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SCIENTIFIC REPORT OF EFSA

Results of the monitoring of dioxin levels in food and feed[1]

European Food Safety Authority[2, 3]

European Food Safety Authority (EFSA), Parma, Italy

ABSTRACT

Environmentally persistent dioxins and dioxin-like compounds include 29 congeners of dioxins, furans and polychlorinated biphenyls (PCB) with similar toxic effects, their quantification commonly expressed as toxic equivalent units according to their varying potency. While the amount of those compounds in the environment has declined since the late 1970s, there is a continued concern because of their accumulation in the food chain, particularly in animal fat. In 2002 the European Commission prescribed a list of actions to further reduce the presence of dioxins and dioxin-like PCBs and later introduced action and maximum levels with random monitoring by Member States. A total of 7,270 samples collected in the period 1999-2008 from 19 Member States, Norway and Iceland were analysed in detail. Dioxin and furan congeners comprised between 30% and 74% of the total concentrations depending on food or feed group, while mono-*ortho* PCBs comprised between 15% and 45% of the dioxin-like PCBs. The highest mean levels of dioxins and dioxin-like PCBs in food expressed on fat basis were observed for 'liver and products thereof from terrestrial animals' and on whole weight basis for 'fish liver and products thereof'. In feed the highest levels were found in 'fish oil'. An overall 8% of the samples exceeded different maximum levels and a further 4% exceeded some action levels. However, some of these samples clearly originated from targeted sampling during specific contamination incidences and there were large variations between groups. Changing the basis for calculating toxic equivalent units to the new recommendations issued by WHO in 2005 will overall result in 14% lower values with the extent of the difference highly variable across food and feed groups. To ensure accurate assessments of the presence of dioxins and dioxin-like PCBs, continuous random testing of a sufficient number of samples in each food and feed group is recommended.

KEY WORDS

Polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, dioxin-like polychlorinated biphenyls, toxicity equivalency factors, toxic equivalents, food, feed.

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SUMMARY

Dioxins and dioxin-like compounds include a range of toxic and environmentally persistent substances. The terms most often refer to 29 congeners of polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans and dioxin-like polychlorinated biphenyls (PCB). Dioxin and furan congeners are formed as unintentional by-products during combustion processes such as waste incineration and forest fires, as well as during some industrial processes such as paper pulp bleaching and the manufacturing of chlorinated pesticides. PCBs are synthesised by direct chlorination of biphenyl and can be divided into different groups according to their biochemical and toxicological properties. Non-*ortho* and mono-*ortho* substituted PCBs show toxicological properties that are similar to dioxins. They are therefore often termed 'dioxin-like PCBs'. The other PCBs don't exhibit a dioxin-like toxicological profile and are therefore termed 'non-dioxin-like PCBs'. PCBs have been used in a variety of applications such as dielectric fluids in transformers and as heat transfer fluids because of their non-flammability and electrical insulation properties. The production and use of PCBs have been discontinued in most countries since a ban on their manufacturing, processing and distribution was introduced in 1985, but large amounts remain in electrical equipment, plastic products and buildings.

While the amount of dioxins and dioxin-like compounds in the environment has declined since the late 1970s, there is a continued concern about the safety of the food supply and the potential adverse health effects of exposure to this group of substances. Because of their lipophilicity, together with their persistency in the environment, dioxins have accumulated in the food chain, particularly in animal fat, dairy products, and fish.

The presence of dioxins and dioxin-like PCBs is expressed as toxic equivalents (TEQ) after multiplication of congener-specific concentration levels with toxicity equivalency factors (TEF) developed based on their relative toxicity compared to 2,3,7,8-TCDD. The current European legislation is based on TEFs set by the World Health Organisation (WHO) in 1998 with the results expressed as TEQ_{WHO98}. New TEFs were suggested in 2005 with the results expressed as TEQ_{WHO05}.

In 2002 the European Commission prescribed a list of actions to further reduce the presence of dioxins and dioxin-like PCBs and later introduced regular monitoring by Member States of food and feed, including, if possible, also non-dioxin-like PCBs. Data on the presence of 17 congeners of dioxins and furans, and 12 congeners of dioxin-like PCBs in food and feed have been reported on a regular basis to the Commission. In April 2008 the Commission handed the collected information to the European Food Safety Authority (EFSA) for assessment.

A total of 7,270 samples collected in the period 1999-2008 from 19 Member States, Norway and Iceland were analysed in detail. The percentage of samples below the limit of quantification (LOQ) varied considerably at the congener level. Overall, the percentages of censoring, defined as the proportion of non-quantified (<LOQ) observations, varied sizeably depending on how results were expressed: on a fat basis (about 40%), on a whole weight basis (about 30%), or for feed on '12% moisture' basis (about 60%).

The highest mean levels of dioxins and dioxin-like PCBs in food were observed for 'Fish liver and products thereof' (32.6 pg TEQ_{WHO98}/g) and 'Muscle meat eel' (6.7 pg TEQ_{WHO98}/g) expressed on whole weight basis, and for 'Liver and products thereof from terrestrial animals' (5.7 pg TEQ_{WHO98}/g) expressed on fat basis. The highest level in feed was found in 'Fish oil' (10.0 pg TEQ_{WHO98}/g) expressed on 12% moisture basis.

Ad hoc analyses were conducted for the groups 'Meat and meat products ruminants', 'Muscle meat fish and fish products excluding eel', 'Raw milk and dairy products including butter', and 'Hen eggs and egg products' to evaluate the influence of species, geographical or production differences. No clear conclusion could be drawn for the ruminant meat group because of low sample numbers for some species. For the food group muscle meat of fish and fish products excluding eel there were

differences in dioxins and dioxin-like PCBs between the different sub-groups, with mean values ranging from 1.20 (‘Farmed trout’) to 7.99 (‘Salmon’) pg TEQ_{WHO98}/g expressed on whole weight basis. Mean levels of dioxins and dioxin-like PCBs in herring were overall higher for samples collected in countries from the Baltic Sea area (8.64 pg TEQ_{WHO98}/g) compared to countries outside the Baltic area (2.30 pg TEQ_{WHO98}/g). In the food group milk and dairy products, slightly lower mean levels of dioxins and dioxin-like PCBs were found when moving from farm (1.27 pg TEQ_{WHO98}/g) and bulk milk (1.30 pg TEQ_{WHO98}/g) to retail milk (0.95 pg TEQ_{WHO98}/g) expressed on fat basis. This could be related to a slight dilution effect at retail level in the mixing of milk from different origins or to a targeting of possible suspect samples at farm level. Too few egg samples had been assigned a specific production method to serve as a basis for any detailed analysis.

The percentage of results exceeding different maximum levels for dioxins and dioxin-like PCBs set by legislation was on average 8% with a further 4% exceeding some action levels, but there were large variations between groups. Overall, a lower percentage of results exceeded maximum levels set for feed than for food. It is important to bear in mind that a varying proportion of product testing reflects targeted and not random monitoring. This has the potential of introducing a degree of uncertainty and bias in the evaluation of background levels of dioxins and dioxin-like PCBs in food and feed, as higher total values are expected in targeted compared to random samples.

The impact of changing the basis for the calculation of TEQ from TEF_{WHO98} to TEF_{WHO05} was evaluated with levels of dioxins and dioxin-like PCBs using the latter being overall 14% lower than levels using the former. This difference was mainly due to changes in TEFs for mono-*ortho* PCB and furan congeners with little change in dioxin and non-*ortho* PCB congeners. However, there were large variations observed for different food and feed categories and between products within food and feed categories.

Dioxin and furan congeners comprised between 30% and 74% of the total concentration of dioxins and dioxin-like PCBs depending on the food or feed group. There was considerable variation within food and feed groups. Mono-*ortho* PCBs comprised between 15% and 45% of the concentration of dioxin-like PCBs. This proportion was considerably lower when using the TEF_{WHO05} rather than TEF_{WHO98} as the basis for calculating the TEQ.

The current results clearly include results from both random and targeted monitoring although not specifically stated and should be interpreted with some caution. The lack of such sampling information and the irregular coverage of food and feed groups over time did unfortunately not allow for a time trend analysis to be performed. To improve the validity of any assessment of the presence of dioxins and dioxin-like PCBs in food and feed in Europe random testing and separate reporting of a sufficient number of samples in each food and feed group is important. Targeted sampling during contamination incidences should be clearly indicated as such in the reporting.

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BACKGROUND AS PROVIDED BY THE REQUESTOR

The term "dioxins" refers to a group of chemically and structurally related halogenated aromatic hydrocarbons, including 75 polychlorinated dibenzo-*p*-dioxin (PCDD) and 135 polychlorinated dibenzofuran (PCDF) congeners. Dioxins are widely distributed contaminants formed as unwanted by-products in a number of anthropogenic activities.

The toxicity of individual dioxin and furan congeners differs considerably. From the 210 theoretically possible congeners, only those substituted in each of the 2-, 3-, 7- and 8-positions of the two aromatic rings are of toxicological concern. These 17 congeners exhibit a similar toxicological profile, with 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) the most toxic congener.

Polychlorinated biphenyls (PCBs) are chlorinated aromatic hydrocarbons, which are synthesised by direct chlorination of biphenyl. Depending on the number of chlorine atom substituents (1-10) and their position on the two rings there are 209 theoretically possible congeners. PCBs can be divided into different groups according to their biochemical and toxicological properties. Non-*ortho* and mono-*ortho* substituted PCBs show toxicological properties that are similar to dioxins. They are therefore often termed 'dioxin-like PCBs'. Most other PCBs do not show dioxin-like toxicity.

In order to be able to sum up the toxicity of the different congeners of concern (17 dioxins and 12 dioxin-like PCBs), Commission Regulation (EC) No 1881/2006 lays down the use of toxicity equivalency factors (TEFs) to facilitate risk assessment and regulatory control. The analytical results of all individual dioxin and dioxin-like PCB congeners should be expressed in terms of 2,3,7,8-TCDD toxic equivalents (TEQs) using the TEF values proposed by the World Health Organisation in 1998.

In 2002 a Commission Recommendation (2002/201/EC) prescribed a list of actions to be taken to reduce the presence of dioxins and dioxin-like PCBs in food and feed. Target levels for food and feed were recommended based on the opinions produced by the Scientific Committee for Food (SCF, 2000) and the Scientific Committee on Animal Nutrition (SCAN, 2000). In an effort to harmonise the legislation on both dioxins and dioxin-like PCBs in light of more accurate information on their presence in food and feed, a new Commission Recommendation (2006/794/EC) was issued in 2006. This Recommendation introduced random monitoring of the presence of dioxins, dioxin-like PCBs and, if possible, non-dioxin-like PCBs, by Member States on the basis of criteria defined by Commission Recommendations 2004/704/EC and 2004/705/EC for feed and food, respectively. Data on the background presence of dioxins, furans, and dioxin-like PCBs in food and feed have been reported on a regular basis to the Commission. In April 2008 the Commission handed the collected information to EFSA for assessment.

TERMS OF REFERENCE AS PROVIDED BY THE REQUESTOR

The European Food Safety Authority is requested to:

1. Extract from the Member State submissions the original information for each of the 17 dioxins, 12 dioxin-like PCBs and, when relevant, information supplied for non-dioxin-like PCBs.
2. Collate and check the accuracy and details of the submitted information.
3. Evaluate contamination levels for food and feed categories as nominated in the Commission legislation.
4. Assess the impact of changing the legislation from the current TEF system from 1998 in relation to the new TEFs proposed by the WHO in 2005.
5. Document the findings in a report to the Commission and present the results to the Commission Expert Group on persistent organic pollutants (POPs).
6. Provide on-going support in evaluating the annual submissions of data on dioxins, dioxin-like PCBs and non-dioxin-like PCBs.

ASSESSMENT

1. Introduction

Dioxins and dioxin-like PCBs (polychlorinated biphenyls) form a group of toxic and environmentally persistent chemicals whose effects on human health include dermal toxicity, immunotoxicity reproductive effects and teratogenicity, endocrine disrupting effects and carcinogenicity (van den Berg *et al.*, 1998).

The term "dioxins" refers to a group of chemically and structurally related chlorinated aromatic hydrocarbons (Liem and van Zorge, 1995). There are 210 theoretically possible congeners in the group, including 75 polychlorinated dibenzo-*p*-dioxin (PCDD) and 135 polychlorinated dibenzofuran (PCDF) congeners. They are widely distributed contaminants that are of no particular use, but are mainly formed as unwanted by-products in a number of anthropogenic activities. Such activities include manufacturing of certain chemicals, incineration of municipal waste and the bleaching of wood pulp (Rappe and Buser, 1981; WHO/EURO, 1987; Gillespie and Gellman, 1989). Dioxins are very stable against chemical and microbiological degradation and therefore persistent in the environment.

Polychlorinated biphenyls (PCBs) are chlorinated aromatic hydrocarbons, which were previously intentionally manufactured and due to their physical and chemical properties, such as non-flammability, chemical stability, high boiling point, low heat conductivity and high dielectric constants, were widely used in a number of industrial and commercial applications. There are 209 theoretically possible congeners of PCBs that can be divided into different groups according to their biochemical and toxicological properties (ATSDR, 2001). Non-*ortho* and mono-*ortho* substituted PCBs show toxicological properties that are similar to dioxins. They are therefore often termed 'dioxin-like PCBs'. Most other PCBs do not show dioxin-like toxicity and are therefore termed 'non-dioxin-like PCBs'. The production and use of PCBs have been discontinued in most countries since a ban on their marketing was introduced in 1985, but large amounts remain in electrical equipment, plastic products and buildings (e.g. plastic carpeting and sealing materials). While certain lower chlorinated PCB congeners are metabolised quickly, higher chlorinated congeners with certain chlorine substitution patterns are notably more stable and accumulate within the food chain.

Toxicity of dioxins and dioxin-like PCBs is mainly mediated through binding to the aryl hydrocarbon (Ah) receptor thereby inducing protein synthesis. However, the toxicity of individual dibenzodioxin, dibenzofuran and PCB congeners differs considerably. From the 210 theoretically possible congeners of dioxin and furan, only those substituted in each of the 2-, 3-, 7- and 8-positions of the two aromatic rings are of toxicological concern. These 17 congeners exhibit a similar toxicological profile, with 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) the most toxic congener (Ahlborg *et al.*, 1990; IARC, 1997). From the 209 theoretically possible PCB congeners, only 12 are considered to have dioxin-like toxicity since they can easily adopt a coplanar structure with the capability to bind to the Ah receptor, thus showing toxicological properties similar to dioxins (Poland *et al.*, 1985; Safe, 1986; Safe *et al.*, 2005). However, most dioxins are considerably more toxic than the PCBs, but the quantities of PCBs released to the environment are several times higher and they, thus, often show much higher levels in food and feed than dioxins.

Dioxins and dioxin-like PCBs are fat soluble and tend to bioaccumulate in body fat, both in animals and humans, biomagnifying through the food chain. They are generally not taken up or absorbed by plants, with the exception of some members of the cucurbit family (Hülster *et al.*, 1994; White *et al.*, 2005), but may settle on the surfaces of the leaves. They can then enter the food chain when animals eat the contaminated leaves. In aquatic environments, fish and other marine animals can absorb dioxins and dioxin-like PCBs.

International studies have concluded that around 95% of human exposure occurs through consumption of food of animal origin, with meat, dairy products and fish being the main sources (Gilman *et al.*, 1991). Other ways of contamination are through breathing in air contaminated by dioxins and dioxin-like PCBs from smoke, factory or incinerator emissions or from uncontrolled hazardous waste sites.

Dioxins are reputed to be among the most toxic of organic compounds. Chronic exposure of animals to dioxins has resulted in several types of cancer. Based on both animal studies and epidemiologic evidence, 2,3,7,8-TCDD was classified as a 'known human carcinogen' (class 1) by the World Health Organisation's (WHO) International Agency for Research on Cancer (IARC) in 1997. However, 2,3,7,8-TCDD does not directly affect genetic material and there is a level of exposure below which cancer risk would be negligible.

Dioxins and dioxin-like PCBs in general contain complex mixtures of different PCDD, PCDF and PCB congeners. For risk assessment purposes, the concept of toxic equivalency (TEQ) was developed to describe the cumulative toxicity of complex mixtures of these compounds (Ahlborg *et al*., 1992). The procedure involves assigning individual toxicity equivalency factors (TEFs) to the PCDD, PCDF, and PCB congeners in terms of their relative toxicity compared to 2,3,7,8-TCDD, which is considered as the reference congener (TEF=1). The toxic equivalency (TEQ) of a mixture is calculated by multiplying the concentrations of individual congeners by their respective TEF, and then adding the individual TEQs to obtain a total TEQ concentration for the mixture.

During the last 15 years, WHO has through the International Program on Chemical Safety (IPCS) established and re-evaluated TEFs for dioxins and related compounds through expert consultations. So called WHO-TEF values have been established for humans and mammals, birds and fish (Ahlborg *et al.*, 1990; van den Berg *et al.*, 1998). During the WHO/IPCS expert consultation in 1997, it was agreed to re-evaluate the TEF values on a regular basis, preferably at five-year intervals. The last re-evaluation was undertaken in 2005. As a result, a number of TEF values have been changed, notably for PCBs, octachlorinated dioxin and furan and pentachlorinated furans as indicated in Table 1 (van den Berg *et al.*, 2006). To avoid confusion, it is very important to clearly state what set of factors has been used by indicating the year in which they were expressed, TEF_{WHO98} and TEF_{WHO05} and the associated TEQ_{WHO98} and TEQ_{WHO05} values.

Table 1: Change in WHO toxicity equivalency factors (TEF_{WHO98} and TEF_{WHO05}) between assessments in 1998 and in 2005 with changes in bold.

Compound	TEF_{WHO98}	TEF_{WHO05}	Compound	TEF_{WHO98}	TEF_{WHO05}
Chlorinated dibenzo-p-dioxins			**Non-*ortho* substituted PCBs**		
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**			
Chlorinated dibenzofurans			**Mono-*ortho* substituted PCBs**		
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**			

There is considerable public, scientific and regulatory concern over the negative effects on human health and on the environment of long-term exposure to even the smallest amounts of dioxins and dioxin-like PCBs. The Scientific Committee on Food (SCF) assessed the risks to public health arising from the presence of dioxins and dioxin-like PCBs in food in November 2000 and May 2001 (SCF, 2000; SCF, 2001). On 6 November 2000, the Scientific Committee on Animal Nutrition (SCAN) adopted an opinion on the dioxin contamination of feed and its contribution to the contamination of food of animal origin (SCAN, 2000). These two opinions provided the scientific basis for the Community measures to limit the presence of these contaminants in food and feed as part of an overall strategy to reduce their presence in the environment and the food chain.

A community strategy for dioxins, furans and PCBs was adopted by the Commission on 24 October 2001, addressing measures to limit or to eliminate their emission into the environment through source-directed measures and addressing the way to actively decrease the presence of dioxins, furans and PCBs in food and feed.

The Commission developed this strategy in view of the general concern that at the current levels of exposure a considerable part of the European population would exceed the Tolerable Weekly Intake of 14 pg TEQ_{WHO98}/kg body weight as derived by the SCF.

The Dioxin Strategy describes an integrated approach to legislation on food and feed to reduce the presence of dioxins, furans and PCBs throughout the food chain. This integrated approach consists of three pillars:

1. The establishment of strict but feasible maximum levels in food and feed taking into account the results obtained in lowering the presence of dioxins in the environment.
2. The establishment of action levels to trigger action when levels in food or feed are found clearly above background levels. These action levels have an early warning function.
3. The establishment of target levels to be achieved over time so as to bring the exposure of the majority of the European population within the limits recommended by the Scientific Committee on Food.

In 2001, Council Regulation (EC) No 2375/2001 established maximum levels for dioxins in meat and meat products, fish and fishery products, milk and dairy products, hen eggs and egg products, and oils and fat. Directive 2002/32/EC of the European Parliament and of the Council (as amended by Commission Directive 2003/57/EC) established maximum levels for dioxins in feed materials of plant origin, minerals, binders, animal fat, and other products of animal origin, fish oil, fish meal, and compound feed, including fish feed. In 2002 a Commission Recommendation (2002/201/EC) prescribed a list of actions to be taken to reduce the presence of dioxins and dioxin-like PCBs in food and feed. Target levels for food and feed were recommended based on the previous opinions of SCF (SCF, 2000) and SCAN (SCAN, 2000). In an effort to harmonise the legislation on both dioxins and dioxin-like PCBs in the light of more accurate information on their presence in food and feed, a new Commission Recommendation (2006/794/EC) was issued in 2006. This Recommendation introduced random monitoring of the presence of dioxins, dioxin-like PCBs and, if possible, non-dioxin-like PCBs, by Member States on the basis of criteria defined by Commission Recommendations 2004/704/EC and 2004/705/EC for feed and food, respectively. In order to be able to sum up the toxicity of the different congeners of concern (the 17 dioxins and the 12 dioxin-like PCBs), Commission Regulation (EC) No 1881/2006 lays down the use of TEF to facilitate risk assessment and regulatory control. The analytical results relating to all the individual dioxin, furan and dioxin-like PCB congeners should be expressed in terms of 2,3,7,8-TCDD toxic equivalents using the TEF values proposed by the World Health Organisation in 1998.

Data on the background presence of dioxins, furans, and dioxin-like PCBs in food and feed have been reported on a regular basis to the Commission. In April 2008 the Commission handed the information collected to EFSA for a detailed assessment.

2. Objectives

1. Extract from the Member State submissions the original information for each of the 17 dioxins and furans, 12 dioxin-like PCBs and, when relevant, information supplied for non-dioxin-like PCBs.
2. Collate and check the accuracy and details of the submitted information.
3. Evaluate contamination levels for food and feed categories as nominated in the Commission legislation.
4. Assess the impact of changing the legislation from the current TEF system from 1998 to the new TEF values proposed by the WHO in 2005.

3. Materials and Methods

3.1. Sampling and analytical procedure

The procedures for sample collection, preparation and analyses to monitor the levels of dioxins (PCDD), furans (PCDF) and dioxin-like PCBs in foodstuffs are detailed in Commission Regulation (EC) No 1883/2006. It also states that in accordance with the provisions of Regulation (EC) No 882/2004 of the European Parliament and of the Council, laboratories shall be accredited by a recognised body operating in accordance with ISO Guide 58 to ensure that they are applying analytical quality assurance. Laboratories shall be accredited following the EN ISO/IEC 17025 standard.

Analytical results shall be reported as the upper bound levels of the individual PCDD, PCDF and dioxin-like PCB congeners as well as the combined TEQ_{WHO98} in order to enable interpretation of the results according to legislative requirements. As some of the data received by EFSA did not include information on the specific food and feed categories, a classification was undertaken according to the legislation for food in Commission Regulation (EC) No 1881/2006 and feed in Directive 2002/32/EC.

The availability of the unit of measure is a prerequisite for data analyses. Commission Recommendation 2006/794/EC suggests to adopt picogram/gram (pg/g) when reporting results for dioxins, furans and dioxin-like PCBs, and nanogram/gram or microgram/kilogram (ng/g or µg/kg) for the non-dioxin-like PCBs. When the information was missing it was assumed that the results were expressed in the same unit as the maximum levels laid down in Commission Regulation (EC) No 1881/2006 for the specific commodity.

This report includes data from 1999 onwards, as most of the data received were collected from this period. Inclusion of older data in the analysis entails comparability issues because the analytical methods for the substances considered have likely improved over time.

3.2. Data management and validation

EFSA was handed 26,600 sets of individual sample results in the form of Microsoft Excel spreadsheets, Microsoft Word files or Adobe Acrobat portable document files (pdf). Data sets including results for only non-dioxin-like PCBs were deferred to a future analysis to be covered in a separate report. A list of validation steps was applied to the remaining 13,854 data sets: samples with a number of relevant fields left blank, samples where only the total TEQ_{WHO98} was reported without individual values at the congener level, or samples with other inconsistencies in the way results were reported making interpretation difficult were excluded from the dataset. After further clarifications received through bilateral contacts with Member States the remaining datasets were consolidated in the database. These validation steps resulted in the number of samples listed in the ‘Validated Number’ column in Table 2.

Table 2: Number of country-specific samples initially submitted, retained after a number of validation and cleaning steps, included in the final database, and their proportion of the total.

Country	Initial Number	Validated Number	Cleaned Number	Final Number	Percent
Austria	228	227	227	215	3.0
Belgium	1,066	1,054	861	577	7.9
Cyprus	48	28	28	17	0.2
Czech Republic	175	117	90	65	0.9
Denmark	277	277	260	257	3.5
Estonia	21	21	21	21	0.3
Finland	739	739	392	392	5.4
France	598	443	130	129	1.8
Germany	3,543	3,539	1,302	1,260	17.3
Greece	586	260	260	148	2.0
Iceland	290	288	265	245	3.4
Ireland	803	791	761	697	9.6
Italy	422	365	-	-	-
Lithuania	3	3	3	3	0.1
Luxembourg	12	12	12	12	0.2
Netherlands	825	643	488	363	5.0
Norway	575	567	429	422	2.8
Poland	389	222	222	47	0.7
Romania	247	-	-	-	-
Slovenia	522	355	262	262	3.6
Spain	204	203	152	152	2.1
Sweden	639	639	593	568	7.8
United Kingdom	1,642	1,589	1,585	1,418	19.5
Total	13,854	12,382	8,343	7,270	100

3.3. Missing values for individual congener measurements and exclusions

In this report, only samples with complete information for the 17 congeners of dioxins and furans, and for the 12 congeners of dioxin-like PCBs were retained for statistical analyses. This included an initial 6,616 samples. An imputation technique was adopted to treat missing values. An exploratory analysis of the toxic equivalent sum of dioxin, furan and dioxin-like PCB congeners showed that, overall, more than 85% of the sum was determined by five congeners (i.e. 2,3,4,7,8-PeCDF; 1,2,3,7,8-PeCDD; 2,3,7,8-TCDD; 2,3,7,8-TCDF; PCB-126). At the congener level, the LOQ values of samples for which at least the five aforementioned congeners were present were imputed using country- and food/feed-specific LOQ median values (‘Cleaned number’ in Table 2).

As a last quality control check, lower and upper bound estimates were compared. Lower and upper bound contamination values were determined by setting to zero and LOQ, respectively, congener-specific analytical results reported to be below the LOQ. In accordance with Commission Regulation (EC) No 1883/2006, samples were excluded when the percentage difference between lower bound and upper bound (reference) estimates of total dioxin levels was greater than pre-defined threshold values. Specifically, thresholds were set to 60% for contamination in the range of 0.2 to 0.4 pg TEQ_{WHO98}/g, to 50% in the range of 0.4 to 0.8 pg TEQ_{WHO98}/g, and to 30% for contamination levels greater than 0.8 pg TEQ_{WHO98}/g. After these exclusions, the “final” database included 210,830 results covering 7,270 samples from 19 Member States, Iceland and Norway, but no samples from the Italian or Romanian submissions since they contained insufficient information (Table 2).

3.4. Expression of results

Most of the original files handed to EFSA included information on the fat content of the sample, as well as on the method used for fat extraction, as required by the legislation. The legislation also prescribes how the results should be expressed for the respective food and feed groups, either on fat, 12% standardised moisture content or whole weight basis. When not reported, the expression of results was assumed to be compliant with the legislation. On the other hand, when the expression of results was not in agreement with legislation requirements, the dioxin concentration was converted to the right expression using the reported fat content, pending its availability.

3.5. Limits of quantification

According to Commission Regulation (EC) No 1883/2006, the accepted specific limit of quantification (LOQ) of an individual congener is the concentration of an analyte in the extract of a sample which produces an instrumental response at two different ions to be monitored with an S/N (signal/noise) ratio of 3:1 for the less sensitive signal and fulfilment of the basic requirements such as e.g. retention time, isotope ratio according to the determination procedure as described in EPA method 1613 revision B (EPA, 1994).

In accordance with the legislation, upper bound results were used throughout this report except when responding to a Commission request to test the impact of using lower or upper bound.

3.6. TEQ values

The concentration of the individual congeners in each sample was multiplied by their respective TEF, as established by the World Health Organisation (van den Berg *et al.*, 1998), and subsequently summed up to give the total concentration of dioxins and dioxin-like PCBs expressed as Toxic Equivalents (TEQs):

$$TEQ = \sum_{i=1}^{n} \left(C_i * TEF_i \right)$$

where C_i expresses the concentration of a congener i=1,…, n, and its associated TEF_i value.

To respond to the Commission request to assess the impact of changing the current 1998 TEF values to the new TEFs proposed by the WHO in 2005, the same calculation was performed using the 2005 TEFs.

3.7. Statistical analyses

Frequency tables and summary statistics were produced to describe the dioxin data by year of collection, country of testing, food and feed group. Sample TEQ means and 25^{th}, 50^{th}, 75^{th}, 90^{th}, 95^{th} and 99^{th} percentiles were computed at the congener level, using in turn TEF_{WHO98} and TEF_{WHO05}. These statistics were computed for dioxins, furans, the sum of dioxins and furans, mono-*ortho* PCB, non-*ortho* PCB, their sum (dioxin-like PCBs), and the overall sum of dioxins, furans and dioxin-like PCBs, here referred to as total dioxins. In general, food and feed-specific statistics were computed and reported.

To compare the impact of using TEF_{WHO98} and TEF_{WHO05} values, the percentage TEQ difference was computed at the individual (sample) level, for each food and feed category. Moreover, the ratio of dioxins and furans over total dioxins, and the ratio of mono-*ortho* PCBs over, in turn, total dioxin-like PCBs and total dioxins were computed at the individual (sample) level to provide an indication of their general proportional distribution in food and feed.

A trend analysis was undertaken to see if the levels of dioxins and dioxin-like PCBs had changed over time. The results were inconclusive with some food groups increasing while others decreased. Targeted sampling likely biases any attempt to assess time trends.

All analyses were run using the SAS Statistical Software (SAS software, 1999).

4. Results and Discussion

Most results in the dioxin database were received from the United Kingdom followed by Germany and Belgium. Eight Member States did not submit any results for the relevant compounds. The data collection covers results from 1999 to 2008 with the majority of samples between 2003 and 2007. Table 3 details the number of samples covered for each sampling year in the different countries. Some countries delivered sample results on a regular basis while other country submissions covered only a few years. Sample submissions for 2008 were incomplete. The year of collection was missing in 49 samples, which are not reported in this table.

Table 3: Number of accepted samples submitted for each sampling year by the respective country.

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
Austria	-	-	-	-	-	48	39	87	-	41	215
Belgium[1]	-	-	58	106	102	73	59	77	92	-	567
Cyprus	-	-	-	-	-	17	-	-	-	-	17
Czech Republic	-	-	-	-	-	-	51	-	-	14	65
Denmark	-	38	40	60	15	85	13	6	-	-	257
Estonia	-	-	-	-	-	-	21	-	-	-	21
Finland	-	-	-	235	29	-	30	50	37	11	392
France	-	-	-	1	97	31	-	-	-	-	129
Germany	-	-	-	-	9	100	214	349	588	-	1,260
Greece	-	-	-	54	-	-	28	4	62	-	148
Iceland	-	-	-	-	60	144	41	-	-	-	245
Ireland[2]	-	-	-	-	203	166	137	152	-	-	658
Lithuania	-	-	-	-	-	-	3	-	-	-	3
Luxembourg	-	-	-	12	-	-	-	-	-	-	12
Netherlands	-	-	40	46	-	106	106	4	61	-	363
Norway	2	-	8	25	95	178	114	-	-	-	422
Poland	-	-	-	-	-	-	-	-	-	47	47
Slovenia	-	-	-	-	-	-	88	78	96	-	262
Spain	-	-	-	62	64	26	-	-	-	-	152
Sweden	-	21	40	60	35	186	103	59	40	24	568
United Kingdom	-	-	19	-	453	84	615	157	90	-	1,418
Total	2	59	205	661	1,162	1,244	1,662	1,023	1,066	137	7,221

[1]Information on the sampling year not available in n=10 samples;
[2]Information on the sampling year not available in n=39 samples.

The food and feed groups sampled are illustrated in Table 4. There are 1,640 feed samples, and 5,624 food samples spread over categories defined by Commission Directive 2006/13/EC and Commission Regulation (EC) No 1881/2006, respectively. The group ‘Muscle meat fish and fish products excluding eel’ contained the largest number of samples (n=1,976), followed by the group ‘Raw milk and dairy products including butter’ (n=931). In the feed area most samples belonged to the group ‘Compound feed, excluding feed for fur animals, pets and fish’ (n=482) followed by ‘Feed materials of plant origin, excluding oils’ (n=378). There were six results that could not be classified because they lacked sufficient information of the food and feed product examined.

In many cases there were no indications on what basis the results were expressed, whether on 12% moisture content, fat or whole weight basis and the fat content was not always given as required by legislation. Throughout this report it was assumed that, when this information was lacking, the results were expressed in the format specified in the legislation for the respective food and feed category.

Table 4: Number of samples distributed in food and feed groups. 'State' indicates on what basis the results have been expressed, whether on fat, whole weight (ww), or 12% moisture (12%) basis.

Food group	Frequency	Percent	State
Meat and meat products ruminants	175	2.4	fat
Meat and meat products poultry	94	1.3	fat
Meat and meat products pigs	90	1.2	fat
Liver and products terrestrial animals	91	1.3	fat[1]
Muscle meat fish and fish products excluding eel	1,976	27.2	ww
Muscle meat eel	139	1.9	ww
Raw milk and dairy products including butter	931	12.8	fat
Hen eggs and egg products	785	10.8	fat
Fat ruminants	80	1.1	fat
Fat poultry	66	0.9	fat
Fat pigs	89	1.2	fat
Mixed animal fats	43	0.6	fat
Vegetable oils and fats	97	1.3	fat
Marine oils	111	1.5	fat
Fish liver and products	43	0.6	ww
Fruits, vegetables and cereals	260	3.6	ww
Other products	335	4.6	-
Infant and baby food	219	3.0	fat[1]
Feed materials of plant origin excl. oils	378	5.2	12%
Vegetable oils and their by-products	68	0.9	12%
Feed materials of mineral origin	114	1.6	12%
Animal fat, including milk fat and egg fat	37	0.5	12%
Other land animal products incl. milk, eggs	31	0.4	12%
Fish oil	89	1.2	12%
Aquatic animals excl. fish oil and protein	128	1.8	12%
Fish protein hydrolysates >20% fat	-	-	-
Additives binders and anti-caking agents	-	-	-
Additives compounds of trace elements	79	1.1	12%
Pre-mixtures	91	1.3	12%
Compound feed, excl. fur animals, pets, fish	482	6.6	12%
Feed for fur animals, pets and fish	143	2.0	12%
Feed not specified	3	<0.1	12%
Food not specified	3	<0.1	12%

[1]Contamination levels were computed for results expressed both as fat and whole weight basis (section 4.7 for a comparison).

4.1. Number of samples by country and food and feed groups

The number of samples retained for further analyses are reported in Table 5 for each food and feed group, respectively, for each country. Although in general most countries contributed information to evaluate dioxin levels, thus following Commission Recommendation 2004/704/EC on annual sampling, a number of countries provided suitable dioxin information on a limited range of food groups only.

A general caution is in place in relation to random and targeted sampling. Some of the results reported might have originated from testing during specific contamination incidences involving dioxins.

Table 5: Country ISO code and food and feed group specific sample numbers.

	AT	BE	CY	CZ	DE	DK	EE	ES	FI	FR	GB	GR	IE	IS	LT	LU	NL	NO	PL	SE	SI	Total
Food category																						
Meat ruminants	11	40	.	1	68	.	.	.	.	.	.	18	.	9	.	.	.	2	9	.	17	175
Meat poultry	6	21	.	.	29	.	.	.	.	.	20	14	.	4	.	.	.	.	.	.	.	94
Meat pigs	6	2	.	19	38	.	.	.	.	.	.	8	.	3	.	.	.	2	8	2	2	90
Liver terrestrial animals	2	6	.	.	29	.	.	.	5	1	.	7	30	2	.	.	.	3	.	6	.	91
Muscle meat fish	10	21	6	6	106	48	18	107	319	73	474	30	120	106	3	12	.	208	14	247	48	1,976
Muscle meat eel	.	.	.	.	32	10	3	.	.	.	.	.	.	.	.	.	81	.	.	13	.	139
Raw milk and dairy	10	268	11	13	273	24	.	.	15	11	60	20	36	13	.	.	.	12	12	46	107	931
Hen eggs	14	49	.	.	353	20	.	.	10	35	39	14	145	5	.	.	.	6	.	83	12	785
Fat ruminants	.	6	.	.	.	24	.	.	.	.	.	.	37	.	.	.	.	.	.	7	6	80
Fat poultry	.	10	.	.	1	15	.	.	.	.	.	.	21	.	.	.	.	.	.	12	7	66
Fat pigs	1	3	.	.	43	14	.	.	.	.	.	1	14	.	.	.	.	.	.	9	4	89
Mixed animal fats	1	10	.	1	1	.	.	.	.	.	4	.	1	.	.	.	.	10	.	4	11	43
Vegetable oils and fats	1	16	.	2	45	.	.	.	.	.	15	3	2	.	.	.	.	2	.	11	.	97
Marine oils	1	.	.	.	34	5	.	.	.	1	5	3	2	2	.	.	.	21	.	16	21	111
Fish liver and products	.	.	.	.	27	.	.	.	.	.	.	.	.	10	.	.	5	1	.	.	.	43
Fruits, vegetables and cereals	6	14	.	12	111	.	.	.	.	7	35	17	14	1	.	.	.	3	.	36	4	260
Other products	5	24	.	2	10	1	.	.	23	.	250	1	1	2	.	.	.	10	4	.	2	335
Infant and baby food	5	.	.	.	60	.	.	.	20	.	106	5	.	.	.	.	.	.	.	23	.	219
Total food	*79*	*490*	*17*	*56*	*1,260*	*161*	*21*	*107*	*392*	*128*	*1,008*	*141*	*423*	*157*	*3*	*12*	*86*	*280*	*47*	*515*	*241*	*5,624*
Feed category																						
Feed plant origin	73	23	.	3	.	8	.	.	.	.	101	.	66	16	.	.	60	16	.	10	2	378
Vegetable oils	1	14	.	4	.	5	.	.	.	.	11	1	28	.	.	.	3	.	.	.	1	68
Feed mineral origin	.	1	.	.	.	8	.	.	.	.	24	.	57	.	.	.	20	1	.	3	.	114
Animal fat	.	7	.	.	.	8	.	.	.	.	.	3	7	2	.	.	6	4	.	.	.	37
Other land animal products	.	.	.	.	.	.	.	.	.	.	5	2	16	2	.	.	6	.	.	.	.	31
Fish oil	.	3	.	.	.	11	.	6	.	.	16	1	7	17	.	.	4	23	.	1	.	89
Aquatic animals	.	1	.	2	.	28	.	9	.	.	17	.	10	33	.	.	4	21	.	3	.	128
Additives comp. trace elements	9	6	.	.	.	3	.	.	.	.	11	.	24	.	.	.	23	.	.	1	2	79
Pre-mixtures	12	3	.	.	.	1	.	.	.	.	46	.	7	.	.	.	15	1	.	5	1	91
Compound feed	41	27	.	.	.	9	.	25	.	1	144	.	49	12	.	.	131	7	.	28	8	482
Feed for fur animals and fish	.	2	.	.	.	15	.	5	.	.	35	.	3	6	.	.	5	66	.	2	4	143
Total feed	*136*	*87*	*0*	*9*	*0*	*96*	*0*	*45*	*0*	*1*	*410*	*7*	*274*	*88*	*0*	*0*	*277*	*139*	*0*	*53*	*18*	*1,640*

4.2. Frequency and descriptive statistics for samples below LOQ

The proportion of samples below the LOQ at the congener level, stratified on the basis of the expression of results (12% moisture, fat or whole weight) is shown in Table 6. The median of the LOQ and the range are also reported.

The congeners most commonly detected were OCDD and PCB-77 for feed, PCB-118 for food expressed on a fat weight basis and PCB-77 when expressed on whole weight basis, while 1,2,3,4,7,8,9-HpCDF was the least commonly detected in both food and feed. The maximum LOQ values reported for a few of the congeners were relatively high. This was particularly the case for mono-*ortho* PCBs, although this group also included some relatively low minimum LOQ values. The greater heterogeneity in LOQ values observed in the dioxin-like PCB group compared to dioxins and furans could be due to a different analytical set up in case they were analysed together with the non-dioxin-like PCB group. For this latter group indeed less sensitivity is required because of the expected higher concentration levels.

Table 6: Proportion of results below the LOQ (<LOQ), median (P50) and range (minimum and maximum) of LOQ values over the 29 individual congeners expressed in pg/g.

	Expressed on 12% moisture			Expressed on fat basis			Expressed on whole weight		
Congener	**<LOQ %**	**P50**	**Range (min-max)**	**<LOQ %**	**P50**	**Range (min-max)**	**<LOQ %**	**P50**	**Range (min-max)**
2,3,7,8-TCDD	76	0.030	<0.001-0.51	61	0.050	0.001-1.50	25	0.006	<0.001-0.54
1,2,3,7,8-PeCDD	75	0.033	0.003-0.70	42	0.050	0.001-2.20	22	0.006	<0.001-0.62
1,2,3,4,7,8-HxCDD	87	0.030	0.002-0.92	49	0.060	0.001-1.70	50	0.010	<0.001-0.92
1,2,3,6,7,8-HxCDD	69	0.031	0.001-0.65	31	0.066	0.001-1.60	21	0.010	<0.001-0.80
1,2,3,7,8,9-HxCDD	78	0.030	0.002-0.87	49	0.060	0.001-1.50	48	0.011	<0.001-0.70
1,2,3,4,6,7,8-HpCDD	38	0.055	0.006-4.92	21	0.140	0.001-30.0	30	0.040	<0.001-4.06
OCDD	22	0.084	<0.001-20.8	21	0.380	0.003-35.0	30	0.100	0.001-7.63
2,3,7,8-TCDF	53	0.039	0.002-0.35	42	0.051	<0.001-1.70	9	0.014	<0.001-0.42
1,2,3,7,8-PeCDF	64	0.031	0.001-0.42	54	0.050	0.001-1.80	16	0.010	<0.001-0.40
2,3,4,7,8-PeCDF	60	0.035	0.001-0.25	22	0.050	0.001-1.90	11	0.010	<0.001-0.40
1,2,3,4,7,8-HxCDF	67	0.034	0.002-0.75	29	0.058	0.001-0.77	26	0.010	<0.001-0.75
1,2,3,6,7,8-HxCDF	69	0.030	0.001-0.62	34	0.050	0.001-1.00	25	0.010	<0.001-0.72
1,2,3,7,8,9-HxCDF	91	0.030	0.001-0.82	76	0.050	<0.001-1.60	81	0.010	<0.001-0.90
2,3,4,6,7,8-HxCDF	71	0.030	0.002-1.12	43	0.070	0.001-1.10	27	0.010	<0.001-0.77
1,2,3,4,6,7,8-HpCDF	50	0.042	<0.001-0.25	24	0.070	0.001-0.20	34	0.029	<0.001-0.20
1,2,3,4,7,8,9-HpCDF	93	0.040	<0.001-1.20	75	0.060	0.001-5.20	86	0.013	<0.001-0.94
OCDF	62	0.100	<0.001-20.8	47	0.199	0.001-12.0	60	0.050	0.001-2.30
PCB-77	24	0.985	<0.001-64.6	17	2.180	0.062-160	4	0.350	0.007-77.5
PCB-81	50	0.220	<0.001-208	38	0.400	0.001-35.0	25	0.250	<0.001-26.3
PCB-126	44	0.180	<0.001-45.0	12	0.360	0.001-9.00	6	0.044	0.002-3.53
PCB-169	60	0.050	<0.001-10.0	21	0.270	0.002-17.2	12	0.035	0.002-4.78
PCB-105	47	10.00	<0.001-790	22	20.00	0.004-1071	8	10.00	0.036-200
PCB-114	66	10.00	<0.001-159	48	10.00	0.004-1071	26	1.483	0.001-250
PCB-118	38	10.00	0.009-750	13	10.00	0.001-1071	12	1.590	<0.001-1000
PCB-123	68	10.00	<0.001-208	54	10.00	0.002-5357	28	1.000	<0.001-286
PCB-156	49	10.00	<0.001-140	23	12.00	0.010-1071	10	10.00	0.008-200
PCB-157	62	10.00	<0.001-90.0	40	10.00	0.004-1071	18	1.300	0.002-200
PCB-167	54	10.00	<0.001-1263	33	10.00	0.010-2142	11	9.560	0.008-200
PCB-189	69	7.000	<0.001-158	52	10.00	0.003-2810	29	2.700	0.001-630

4.3. The impact of using lower or upper bound calculations

Lower and upper bound PCDD, PCDF, non-*ortho* and mono-*ortho* PCB mean levels were compared, and results displayed in Tables 7 and 8. Use of upper bound figures is prescribed by the legislation to check for compliance. Overall upper bound results showed 5% higher levels than lower bound results, although this varied between 2% for non-*ortho* PCBs to 24% for PCDDs. In food, the differences between lower and upper bound estimates varied considerably between food groups, with upper bound values showing on average 4% higher levels than lower bound values, but with a variations of between 0.03% to 71% for the different food groups.

Table 7: Food group specific means (in pg TEQ_{WHO98}/g) of dioxins (PCDD), furans (PCDF), non-*ortho* (NO PCB) and mono-*ortho* dioxin-like PCB (MO PCB) using lower and upper bound.

	Lower bound pg TEQ_{WHO98}/g				**Upper bound pg TEQ_{WHO98}/g**			
Food group[1]	**PCDD**	**PCDF**	**NO PCB**	**MO PCB**	**PCDD**	**PCDF**	**NO PCB**	**MO PCB**
Meat and meat products ruminants	1.47	0.99	0.82	0.23	1.58	1.03	0.84	0.24
Meat and meat products poultry	0.18	0.27	0.27	0.15	0.38	0.34	0.30	0.18
Meat and meat products pigs	0.06	0.17	0.15	0.27	0.23	0.24	0.18	0.28
Liver and products terrestrial animals	0.69	2.42	2.23	0.12	0.89	2.45	2.25	0.13
Muscle meat fish and products excl. eel*	0.51	1.37	1.46	0.62	0.52	1.37	1.46	0.63
Muscle meat eel*	1.43	1.14	3.25	0.87	1.44	1.15	3.25	0.88
Raw milk and dairy products incl. butter	0.26	0.38	0.90	0.09	0.37	0.42	0.90	0.10
Hen eggs and egg products	0.40	0.44	0.79	0.26	0.48	0.47	0.80	0.29
Fat ruminants	0.27	0.21	0.43	0.11	0.30	0.23	0.44	0.13
Fat poultry	0.16	0.12	0.15	0.03	0.23	0.14	0.17	0.05
Fat pigs	0.11	0.69	0.73	0.20	0.20	0.72	0.74	0.21
Mixed animal fats	0.50	0.27	1.25	0.42	0.58	0.31	1.27	0.44
Vegetable oils and fats	0.03	0.06	0.10	0.05	0.11	0.09	0.14	0.07
Marine oils	0.12	0.21	1.37	0.46	0.25	0.26	1.37	0.47
Fish liver and products*	2.46	6.05	18.06	5.97	2.47	6.05	18.06	5.97
Fruits, vegetables and cereals*	0.21	0.15	0.04	0.03	0.27	0.18	0.05	0.04
Other products	0.72	1.84	1.11	0.13	0.82	1.87	1.11	0.19
Infant and baby food	0.05	0.06	0.16	0.04	0.11	0.08	0.17	0.05

[1]All food groups expressed on fat basis with the exception of the ones indicated by (*) expressed on whole weight.

Overall, feed groups showed larger differences between lower and upper bound contamination levels with upper bound values at an average 13% higher than lower bound values, but with a variation of between 1% to 800% for the different feed groups albeit at some low levels. Although not shown here, dioxin concentrations expressed as TEQ_{WHO05} displayed very similar patterns as would be expected.

Table 8: Feed group specific means (in pg TEQ_{WHO98}/g) of dioxins (PCDD), furans (PCDF), non-*ortho* (NO PCB) and mono-*ortho* dioxin-like PCB (MO PCB) using lower and upper bound.

	Lower bound pg TEQ_{WHO98}/g				**Upper bound pg TEQ_{WHO98}/g**			
Feed group	**PCDD**	**PCDF**	**NO PCB**	**MO PCB**	**PCDD**	**PCDF**	**NO PCB**	**MO PCB**
Feed materials of plant origin excl. oils	0.02	0.07	0.02	0.01	0.11	0.11	0.06	0.02
Vegetable oils and their by-products	0.04	0.03	0.02	0.01	0.17	0.09	0.13	0.02
Feed materials of mineral origin	<0.01	0.01	0.02	0.01	0.08	0.05	0.08	0.02
Animal fat, including milk fat and egg fat	0.07	0.09	0.18	0.10	0.28	0.16	0.25	0.11
Other land animal products	<0.01	0.01	0.01	0.01	0.13	0.06	0.06	0.02
Fish oil	0.74	2.01	5.54	1.60	0.80	2.03	5.54	1.60
Aquatic products excl. oil, hydrolysates	0.10	0.28	0.65	0.20	0.12	0.29	0.65	0.20
Additives compounds of trace elements	0.06	0.01	0.01	0.01	0.13	0.06	0.05	0.02
Pre-mixtures	0.01	0.02	0.01	<0.01	0.07	0.05	0.02	0.01
Compound feed, excl. next group	0.03	0.07	0.18	0.05	0.11	0.11	0.20	0.06
Feed for fur animals, pets and fish	0.15	0.46	1.11	0.31	0.18	0.47	1.15	0.31

4.4. Comparison of TEQ levels using TEF_{WHO98} and TEF_{WHO05}

Changing the basis for calculating TEQ to the new TEF recommendations issued by WHO in 2005 will overall result in 14% lower values with the extent of the difference highly variable across and within food (Figure 1) and feed groups (Figure 2). In food a change would result in 9% to 17% lower values and in feed between 4% and 15% lower values, when evaluating food and feed-specific group median values. In food, the smallest variation between samples (measured as the difference between P5 and P95) was seen in the groups 'Fish liver and products', 'Fat poultry' and 'Raw milk and dairy products', while the most heterogeneous variation patterns were observed in 'Mixed animal fats', 'Meat and meat products pigs' and 'Marine oils'. Among feed groups, large variations were observed in 'Feed material of mineral origin' and 'Additive compounds of trace elements'.

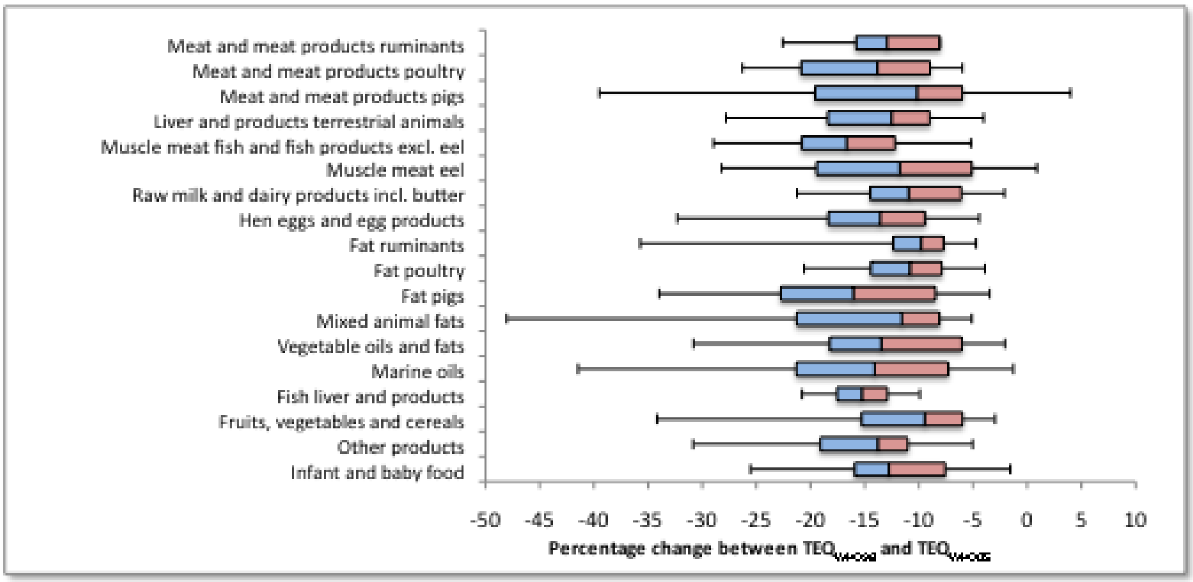

Figure 1: Box-plot (whiskers at P5 and P95, box at P25 and P75 with line at P50) of the percentage change when comparing TEQ_{WHO98} with TEQ_{WHO05} values (TEQ_{WHO98} used as reference) for food.

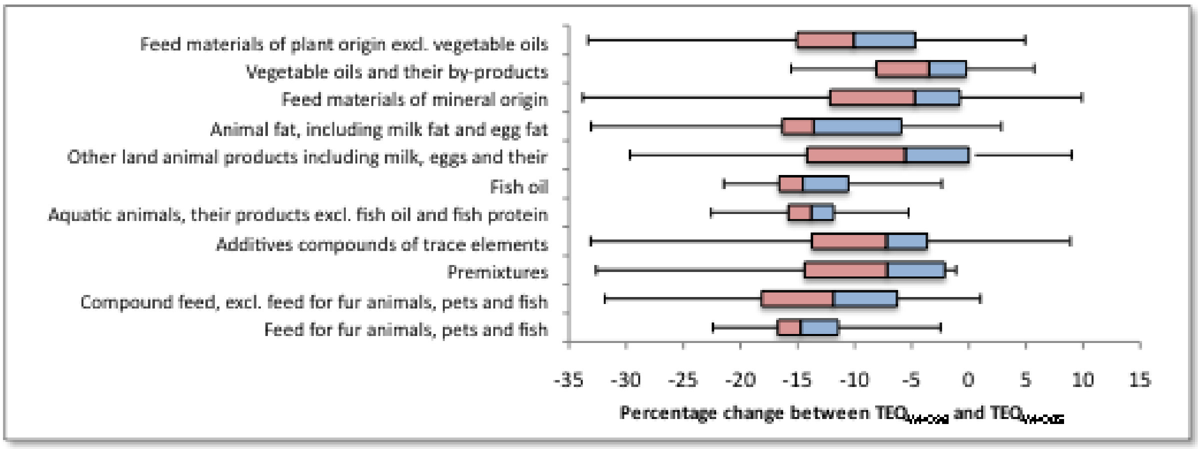

Figure 2: Box-plot (whiskers at P5 and P95, box at P25 and P75 with line at P50) of the percentage change when comparing TEQ_{WHO98} with TEQ_{WHO05} values (TEQ_{WHO98} used as reference) for feed.

Details of these variations are further illustrated in Tables 9 to 11 where the percentage differences for dioxins/furans (Table 9), dioxin-like PCBs (Table 10) and total dioxins (Table 11) are displayed for each food and feed group. As expected changes in PCDD/F TEQ levels are less pronounced than changes in the dioxin-like PCB levels. Overall, differences were slightly more pronounced in food compared to feed groups.

Table 9: Mean, and percentiles for TEQ_{WHO98} and TEQ_{WHO05} dioxin and furan (PCDD/F) levels across food and feed groups, together with the expression of result (ER) and the percentage difference between TEQ_{WHO98} and TEQ_{WHO05} calculated at the individual sample level (Diff).

		PCDD/F pg TEQ_{WHO98}/g								PCDD/F pg TEQ_{WHO05}/g								
Food group	**ER**	**Mean**	**P25**	**P50**	**P75**	**P90**	**P95**	**P97.5**	**P99**	**Mean**	**P25**	**P50**	**P75**	**P90**	**P95**	**P97.5**	**P99**	**Diff**
Meat and meat products ruminants	fat	2.61	0.26	0.62	1.09	2.33	2.92	3.90	8.87	2.39	0.23	0.51	0.94	1.97	2.86	3.30	8.75	-13
Meat and meat products poultry	fat	0.72	0.25	0.39	1.00	1.48	1.90	4.02	5.65	0.64	0.23	0.36	0.89	1.25	1.65	3.63	4.14	-9
Meat and meat products pigs	fat	0.47	0.17	0.23	0.67	1.08	1.17	1.29	5.76	0.42	0.16	0.21	0.58	0.97	1.10	1.12	4.96	-8
Liver and products terrestrial animals	fat	3.34	0.77	1.63	3.67	5.84	13.64	18.38	38.51	2.63	0.71	1.58	2.96	4.33	9.76	14.76	27.90	-16
Muscle meat fish and fish products excl. eel	ww	1.89	0.13	0.42	1.85	4.63	8.97	13.36	18.65	1.45	0.12	0.36	1.46	3.53	6.74	9.75	13.31	-16
Muscle meat eel	ww	2.59	0.95	2.27	3.93	5.09	6.24	6.67	8.16	2.21	0.79	1.93	3.39	4.50	5.28	6.15	7.22	-15
Raw milk and dairy products incl. butter	fat	0.78	0.26	0.45	0.87	1.61	2.86	3.53	4.79	0.67	0.22	0.39	0.75	1.37	2.35	2.94	4.04	-14
Hen eggs and egg products	fat	0.94	0.28	0.47	1.02	2.18	3.04	4.60	7.24	0.83	0.26	0.42	0.90	1.88	2.59	3.71	6.48	-10
Fat ruminants	fat	0.53	0.29	0.42	0.62	1.07	1.21	1.79	1.96	0.46	0.26	0.36	0.54	0.93	1.09	1.54	1.71	-13
Fat poultry	fat	0.37	0.14	0.19	0.35	0.83	1.32	2.43	2.88	0.34	0.13	0.17	0.32	0.67	1.29	2.40	2.84	-10
Fat pigs	fat	0.92	0.13	0.33	0.71	1.84	5.10	6.71	11.22	0.70	0.12	0.32	0.58	1.40	3.84	4.51	7.61	-14
Mixed animal fats	fat	0.89	0.17	0.23	0.33	0.76	1.17	9.78	17.16	0.81	0.16	0.21	0.28	0.63	1.01	8.00	16.85	-10
Vegetable oils and fats	fat	0.20	0.11	0.16	0.24	0.33	0.41	0.64	1.47	0.18	0.10	0.15	0.22	0.28	0.33	0.60	1.18	-9
Marine oils	fat	0.51	0.17	0.25	0.55	0.91	1.90	2.34	2.60	0.46	0.16	0.23	0.45	0.84	1.68	2.26	2.43	-9
Fish liver and products	ww	8.52	1.90	6.39	14.26	20.65	21.65	26.46	28.26	7.10	1.68	5.16	11.95	17.14	17.60	21.34	23.15	-13
Fruits, vegetables and cereals	ww	0.45	<0.01	0.02	0.10	0.78	1.90	4.60	8.62	0.42	<0.01	0.02	0.09	0.72	1.83	4.55	8.33	-7
Other products	-	2.67	0.27	0.55	1.34	4.07	10.50	19.99	45.28	2.10	0.25	0.49	1.18	3.42	7.59	14.80	33.47	-12
Infant and baby food	fat	0.20	0.03	0.13	0.23	0.42	0.73	1.19	1.24	0.18	0.03	0.12	0.20	0.38	0.63	1.12	1.17	-9
Feed materials of plant origin excl. vegetable oils	12%	0.21	0.07	0.12	0.28	0.37	0.48	0.72	1.15	0.19	0.06	0.11	0.26	0.35	0.46	0.63	1.12	-7
Vegetable oils and their by-products	12%	0.26	0.20	0.23	0.30	0.42	0.57	0.75	0.86	0.25	0.18	0.22	0.28	0.38	0.56	0.79	0.80	-5
Feed materials of mineral origin	12%	0.13	0.06	0.10	0.18	0.29	0.29	0.30	0.39	0.12	0.05	0.10	0.17	0.27	0.27	0.28	0.36	-7
Animal fat, including milk fat and egg fat	12%	0.44	0.22	0.31	0.51	0.83	1.72	1.81	1.81	0.41	0.20	0.28	0.47	0.80	1.57	1.63	1.63	-7
Other land animal products	12%	0.19	0.09	0.12	0.19	0.29	0.82	0.91	0.91	0.18	0.09	0.12	0.18	0.27	0.78	0.87	0.87	-6
Fish oil	12%	2.83	1.71	2.52	3.95	5.28	5.53	5.96	7.08	2.43	1.47	2.08	3.44	4.46	5.03	5.44	6.35	-14
Aquatic products excl. fish oil and protein	12%	0.41	0.22	0.35	0.52	0.74	0.97	1.12	1.61	0.36	0.20	0.30	0.44	0.62	0.80	1.12	1.36	-11
Additives compounds of trace elements	12%	0.19	0.07	0.12	0.29	0.55	0.71	0.77	0.83	0.18	0.06	0.11	0.27	0.53	0.69	0.75	0.81	-6
Pre-mixtures	12%	0.12	0.05	0.07	0.17	0.29	0.30	0.35	0.97	0.12	0.04	0.07	0.16	0.27	0.28	0.33	0.83	-7
Compound feed, excl. fur animals, pets and fish	12%	0.22	0.06	0.17	0.29	0.44	0.69	0.90	1.14	0.19	0.05	0.16	0.27	0.38	0.58	0.74	0.97	-8
Feed for fur animals, pets and fish	12%	0.65	0.28	0.53	0.91	1.36	1.57	1.70	1.94	0.55	0.24	0.44	0.75	1.15	1.31	1.45	1.78	-15

Table 10: Mean, and percentiles for TEQ_{WHO98} and TEQ_{WHO05} dioxin-like PCB (DL PCB) levels across food and feed groups, together with the expression of result (ER) and the percentage difference between TEQ_{WHO98} and TEQ_{WHO05} calculated at the individual sample level (Diff).

		DL PCB pg TEQ_{WHO98}/g								DL PCB pg TEQ_{WHO05}/g								
Food group	**ER**	**Mean**	**P25**	**P50**	**P75**	**P90**	**P95**	**P97.5**	**P99**	**Mean**	**P25**	**P50**	**P75**	**P90**	**P95**	**P97.5**	**P99**	**Diff**
Meat and meat products ruminants	fat	1.08	0.34	0.69	1.30	2.33	2.81	3.91	9.98	0.93	0.30	0.63	1.16	1.92	2.56	3.44	8.57	-12
Meat and meat products poultry	fat	0.48	0.12	0.25	0.45	1.20	1.77	2.02	5.84	0.36	0.09	0.17	0.39	0.74	1.61	1.84	3.64	-23
Meat and meat products pigs	fat	0.46	0.02	0.12	0.33	0.73	1.38	5.46	9.74	0.28	0.02	0.09	0.23	0.53	1.13	2.25	4.79	-17
Liver and products terrestrial animals	fat	2.38	0.13	0.62	1.40	2.74	4.25	32.07	56.90	2.30	0.13	0.61	1.30	2.71	4.09	31.75	56.52	-8
Muscle meat fish and fish products excl. eel	ww	2.08	0.24	0.89	2.10	5.67	7.99	10.63	14.53	1.65	0.20	0.74	1.71	4.08	6.35	8.53	11.34	-17
Muscle meat eel	ww	4.12	0.05	2.44	5.80	8.51	12.74	16.43	27.56	3.56	0.03	2.22	5.35	7.75	12.12	15.19	18.44	-16
Raw milk and dairy products incl. butter	fat	1.00	0.25	0.53	0.97	1.92	3.04	5.48	10.65	0.95	0.23	0.45	0.95	1.79	3.11	5.62	8.73	-6
Hen eggs and egg products	fat	1.09	0.16	0.31	0.90	2.32	3.72	6.49	10.23	0.88	0.11	0.22	0.75	1.75	2.91	5.12	9.71	-22
Fat ruminants	fat	0.56	0.24	0.34	0.56	1.43	1.67	2.30	4.09	0.49	0.21	0.32	0.46	1.25	1.51	1.97	3.43	-10
Fat poultry	fat	0.21	0.09	0.15	0.32	0.46	0.52	0.59	0.94	0.18	0.07	0.13	0.29	0.38	0.42	0.60	0.97	-14
Fat pigs	fat	0.95	0.07	0.26	0.56	1.76	4.94	7.42	22.19	0.89	0.05	0.16	0.51	1.66	3.83	7.40	22.15	-19
Mixed animal fats	fat	1.72	0.07	0.56	1.11	3.28	6.45	15.55	24.56	1.41	0.03	0.42	0.90	3.09	4.48	14.83	18.87	-20
Vegetable oils and fats	fat	0.22	0.04	0.08	0.22	0.34	0.66	1.02	5.15	0.17	0.02	0.07	0.16	0.30	0.40	0.42	4.38	-21
Marine oils	fat	1.84	0.27	0.89	1.81	5.46	6.50	8.04	14.76	1.53	0.23	0.64	1.54	3.66	5.88	6.80	13.69	-18
Fish liver and products	ww	24.03	6.09	14.12	45.91	59.90	63.63	66.97	77.86	20.25	5.00	11.64	38.55	51.46	53.73	58.22	67.49	-16
Fruits, vegetables and cereals	ww	0.09	<0.01	0.01	0.02	0.15	0.50	1.20	1.71	0.06	<0.01	<0.01	0.02	0.12	0.29	0.74	1.33	-22
Other products	-	1.29	0.13	0.33	0.91	2.36	5.36	9.27	18.37	1.18	0.09	0.27	0.79	2.17	4.33	7.37	17.18	-20
Infant and baby food	fat	0.22	0.02	0.07	0.27	0.57	0.71	1.62	2.20	0.19	0.01	0.06	0.23	0.49	0.58	1.38	1.90	-17
Feed materials of plant origin excl. vegetable oils	12%	0.08	0.02	0.03	0.09	0.18	0.25	0.37	0.82	0.07	0.01	0.02	0.07	0.18	0.27	0.38	0.69	-25
Vegetable oils and their by-products	12%	0.15	0.05	0.11	0.18	0.29	0.44	0.86	0.87	0.15	0.04	0.11	0.18	0.33	0.40	0.96	0.98	-10
Feed materials of mineral origin	12%	0.10	0.02	0.03	0.13	0.18	0.37	0.60	0.66	0.09	0.01	0.03	0.13	0.23	0.34	0.65	0.67	-19
Animal fat, including milk fat and egg fat	12%	0.36	0.14	0.29	0.59	0.71	0.78	0.86	0.86	0.29	0.07	0.23	0.49	0.64	0.71	0.74	0.74	-24
Other land animal products	12%	0.08	0.02	0.06	0.11	0.15	0.23	0.46	0.46	0.08	0.02	0.04	0.09	0.14	0.27	0.53	0.53	-17
Fish oil	12%	7.14	3.69	6.38	9.54	13.23	16.17	17.53	26.31	6.15	3.56	5.35	8.07	10.99	13.69	14.80	22.39	-13
Aquatic products excl. fish oil and protein	12%	0.86	0.29	0.67	1.05	1.72	2.53	3.38	3.96	0.73	0.22	0.57	0.92	1.35	2.22	2.88	3.45	-19
Additives compounds of trace elements	12%	0.06	0.02	0.03	0.07	0.12	0.19	0.24	1.22	0.06	0.01	0.01	0.06	0.14	0.22	0.25	1.22	-29
Pre-mixtures	12%	0.03	0.02	0.03	0.03	0.04	0.11	0.16	0.27	0.03	0.01	0.02	0.03	0.03	0.12	0.17	0.28	-26
Compound feed, excl. fur animals, pets and fish	12%	0.26	0.02	0.03	0.09	0.96	1.63	2.14	2.67	0.22	0.01	0.02	0.08	0.96	1.50	1.79	2.24	-34
Feed for fur animals, pets and fish	12%	1.46	0.73	1.34	1.95	2.51	2.93	4.28	4.75	1.27	0.67	1.13	1.66	2.22	2.48	3.89	4.56	-14

Table 11: Mean, and percentiles for TEQ_{WHO98} and TEQ_{WHO05} dioxin, furan (PCDD/F) and dioxin-like PCB (DL PCB) levels across food and feed groups, together with the expression of result (ER) and the percentage difference between TEQ_{WHO98} and TEQ_{WHO05} calculated at the individual sample level (Diff).

		PCDD/F + DL PCB pg TEQ_{WHO98}/g								PCDD/F + DL PCB pg TEQ_{WHO05}/g								
Food group	**ER**	**Mean**	**P25**	**P50**	**P75**	**P90**	**P95**	**P97.5**	**P99**	**Mean**	**P25**	**P50**	**P75**	**P90**	**P95**	**P97.5**	**P99**	**Diff**
Meat and meat products ruminants	fat	3.69	0.75	1.42	2.37	4.07	5.07	7.55	17.98	3.33	0.67	1.29	2.15	3.57	4.26	6.27	14.71	-12
Meat and meat products poultry	fat	1.20	0.42	0.69	1.37	2.01	3.50	7.42	9.83	1.00	0.38	0.60	1.24	1.79	2.11	5.98	7.27	-15
Meat and meat products pigs	fat	0.93	0.24	0.36	1.18	1.63	3.71	6.47	9.96	0.69	0.20	0.33	0.85	1.47	2.84	2.97	5.58	-13
Liver and products terrestrial animals	fat	5.72	0.94	2.26	5.08	7.86	20.24	56.41	95.41	4.93	0.86	1.82	4.41	6.54	17.02	48.81	84.42	-14
Muscle meat fish and fish products excl. eel	ww	3.98	0.38	1.35	4.17	11.16	16.60	22.58	29.94	3.09	0.31	1.12	3.24	8.65	12.76	16.71	22.71	-17
Muscle meat eel	ww	6.71	3.24	4.56	8.53	12.54	19.19	24.71	29.74	5.77	2.68	3.98	7.68	10.62	16.44	20.19	22.65	-12
Raw milk and dairy products incl. butter	fat	1.78	0.67	1.04	1.86	3.36	5.82	8.42	13.98	1.61	0.58	0.90	1.70	2.92	5.42	7.79	13.01	-11
Hen eggs and egg products	fat	2.03	0.50	0.82	1.95	4.66	6.64	9.87	15.28	1.71	0.41	0.69	1.60	3.74	5.35	8.38	13.32	-15
Fat ruminants	fat	1.09	0.55	0.81	1.18	2.33	3.11	3.66	5.24	0.95	0.50	0.66	1.01	2.06	2.88	3.08	4.38	-12
Fat poultry	fat	0.58	0.23	0.36	0.61	1.19	1.77	2.74	3.40	0.52	0.20	0.32	0.55	1.11	1.63	2.58	3.23	-11
Fat pigs	fat	1.87	0.20	0.64	1.37	3.66	10.67	15.48	24.52	1.59	0.17	0.54	1.11	4.26	9.70	12.45	23.95	-16
Mixed animal fats	fat	2.60	0.23	0.73	1.32	4.05	6.90	25.33	41.72	2.22	0.20	0.48	1.07	3.72	4.86	22.83	35.72	-15
Vegetable oils and fats	fat	0.42	0.16	0.30	0.46	0.64	0.88	1.24	6.62	0.35	0.15	0.24	0.38	0.53	0.63	0.80	5.56	-13
Marine oils	fat	2.35	0.53	1.20	2.19	6.05	7.89	9.63	16.36	1.99	0.46	1.00	1.87	4.24	7.21	7.88	15.03	-16
Fish liver and products	ww	32.55	11.06	17.67	56.17	80.85	86.10	86.36	98.50	27.35	9.12	14.66	46.69	68.97	72.80	74.23	85.03	-15
Fruits, vegetables and cereals	ww	0.54	0.01	0.02	0.14	0.90	2.05	5.69	11.41	0.48	0.01	0.02	0.12	0.81	1.90	4.99	9.77	-13
Other products	-	3.96	0.45	0.94	2.48	7.22	15.13	28.97	62.07	3.28	0.37	0.85	2.08	6.10	11.90	23.71	50.15	-15
Infant and baby food	-	0.42	0.05	0.19	0.58	0.89	1.45	2.16	3.09	0.36	0.06	0.16	0.48	0.78	1.33	1.83	2.69	-10
Feed materials of plant origin excl. vegetable oils	12%	0.29	0.09	0.19	0.32	0.50	0.73	1.05	1.41	0.26	0.09	0.17	0.29	0.47	0.69	1.04	1.29	-11
Vegetable oils and their by-products	12%	0.41	0.30	0.37	0.50	0.72	0.88	1.14	1.15	0.40	0.29	0.36	0.47	0.64	0.85	1.20	1.26	-4
Feed materials of mineral origin	12%	0.23	0.08	0.21	0.31	0.34	0.67	0.70	0.98	0.22	0.08	0.21	0.28	0.36	0.58	0.75	0.77	-8
Animal fat, including milk fat and egg fat	12%	0.79	0.38	0.72	0.93	1.39	2.10	2.17	2.17	0.70	0.35	0.64	0.91	1.17	1.94	1.99	1.99	-13
Other land animal products	12%	0.27	0.19	0.21	0.31	0.34	0.92	0.95	0.95	0.25	0.17	0.18	0.27	0.35	0.87	0.91	0.91	-7
Fish oil	12%	9.97	6.00	8.64	13.11	17.83	22.08	24.62	32.89	8.58	5.09	7.46	11.76	14.86	19.1	21.14	28.64	-13
Aquatic products excl. fish oil and protein	12%	1.27	0.54	1.04	1.58	2.37	3.43	4.14	4.77	1.09	0.47	0.89	1.43	2.07	2.97	3.59	4.23	-14
Additives compounds of trace elements	12%	0.25	0.08	0.19	0.31	0.71	0.80	0.86	1.34	0.24	0.07	0.17	0.30	0.62	0.76	0.82	1.33	-9
Pre-mixtures	12%	0.16	0.07	0.09	0.22	0.31	0.34	0.40	1.02	0.14	0.07	0.08	0.19	0.29	0.31	0.37	0.87	-11
Compound feed, excl. fur animals, pets and fish	12%	0.47	0.08	0.22	0.33	1.44	2.16	2.98	3.81	0.41	0.07	0.20	0.29	1.34	1.95	2.56	3.21	-13
Feed for fur animals, pets and fish	12%	2.11	1.07	1.95	2.95	3.75	4.31	5.68	6.89	1.82	0.94	1.58	2.42	3.27	3.72	4.76	6.11	-14

For a comparison of absolute values of contamination across the different groups, the basis on which results are expressed must be taken into account. The highest mean levels of dioxins and dioxin-like PCBs in food when expressed on a whole weight basis were observed for 'Fish liver and products thereof' (32.6 pg TEQ_{WHO98}/g) and 'Muscle meat eel' (6.7 pg TEQ_{WHO98}/g), and when expressed on a fat basis for 'Liver and products thereof from terrestrial animals' (5.7 pg TEQ_{WHO98}/g). In feed, all expressed on 12% moisture basis, the highest levels were found in 'Fish oil' (10.0 pg TEQ_{WHO98}/g).

4.5. Dioxin congener group proportions

The ratio of the combined group of dioxins and furans over total dioxin levels computed at the sample level is described in Table 12 for TEQ_{WHO98} and TEQ_{WHO05}.

Table 12: The proportion of dioxins and furans (PCDD/F) over total dioxins in percent (mean, percentiles 1^{st}, 25^{th}, 50^{th} 75^{th}, 99^{th}) for TEQ_{WHO98} and TEQ_{WHO05}.

Food group	% PCDD/F of total dioxin TEQ_{WHO98}						% PCDD/F of total dioxin TEQ_{WHO05}					
	Mean	**P1**	**P25**	**P50**	**P75**	**P99**	**Mean**	**P1**	**P25**	**P50**	**P75**	**P99**
Meat and products ruminants	46	5	30	44	59	96	46	5	30	45	61	97
Meat and products poultry	62	8	49	65	74	95	66	7	57	66	79	96
Meat and meat products pigs	68	2	51	67	91	96	71	7	59	74	93	97
Liver and products terrestrial	73	20	67	76	83	98	71	15	64	75	82	98
Muscle meat fish and products	41	8	26	42	54	92	42	9	27	42	54	92
Muscle meat eel	48	4	25	36	98	99	47	5	24	33	99	99
Raw milk and products, butter	50	10	35	45	60	99	49	10	33	45	60	99
Hen eggs and egg products	58	14	48	58	70	94	62	14	50	64	75	95
Fat ruminants	53	22	45	53	61	94	53	22	44	53	60	92
Fat poultry	60	33	51	58	67	93	61	32	51	60	69	93
Fat pigs	59	10	50	57	69	95	61	8	51	61	72	96
Mixed animal fats	45	4	21	39	73	93	48	8	19	47	75	92
Vegetable oils and fats	62	11	49	60	84	98	65	9	51	64	86	98
Marine oils	34	6	14	25	54	93	36	7	17	27	57	92
Fish liver and products	30	12	18	21	26	99	30	12	19	21	27	99
Fruits, vegetables and cereals	71	11	58	73	87	98	76	18	69	79	89	98
Other products	63	17	51	65	78	95	65	16	54	68	80	95
Infant and baby food	56	15	39	56	71	96	59	5	41	58	79	96
Feed of plant origin excl. oils	71	23	60	74	87	98	76	21	64	81	90	99
Vegetable oils and by-products	67	23	55	66	84	94	67	20	56	61	86	97
Feed materials of mineral origin	64	15	47	62	87	94	67	13	45	66	90	97
Animal fat, incl. milk and egg	55	24	38	52	77	91	60	22	41	61	84	95
Other land animal products	68	28	51	67	87	95	69	25	49	67	89	97
Fish oil	30	7	23	29	37	86	30	6	23	29	36	86
Aquatic products excl. oil, protein	38	11	26	36	43	86	40	16	27	35	44	95
Additives trace elements	74	9	59	81	91	97	78	8	61	87	95	99
Pre-mixtures	74	45	65	72	88	95	78	40	61	85	92	97
Compound feed, excl. below	67	14	51	70	89	96	72	14	55	83	93	97
Feed fur animals, pets and fish	33	8	22	30	38	94	33	7	23	30	36	93

Using TEQ_{WHO98} values, the mean percentages of dioxins and furans over total dioxin levels ranged from 30% for 'Fish liver and products' and 34% for 'Marine oils' to 71% for 'Fruits, vegetables and cereals' and 73% for 'Liver and products terrestrial animals' in food, and from 33% in 'Feed fur animals, pets and fish' to 74% in 'Additives trace elements' and 'Pre-mixtures' in feed. Overall, mean ratios were of similar magnitude in foods and feeds. TEQ_{WHO05} mean ratios in the different food and feed groups were overall between 1% and 4% higher than based on TEQ_{WHO98} values.

The ratio of mono-*ortho* PCBs over total dioxin-like PCBs computed at the sample level is described in Table 13 for TEQ_{WHO98} and TEQ_{WHO05}. For TEQ_{WHO98}, the mean percentages of mono-*ortho* PCB over total dioxin-like PCBs ranged from 15% to 41% in food, and from 21% to 45% in feed. The mean ratios using TEQ_{WHO05} were overall lower, ranging from 4% to 13% and from 6% to 16% in food and feed, respectively. These differences show the sizeable decrease in the relative toxicity of mono-*ortho* PCBs for calculating TEQ_{WHO05} levels compared to TEQ_{WHO98} levels.

Table 13: The proportion of mono-*ortho* PCBs (MO PCB) over dioxin-like PCBs (DL PCB) in percent (mean, percentiles 1st, 25th, 50th 75th, 99th) for TEQ_{WHO98} and TEQ_{WHO05}.

Food group	% MO PCB of DL PCB TEQ_{WHO98}						% MO PCB of DL PCB TEQ_{WHO05}					
	Mean	P1	P25	P50	P75	P99	Mean	P1	P25	P50	P75	P99
Meat and products ruminants	23	6	15	19	27	81	6	1	3	4	6	43
Meat and products poultry	34	8	23	32	42	92	10	1	5	8	12	54
Meat and meat products pigs	39	3	20	40	56	89	11	<1	3	7	14	59
Liver and products terrestrial	15	1	5	10	20	68	4	<1	1	2	4	33
Muscle meat fish and products	27	2	18	25	31	83	7	<1	4	7	9	32
Muscle meat eel	25	<1	<1	25	35	68	8	<1	<1	7	10	30
Raw milk and products, butter	15	<1	2	15	20	63	4	<1	<1	3	5	20
Hen eggs and egg products	31	<1	19	26	40	76	8	<1	4	6	10	38
Fat ruminants	20	<1	11	16	22	83	4	<1	2	2	4	20
Fat poultry	24	<1	17	21	28	71	5	<1	3	5	6	28
Fat pigs	41	2	29	38	54	81	9	<1	4	6	12	42
Mixed animal fats	33	9	15	27	49	81	10	2	3	5	15	40
Vegetable oils and fats	33	1	21	31	45	89	9	<1	5	7	11	45
Marine oils	29	<1	14	27	39	80	8	<1	3	6	11	36
Fish liver and products	25	12	22	24	27	41	6	2	6	6	7	12
Fruits, vegetables and cereals	36	2	20	30	41	94	13	<1	4	6	11	63
Other products	31	1	15	26	42	86	8	<1	3	5	9	47
Infant and baby food	31	2	18	26	39	86	9	<1	4	6	10	49
Feed of plant origin excl. oils	39	1	16	31	61	94	13	<1	3	7	18	65
Vegetable oils and by-products	24	<1	6	16	40	87	7	<1	1	3	12	48
Feed materials of mineral origin	37	1	14	21	70	95	13	<1	3	5	24	65
Animal fat, incl. milk and egg	36	8	18	28	50	92	12	1	3	6	16	75
Other land animal products	35	<1	16	26	57	78	11	<1	3	8	18	27
Fish oil	21	<1	19	25	27	45	6	<1	4	7	8	18
Aquatic products excl. oil, protein	29	3	20	24	29	98	14	<1	5	6	8	99
Additives trace elements	43	<1	12	36	77	94	16	<1	2	11	27	65
Pre-mixtures	43	2	16	36	77	95	16	<1	3	8	27	70
Compound feed, excl. below	45	<1	21	46	74	90	15	<1	4	12	25	56
Feed fur animals, pets and fish	22	<1	17	23	26	83	7	<1	4	6	7	46

The comparison of the ratio of mono-*ortho* PCBs over total dioxins is shown in Table 14 for TEQ_{WHO98} and TEQ_{WHO05}, respectively. The mean proportion of mono-*ortho* PCBs ranged from 4% to 20% in food and from 6% to 16% in feed when evaluating TEQ_{WHO98} levels. Lower mean proportions were observed for TEQ_{WHO05}, with the mean percentage ranging from 1% to 5% for food and 1% to 4% for feed.

Table 14: The proportion of mono-*ortho* PCBs (MO PCB) over total dioxins in percent (mean, percentiles 1^{st}, 25^{th}, 50^{th} 75^{th}, 99^{th}) for TEQ_{WHO98} and TEQ_{WHO05}.

Food group	% MO PCB of total dioxin TEQ_{WHO98}						% MO PCB of total dioxin TEQ_{WHO05}					
	Mean	**P1**	**P25**	**P50**	**P75**	**P99**	**Mean**	**P1**	**P25**	**P50**	**P75**	**P99**
Meat and products ruminants	12	1	7	11	16	12	3	<1	1	2	3	19
Meat and products poultry	14	2	6	10	21	14	3	<1	1	2	5	16
Meat and meat products pigs	15	<1	2	9	20	15	4	<1	<1	2	4	39
Liver and products terrestrial	4	<1	1	2	4	4	1	<1	<1	<1	1	17
Muscle meat fish and products	16	<1	10	13	19	16	4	<1	2	3	5	19
Muscle meat eel	9	<1	<1	<1	19	9	2	<1	<1	<1	4	13
Raw milk and products, butter	8	<1	<1	7	11	8	2	<1	<1	2	2	10
Hen eggs and egg products	13	<1	7	11	17	13	3	<1	1	2	4	16
Fat ruminants	10	<1	5	8	11	10	2	<1	1	1	2	6
Fat poultry	9	<1	6	8	10	9	2	<1	1	2	2	7
Fat pigs	17	1	7	14	25	17	3	<1	1	2	4	17
Mixed animal fats	18	1	8	11	25	18	5	<1	1	3	6	29
Vegetable oils and fats	13	<1	3	10	19	13	3	<1	1	2	4	24
Marine oils	20	<1	7	17	28	20	5	<1	1	4	7	26
Fish liver and products	17	<1	13	19	22	17	4	<1	3	5	6	9
Fruits, vegetables and cereals	11	<1	3	7	13	11	3	<1	1	2	3	12
Other products	12	<1	5	9	16	12	2	<1	1	2	3	12
Infant and baby food	12	1	7	11	16	12	3	<1	1	2	4	20
Feed of plant origin excl. oils	10	<1	4	6	10	10	2	<1	1	1	2	8
Vegetable oils and by-products	6	<1	3	5	6	6	1	<1	1	1	2	8
Feed materials of mineral origin	10	<1	5	6	10	10	2	<1	1	1	3	10
Animal fat, incl. milk and egg	14	1	7	13	18	14	4	<1	1	3	4	29
Other land animal products	8	<1	3	6	10	8	2	<1	1	1	2	11
Fish oil	15	<1	11	16	20	15	4	<1	3	4	5	17
Aquatic products excl. oil, protein	16	2	12	15	19	16	4	<1	3	4	5	11
Additives trace elements	9	<1	2	5	13	9	2	<1	<1	1	3	7
Pre-mixtures	10	<1	5	6	10	10	2	<1	1	1	2	10
Compound feed, excl. below	12	<1	6	7	18	12	3	<1	1	1	4	8
Feed fur animals, pets and fish	14	<1	11	16	17	14	4	<1	3	4	5	11

The proportion of PCDD, PCDF, NO PCB and MO PCB across food and feed groups are displayed in Figure 3 for upper bound TEQ_{WHO98}. The highest proportion of PCDD expressed on fat basis was found in the group 'Meat and meat products ruminants', of PCDF in the group 'Other products', of NO PCB in 'Marine oils', and of MO PCB in 'Meat and meat products pigs' (3a). The corresponding results for food expressed on whole weight basis were 'Fruit vegetables and cereals', 'Muscle meat fish and fish products excl. eel', 'Fish liver and products' and 'Fish liver and products', respectively (3b), and for feed 'Additive compounds of trace elements', 'Feed materials of plant origin excl. vegetable oils', 'Fish oil' and 'Fish oil, respectively (3c).

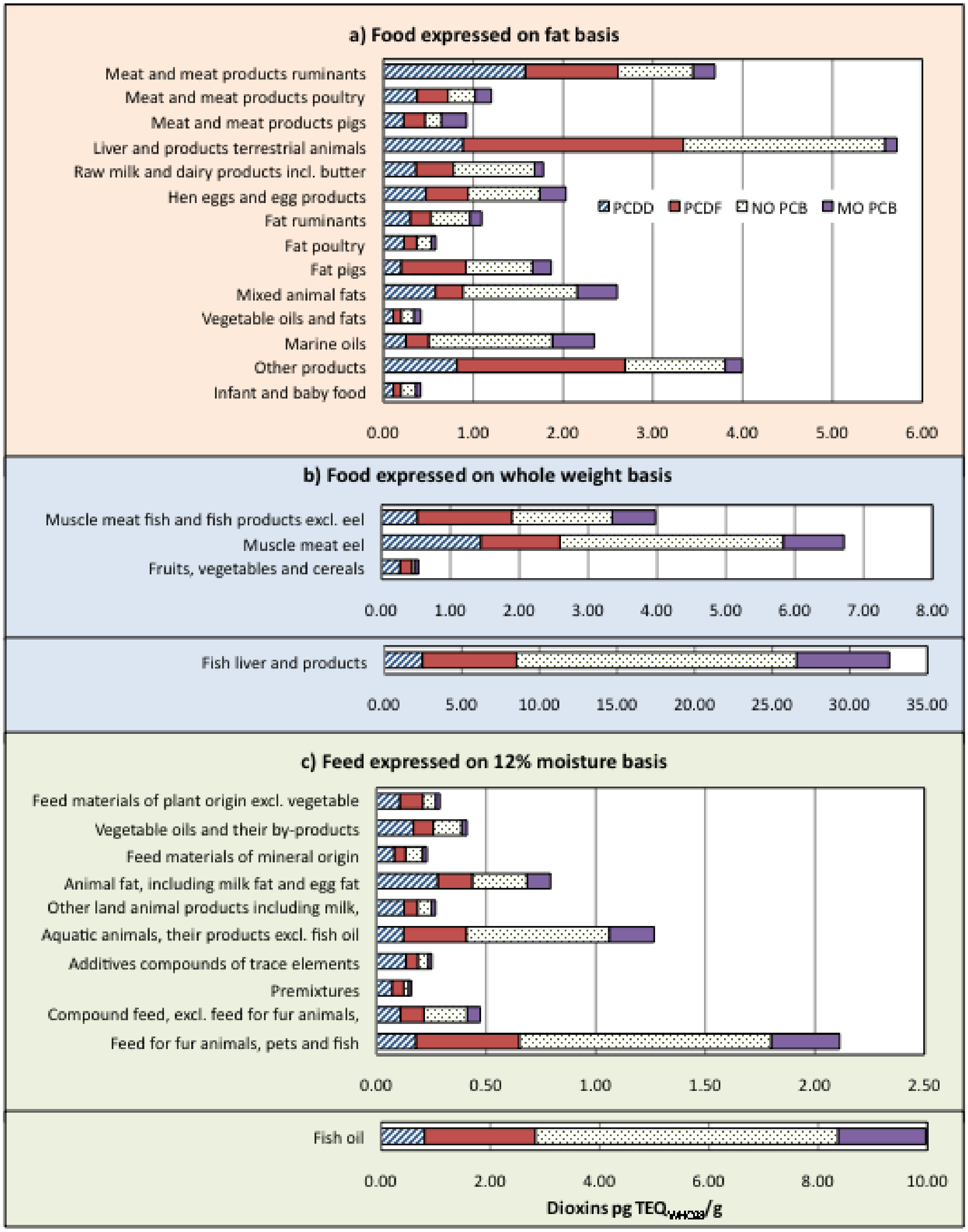

Figure 3: Upper bound TEQ_{WHO98} total dioxin content and the proportion of dioxin (PCDD), furan (PCDF), non-*ortho* (NO PCB) and mono-*ortho* (MO PCB) dioxin-like PCB congener groups across the different food and feed categories split according to the prescribed unit of expressing results. Note the different scales used for the x-axes to allow the proportions of the congener groups to be clearly illustrated.

4.6. Comparison of dioxin levels with action and maximum levels

Action (AL) and maximum (ML) levels for the different food and feed categories were set in the Commission Recommendation 2006/88/EC and Regulation (EC) No 1881/2006, respectively. An overall 8% of the samples exceeded different MLs and a further 4% exceeded some ALs. For PCDD/F the percentage of samples exceeding AL or ML are reported in Table 15. For TEQ_{WHO98} values in food, the percentage exceedance for the AL ranged between 4% and 40%. In feed, the corresponding percentage exceedance ranged between 1% and 10%. More than 10% of the samples exceeded the ML in four food groups on the basis of TEQ_{WHO98} values. In feed, the exceedance of ML was consistently well below 10%.

In reviewing the percentage of non-compliant samples for each food category it is important to acknowledge that some of the samples included in this analysis are the result of multiple targeted sampling during contamination incidences and therefore do not reflect background dioxin content in food or feed.

Table 15: Number (N) and percentage (%) of samples in the food and feed groups exceeding the respective action (AL) (Recommendation 2006/88/EC) and maximum (ML) levels (Regulation 1881/2006) for PCDD/F expressed in pg/g using TEQ_{WHO98} and TEQ_{WHO05}, respectively.

Food group	ER[1]	AL	ML	Samples > AL				Samples > ML				New levels based on TEQ_{WHO05}	
				TEQ_{WHO98}		TEQ_{WHO05}		TEQ_{WHO98}		TEQ_{WHO05}			
				N	%	N	%	N	%	N	%	AL	ML
Meat and products ruminants	fat	1.5	3	28	16.0	20	11.4	7	4.0	7	4.0	1.3	3
Meat and products poultry	fat	1.5	2	8	8.5	8	8.5	4	4.3	4	4.3	1.5	1.6
Meat and meat products pigs	fat	0.6	1	25	27.8	22	24.4	11	12.2	8	8.9	0.5	0.9
Liver and products terrestrial	fat	4	6	18	19.8	13	14.3	8	8.8	6	6.6	3.5	4.9
Muscle meat fish and products	ww	3	4	345	17.5	237	12.0	226	11.4	173	8.8	2.3	3.2
Muscle meat eel	ww	3	4	56	40.3	43	30.9	32	23.0	22	15.8	2.5	3.6
Raw milk and products, butter	fat	2	3	77	8.3	62	6.7	38	4.1	22	2.4	1.7	2.5
Hen eggs and egg products	fat	2	3	89	11.3	69	8.8	41	5.2	30	3.8	1.8	2.6
Fat ruminants	fat	1.5	3	3	3.8	3	3.8	0	0	0	0	1.3	-
Fat poultry	fat	1.5	2	3	4.5	3	4.5	3	4.5	2	3.0	1.3	1.3
Fat pigs	fat	0.6	1	26	29.2	22	24.7	18	20.2	12	13.5	0.5	0.8
Mixed animal fats	fat	1.5	2	2	4.7	2	4.7	2	4.7	2	4.7	8	8
Vegetable oils and fats	fat	0.5	0.8	4	4.1	4	4.1	1	1.0	1	1.0	0.5	1.2
Marine oils	fat	1.5	2	9	8.1	7	6.3	4	3.6	4	3.6	1.1	2
Fish liver and products	ww	-	-	-	-	-	-	-	-	-	-	-	-
Fruits, vegetables and cereals	ww	0.4	-	31	11.9	31	11.9	-	-	-	-	0.5	-
Feed of plant origin excl. oils	12%	0.5	0.75	16	4.2	14	3.7	8	2.1	6	1.6	0.5	0.7
Vegetable oils and by-products	12%	0.5	0.75	4	5.9	4	5.9	1	1.5	2	2.9	0.6	0.8
Feed materials of mineral origin	12%	0.5	1	1	0.9	0	0	0	0	0	0	0.4	-
Animal fat, incl. milk and egg	12%	1	2	3	8.1	3	8.1	0	0	0	0	0.8	-
Other land animal products	12%	0.5	0.75	2	6.5	2	6.5	2	6.5	2	6.5	0.8	0.8
Fish oil	12%	5	6	9	10.1	6	6.7	2	2.2	2	2.2	4.5	5.4
Aquatic products excl. oil, protein	12%	1	1.25	6	4.7	4	3.1	3	2.3	3	2.3	0.8	1.4
Additives trace elements	12%	0.5	1	8	10.1	8	10.1	0	0	0	0	0.3	-
Pre-mixtures	12%	0.5	1	1	1.1	1	1.1	0	0	0	0	0.3	-
Compound feed, excl. below	12%	0.5	0.75	37	7.7	29	6.0	19	3.9	12	2.5	0.4	0.6
Feed fur animals, pets and fish	12%	1.75	2.25	3	2.1	2	1.4	0	0	0	0	1.5	-

[1]ER: Expression of results.

Applying the same action and maximum levels for TEQ_{WHO05} values resulted in a reduced number of samples exceeding the respective level. Thus, the Commission requested a calculation of necessary adjustments to action and maximum levels to counter the impact of moving from TEF_{WHO98} to TEF_{WHO05}. New levels resulting in the same number of samples exceeding the respective AL and ML were determined for each food and feed group (Table 15). As expected, these levels were generally lower than the current levels set by the legislation on the basis of TEQ_{WHO98}.

There is no current AL for total dioxins. The comparison of total dioxins TEQ levels with ML is shown in Table 16. For TEQ_{WHO98}, a relatively large number of samples exceeded the ML for ‘Fish liver and products’ (39.5%), ‘Fat pigs’ (22.5%) and ‘Muscle meat fish and products thereof’ (14.9%). In feed, the number of samples exceeding the ML was consistently below 4% with the exception of the group ‘Compound feed’ (9.5%). Similar to above, new maximum levels when using TEQ_{WHO05} are suggested.

Table 16: Number (N) and percentage (%) of samples in the respective food and feed group exceeding the respective maximum levels (ML) (Regulation 1881/2006) in pg/g for total dioxins (dioxins, furans and dioxin-like PCBs) using TEQ_{WHO98} and TEQ_{WHO05}, respectively.

Food group	ER[1]	ML	Samples > ML				New ML based on TEQ_{WHO05}
			TEQ_{WHO98}		TEQ_{WHO05}		
			N	%	N	%	
Meat and products ruminants	Fat	4.5	13	7.4	7	4.0	3.7
Meat and products poultry	Fat	4	4	4.3	4	4.3	2.1
Meat and meat products pigs	Fat	1.5	11	12.2	8	8.9	1.5
Liver and products terrestrial	Fat	12	6	6.6	6	6.6	12.5
Muscle meat fish and products	ww	8	295	14.9	218	11.0	5.9
Muscle meat eel	ww	12	17	12.2	11	7.9	10.5
Raw milk and products, butter	Fat	6	45	4.8	41	4.4	5.5
Hen eggs and egg products	Fat	6	51	6.5	33	4.2	5
Fat ruminants	Fat	4.5	1	1.3	0	0	3.7
Fat poultry	Fat	4	0	0	0	0	-
Fat pigs	Fat	1.5	20	22.5	14	15.7	1.3
Mixed animal fats	Fat	3	6	14.0	5	11.6	2.8
Vegetable oils and fats	Fat	1.5	2	2.1	2	2.1	2
Marine oils	Fat	10	2	1.8	2	1.8	15
Fish liver and products	ww	25	17	39.5	16	37.2	24.3
Fruits, vegetables and cereals	ww	-	-	-	-	-	-
Feed of plant origin excl. oils	12%	1.25	7	1.9	5	1.3	1.2
Vegetable oils and by-products	12%	1.5	0	0	0	0	-
Feed materials of mineral origin	12%	1.5	0	0	0	0	-
Animal fat, incl. milk and egg	12%	3	0	0	0	0	-
Other land animal products	12%	1.25	0	0	0	0	-
Fish oil	12%	24	3	3.4	1	1.1	21.1
Aquatic products excl. oil, protein	12%	4.5	2	1.6	1	0.8	4.2
Additives trace elements	12%	1.5	0	0	0	0	-
Pre-mixtures	12%	1.5	0	0	0	0	-
Compound feed, excl. below	12%	1.5	46	9.5	43	8.9	1.4
Feed fur animals, pets and fish	12%	7	1	0.7	1	0.7	6.1

[1]ER: Expression of results.

There are action levels set for dioxin-like PCB TEQ values and comparisons of compliance are reported in Table 17. The proportion of samples exceeding the AL was high for the groups 'Meat and meat product ruminants' (35.4%), 'Mixed animal fats' (32.6%), 'Fat pigs' (27.0%) and 'Muscle meat eel' (23.7%) using TEQ_{WHO98}. Again new maximum levels when using TEQ_{WHO05} are suggested.

Table 17: Number (N) and percentage (%) of samples in the respective food and feed group exceeding the respective action levels (AL) (Commission Recommendation 2006/88/EC) in pg/g for dioxin-like PCBs using TEQ_{WHO98} and TEQ_{WHO05}, respectively.

Food group	ER[1]	AL	Samples > AL TEQ_{WHO98} N	Samples > AL TEQ_{WHO98} %	Samples > AL TEQ_{WHO05} N	Samples > AL TEQ_{WHO05} %	New AL based on TEQ_{WHO05}
Meat and products ruminants	fat	1	62	35.4	49	28.0	0.8
Meat and products poultry	fat	1.5	6	6.4	5	5.3	1
Meat and meat products pigs	fat	0.5	16	17.8	10	11.1	0.3
Liver and products terrestrial	fat	4	5	5.5	5	5.5	4.1
Muscle meat fish and products	ww	3	382	19.3	303	15.3	2.2
Muscle meat eel	ww	6	33	23.7	27	19.4	5.5
Raw milk and products, butter	fat	2	82	8.8	78	8.4	2
Hen eggs and egg products	fat	2	89	11.3	66	8.4	1.6
Fat ruminants	fat	1	12	15	11	13.8	0.7
Fat poultry	fat	1.5	0	0	0	0	-
Fat pigs	fat	0.5	24	27.0	23	25.8	0.5
Mixed animal fats	fat	0.8	14	32.6	12	27.9	0.7
Vegetable oils and fats	fat	0.5	6	6.2	2	2.1	0.4
Marine oils	fat	6	9	8.1	5	4.5	4.1
Fish liver and products	ww	-	-	-	-	-	-
Fruits, vegetables and cereals	ww	0.2	21	8.1	21	8.1	0.2
Feed of plant origin excl. oils	12%	0.35	11	2.9	10	2.6	0.3
Vegetable oils and by-products	12%	0.5	2	2.9	2	2.9	1
Feed materials of mineral origin	12%	0.35	6	5.3	5	4.4	0.3
Animal fat, incl. milk and egg	12%	0.75	2	5.4	0	0	0.7
Other land animal products	12%	0.35	1	3.2	1	3.2	0.3
Fish oil	12%	14	7	7.9	4	4.5	11
Aquatic products excl. oil, protein	12%	2.5	7	5.5	5	3.9	2.1
Additives trace elements	12%	0.35	1	1.3	1	1.3	0.3
Pre-mixtures	12%	0.35	0	0	0	0	-
Compound feed, excl. below	12%	0.5	71	14.7	69	14.3	0.5
Feed fur animals, pets and fish	12%	3.5	5	3.5	4	2.8	2.9

[1]ER: Expression of results.

4.7. Dioxin levels in specific food groups

The levels of dioxins were examined in more detail in a number of food categories. For each food sub-group, the overall means of dioxin TEQ_{WHO98} levels, as well as the means for dioxins, furans, non-*ortho* and mono-*ortho* PCBs were calculated. Results are shown in Table 18.

The category 'Meat and meat products ruminants' was divided into the sub-groups 'Bovine' (n=130), Ovine (n=40), and 'Caprine' (n=3). One sample from the 'Caprine' group was removed for this analysis because of an extreme total dioxin value of 302.9 pg TEQ_{WHO98}/g. It has been previously reported that samples from grazing animals showed high dioxin levels if coming from contaminated soil intake (Schultz *et al.,* 2005). In this survey, some differences in mean total dioxin levels between the ruminant species were noted. The slightly higher levels for caprine animals are consistent with the fact that they graze closer to the soil, but with the few samples tested no conclusion should be drawn.

Table 18: Expression of result (ER), sample size (N), mean levels of dioxins (PCDD), furans (PCDF), dioxins and furans (PCDD/F), non-*ortho* PCB (NO PCB), mono-*ortho* PCB (MO PCB), dioxin-like PCB (DL PCB), and total TEQ_{WHO98} values (in pg/g) in a number of food subgroup.

Food group	Food sub-group	ER	N	PCDD	PCDF	PCDD/F	NO PCB	MO PCB	DL PCB	Total
Meat and meat products ruminants	Bovine	fat	130	0.31	0.55	0.86	0.94	0.24	1.18	2.03
	Ovine	fat	40	0.53	0.39	0.91	0.56	0.26	0.82	1.73
	Caprine	fat	3	1.29	0.34	1.63	0.46	0.05	0.52	2.15
Muscle meat fish and fish products excluding eels	Seafood	ww	98	0.56	0.80	1.36	0.94	0.24	1.18	2.54
	Farmed salmon	ww	144	0.15	0.29	0.44	0.91	0.20	1.11	1.55
	Farmed trout	ww	25	0.11	0.21	0.31	0.78	0.11	0.88	1.20
	Farmed other	ww	125	0.64	1.25	1.89	3.84	1.09	4.92	6.82
	Herring	ww	389	1.20	3.73	4.93	1.83	0.89	2.72	7.65
	Salmon	ww	95	0.94	2.34	3.28	3.47	1.24	4.71	7.99
	Sprat	ww	48	0.79	2.27	3.05	2.65	0.61	3.26	6.31
	Trout	ww	71	0.33	1.00	1.33	1.44	0.79	2.23	3.56
	Other fish	ww	980	0.26	0.57	0.83	0.84	0.50	1.34	2.17
Raw milk and dairy products including butter	Milk not specified	fat	420	0.50	0.55	1.05	1.28	0.09	1.37	2.42
	Butter	fat	141	0.28	0.26	0.54	0.65	0.07	0.72	1.26
	Cheese	fat	71	0.35	0.32	0.68	0.74	0.13	0.87	1.54
	Milk from farm	fat	123	0.18	0.26	0.43	0.69	0.14	0.84	1.27
	Milk bulk	fat	61	0.20	0.42	0.62	0.56	0.12	0.68	1.30
	Milk from retail	fat	36	0.28	0.22	0.51	0.35	0.09	0.44	0.95
	Other milk products	fat	79	0.30	0.37	0.67	0.33	0.06	0.40	1.07
Hen eggs and egg products	Caged	fat	26	0.19	0.11	0.30	0.10	0.01	0.11	0.41
	Free range	fat	34	0.21	0.09	0.30	0.13	0.03	0.16	0.46
	Not specified	fat	725	0.50	0.50	1.00	0.86	0.31	1.17	2.16

Overall, there was little difference between ‘Milk from farm’ and ‘Milk bulk’, with mean dioxin levels equal to 1.27 and 1.30 pg TEQ_{WHO98}/g, respectively. Slightly lower values were observed for the group ‘Milk from retail’ with a mean dioxin level of 0.95 pg TEQ_{WHO98}/g. The lower level in milk from retail could indicate the effect of dilution when moving from detailed collection of milk up to the retailers. Alternatively the difference may reflect targeted sampling at the farm or bulk milk level.

Sub-group analyses for the food group ‘Hen eggs and egg products’ revealed that ‘Caged eggs’ (n=26) and ‘Free range eggs’ (n=34) had very similar mean dioxin levels, equal to 0.41 and 0.46 pg TEQ_{WHO98}/g respectively, although in the vast majority of samples the origin of egg samples, i.e. free-range vs. caged, was not available.

Subgroup analyses on the group ‘Muscle meat fish and fish products excluding eels’ revealed that there were differences in total dioxin between the different sub-groups. The highest total dioxin level was reported for the group ‘Salmon’ (8.9 pg $TEQ_{WHO1998}$/g) followed by ’Herring’ (7.6 pg TEQ_{WHO98}/g).

By way of derogation from Article 1 in Commission Regulation (EC) No 1881/2006, Finland and Sweden may authorise until 31 December 2011 the placing on their market of salmon (*Salmo salar*), herring (*Clupea harengus*), river lamprey (*Lampetra fluviatilis*), trout (*Salmo trutta*), char (*Salvelinus spp*.) and roe of vendace (*Coregonus albula*) originating in the Baltic region and intended for consumption in their territory with levels of dioxins and/or levels of the sum of dioxins and dioxin-like PCBs higher than those set out in the legislation. In this report, within the food group ‘Muscle meat fish and fish products excluding eel’, there were differences displayed in total dioxin between the different sub-groups. To check whether a particular country-dependent pattern of total dioxin levels could be identified in the dioxin database, in the absence of complete information on the country of origin for the vast majority of samples transmitted to EFSA, the country of collection of herring samples was detailed in Table 19, separately for countries from or outside of the Baltic Sea area. Mean values were decidedly higher in the Baltic Sea area (8.6 pg TEQ_{WHO98}/g, based on 328 samples) than in countries not in the Baltic Sea area (2.3 pg TEQ_{WHO98}/g, n=61). High values were reported in Finland (11.0 pg TEQ_{WHO98}/g, n=171) and Sweden (6.8 pg TEQ_{WHO98}/g, n=135).

Table 19: Sample size (N), mean, median, percentiles 95th and 99th, and maximum of total dioxin levels by country of collection of samples for the food subgroup ‘Herring’. All samples expressed as whole weight.

	Country of collection	**N**	**Mean**	**Median**	**P95***	**P99***	**Max**
Baltic region	Estonia	10	2.41	2.46	3.36	3.36	3.36
	Finland	171	10.98	6.92	28.81	36.63	47.45
	Lithuania	3	3.94	3.46	-	-	5.11
	Poland	9	1.14	0.15	-	-	0.31
	Sweden	135	6.82	4.26	18.17	27.16	33.48
	Total	*328*	*8.64*	*5.25*	*25.47*	*33.48*	*47.45*
Non Baltic region	Belgium	4	1.12	0.97	-	-	1.74
	Denmark**	27	3.80	2.89	12.55	12.85	12.85
	Iceland	3	0.36	0.34	-	-	0.59
	Ireland	6	0.87	0.88	-	-	0.98
	Norway	21	1.28	1.23	1.71	2.01	2.01
	Total	*61*	*2.30*	*1.39*	*7.37*	*12.85*	*12.85*

*These statistics were not reported when N<10, and should be interpreted with caution in groups with limited sample size (i.e. N <50).

**Denmark was included in the non-Baltic region but it is acknowledged that the country straddles the two areas.

The group ‘Infant and baby food’ was consistently expressed as fat throughout this report, with the mean of total dioxins equal to 0.42 pg TEQ_{WHO98}/g. The same mean value was equal to 0.015 pg TEQ_{WHO98}/g when expressed on whole weight basis. Similarly, the results of the group ‘Liver and products terrestrial animals’ were consistently expressed on fat basis, with a total dioxin mean equal to 5.72 pg TEQ_{WHO98}/g. In 78 out of 91 samples, the percentage of fat was available, and used to express dioxins levels on whole weight basis, with a mean equal to 0.28 pg TEQ_{WHO98}/g.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

- Following Commission Recommendations for the periodic evaluation of dioxin levels in Europe, data on the presence of 17 congeners of dioxins and furans, and 12 congeners of dioxin-like PCBs in food and feed have been reported. However, not all submissions contained the required information necessitating some considerable review and interpretation to harmonise the results. Non-dioxin-like PCBs will be covered in a separate report.

- A total of 7,270 samples collected in the period 1999-2008 from 19 Member States, Norway and Iceland were retained for a detailed analysis. At the congener level, the percentage of samples below the limit of quantification (LOQ) varied considerably, and were on average about 40% for results expressed on a fat basis, about 30% for results expressed on whole weight basis, and about 60% when expressed on '12% moisture' basis.

- The impact of changing the basis for the calculation of TEQ from the TEF_{WH98} to TEF_{WHO05} was evaluated. Lower TEQ_{WHO05} values were observed compared to TEQ_{WH98}, consistently across all food and feed groups, ranging between 4% and 17% with an average of 14% for the total dioxin level. The reduction was mainly due to changes in TEFs for mono-*ortho* PCB and furan congeners with little change in dioxin and non-*ortho* PCB congeners. However, there were large variations observed for different food and feed categories and between products in food and feed categories.

- Dioxins and furans comprised, on average, between 30% and 74% of the total dioxins and dioxin-like PCBs across different food and feed groups. There was also considerable variation within food and feed groups. Mono-*ortho* PCBs comprised between 15% and 45% of the dioxin-like PCBs. This latter proportion was reduced considerably when using TEF_{WHO05} rather than TEF_{WHO98} as the basis for calculating the TEQ.

- Subgroup analyses on the group 'Muscle meat fish and fish products excluding eels' revealed that there were differences in total dioxin between the different sub-groups. The highest total dioxin level was reported for the group 'Salmon' followed by 'Herring' with 'Herring' linked to the Baltic Sea close to four times higher that other 'Herring'. Lower dioxin levels in retail milk compared to farm or bulk milk could be due to specific targeted sampling in the latter two categories.

- It is important to bear in mind that a varying proportion of product testing reflects targeted and not random monitoring. This has the potential of introducing a high degree of uncertainty and bias in the evaluation of background levels of dioxins in food and feed**,** as higher total dioxin values are expected in targeted compared to random samples. Such potential influence made it impossible to perform an accurate trend analysis based on the present material.

RECOMMENDATION

It is suggested that the current results be interpreted with some caution. To improve the evaluation of the dioxin background distribution across food groups in Europe compliance with the stratified random sampling scheme specified in Commission Recommendation 2006/794/EC will be required and the requested information prescribed in the associated form listed in the same Recommendation provided in full.

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GLOSSARY / ABBREVIATIONS

2,3,7,8-TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
1,2,3,7,8-PeCDD	1,2,3,7,8-Pentachlorodibenzo-p-dioxin
1,2,3,4,7,8-HxCDD	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin
1,2,3,6,7,8-HxCDD	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin
1,2,3,7,8,9-HxCDD	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin
1,2,3,4,6,7,8-HpCDD	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin
OCDD	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin
2,3,7,8-TCDF	2,3,7,8-Tetrachlorodibenzofuran
1,2,3,7,8-PeCDF	1,2,3,7,8-Pentachlorodibenzofuran
2,3,4,7,8-PeCDF	2,3,4,7,8-Pentachlorodibenzofuran
1,2,3,4,7,8-HxCDF	1,2,3,4,7,8-Hexachlorodibenzofuran
1,2,3,6,7,8-HxCDF	1,2,3,6,7,8-Hexachlorodibenzofuran
1,2,3,7,8,9-HxCDF	1,2,3,7,8,9-Hexachlorodibenzofuran
2,3,4,6,7,8-HxCDF	2,3,4,6,7,8-Hexachlorodibenzofuran
1,2,3,4,6,7,8-HpCDF	1,2,3,4,6,7,8-Heptachlorodibenzofuran
1,2,3,4,7,8,9-HpCDF	1,2,3,4,7,8,9-Heptachlorodibenzofuran
OCDF	1,2,3,4,6,7,8,9-Octachlorodibenzofuran
PCB-77	3,3',4,4'-Tetrachlorobiphenyl
PCB-81	3,4,4',5-Tetrachlorobiphenyl
PCB-126	3,3',4,4',5-Pentachlorobiphenyl
PCB-169	3,3',4,4',5,5'-Hexachlorobiphenyl
PCB-105	2,3,3',4,4'-Pentachlorobiphenyl
PCB-114	2,3,4,4',5- Pentachlorobiphenyl
PCB-118	2,3',4,4',5- Pentachlorobiphenyl
PCB-123	2',3,4,4',5- Pentachlorobiphenyl
PCB-156	2,3,3',4,4',5- Hexachlorobiphenyl
PCB-157	2,3,3',4,4',5'- Hexachlorobiphenyl
PCB-167	2,3',4,4',5,5'- Hexachlorobiphenyl
PCB-189	2,3,3',4,4',5,5'-Heptachlorobiphenyl
PCDD	Polychlorinated dibenzo-p-dioxins
PCDF	Polychlorinated dibenzo-p-furans
PCDD/F	Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans
TEF	Toxicity equivalency factor
TEQ	Toxic equivalents