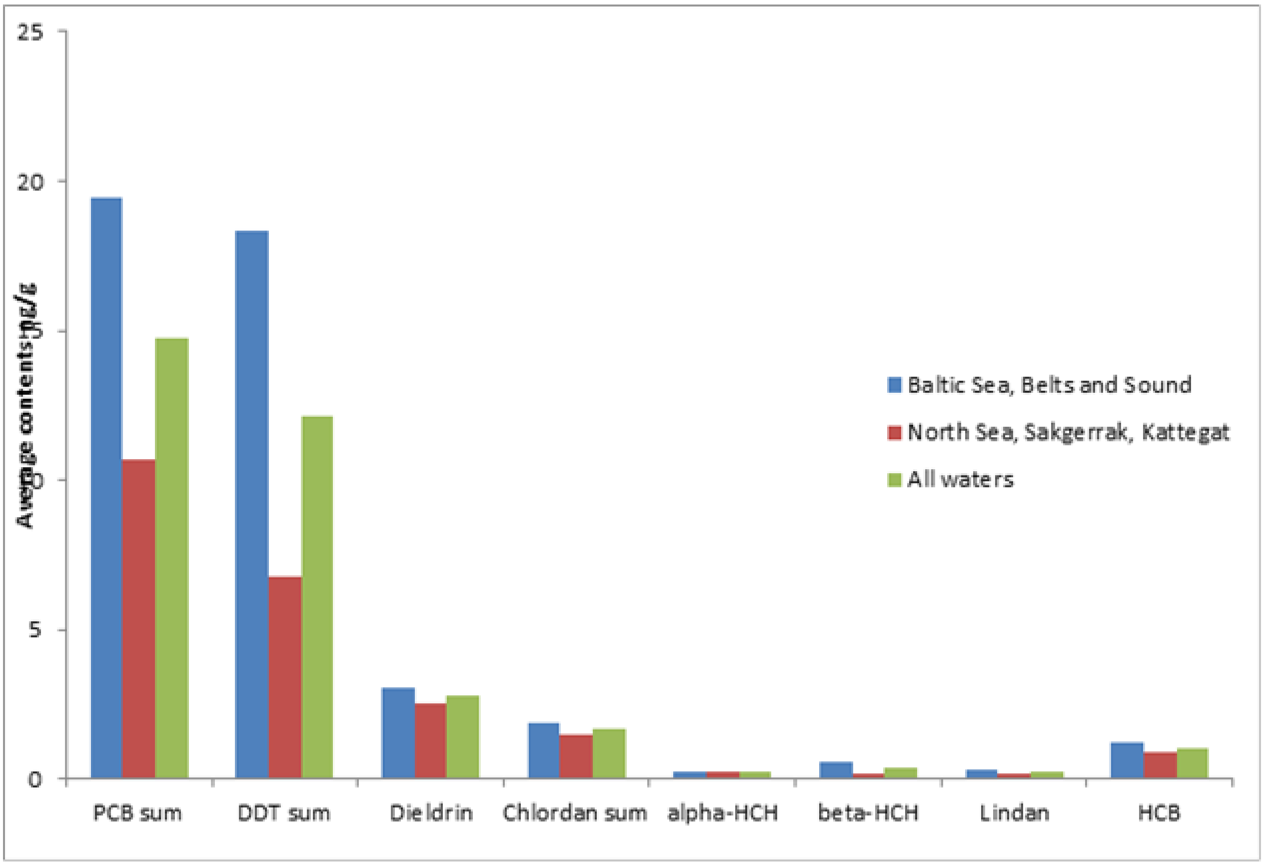


Figure 9.8. *Levels of organochlorine contaminants in herrings from Danish waters*

Figure 9.8 shows the average levels of organochlorine compounds in herring distributed across the different Danish fishing grounds. The bars illustrate herring samples from 1) the Baltic Sea, the Belts, the Sound; and 2) the North Sea, the Skagerrak, the Kattegat 3) all waters.

Levels in products of animal origin

In animal fat, DDT and PCBs were detected at low levels in the majority of the samples. HCB was also detected at low levels in a majority of samples, except for poultry and pork samples where HCB was detected in a minority of samples. Figure 9.9 shows a comparison between the levels found in the various meat samples.

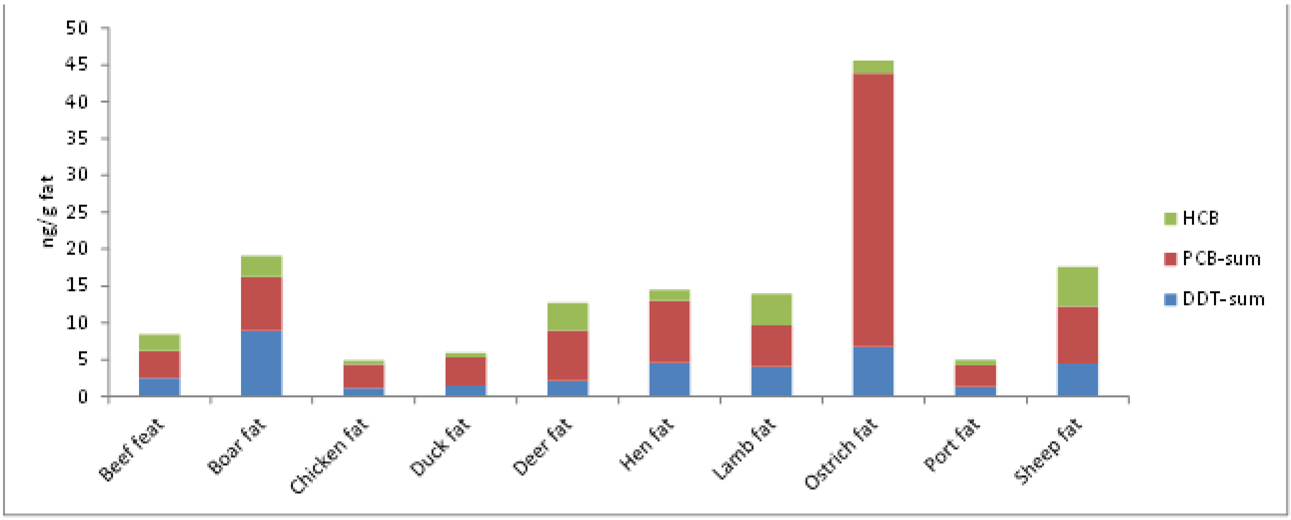


Figure 9.9. *Estimated levels of HCB, PCB-sum and DDT-sum in animal fats*

9.2.3 Development over time for fish

The following section focuses on the development over time for the levels of organochlorine pesticides and indicator PCB. As already published, the levels of organochlorine environmental contaminants in fish decreased significantly during the 1970s and the beginning of the 1980s (Hilbert et al., 1997; Danish Veterinary and Food Administration, 2005). However, the previous monitoring period (1998-2003) did not continue to show strong decline, but rather a steady-state condition. The levels of contaminants in fish depend significantly on factors not taken into consideration when sampling, because the samples are generally selected from foods intended for consumption. For a long period, cod liver has been used as a model for the development over time for fish from different Danish fishing grounds.

Cod liver has for a long period been used as model for the development over time for fish from different Danish fishing grounds. A statistical analysis of the levels of organochlorine contaminants in cod liver showed that the distribution of concentrations is best described by a logarithmic normal distribution, and that the development over time can be described by a linear regression based on logarithmised data (Sommer Statistics, 1999). By means of an analysis of variance an assessment was made whether the regression lines for the different waters could be pooled and the results are presented in figure 9.10.

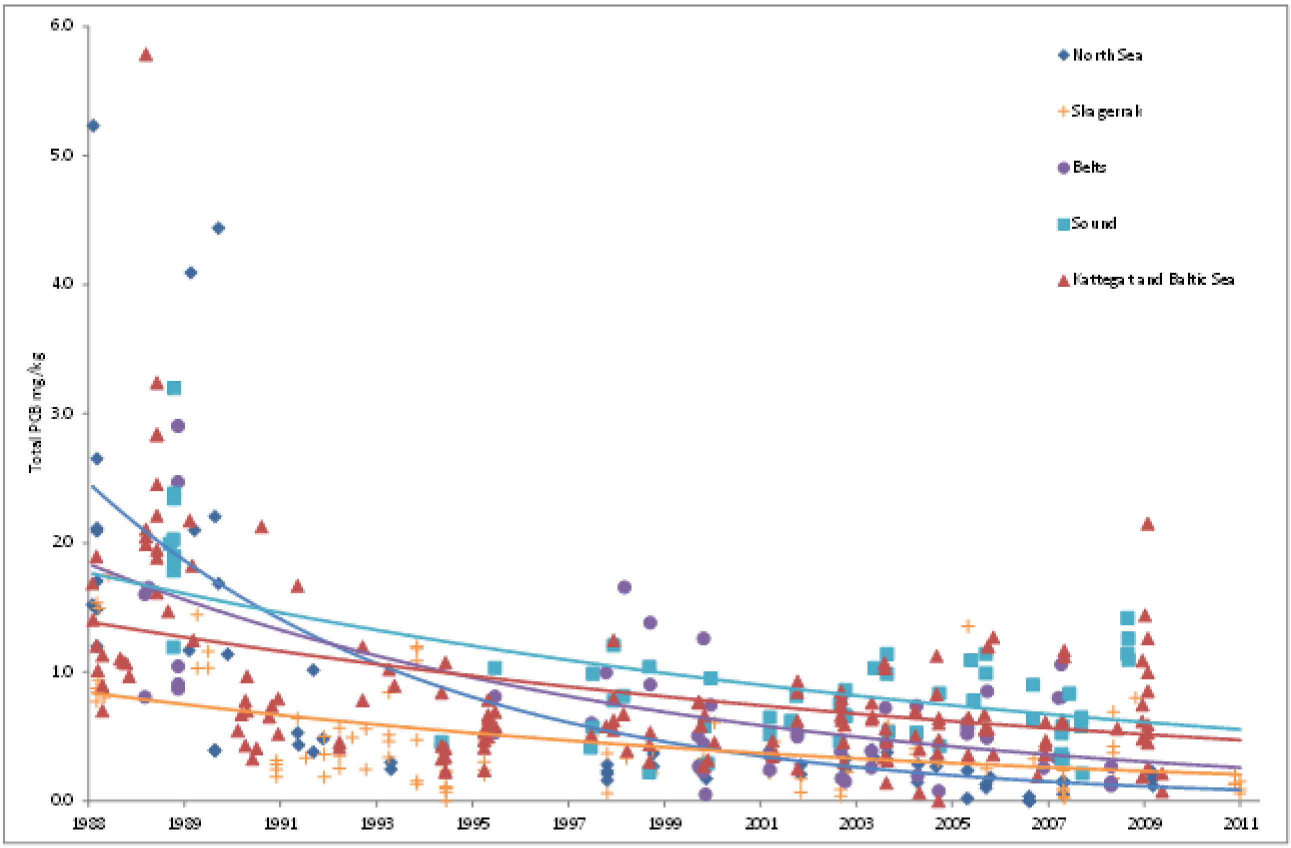


Figure 9.10*. Estimated Total PCB in cod liver from Danish waters, 1998 - 2011*

Total PCB is a previously used measure of the entire PCB and estimation of the levels today are based on a previously established correlation between the PCB sum measured today and the Total PCB level (Danish Veterinary and Food Administration, 2001). As figure 9.10 shows, the levels have declined significantly since 1988, but for at least a decade the levels in cod liver seems to be stable, though with a small tendency for having the higher levels in the Baltic sea, the Sound and Kattegat.

Figure 9.11 shows the development over time for DDT in cod liver, with a significant decline in the levels of DDT since 1988, but almost steady-state conditions in the levels for almost two decades. The lowest levels of DDT in cod liver are found in the North Sea and Skagerrak and the highest in the Baltic Sea, followed by Kattegat and the Sound.

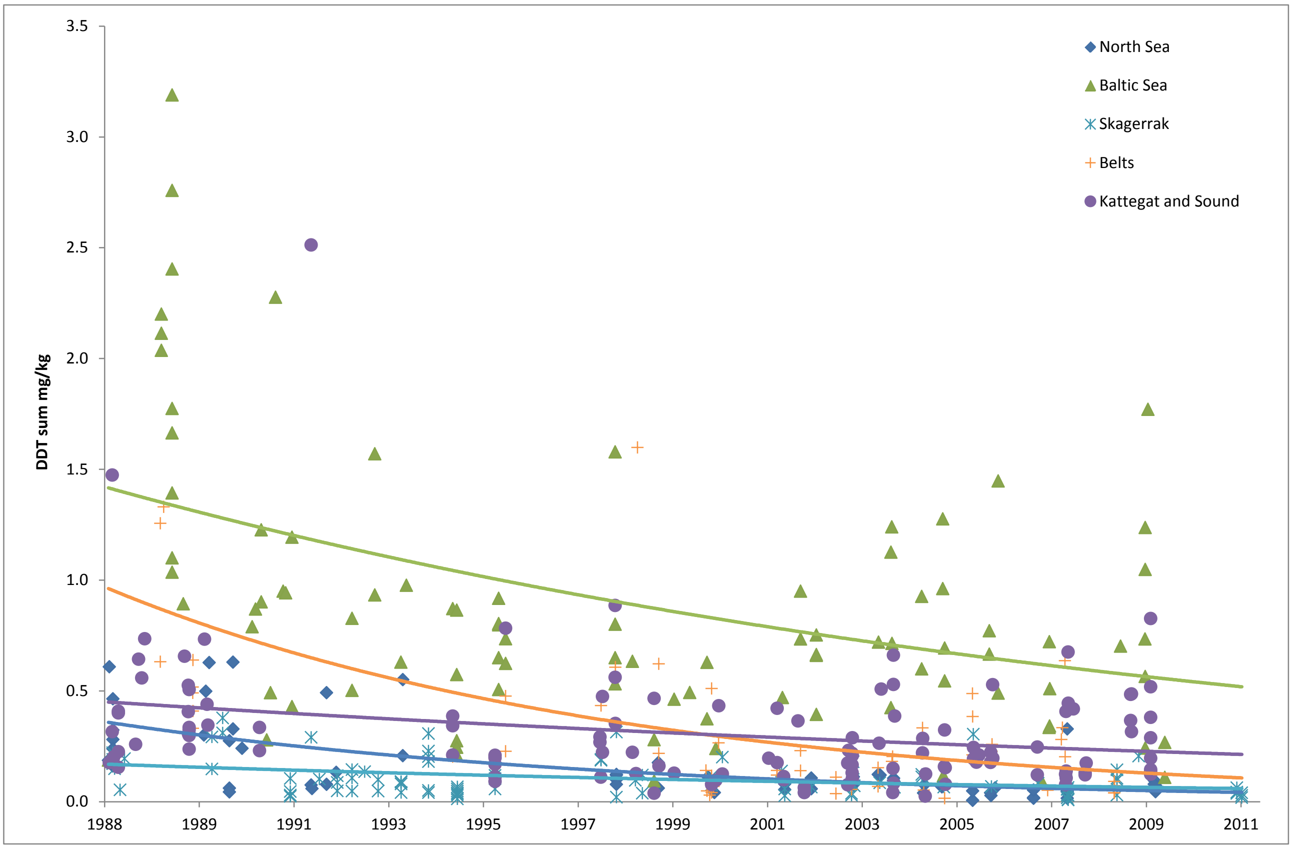


Figure 9.11. *DDT in cod liver from Danish waters, 1988 - 2011*

Figure 9.12 shows the developments over time for HCB with almost the same levels found in cod liver from all waters, except for the higher levels found in the Baltic Sea. For dieldrin (see Figure 9.13), the highest levels are found in the Baltic Sea and the lowest levels are found in the North Sea and Skagerrak.

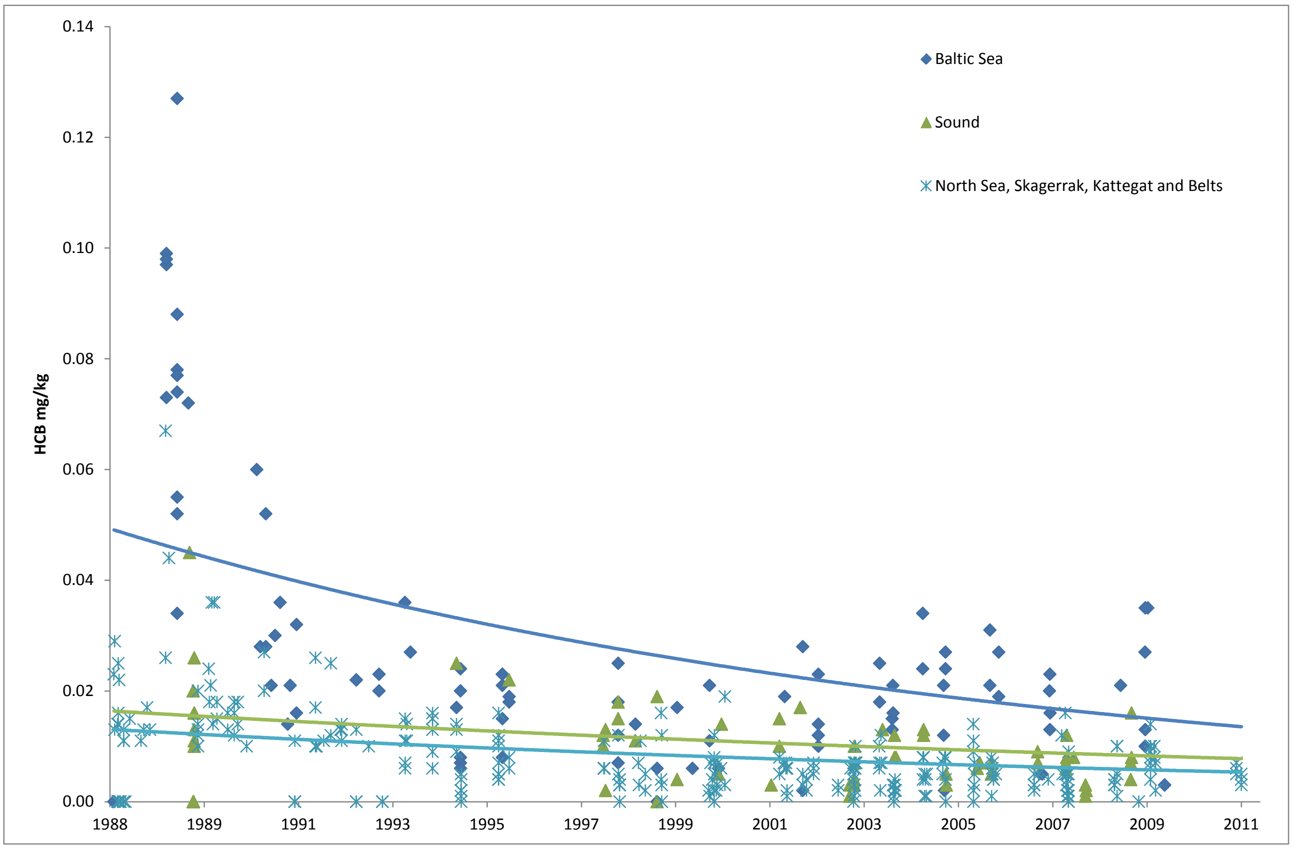


Figure 9.12. *HCB in cod liver from Danish waters, 1988 - 2011.*

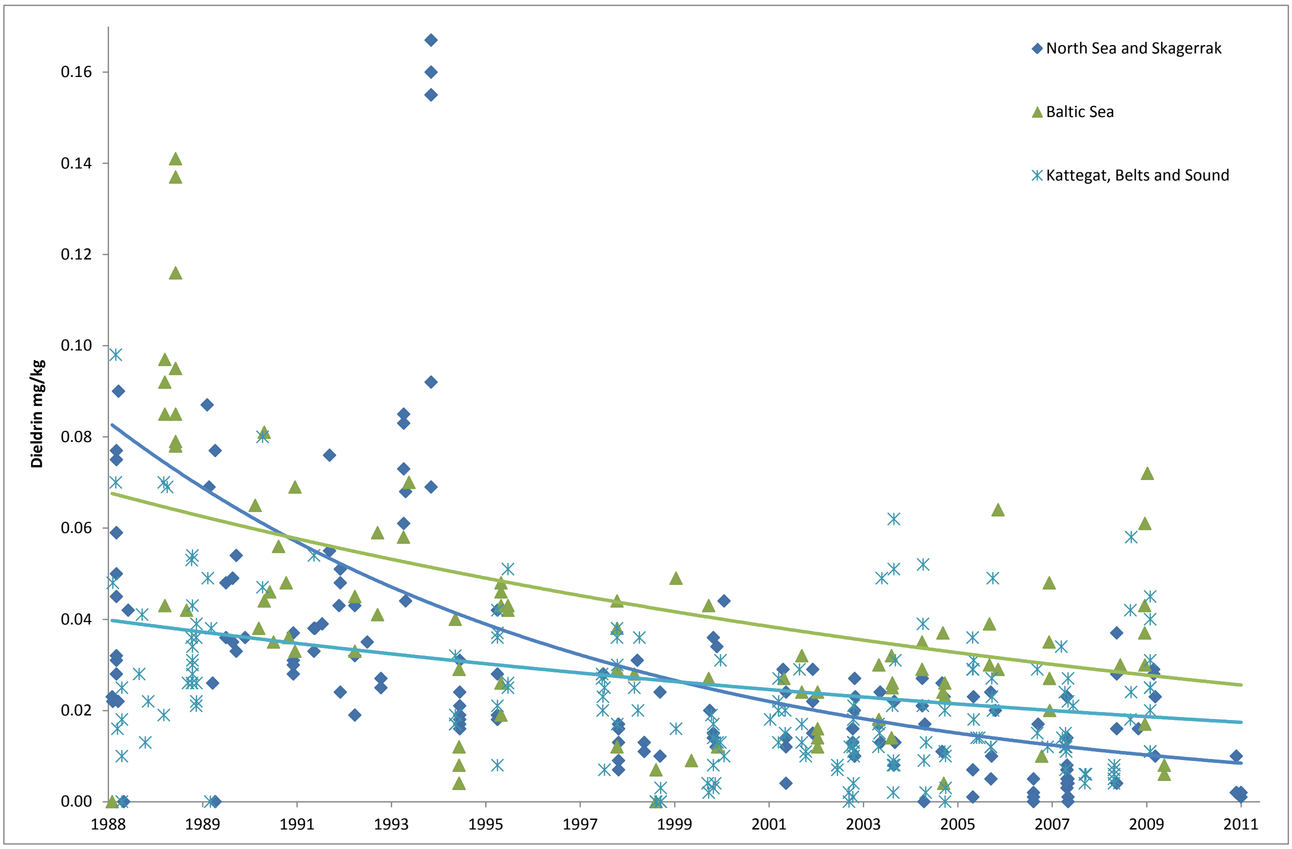


Figure 9.13. *Dieldrin in cod liver from Danish waters, 1988 - 2011*

Most samples of herring from 1998 until today contain DDT, and Figure 9.14 shows the levels with a distribution for the Baltic Sea samples resulting in an estimated small increase in the levels; however based on very scattered data points ant it should therefore only be concluded, that the levels for DDT in herring from the Baltic Sea are usually higher than the level in herring from other waters.

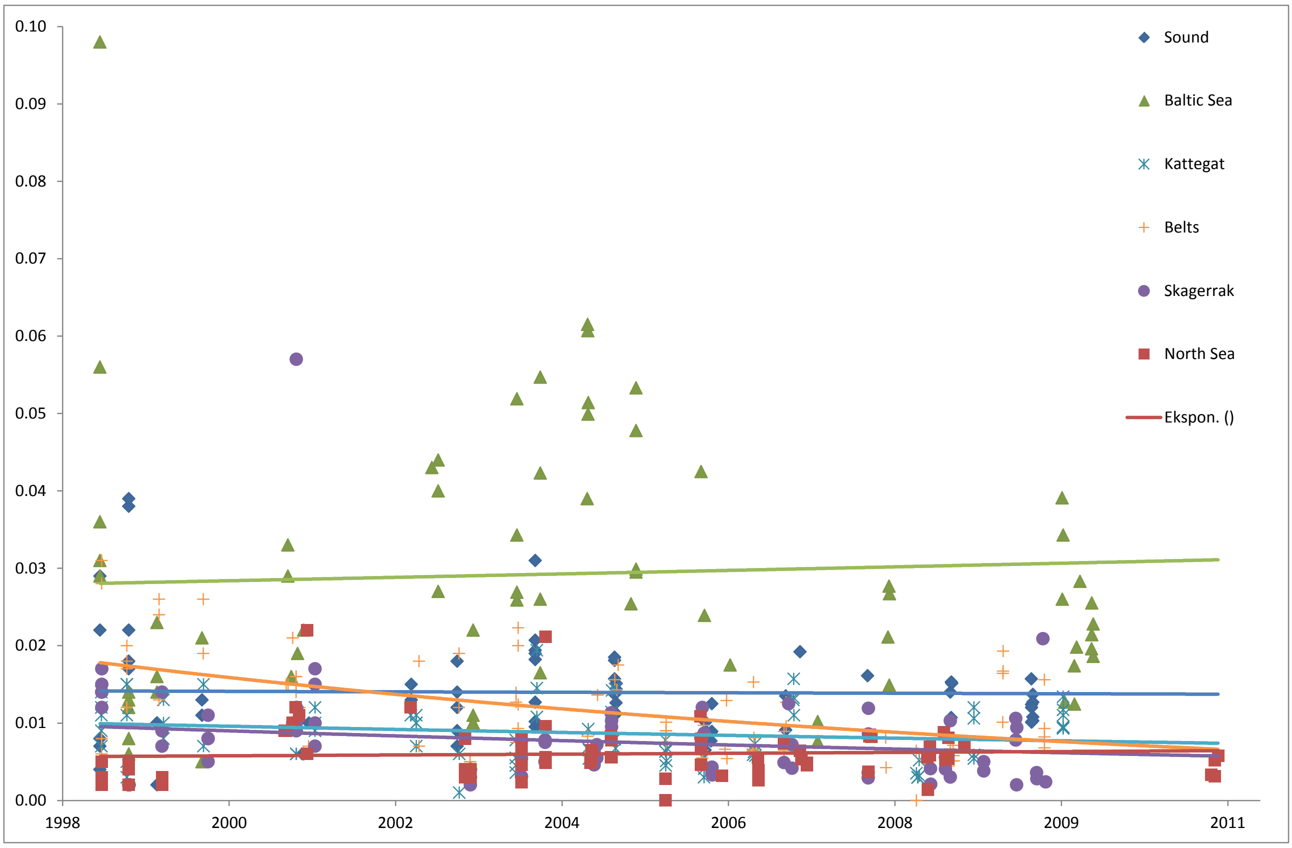


Figure 9.14. *DDT in herring from Danish waters, 1998 – 2011*

To conclude this section, contamination levels in fish from Danish waters seem to have declined since 1998, but with almost steady-state conditions for nearly two decades. Levels in the Baltic Sea are the highest and the lowest levels are found in the North Sea.

9.2.4 Products of animal origin

There are also some general trends for the group of products of animal origin: only a limited number of compounds are found and only low levels were observed. This means that only levels can be estimated for few compounds. The estimated average levels do not differ much from year to year, though they seem to be decreasing, as for example shown for pork in Figure 9.15.

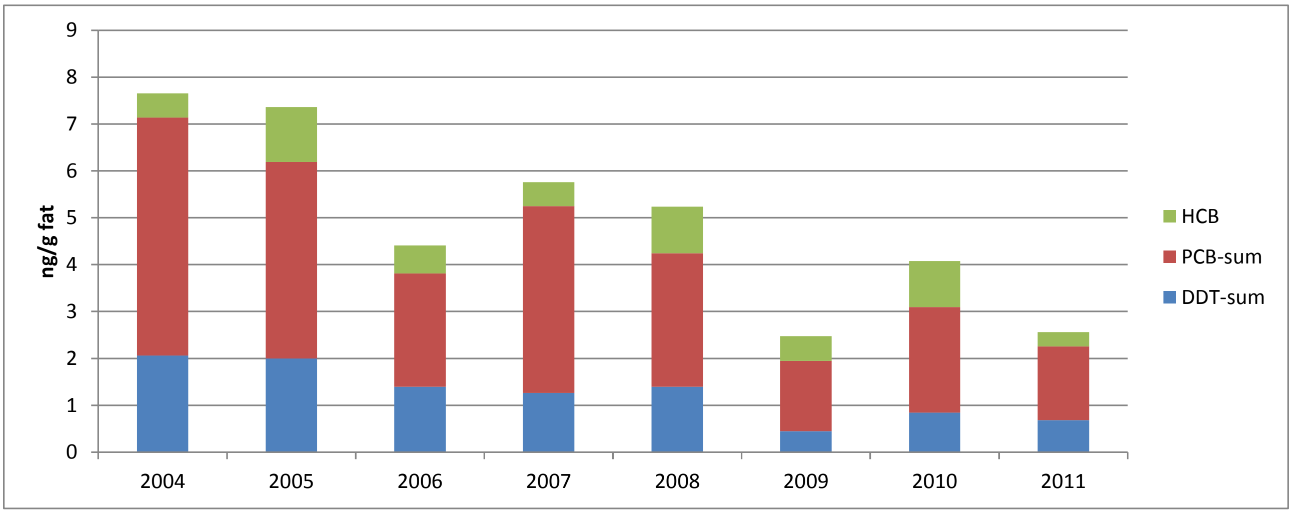


Figure 9.15. *Pork fat, estimated average level*

When the levels in organically produced meat and conventionally produced meat are compared, the estimated levels for HCB, PCB sum and DDT sum are significantly higher in organically produced pork, however they are at the same level for beef samples – see Figure 9.16.

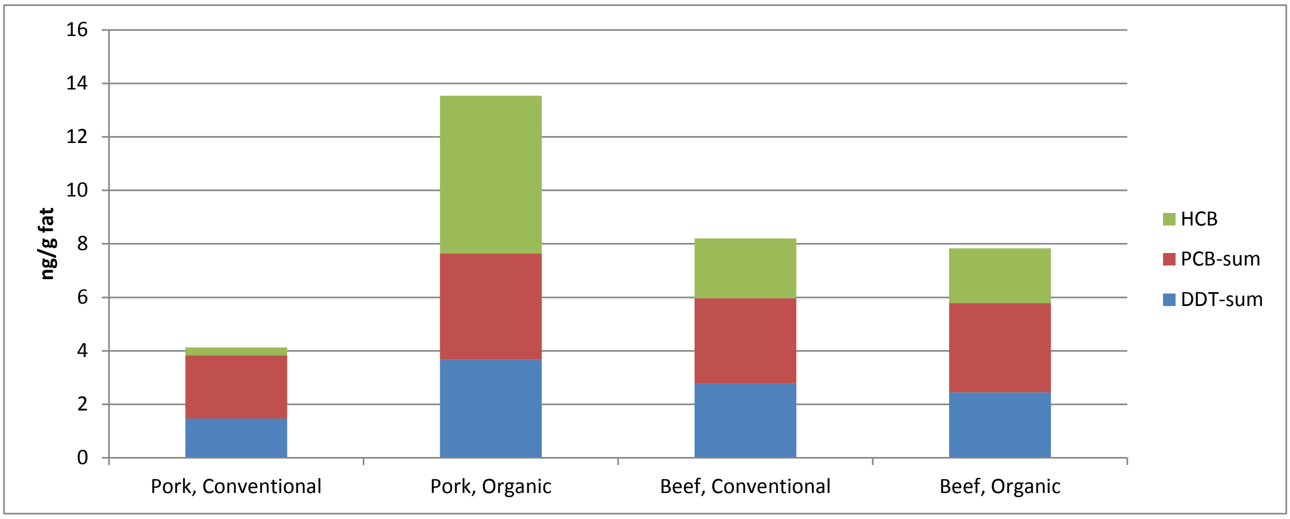


Figure 9.16. *Levels in organic produced vs. conventionally produced meat.*

The levels found for DDT sum, PCB sum and HCB in beef are at almost the same low level for all years and no tendency can be found, as illustrated in Figure 9.17.

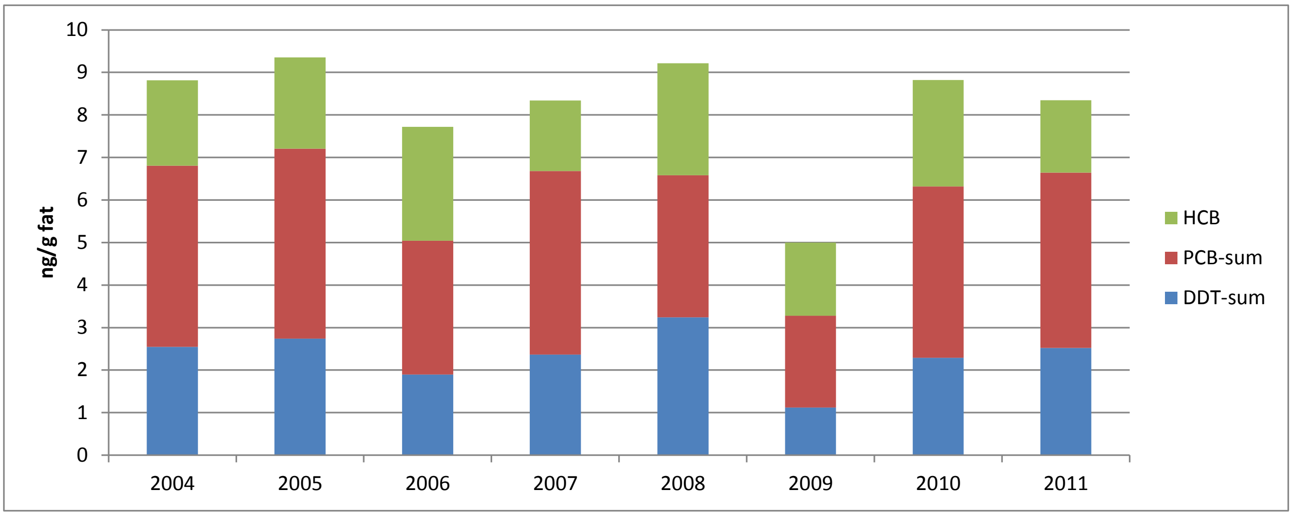


Figure 9.17. *Beef fat, estimated average level*

For poultry fat the estimated levels seem to have a slightly decreasing tendency, as shown in Figure 9.18

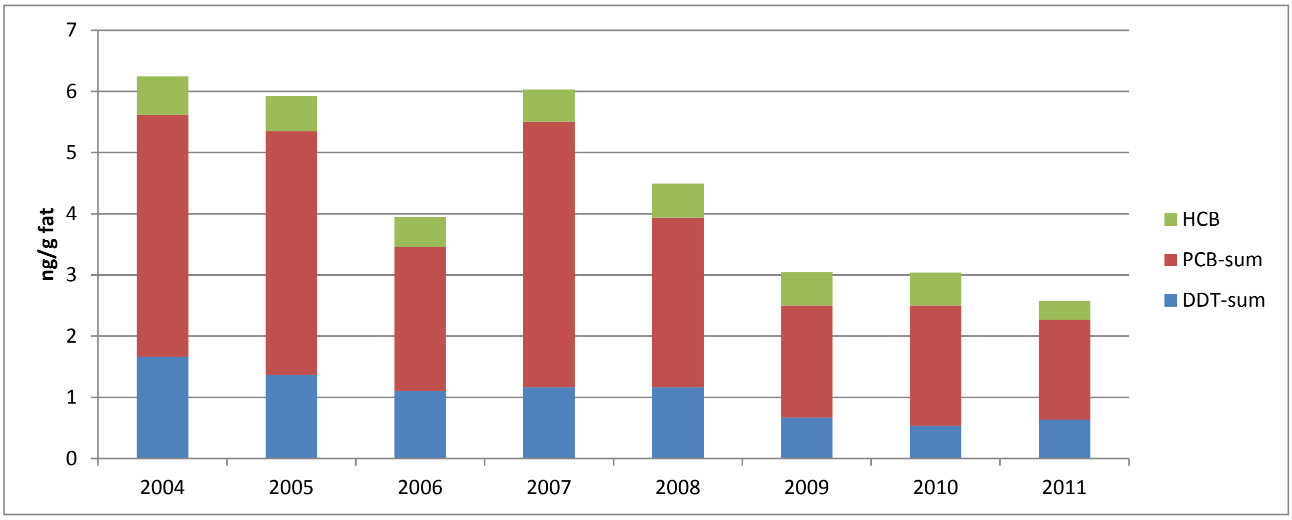


Figure 9.18. *Poultry fat, estimated average level*

For dairy products (see Figure 9.19) the estimated levels are shown and sub-divided into groups of Danish produced milk and foreign produced milk and butter. Significantly lower levels for the PCB sum and the DDT sum are observed in the Danish produced milk samples. Samples of both organically and conventional Danish milk were taken, however no differences in the levels were observed.

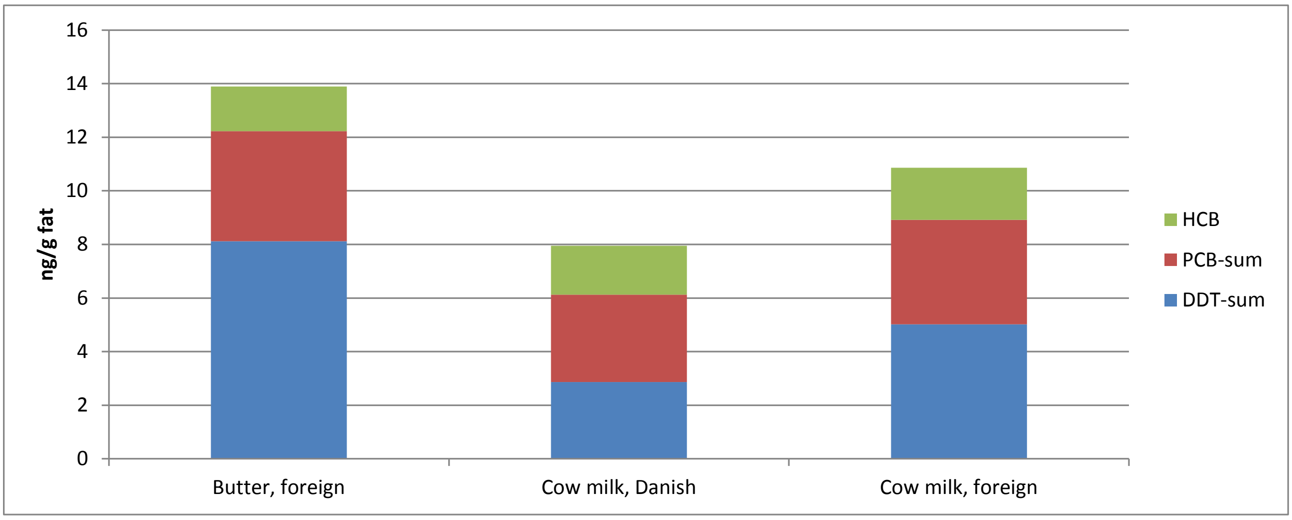


Figure 9.19. *Dairy products, estimated average level*

Figure 9.20 shows the levels found in animal fat.

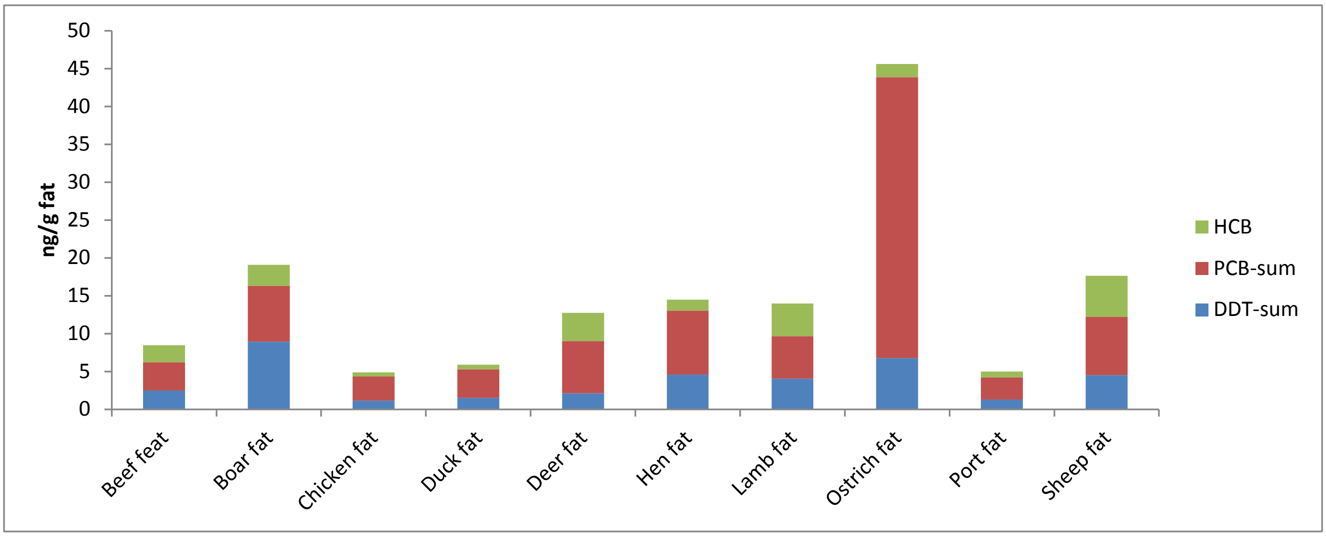
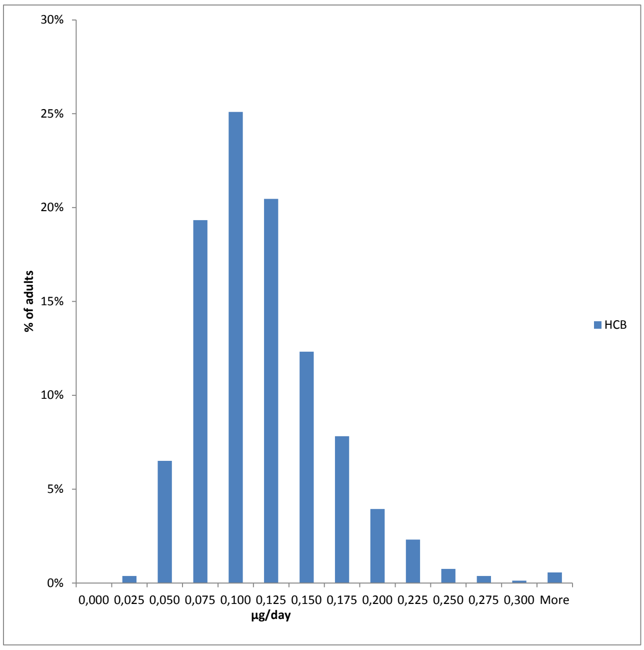


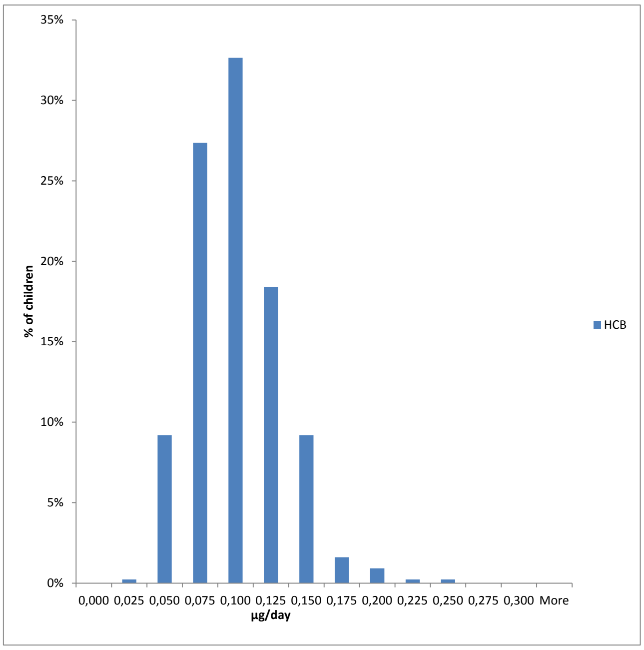
Figure 9.20. *Estimated average levels in animal fat*

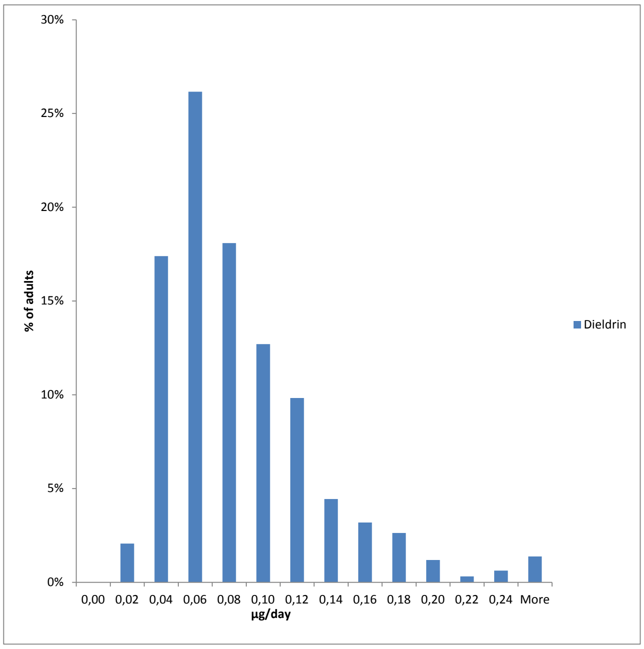
When the levels of organochlorine pesticide found in the different foods of animal origin are compared, they are more or less the same, although for some of the products with minor consumption and very few samples, e.g. boar fat and ostrich fat, levels seem to have a tendency to be higher.

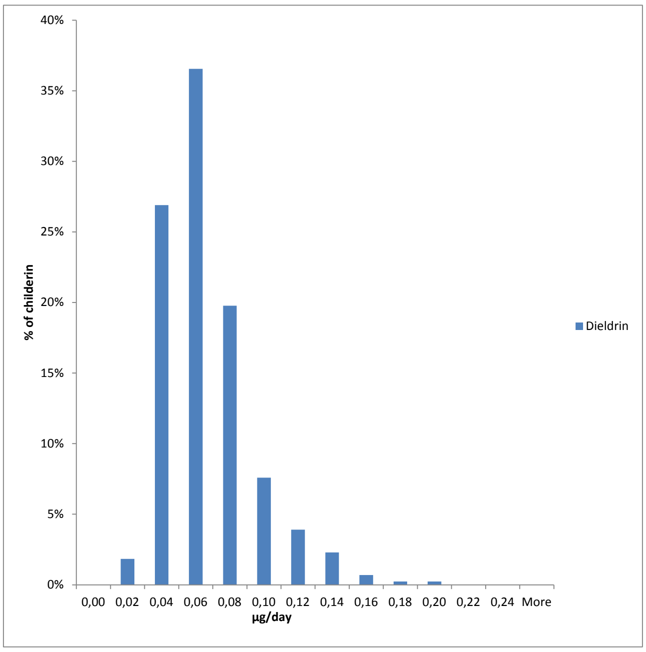
9.2.5 Exposure and risk assessment of organochlorine pesticides

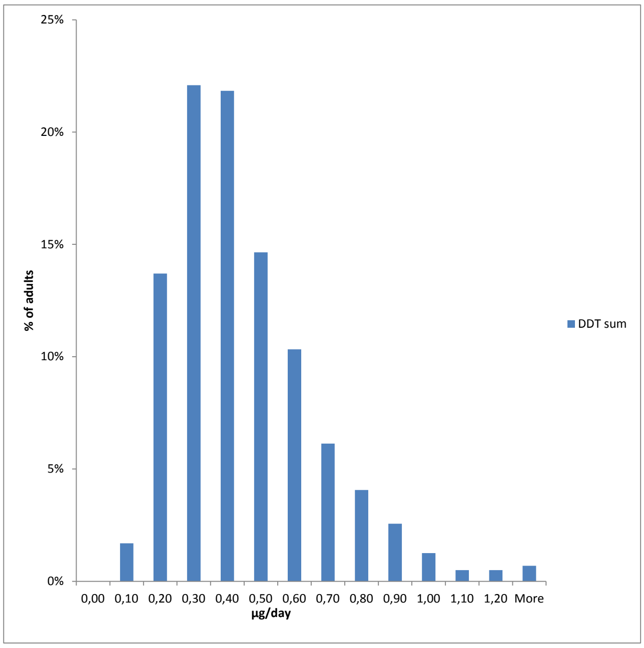
The exposure calculations were carried out as previously described including only the fatty tissues where the organochlorine contaminants accumulate, and they therefore represent the exposure to the compounds found as environmental contaminants. Only selected figures of the compounds are presented in order to illustrated differences between the different compounds. Figure 9.21 shows the daily exposure estimated for HCB, dieldrin and DDT sum, subdivided between adults (aged 15-75) and children (aged 4-14).











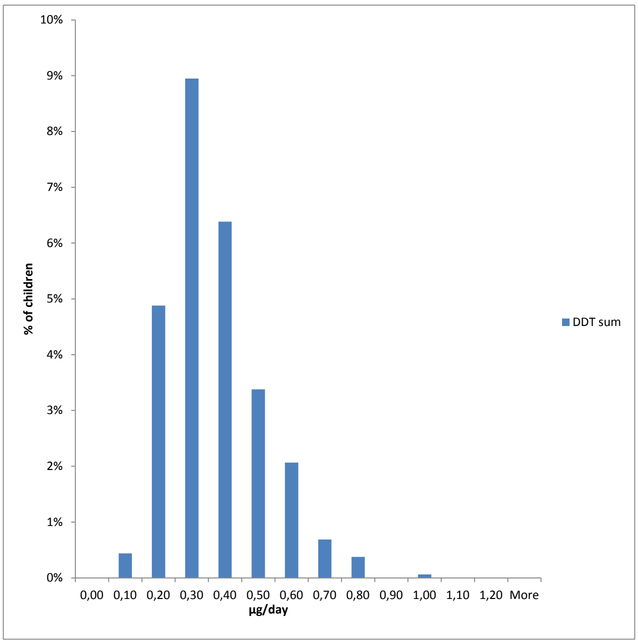
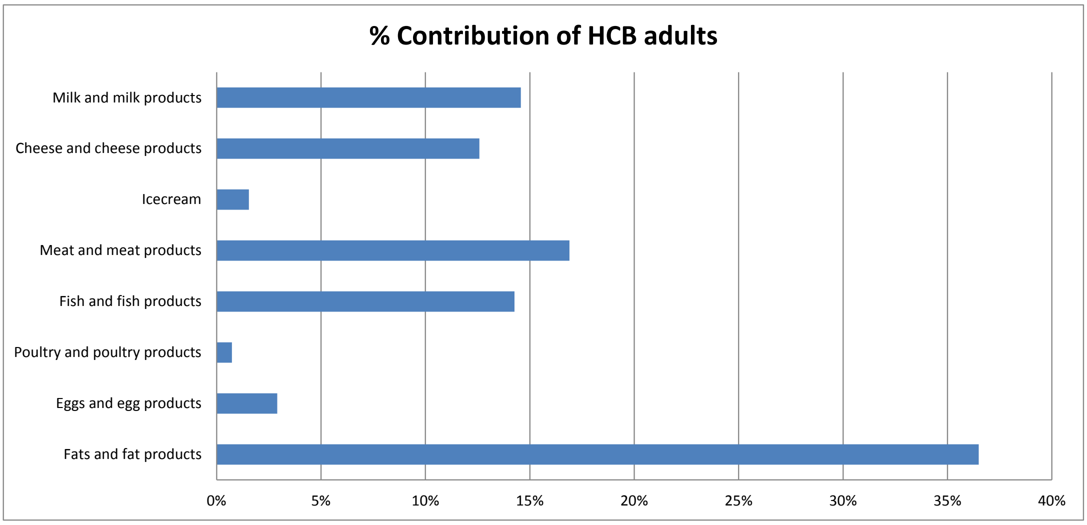
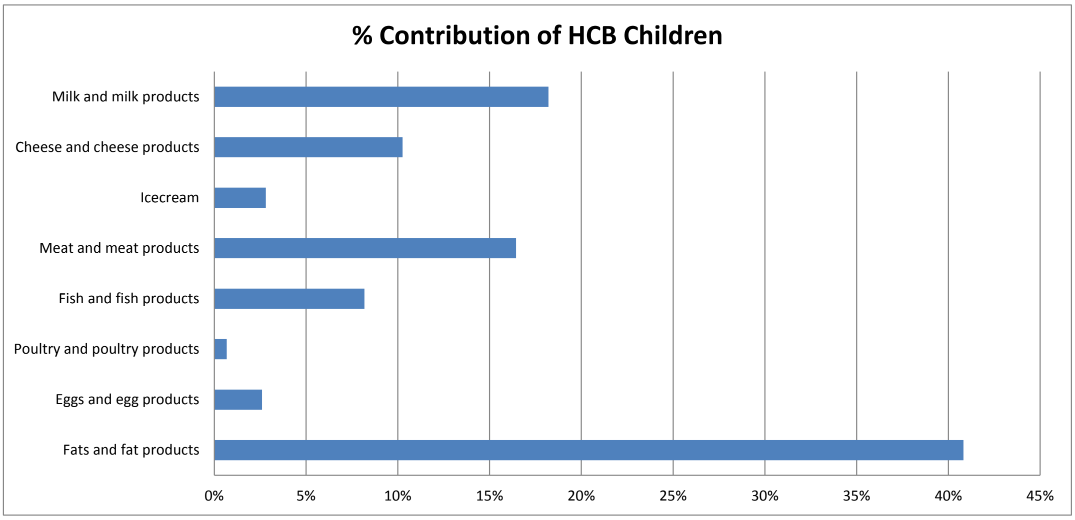
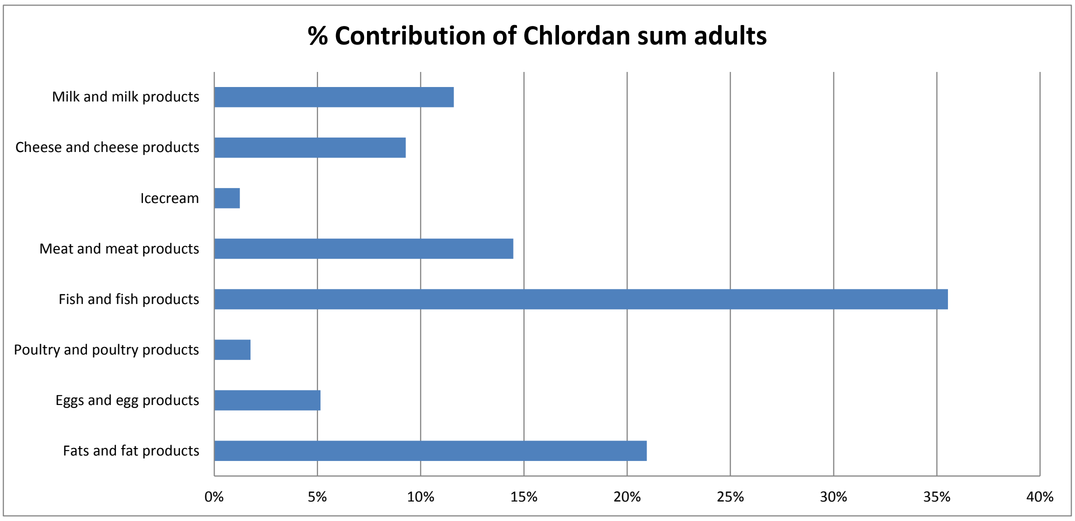


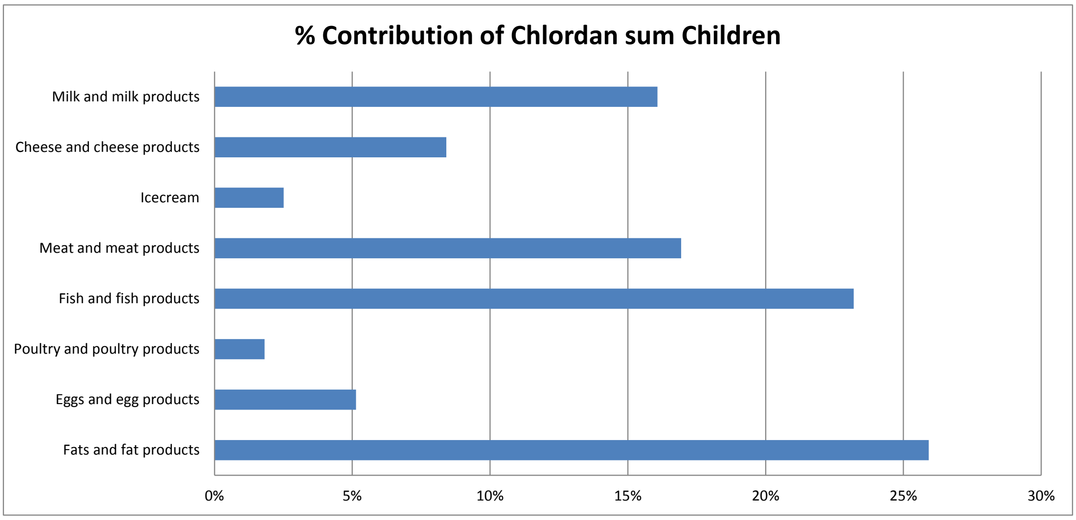
Figure 9.21. *Daily exposure to for HCB, dieldrin and DDT sum (top to bottom) for adults (left) and children (right) in µg/kg*

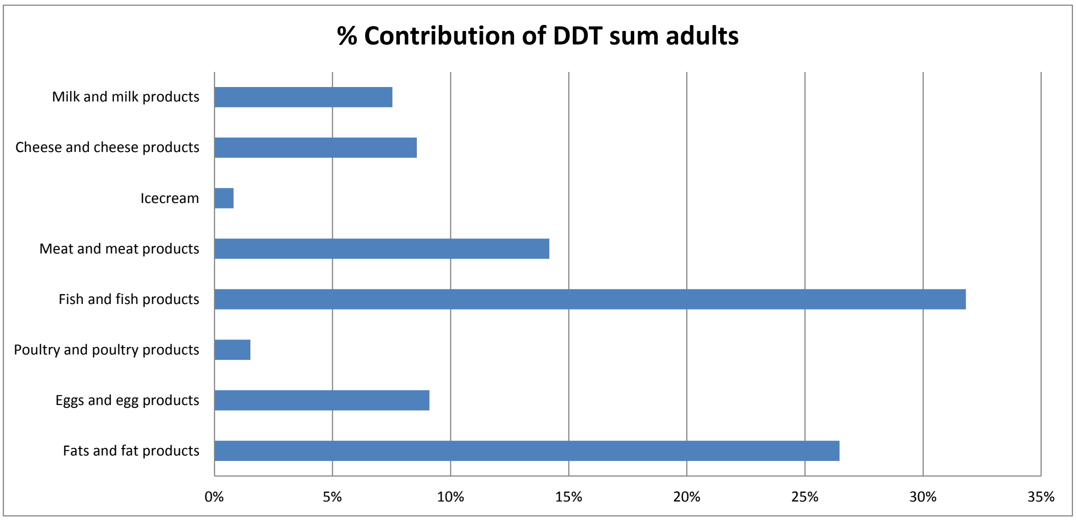
When the intake of organochlorine contaminants for children and adults is compared, there are differences in the amount consumed as well as in the exposure pattern. Figure 9.22 shows the contribution from the various food groups for HCB, chlordane sum and DDT sum. One general trend is the adults' relatively higher intake of the contaminants from fish and the children's relatively higher intake of contaminants from milk




% Contribution of HCB Children
Milk and milk products
Cheese and cheese products
Icecream
Meat and meat products
Fish and fish products
Poultry and poultry products
Eggs and egg products
Fats and fat products
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%


% Contribution of Chlordan sum adults
Milk and milk products
Cheese and cheese products
Icecream
Meat and meat products
Fish and fish products
Poultry and poultry products
Eggs and egg products
Fats and fat products
0%
5%
10%
15%
20%
25%
30%
35%
40%


% Contribution of Chlordan sum Children
Milk and milk products
Cheese and cheese products
Icecream
Meat and meat products
Fish and fish products
Poultry and poultry products
Eggs and egg products
Fats and fat products
0%
5%
10%
15%
20%
25%
30%


% Contribution of DDT sum adults
Milk and milk products
Cheese and cheese products
Icecream
Meat and meat products
Fish and fish products
Poultry and poultry products
Eggs and egg products
Fats and fat products
0%
5%
10%
15%
20%
25%
30%
35%

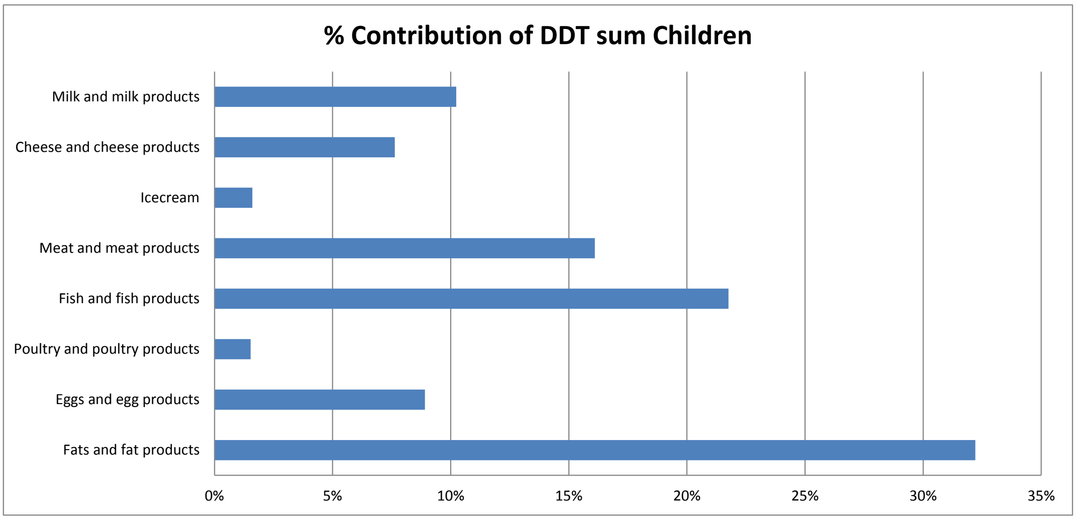
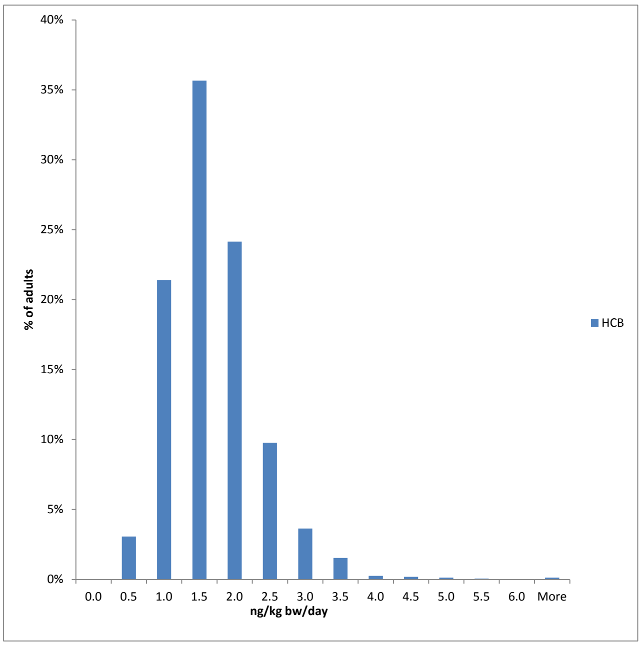


Figure 9.22. *Contribution from food groups to the intake of HCB, chlordane sum and DDT sum (top to bottom) for adults and children, respectively*

To make it possible to compare the exposure estimates to the toxicological reference values individual bodyweight from the dietary exposure data were used in the following calculations of the exposure in order to have results based on "per kg bodyweight per day".

The daily exposures were estimated for adults and children. Figure 9.23 shows the exposure distributions for HCB for adults (left) and children (right).



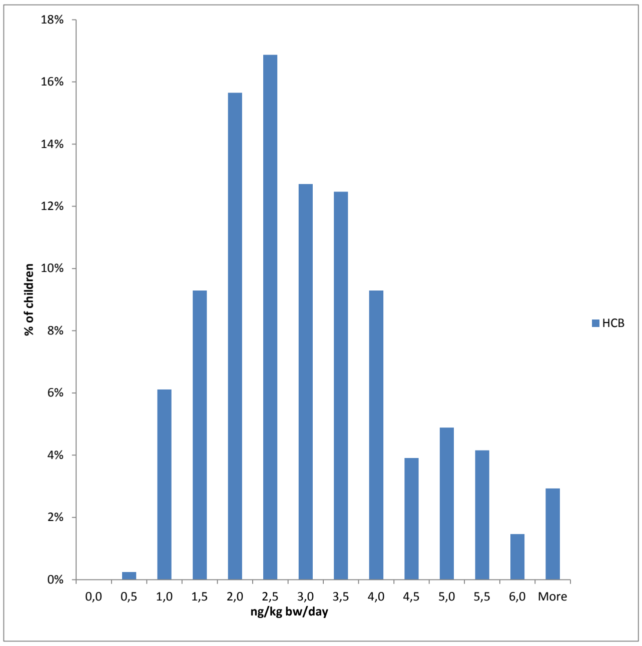


Figure 9.23. *HCB exposure in ng per kg bw*

As children have relatively high food consumption relative to their bodyweight, the figure shows the difference between the distribution for adults and children, where children have about twice the daily exposure of adults when compared relative to their bodyweight.

Table 9.7 shows the estimated average exposures and the 95th percentile. The exposures were calculated using 1/3 LOD for samples with non-detected residues.

Table 9.7. *Estimated exposures for organochlorine pesticides*

Organochlorine pesticides	**ng/kg bw/day**	
	Average	95 % percentile
alpha-HCH adults	0.3	0.6
alpha-HCH children	0.3	1.2
beta-HCH adults	0.5	0.9
beta-HCH children	0.5	2.0
Lindane adults	0.2	0.4
Lindane children	0.5	0.9
DDT sum adults	5.5	11
DDT sum children	10	22
Dieldrin adults	1.1	2.2
Dieldrin children	1.8	4.1
Chlordane sum adults	1.5	2.6
Chlordane sum children	2.8	5.4
HCB adults	1.5	2.6
HCB children	2.8	5.3
Heptachlor sum adults	1.2	2.5
Heptachlor sum children	2.2	5.0

Similar calculations have been performed for men versus women for DDT in order to illustrate the differences for the two groups (see Table 9.8).

Table 9.8. *DDT sum exposure for men and women*

DDT sum	**ng/kg bw/day**	
	Average	95th percentile
Men	7.0	16
Women	6.1	14

The DDT example above takes account of men's higher food consumption for men than for women, but it results only in small differences in the daily exposure.

Toxicological reference values for the relevant organochlorine pesticides are listed in Table 9.9.

Table 9.9. *Toxicological reference values for relevant organochlorine pesticides*

Compound	**ADI (µg/kg bw/day)**	**Reference**
HCB	0.6 [1)]	JMPR (1970)
	0.16[2)]	IPCS (1998)
Lindane	5	JMPR (2003 – as cited in the EU Pesticides database)
alpha-HCH	8 [3)]	ATSDR (1997)
beta-HCH	0.6 [3)]	ATSDR (1997)
Chlordane	0.5	JMPR (1994 – as cited in the EU Pesticides database)
Heptachlor	0.1	JMPR (1994 – as cited in the EU Pesticides database)
DDT	10	JMPR (2000 – as cited in the EU Pesticides database)
	0.5[4)]	US Environmental Protection Agency (1998)
Dieldrin and aldrin	0.1 sum of dieldrin and aldrin	JMPR (1994 – as cited in the EU Pesticides database)

[1)] "Tentative Negligible Daily Intake". The ADI is withdrawn (JMPR 1978 – as cited in the EU Pesticides database).
[2)] "Health-based guidance value". Since the ADI has been withdrawn this is used as a surrogate for the ADI in the risk assessment.
[3)] "Minimal Risk Level". ADIs not established by JMPR or EU.
4) "Oral Reference Dose" (RfD), which in essence corresponds to a TDI or ADI. This value is based on more recent studies and assessments than the ADI from JMPR and is, therefore, used in the risk assessment.

For the selected organochlorine compounds the average daily exposure as well as the 95th percentiles are all well below the toxicological reference values (0.004-2.2 % and 0.008-5 %, respectively) for both adults and children.

10 Polycyclic Aromatic hydrocarbons (PAH)

Polycyclic aromatic hydrocarbons (PAH) constitute a large class of organic chemicals that normally occur in complex mixtures of several hundred compounds. They are composed of two or more aromatic rings, formed by incomplete combustion of e.g. organic material in industrial processes, waste incineration, and in motor vehicle exhaust. Food can be contaminated from environmental sources and during the processing of foods e.g. drying, smoking and barbecuing. During smoking, drying and barbequing PAH are found bound to particles in the smoke, formed either from the heating source itself (e.g. wood or charcoal burning) or from lipids dripping on the heating source. For non-smokers, food is the main source of human exposure to PAH.

For most PAH the critical toxicological effects are their genotoxic and carcinogenic potential. Previously SCF (2002) recommended to use BaP as a marker for the carcinogenic PAH in food and based the risk assessment of the carcinogenicity of PAH in food on the level of BaP, one of the most potent and best studied PAH (SCF, 2002). Legislation within the European Community was then based on BaP (EC Regulation No. 1881/2006 with amendments (EC, 2006a)).

Because BaP could not be detected in more than half of the analysis performed on PAH in food EFSA in 2008 (EFSA, 2008) has reviewed the Scientific opinion given by SCF in 2002. Based on the available data on the occurrence and toxicity, the EFSA CONTAM Panel concluded the 4 PAH (PAH4): BaP, chrysene, benz[a]anthracene and benzo[b]fluoranthene were suitable indicators of PAH in foods. From 2012 (EC, 2011b) PAH4 is included in the EU legislation. Occurrences of BaP and PAH4 for products on the Danish market have been investigated in the period 2005 to 2011. Risk assessment of PAH for the Danish population includes calculation of Margin of Exposure (MOE) for both BaP and PAH4 as advocated by EFSA (EFSA, 2008). The recommendation to keep the exposure of BaP and PAH4 as low as reasonable achievable (ALARA) by the Scientific Committee of Food (SCF, 2002) still applies.

10.1 Introduction

Although studies in experimental animals on individual PAH, most notably BaP, have shown various toxicological effects, such as haematological effects, reproductive and developmental toxicity and immunotoxicity, the critical effects are genotoxicity and cancer. Only very few single PAH and a few complex mixtures have been toxicological evaluated. The European Scientific Committee on Food (SCF) has evaluated 33 compounds. It was concluded that 15 PAH (benz[a]anthracene, cyclopenta[cd]pyrene, chrysene, 5-methylchrysene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, dibenzo[ah]anthracene, benzo[g,h,i]perylene, dibenzo[a,l]pyrene, dibenzo[a,e]pyrene, dibenzo[a,i]pyrene, dibenzo[a,h]pyrene) showed clear evidence of genotoxicity and all of these, except benzo[g,h,i]perylene, were carcinogenic in animals (SCF, 2002). For genotoxic and carcinogenic compounds, like some PAH, it is assumed that there is a no effect threshold, and therefore the ALARA should apply In its assessment of PAH in food the EFSA (2008) recommended that the lowest acceptable $BMDL_{10}$ value for PAH4 of 0.34 mg/kg bw per day should be used for PAH4 (EFSA , 2008b).

Maximum limits for BaP were introduced in 2005 in certain types of food and included in EC Regulation No. 1881 in 2006 with amendments. Table 10.1 shows relevant maximum limits for BaP levels and the new PAH4 limits valid from 2012 (EC, 2006a and EC, 2011a).

Table 10.1. *Maximum limits for benzo[a]pyrene (BaP) and PAH4 in selected foods (EC 2006a and 2011a)*

Food	**BaP (µg/kg)**	**PAH 4 (µg/kg)[a)]**
Processed cereal-based foods and baby foods for infants and young children.	1	1
Infant formulae and follow-on formulae, including infant milk and follow-on milk	1	1
Oils and fats (excl. cocoa butter and coconut oil) intended for direct human consumption or use as an ingredient in foods	2	10
Muscle meat of fish other than smoked	2[b)]	
Smoked meat and smoked meat products	5[c)]	30[d)]
Muscle meat of smoked fish and smoked fish products	5[c)]	30[d)]
Bivalve molluscs.	10[e)]	30

[a)]Included from September 2012
[b)]Not included from September 2012
[c)] From Sept. 2014 reduced to 2µg/kg
[d)] From Sept. 2014 reduced to 12 µg/kg
[e)] From Sept. 2012 reduced to 5 µg/kg

The estimation of MOEs are based on the BMD lower confidence limit for a 10% increase in the number of e.g. tumour bearing animals compared to control animals ($BMDL_{10}$ derived from two coal tar mixtures used in carcinogenicity studies ((EFSA 2008b)). MOEs are calculated by dividing the $BMDL_{10}$ values with the estimates based on and occurrence data for BaP and PAH 4, respectively (see also Table 10.2).

10.2 Methods of sampling, analysis and quality assurance

PAH have been included in the national control programme since 2005. All sampling was performed by authorised personnel from the Danish Veterinary and Food Administration. The first samples were vegetable oils, followed by mussels, smoked meat and smoked fish products in 2006, barbecued meat in 2007 and finally baby foods and dried products e.g. flour, dried fruit, tea and coffee in 2010. The collection of smoked samples included information on the type of heating used, heating material, and time. In 2006 analysis of PAH in mussels were carried out by accredited analysis at the Technical University of Denmark, National Food Institute,. All other PAH analyses were carried out at the Danish Veterinary and Food Administration, Region West, Aarhus. All sampling and analysis was carried out in compliance with, the method performance criteria for BaP in EC

Regulation No. 333/2007 (EC, 2007a) with amendments in EC Regulation No. 836/ 2011 (EC, 2011c). For vegetable oils, the implementation of risk-assessment and own-control systems by food producers has resulted in the collection of fewer samples from 2007, relying on the companies' own documentation on BaP values in their products. Between the selected focus areas, e.g. smoked products the sampling was random.

10.3 Data on levels on contamination

A total of 971 samples were analysed. Appendix 16.6 gives the total number of samples for each food group, the number of samples with levels above the detection limits; the average levels of BaP (Appendix 16.6.1) and average sum of PAH4 (Appendix 16.6.2), and minimum, maximum, median and 95th percentile values. The calculation of the sum of PAH4 includes the sum of actual values for benzo[a]pyrene, benz[a]anthracene, chrysene and benzo[b]fluoranthene (found as ½ benzo[$b+j$]fluoranthene). For levels below LOD or not detected, the value zero is applied. In general, a slightly higher number of samples were found to have PAH4 concentrations than BaP, mainly due to the presence of chrysene and absence of BaP in some of the samples.

The highest mean levels of BaP were found in tea (11 µg/kg) followed by smoked cod roe (3.9 µg/kg), pastrami (2.2 µg/kg), grilled minced meat (1.7 µg/kg), and smoked mussel (1.6 µg/kg). All the other food group mean levels were considerably lower than 1 µg/kg fresh weight.

For vegetable oils, a total of 124 samples, with 54 olive oils, 22 rapeseed oils and 15 sunflower oils were analysed. Other vegetable oils included less than seven samples per type of oil. Three vegetable oils contained BaP concentrations above the EU maximum limit of 2 µg/kg fresh weight. The highest concentrations were found in sunflower oils, with BaP concentrations of 4.4 and 4.0 µg/kg as the highest concentrations. Due to the lack of statistical differences in BaP and PAH4 concentrations for virgin olive oils (37) compared to olive oils not stated as virgin oils (17), data from all olive oils were pooled. Similarly, some samples of organic grown foods have been sampled but since the concentrations were similar to those of conventionally grown samples, the data were merged. .

Living animals, including fish, metabolise PAH, whereas other organisms such as mussels and oysters accumulate PAH. Levels in raw fish are therefore generally low (see Figure 10.1)

For the smoking of fish, more than 70 % of all local smoke houses in Denmark use direct smoking, in which products are placed in the same chamber as the heating source (typically a wood fire). Analyses of 289 fish samples were carried out in the period 2006 to 2011, with 26 different kind of raw fish including cod roe, herring, mackerel, salmon, trout, and eel. The effects of smoking on the concentration of both BaP and PAH4 in the final product are illustrated in Figure 10.1, where concentrations of BaP and PAH4 for herring and salmon prepared with different smoking technologies are related to the concentrations in raw material. For smoked cod roe a single sample was found to have a BaP level of 25µg/kg with the corresponding sum of PAH4 of 158 µg/kg fresh weight. In total, 5 smoked cod roe samples had BaP concentrations above the EU maximum limit of 5 µg/kg. On the other hand,, there were 3 samples in which no PAH were detected. As can be seen from Figure 10.1, smoking increases the levels of BaP and PAH4 remarkably.

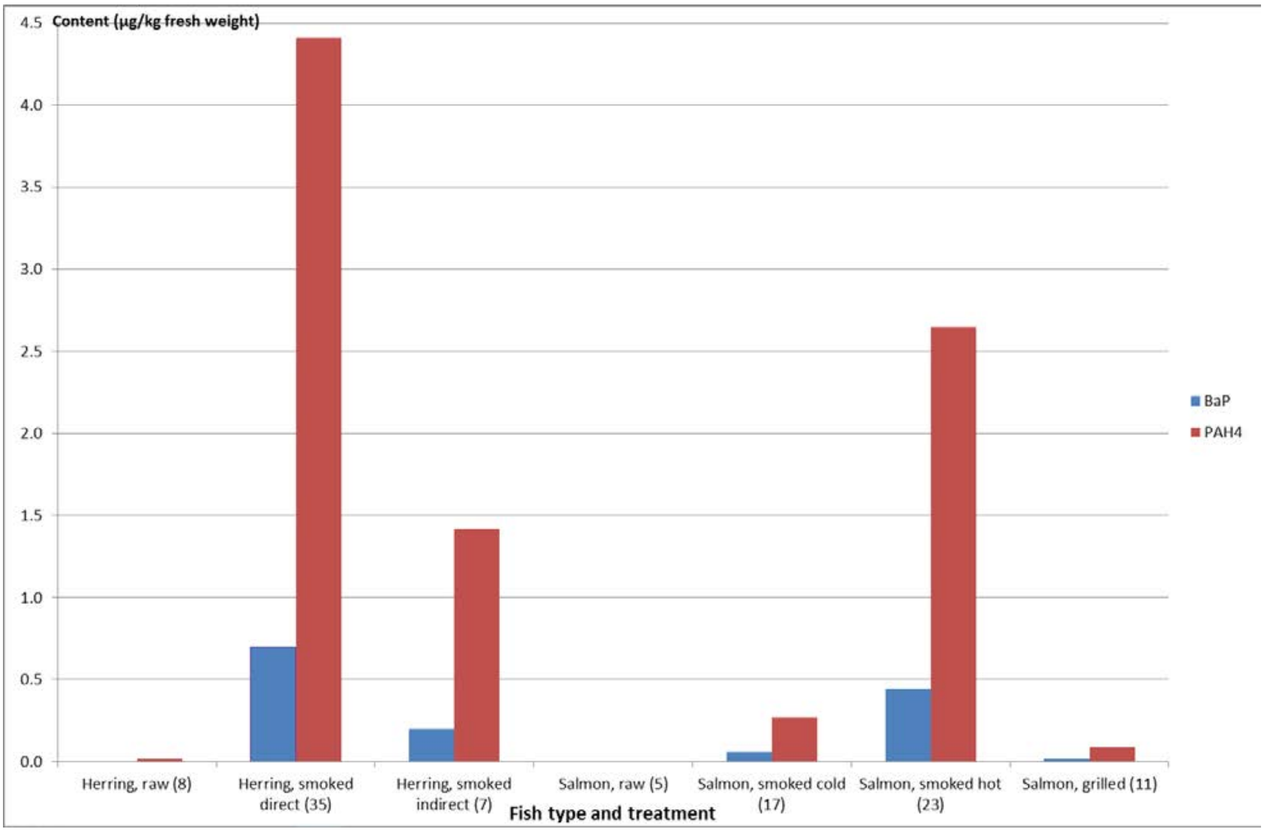


Figure 10. 1. *Average level of BaP (blue bars) and PAH4 (red bars) in µg/kg fresh weight for smoked and raw herring, for smoked, grilled and raw salmon with smoking technology information. Numbers of samples for each treatment are given in brackets*

Analysis of 186 mussel samples (*Mytilus edulis*) from Danish waters showed a low level of PAH with an average of BaP of 0.16 µg/kg and average sum PAH4 of 1.4 µg/kg. A slightly higher average level of BaP was found for oysters, namely 0.40 µg/kg (maximum level of 0.72 µg/kg) with the average sum PAH4 of 4.4 µg (maximum level of 7.7 µg/kg). Mussels and oysters grown for food purposes are normally harvested after 2 years of growth with less accumulation than in wild samples.

All together 198 meat products, including smoked meat and meat products, were analysed. They revealed BaP levels well below the EU maximum levels of 5 µg/kg for smoked fish. Only 4 grilled beef burgers and a grilled pork chop had BaP concentrations above 5.0 µg/kg. It should be noted that no legislation was in place at the time.

The analyses of grilled meat samples (see Figure 10.2) confirm that grilling increase BaP and PAH4 concentrations in the products. The highest average concentrations of both BaP and PAH4 were detected in grilled beef and grilled lamb.

Analysis of other types of products included dried baby food, infant formula and flour samples. With BaP levels below 0.3 µg/kg and for the large majority of samples below the detection limits, the EU maximum limit of 1 µg/kg was not exceeded. For tea leaves, coffee beans and dried fruits a few samples with high concentrations were found. One dried fruit sample had a BaP level of 4.6 µg/kg product whereas the remaining samples contained no BaP or had concentrations below 0.6 µg/kg.. For dried tea leaf samples, 80% had BaP levels above 4.1 µg/kg with a maximum of 32 µg/kg. No EU limits for PAH levels apply to these products.

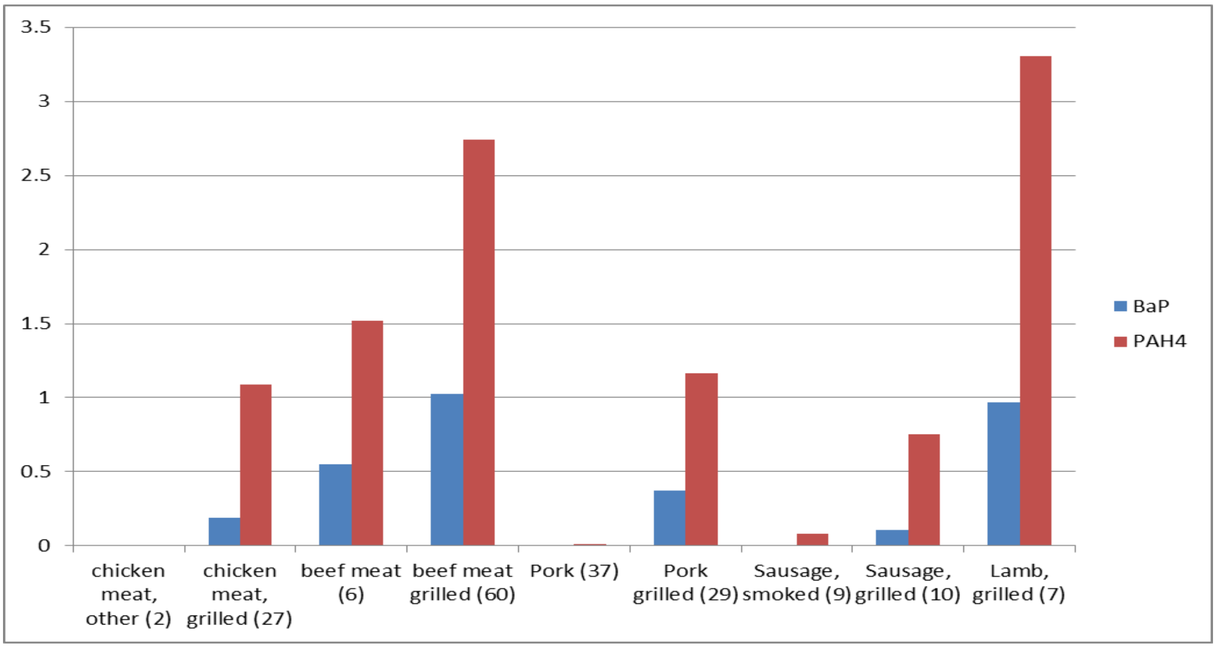


Figure 10. 2. *Average level of BaP (blue bars) and PAH4 (red bars) in µg/kg fresh weight for grilled samples collected at restaurants*

10.4 Exposure and risk assessment

For exposure calculation average consumption data were combined with an average concentration. Long-term exposure is applied due to the lack of acute effects from BaP and PAH4. For tea and coffee, conversion to liquid solution was done by dividing with 18 (solid to beverage) and multiplication by 26% (transfer rate to drinkable solution) as described by EFSA in 2008 (EFSA, 2008b). For food items not included in Danish occurrence surveys, concentration data from other European countries used by EFSA's CONTAM panel on evaluation of PAH in food in 2008 are included (16.6.1 and 16.6.2).

Figure 10.3 shows the distribution of the exposures to BaP and PAH4 for the total Danish population. The resulting mean exposure to BaP for the Danish population was 4.5 ng/kg bw/day (0.0045 µg/kg bw/day), whereas the mean exposure for PAH4 was 19 ng/kg bw/day (0.019 µg/kg bw/day). For PAH4 the mean daily exposure in the French population has recently been reported to be much lower, namely, 1.5 ng/kg bw/day (ANSES, 2012b).

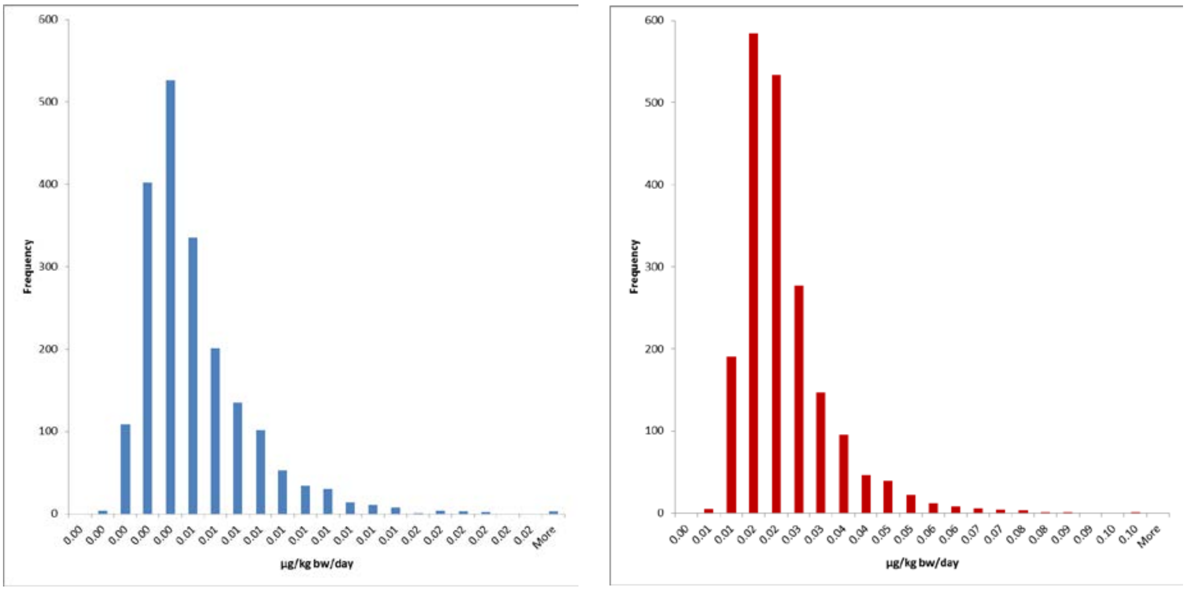


Figure 10.3. *Distribution of BaP exposure (blue, to the left) and of PAH4 exposure (red, to the right) in the Danish population (1974, aged 4-75 in µg/kg bw/day*

The mean exposure for children (see Figure 10.4) was 6.9 ng/kg bw/day for BaP and 31 ng/kg bw/day for PAH4 and thereby higher than for the total Danish population. The distribution of both BaP and PAH4 exposure is broader for children than for the total Danish population.

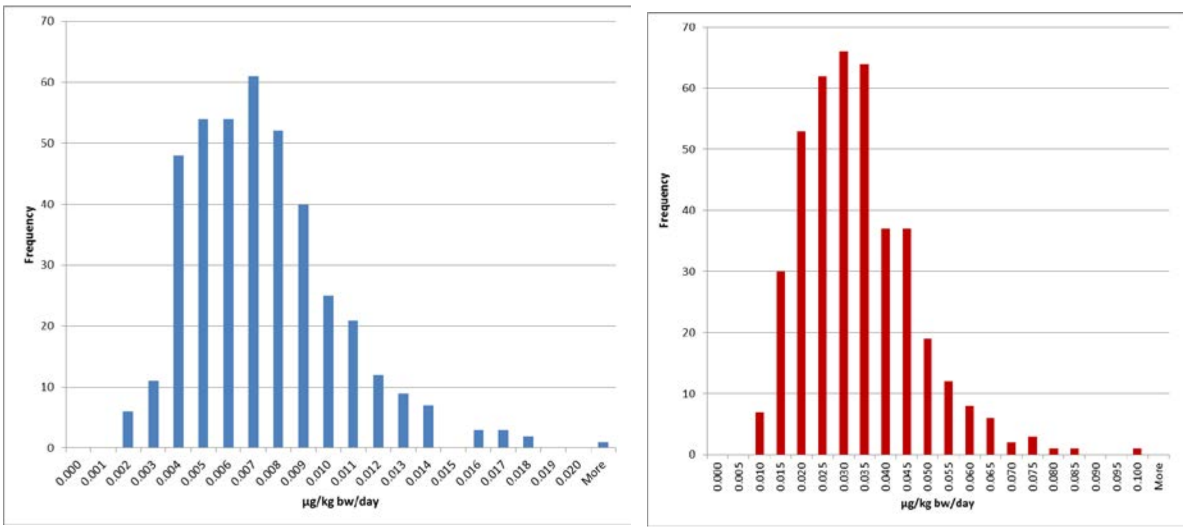


Figure 10.4. *Distribution of BaP (blue to the left) and PAH4 (red to the right) exposure in children (409, aged 4-14) in µg/kg bw/day.*

The mean exposure to BaP at 271 ng/day for the Danish population is slightly higher than previously reported values for the BaP exposure of European citizens (185 to 255 ng/day) calculated by EFSA in 2008, with a median for EU citizens of 235 ng BaP/ day (EFSA, 2008b). For PAH4 the average exposure is 1140 ng/day for the Danish population which is similar to exposure data from EFSA ranging PAH4 exposure from 948 to 1449 ng/day for 16 European Countries, with a median for EU of 1168 ng/day (EFSA, 2008b). Estimates were made of the influence of meat processing for grilled meat were included and found to result in slightly increased exposure levels.

Figure 10.5 shows the exposure to BaP from various food groups Figure 10.6 shows the exposure to PAH4. For both BaP and PAH4, the highest contribution to exposure comes from vegetables and vegetable products with 33% for BaP and 36% for PAH4. The food groups making the next highest contributions are cereals and cereal products, milk and milk products followed by beverages (see Figures 10.5 and 10.6).

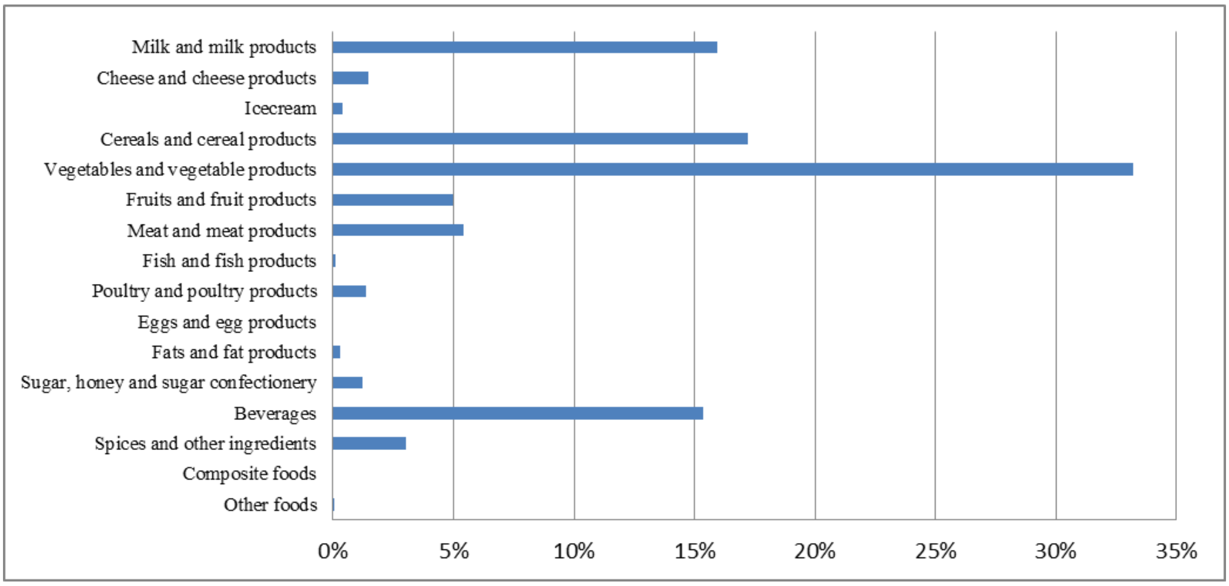


Figure 10.5. *Exposure of the Danish population (aged 4-75) to BaP from main food groups*

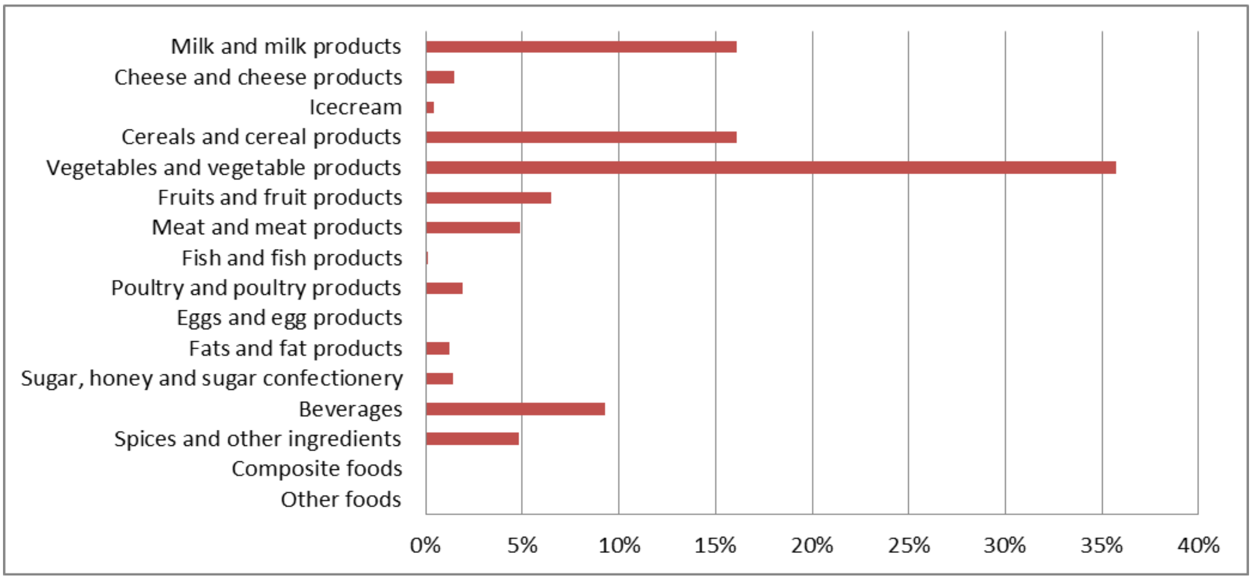


Figure 10.6. *Exposure of the Danish population (aged 4-75) to PAH4 from main food groups*

No Danish occurrence data exists for the level of BaP and PAH4 in vegetables, so data for other vegetables and nuts (Table 9 in EFSA, 2008b) were used in figure 10.5 and 10.6 because they are believed to be the best possible estimate for occurrence levels. If levels based only on samples of other vegetables (and therefore no nuts or dried vegetables) (EFSA, 2008b) decreased the level of BaP from 0.38 µg/kg to 0.04 µg/kg and of PAH4 from 1.72 to 0.42 µg/kg from this food group (see Figures 10.7 and 10.8).

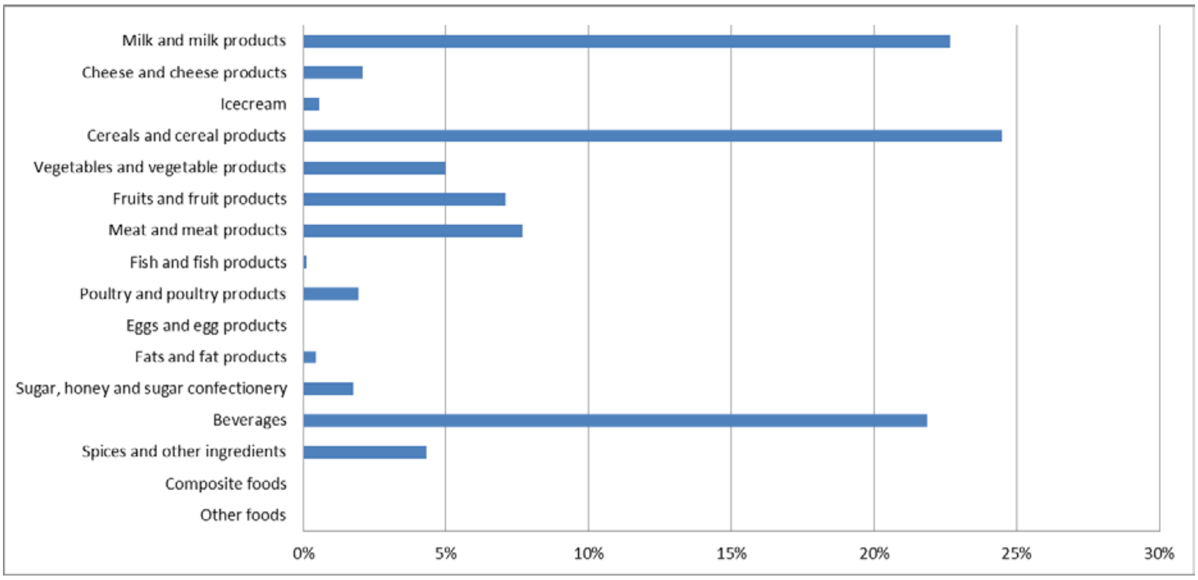


Figure 10.7. *Exposure of the Danish population to BaP from main food groups in with a reduced BaP level in vegetables*

Using these reduced levels for estimating the contribution from the various food groups, the highest contribution shifts to cereals and cereal products with contributions of 24% and 22% for BaP and

PAH4, respectively (Figure 10.7 and 10.8). Using the low concentration levels for vegetables confirms data found by EFSA (EFSA, 2008b) and ANSES (ANSES, 2012b). As Figures 10.6 and 10.8 show the high consumption of a food group (e.g. cereals), can contribute considerably to the total exposure even with low occurrence levels. Moreover, a slightly increased occurrence level contributes considerably to the exposure from food groups with high consumption (e.g. vegetables).

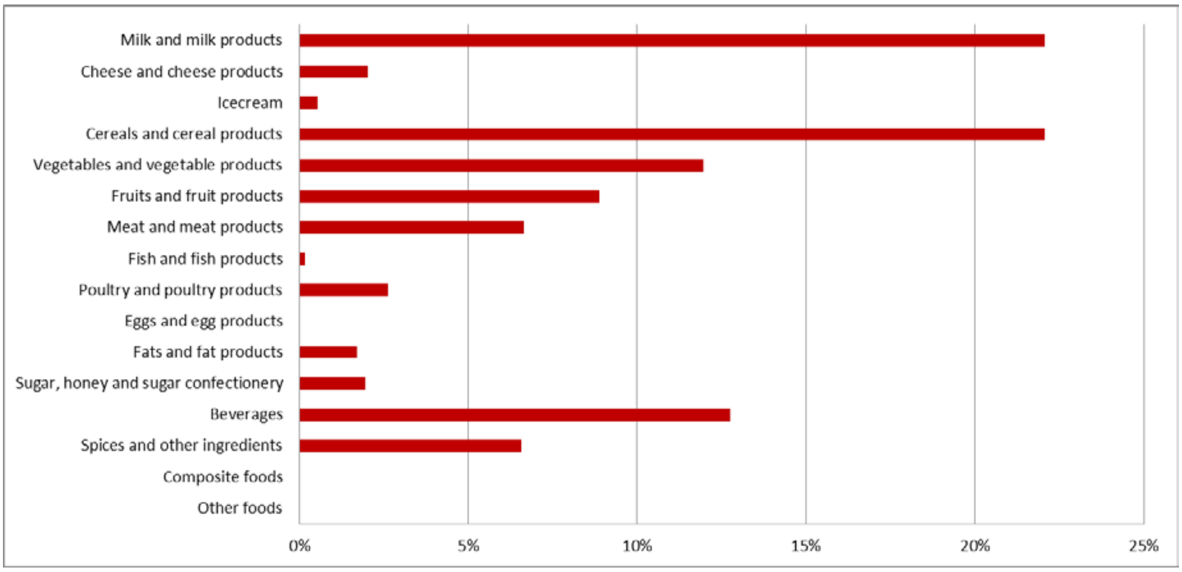


Figure 10.8. *Exposure of the Danish population to PAH4 from main food groups in with reduced PAH4 level in vegetables*

To calculate the MOE values, the approach with the higher concentration in vegetables was used due to the larger number of samples and the to evaluate the MOE values for the worst possible situation for the Danish population.

To estimate of human exposure for carcinogenic effects, we calculated MOEs using $BMDL_{10}$ levels of 70 µg/kg bw/day (0.07 mg/kg bw/day) for BaP and of 340 µg/kg bw/day (0.34 mg/kg bw /day) for PAH4 used by EFSA in 2008. MOEs were calculated by dividing the $BMDL_{10}$ values by the mean and high level estimates of dietary exposure to BaP and PAH 4. The results are shown in Table 10.2.

Table 10.2. *Calculation of MOE for BaP and PAH4 for the Danish population and children*

	$BMDL_{10}$ (µg/kg bw/day)	**Exposure group**	**Danish Population (µg/kg bw/day)**	**MOE**	**Children (µg/kg bw/day)**	**MOE**
BaP	70	Mean	0.0045	15600	0.0069	10100
		95^{th} percentile	0.0093	7500	0.013	5400
		Mean, grilled meat	0.0056	12500	-	-
PAH4	340	Mean	0.019	17900	0.031	11000
		95^{th} percentile	0.039	8700	0.056	6100
		Mean, grilled meat	0.022	15500	-	-

Grilled meat which mimics home food preparation is normally not included in the data. A calculation of MOE resulted in values of 15600 for BaP and 17900 for PAH4. These values are similar to the values obtained by EFSA of 17900 for BaP and 17500 for PAH4 (EFSA, 2008b). For the 95th percentile estimates of dietary exposure, the values obtained were MOEs of 7500 for BaP and 8700 for PAH4. Including grilled meat in exposure estimates indicated there should be low concern for consumer health. However, for high level consumers, the MOEs are less than 10,000, which, as proposed by EFSA Scientific Committee, indicate a low concern for consumer health (EFSA, 2005a). Also the mean exposure data for both BaP and PAH4 for children resulted in MOEs close to 10,000.

11 Acrylamide

Acrylamide is a process contaminant which is formed as part of the Maillard reactions when carbohydrate rich food is heat treated. In 2002, its occurrence in food was identified by Swedish researchers who found acrylamide in a range of heat treated foods (Tareke et al., 2002). The original suspicion had arisen when measurements using blood of unexposed control persons was shown to contain acrylamide haemoglobin a biomarker for acrylamide exposure (Tareke et al. 2000). . The main precursors of the acrylamide formation is the amino acid asparagine and reducing sugars which form Maillard reaction intermediates resulting in acrylamide forming during food heating processes such as frying, roasting, toasting, grilling, etc.. Even autoclaving of e.g. baby food cereals in glass generates acrylamide.

It should be noted that smoking is an additional source of acrylamide exposure. On average smokers has been shown to be exposed to 3.5 times higher acrylamide levels than non-smokers (Olesen et al. 2008).

Acrylamide is classified by the International Agency for Research on Cancer (IARC, 1994) as probably carcinogenic to humans. The WHO expert group JECFA considers acrylamide a compound that is both genotoxic and carcinogenic with a margin of exposure (MOE) of 78-310 indicating a human health concern (JECFA, 2010). As a result, since 2007 the European Commission has recommended that the levels of acrylamide in food should be to monitored and investigated (EC 2007, 2010, and 2011). This chapter presents occurrence data for 2003-2011 and exposure estimates for the Danish population. The margins of exposure (MOE) for Danish consumers are estimated and compared with European results.

11.1 Introduction

Acrylamide is a genotoxic compound so there is no threshold level below which food safety concerns can be disregarded. This means the ALARA (‘As Low As reasonably achievable’) principle should be followed with regard to levels of acrylamide in food. In their latest recommendation (2011a), the Commission recommends the member states in addition to the monitoring of acrylamide in foods ‘*to carry out further investigations into the production and processing methods used by food producers in cases where the level of acrylamide in a foodstuff, tested in the monitoring exercise pursuant to Recommendation 2010/307/EU, exceeds the acrylamide indicative value set for the respective food category in the Annex to this recommendation*’.

‘*The indicative values have been set for most of the food categories of Recommendation 2010/307/EU, with the exception of products for home cooking and other products. The indicative values are intended to indicate the need for an investigation. They are not safety thresholds. There-*

fore, enforcement action and/or the issuing of a Rapid Alert should only be undertaken on the basis of a sound risk assessment carried out on a case by case basis, but not merely because an indicative value is exceeded'.

Table 11.1 shows the indicative values that have been set based on the EU monitoring results for 2007-2008 for various food categories.

Table 11.1. *Indicative acrylamide values based on the EFSA monitoring data (EFSA 2011c) and Danish monitoring samples above the indicative values in percentages and in numbers*

Food	**Indicative value [µg/kg]**	**Percentage (*no. samples*) above indicative values**
French fries ready-to-eat	600	14 % *(11)*
Potato crisps	1000	4 % *(2)*
Soft bread	150	0 % *(0)*
Breakfast cereals (excl. muesli and porridge)	400	10 % *(5)*
Biscuits, crackers, wafers, crisp bread and similar, excl. ginger bread	500	6 % *(3)*
Roast coffee	450	0 % *(0)*
Instant (soluble) coffee	900	0 % *(0)*
Baby foods, other than processed cereal based foods	80	0 % *(0)*
Biscuits and rusks for infants and young children	250	-
Processed cereal based foods for infants and young children	100	0 % *(0)*

11.2 Methods of sampling, analysis and quality assurance

Since the identification of acrylamide as a food process contaminant it has been monitored and investigated in Danish food products. In 2002 an analytical method based on LC-MS/MS was validated and accredited at the Technical University of Denmark (DTU), The National Food Institute. In 2009, the method was implemented at the Danish Veterinary and Food Administration, Region West. The method was used to investigate acrylamide formation and mitigation in food and to survey and monitor acrylamide occurrence in relevant food products. In 2003-2004 coffee, breakfast cereals and potato products were surveyed. In 2005, 2009, 2010 and 2011 general monitoring of various food products started, and since 2007 this has included the food categories recommended by EC (EC 2007, 2010, 2011). For the surveys, the foods were sampled by DTU, while for the general monitoring projects, the food were sampled in manufacturing, wholesale and catering companies by the food inspectors of the Danish Veterinary and Food Administration.

11.3 Data on levels of contamination

Table 12.1 shows the levels of acrylamide in various food products. All the food products, except nuts, pie, pancake and baked potato were sampled on the Danish market 2003-2011. All the food products had been subjected to some kind of heat treatment in which acrylamide is likely to be formed. The highest mean values were found in the instant coffee (580 µg/kg), popcorn (483 µg/kg), French fries sold as ready-to-eat (472 µg/kg), crisps (448 µg/kg), potatoes *'home'* fried in oven (312 µg/kg), biscuits (278µg/kg), and roasted coffee beans (275 µg/kg). The corresponding figures for the European acrylamide levels in food from monitoring years 2007-2009 are for instant coffee (298 µg/kg), French fries sold as ready-to-eat (277 µg/kg), crisps (580 µg/kg), potatoes from fresh potatoes (251 µg/kg), biscuits (272µg/kg) and roasted coffee beans (197 µg/kg) (EFSA, 2011c). The differences between Danish and European mean results may partly be due to variations in sampling years and random variation. In the first sampling years, just after the identification of acrylamide in food, the levels may have been higher than in the subsequent years. For example many of the instant coffee and coffee samples were taken in 2003. Furthermore, most of the roasted coffee consumed in Denmark is medium roasted coffee which has relatively high acrylamide levels compared to dark roasted coffee used in e.g. espresso coffee. The French fries sold as ready-to-eat show higher mean values in Denmark than in Europe as a whole. The northern temperate climate is known to cause higher sugar levels in potatoes during growth. Since sugar is a precursor of the acrylamide, this may cause higher acrylamide levels in the final products.

Some of acrylamide monitoring results from foods sampled in 2003-2011 exceeded the indicative values set by the Commission in the recommendation of 2011 (EC, 2011a). Table 11.1 shows that 14% of the ready-to-eat French fries, 10% of the breakfast cereals, 6% of the biscuits, crispbread etc. and 4% of the potato crisps sampled exceeded the indicative values. However, apart from two samples collected in 2011 of ready-to-eat French fries containing 1490 µg/kg and 2900 µg/kg acrylamide, all these samples were collected before the recommendation entered into force.

Table 11.2. Levels of acrylamide (µg/kg) in food

Food	No. of samples	Positive[3)]	Mean µg/kg	Minimum µg/kg	Maximum µg/kg	Median µg/kg	95th percentile µg/kg
Bread, rye	22	20	10.2	3.9	27.0	7.4	19
Pita bread	3	1	1.5	0.6	3.1	0.8	
Bread, wheat fine	15	10	10.1	0.2	41	7.5	28
Bread, wheat coarse	5	4	13.9	2.0	34	13.7	30
Crispsbread	12	12	86	15	200	73	182
Fine bakery	10	8	5	<2.1	17	5	13
Rusks	1	1	34	34	34	34	
Biscuits	22	22	278	26	810	190	678
Cookies	15	14	101	<2.1	370	66	333
Cake	16	11	19	<2.1	250	4	75
Breakfast cereals	30	27	200	<2.1	961	88	717
Cornflakes	20	20	79	17	169	67	158
Muesli	28	14	29	<2.1	181	7	96
Oatmeal	14	2	4	<2.1	15	2	14
Oat porridge, rye porridge	1	1	0.5	<2.1		0	
Rye mixture, fibre mixture	5	4	31	<2.1	86	23	

Food	No. of samples	Positive[3)]	Mean µg/kg	Minimum µg/kg	Maximum µg/kg	Median µg/kg	95th percentile µg/kg
Burger	3	3	7	3	14	3	
Spring roll	1	1	25	25	25	25	
Pita sandwich	2	2	4	3	5	4	
Toast	2	2	4	3	4	4	
Pizza	2	2	15	12	18	15	
Pancake	4[1)]	4	15	13	17		
Pie	4[1)]	4	25	18	33		
Crisps, potato maize	55	55	448	9	1950	330	1013
Nuts, hazelnuts, almonds	14[2)]		61				
Peanuts, pistachios etc.	5	3	29	<2.1	84	0	
Popcorn	7	7	483	260	1461	324	1140
Pretzels	2	2	100	84	116	100	
Chocolate	15	14	74	<6	300	58	202
Chocolate, thin slices	2	2	47	24	70	47	
Cocoa	11	10	44	3	82	56	78
Cocoa to drink	11	10	1.7	0.4	2.6	1.7	2.5
Coffee	61	61	195	64	390	187	350
Coffee, to drink	61	61	7.8	2.4	15.6	7.5	14
Instant coffee	16	16	580	176	890	597	838
Instant coffee, to drink	16	16	7.8	2.4	11.9	8.0	11.2
French fries	80	80	472	35	2900	370	1290
Potatoes fries in oven	24	24	312	59	695	275	609
Potatoes in oven, others	2	2	65	<3.6	130	65	
Potato, baked	4[1)]	4	26	17	32	26	

1) Data from FDA 2012

2) Data on extracted from Amrein et al. 2005 (25% roasted products, 50% hazelnuts and 50% almonds)

3) Number of samples above LOD/LOQ

11.4 Development over time

The results of the Danish monitoring of acrylamide in food are too few for sensible trend analysis. Instead, we refer to the European monitoring programme compiled by EFSA for the monitoring years 2007-2009 (EFSA, 2011). The trend analyses based on 13162 acrylamide data show only few changes in acrylamide levels from 2007 to 2009. At major food category level, a ‘common European trend’ was a decrease in acrylamide levels for ‘processed cereal-based foods for infants and young children’ and an increase for ‘coffee and coffee substitutes’. As a ‘common European trend’ at sub-category level, acrylamide levels for ‘biscuits and rusks for infants and young children’ and ‘non-potato savoury snacks’ showed a decrease, while an increase was seen for ‘crisp bread’.

DTU has contributed to studies on the formation and mitigation on acrylamide in food, also in collaboration with food industry (Granby et al., 2008; Hedegaard et al, 2007a,b,c; Jensen et al., 2008, Pedreschi et al,. 2004, 2005, 2006, 2007a,b, 2008, 2010, 2011). Several mitigation methods have been found effective, from the selection of crops low in precursors, improvement of agricultural practices, blanching or leaching out acrylamide precursors in potatoes, the addition of acids, salts or the enzyme asparaginase to reduce the precursor asparagine. Some optimisation has been made by the industry and the European industry has developed a toolbox on how to reduce acrylamide in food (CIAA, 2009). However, the trends assessed by EFSA 2007-2009 show no significant effects on the occurrence of acrylamide in food.

11.5 Exposure and safety assessment

Exposure calculations were made on the basis of individual consumption data for foods that contribute most to acrylamide exposure~~.~~ The food consumption data were multiplied by the average concentrations of acrylamide in the most relevant food, reflecting the consumer's long-term exposure to acrylamide. All the foods shown in Table 11.2 were included in the exposure assessment

Figure 11.3 shows the distribution of acrylamide exposure for the adult population in Denmark (aged 15-75) appears. The mean exposure is 0.2~~1~~ µg/kg body weight per day and the 95^{th} percentile 0.46 µg/kg bw/day (see Table 11.3). Children have higher food consumption on a body weight basis, so the acrylamide exposure is higher for children (see Figure 11.4). The mean exposure for children aged 4-14 is 0.39 µg/kg bw/day and the exposure of the high consumers estimated as the 95^{th} percentile is 0.89 µg/kg bw/day (see Table 11.3).

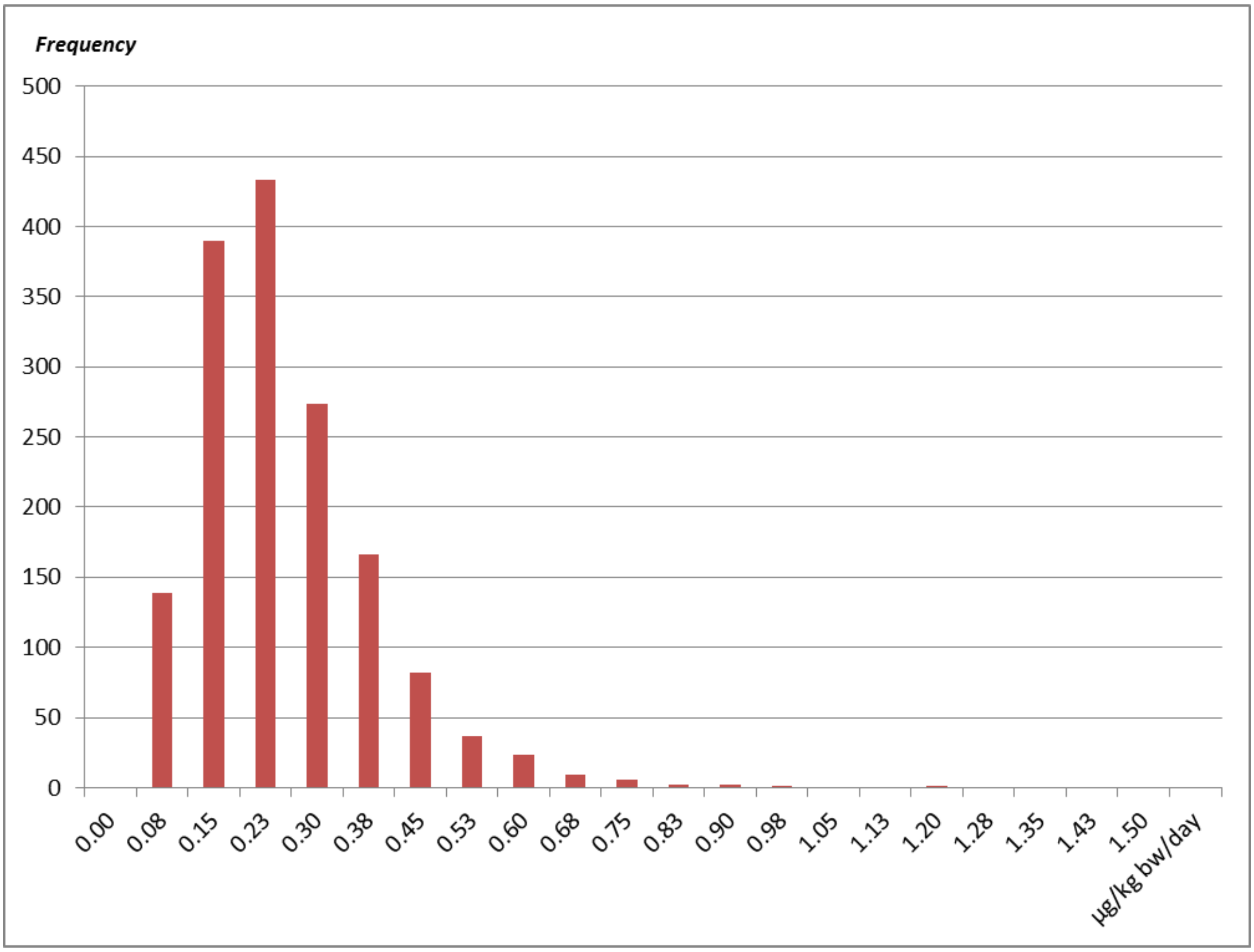


Figure 11.3. *Distribution of acrylamide exposure in µg/kg bw/day for the Danish adults (aged 15-75)*

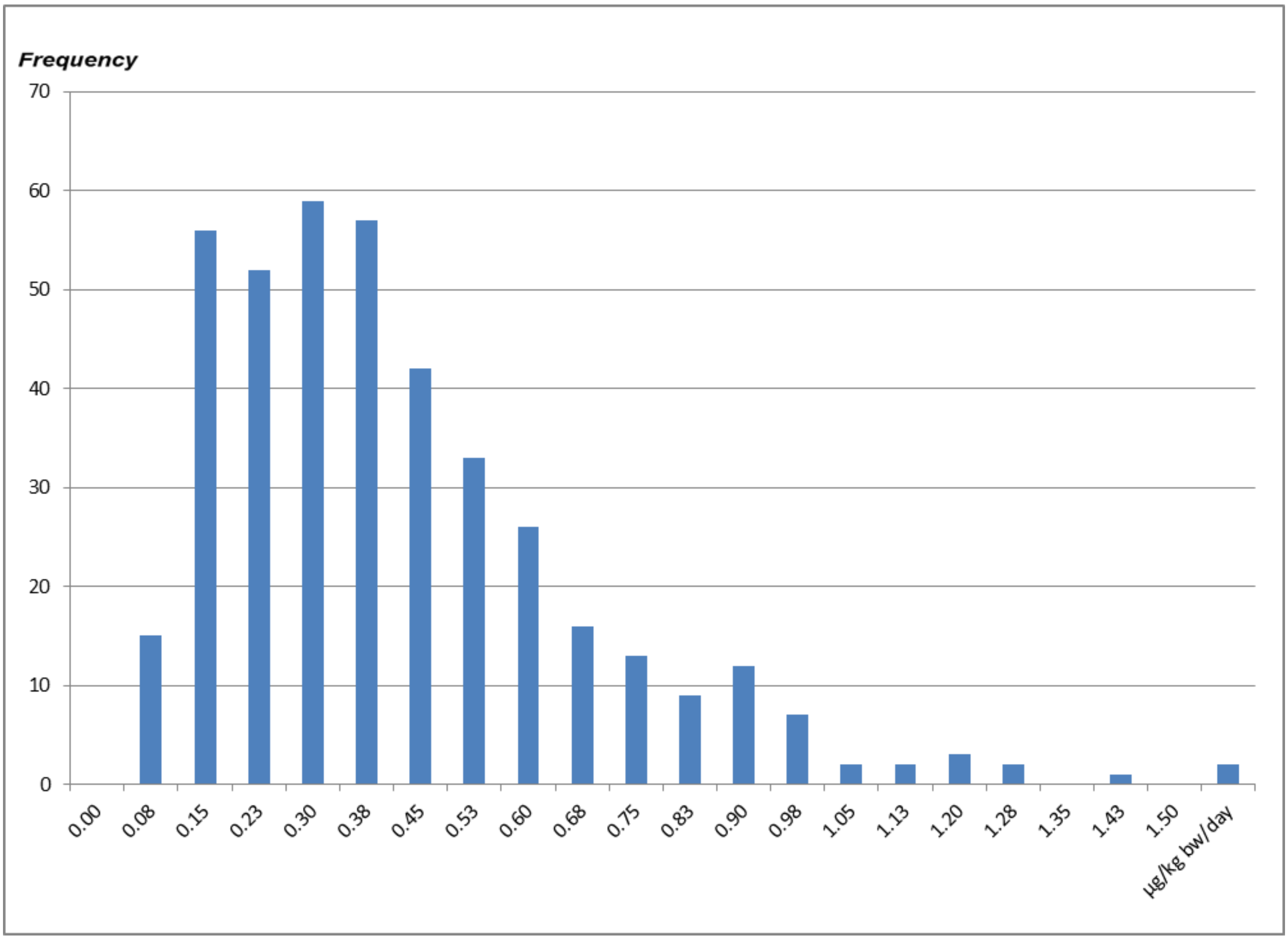


Figure 11.4. *Distribution of acrylamide exposure for Danish children (aged 4-14) in µg/kg bw/day*

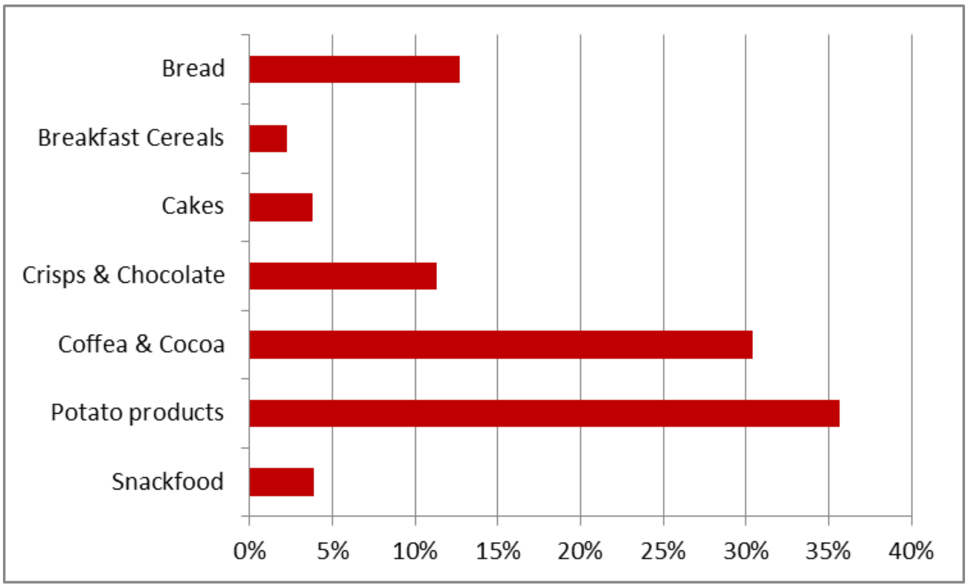


Figure 11.5. *Exposure of Danish adults (aged 15-75) to acrylamide from main food groups*

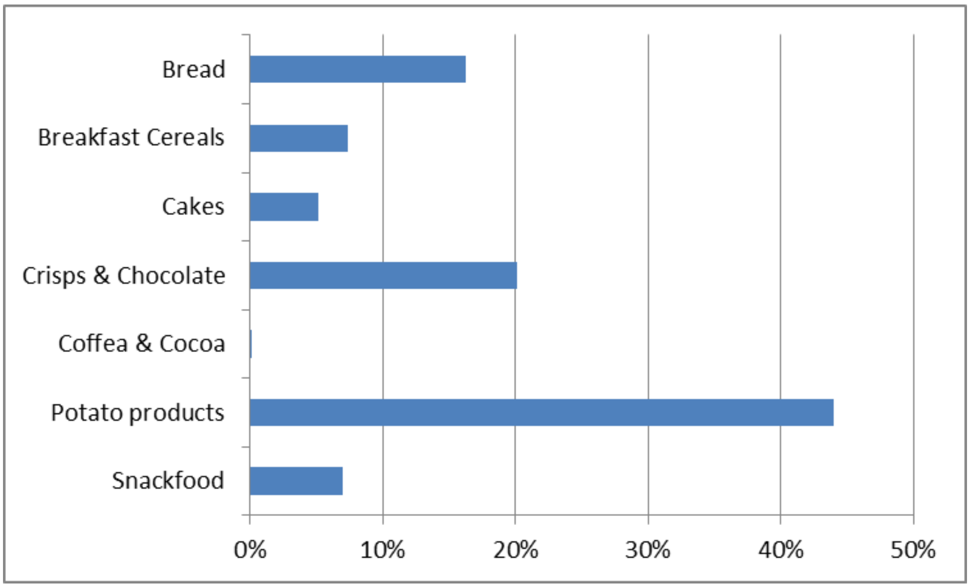


***Figure 11.6**. Exposure of Danish children (aged 4-14) to acrylamide from main food groups*

The distribution of acrylamide exposure in various food categories is shown in Figures 11.5 and 11.6. For adults the food category with the highest acrylamide exposure is potato products constituting 36% followed by coffee and cocoa at 30 % of which coffee contributes the most. Bread is the third largest contributor with 13 %.

The highest acrylamide exposure for children is also from potato products at 43 % but in addition the contribution from crisps and chocolate is 20 %. Bread is the third largest contributor to children's acrylamide exposure with 16 %, breakfast cereals constitute 7 %, snackfood 7 % and cakes 5%.

Table 11.3 presents the estimated MOEs based on the mean and 95th percentiles (representing high consumption) Danish exposure estimates. The MOEs were calculated relative to the most sensitive adverse non-carcinogenic effect, namely the morphological changes in nerves of rats with a NOAEL of 200 µg/kg bw/day. Likewise MOE is calculated for the most sensitive carcinogenic effects of acrylamide. JECFA considered it appropriate to use 180 µg/kg bw/day (the lowest value in the range of $BMDL_{10}$ values) for tumours in the Harderian gland of male mice and 310 µg/kg bw per day for mammary tumours in female rats as the point of departures (POD) hence MOEs for both effects are included. (JECFA, 2010).

The MOE based on the most carcinogenic effect for children aged 4-14 is 466 based on mean exposure and 202 for the consumers with high consumption (95^{th} percentiles). The adults have an MOE of 873 and 391 for mean and 95^{th} percentile exposure. An MOE above 10,000 for a compound that is both genotoxic and carcinogenic is considered of low health concern. From the results it can be concluded that the MOE for acrylamide is far below the 10.000 level and the exposure is of food safety concern. In regard to neurological effects the acrylamide exposure from food alone is not likely to cause any adverse effects even among children aged 4-14 with high consumption (95^{th} per-centiles). A safety factor of 100 is applied for assessing this non-carcinogenic endpoint.

Table 11.3. *Calculation of MOE of acrylamide for Danish adults (aged 15-75) and children (aged 4-14).*

	Effect level (µg/kg bw/day)	**Exposure group**	**Danish adults (µg/kg bw/day)**	**MOE**	**Danish children (µg/kg bw/day)**	**MOE**
NOAEL ***morphological changes in nerves***	200	Mean	0.21	930	0.39	518
		95^{th} percentile	0.46	438	0.89	225
$BMDL_{10}$ ***Mammary tumours in rats***	310	Mean	0.21	1442	0.39	803
		95^{th} percentile	0.46	678	0.89	348
$BMDL_{10}$ Harderian gland **in mice**	180	Mean	0.21	873	0.39	466
		95^{th} percentile	0.46	391	0.89	202

12 Brominated flame retardants

Brominated flame retardants (BFRs) are mixtures of man-made chemicals that are added to a wide variety of industrial and household products to make them less flammable. They are used commonly in plastics, textiles and electrical/electronic equipment. The main classes of BFRs are the following: tetrabromobisphenol A (TBBP-A), polybrominated diphenyl ethers (PBDEs), hexabromocyclododecane (HBCDD), decabromodiphenyl ethane (DBDPE), 1,2-bis(2,4,6-tribromophenoxy)-ethane (BTBPE) and 2,4,6-tribromophenol (WHO, 1997; Örn and Bergman, 2004; Harju et al., 2009).

HBCDD is a group of additive flame retardant, primarily used in expanded and extruded polystyrene applied as construction and packing materials, and in textiles. Technical HBCDD is a mixture of isomers of 1,2,5,6,9,20 hexabromocyclo-dodecane (approximately 10% α, 10% β and 80% γ) (Heeb et al. 2008). While HBCDD is mixed with the polymers of the products, tetrabromobisphenol A (TBBPA) is covalently bonded and not released as easily (EFSA, 2011d). As other flame retardants such as polybrominated diphenylethers (PBDE), are phased out, the HBCDD and TBBPA have received greater attention. The EU has made an evaluation of HBCDD because the impacts on humans are not well known and HBCDD is used more in Europe than in the US and Asia (EFSA, 2011e). The substance is present in the environment, e.g. in air, dust, wastewater, sewage sludge, plants and animals (Morris et al., 2004). It is relatively persistent and bio-accumulates, e.g. in fish and meat (Remberger et al., 2004). The high persistence and bio-accumulation of α-HBCDD may explain the observed predominance of α in biota (Szabo et al., 2011).

This chapter presents the occurrence of ∑HBCDD in fish from Danish waters and the exposure Danish adults and children to ∑HBCDD are estimated.

12.1 Introduction

Since all toxicity studies were carried out with technical HBCDD, a risk assessment of individual stereoisomers was not possible. Main targets were the liver, thyroid hormone homeostasis and the reproductive, nervous and immune systems. HBCDD is not genotoxic. EFSA identified neurodevelopmental effects on behaviour as the critical endpoint, and derived a benchmark dose lower confidence limit for a benchmark response of 10 % ($BMDL_{10}$) of 0.79 mg/kg body weight. Due to the limitations and uncertainties in the current data base, the EFSA concluded that it was not appropriate to use this BMDL to establish a health-based guidance value, and instead used the MOE approach for the health risk assessment of HBCDDs (EFSA, 2011e). Since elimination characteristics of HBCDDs in animals and humans differ, the Panel used the body burden as the starting point for the MOE approach. The CONTAM Panel concluded that a current dietary exposure to HBCDDs in the EU does not raise a health concern.

12.2 Methods of sampling, analysis and quality assurance

The samples for this project were selected from samples previously analysed for dioxins and PCB by the Danish Veterinary and Food Administration, Region East. The fish has been collected from Danish catching areas in Baltic Sea and the North Sea in 2002, 2003 and 2006, as well as from fish farms. Most of the samples are pools of 3 to 10 individual fish from the same age group except for the salmons from the Baltic Sea which were individual fish. The samples were stored at -20° C until analysis for HBCDD isomers and TBBPA**.**

An LC-MS/MS method was developed for the relatively polar flame retardants TBBPA and α-, β-, γ-HBCD. The principle of the methods is that the substances are Soxhlet extracted for seven hours with 150 ml acetone:hexane 1:1. The extract was evaporated until there was a clear remainder of lipid. The lipid level is determined by weighing. Approx. 500 mg lipid was dissolved in 2.0 ml internal standard solution in hexane and cleaned up in 10 ml concentrated sulphuric acid followed by water and evaporated using a gentle stream of nitrogen. The sample was dissolved in methanol:water (4:1). The detection was performed with LC/MS/MS.

The analytical method was validated by performing recoveries of different fish samples spiked at four different spiking levels from 1-12 ng/g wet weight. The mean recoveries of α-HBCDD spiked at 1, 3-5 and 10-12 ng/g we were 95, 95 and 108 %(n=22). In seafood samples α-HBCDD is the dominant isomer of HBCDD contributing more than 90% of the HBCDD sum (Granby & Cederberg, 2007). The relative standard variation of double determinations was on average 15% for concentration levels < 0.5 ng/g we (n=8) and 5% for concentration levels > 1 to 16 ng/g we (n=12).

12.3 Data on levels of contamination

The results show that α-HBCDD was present in the highest amounts, followed by γ-HBCDD and β-HBCDD. TBBPA was almost not present in the samples (see Table 12.1). The highest levels of the sum of the HBCDD isomers ((ΣHBCDD) were found in cod liver that is used e.g. for the production of vitamin supplies (Vitamin D). The cod liver contained 37-66% lipid and 11 ng/g we ΣHBCDD. Salmon being a fatty fish with lipid levels from 10-23% contained the second largest contaminant levels, 2.45 ng/g we. The mackerel taken from the North Sea contained 23-29% lipid and an average ΣHBCDD level of 0.93 ng/g wet weight.

The concentrations found are comparable with other studies. In a Swedish study herring from the Baltic Sea and the North Sea contained 21-58 ng/g lipid and 34-180 ng/g lipid (Remberger et al., 2004). In the present study the level in herring ranged from 7-110 ng/g lipid with an average of 36 ng/g lipid (see Table 12.1).

In conclusion the results of 63 fish samples for food consumption show ΣHBCDD levels from <0.01-16.7 ng/g we or <0.1-110 ng/g lipid.

Table 12.1. *Concentrations of HBCDD isomers and TBBPA in fish for food consumption*

Fish	n	α-HBCDD ng/g ww	β-HBCDD ng/g ww	γ-HBCDD ng/g ww	TBBPA ng/g ww	ΣHBCDD ng/g ww	ΣHBCDD ng/g lipid	ΣHBCDD max. ng/g ww	ΣHBCDD Std.dev. ng/g ww
Cod, North Sea	1	0.02	0.00	0.00	0.00	0.02	19.2	0.02	
Cod liver,1 North, 10 Baltic	11	10.7	0.02	0.35	0.00	11.0	22.4	16.7	4.79
Eel, farmed	3	1.17	0.00	0.03	0.00	1.21	15.2	1.78	0.82
Herring, 7 North 13 Baltic	20	1.14	0.03	0.10	0.02	1.27	36.4	3.73	0.56
Mackerel, North Sea	13	0.91	0.01	0.02	0.00	0.93	3.5	6.35	1.64
Plaice, North Sea	4	0.003*	0.000	0.001*	0.00	0.004*	3.0	0.005	0.00
Salmon, Baltic Sea	9	2.32	0.02	0.10	0.00	2.45	22.0	3.57	0.58
Salmon, farmed	1	1.43	0.01	0.05	0.01	1.49	20.4	1.49	
Trout, farmed	1	0.28	0.04	0.03	0.00	0.35	18.0	0.35	

*< LOD (0.01 ng/g wet weight (ww))

12.4 Exposure and risk assessment

Figure 12.1 shows the distribution of ΣHBCDD exposure from fish for the adult population in Denmark (aged 15-75) and Figure 12.2 shows the children's exposure to ΣHBCDD from fish. Both distributions have the same shape. Some people are not exposed to HBCDD because they have no consumption of fish. A very large proportion of the population has a very low exposure to HBCDD from fish. The curve decreases only slowly as some individuals have a relatively high HBCDD exposure from fish. The mean exposure for adults is 0.19 ng/kg body weight per day and the 95th percentile 0.75 ng/kg bw/day. The ΣHBCDD exposure for children aged 4-14 is 0.23 ng/kg bw/day and the exposure for high consumers estimated as the 95 percentile is 1.28 ng/kg bw/day (see Table 12.2). The ΣHBCDD exposure is mainly derived from eating salmon and herring.

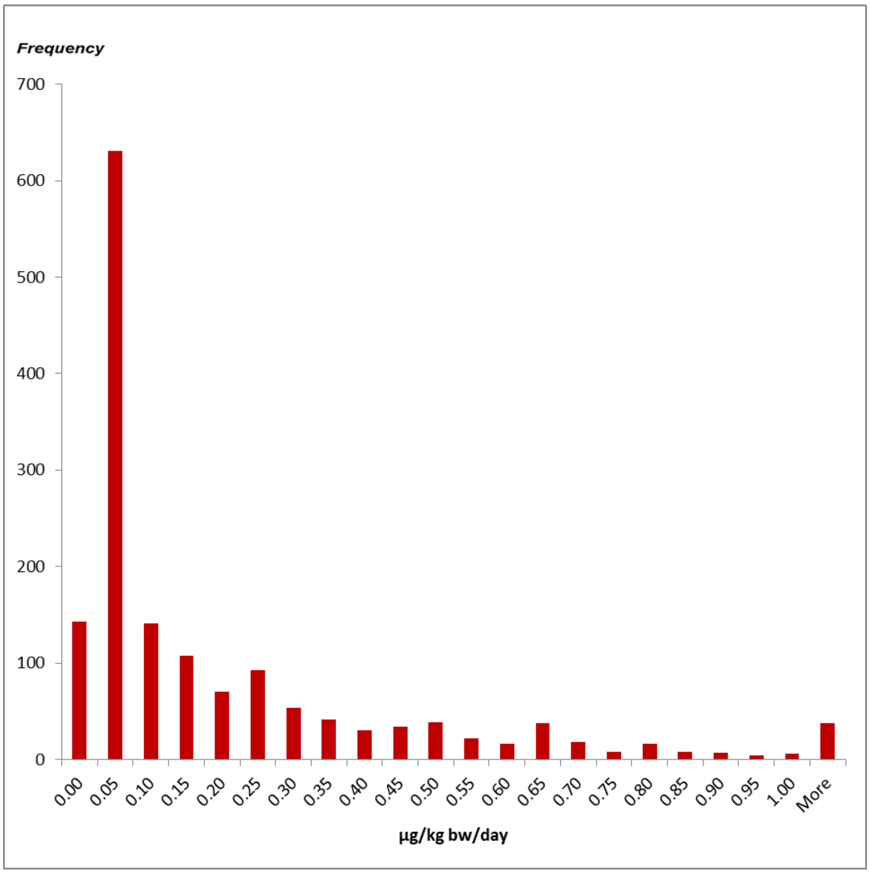


Figure 12. 1. *Distribution of ΣHBCD exposure from fish for the Danish adults (2033, aged 15-75 years) in µg/kg bw/day*

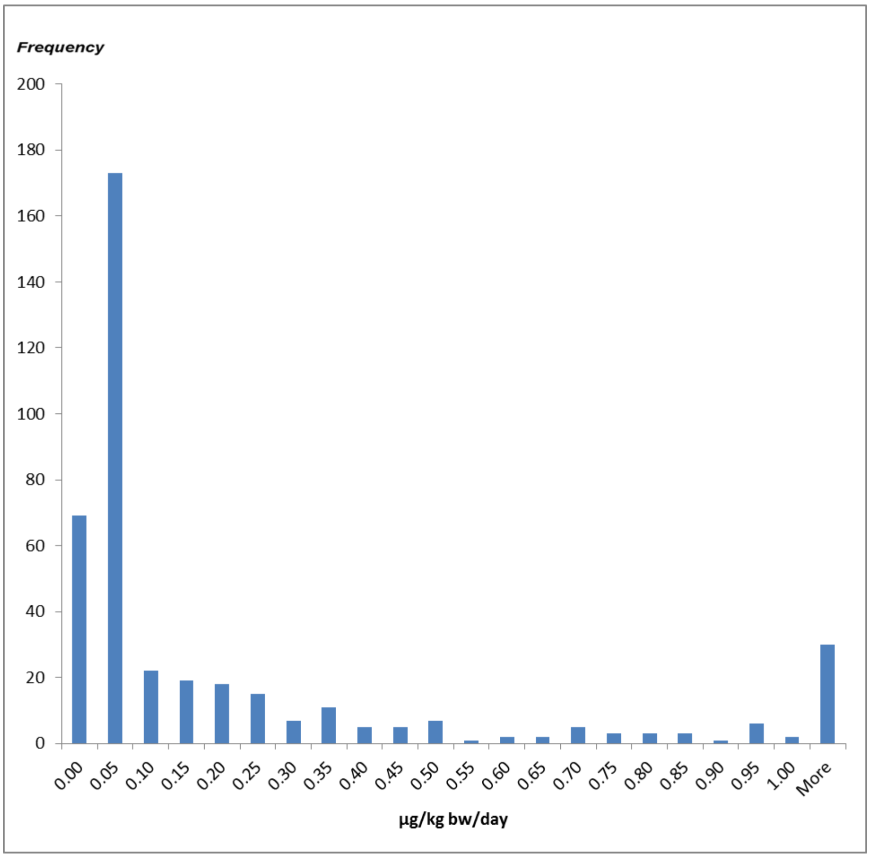


Figure 12.2. *Distribution of ΣHBCDD exposure from fish for Danish children (409, aged 4-14) in µg/kg bw/day*

In a Dutch study, the mean exposure to HBCDD from seafood was 0.06-0.17 ng/kg bw per day, this exposure derived mainly from the herring (65%), cod (8%), farmed salmon (7%), mackerel (5%) and shrimps (4%) (van Leeuwen and Boer, 2008). In a Swedish study the dietary exposure to HBCDD was 2.5 ng/kg bw/day for Swedish women, 70% of which derived from fish consumption (Lind et al. 2002). However a large variation in the exposure to HBCDD is found in different studies (Goscinny et al., 2011) ranging from 0.067 ng/kg bw per day from fish and fishery products in a Belgian study (Goscinny et al. 2011) to 4.9 ng/kg bw per day upper bound from fish and fishery products in a British study (Driffield et al., 2008). The Danish mean and 95th percentiles range from 0.19-1.28 ng/g bw/day. The exposure is lower than in the Swedish study. However, the Danish fish consumption is also relatively low (<100 g/day) compared to the other Scandinavian countries (Danish Food and Veterinary Administration, 2003).

The MOE was calculated relative to the effect of the most sensitive end-point. EFSA identified neurodevelopmental effects on behaviour in mice, observed in a study with a single administration of technical HBCDD on postnatal day (PND) 10, as the critical end-point and derived a benchmark dose lower confidence limit for a benchmark response of 10% ($BMDL_{10}$) of 0.93 mg/kg bw to be used as a reference point for the hazard characterisation. Because the elimination kinetics of HBCDDs in rodents and humans differ, external dose levels of HBCDDs associated with toxic effects in animals cannot be simply extrapolated for the risk assessment in humans. Instead, the internal dose or body burden provides a more appropriate dose metric for a direct comparison of effects in animals and humans. Based on the calculated $BMDL_{10}$ value of 0.93 mg/kg bw as derived from a study using a single oral administration, and considering an oral absorption in rodents of 85 %, a body burden at the $BMDL_{10}$ of 0.79 mg/kg bw (790 µg/kg bw/day) was derived. Table 11.3 shows the MOEs which are based on the mean and the 95th percentiles (representing high consumption) Danish exposure estimates. The MOE for children aged 4-14 is 3.435.000 based on mean exposure and 617.000 for the consumers with high consumption (95th percentile). The adults have a MOE of 4.158.000 and 1.053.000 for mean and 95th percentile exposure, respectively. The MOEs are of no food safety concern.

Table 12. 2. *Calculation of MOE of ΣHBCDD for Danish adults (aged 15-75) and children (aged 4-14).*

	Effect level (µg/kg bw/day)	**Exposure group**	**Danish adults (ng/kg bw/day)**	**MOE**	**Danish children (ng/kg bw/day)**	**MOE**
$BMDL_{10}$ ***neurodevelopmental effects on behaviour***	790	Mean	0.19	$4.1x10^6$	0.23	$3.4x10^6$
		95th percentile	0.75	$1x10^6$	1.28	617,000

13 Perfluorinated compounds

Perfluorinated compounds (PFC, also called perfluoroalkyl substances (PFAS)) have been used for decades in industrial and chemical applications for example as impregnation agents for shoes, textiles, furniture, carpets, paper, packaging materials, pesticide formulations and in waxes or polish agents. The high persistence and the wide use of some per- and polyfluorinated compounds have resulted in their ubiquitous occurrence in humans and biota. Food exposure is assumed to be the main source of the general population's exposure to perfluorinated compounds (PFCs) (Fromme et al. 2009). In this report results of analyses of perfluorooctanoic acid (PFOA) and perfluorooctane sulphonic acid (PFOS) in Danish fish and meat for human consumption are presented and used to estimate the mean dietary exposure of Danish adults and children to PFOS.

13.1 Introduction

Perfluorinated compounds in the environment are of concern due to their high persistence (Kissa, 2001) and their potential to accumulate in biota. In particular, homologues of perfluoro carboxylic acids (PFCA) and perfluoro alkane sulfonic acids (PFSA) are persistent and occur in the environment Fluorotelomer alcohols (FTOH) and polyfluoroalkyl phosphate esters (diPAPs and monoPAPs) are used for e.g. the impregnation of paper and board and the PAPs have been found in food contact materials (Trier et al. 2011).

The PFCA perfluorooctanoate (PFOA) and the PFSA perfluorooctane sulfonate (PFOS) are the best known PFASs. In 2010, PFOS and its salts were included as persistent organic pollutants (POPs) in Annex B of the Stockholm Convention (Stockholm Convention on Persistent Organic Pollutants, 2010) meaning that their use is accepted only for a defined list of applications.

In 2008 EFSA performed a risk assessment on PFOS and PFOA. They established a tolerable daily intake (TDI) of 150 ng/kg bw per day for PFOS and 1500 ng/kg bw per day for PFOA (EFSA 2008). However, a lack of data meant that only a limited exposure assessment was possible so the EFSA CONTAM Panel recommended that more occurrence data for PFAS in foods should be collected to improve the accuracy of future exposure calculations. Subsequently, the European Commission issued the Commission Recommendation 2010/161/EU on the monitoring of perfluoroalkylated substances (PFASs) in food of 17 March 2010 required the Member States to carry out monitoring in the years 2010 and 2011 on the presence of perfluoroalkylated substances in foods.

PFOS is slowly eliminated and therefore accumulates in the body. PFOA and PFOS bioaccumulate in humans and the half-life is around 4-6 years, which means that it takes around 20-30 years before the compounds are eliminated from the body. In sub-acute and chronic studies the liver was the main target organ and developmental toxicity was also seen. Other sensitive effects were changes in thyroid hormones and high density lipoprotein (HDL) levels in rats and Cynomolgus monkeys. PFOS induced liver tumours in rats, in what appears to be a non-genotoxic mode of action. The tolerable daily intake (TDI) for PFOS was based on a subchronic study in Cynomolgus monkeys with a no-observed adverse-effect level (NOAEL) of 0.03 mg/kg bw per day. The CONTAM Panel established a TDI for PFOS of 150 ng/kg bw per day by applying an overall uncertainty factor (UF) of 200 to the NOAEL.

With regards to PFOA, EFSA (2008) concluded that epidemiological studies in PFOA-exposed workers do not indicate an increased cancer risk. Some showed associations with elevated cholesterol and triglycerides or with changes in thyroid hormones, but there is no consistent overall pattern of change. In two recent studies, PFOA exposure of pregnant women, measured by maternal and/or cord serum levels, was associated with reduced birth weight. The lowest NOAEL identified of 0.06 mg/kg per day, originated from a sub-chronic study in male rats, while results from long-term studies indicated higher NOAELs for effects on the liver. BMDL10 values from a number of studies in mice and male rats were in the region of 0.3 - 0.7 mg/kg bw per day. So a $BMDL_{10}$ of 0.3 mg/kg bw per day was set as point of departure for deriving a TDI of 1.5 µg/kg bw per day by applying an overall uncertainty factor of 200 to the $BMDL_{10}$.

13.2 Methods of sampling, analysis and quality assurance

The sampling for this project were carried out by the Danish Veterinary and Food Administration, and organized by Region North. In 2011 fish were collected from Danish catching areas in the Baltic Sea and the North Sea and from Danish aquaculture farms. Most of the samples were pools of 3 to 10 individual fish from the same age group but samples of larger fish were individual fish. The samples were stored at -20° until analysis for the perfluorinated compounds perfluorooctanoic acid (PFOA and perfluorooctane sulphonic acid (PFOS).

The solid phase extraction used was based on the method first described by Taniyasu et al. (2005). The principle of the method was that an aliquot of the homogenised and spiked food samples was extracted with methanol. The tube was then centrifuged, water was added, and the methanol was evaporated. Next, potassium hydroxide (0.1 M) was added to the extract to saponife the fat present in the food. An SPE cartridge was pre-conditioned and the sample was loaded on the SPE cartridge. Next, the cartridge was washed with ammonium acetate and the sample was eluted with ammonium hydroxide in methanol. The eluate was transferred to HPLC vials for LC-MS/MS analysis. The method is accredited for the analyses of PFOA and PFOA. The detection limits for both substances were 0.5 ng/g (0.5 µg/kg).

13.3 Occurrence of perfluorinated compounds in fish

In 2011, The Danish Directorate of Fisheries in collaboration with the Danish Veterinary and Food Administration, collected from fish wholesale companies nine samples of wild fish, including six samples of herring, one sample of flounder, one sample of plaice and one sample of cod. The fish has been caught in the North Sea. In addition eight samples from aquaculture produce were collected: four from freshwater farms, and four from marine farms. The perfluorinated compounds were analysed in the muscle tissue, because the perfluorinated compounds bind to proteins.

The perfluorinated compound PFOS (perfluoroctane sulphonic acid) are found in all samples of wild fish. Perfluorooctanoic acid (PFOA) was not found in levels above the detection limit of 0.5 ng/g wet weight. The level was highest in plaice, which is a bottom-dwelling fish (flatfish). Since the perfluorinated substances accumulate in muscle tissue and not in the lipids, there was no correlation with the fat level, as is the case with other organic contaminants, for example dioxin.

Table 13.1 *Calculation of MOE of HBCDD sum for Danish adults (aged 15-75) and children (aged 4-14)*

	No. of samples	No >0.5ng/g PFOS	max PFOS ng/g	Mean PFOS ng/g	antal >0.5ng/g PFOA
Cod	1	1	1.3	1.3	0
Flounder	1	1	1.7	1.7	0
Herring	6	6	2.0	1.6	0
Plaice	1	1	3.3	3.3	0
Trout, marine farm	4	1	0.53	0	0
Trout, freshwater farm	4	0	<0.5	0	0
Beef meat	4	0	<0.5	0	0
Pork meat	27	0	<0.5	0	0
Poultry meat	4	0	<0.5	0	0

The results in fish on the Danish marked are comparable with those of other studies. EFSA (2012) compiled European results 2010-2011 for PFOS in fish meat (n= 1982) and found a mean level in the range 2.1-2.5 ng/g (lower to upper bound where lower bound is obtained by assigning a value of zero to all samples reported<LOD or <LOQ; whereas upper bound values <LOD/LOQ are set to LOD/LOQ). In this study, as in others generally, the level of PFOS in fish was found to be higher than the level of PFOA (Fromme et al., 2009).

13.4 Exposure and risk assessment

The results for perfluorinated substances in food are relatively sparse, so exposure distributions were not performed and only the mean dietary exposure in ng/kg bw/day for the Danish population aged 4-75 was estimated. For food consumption data on fish species not included in the present survey the most appropriate result from the fish species analysed were used. For PFC results lower than LOD of 0.5 ng/g PFOS, LOD was used as result. Based on these assumptions the mean exposure of the Danish population to PFOS is 27 ng/day or 0.45 ng/kg bw/day. EFSA (2012) have estimated that the highest contributors to dietary PFOS exposure across all age classes were ‘Fish and other seafood' (50 to 80 %) followed by 'Fruits and fruit products' (8 to 27 %) and 'Meat and meat products' (5 to 8 %).

A recent Norwegian study found that in general the main dietary exposure of PFCs in Norway was PFOS (18 ng/day ~0.3 ng/kg bw/day) which is lower in exposure than what has been reported from Spain, Germany, the UK, Canada and Japan (Haug et al., 2010a,b). Fromme et al. (2007) found the median intake to PFOS was found to be 1.4 ng/kg bw/day based on analysis of duplicate diet samples (n=214) of 31 healthy German individuals (age 16 – 45).

The present Danish exposure estimate of 27 ng/day or 0.45 ng/kg bw/day is in between the Norwegian and the German results and is low compared to the TDI set by EFSA of 150 ng/kg bw/day. . However, unlike the other results, the Danish estimate covers only fish consumption.

Some epidemiological studies have shown association between PFC exposure and developmental, metabolic, endocrine effects (Kliff report 2013,). Furthermore a recent study on the Faroe Island of children's postnatal PFC exposure and reduced immune response to vaccination revealed a BMDL of 1.3 ng/mL and 0.3 ng/mL for PFOS and PFOA(Grandjean & Budtz-Jørgensen 2013); somewhat lower than those currently used for estimating TDI. Besides, humans are exposed to other fluorinated compounds of other chain lengths present in the environment. Ideally, the combined exposure to all fluorinated compounds should be considered in the risk assessment. Overall, it is a reason for concern that these persistent chemicals are used in food packaging etc. since it takes 20-30 years before they are eliminated from the human body.

14 Furan and 3-MPCD

Furan and 3-MPCD are process contaminants and, like other process contaminants, such as acrylamide and PAHs, they are formed during the processing of food, either during manufacture or during the final preparation of the meal, including home-cooked meals.

14.1 Furan

Furan is a volatile contaminant found in cooked or thermally processed foods and, like acrylamide, is formed during Maillard reactions (Maga, 1979). Furan contributes to the flavour properties of the food, but has been shown to be carcinogenic and possibly toxic to reproduction in animal experiments. High levels of furan have been found, especially in canned and jarred ready-to-eat food items, but also in coffee and fried foods (Fromberg et al., 2009).

The results presented here are from three surveys in 2009, 2010 and 2011, respectively, which were planned to collect samples as described in the EU recommendation on the monitoring of the presence of furan in foodstuffs (EC 2007c, EFSA 2011f). The number of results and the number of food items covered are limited, and furthermore it is difficult to obtain appropriate consumption data for processed foods, so there is no basis for intake calculations based on these results. Evaluations made by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) on furan led to estimates for MOEs of 960 for average and 480 for high dietary exposures (WHO 2011). The levels of furan in the foods analysed in the three Danish surveys are shown in Table 14.1.

Table 14.1 *Levels of furan in selected processed foods*

Foods	No. samples	No. detected	Mean	Maximum	Median	95%-percentile
Bread products	3	3		33		
Breakfast cereals	1	1		8		
Coffee, ground beans	18	18	3710	7350	3460	6509
Coffee, instant	23	23	239	625	249	513
Crisps	10	10	21	39	18.5	38
Fruit	6	1		1		
Fruit syrup	11	0				
Infant meals, jarred	13	10	19	44	17	40
Ready-to-eat meals	11	10	29	130	17.4	95
Sauces	14	11	22	87	5.2	63
Soups, canned	28	26	30	85	28.1	66
Vegetables, canned	23	17	9	56	4.2	26

Furan is a known volatile flavour compound in coffee. High levels of furan were found in ground coffee beans, probably due to the high temperatures used during the roasting of coffee beans to achieve the desired aroma profile. Lower levels of furan were determined in instant coffee. Experiments have shown a transfer of around half (20-100%) of the theoretical furan amount from the coffee to the brewed coffee regardless of the source (coffee beans or instant coffee). However, lower levels were found in the brewed instant coffee, where only few nano-gram furan per gram brewed instant coffee was observed compared to the about 50 ng/g found in brewed coffee when using coffee beans. So even though furan is volatile, a relatively high amount of furan is found in coffee brewed from coffee beans.

About 20 to 30 µg/kg of furan was found in canned and jarred foods, including infant meals, ready-to-eat meals, soups and sauces. As with coffee, about half of the initial furan is expected to be present in the food when heated. For fruit, including canned fruit and fruit syrups, almost no furan was detected.

14.2 3-MCPD

High levels of 3-Monochlorpropandiol (3-MCPD) have been found previously in soy sauce and products containing Hydrolysed Vegetable Protein (HVP) (Collier et al. 1991, Velisek et al. 1980, Velisek et al. 1978, Davidek et al. 1980). Animal studies have associated 3-MCPD exposure with infertility, suppression of the immune function, and possible carcinogenicity (EFSA, 2013). In 2001, the EU’s Scientific Committee on Food established a TDI of 2 µg/kg body weight for 3-MCPD (EC, 2001b), and EU maximum levels for 3-MCPD in soy sauce and hydrolysed vegetable proteins (HVP) were introduced (see Table 14.2). The current legislation can be found in EC Commission Regulation 1881/2006 (EC, 2012c).

Table 14.2. *EU maximum levels for 3-MCPD*

Section 4: 3-monochloropropane-1,2-diol (3-MCPD)

Foodstuffs		Maximum levels (µg/kg)
4.1	Hydrolysed vegetable protein ([30])	20
4.2	Soy sauce ([30])	20

([30]) The maximum level is given for the liquid product containing 40 % dry matter, corresponding to a maximum level of 50 µg/kg in the dry matter. The level needs to be adjusted proportionally according to the dry matter level of the products.

Annual surveys of 3-MCPD, especially in food ingredients, were carried out in 2003, 2004, 2005, 2008 and 2009, focusing on food products and ingredients most likely to contain 3-MCPD. The results do not therefore represent general levels for 3-MCPD in foods and food ingredients and there is no basis for any intake calculation based on these results. The results for the samples analysed are shown in Table 14.3.

Table 14.3. *Levels of 3-MCPD in foods and food ingredients*

Foods	No. samples	No. detected	Mean[1]	Maximum	Median[1]
Biscuits, cookies and Crispbread	15	8	0.03	0.05	0.02
Bouillon	4	1		0.03	
Bread	9	0			
HVP	14	5	0.06	0.24	0.02
Noodles	13	8	0.03	0.05	0.03
Ready-to-eat products	8	2		0.03	0.03
Salami and sausage	15	8	0.04	0.07	0.04
Sauce	6	1		0.02	
Soy sauce	104	8	11.6	72	0.02

1 Calculated on positive results

As can be seen from Table 14.3, levels of 3-MCPD were observed in most of the samples in the surveys, but mostly at a low level. Soy sauce is the exception. It was a sample type included in four of the surveys, due to its high levels of 3-MCPD, which led to the introduction of the EC maximum level (see Table 14.4).

Table 14.4. *Levels of 3-MCPD in soy sauce sorted by year*

Soy sauce [mg/kg dry matter]	Year	No. samples	No. detected	Mean	Maximum
	2003	43	6	3.3	20
	2004	38	2	36	72
	2008	15	0		
	2009	8	0		

The results for soy sauce from the different years reveal a tendency to a decrease in the 3-MCPD levels probably due to the introduction and awareness of the EC maximum level for soy sauce, and no violations of the maximum levels were observed in 2008 and 2009.

15 References

AFSSA, 2007, Opinion of the French Food Safety Agency (AFSSA) on the establishment of relevant maximum levels for non-dioxin-like polychlorobiphenyls (NDL-PCB) in some foods, AFSSA – Request No. 2006-SA-0305. Maisons-Alfort, 23 October 2007.

Amrein T. M., Lukac H., Andres L., Perren R., Escher F., Amado R., 2005. Acrylamide in roasted almonds and hazelnuts. J. Agricul. Food Chem.53, 7819-7825.

ANSES 2011a, Second French Total Diet Study (TDS 2). Report 1, Inorganic contaminants, minerals, persistent organic pollutants, mycotoxins and phytoestrogens, France (ISBN 978-2-11-128699-3).

ANSES, 2011 b, Second French Total Diet Study (TDS 2), Report 2, Pesticide Residues, Additives, Acrylamide and poly aromatic hydrocarbons), France (ISBN 978-2-11-128699-3).

Arnoud (2001). Autres oligoelements. In "Apport nutritionnels conseillés pour la population francaise". 3rd edition "Ed. Tec&Doc. P (170-196), Lavosier, Paris, France.

Cederberg, T., Sørensen, S., Lund, K.H., and Friis-Wandall, S. (2010a). Danish monitoring of dioxins and PCBs in food and feed during the years 2000 to 2009 – levels, time trend and human exposure. Organohalogen Compounds 72 952-955.

Cederberg, T.L., Timm-Heinrich, M., Sorensen, S., Lund, K. (2010b), Dioxins and PCB in salmon from the Southern Baltic Sea and reduction in levels during processing. Organohalogen Compounds 72 1430-1433.

CIAA (Confederation of the European Food and Drink Industries), 2009. Rev 12. The CIAA acrylamide toolbox. Confederation of the European Food and Drink Industries (CIAA), Brussels, 41 pp.

Collier, P.D., Cromie, D.D.O. and Davies, A.P. (1991) Mechanism of formation of chloropropanols present in protein hydrolysates. Journal of the American Oil Chemist Society, 68, 785-790

Danish Veterinary and Food Administration, 1999. Journal number 521.1030-0035: Vejledende værdier for acceptabelt indhold af PCB og chlorholdige pesticider i fiskeolie (Recommended values for acceptable levels of PCB and organochlorine pesticides in fish oils.

Danish Veterinary and Food Administration, 2001. Monitoring system for foods, 1993-1997, Part 2, Chemical contaminants. Publication No. 2001:18.

Danish Veterinary and Food Administration, 2003 (Fødevarestyrelsen). Helhedssyn på fisk og fiskevarer FødevareRapport 2003:17 October 2003 Schultz ISBN: 87-91399-31-9 – in Danish.

Danish Veterinary and Food Administration, 2005. Food Monitoring 1998-2003, Part 1, Chemical contaminants. Publication No. 2005:01.

Davidek, J., Velisek, J., Kubelka, V., Janicek, G., and Simicova, Z. 1980 Glycerol chlorohydrins and their esters as products of the hydrolysis of tripalmitin, tristearin and triolein with hydrochloric acid. Z. Lebensm. Unters. Forsch. 171, 14-17.

Driffield, M., Hamer, N., Bradley, N. et al. 2008. Determination of brominated flame retardants in food by LC-MS/MS: diastereoisomer-specific hexabromocyclododecane and tetrabromobisphenol A. Food Addit. Contam.25, 895-903.

EC, 1996, Council directive 96/23/EC on measures to monitor certain substances and residues thereof in live animals and animal products repealing Directives 85/358/EEC and 86/469/EEC and Decisions 89/187/EEC and 91/664/EEC. Official Journal of the European Communities L125/10S.

EC, 2001a. Council Regulation (EC) 2375/2001 of 29 November 2001 amending Commission Regulation (EC) No 466/2001 setting maximum levels for certain contaminants in foodstuffs.

EC, 2001b, European Commission Scientific Committee on Food "Opinion of the scientific committee on food on 3-Monochloro-propane-1,2-diol (3-MCPD) updating the SCF opinion of 1994. Adopted on 30 May 2001. SCF7CS7CNTM7OTH717 FINAL.

EC, 2002a, Commission Recommendation 2002/201/EC of 4 March 2002 on the reduction of the presence of dioxin, furans and PCBs in feedingstuffs and foodstuffs.

EC, 2002b, Commission Directive 2002/69/EC of 26 July 2002 laying down methods of sampling and analysis for the official control of levels of dioxins and dioxin-like PCBs in foodstuffs.

EC, 2004. Commission Regulation EC No. 655/2004 of 7 April 2004 amending Regulation (EC) No. 466/2001 as regards nitrate in foods for infants and young children.

EC, 2005. Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin and amending Council Directive 91/414/EEC. Official Journal of the European Union L70/1.

EC, 2006a. Commission Regulation No. 1881/2006/EC of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. Official Journal of the European Union L 364:5 – 24.

EC, 2006b, Commission Regulation (EC) No 1883/2006 of 19 December 2006 laying down methods of sampling and analysis for the official control of levels of dioxins and dioxin-like PCBs in certain foodstuffs.

EC, 2006c. Commission Recommendation 2006/88/EC of 6 February 2006 on the reduction of the presence of dioxins, furans and PCBs in feedingstuffs and foodstuffs.

EC, 2007a. Commission Regulation No. 333/2007/EC of 28 March 2007 laying down the methods of sampling and analysis for the official control of the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD and benzo(a)pyrene in foods. Official Journal of the European Union L 88: 29-38.

EC, 2007b. Commission recommendations of 3 May 2007 on the monitoring of Acrylamide levels in food. Official Journal of the European Union, L 123, 12.5.2007, pp.33-39.

EC, 2007c, Commission Regulation (EC) No 199/2006 of 3 February 2006 amending Regulation (EC) No 466/2001 setting maximum levels for certain contaminants in foods as regards dioxins and dioxin-like PCBs.

EC, 2007d, EU recommendation of 28 March 2007 on the monitoring of the presence of furan in foodstuffs, Official Journal of the European Union. L88, 29.3 2007, pp. 56-57

EC, 2010. Commission recommendations of 2 June 2010 on the monitoring of acrylamide levels in food. Official Journal of the European Union, L 137, 3.6.2010, pp.4-10.

EC, 2011a. Commission Recommendation of 11 January 2011 on investigations into the levels of acrylamide in food, C (2010) 9681 final.

EC, 2011b.Commission Regulation No. 835/2011 of 19 August 2011a amending Regulation (EC) No. 1881/2006 as regards maximum levels for polycyclic aromatic hydrocarbons in foods. Official Journal of the European Union L 215: 4 – 8.

EC, 2011c. Commission Regulation (EU) No.836/2011 of 19 August 2011b amending Regulation (EC) No. 333/2007 laying down the methods of sampling and analysis for the official control of the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD, and benzo(*a*)pyrene in foods. Official Journal of the European Union L 215:9-16.

EC, 2011d, Commission Recommendation of 23 August 2011 on the reduction of the presence of dioxin, furans and PCBs in feed and food (2011/516/EU).

EC, 2011e, Commission Regulation (EU) No 1258/2011 of 2 December 2011 amending Regulation (EC) No 1881/2006 as regards maximum levels for nitrates in foods.

EC, 2011f, Commission Regulation (EU) No 1259/2011 of 2 December 2011 amending Regulation (EC) No 1881/2006 as regards maximum levels dioxins, dioxin-like PCBs and non dioxin-like PCBs in foods.

EC, 2012a, Commission Regulation (EU) No 252/2012 of 21 March 2012 laying down methods of sampling and analysis for the official control of levels of dioxins, dioxin-like PCBs and non dioxin-like PCBs in certain foods and repealing Regulation (EC) No 1883/2006.

EC, 2012b. Commission Regulation (EU) No. 594/2012 of 5 July 2012 amending Regulation (EC) 1881/2006 as regards the maximum levels of the contaminants ochratoxin A, non dioxin-like PCBs and melamine in foods.

EC, 2012c, Commission Regulation No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs consolidated version of 03.12.2012.

EFSA, 2005a. Opinion of the Scientific Committee on a request from EFSA related to a harmonised approach for risk assessment of substances which are both genotoxic and carcinogenic. The EFSA Journal 282:1-31.

EFSA, 2005b. Opinion of the Scientific Panel on Dietetic Products, Nutrition and Allergies on a request from the Commission related to the Tolerable Upper Exposure Level of Nickel, EFSA Journal, 146, 1-21.

EFSA, 2008a. Safety of aluminium from dietary exposure, Scientific Opinion of the Panel on Food Additives, Flavourings, Processing Aids and Food Contact Materials (AFC), EFSA Journal, 754, 1-31.

EFSA, 2008b, Scientific Opinion of the Panel on Contaminants in the Food Chain on a request from the European Commission on Polycyclic Aromatic Hydrocarbons in Food. The EFSA Journal (2008) 724, 1-114. Available online: www.efsa.europa.eu/efsajournal.

EFSA 2008c, Opinion of the scientific panel on contaminants in the food chain on perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and their salts (EFSA-Q-2004-163. Available online: www.efsa.europa.eu/efsajournal.

EFSA, 2009a. EFSA Panel on Contaminants in the Food Chain (CONTAM); Scientific Opinion on Arsenic in Food. EFSA Journal 2009; 7(10):1351. [199 pp.]. doi:10.2903/j.efsa.2009.1351. Available online: www.efsa.europa.eu/efsajournal.

EFSA, 2009b, Scientific Opinion Cadmium in Food, Scientific Opinion of the Panel on Contaminants in the Food Chain EFSA Journal, 980, 1-139. Available online: www.efsa.europa.eu/efsajournal.

EFSA, 2009c. Scientific Opinion of the Panel on Food Additives and Nutrient Sources added to Food (ANS). L-Selenomethionine as a source of selenium added for nutritional purposes to food supplements. EFSA Journal, 1083, 1-39. Available online: www.efsa.europa.eu/efsajournal.

EFSA, 2010, Scientific Opinion on Lead in Food, Scientific Opinion of the Panel on Contaminants in the Food Chain EFSA Journal, 8(4), 1570 Available online: www.efsa.europa.eu/efsajournal.

EFSA, 2011a, Scientific Opinion – Statement on tolerable weekly intake for cadmium, EFSA Journal, 9(2), 1975. Available online: www.efsa.europa.eu/efsajournal.

EFSA 2011b. Statement of EFSA on the Evaluation of a new study related to the bioavailability of aluminium in food, EFSA Journal, 9(5), 2157. Available online: www.efsa.europa.eu/efsajournal.

EFSA, 2011c. Results on acrylamide levels in food from monitoring years 2007-2009. EFSA Journal 2011;9(4):2133. [48 pp.] doi:10.2903/j.efsa.2011.2133. Available online: www.efsa.europa.eu/efsajournal.

EFSA 2011d. Scientific Opinion on Polybrominated Diphenyl Ethers (PBDEs) in Food, EFSA Journal 2011, 9(5), 2156. Opinion of the CONTAM Panel, (replaces the opinion published 30 May 2011) Available from: http://www.efsa.europa.eu/en/

EFSA 2011e. Scientific Opinion on Hexabromocyclododecanes (HBCDDs) in Food. EFSA Panel on Contaminants in the Food Chain (CONTAM) EFSA Journal 2011, 9(7):2296. Available online: www.efsa.europa.eu/efsajournal.

EFSA 2011f: Update on furan levels in food from monitoring years 2004-2010 and exposure assessment. EFSA Journal EFSA Journal 2011; 9(9):2347. [33 pp.]. Available online: http://www.efsa.europa.eu/en/efsajournal/pub/2347.htm

EFSA, 2012a. Scientific Opinion on the risk for public health related to the presence of mercury and methylmercury in Food, EFSA Journal, 10(12), 2985. Available online: www.efsa.europa.eu/efsajournal.

EFSA, 2012b, Lead dietary exposure in the European population, EFSA Journal, 10(7), 2831. Available online: www.efsa.europa.eu/efsajournal.

EFSA 2012c, Perfluoroalkylated substances in food: occurrence and dietary exposure. EFSA Journal 2012; 10(6):2743. Available online: www.efsa.europa.eu/efsajournal.

EFSA, 2012d; Scientific Opinion, Guidance on selected default values to be used by the EFSA Scientific Committee, Scientific Panels and Units in the absence of actual measured data, EFSA Journal 2012;10(3):2579. Available online: www.efsa.europa.eu/efsajournal.

EFSA 2013. http://www.efsa.europa.eu/en/topics/topic/monochloropropane.htm; visit13-03-2013

Danish Veterinary and Food Administration, Analytical method FC024.1 (in Danish).

Eriksen, G.S. and Alexander, J., 1998 Fusarium Toxins in Cereals: A Risk Assessment (Tema Nord: Nordic Council of Ministers.

FDA 2012. Survey Data on Acrylamide in Food: Total Diet Study Results, last updated 2006. http://www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/ChemicalContaminants/Acrylamide/ucm053566.htm#table4

Fries, G.F., Cook, R.M., and Prewitt, L.R., 1978, Distribution of polybrominated biphenyl residues in the tissues of environmentally contaminated dairy cows, J. Dairy Sci. 61, 420-425.

Fries, G.F. and Marrow, G.S., 1977. Distribution of hexachlorobenzene residues in beef steers, J. Animal Sci. 45, 1160.

Fromber, A., Fagt, S. and Granby, K., 2009, SCIENTIFIC REPORT submitted to EFSA. Furan in heat processed food products including home cooked food products and ready-to-eat products. http://www.efsa.europa.eu/fr/scdocs/doc/1e.pdf visited 06-03-2013.

Fromme, H., Schlummer, M., Möller, A., Gruber, L., Wolz, G., Ungewiß, J., Böhmer, S., Dekant, W., Mayer, R., Liebl, B., Twardella, D., 2007. Exposure of an adult population to perfluorinated substances using duplicate diet portions and biomonitoring data. Environ. Sci. Technol. 41, 7928–7933.

Fromme, H., Tittlemier, S.A., Völkel, W., Wilhelm, M., Twardella, D., 2009. Perfluorinated compounds – Exposure assessment for the general population in western countries. Int J Hyg Environ Health 212, 239-270.

Goscinny, S., Vandevijvere, S., Maleki, M. et al. 2011. Dietary intake of hexabromocyclododecane diastereoisomers (α,β, γ-HBCD) in the Belgian adult population. Chemosphere 84, 279-288.

Granby, K., and Cederberg, T.L., 2007. LC-MS/MS analysis of Hexabromocyclododecane (HBCD) isomers and Tetrabromobisphenol A (TBBPA) and levels in Danish fish for food consumption. Proceedings of the 4th Int. Conf. on Brominated Flame Retardants, Amsterdam 24-27 April 2007

Granby, K., Nielsen, N.J., Hedegaard, R.V., Christensen, T., Kann, M., Skibsted, L.H., 2008. Acrylamide-asparagine relationship in baked/toasted wheat and rye breads. Food Additives and Contaminants,25, 921-929.

Harju, M., Heimstad, E.S., Herzke, D., Sandaanger, T., Posner, S., Wania, F (2009). Current state of knowledge and monitoring requirements: Emerging "new" brominated flame retardants in flame retarded products and the environment. Norwegian Pollution Control Authority, 1-114.

Haug, L.S., Thomsen, C., Brantsæter, A.L., Kvalem, H.E., Haugen, M., Becker, G., Alexander, J., Meltzer, H.M., Knutsen, H.K. 2010b. Diet and particularly seafood are major sources of perfluorinated compounds in humans. Environment International, 36, 772-778.

Hedegaard, R.V., Frandsen, H., Granby, K., Apostolopoulou, A., and Skibsted, L.H. 2007a. Model studies on Acrylamide Generation from Glucose/Asparagine in Aqueous Glycerol. J. Agric. Food Chem., 55, 486-492.

Hedegaard, R.V., Granby, K., Frandsen, H., Thygesen, J. and Skibsted, L.H. 2007b. Acrylamide in bread. Effect of prooxidants and antioxidants. Eur. Food. Res. Technol.227, 519-525.

Hedegaard, R.V., de Andrade Sobrinho, L.G., Granby, K. and Skibsted, L.H. 2007c. Formation of acrylamide in cheese bread. Milchwissenschaft., 63, 168-170.

Heeb, N.V., Schweizer, W.B., Mattrel, P., Haag, R., Gerecke, A.C., Schmid, P., Zennegg, M., and Vonmont, H. (2008). Regio- and steroeselective isomerization of hexabromocyclododecanes (HBCDs): kinetics and mechanism of γ - to α -HBCD isomerization. Chemosphere 73, 1201–1210

Hilbert, G., L. Lillemark and P. Nilsson, PCB in cod liver - Time trend study and correlation between total PCB (Aroclor 1260) and PCB congeners, Organohalogen compounds 32. 340-343, 17th International symposium on chlorinated dioxins and related compounds, Indianapolis, Indiana (1997).

IARC 1994. Acrylamide, In IARC (International Agency for Research on Cancer) monographs on the evaluation of carcinogenic risks to humans, some industrial chemicals, Vol. 60, pp. 387-433, WHO, Geneva, Switzerland.

IUPAC, 2007. IUPAC Glossary of Terms Used in Toxicology, 2nd Edition, Published in Pure Appl. Chem., Vol. 79, No. 7, pp. 1153-1344, 2007. The list is taken from: http://sis.nlm.nih.gov/enviro/iupacglossary/frontmatter.html

IUPAC, 2010,
http://agrochemicals.iupac.org/index.php?option=com_sobi2&sobi2Task=sobi2Details&catid=7&sobi2Id=13

Jensen, B.B.B., Lennox, M., Granby, K. and Adler-Nissen, J., 2008, Robust modelling of heat-induced reactions in an industrial food production process exemplified by acrylamide generation in breakfast cereals Food and Bioproducts Processing, 86, pp. 154–162.

JECFA, 2004, Evaluation of certain food additives and contaminants. Sixty-first report of the Joint FAO/WHO Expert Committee on Food Additives. WHO technical report series 922. FAO/WHO, Geneva, Switzerland.

JECFA, 2006, Evaluation of certain food additives and contaminants. Sixty-seventh report of the Joint FAO/WHO Expert Committee on Food Additives. WHO technical report series 940. FAO/WHO, Rome, Italy.

JECFA, 2010, Summary and conclusions report of the seventy-second meeting of the Joint FAO/WHO Expert Committee on Food Additives, pp. 1-16. Available from http://www.fao.org/ag/agn/agns/ jecfa_output _en.asp

JECFA, 2011a.Evaluation of certain food additives and contaminants. Seventy-second report of the joint FAO/WHO expert committee on food additives. WHO technical report series 959.

JECFA, 2011b., Evaluation of certain food additives and contaminants. Seventy-third report of the joint FAO/WHO expert committee on food additives. WHO technical report series 960.

Kissa, E., 2001. Fluorinated surfactants and repellents. Surfactant Science Series, Marcel Dekker, New York, NY, 97, (Fluorinated Surfactants and Repellents (2nd Edition)), 1-615.

Lind, Y., Aune, M., Atuma, S., Becker, W. et al. 2002. Food intake of the brominated flame retardants PBDEs and HBCD in Sweden. Organohalogen compounds 58, 181-184.

Lorber, M., Feil, V., Winters, D., and Ferrario, J., 1997. Distribution of dioxins, furans, and coplanar PCBs in different fat matrices in cattle, Organohalogen compounds, 32, 327

Lund, K., Sorensen, S., Cederberg, T. (2008), PCDD/F and PCB content in different parts of sheep. Organohalogen Compounds 7

Maga, J.A. (1979). Furans in Foods. Critical Reviews in Food Science and Nutrition 4, 355-400. 11:355–400.

Morris, S., Allchin, C.R., Zegers, B.N. et al. 2004. Distribution and fate of HBCD and TBBPA brominated flame retardants in North Sea Estuaries and aquatic food webs. Environ. Sci. Technol, 38, 5497-5504.

National Food Agency of Denmark, 1990. Food Monitoring in Denmark, Nutrients and Contaminants 1983-1987. Publication No. 195 (September, 1990).

National Food Agency of Denmark, 1995, Food Monitoring in Denmark, Nutrients and Contaminants 1988-1992. Publication No. 232 (December, 1995).

CDC (Centers for Disease Control and Prevention), 2009, National Report on Human Exposure to Environmental Chemicals, Fourth Report 2009.

NNR (Nordic Nutrition Recommendations), 2004, 4th edition, The Nordic Council (www.norden.org).

NNR (Nordic Nutrition Recommendations), 2012, draft 5th edition (accessed via www.slv.se)
Nordforsk 2013. KLIFF report Investigation of use and emission of per- and polyfluorinated substances in the Nordic countries.

Pedreschi, F., Kaack, K. and Granby, K. 2004. Reduction of Acrylamide Formation in Potato Slices During Frying. Lebensmittel-Wissenschaft und-Technologie/Food Science and Technology 37, 6, 679-685

Pedreschi, F., Moyano, P., Kaack, K., Granby, K., 2005. Color changes and acrylamide formation in fried potato slices. Food Research International, 38, 1-9

Pedreschi, F., Kaack, K., Granby, K., 2006. Acrylamide content and color development in fried potato strips. Food Research International, 39, 40-46

Pedreschi, F., Kaack, K., Granby, K. and Troncoso E., 2007. Acrylamide reduction under different pre-treatments in French fries. Journal of Food Engineering, 79, 1287-1294.

Pedreschi, F., Bustos, O, Mery, D., Moyano, P., Kaack K. and Granby K., 2007. Color kinetics and acrylamide formation in NaCl soaked potato chips. Journal of Food Engineering, 79, 989-997.

Pedreschi, F., Kaack, K. and Granby K., 2008. The effect of asparaginase on acrylamide formation in French fries. Food Chemistry 109, 386-392.

Pedreschi, F., Granby, K., Risum, J., 2010. Acrylamide Mitigation in Potato Chips by Using NaCl Food and Bioprocess Technology, 3(6), 917-921.

Pedreschi, F. Mariotti, S., Granby, K. and Risum J., 2011. Acrylamide reduction in potato chips by using commercial asparaginase in combination with conventional blanching. LWT - Food Science and Technology 44(6), p. 1473-1476.

Rasmussen, P.H., Ghorbani, F. and Berg, T., 2003. Deoxynivalenol and other *Fusarium* toxins in wheat and rye flours on the Danish market. Food Addit Contam 20: 396 – 404.

Rasmussen, P.H., Petersen, A. and Ghorbani, F., 2007 Annual variation of deoxynivalenol in Danish wheat flour 1998-2003 and estimated daily intake by the Danish population. Food Addit Contam 24: 315-325.

Remberger, M., Sternbeck, J., Palm, A., Kaj, L., Strömberg, K. and Brorström-Lundén, E., 2004. The environmental occurrence of hexabromocyclododecane in Sweden, Chemosphere 54, 9-21.

Rumsey, T.S., Putnam, P.A., Davis, R.E., and Corley, C., 1967, Distribution of p,p'-DDT residues in adipose and muscle tissues of beef cattle, J. Agr. Food Chem., 15, 898.

SCOOP (Scientific Cooperation), 1997, Assessment of dietary intake of ochratoxin A by the population of EU member states. EUR 17523 EN, European Commission.

SCOOP (Scientific Cooperation), 2003. Collection of occurrence data of Fusarium toxins in food and assessment of dietary intake by the population of EU member states.

SFC, (Scientific Committee for Food), 1997. Opinion of the Scientific Committee for Food on nitrates and nitrite. Available at: http://ec.europa.eu/food/fs/sc/scf/reports/scf_reports_38.pdf

SFC (Scientific Committee on Food), 2001. Opinion of the SCF on the Risk Assessment of Dioxins and Dioxin-like PCBs in Food (update on the new scientific information available since the adoption of the SCF Opinions of 22 November 2000). Adopted by the SCF on 30 May 2001. Reports CS/CNTM/DIOxIN/20 final. Available at: http://ec.europa.eu/food/fs/sc/scf/out78_en.pdf

SFC (Scientific Committee on Food), 2002. Opinion of the Scientific Committee on Food on the risks to human health of Polycyclic Aromatic Hydrocarbons in food expressed on 4 December 2002. SCF/CS/CNTM/PAH/29 Final. Available at: http://ec.europa.eu/food/food/chemicalsafety/contaminants/out153_en.pdf.

SCF (Scientific Committee on Food), 2006. Tolerable upper exposure levels for vitamins and minerals, Scientific Panel on Dietetic Products, Nutrition and Allergies, The EFSA journal (2006) 328,1-4, Available from: http://www.efsa.eu.int

Sommer Statistics, Torskelever, Notat angående principperne i analyse af torskeleverdata. Specifikt er der set på total-PCB fra perioden 1988-1996 (Cod liver, Note concerning the principles of analysis of cod liver data, with special reference to total PCB during the period 1988-1996) (May 1999).

Szabo, D.Z., Diliberto, J.J., Hakk, H., Huwe, J.K., Birnbaum, L.S., 2011.Toxicokinetics of the Flame Retardant Hexabromocyclododecane Alpha: Effect of Dose, Timing, Route, Repeated Exposure, and Metabolism. Toxicological Sciences 121, 2, 234–244.

Tareke, E., Rydberg, P., Karlsson, P., Eriksson, S. and Tornqvist, M., 2002. Analysis of Acrylamide, a carcinogen formed in heated foods. Journal of Agricultural and Food Chemistry 50, 4998-5006.

Taniyasu, S., Kannan, K., So, M.K., Gulkowska, A., Sinclair, E., Okazawa, T., Yamashita, N.. 2005. Analysis of fluorotelomer alcohols, fluorotelomer acids, and short- and long-chain perfluorinated acids in water and biota. Journal of Chromatography A, 1093, 89–97

Trier, x., Granby, K., Christensen, J.H., 2011 Polyfluorinated surfactants (PFS) in paper and board coatings for food packaging. Environ Sci Pollut Res, 18, 1108-1120.

Van den Berg, M., et al., 1998 Environ Health Perspective 106:775-792.

Van den Berg, M., et al.,2006, The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds. Toxicology Science 93: 223-243.

van Leeuwen, S.P.J. and Boer, J., 2008. Brominated flame retardants in fish and shellfish –levels and contribution of fish consumption to dietary exposure of Dutch citizens to HBCD Mol. Nutr. Food Res. 2008, 52, 194 – 203.

Velisek, J., Davidek, J., Hajslova, J., Kubelka, V., Janicek, G. and Mankova, B. 1978 Chlorohydrins in Protein Hydrolysates. Z. Lebensm. Unters. Forsch. 167, 241-244.

Velisek, J., Davidek, J., Kubelka, V., Janicek, G., Svobodova, Z. and Simicova, Z. 1980 New Chlorine-Containing Organic Compounds in Protein Hydrolysates. J. Agric. Food Chem. 28, 1142-1144

WHO, 1997. Environmental Health Criteria 192. Flame Retardants: A General Introduction. Geneva, Switzerland: International Program on Chemical Safety, World Health Organization

WHO, 2005. Nickel in drinking water, Background document for development of WHO Guidelines for Drinking-water quality (WHO/SDE/WSH/05.08/55).

WHO, 2009. Dietary exposure assessment of chemicals in food (Chapter7). Principles and methods for the risk assessment of chemicals in food. Environmental Health Criteria 240. FAO/WHO. International Programme on Chemical Safety (IPCS). Geneva: WHO, 2009. Available from http://www.who.int/ipcs/food/principles/en/index.html

WHO, 2011, http://whqlibdoc.who.int/trs/WHO_TRS_959_eng.pdf visited 13-03-2013

WHO (publication year not indicated but after 1998), Descriptions of selected key generic terms used in chemical hazard/risk assessment, International Programme on Chemical Safety Joint Project with OECD on the Harmonisation of Hazard/Risk Assessment Terminology. Available from: http://www.who.int/ipcs/publications/methods/harmonization/definitions_terms/en/

Örn, U., Bergman, Å. (2004). An attempt to assess the present commercial production of brominated flame retardants. The Third International Workshop on Brominated Flame Retardants. Toronto, Canada. 467-472.

16 Appendices

An “x” in the column “Included in exposure” refer to that this food has been included in the exposure calculations

16.1 Appendices to trace elements

16.1.1 Levels of mercury (µg/ kg)

Foods	Included in exposure	No. of samples	Positive	Average	Min.	Max.	Median	95th percentile
Angler (Lophius piscatorius)		4	4	0.172	0.078	0.246	0.182	
Cod	x	12	12	0.066	0.021	0.125	0.057	0.124
Crayfish (Astacus spp.)		1	1	0.048	0.048	0.048	0.048	
Escolar		4	4	0.650	0.290	1.010	0.650	
Fish and other seafood		49	46	0.156	<0.0018	1.510	0.011	0.810
Fish soup		1	1	0.321	0.321	0.321	0.321	
Greenland Halibut		32	32	0.071	0.018	0.174	0.061	0.169
Halibut		3	3	0.112	0.070	0.148	0.117	
Herring (Clupea)		2	2	0.039	0.035	0.042	0.039	
Mackerel (Scomber)		2	2	0.304	0.036	0.572	0.304	
Pike (Esox lucius)		2	2	0.088	0.075	0.102	0.088	
Plaice (Pleuronectes)	x	3	3	0.043	0.034	0.051	0.043	
Rays (Hypotremata)		2	2	0.196	0.177	0.215	0.196	
Redfish, rockfish		4	4	0.047	0.029	0.087	0.036	
Salmon,	x	4	4	0.011	0.006	0.014	0.013	
Sea catfish (Anarhichas)		4	4	0.105	0.020	0.228	0.085	
Trout	x	43	43	0.031	0.012	0.069	0.029	0.050
Tuna (Thunnus)		23	23	0.271	0.034	0.610	0.210	0.610
Tuna, canned	x	5	5	0.280	0.058	0.730	0.089	
Sharks		3	3	1.753	0.830	2.570	1.860	
Swordfish		8	8	1.001	0.318	2.550	0.760	
Zander (Sander lucioperca)		5	5	0.120	0.042	0.284	0.091	
BIVALVES AND SHELLFISH								
Bivalves, unspecific		15	15	0.006	0.004	0.010	0.006	0.010
Cockle (Cardium edule)		9	9	0.014	0.013	0.017	0.015	0.017
Crab (Cancer spp.)		5	5	0.040	0.019	0.051	0.048	0.051
Mussel (Mytilus edulis)		259	259	0.008	0.003	0.039	0.008	0.016
Mussel (Spisula sp.)		28	28	0.026	0.018	0.043	0.024	0.041
Oyster		75	75	0.015	0.008	0.169	0.012	0.026
Scallop		7	7	0.019	0.014	0.025	0.018	0.025
Shrimps (Crangon crangon)	x	157	157	0.022	0.003	0.077	0.019	0.051

MEAT							
Beef kidney		149	146	0.005	<0.0013	0.035	0.004	0.011
Beef liver	x	9	7	0.001	<0.0013	0.002	0.001	
Beef meat	x	255	11	<0.0013	0	0.005	<0.0013	<0.0013
Boar meat (Sus scrofa)		5	3	0.005	<0.0013	0.012	0.003	
Chicken meat		155	10	<0.0013	0	0.038	0	0.001
Duck meat (Anas spp.)	x	38	30	0.021	0	0.184	0.006	0.130
Duck meat (wild duck)	x	67	59	0.007	0	0.047	0.003	0.025
Game, deer, smoked meat		16	0	<0.0011	0	<0.0011	<0.0011	<0.0011
Game		145	7	<0.0013	0	<0.0013	<0.0013	0.002
Horse kidney		9	9	0.045	0.008	0.096	0.039	
Horse meat		29	0	<0.0013	0	<0.0013	<0.0013	<0.0013
Ostrich meat (Struthio camelus)		43	0	<0.0013	0	<0.0013	<0.0013	<0.0013
Pheasant meat (Phasianus colchius)		309	98	<0.0013	0	0.007	<0.0013	0.003
Pigeon meat (Columba spp.)		46	2	<0.0013	0	0.002	<0.0013	<0.0013
Pork liver	x	39	14	<0.0013	0	0.003	<0.0013	0.003
Pork meat	x	384	27	<0.0013	0	0.004	<0.0013	0.001
Sheep meet	x	34	1	<0.0013	0	<0.0013	<0.0013	<0.0013
Swine Kidney		42	30	0.003	0	0.010	0.002	0.008
Veal kidney	x	5	5	0.003	0.001	0.006	0.004	
Veal liver	x	15	6	0.001	0	0.004	<0.0011	0.004
DAIRY PRODUCTS								
Buttermilk	x	14	0	<0.0013	0	<0.0013	0	<0.0013
Cow milk, 1 - 2.9% fat	x	7	0	<0.0013	0	<0.0013	0	
Cow milk, < 1% fat	x	14	0	0	0	<0.0013	0	<0.0013
Milk	x	7	0	<0.0013	0	<0.0013	0	
BABY FOOD								
Babyfood, based on fruits and vegetables, canned		25	0	<0.0034	0	<0.0034	<0.0034	<0.0034
Babyfood, based on fruits and vegetables, powder		2	0	<0.0016	<0.0016	<0.0016	<0.0016	0.001
Babyfood, cereal based, canned		1	0	0	0	0	0	0
Babyfood, cereal based, powder		28	11	<0.0016	0	0.004	<0.0016	0.003
Infant formulae, powder		8	0	0	0	0	0	0
Ready-to-eat meal for infants and young children, canned		10	0	<0.0016	0	<0.0016	<0.0016	<0.0016
CEREALS								
Breadcrumbs	x	20	0	<0.0027	0	<0.0027	0	<0.0027
Breakfast cereals	x	22	0	0	0	0	0	0

Bulgur		9	0	<0.0023	0	<0.0023	0	<0.0023
Flour mix		1	0	0	0	0	0	0
Pasta	x	21	0	<0.0027	0	<0.0027	0	<0.0027
Rice flour		4	0	<0.0027	0	<0.0027	0	<0.0027
Rice	x	37	10	0.003	0	0.007	<0.0027	0.005
Rolled oat	x	18	0	0	0	0	0	0
Rye bread	x	22	1	<0.0027	0	0.003	0	<0.0027
Wheat bread, brown	x	22	0	<0.0027	0	<0.0027	0	<0.0027
Wheat bread, white	x	20	0	<0.0027	0	<0.0027	0	<0.0027
Wheat flour	x	34	0	<0.0027	0	<0.0027	0	<0.0027
Wheat kernels		3	0	<0.0023	0	<0.0023	<0.0023	<0.0023
VEGETABLES								
Cantharelle (Cantharellus cibarius)		5	2	0.005	<0.0022	0.016	<0.0022	0.016
Chick pea	x	7	0	<0.0023	0	<0.0023	0	
Fungi		12	8	0.091	<0.0022	0.620	0.003	0.337
Fungi, unspecified, dried		5	3	0.109	0	0.530	0.002	
Linseed		13	0	<0.0023	0	<0.0023	0	<0.0023
Mushroom (Agaricus bispo-rus)	x	11	9	0.005	<0.0022	0.010	0.004	0.010
Mushroom, oyster (Pleuro-tus)		9	7	0.006	<0.0022	0.013	0.006	
Potatoes	x	81	3	<0.0003	0	<0.0003	<0.0003	<0.0003
Tomato, dried, pickled		1	0		<0.0016			
FRUITS								
Fruit, dried		9	1	<0.0016	0	0.002	<0.0016	
Juice, cranberry, conc.		1	0		0			
Nuts		16	1	<0.0023	0	0.002	<0.0023	<0.0023
Prune	x	2	0	<0.0016	<0.0016	<0.0016	<0.0016	
Raisin	x	8	3	<0.0016	<0.0016	0.002	<0.0016	
OTHERS								
Cinnamon		13	9	0.008	<0.0034	0.041	0.005	
Cocoa beverage-preparation, powder	x	13	11	0.007	<0.0034	0.012	0.007	0.012
Dietary supplement		90	58	0.072	0	5.500	0.005	0.051
Honey	x	174	1	<0.0019	0	<0.0019	0	<0.0019
Liquorice		3	0	<0.0034	<0.0034	<0.0034	<0.0034	
Paprika powder		15	2	<0.0034	0	<0.0034	<0.0034	0.011
Ready-to-eat meal		11	0	0	0	0	0	0
Tea, fruit	x	2	1	0.010	<0.0017	0.019	0.010	
Tea, herbal	x	14	14	0.007	0.002	0.020	0.005	0.020
Tofu		4	0	<0.0023	0	<0.0023	<0.0023	

16.1.2 Levels of lead

Foods	Included in expo-sure	No. of samples	Positive	Average	Minimum	Maximum	Median	P95th percentile
FISH								
Angler (Lophius piscatorius)		4	1	0.007	0	0.027		
Cod	x	12	2	<0.0045	0	0.005	<0.0045	<0.0045
Crayfish (Astacus spp.), meat		1	1	0.007	0.007	0.007	0.007	
Escolar, Snake Mackerel		4	0	<0.0025	<0.0025	<0.0025	<0.0025	
Fish, unspecified		49	9	<0.0052	0	0.027	<0.0052	0.006
Fish soup		1	0	0	0	0	0	
Greenland Halibut		32	3	<0.0035	0	0.013	<0.0035	<0.0035
Halibut		3	0	.0	0	0	0	
Herring (Clupea)		2	0	<0.0033	0	<0.0033	<0.0033	
Mackerel (Scomber)		2	2	0.003	0.002	0.005	0.003	
Pike (Esox lucius)		2	0	0	0	0	0	
Plaice (Pleuronectes)	x	3	0	<0.0033	0	<0.0033	<0.0033	
Rays (Hypotremata)		2	2	0.013	0.011	0.015	0.013	
Redfish, rockfish		4	0	<0.0033	0	<0.0033	0	
Salmon, meat		4	1	<0.0052	0	0.009	<0.0052	
Sea catfish (Anarhichas)		4	1	<0.0023	0	0.005	0	
Shark		3	2	0.041	0.002	0.006	0.005	
Trout	x	43	21	<0.0039	0	0.039	<0.0039	<0.0039
Tuna (Thunnus)		23	7	<0.0033	0	0.007	<0.0033	0.006
Tuna , canned	x	5	0	<0.0025	< 0.0025	< 0.0025	<0.0025	
Swordfish		8	4	0.007	0	0.041	0.003	
Zander (Sander lucioperca)		5	0		0	0	0	
BIVALVES AND SHELLFISH								
Bivalves, unspecific (Bivalvia)		15	15	0.075	0.029	0.104	0.079	0.104
Cockle (Cardium edule)		9	9	0.206	0.172	0.24	0.206	
Crab (Cancer spp.)		5	5	0.008	0.004	0.015	0.006	
Mussel		287	287	0.142	0.042	0.51	0.129	0.261
Oyster		75	75	0.07	0.013	0.28	0.052	0.187
Scallop		7	7	0.013	0.008	0.022	0.011	
Shrimps (Crangon crangon)	x	157	55	<0.0052	0	0.021	<0.0052	0.01
MEAT								
Beef kidney		149	149	0.072	0.011	5.5	0.03	0.074
Beef liver	x	9	8	0.014	0.002	0.023	0.016	
Beef meat	x	255	24	<0.0058	0	0.016	<0.0058	<0.0058
Boar meat (Sus scrofa)		5	1	<0.0024	0	0.003	0	

Chicken meat	x	155	9	<0.0058	0	0.015	<0.0058	
Duck meat (Anas spp.)	x	38	32	0.08	0.003	1.27	0.013	0.75
Duck meat (wild duck)	x	67	53	0.067	0.001	1.09	0.008	0.56
Game, deer, smoked meat		16	7	<0.0038	0	0.011	<0.0038	
Game, farmed, deer		90	24	0.028	0	1.05	<0.0058	0.146
Game, wild, deer		55	22	1.439	0	78	<0.0058	0.107
Horse kidney		9	9	0.025	0.009	0.043	0.021	
Horse meat		29	4	<0.0058	0	<0.0058	<0.0058	
Ostrich meat (Struthio camelus)		43	20	<0.0058	0	0.013	<0.0058	0.009
Pheasant meat (Phasianus colchius)		309	245	0.695	0	81.	0.014	0.982
Pigeon meat (Columba spp.)		46	17	0.232	0	9.9	<0.0058	0.066
Pork liver	x	39	21	<0.0058	0	0.036	<0.0058	0.018
Pork meat	x	384	43	<0.0058	0	0.021	<0.0058	<0.0058
Sheep meet	x	34	5	<0.0058	0	0.016	<0.0058	
Swine Kidney		42	28	0.008	0	0.16	<0.0058	0.015
Veal kidney		5	5	0.035	0.022	0.045	0.038	
Veal liver	x	15	15	0.02	0.005	0.063	0.011	0.063
DAIRY PRODUCTS								
Buttermilk	x	14	0	<0.0058	0	<0.0058	<0.0058	<0.0058
Cow milk, 1 - 2.9% fat (semi-skimmed milk)	x	7	0	<0.0058	0	<0.0058	<0.0058	
Cow milk, < 1% fat (skimmed milk)	x	14	0	<0.0058	0	<0.0058	<0.0058	<0.0058
Milk	x	7	1	<0.0058	0	0.007	<0.0058	
BABYFOOD								
Babyfood, based on fruits and vegetables, canned		25	20	0.004	0.002	0.013	<0.0042	<0.0042
Babyfood, based on fruits and vegetables, powder		2	2	0.006	0.004	0.007	0.006	
Babyfood, cereal based, canned		1	1	0.004	0.004	0.004	0.004	
Babyfood, cereal based, powder		28	27	0.004	0.001	0.013	0.003	0.011
Infant formulae, powder		8	5	0.005	0.001	0.008	0.006	
Ready-to-eat meal for infants and young children, canned		10	10	0.004	0.003	0.005	0.004	0.005
CEREALS								
Breadcrumbs	x	20	17	0.011	0	0.023	0.012	0.022
Breakfast cereals	x	22	16	0.011	0	0.08	0.008	0.027
Bulgur		9	2	<0.0073	0	0.008	<0.0073	0.008
Flour mix		1	0	<0.0073	<0.0073	<0.0073	<0.0073	
Pasta	x	21	10	<0.0073	0	<0.0073	<0.0073	<0.0073
Rice flour		4	2	<0.0052	0	0.007	<0.0052	
Rice	x	37	9	0.005	0	0.044	0.021	0.019

Rolled oat	x	18	3	<0.0052	0	0.007	<0.0052	0.007
Rye bread	x	22	12	0.009	0	0.039	0.006	0.03
Wheat bread, brown	x	22	20	0.009	0	0.034		8
Wheat bread, white	x	20	6	0.007	0	0.034	<0.0052	0.019
Wheat flour	x	34	7	<0.0073	0	<0.0073	<0.0073	<0.0073
Wheat kernels		3	0	<0.0073	<0.0073	<0.0073	<0.0073	
VEGETABLES								
Asparagus, canned	x	10	9	0.005	0.001	0.01	0.005	0.01
Cantharelle (Cantharellus cibarius)		5	5	0.084	0.014	0.354	0.016	
Chick pea	x	7	7	0.01	0.008	0.015	0.01	
Fungi, others		12	7	0.032	0.001	0.234	0.011	0.138
Fungi, unspecified, dried		5	3	0.17	0.003	0.72	0.037	
Linseed		13	3	0.011		0.048	<0.0073	0.048
Mushroom (Agaricus bisporus)	x	11	4	0.002	0.001	0.01	<0.0019	0.01
Mushroom, oyster (Pleurotus)		8	5	0.008	0.001	0.038	0.003	
Potatoes	x	81	32	<0.0012	0	0.006	<0.0012	0.003
Sweet corn	x	8	6	0.002	0	0.004	0.002	
Tomato, dried, pickled		1	1	0.11	0.11	0.11	0.11	
FRUIT								
Dried fruit		9	9	0.036	0.013	0.069	0.042	
Juice, cranberry, conc.		1	1	0.008	0.008	0.008	0.008	
Nuts		16	5	<0.0073	<0.0073	0.015	<0.0073	0.014
Peaches, canned	x	11	11	0.03	0.014	0.08	0.024	0.08
Pear, canned	x	9	9	0.029	0.017	0.063	0.028	
Pineapple, canned	x	8	8	0.004	0.002	0.01	0.002	
Prune	x	2	2	0.04	0.015	0.065	0.04	
Raisin	x	8	8	0.026	0.012	0.044	0.023	
OTHERS								
Chocolate products	x	8	8	0.023	0.009	0.052	0.02	
Cinnamon		13	13	0.732	0.057	4.82	0.264	4.82
Cocoa	x	18	18	0.141	0.026	0.5	0.121	0.5
Cocoa butter		2	2	0.079	0.067	0.09	0.079	
Dietary supplement		90	85	1.178	0	36.8	0.435	3.5
Honey	x	174	134	0.012	0	0.123	0.006	0.059
Liquorice		3	3	0.355	0.226	0.657	0.226	
Milk chocolate	x	12	11	0.017	0.005	0.037	0.037	12.
Paprika powder		15	15	0.311	0.047	1.08	0.263	1.08
Ready-to-eat meal		11	7	0.005	0.001	0.013	<0.0052	0.013
Tea, fruit	x	2	2	0.687	0.064	1.31	0.687	
Tea, herbal	x	14	14	0.565	0.114	1.33	0.435	1.33
Tofu		4	4	0.016	0.013	0.022	0.014	

16.1.3 Levels of cadmium

Foods	Included in exposure	Analysed	Positive	Average	Minimum	Maximum	Median	P95percentile
FISH								
Angler (Lophius piscatorius)		4	0	0	0	0	0	
Cod		12	1	<0.0025	0	<0.0025	<0.0025	
Escolar		4	4	0.017	0.008	0.024	0.018	
Fish, unspecified		49	11	<0.0063	0	<0.0063	<0.0063	<0.0063
Fish soup		1	1	0.037	0.037	0.037		
Greenland Halibut		32	1	<0.0086	0	<0.0086	<0.0086	<0.0086
Halibut		3	0	0	0	0	0	
Herring		2	1	0.002	<0.0014	0.003		
Mackerel (Scomber)		2	2	0.008	0.007	0.009	0.008	
Pike (Esox lucius)		2	0	0	0	0	0	
Plaice (Pleuronectes)	x	3	0	<0.0014	0	<0.0014	<0.0014	
Rays (Hypotremata)		2	0	0	0	0	0	
Redfish, rockfish		4	0	<0.0017	0	<0.0017	0	
Salmon, meat	x	4	0	<0.0063	0	<0.0063	<0.0063	
Sea catfish (Anarhichas)		4	1	<0.0017	0	0.004	0	
Shark		3	3	0.010	0.003	0.014	0.013	
Swordfish		8	8	0.058	0.012	0.125	0.061	
Trout	x	43	3	<0.0041	0	<0.0041	<0.0041	<0.0041
Tuna (Thunnus)		23	23	0.009	0.002	0.019	0.008	0.017
Tuna, canned	x	5	5	0.027	0.004	0.088	0.008	
Zander (Sander lucioperca)		5	0	0	0	0	0	
BIVALVES AND OTHER SHELLFISH								
Bivalves, unspecific		15	15	0.070	0.045	0.094	0.066	0.093
Cockle (Cardium edule)		9	9	0.039	0.025	0.072	0.037	
Crab (Cancer spp.)		5	5	0.010	0.005	0.014	0.010	
Crayfish (Astacus spp.), meat		1	1	0.081	0.081	0.081	0.081	
Mussels		287	287	0.113	0.025	0.640	0.099	0.185
Oyster		75	75	0.440	0.091	0.780	0.450	0.690
Scallop		7	7	0.498	0.358	0.650	0.500	
Shrimps (Crangon crangon)	x	157	136	0.048	<0.0086	1.11	0.016	0.179
MEAT								
Beef kidney		149	149	0.360	0.031	2.05	0.270	1.072
Beef liver	x	9	9	0.035	0.019	0.061	0.023	
Beef meat	x	255	7	<0.0033	0	0.005	0	<0.0033
Boar meat (Sus scrofa)		5	0	<0.0017	0	<0.0017	0	
Chicken meat	x	155	1	<0.0033	0	0.004	0	<0.0033

Duck meat (Anas spp.)	x	38	10	<0.0032	0	0.025	<0.0032	0.016
Duck meat (wild duck)	x	67	11	<0.0033	0	0.015	<0.0033	0.009
Game, deer, smoked meat		16	1	<0.003	<0.003	0.003	<0.003	<0.0033
Game		145	7	<0.0033	0	0.004	<0.0033	<0.0033
Horse kidney		9	9	15.2	2.28	27.3	16.9	
Horse meat		29	25	0.035	<0.0033	0.159	0.021	0.093
Ostrich meat (Struthio camelus)		43	0	<0.0033	0	<0.0033	<0.0033	<0.0033
Pheasant meat (Phasianus colchius)		309	156	0.004	0	0.139	<0.0033	0.009
Pigeon meat (Columba spp.)		46	31	0.016	0	0.070	0.006	0.046
Pork liver	x	39	39	0.028	0.010	0.067	0.026	0.053
Pork meat		384	4	<0.0033	0	0.004	0	<0.0033
Sheep meet	x	34	1	<0.0033	0	0.005	<0.0033	<0.0033
Swine Kidney		42	42	0.153	0.009	0.306	0.156	0.227
Veal kidney		5	5	0.165	0.059	0.320	0.140	
Veal liver	x	15	15	0.030	0.012	0.056	0.029	0.056
DAIRY PRODUCTS								
Buttermilk	x	14	0	<0,0033	0,000	<0,0033	0,000	<0,0033
Cow milk, 1 - 2.9% fat (semi-skimmed milk)	x	7	0	<0,0033	0,000	<0,0033	0,000	
Cow milk, < 1% fat (skim-med milk)	x	14	0	<0,0033	0,000	<0,0033	0,000	<0,0033
Milk	x	7	0	<0,0033	0,000	<0,0033	0,000	
BABYFOOD								
Babyfood, based on fruits and vegetables, canned		25	12	0,002	0,000	0,009	<0,0015	0,009
Babyfood, based on fruits and vegetables, powder		2	2	0,048	0,041	0,055	0,048	
Babyfood, cereal based, canned		1	1	0,013	0,013	0,013	0,013	
Babyfood, cereal based, powder		28	28	0,012	0,002	0,046	0,008	0,032
Breadcrumbs		20	20	0,032	0,017	0,043	0,032	0,042
Infant formulae, powder		8	3	0,001	0,000	0,003	<0,0013	
Ready-to-eat meal		11	9	0,011	<0,0033	0,053	0,006	0,053
Ready-to-eat meal for in-fants and young children, canned		10	10	0,008	0,006	0,011	0,007	0,011
CEREALS								
Breakfast cereals	x	22	22	0,021	0,006	0,038	0,021	0,033
Bulgur		9	9	0,035	0,010	0,096	0,020	
Flour mix		1	1	0,021	0,021	0,021	0,021	
Pasta	x	21	21	0,034	0,012	0,103	0,025	0,069
Rice flour		4	4	0,020	0,012	0,027	0,021	

Rice	x	37	37	0,024	0,004	0,065	0,020	0,064
Rolled oat	x	18	18	0,017	0,008	0,031	0,015	0,031
Rye bread	x	22	22	0,016	0,007	0,067	0,011	0,037
Wheat bread, brown	x	22	22	0,046	0,015	0,100	0,037	0,093
Wheat bread, white	x	20	20	0,021	0,014	0,028	0,021	0,028
Wheat flour	x	34	34	0,039	0,017	0,107	0,032	0,084
Wheat kernels		3	3	0,050	0,019	0,107	0,023	
VEGETABLES								
Asparagus, canned	x	10	4	0,001	0,000	0,004	<0,0012	0,004
Cantharelle (Cantharellus cibarius)		5	5	0,039	0,013	0,117	0,016	
Chick pea	x	7	0	<0,0085	<0,0085	<0,0085	<0,0085	
Fungi, others		12	10	0,121	<0,0085	0,363	0,112	0,307
Fungi, unspecified, dried		5	3	0,233	<0,0085	0,870	0,067	
Linseed		13	13	0,391	0,122	0,500	0,467	0,500
Mushroom (Agaricus bispo-rus)	x	11	10	0,009	<0,0026	0,025	0,007	0,025
Mushroom, oyster (Pleuro-tus)		9	9	0,084	0,003	0,332	0,032	
Potatoes	x	81	81	0,020	0,005	0,060	0,016	0,039
Sweet corn	x	8	3	<0,0012	<0,0012	0,002	<0,0012	
Tomato, dried, pickled		1	1		0,034	0,034		
FRUITS								
Dried fruit		9	3	0,009	0,000	0,031	<0,0028	
Juice, cranberry, conc.		1	1		0,006	0,006		
Nuts		16	4	0,005	<0,0028	0,022	<0,0028	0,019
Peaches, canned	x	11	1	0,002	0,000	0,015	<0,012	0,015
Pear, canned	x	9	2	<0,0012	0,000	0,003	<0,0012	
Pineapple, canned	x	9	7	0,021	0,000	0,079	0,005	
Prune	x	2	0	<0,0028	<0,0028	<0,0028		
Raisin	x	8	1	0,005	0,000	0,031	<0,0028	
OTHERS								
Bitter-sweet chocolate	x	20	20	0,161	0,033	0,610	0,128	0,530
Chocolate products	x	8	8	0,096	0,006	0,361	0,059	
Cinnamon		13	13	0,279	0,134	0,378	0,292	0,378
Cocoa powder	x	18	18	0,248	0,026	1,910	0,154	1,910
Cocoa butter		2	2	0,142	0,055	0,229	0,142	
Dietary supplement		90	72	0,077	0,000	0,780	0,045	0,253
Honey	x	174	40	<0,0051	0,000	0,025	<0,0051	0,005
Liquorice		3	3	0,007	0,005	0,010	0,007	
Milk chocolate		12	11	0,011	<0,0038	0,020	0,010	0,184
Paprika powder		15	15	0,170	0,027	0,802	0,072	0,802
Seaweed, dried		27	27	1,087	0,010	3,900	0,480	3,600

Tea, fruit	x	2	2	0,114	0,006	0,222	0,114	0,222
Tea, herbal	x	14	14	0,089	0,035	0,310	0,073	0,310
Tofu		4	1	<0,0085	<0,0085	0,010	<0,0085	

16.1.4 Levels of inorganic arsenic in mg/kg

Foods	Included in exposure calculation	No. of sam-ples	Posi tive	Average	Mini-mum	Maximum	Median	95th percentile
FISH								
Cod	x	1	0	<0.04	<0.04	<0.04	<0.04	
Herring, meat	x	1	0	0	0	0	0	
Mackerel (Scomber)	x	1	0	<0.04	<0.04	<0.04	<0.04	
Plaice (Pleuronectes)	x	1	0	<0.04	<0.04	<0.04	<0.04	
Pollack (Pollachius pollachius)	x	2	0	<0.04	<0.04	<0.04	<0.04	
SHELLFISH AND BIVALVES								
Mussel (Mytilus edulis)		18	7	0.042	<0.040	0.092	0.041	0.092
Oyster		6	3	<0.04	<0.04	<0.04	<0.04	
CEREALS								
Rice cake (puffed)	x	15	15	0.31	0.21	0.46	0.31	0.46
Rice, brown	x	28	12	0.16	<0.05	0.48	0.15	0.32
Rice, short grained	x	8	1	0.10	<0.05	0.17	0.11	
Rice, white	x	47	1	0.084	<0.05	0.22	<0.078	0.13
Rice, wild	x	5	0	0.089	<0.05	0.16	0.093	
OTHERS								
Seaweed, unspecified, dried		27	8	0.55	0	9.7	<0.099	3.6

16.1.5 Levels of total arsenic in mg/kg

Foods	Included in expo-sure	No. Of samples	Posi-tive	Average	Minimum	Maximum	Median	95th percen-tile
FISH								
Angler (Lophius piscatorius)		4	4	18.2	9.5	32.6	15.3	
Cod		5	5	3.6	2.1	5.6	4.0	
Fish, unspecifed		20	20	10.3	0.5	118	3.1	21.2
Fish soup		1	1	0.6	0.6	0.6		
Greenland Halibut		6	6	3.8	1.0	6.5	3.8	
Halibut		3	3	6.8	4.0	10.0	6.3	
Herring (Clupea)		2	2	1.8	1.7	2.0		
Mackerel (Scomber)		2	2	1.5	0.7	2.4		
Pike (Esox lucius)		2	2	0.0	0.0	0.1		
Plaice (Pleuronectes)	x	3	3	11.2	8.3	14.1	11.3	
Porbeagle (Lamna nasus)		2	2	2.0	1.3	2.7		
Rays (Hypotremata)		2	2	209	160	257		
Redfish, rockfish		3	3	2.1	0.6	4.0	1.6	
Sea catfish and wolf-fish (Anarhichas)		4	4	6.1	2.2	11.0	5.7	
Swordfish		3	3	0.58	0.44	0.72	0.58	
Tuna (Thunnus)		9	9	1.06	0.38	2.27	0.98	
Zander (Sander lucioperca)		5	5	0.05	0.03	0.08	0.04	
BIVALVES								
Cockle (Cardium edule)		5	5	0.92	0.84	0.98	0.91	
Mussel (Mytilus edulis)		82	82	1.12	0.80	1.73	1.06	1.60
Oyster		37	37	0.99	0.73	1.56	0.94	1.44
CEREALS								
Breadcrumbs	x	20	3	<0.011	0.00	0.03	0.00	0.02
Breakfast cereals	x	22	13	0.01	0.00	0.07	0.01	0.02
Bulgur		9	6	0.01	<0.0065	0.02	0.01	
Flour mix		1	0	0.00	0.00	0.00		
Pasta	x	21	12	0.01	0.00	0.03	0.01	0.03
Rice cake (puffed)		15	15	0.36	0.24	0.64	0.33	0.64
Rice flour		4	4	0.13	0.04	0.20	0.13	
Rice	x	125	125	0.25	0.01	0.49	0.25	0.30
Rolled oat	x	18	8	<0.011	0.00	0.04	<0.011	0.04
Rye bread	x	22	5	<0.011	0	0.02	<0.011	0.02
Wheat bread, brown	x	22	9	<0.011	0	0.02	<0.011	0.02
Wheat bread, white	x	20	0	<0.011	0	<0.011		<0.011
Wheat flour	x	34	6	0.02	0	0.03	0.01	0.02
Wheat kernels		3	0	<0.065	<0.065	<0.065	<0.065	

VEGETABLES								
Cantharelle (Cantharellus cibarius)		5	1	0.02	<0.014	0.09	<0.014	
Chick pea	x	7	7	0.02	0.01	0.02	0.02	
Fungi,		4	1	0.02	0	0.06	<0.014	
Fungi, dried		5	3	0.04	<0.014	0.10	0.04	
Linseed		13	6	0.01	0	0.03	<0.0065	0.03
Mushroom (Agaricus bispo-rus)	x	11	1	<0.014	<0.014	0.02	<0.014	0.02
Mushroom, oyster (Pleurotus)		9	4	0.02	<0.014	0.12	0.01	
Potatoes	x	81	25	<0.0011	0	0.01	<0.0011	0
FRUIT								
Juice, cranberry, conc.		1	1		0.01	0.01		
Nuts		14	5	<0.0065	0	0.04	<0.0065	0.02
OTHERS								
Cocoa beverage-preparation, powder	x	13	13	0.04	0.01	0.08	0.04	0.08
Cinnamon		13	13	0.05	0.01	0.21	0.03	0.21
Dietary supplement		89	81	0.34	0	5.0	0.13	1.11
Liquorice		3	3	0.40	0.13	0.63	0.45	
Paprika powder		15	15	0.09	0.02	0.43	0.05	0.43
Ready-to-eat meal		1	1	0.03	0.03	0.03		
Seeweed, unspecified, dried		27	27	23	0	61	22	43
Tea, fruit	x	2	2	0.18	0.02	0.34		
Tea, herbal	x	14	14	0.13	0.03	0.26	0.12	0.26
Tofu		4	0	<0.065	<0.065	<0.065	<0.065	

16.1.6 Levels of selenium in mg/kg

Foods	Included in exposure	Number of samples	Positive	Average	Minimum	Maximum	Median	95th percentile
FISH								
Angler (Lophius piscatorius)		4	4	0.290	0.209	0.357	0.296	
Fish , unpsecified		21	21	0.355	0.16	0.593	0.388	0.593
Fish soup		1	1	0.465	0.465	0.465	0.465	
Greenland Halibut		6	6	0.240	0.157	0.352	0.221	
Halibut		3	3	0.461	0.385	0.516	0.481	
Mackerel (Scomber)		1	1	0.318	0.318	0.318	0.318	
Pike (Esox lucius)		2	2	0.262	0.183	0.341	0.262	
Porbeagle (Lamna nasus)		2	2	0.312	0.306	0.318	0.312	
Rays (Hypotremata)		2	2	0.45	0.413	0.486	0.45	
Redfish, rockfish		3	3	0.361	0.266	0.461	0.355	
Sea catfish and wolf-fish (Anarhichas)		4	4	0.319	0.168	0.453	0.328	
Swordfish		3	3	0.724	0.578	0.849	0.746	
Trout	x	40	40	0.165	0.123	0.204	0.162	0.195
Tuna (Thunnus)		9	9	0.683	0.426	0.777	0.724	
Zander (Sander lucioperca)		5	5	0.128	0.107	0.171	0.121	
CEREALS								
Breadcrumbs	x	20	19	0.028	<0.012	0.045	0.029	0.045
Breakfast cereals	x	22	15	0.032	0	0.095	0.04	0.06
Bulgur		9	5	0.026	0	0.078	0.02	
Flour mix		1	1	0.069	0.069	0.069	0.069	
Pasta	x	21	21	0.223	0.031	0.617	0.17	0.611
Rice flour		4	4	0.109	0.025	0.192	0.109	
Rice	x	37	35	0.077	0	0.282	0.037	0.18
Rolled oat	x	18	6	<0.012	0	0.024	<0.012	0.024
Rye bread	x	22	10	0.012	0	0.06	<0.012	0.033
Wheat bread, brown	x	22	22	0.071	0.022	0.28	0.05	0.141
Wheat bread, white	x	20	14	0.017	0	0.042	0.02	0.042
Wheat flour	x	34	27	0.033	0	0.103	0.033	0.055
Wheat kernels		3	2	0.045	0	0.072	0.062	
VEGETABLES								
Cantharelle (Cantharellus cibarius)		5	1	0.039	<0.011	0.165	<0.011	
Chick pea	x	7	5	0.034	0	0.071	0.034	
Fungi, unspecified		12	9	0.708	<0.011	3.93	0.021	
Fungi, unspecified, dried		5	3	0.719	0	3.51	0.019	
Linseed		13	8	0.225	0	0.73	0.021	
Mushroom (Agari-	x	11	11	0.148	0.033	0.4	0.115	0.4

cus bisporus)								
Mushroom, oyster (Pleurotus)		9	7	0.029	<0.011	0.137	0.014	
Potatoes	x	81	45	0.002	0	0.011	0.001	0.005
OTHERS								
Cinnamon		13	9	0.022	0	0.11	0.021	
Cocoa beverage-preparation, powder	x	13	13	0.087	0.027	0.114	0.091	0.114
Dietary supplement		1	1	0.074	0.074	0.074	0.074	
Liquorice		3	3	0.108	0.074	0.131	0.034	
Nuts		14	13	0.177	<0.014	0.480	0.134	0.480
Paprika powder		15	12	0.059	0.	0.187	0.061	0.187
Ready-to-eat meal		1	1	0.42	0.42	0.42	0.42	
Tofu		4	0	0	0	0	0	

16.1.7 Levels of aluminium in mg/kg

Foods	No. of samples	Positive	Average	Minimum	Maximum	Median	95th percentile
Babyfood, based on fruits and vegetables, canned	19	19	0.97	0.19	4.40	0.66	4.40
Babyfood, based on fruits and vegetables, powder	2	2	0.75	0.70	0.79	0.75	
Babyfood, cereal based, powder	28	25	0.83	<0.1	3.90	0.49	3.57
Ready-to-eat meal for infants and young children, canned	10	10	1.34	0.70	4.10	0.86	4.10

16.1.8 Levels of nickel in mg/kg

Foods	Included in exposure	Analysed	Positive	Mean	Minimum	Maximum	Median	P95percentil
FISH								
Angler (Lophius piscatorius)		4	1	<0.008	0	<0.008	0	
Fish and other seafood		20	6	0.0044	0	0.0224	0	0.0196
Fish soup		1	0		0	0		
Greenland Halibut		6	3	<0.008	0	0.0153	<0.008	
Halibut		3	0	0.	0	0.	0	
Mackerel (Scomber)		1	0		0			
Pike (Esox lucius)		2	0	<0.008	0	<0.008	<0.008	
Porbeagle (Lamna nasus)		2	0	<0.008	0	<0.008	<0.008	
Rays (Hypotremata)		2	0	0	0	0		
Redfish, rockfish		3	0	0	0	0	0	
Sea catfish (Anarhichas)		4	0	<0.008	0	<0.008	<0.008	
Swordfish		3	0	<0.008	0	<0.008	0.	
Tuna (Thunnus)		9	3	<0.008	0	0.029	<0.008	
Zander (Sander lucioperca)		5	1	0.013	0	0.0589	0	
VEGETABLES								
Potatoes	x	81	81	0.0295	0.0038	0.257	0.0227	0.0651
Tomato, dried, pickled		1	1		0.7222	0.7222		
FRUIT								
Dried fruit		7	7	0.4646	0.0451	1.9424	0.1236	
Coconuts, flakes		2	2	2.66	2.11	3.2	2.66	
Prune	x	2	2	0.2781	0.2348	0.3213	0.2781	
Raisin	x	8	8	0.0614	0.0356	0.1202	0.052	
BABYFOOD								
Babyfood, based on fruits and vegetables, canned		6	6	0.0693	0.053	0.128	0.0575	
Babyfood, cereal based, canned		1	1	0.026	0.026	0.026	0.026	
Infant formulae, powder		8	8	0.0909	0.042	0.252	0.066	
CEREALS								
Breadcrumbs	x	20	20	0.0569	0.024	0.161	0.0485	0.1445
Breakfast cereals	x	22	22	0.7704	0.173	1.56	0.699	1.466
Pasta	x	19	19	0.0793	0.0468	0.175	0.0766	0.175

Rice flour		4	4	0.1995	0.163	0.234	0.2005	
Rice	x	37	37	0.2504	0.0272	0.757	0.235	0.4467
Rolled oat	x	18	18	0.7099	0.426	1.5	0.675	1.5
Rye bread	x	22	22	0.0673	0.022	0.265	0.0435	0.2039
Wheat bread, brown	x	22	22	0.1809	0.029	0.63	0.1445	0.54
Wheat bread, white	x	20	18	0.0341	<0.022	0.099	0.0285	0.0563
Wheat flour	x	21	16	0.0456	<0.022	0.157	0.028	0.126
OTHERS								
Bitter-sweet chocolate	x	20	20	3.41	2.1	5.4	3.25	5.25
Chocolate products	x	8	8	3.15	0.73	5.8	3.15	5.8
Cinnamon		13	13	0.3163	0.106	1.71	0.167	1.71
Cocoa powder	x	18	18	10.73	2.41	12.8	11.1	12.8
Cocoa butter		2	2	6.9	5.3	8.5	6.9	8.5
Liquorice		2	2	2.71	1.74	3.78	2.62	
Milk chocolate	x	12	12	0.7326	0.031	1.16	0.765	1.094
Paprika powder		15	15	2.25	0.86	5.58	1.74	5.58
Ready-to-eat meal		11	9	0.0597	0.0106	0.165	0.046	0.165

16.1.9 Levels of manganese

Foods	No. of samples	Positive	Average	Minimum	Maximum	Median	95th percentile
Babyfood, based on fruits and vegetables, canned	25	25	1.18	0.17	3.70	0.87	3.50
Babyfood, based on fruits and vegetables, powder	2	2	2.42	2.30	2.53	2.42	-
Babyfood, cereal based, canned	1	1	1.40	1.40	1.40	-	-
Babyfood, cereal based, powder	28	28	6.41	0.55	20.0	4.40	19.6
Infant formulae, powder	8	8	2.08	0.36	5.5	0.66	-
Ready-to-eat meal	10	10	0.95	0.27	1.99	0.81	1.99
Ready-to-eat meal for infants and young children, canned	10	10	0.90	0.68	1.05	0.93	1.05

16.1.10 Levels of tin in mg/kg

Foods	No. of samples	Positive	Average	Minimum	Maximum	Median	95th percentile
Asparagus, canned	10	9	0.53	0	2.19	0.34	2.19
Peaches, canned	11	11	67.3	41.3	98.0	61.5	98.0
Pear, canned	9	9	85.9	37.9	132	82.0	-
Pineapple, canned	8	8	64.2	40.5	93.0	58.5	-
Sweet corn	8	8	1.38	<0.007	5.90	0.90	-

16.1.11 Levels of cupper in mg/kg

Foods	No. of samples	Positive	Average	Minimum	Maximum	Median
Apricot, dried	1	1	3.29	3.29	3.29	3.29
Banana, dried	1	1	1.53	1.53	1.53	1.53
Coconuts, flakes	2	2	6.84	6.23	7.44	6.84
Cranberry, dried	1	1	0.58	0.58	0.58	0.58
Dates, dried	2	2	2.53	2.38	2.68	2.53
Figs, dried	2	2	3.88	3.85	3.91	3.88
Mango, dried	1	1	1.34	1.34	1.34	1.34
Pineapple, dried	1	1	0.79	0.79	0.79	0.79
Prune	2	2	2.81	2.72	2.9	2.81
Raisin	8	8	3.90	3.03	5.42	3.65
Tomato, dried, pickled	1	1	5.19	5.19	5.19	5.19

16.2 Nitrate

Nitrate level (mg/kg fresh weight) in vegetables and other products collected between 2004 and 2011.

Foods	Nu. of samples	Included in exposure	Positive	Average	Min	Max	Median	95th percentile
Baby food based on fruit and vegetable, Danish	50		46	19	<5	120	11	61
Baby food based on fruit and vegetable, foreign	24		21	18	<5	52	13	52
Baby food, cereal based, canned	4		3	6	<5	11	6	-
Iceberg, Danish	3	x	3	720	420	1100	640	-
Iceberg, foreign	40	x	40	969	210	1800	985	1400
Iceberg, all	43	x	43	952	210	1800	970	1400
Lettuce, Danish	232	x	232	2287	<5	6800	2300	4000
Lettuce, foreign	131	x	131	1793	75	4700	1600	3800
Lettuce, all	363	x	363	2109	<5	6800	2100	3900
Potatoes, Danish	288	x	288	148	148	660	140	280
Potatoes, foreign	66	x	66	274	37	720	240	620
Potatoes, all	354	x	154	172	6	720	155	370
Potatoes, new, Danish	37	x	37	122	31	250	120	210
Potatoes, new, foreign	12	x	12	342	98	710	290	710
Spinach, Danish	13	x	13	1929	350	3600	1900	3600
Spinach, foreign	12	x	12	2477	430	4500	2800	4500
Spinach, all	25	x	25	2192	350	4500	2200	3700
Rucola, Danish	33		33	4124	590	7000	4300	6600
Rucola, foreign	40		40	5578	2700	7600	5700	7250
Spices, Danish	5		5	72	15	190	54	-
Spices, foreign	31		27	148	<5	540	75	500
Chinese cabbage, Danish	4		4	593	260	960	575	-
Dill, dry	3		3	10167	5800	12700	12000	-

16.3 Mycotoxins

16.3.1 Levels of deoxynivalenole

Foods	Number of samples	Number < LOQ	Mean	Median	Max	95 % percentile
Wheat flour	177	74	70	29	2600	190
Wheat kernel	6	3	24	20	52	160
Wheat bran	28	6	185	63	1500	750
Wheat meal	12	4	50	29	160	29
Rye flour	138	94	29	10	440	98
Oat (rolled)	82	39	75	30	1000	260
Oatkernel	34	9	227	42	1700	820
Oatbran	2	0	185	185	200	200
Einkorn	4	2	32	20	79	79
Spelt flour	18	11	57	13	430	430
Spelt bran	2	2	<LOQ	<LOQ	<LOQ	<LOQ
Baby food	3	3	<LOQ	<LOQ	<LOQ	<LOQ

LOQ for DON 20 µg/kg

16.3.2 Levels of HT-2 in µg/kg

Foods	Number of samples	Number < LOQ	Mean	Median	Max	95 % percentile
Wheat flour	57	57	<LOQ	< LOQ	<LOQ	<LOQ
Wheat kernel	6	6	<LOQ	< LOQ	<LOQ	<LOQ
Wheat bran	28	10	10	5	42	32
Wheat meal	12	10	1.2	1	5	5
Rye flour	42	41	0.9	1	2	1
Oatmeal	35	7	5.2	21	4	13
Oatkernel	34	2	40	13	400	180
Oatbran	2		5.2	5	8	8
Einkorn	4	3	1.5	1	3	3
Spelt flour	18	17	<LOQ	<LOQ	3.1	3.1

LOQ for HT-2 toxin 2.0 µg/kg

16.3.3 Levels of T-2 in µg/kg

Foods	Number of samples	Number <LOQ	Mean	Median	Max	95% percentile
Wheat flour	57	54	< LOQ	<LOQ	2.8	2.5
Wheat kernel	6	6	< LOQ	< LOQ	<LOQ	<LOQ
Wheat bran	28	19	1.7	<LOQ	4.6	4.1
Wheat meal	12	10	<LOQ	<LOQ	3.2	3.2
Rye flour	42	42	<LOQ	<LOQ	1.4	1.1
Oatmeal	35	17	1.9	1.6	5.6	4.8
Oatkernel	34	8	13	3.6	170	46
Oatbran	2	1	2.3	2.3	3.8	3.8
Einkorn	4	4	<LOQ	<LOQ	<LOQ	<LOQ
Spelt flour	18	18	<LOQ	<LOQ	<LOQ	<LOQ

LOQ for T-2 toxin 1.6 µg/kg

16.3.4 Levels of ochratoxin A (OTA) in µg/kg

Foods	Number of samples	Number <LOQ	Mean	Median	Max	95th percentile
Rye flour	121	40	0.6	0.17	12	2.9
Rye kernels	1	1	<LOQ	<LOQ	<LOQ	<LOQ
Wheat bran	25	8	0.4	0.18	1.2	1.1
Wheat meal	2	1	1	0.18	0.3	0.3
Spelt flour	9	5	0.2	0.1	1.1	1.1
Spelt bran	2	1	0.1	0.1	0.1	0.1
Oat bran	1	1	<LOQ	<LOQ	<LOQ	<LOQ
Babyfood	6	6	<LOQ	<LOQ	<LOQ	<LOQ

LOQ for OTA 0.1 µg/kg

16.4 Dioxin and PCB

16.4.1 Sampling plan during 2004 to 2011

	2004	2005	2006	2007	2008	2009	2010	2011
Pig	10	10	10	10	10	100	98	94
Bovine	10	10	10	10	10	100	102	110
Sheep	10	10	10	10	10	3	4	
Poultry	29	30	30	30	25	5	5	5
Horse							2	
Deer, farmed								5
Goat								3
Wild boar								5
Meat products and ready meals								11
Hen eggs	20	20	20	20	20	20	26	20
Raw milk, cow	20	20	20	20	20	20	20	20
Dairy products	6	3	3					
Cereals, fruit, vegetables	15	7	7					
Vegetable oil	6	3	3					
Aquaculture fish	10	10	10	10	5	5	5	5
Wild fish	10	11	10	26	17	5	31	16
Fish and fish products, detail			31	15	19	16	20	23
Mussels, shrimp	2	12	11	12	24	7	9	
Fish oil, dietary supplement	9	6	6		10	6	6	
Food for infants				10				
Total number of samples	**157**	**152**	**181**	**173**	**170**	**287**	**328**	**317**

16.4.2 Levels of WHO-TEQ[2005] PCDD/F+PCB (pg/g fat)

Food	Included in exposure calculation	Number of samples	Average	Median	Minimum	Maximum	95th percentile
Raw milk, cow	x	162	0.52	0.50	0.18	1.11	0.78
Dairy products	x	13	0.54	0.52	0.44	0.67	0.63
Hen eggs - cage	x	50	0.44	0.35	0.18	2.30	0.74
Hen eggs - free range	x	116	1.16	0.81	0.21	6.31	3.45
Pasteurized hen eggs		6	0.53	0.48	0.30	0.86	-
Bovine fat	x	377	0.82	0.61	0.11	5.88	1.94
Bovine meat		12	0.75	0.68	0.46	1.16	1.12
Pig fat	x	340	0.20	0.18	0.07	0.98	0.35
Wild boar fat		5	0.45	0.44	0.10	0.87	-
Sheep fat	x	50	1.04	0.87	0.28	2.62	2.37
Goat fat		3	1.56	1.57	1.50	1.62	-
Chicken fat	x	128	0.32	0.19	0.08	3.74	0.87
Hen fat	x	24	1.08	1.07	0.20	2.76	2.01
Deer fat - farmed		5	1.96	1.94	1.03	3.00	-
Sausages	x	8	0.35	0.24	0.16	0.89	-
Bovine liver	x	3	1.26	0.99	0.96	1.83	-
Pig liver	x	3	0.89	0.87	0.68	1.12	-
Sheep liver		7	13.28	12.58	4.64	25.17	-
Chicken liver		5	0.53	0.51	0.44	0.70	-
Vegetable oils	x	9	0.13	0.12	0.04	0.27	-
Food for infants		8	1.22	1.02	0.20	3.30	-
Cereals*		10	0.03	0.03	0.02	0.05	0.05
Fruits and vegetables*		19	0.05	0.04	0.02	0.10	0.09

*pg/g wet weight

16.4.3 Levels of WHO-TEQ2005 PCDD/F+PCB in fish and seafood (pg/g wet weight)

Food	Included in exposure calculation	Number of samples	Average	Median	Minimum	Maximum	95th per-centile
Greenland halibut - Greenland	x	25	0.54	0.41	0.19	2.72	1.27
Sprat - The Baltic Sea		10	5.83	5.59	4.92	7.31	7.00
Sea Trout - The Baltic Sea		2	8.59	8.59	8.10	9.08	-
Salmon - The Baltic Sea		11	7.93	7.99	5.83	10.56	10.08
Smoked salmon - The Baltic Sea		10	8.32	8.12	6.00	12.33	11.58
Herring - The Baltic Sea		58	2.98	2.68	1.12	7.72	5.62
Trout - aquaculture	x	44	0.42	0.35	0.04	1.20	1.02
Trout - marine aquaculture		6	0.65	0.67	0.30	0.92	-
Eel - aquaculture	x	12	1.52	1.42	1.04	2.53	2.09
Fish oil dietary supplement		43	1.14	0.65	0.18	6.31	4.79
Fresh water fish		10	0.25	0.17	0.11	0.66	0.57
Cod liver		8	35.12	38.82	0.86	62.65	-
Blue mussels	x	40	0.29	0.24	0.04	1.16	0.52
Oyster		6	0.61	0.61	0.15	1.19	-
Scallops - Greenland		21	0.02	0.02	0.01	0.04	0.03
Shrimp - Greenland	x	10	0.03	0.03	0.02	0.03	0.03
Monkfish		5	0.11	0.11	0.10	0.12	-
Halibut		4	0.29	0.17	0.10	0.72	-
Salmon	x	31	0.83	0.58	0.10	3.14	2.62
Mackerel	x	12	0.87	0.67	0.23	3.27	2.30
Pangasius		10	0.04	0.04	0.02	0.07	0.07
European plaice	x	4	0.58	0.59	0.34	0.80	-
Herring	x	8	1.10	1.02	0.84	1.47	-
Herring - smoked		3	0.76	0.76	0.67	0.84	-
European flounder	x	4	0.65	0.62	0.16	1.20	-
Tuna	x	6	0.43	0.06	0.05	2.27	-
Eel		11	2.62	2.61	1.33	4.46	4.11

16.4.4 Levels of WHO-TEQ^{2005} PCDD/F (pg/g fat)

Food	Included in exposure calculation	Number of samples	Average	Median	Minimum	Maximum	95th per-centile
Raw milk, cow	x	162	0.27	0.26	0.12	0.76	0.44
Dairy products	x	13	0.27	0.28	0.15	0.40	0.37
Hen eggs - cage	x	50	0.29	0.24	0.10	1.41	0.62
Hen eggs - free range	x	116	0.69	0.45	0.14	4.54	2.27
Pasteurized hen eggs		6	0.46	0.42	0.25	0.75	-
Bovine fat	x	377	0.37	0.29	0.07	2.49	0.90
Bovine meat		12	0.29	0.25	0.19	0.49	0.44
Pig fat	x	340	0.17	0.15	0.05	0.68	0.31
Wild boar fat		5	0.36	0.38	0.09	0.70	-
Sheep fat	x	50	0.62	0.44	0.15	1.83	1.39
Goat fat		3	0.57	0.48	0.46	0.76	0.73
Chicken fat	x	128	0.21	0.15	0.05	2.20	0.39
Hen fat	x	24	0.47	0.43	0.12	1.21	0.88
Deer fat - farmed		5	0.53	0.49	0.23	0.85	-
Sausages	x	8	0.20	0.19	0.14	0.26	-
Bovine liver	x	3	0.97	0.78	0.72	1.40	-
Pig liver	x	3	0.70	0.75	0.54	0.82	-
Sheep liver		7	10.08	10.77	3.31	19.68	-
Chicken liver		5	0.49	0.49	0.38	0.65	-
Vegetable oils	x	9	0.10	0.10	0.03	0.25	-
Food for infants		8	0.98	0.81	0.08	2.93	-
Cereals*		10	0.03	0.03	0.02	0.04	0.04
Fruits and vegetables*		19	0.04	0.03	0.01	0.08	0.06

*pg/g wet weight

16.4.5 Levels of WHO-TEQ^{2005} PCDD/F in fish and seafood (pg/g wet weight)

Food	Included in exposure calculation	Number of samples	Average	Median	Minimum	Maximum	95th per-centile
Greenland halibut - Greenland	x	25	0.18	0.15	0.06	0.53	0.39
Sprat - The Baltic Sea		10	2.30	2.26	1.76	3.03	2.88
Sea Trout - The Baltic Sea		2	2.70	2.70	2.31	3.09	-
Salmon - The Baltic Sea		11	2.88	2.76	2.34	3.46	3.43
Smoked salmon - The Baltic Sea		10	2.97	2.77	2.34	4.21	4.01
Herring - The Baltic Sea		58	1.47	1.24	0.57	3.87	2.84
Trout - aquaculture	x	44	0.11	0.08	0.03	0.33	0.24
Trout - marine aquaculture		6	0.16	0.16	0.09	0.22	-
Eel - aquaculture	x	12	0.28	0.27	0.17	0.47	0.45
Fish oil dietary supplement		43	0.25	0.23	0.07	1.11	0.46
Fresh water fish		10	0.12	0.06	0.04	0.34	0.29
Cod liver		8	7.87	7.57	0.19	14.47	-
Blue mussels	x	40	0.15	0.14	0.03	0.56	0.29
Oyster		6	0.50	0.53	0.11	0.94	-
Scallops - Greenland		21	0.02	0.02	0.01	0.03	0.03
Shrimp - Greenland	x	10	0.02	0.02	0.02	0.02	0.02
Monkfish		5	0.06	0.06	0.05	0.08	-
Halibut		4	0.13	0.10	0.04	0.27	-
Salmon	x	31	0.25	0.18	0.04	1.12	0.84
Mackerel	x	12	0.26	0.19	0.07	1.01	0.68
Pangasius		10	0.04	0.03	0.02	0.07	0.06
European plaice	x	4	0.33	0.33	0.19	0.48	-
Herring	x	8	0.52	0.52	0.39	0.75	-
Herring, smoked		3	0.40	0.38	0.33	0.47	-
European flounder	x	4	0.25	0.20	0.07	0.54	-
Tuna	x	6	0.08	0.04	0.02	0.28	-
Eel		11	0.65	0.56	0.27	1.17	1.08

16.4.6 Levels of WHO-TEQ^{2005} PCB (pg/g fat)

Food	Included in exposure calculation	Number of samples	Average	Median	Minimum	Maximum	95th per-centile
Raw milk, cow	x	162	0.24	0.22	0.01	0.85	0.41
Dairy products	x	13	0.27	0.30	0.19	0.37	0.36
Hen eggs – cage	x	50	0.15	0.11	0.02	0.95	0.28
Hen eggs - free range	x	116	0.47	0.34	0.05	1.80	1.33
Pasteurized hen eggs		6	0.07	0.06	0.03	0.11	-
Bovine fat	x	377	0.45	0.31	0.01	4.23	1.21
Bovine meat		12	0.46	0.44	0.14	0.83	0.81
Pig fat	x	340	0.03	0.02	0.00	0.66	0.07
Wild boar fat		5	0.10	0.09	0.01	0.18	-
Sheep fat	x	50	0.42	0.33	0.14	1.21	0.92
Goat fat		3	1.00	1.10	0.74	1.15	-
Chicken fat	x	128	0.11	0.04	0.01	1.53	0.45
Hen fat	x	24	0.61	0.55	0.08	1.55	1.24
Deer fat - farmed		5	1.43	1.44	0.56	2.38	-
Sausages	x	8	0.16	0.02	0.02	0.63	-
Bovine liver	x	3	0.29	0.24	0.21	0.43	-
Pig liver	x	3	0.19	0.14	0.12	0.29	-
Sheep liver		7	3.20	3.09	1.33	5.96	-
Chicken liver		5	0.04	0.04	0.02	0.06	-
Vegetable oils	x	9	0.03	0.01	0.00	0.09	-
Food for infants		8	0.23	0.16	0.03	0.73	-
Cereals*		10	0.00	0.00	0.00	0.01	0.01
Fruits and vegetables*		19	0.01	0.00	0.00	0.07	0.02

*pg/g wet weight

16.4.7 Levels of WHO-TEQ^{2005} PCB in fish and seafood (pg/g wet weight)

Food	Included in exposure calculation	Number of samples	Average	Median	Minimum	Maximum	95th per-centile
Greenland halibut - Greenland	x	25	0.37	0.26	0.14	2.19	0.91
Sprat - The Baltic Sea		10	3.53	3.34	3.08	4.28	4.26
Sea Trout - The Baltic Sea		2	5.89	5.89	5.79	5.99	-
Salmon - The Baltic Sea		11	5.05	5.24	3.46	7.10	6.69
Smoked salmon - The Baltic Sea		10	5.36	5.25	3.66	8.12	7.57
Herring - The Baltic Sea		58	1.51	1.41	0.55	3.84	2.76
Trout - aquaculture	x	44	0.31	0.25	0.02	0.98	0.78
Trout - marine aquaculture		6	0.49	0.50	0.21	0.72	-
Eel - aquaculture	x	12	1.24	1.18	0.88	2.06	1.72
Fish oil dietary supplement		43	0.90	0.35	0.02	5.21	4.63
Fresh water fish		10	0.14	0.11	0.06	0.32	0.29
Cod liver		8	27.25	30.78	0.66	50.04	-
Blue mussels	x	40	0.13	0.10	0.01	0.61	0.30
Oyster		6	0.11	0.08	0.04	0.26	-
Scallops - Greenland		21	0.00	0.00	0.00	0.00	0.00
Shrimp - Greenland	x	10	0.01	0.01	0.00	0.01	0.01
Monkfish		5	0.05	0.05	0.03	0.06	-
Halibut		4	0.16	0.07	0.06	0.45	-
Salmon	x	31	0.58	0.40	0.03	2.08	1.77
Mackerel	x	12	0.61	0.49	0.14	2.26	1.62
Pangasius		10	0.01	0.01	0.00	0.01	0.01
European plaice	x	4	0.25	0.25	0.15	0.35	-
Herring	x	8	0.59	0.52	0.45	0.86	-
Herring, smoked		3	0.36	0.36	0.28	0.43	-
European flounder	x	4	0.40	0.43	0.08	0.66	-
Tuna	x	6	0.35	0.02	0.01	1.99	-
Eel		11	1.97	1.95	0.80	3.29	3.15

16.4.8 Levels of PCB-6 (ng/g fat)

Food	Included in exposure calculation	Number of samples	Average	Median	Minimum	Maximum	95th per-centile
Raw cows milk	x	162	1.36	1.21	0.50	4.60	2.55
Dairy products	x	13	1.43	1.25	0.60	2.61	2.39
Hen eggs – cage	x	50	2.43	1.88	0.31	11.55	7.04
Hen eggs - free range	x	116	4.22	3.61	0.56	31.11	9.64
Pasteurized hen eggs		6	0.77	0.75	0.42	1.14	-
Bovine fat	x	377	2.38	1.49	0.22	104.19	5.90
Bovine meat		12	2.34	2.13	0.43	4.60	4.35
Pig fat	x	340	0.85	0.48	0.04	17.52	2.02
Wild boar fat		5	2.77	2.13	0.57	5.49	-
Sheep fat	x	50	4.17	2.67	0.91	47.82	7.02
Goat fat		3	1.63	1.60	1.53	1.76	-
Chicken fat	x	128	1.23	0.70	0.08	13.87	4.01
Hen fat	x	24	5.32	4.30	0.45	15.27	13.30
Deer fat - farmed		5	5.76	4.65	3.08	11.74	-
Sausages	x	8	1.01	0.86	0.40	2.24	-
Bovine liver	x	3	8.00	6.93	4.90	12.19	-
Pig liver	x	3	3.92	4.06	3.56	4.14	-
Sheep liver		7	10.62	8.99	4.75	26.36	-
Chicken liver		5	1.86	1.60	1.22	2.79	-
Vegetable oils	x	9	0.28	0.20	0.04	0.78	-
Food for infants		8	5.38	4.86	0.96	13.11	-
Cereals*		10	0.14	0.14	0.09	0.18	0.17
Fruits and vegetables*		19	0.18	0.12	0.08	0.96	0.33

*pg/g wet weight

16.4.9 Levels of PCB-6 in fish and seafood (ng/g wet weight)

Food	Included in exposure calculation	Number of samples	Average	Median	Minimum	Maximum	95th per-centile
Greenland halibut - Greenland	x	25	3.79	2.67	1.76	18.45	10.31
Sprat - The Baltic Sea		10	28.86	27.85	22.91	37.54	37.06
Sea Trout - The Baltic Sea		2	54.16	54.16	51.13	57.19	-
Salmon - The Baltic Sea		11	47.17	45.19	32.27	72.51	69.14
Smoked salmon - The Baltic Sea		10	46.31	44.99	31.93	70.74	66.09
Herring - The Baltic Sea		58	13.48	12.54	5.87	32.46	21.73
Trout - aquaculture	x	44	3.49	2.52	0.67	10.69	9.77
Trout - marine aquaculture		6	4.57	4.28	2.32	6.37	-
Eel - aquaculture	x	12	10.10	9.53	7.68	18.06	14.52
Fish oil dietary supplement		43	19.83	2.44	0.04	240.61	59.90
Fresh water fish		10	1.72	1.47	0.53	3.95	3.60
Cod liver		8	225.80	229.29	58.97	477.10	-
Blue mussels	x	40	1.27	0.92	0.10	4.95	3.94
Oyster		6	0.76	0.41	0.22	2.06	-
Scallops - Greenland		21	0.04	0.03	0.02	0.07	0.06
Shrimp - Greenland	x	10	0.04	0.04	0.03	0.07	0.07
Monkfish		5	0.39	0.49	0.19	0.55	-
Halibut		4	1.27	0.45	0.41	3.75	-
Salmon	x	31	5.53	4.15	0.36	17.69	15.12
Mackerel	x	12	4.82	3.43	1.24	21.54	13.00
Pangasius		10	0.06	0.04	0.02	0.14	0.14
European plaice	x	4	1.98	1.42	1.03	4.05	-
Herring	x	8	6.03	6.06	4.54	7.43	-
Herring, smoked		3	5.53	5.36	4.22	7.01	-
European flounder	x	4	3.12	3.40	0.45	5.25	-
Tuna	x	6	1.52	0.19	0.05	8.11	-
Eel		11	20.32	19.50	9.14	34.04	31.74

16.4.10 Ratio WHO-TEQ^{2005}/WHO-TEQ^{1998} (%)

Food	Included in exposure calculation	Number of samples	Average	Median	Minimum	Maximum	95th percentile
Raw milk, cow	x	162	88	88	71	97	95
Dairy products	x	13	89	89	83	93	92
Hen eggs - cage	x	50	87	88	49	97	94
Hen eggs - free range	x	116	86	86	79	95	93
Pasteurized hen eggs		6	88	88	83	94	-
Bovine fat	x	377	89	89	51	108	95
Bovine meat		12	90	91	83	97	-
Pig fat	x	340	90	92	53	101	96
Wild boar fat		5	87	88	78	95	-
Sheep fat	x	50	89	89	82	95	93
Goat fat		3	92	91	90	95	-
Chicken fat	x	128	88	89	58	96	95
Hen fat	x	24	86	86	79	92	90
Deer fat - farmed		5	90	91	85	92	-
Sausages	x	8	91	90	88	94	-
Bovine liver	x	3	91	90	82	101	-
Pig liver	x	3	86	91	74	92	-
Sheep liver		7	80	80	76	83	-
Chicken liver		5	93	93	89	97	-
Vegetable oils	x	9	87	87	62	95	-
Food for infants		8	91	91	85	96	96
Cereals		10	89	92	66	96	95
Fruits and vegetables		19	88	89	82	94	92

16.4.11 Ratio WHO-TEQ^{2005}/WHO-TEQ^{1998} (%) continued

Food	Included in exposure calculation	Number of samples	Average	Median	Minimum	Maximum	95th per-centile
Greenland halibut - Greenland	x	25	88	88	80	92	91
Sprat - The Baltic Sea		10	84	85	82	86	86
Sea Trout - The Baltic Sea		2	81	81	80	82	-
Salmon - The Baltic Sea		11	82	83	79	84	84
Smoked salmon - The Baltic Sea		10	83	83	83	84	84
Herring - The Baltic Sea		58	80	80	76	86	84
Trout - aquaculture	x	44	85	85	60	91	89
Trout - marine aquaculture		6	85	85	84	86	-
Eel - aquaculture	x	12	85	85	82	87	87
Fish oil dietary supplement		43	83	91	27	109	100
Fresh water fish		10	85	84	79	92	91
Cod liver		8	80	87	30	92	-
Blue mussels	x	40	88	88	79	98	92
Oyster		6	94	94	92	96	-
Scallops - Greenland		21	93	94	89	95	95
Shrimp - Greenland	x	10	92	93	89	94	94
Monkfish		5	86	86	82	91	-
Halibut		4	86	87	83	90	-
Salmon	x	31	86	85	74	94	94
Mackerel	x	12	89	88	86	92	92
Pangasius		10	94	95	92	97	97
European plaice	x	4	85	85	84	86	-
Herring	x	8	83	82	80	87	-
Herring, smoked		3	78	78	76	79	-
European flounder	x	4	88	88	86	89	-
Tuna	x	6	96	96	92	102	-
Eel		11	82	85	69	90	88

16.5 PCB and organochlorine pesticides

Positive: Number of samples with concentration in ng/g fish, ng/g egg or ng/g fat for other foods

16.5.1 Alpha-HCH

Foods	Included in exposure	No. of samples	Positive	Mean	Max.	Median	95th percentile
Butter, foreign	x	77	1		1.0		
Butter and veg. mix	x	3	0				
Milk, raw, Danish	x	421	10	0.2	3.0	0.2	0.2
Milk, foreign	x	45	6	0.3	2.2	0.2	
Cheese	x	250	18	0.3	6.0	0.2	0.9
Cream	x	9	0				
Eggs, hen	x	276	0				
Fat, beef	x	208	2		1.1		
Fat, boar		5	0				
Fat, chicken	x	207	0				
Fat, duck	x	4	0				
Fat, farmed deer	x	50	0				
Fat, hen	x	29	0				
Fat, horse		4	0				
Fat, lamb	x	33	0				
Fat, ostrich		28	0				
Fat, pork	x	933	2		1.3		
Fat, sheep		26	0				
Cod roe	x	11	5	0.0	0.1	0.0	0.1
Butterfish		5	1		0.1		
Mackerel	x	22	19	0.5	1.6	0.5	1.4
Mackerel in tomato, canned	x	7	7	0.3	0.4	0.3	
Mackerel, smoked	x	7	6	0.6	1.0	0.6	
Swordfish		8	0				
Eel	x	51	44	0.8	9.0	0.5	1.6
Eel, smoked	x	7	7	0.6	1.7	0.3	
Greenland halibut	x	22	21	1.0	1.8	1.1	1.6
Herring	x	17	16	0.3	0.5	0.3	0.5
Herring, pickled	x	23	18	0.3	0.6	0.3	0.5
Herring, smoked	x	13	13	0.4	0.9	0.4	0.8
Lumpsucker		10	8	0.4	0.8	0.5	
Lumpsucker, roe	x	8	7	0.1	0.3	0.1	
Pollack	x	8	0				
Salmon	x	38	32	0.3	0.9	0.3	0.7
Salmon, smoked	x	20	16	0.4	1.1	0.4	0.8
Sardine/pilchard/kippers/anchovy		13	7	0.1	1.0	0.1	
Trout	x	16	1		0.2		
Trout, aquaculture	x	484	87	0.0	0.7	0.0	0.1
Trout, salt water aquaculture	x	116	110	0.3	1.1	0.3	0.6
Tuna	x	4	1		0.1		
Fish oil	x	23	0				
Garfish		4	1		0.2		
Cod liver, Belts	x	22	15	0.7	2.1	0.4	2.0
Cod liver, Kattegat	x	23	16	0.5	1.2	0.4	1.1
Cod liver, North Sea	x	25	11	0.2	1.0	0.0	0.9
Cod liver, Skagerrak	x	28	20	0.3	0.9	0.2	0.8
Cod liver, Sound	x	26	20	1.0	2.9	0.9	2.5

Cod liver, Baltic Sea	x	32	27	1.9	4.2	2.1	3.5
Herring, Belts		42	38	0.2	0.6	0.2	0.4
Herring, Kattegat		41	33	0.2	0.7	0.1	0.5
Herring, North Sea		43	32	0.2	0.6	0.2	0.5
Herring, Skagerrak		44	39	0.3	0.7	0.3	0.7
Herring, Sound		32	27	0.4	0.6	0.4	0.7
Herring, Baltic Sea		34	31	0.3	1.0	0.2	0.6

16.5.2 Beta-HCH

Foods	Included in exposure	No of samples	Positive	Mean	Max.	Median	95th percentile
Butter, foreign	x	77	1		1.0		
Butter and veg. mix	x	3	0				
Milk, raw, Danish	x	421	0				
Milk, foreign	x	45	0				
Cheese	x	250	6	0.2	3.5	0.2	
Cream	x	9	0				
Eggs, hen	x	276	0				
Fat, beef	x	208	0				
Fat, boar		5	0				
Fat, chicken	x	207	1		2.0		
Fat, duck	x	4	0				
Fat, farmed deer	x	50	0				
Fat, hen	x	29	3	0.3	2.2	0.3	0.5
Fat, horse		4	0				
Fat, lamb	x	33	0				
Fat, ostrich		28	0				
Fat, pork	x	933	2		1.6		
Fat, sheep		26	0				
Cod roe	x	11	5	0.1	0.2	0.0	0.2
Butterfish		5	2		0.1		
Mackerel	x	22	2		0.5		
Mackerel in tomato, canned	x	7	2		0.3		
Mackerel, smoked	x	7	2		1.2		
Swordfish		8	2		0.1		
Eel	x	51	27	0.7	4.9	0.4	4.1
Eel, smoked	x	7	4	0.7	2.5	0.3	
Greenland halibut	x	22	16	0.2	0.4	0.2	0.4
Herring	x	17	5	0.2	1.4	0.0	
Herring, pickled	x	23	5	0.1	1.2	0.0	
Herring, smoked	x	13	6	0.6	2.6	0.0	
Lumpsucker		10	10	0.7	2.4	0.5	1.9
Lumpsucker, roe	x	8	6	0.1	0.1	0.1	
Pollack	x	8	0				
Salmon	x	38	17	0.1	0.9	0.0	0.5
Salmon, smoked	x	20	7	0.1	0.5	0.0	
Sardine/pilchard/kippers/anchovy		13	1		0.2		
Trout	x	16	2		0.5		
Trout, aquaculture	x	484	69	0.1	1.7	0.0	0.2
Trout, salt water aquaculture	x	116	109	0.9	3.9	0.8	2.0
Tuna	x	4	0				
Fish oil	x	23	1		1.3		
Garfish		4	2		0.4		
Cod liver, Belts	x	22	18	2.1	7.3	1.7	6.2
Cod liver, Kattegat	x	23	16	0.9	2.7	0.9	2.6
Cod liver, North Sea	x	25	7	0.2	1.9	0.0	
Cod liver, Skagerrak	x	28	12	0.3	1.4	0.0	1.3
Cod liver, Sound	x	26	21	2.8	10	2.2	9.2
Cod liver, Baltic Sea	x	32	30	7.5	13	8.7	12
Herring, Belts		42	37	0.4	1.2	0.3	0.9
Herring, Kattegat		41	33	0.3	1.0	0.2	0.9
Herring, North Sea		43	10	0.1	0.4	0.0	0.4
Herring, Skagerrak		44	15	0.1	0.6	0.0	0.5
Herring, Sound		32	29	0.4	0.6	0.4	0.7
Herring, Baltic Sea		34	33	0.9	2.3	0.8	2.0

16.5.3 Lindane

Foods	Included in expo-sure	No. of samples	Positive	Aver-age	Min.	Max.	Median	95th percen-tile.
Butter, foreign	x	77	2		0.6			
Butter and veg. mix	x	3	0					
Milk, raw, Danish	x	421	0					
Milk, foreign	x	45	1		3.4			
Cheese	x	250	20	0.4	4.6	0.3	1.3	
Cream	x	9	0					
Eggs, hen	x	276	0					
Fat, beef	x	208	15	0.5	17	0.2	1.0	
Fat, boar		5	0					
Fat, chicken	x	207	8	0.2	1.9	0.2		
Fat, duck	x	4	0					
Fat, farmed deer	x	50	1		0.8			
Fat, hen	x	29	4	0.7	9.5	0.2		
Fat, horse		4	0					
Fat, lamb	x	33	3	0.9	14	0.2		
Fat, ostrich		28	1		2.1			
Fat, pork	x	933	24	0.2	4.1	0.2	0.3	
Fat, sheep		26	1		16			
Cod roe	x	11	6	0.1	0.2	0.1		
Butterfish		5	1		0.2			
Mackerel	x	22	7	0.2	0.8	0.0		
Mackerel in tomato, canned	x	7	0					
Mackerel, smoked	x	7	1		0.5			
Swordfish		8	3	0.0	0.1	0.0		
Eel	x	51	7	0.2	1.5	0.0		
Eel, smoked	x	7	3	0.5	1.8	0.0		
Greenland halibut	x	22	7	0.2	1.8	0.0		
Herring	x	17	5	0.1	0.5	0.0		
Herring, pickled	x	23	11	0.3	1.5	0.0	1.3	
Herring, smoked	x	13	7	0.3	0.9	0.3		
Lumpsucker		10	8	0.3	0.7	0.3		
Lumpsucker, roe	x	8	7	0.1	0.2	0.1		
Pollack	x	8	3	0.0	0.1	0.0		
Salmon	x	38	18	0.2	0.8	0.0	0.5	
Salmon, smoked	x	20	10	0.2	1.7	0.1	0.8	
Sardine/pilchard/kippers/anchovy		13	2		0.4			
Trout	x	16	10	0.1	0.3	0.1	0.2	
Trout, aquaculture	x	484	188	0.1	0.8	0.0	0.5	
Trout, salt water aquaculture	x	116	61	0.2	2.8	0.1	0.5	
Tuna	x	4	1		0.1			
Fish oil	x	23	7	0.8	5.0	0.2		
Garfish		4	4	0.1	0.2	0.1		
Cod liver, Belts	x	22	19	1.4	3.2	1.2	3.2	
Cod liver, Kattegat	x	23	13	0.5	1.9	0.6	1.6	
Cod liver, North Sea	x	25	20	1.5	8.3	0.8	4.4	
Cod liver, Skagerrak	x	28	16	0.4	2.0	0.2	1.4	
Cod liver, Sound	x	26	23	1.4	2.9	1.4	2.8	
Cod liver, Baltic Sea	x	32	29	2.6	6.3	2.8	4.7	
Herring, Belts		42	40	0.3	0.7	0.2	0.7	
Herring, Kattegat		41	37	0.2	1.3	0.2	0.5	
Herring, North Sea		43	14	0.1	0.6	0.0	0.5	
Herring, Skagerrak		44	18	0.2	1.3	0.0	0.9	
Herring, Sound		32	24	0.3	0.6	0.3	0.6	
Herring, Baltic Sea		34	34	0.4	1.1	0.4	0.8	

16.5.4 HCB

Foods	Included in exposure	No. of samples	Positive	Mean	Max.	Median	95th percentile
Butter, foreign	x	77	70	1.5	1.6	3.2	3.3
Butter and veg. mix	x	3	3	1.1	1.2	1.6	
Milk, raw, Danish	x	421	404	1.5	1.8	3.9	28
Milk, foreign	x	45	44	1.9	1.9	2.6	2.8
Cheese	x	250	237	1.5	1.6	3.4	5.2
Cream	x	9	9	1.9	2.3	5.2	
Eggs, hen	x	276	6	0.7	0.8	0.7	
Fat, beef	x	208	204	1.5	2.2	4.4	44
Fat, boar		5	2		2.6		
Fat, chicken	x	207	28	0.2	0.3	0.7	3.3
Fat, duck	x	4	1		0.4		
Fat, farmed deer	x	50	50	3.4	3.7	7.3	11
Fat, hen	x	29	22	0.9	1.1	3.1	4.7
Fat, horse		4	4	4.8	4.7	5.0	
Fat, lamb	x	33	33	3.4	4.3	8.4	29
Fat, ostrich		28	28	1.6	1.9	3.7	5.0
Fat, pork	x	933	147	0.2	0.5	0.9	48
Fat, sheep		26	26	3.8	5.4	13	21
Cod roe	x	11	11	0.6	0.5	0.7	0.7
Butterfish		5	5	0.9	0.8	1.0	
Mackerel	x	22	22	1.1	1.1	1.7	1.8
Mackerel in tomato, canned	x	7	7	0.5	0.5	0.6	
Mackerel, smoked	x	7	7	1.0	0.9	1.2	
Swordfish		8	8	0.3	0.4	0.7	
Eel	x	51	51	5.7	5.7	8.5	10
Eel, smoked	x	7	7	1.1	1.5	3.2	
Greenland halibut	x	22	22	3.0	3.5	8.1	11
Herring	x	17	17	1.4	1.2	1.8	2.1
Herring, pickled	x	23	23	1.2	1.3	1.8	4.5
Herring, smoked	x	13	13	1.4	1.4	2.1	2.3
Lumpsucker		10	10	2.7	2.9	5.3	5.6
Lumpsucker, roe	x	8	8	0.8	0.8	1.0	
Pollack	x	8	8	0.1	0.1	0.2	
Salmon	x	38	38	1.7	1.8	4.3	5.2
Salmon, smoked	x	20	20	2.1	2.0	3.3	4.4
Sardine/pilchard/kippers/anchovy		13	13	0.6	0.8	1.3	1.3
Trout	x	16	16	0.3	0.4	0.9	1.0
Trout, aquaculture	x	484	482	0.5	0.7	1.5	4.3
Trout, salt water aquaculture	x	116	116	1.3	1.5	3.1	5.4
Tuna	x	4	4	0.1	0.1	0.2	
Fish oil	x	23	3	0.2	0.4	1.7	
Garfish		4	4	0.3	0.4	0.7	
Cod liver, Belts	x	22	21	5.2	6.3	14	16
Cod liver, Kattegat	x	23	23	4.7	5.6	10	14
Cod liver, North Sea	x	25	25	3.5	4.1	8.1	10
Cod liver, Skagerrak	x	28	26	3.8	4.1	10	12
Cod liver, Sound	x	26	26	7.3	7.7	13	16
Cod liver, Baltic Sea	x	32	31	20	18	34	35
Herring, Belts		42	42	0.8	0.9	1.8	2.1
Herring, Kattegat		41	40	0.8	0.9	1.6	2.0
Herring, North Sea		43	43	0.7	0.8	1.6	1.8
Herring, Skagerrak		44	40	1.0	1.0	1.8	2.1
Herring, Sound		32	32	1.3	1.3	1.8	1.2
Herring, Baltic Sea		34	34	1.1	1.5	3.3	5.0

16.5.5 Dieldrin

Foods	Included in exposure	No. of samples	Positive	Mean	Max.	Median	95th percentile
Butter, foreign	x	77	17	0.9	5.4	0.4	3.1
Butter and veg. mix	x	3	0				
Milk, raw, Danish	x	421	38	1.0	8.3	0.7	2.8
Milk, foreign	x	45	5	0.8	3.1	0.7	
Cheese	x	250	89	0.7	13	0.2	2.3
Cream	x	9	0				
Eggs, hen	x	276	0				
Fat, beef	x	208	53	0.5	1.9	0.4	1.2
Fat, boar		5	0				
Fat, chicken	x	207	42	0.5	2.2	0.5	1.0
Fat, duck	x	4	2		1.1		
Fat, farmed deer	x	50	10	0.5	2.3	0.3	1.3
Fat, hen	x	29	19	1.0	3.3	0.9	2.4
Fat, horse		4	3	0.8	1.3	0.8	
Fat, lamb	x	33	4	0.5	2.5	0.4	
Fat, ostrich		28	4	0.6	3.6	0.5	
Fat, pork	x	933	61	0.4	3.7	0.4	0.5
Fat, sheep		26	10	0.7	1.7	0.4	1.6
Cod roe	x	11	11	0.7	1.1	0.7	1.1
Butterfish		5	2		2.1		
Mackerel	x	22	22	3.6	16	3.3	4.6
Mackerel in tomato, canned	x	7	7	1.5	1.9	1.6	
Mackerel, smoked	x	7	7	3.6	4.4	3.6	
Swordfish		8	4	0.2	0.6	0.1	
Eel	x	51	51	10	18	10	15
Eel, smoked	x	7	7	2.0	6.6	1.3	
Greenland halibut	x	22	22	5.3	19	4.8	7.8
Herring	x	17	17	2.6	3.9	2.7	3.8
Herring, pickled	x	23	23	3.1	6.7	2.7	5.5
Herring, smoked	x	13	13	3.7	6.4	3.2	5.9
Lumpsucker		10	10	5.6	9.0	6.9	8.5
Lumpsucker, roe	x	8	8	1.2	1.4	1.4	
Pollack	x	8	3	0.0	0.1	0.0	
Salmon	x	38	38	3.5	9.0	2.8	7.8
Salmon, smoked	x	20	19	3.7	10	2.7	9.1
Sardine/pilchard/kippers/anchovy		13	11	1.5	2.7	1.5	2.6
Trout	x	16	16	0.6	1.3	0.5	1.2
Trout, aquaculture	x	484	463	1.0	4.8	0.8	2.4
Trout, salt water aquaculture	x	116	112	2.0	8.1	1.8	4.5
Tuna	x	4	2	0.2	0.4	0.2	
Fish oil	x	23	5	0.9	5.3	0.4	
Garfish		4	4	1.2	2.6	1.0	
Cod liver, Belts	x	22	21	16	36	13	34
Cod liver, Kattegat	x	23	23	20	49	20	45
Cod liver, North Sea	x	25	23	12	29	10	28
Cod liver, Skagerrak	x	28	26	12	37	8.6	28
Cod liver, Sound	x	26	26	24	62	15	57
Cod liver, Baltic Sea	x	32	31	29	72	29	62
Herring, Belts		42	42	2.5	5.8	2.1	4.7
Herring, Kattegat		41	41	2.5	6.3	2.4	5.2
Herring, North Sea		43	42	2.1	3.8	2.1	3.7
Herring, Skagerrak		44	40	2.6	7.0	2.8	4.5
Herring, Sound		32	32	4.2	5.6	4.2	5.7
Herring, Baltic Sea		34	34	2.7	12	2.5	5.1

16.5.6 Chlordane, sum

Foods	Included in exposure	No. of samples	Positive	Mean	Max.	Median	95th percentile
Butter, foreign	x	77	0				
Butter and veg. mix	x	3	0				
Milk, raw, Danish	x	421	3	1.0	2.1	1.0	
Milk, foreign	x	45	0				
Cheese	x	250	4	0.7	2.6	0.7	
Cream	x	9	0				
Eggs, hen	x	276	0				
Fat, beef	x	208	2		1.8		
Fat, boar		5	0				
Fat, chicken	x	207	1		1.9		
Fat, duck	x	4	0				
Fat, farmed deer	x	50	0				
Fat, hen	x	29	2		1.3		
Fat, horse		4	0				
Fat, lamb	x	33	1		0.8		
Fat, ostrich		28	2		2.0		
Fat, pork	x	933	3	0.5	1.3	0.7	
Fat, sheep		26	2		0.7		
Cod roe	x	11	11	1.1	1.9	1.2	1.7
Butterfish		5	1		0.9		
Mackerel	x	22	21	1.5	3.8	1.2	3.0
Mackerel in tomato, canned	x	7	7	0.7	0.9	0.8	
Mackerel, smoked	x	7	7	2.1	4.0	2.0	
Swordfish		8	7	0.7	3.6	0.4	
Eel	x	51	51	8.9	20	8.2	14.8
Eel, smoked	x	7	7	1.7	5.7	0.9	
Greenland halibut	x	22	22	11.1	51	8.5	32
Herring	x	17	16	1.4	2.7	1.5	2.3
Herring, pickled	x	23	22	3.4	12	2.6	8.6
Herring, smoked	x	13	13	2.6	4.8	2.3	4.3
Lumpsucker		10	10	8.1	14	8.6	13
Lumpsucker, roe	x	8	8	0.9	1.6	0.7	
Pollack	x	8	1		0.2		
Salmon	x	38	38	4.8	16	4.4	13
Salmon, smoked	x	20	19	5.4	11	5.0	11
Sardine/pilchard/kippers/anchovy		13	11	0.6	2.5	0.4	1.9
Trout	x	16	16	0.4	1.0	0.4	0.8
Trout, aquaculture	x	484	479	0.9	8.2	0.7	2.2
Trout, salt water aquaculture	x	116	116	1.7	9.9	1.2	5.0
Tuna	x	4	0				
Fish oil	x	23	7	1.8	7.5	0.7	
Garfish		4	4	2.2	4.5	1.8	
Cod liver, Belts	x	22	22	18.3	60.6	15.8	50.9
Cod liver, Kattegat	x	23	23	25.4	104.0	17.3	53.5
Cod liver, North Sea	x	25	25	11.3	24.2	11.5	19.8
Cod liver, Skagerrak	x	28	27	13.0	86.1	6.0	35.9
Cod liver, Sound	x	26	26	28.5	89.5	19.2	61.9
Cod liver, Baltic Sea	x	32	31	40.5	149.4	39.3	84.8
Herring, Belts		42	42	1.4	4.2	1.3	3.0
Herring, Kattegat		41	41	1.5	3.1	1.5	2.7
Herring, North Sea		43	43	1.5	2.8	1.5	2.4
Herring, Skagerrak		44	40	1.4	3.5	1.1	3.3
Herring, Sound		32	32	2.3	3.1	2.1	4.5
Herring, Baltic Sea		34	34	2.1	6.0	1.6	4.2

16.5.7 Heptachlor, sum

Foods	Included in exposure	No. of samples	Positive	Mean	Max.	Median	95th percentile
Butter, foreign	x	77	7	0.5	1.8	0.7	
Butter and veg. mix	x	3	0				
Milk, raw, Danish	x	421	0				
Milk, foreign	x	45	0				
Cheese	x	250	32	0.6	4.6	0.4	1.6
Cream	x	9	0				
Eggs, hen	x	276	0				
Fat, beef	x	208	0				
Fat, boar		5	0				
Fat, chicken	x	207	0				
Fat, duck	x	4	0				
Fat, farmed deer	x	50	0				
Fat, hen	x	29	3	0.6	0.9	0.7	
Fat, horse		4	0				
Fat, lamb	x	33	0				
Fat, ostrich		28	0				
Fat, pork	x	933	0				
Fat, sheep		26	1		0.7		
Cod roe	x	11	7	0.1	0.3	0.1	
Butterfish		5	0				
Mackerel	x	22	20	0.5	1.5	0.6	0.8
Mackerel in tomato, canned	x	7	6	0.3	0.4	0.3	
Mackerel, smoked	x	7	7	0.6	0.9	0.6	
Swordfish		8	0				
Eel	x	51	44	1.3	2.4	1.5	2.2
Eel, smoked	x	7	4	0.3	0.9	0.3	
Greenland halibut	x	22	21	0.8	2.5	0.8	1.2
Herring	x	17	16	0.4	0.7	0.4	0.6
Herring, pickled	x	23	20	0.4	0.9	0.4	0.7
Herring, smoked	x	13	13	0.6	0.9	0.6	0.9
Lumpsucker		10	10	0.9	1.6	1.1	1.4
Lumpsucker, roe	x	8	7	0.2	0.3	0.2	
Pollack	x	8	0				
Salmon	x	38	32	0.5	1.0	0.5	0.9
Salmon, smoked	x	20	17	0.5	1.1	0.6	1.1
Sardine/pilchard/kippers/anchovy		13	8	0.2	0.5	0.2	
Trout	x	16	7	0.1	0.2	0.1	
Trout, aquaculture	x	484	269	0.1	0.6	0.1	0.4
Trout, salt water aquaculture	x	116	68	0.2	1.2	0.2	0.7
Tuna	x	4	0				
Fish oil	x	23	0				
Garfish		4	2		0.2		
Cod liver, Belts	x	22	19	1.9	5.6	1.8	4.1
Cod liver, Kattegat	x	23	21	1.7	4.9	1.6	4.2
Cod liver, North Sea	x	25	23	1.7	4.1	1.6	3.8
Cod liver, Skagerrak	x	28	23	1.5	5.1	1.4	3.6
Cod liver, Sound	x	26	26	2.3	5.7	1.9	5.0
Cod liver, Baltic Sea	x	32	28	2.0	4.3	2.1	3.7
Herring, Belts		42	42	0.4	1.0	0.4	0.8
Herring, Kattegat		41	37	0.4	1.3	0.4	0.8
Herring, North Sea		43	39	0.4	0.9	0.4	0.6
Herring, Skagerrak		44	38	0.4	1.1	0.5	0.8
Herring, Sound		32	31	0.5	0.6	0.5	0.8
Herring, Baltic Sea		34	28	0.3	1.1	0.2	0.9

16.5.8 DDT, sum

Foods	Included in exposure	No. of samples	Positive	Mean	Max.	Median	95th percentile
Butter, foreign	x	77	70	8.4	59	3.2	39
Butter and veg. mix	x	3	3	10	23	5.1	
Milk, raw, Danish	x	421	295	2.3	15	2.0	4.9
Milk, foreign	x	45	40	4.7	13	4.8	10
Cheese	x	250	205	3.2	34	2.1	9.7
Cream	x	9	8	3.8	15	2.3	
Eggs, hen	x	276	19	6.3	88	5.0	12
Fat, beef	x	208	187	2.7	65	2.2	5.0
Fat, boar		5	2	9.2	30	1.3	
Fat, chicken	x	207	82	1.5	16	1.3	2.6
Fat, duck	x	4	3	1.8	2.0	1.9	
Fat, farmed deer	x	50	48	2.3	7.2	2.1	4.8
Fat, hen	x	29	27	4.2	17	3.1	9.0
Fat, horse		4	4	4.8	11	3.2	
Fat, lamb	x	33	33	4.3	17	4.0	7.5
Fat, ostrich		28	28	8.1	32	5.6	28
Fat, pork	x	933	578	1.5	15	1.3	3.1
Fat, sheep		26	26	4.8	19	3.9	8.7
Cod roe	x	11	11	9.6	17	13	17
Butterfish		5	5	2.7	6.2	2.1	
Mackerel	x	22	22	4.2	12	3.1	7.8
Mackerel in tomato, canned	x	7	7	1.5	2.1	1.4	
Mackerel, smoked	x	7	7	5.0	8.1	4.1	
Swordfish		8	8	5.9	13	5.8	
Eel	x	51	51	23	157	19	40
Eel, smoked	x	7	6	11	20	10	
Greenland halibut	x	22	22	17	193	6.2	40
Herring	x	17	17	6.5	13	5.4	11
Herring, pickled	x	23	23	9.5	28	8.6	23
Herring, smoked	x	13	13	15	28	13	27
Lumpsucker		10	10	19	33	19	29
Lumpsucker, roe	x	8	8	2.3	4.1	2.4	
Pollack	x	8	8	0.2	0.4	0.2	
Salmon	x	38	38	15	36	14	33
Salmon, smoked	x	20	20	16	37	15	32
Sardine/pilchard/kippers/anchovy		13	13	4.7	10	3.5	9.7
Trout	x	16	16	2.3	7.0	1.8	4.2
Trout, aquaculture	x	484	484	3.7	17	2.9	8.3
Trout, salt water aquaculture	x	116	116	9.3	31	7.9	23
Tuna	x	4	3	0.7	1.2	0.7	
Fish oil	x	23	13	7.6	44	2.8	27
Garfish		4	4	29	62	24	
Cod liver, Belts	x	22	22	199	636	193	483
Cod liver, Kattegat	x	23	23	281	826	196	661
Cod liver, North Sea	x	25	25	69	328	52	122
Cod liver, Skagerrak	x	28	27	71	304	60	183
Cod liver, Sound	x	26	26	266	661	215	524
Cod liver, Baltic Sea	x	32	31	700	1771	698	1353
Herring, Belts		42	42	9.3	19	8.2	17
Herring, Kattegat		41	41	8.0	16	6.8	14
Herring, North Sea		43	42	5.5	11	5.4	8.5
Herring, Skagerrak		44	40	6.2	21	5.0	12
Herring, Sound		32	32	13	19	13	18
Herring, Baltic Sea		34	34	35	145	26	76

16.5.9 PCB, sum

Foods	Included in exposure	No. of samples	Positive	Mean	Max.	Median	95th percentile
Butter, foreign	x	77	32	3.5	8.1	2.8	7.8
Butter and veg. mix	x	3	0				
Milk, raw, Danish	x	421	35	4.2	37	3.8	5.4
Milk, foreign	x	45	15	4.6	9.6	3.8	7.6
Cheese	x	250	126	3.0	8.0	2.5	5.7
Cream	x	9	2		6.0		
Eggs, hen	x	276	6	17	991	13	
Fat, beef	x	208	102	3.2	11	2.8	6.0
Fat, boar		5	2		16		
Fat, chicken	x	207	17	2.7	24	2.8	2.9
Fat, duck	x	4	1		2.8		
Fat, farmed deer	x	50	49	6.6	17	5.5	14
Fat, hen	x	29	21	7.4	31	5.4	17
Fat, horse		4	4	20	28	18	
Fat, lamb	x	33	27	5.3	33	4.2	12
Fat, ostrich		28	22	37	216	5.7	146
Fat, pork	x	933	170	2.4	42	2.8	3.4
Fat, sheep		26	19	7.0	54	3.9	18
Cod roe	x	11	10	7.2	15	11	13
Butterfish		5	3	3.3	12.5	0.7	
Mackerel	x	22	20	5.8	19.6	4.9	15
Mackerel in tomato, canned	x	7	7	1.9	3.5	1.6	
Mackerel, smoked	x	7	7	4.7	8.6	4.4	
Swordfish		8	8	2.3	10.4	1.1	
Eel	x	51	51	20	138	16	41
Eel, smoked	x	7	4	11	31	0.6	
Greenland halibut	x	22	22	18	264	3.8	33
Herring	x	17	17	8.9	17	7.3	14
Herring, pickled	x	23	22	10	32	9.8	24
Herring, smoked	x	13	13	20	38	17	36
Lumpsucker		10	10	21	37	21	33
Lumpsucker, roe	x	8	8	2.9	5.8	3.3	
Pollack	x	8	8	0.5	1.0	0.4	
Salmon	x	38	38	16.8	42	14.8	39
Salmon, smoked	x	20	20	17.9	43	17.1	32
Sardine/pilchard/kippers/anchovy		13	11	11.1	30	7.5	24
Trout	x	16	16	2.9	8.3	2.6	5.3
Trout, aquaculture	x	484	483	4.3	42	3.4	10
Trout, salt water aquaculture	x	116	116	9.3	35	7.2	22
Tuna	x	4	3	1.5	3.7	1.1	
Fish oil	x	23	12	8.4	37	3.6	29
Garfish		4	4	34.8	60	30	
Cod liver, Belts	x	22	22	402	980	339	786
Cod liver, Kattegat	x	23	22	622	1982	552	1159
Cod liver, North Sea	x	25	25	194	746	168	370
Cod liver, Skagerrak	x	28	27	279	1251	232	708
Cod liver, Sound	x	26	26	733	1309	749	1136
Cod liver, Baltic Sea	x	32	31	563	1330	524	1100
Herring, Belts		42	42	17	48	14	36
Herring, Kattegat		41	41	13	26	12	22
Herring, North Sea		43	42	8.6	16	8.7	15
Herring, Skagerrak		44	40	9.4	37	9.3	18
Herring, Sound		32	32	16	21	16	21
Herring, Baltic Sea		34	34	26	106	21	48

16.6 PAH

16.6.1 Levels of benz[*a*]pyrene

Levels of benzo[*a*]pyrene in µg/kg fresh weight for samples collected for PAH analysis from 2005-2011. For calculation of average values, median and 95th percentile all samples are included. Samples with no detected values are included as 0.

Food	Included in exposure	No.of samples	Positive[1]	Average	Minimum	Maximum	Median	95th percentile
Baby foods								
Babyfood, fruit and vegetables		7	1	0.01	0	0.10	0	-
Babyfood, cereal based		18	3	0.07	0	1.0	0	1.0
Infant formular		17	3	0.02	0	0.10	0	0.19
Ready to eat meal, canned		6	0	0	0	0	0	-
Milk, dried		3	0	0	0	0	0	-
Cereals								
Flour	x	15	2	0.03	0	0.30	0	0.30
Müsli		1	0	0	-	-	-	-
Fruit and vege-tables								
Dried fruit	x	23	7	0.44	0	4.6	0	2.8
Tomato, dried	x	1	1	0.10	-	-	-	-
Fat and vegetable oils								
Olive oil	x	54	44	0.23	0	1.5	0.20	1.1
Rapeseed oil	x	22	14	0.29	0	2.5	0.10	0.80
Sunflower oil	x	15	10	0.88	0	4.4	0.20	4.4
Vegetable oil		32	16	0.23	0	0.90	0.05	0.80
Vegetable fat	x	2	1	0.05	0	0.10	0.05	-
Coffee and tea								
Coffee, beans	x	9	9	0.40	0.20	0.90	0.30	-
Coffee, instant		2	2	0.60	0.20	1.0	0.60	1.0
Teas	x	10	10	11	0.60	32	11	32
Miscellaneous								
Biscuit, butter		1	1	0.1	-	-	-	-

[1]Number of samples with a value above LOD

Levels of benzo[*a*]pyrene (continued)

Food	Included in exposure	No. of samples	Positive[1]	Average	Min.	Max.	Median	95th percentile
Meat								
Beef meat	x	7	2	0.47	0	2.9	0	-
Beef meat, grilled		29	8	0.28	0	2.1	0	1.8
Beef meat, minced grilled	x	31	15	1.7	0	14	0	13
Beef meat, pastrami		2	2	2.2	1.3	3.1	2.2	-
Pork meat, boiled or roasted	x	2	0	0	0	0	0	-
Pork meat, smoked	x	38	0	0	0	0	0	0
Pork meat, grilled		16	2	0.09	0	1.2	0	1.2
Pork chops, grilled	x	13	2	0.72	0	8.4	0	8.4
Pork meat, Danish type salami	x	3	0	0	0	0	0	
Pork, sausage smoked	x	9	0	0	0	0	0	-
Pork, sausage grilled	x	10	9	0.11	0	0.20	0.10	0.20
Chicken meat	x	2	0	0	0	0	0	-
Chicken meat, grilled	x	27	7	0.19	0	3.1	0	0.60
Lamb, grilled	x	7	5	0.97	0	3.9	0.20	-
Veal meat, grilled		2	1	0.15	0	0.30	0.15	-
Fish and seafood								
Mussels (*Mytilus edulis*)		186	159	0.16	0	0.60	0.13	0.32
Mussels (*Mytilus edulis*), smoked		1	1	1.6	-	-	-	-
Mussels (*Spisula* sp.)		12	12	0.26	0.07	0.40	0.26	0.40
Oyster		25	25	0.40	0.10	0.72	0.30	0.64
Shrimps and scallop, grilled		4	4	0.20	0.10	0.40	0.15	-
Herring, raw	x	8	0	0	0	0	0	-
Herring, smoked	x	44	31	0.61	0	3.1	0.20	2.7
Mackerel, raw	x	7	0	0	0	0	0	-
Mackerel, smoked	x	68	33	0.24	0	4.1	0	1.3
Salmon, raw	x	5	0	0	0	0	0	-
Salmon, smoked	x	41	18	0.32	0	4.3	0	1.8
Salmon, grilled		11	1	0.02	0	0.20	0	0.20
Trout, smoked	x	15	4	0.08	0	0.60	0	0.60
Eels, smoked	x	31	22	0.40	0	1.5	0.30	1.2
Fish and other seafood		25	10	0.11	0	0.80	0	0.39
Smoked fish, other		29	12	0.12	0	1.0	0	0.80
Cod roe, smoked		22	19	3.9	0	25	1.7	13

[1]Number of samples with a value above LOD

16.6.2 Levels of PAH4 (sum of benz[a]anthracene, chrysene, benzo[b]fluoranthene and benzo[a]pyrene)

Levels of sum of PAH4 in µg/kg fresh weight for samples collected for PAH analysis from 2005-2011. For calculation of average values, median and 95th percentile all samples are included. Samples with no detected values are included as 0.

Food	Included in exposure	No. of samples	Positive[1]	Average	Minimum	Maximum	Median	95th percentile
Baby foods								
Babyfood, fruit and vegetables		7	2	0.03	0	0.15	0	-
Babyfood, cereal based		18	11	0.16	0	1.7	0.05	1.7
Infant formular		17	7	0.09	0	0.40	0	0.40
Ready to eat meal, canned		6	0	0	0	0	0	-
Milk, dried		3	0	0	0	0	0	-
Cereals								
Flour	x	15	2	0.29	0	3.5	0	-
Müsli		1	1	0.15	-	-	-	-
Fruit and vegetables								
Dried fruit	x	23	10	6.3	0	63	0	46
Tomato, dried	x	1	1	0.80	-	-	-	-
Fat and vegetable oils								
Olive oil	x	54	47	2.0	0	8.1	1.7	6.9
Rapeseed oil	x	22	18	1.5	0	15	0.40	4.9
Sunflower oil	x	15	12	4.3	0	18	0.90	18
Vegetable oil		32	19	1.3	0	5.3	0.25	5.1
Vegetable fat	x	2	1	0.48	0	0.95	0.48	-
Coffee and tea								
Coffee, beans	x	9	9	1.9	0.90	4.0	1.6	-
Coffee, instant		2	2	3.7	2.2	5.1	3.7	-
Teas	x	10	10	46	2.8	115	48	115
Miscellaneous								
Biscuit, butter		1	1	0.15	-	-	-	-

[1]Number of samples with a value above LOD

Levels of PAH4 (continued)

Food	Included in exposure	No. of samples	Positive[1]	Average	Minimum	Maximum	Median	95th percentile
Meat								
Beef meat	x	7	4	1.2	0	7.2	0.10	-
Beef meat, grilled		29	8	1.3	0	11	0	7.5
Beef meat, minced grilled		31	15	4.1	0	33	0	33
Beef meat, pastrami		2	2	10	6.2	14	10	-
Pork meat, boiled or roasted	x	2	0	0	0	0	0	-
Pork meat, smoked	x	38	1	0.01	0	0.4	0	0
Pork meat, grilled		16	3	0.28	0	3.1	0	3.1
Pork chops, grilled	x	13	3	2.3	0	25	0	25
Pork meat, Danish type salami	x	3	0	0	0	0	0	-
Pork, sausage smoked	x	9	1	0.08	0	0.75	0	-
Pork, sausage grilled	x	10	9	0.75	0	1.9	0.63	1.9
Chicken meat	x	2	0	0	0	0	0	-
Chicken meat, grilled		27	7	1.1	0	21	0	4.4
Lamb, grilled	x	7	5	3.3	0	13	0.55	-
Veal meat, grilled		2	1	0.53	0	1.1	0.53	-
Fish and seafood								
Mussels (*Mytilus edulis*)		186	184	1.4	0	4.5	1.2	3.3
Mussels (*Mytilus edulis*), smoked		1	1	12	-	-	-	-
Mussels (*Spisula* sp.)		12	12	1.8	0.89	2.7	1.7	2.7
Oyster		25	25	4.4	1.2	7.7	3.4	7.6
Shrimps and scallop, grilled		4	4	1.9	1.2	4.0	1.3	-
Herring, raw	x	8	1	0.02	0	0.15	0	-
Herring, smoked	x	44	36	3.8	0	22	1.5	18
Mackerel, raw	x	7	2	0.07	0	0.35	0	-
Mackerel, smoked	x	68	39	1.5	0	17	0.35	8.2
Salmon, raw	x	5	0	0	0	0	0	-
Salmon, smoked	x	41	18	1.9	0	24	0	13
Salmon, grilled		11	1	0.09	0	1.0	0	1.0
Trout, smoked	x	15	7	0.61	0	4.3	0	4.3
Eels, smoked	x	31	24	1.9	0	7.4	1.5	5.8
Fish and other seafood		25	17	0.71	0	2.6	0.20	2.5
Smoked fish, other		29	15	0.89	0	9.9	0.05	2.7
Cod roe, smoked		22	19	23	0	158	9.0	79

[1]Number of samples with a value above LOD

Concentrations of BaP and sum PAH4 within foodgroups not included in the Danish analytical surveys used for exposure calculation. Upper bound values from Table 9 (EFSA, 2008)

Food	Number of samples	Value BaP (µg/kg)	Value PAH4 (µg/kg)
Milk and milkproducts	29	0.12	0.51
Smoked cheese	32	0.14	0.47
Bread and cereals	9	0.26	1.0
vegetables, other	40	0.38	1.72
Processed fruit not dried	1	0.05	0.20
Sugar and sugar products[2]		0.12	0.58
Alcoholic beverages	30	0.009	0.06
Spices	10	3.5	23

[2] Based on values from Table 19 (EFSA, 2008)

Fødevareinstituttet
Danmarks Tekniske Universitet
Mørkhøj Bygade 19
DK - 2860 Søborg

T: 35 88 70 00
F: 35 88 70 01
www.food.dtu.dk

ISBN: 978-87-92763-77-8