## SCIENTIFIC REPORT OF EFSA

# Perfluoroalkylated substances in food: occurrence and dietary exposure[1]

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## ABSTRACT

Perfluoroalkylated substances (PFASs) are highly fluorinated aliphatic compounds with high thermal and chemical stability, as well as high surface activity. PFASs are used in a range of industrial and chemical applications e.g. textiles, paper, packaging materials, paint and varnish, and fire-extinguishing liquids. Several PFASs are recognised as environmentally persistent organic pollutants and are associated with adverse health effects. Diet is considered the main source of exposure to PFASs. In 2008, the EFSA Scientific Panel on Contaminants in the Food Chain (CONTAM Panel) performed a risk assessment for perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) concluding that it is unlikely that adverse effects of PFOS or PFOA are occurring in the general population. The CONTAM Panel acknowledged the limitation of available data and recommended further monitoring of PFAS in food. The present report summarises occurrence data for PFASs collected in 13 European countries during the period 2006 to 2012. A total of 54,195 analytical results covering a list of 27 substances were included in the assessment. The overall proportion of quantified results was very low. Across food groups, PFASs were found more frequently in fish and other seafood and in meat and meat products (liver in particular). For PFOS, the dietary exposure estimates in the adult population was < 3.5 % of the TDI for average consumers and < 6.7 % of the TDI in high consumers. For the same consumer groups, exposure to PFOA represented < 0.3 % and < 0.5 % of the TDI, respectively. Exposure in toddlers was two to three times higher compared to adults. For the other PFASs evaluated, daily dietary exposure was estimated to be in the low ng/kg b.w. range. The current review confirmed that dietary exposure to PFOS and PFOA is highly unlikely to exceed health-based guidance values.



## KEY WORDS

Perfluoroalkylated substances, PFASs, PFOS, PFOA, occurrence, food, dietary exposure

1 On request from the European Commission, Question No EFSA-Q-2011-00227, approved on 28 May 2012.

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3 Acknowledgement: EFSA wishes to thank EFSA staff Valeriu Curtui for the scientific work and support provided to this scientific output and the external reviewers Gianfranco Brambilla, Alessandro di Domenico and Stefan van Leeuwen for their valuable comments.

Suggested citation: European Food Safety Authority; Perfluoroalkylated substances in food: occurrence and dietary exposure. EFSA Journal 2012; 10(6):2743. [55 pp.] doi:10.2903/j.efsa.2012.2743. Available online: www.efsa.europa.eu/efsajournal

## SUMMARY

Perfluoroalkylated substances (PFASs) are highly fluorinated aliphatic compounds with high thermal and chemical stability, as well as high surface activity. PFASs have been used since decades in a range of industrial and chemical applications as processing aids in impregnation agents for textiles, carpets, paper, packaging materials, furniture, shoes, cleaning agents, paint and varnish, wax, floor polishing agents, fire-extinguishing liquids, photo paper, and insecticide formulations. The wide use of certain PFASs led to their global distribution in the environment including humans. Perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are the most known PFASs.

Public health concern towards PFASs was raised after several studies indicated that PFOS and PFOA have adverse health effects in experimental animals e.g. hepatotoxicity, developmental toxicity, neurobehavioral toxicity, immunotoxicity, reproductive toxicity, lung toxicity, hormonal effects, as well as a weak genotoxic and carcinogenic potential.

Dietary exposure has been suggested as the main exposure route to PFASs in the human population. Fish and other seafood are considered as the major contributors.

In 2008, the EFSA Scientific Panel on Contaminants in the Food Chain (CONTAM Panel) performed a risk assessment for PFOS and PFOA concluding that it is unlikely that adverse effects of PFOS and PFOA are occurring in the general population. The CONTAM Panel also established a tolerable daily intake (TDI) of 150 ng/kg b.w. per day for PFOS and 1500 ng/kg b.w. per day for PFOA. However, due to lack of data only a limited exposure assessment was possible and the Panel thus recommended that more occurrence data for PFASs in food should be collected to improve the accuracy of future exposure calculations. Subsequently, the European Commission issued the Commission Recommendation 2010/161/EU on the monitoring of PFASs in food in the Member States. Member States were recommended to monitor the presence of PFASs in a broad range of foods. EFSA collected and assessed the monitoring data.

The present assessment is based on 54,195 analytical results obtained for 7,560 food samples covering a list of 27 PFASs[4], but not all samples were analysed for the full set of PFASs. Data were submitted by 13 European countries for samples collected in the period 2006-2012. Quantified results were reported for 16 PFASs (PFPA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFBS, PFHxS, PFHpS, PFOS, PFDS and FOSA) while for another eleven (PFBA, PFPeDA, PFHxDA, PFODA, PFOSI, 8:2 FTOH, 8:2 monoPAP, 8:2 diPAP, EtFOSA, EtFOSE and FC-807) all analytical results were below the limit of detection or limit of quantification. Most of the results were available for PFOS (n = 7,523) and PFOA (n = 7,536) while results for PFPeDA, 8:2 FTOH, 8:2 monoPAP, 8:2 diPAP, EtFOSA, EtFOSE and FC-807 were very low. Across food groups, the highest number of data were available for 'Fish and other seafood' (n = 25,328) and 'Meat and meat products (including edible offal)' (n = 13,780).

The most frequently quantified PFAS was PFOS (29 %) followed by PFOA (9 %), FOSA (7 %), PFUnDA (7 %), PFDA (6 %), PFDoDA (6 %), PFTriDA (6 %), PFNA (5 %), PFHxA (4 %), PFPA (3 %), PFHpA (2 %), PFBS (2 %), PFHxS (2 %), PFDS (0.7 %), PFTeDA (0.6 %) and PFHpS (0.1 %). Across food groups, PFASs were reported more frequently in fish and other seafood, in meat


[4] PFBA = Perfluorobutanoic acid, PFPA = Perfluoropentanoic acid, PFHxA = Perfluorohexanoic acid, PFHpA = Perfluoroheptanoic acid, PFOA = Perfluorooctanoic acid, PFNA = Perfluorononanoic acid, PFDA = Perfluorodecanoic acid, PFUnDA = Perfluoroundecanoic acid, PFDoDA = Perfluorododecanoic acid, PFTrDA = Perfluorotridecanoic acid, PFTeDA = Perfluorotetradecanoic acid, PFPeDA = Perfluoropentadecanoic acid, PFHxDA = Perfluorohexadecanoic acid, PFODA = Perfluorooctadecanoic acid, PFBS = Perfluorobutane sulfonic acid, PFHxS = Perfluorohexane sulfonic acid, PFHpS = Perfluoroheptane sulfonic acid, PFOS = Perfluorooctane sulfonic acid, PFDS = Perfluorodecane sulfonic acid, PFOSI = Perfluorooctane sulfinic acid, 8:2 FTOH = 8:2 Fluorotelomer alcohol, 8:2 monoPAP = 8:2 Fluorotelomer posphate monoester, 8:2 diPAP = 8:2 fluorotelomer posphate diesters, FOSA = Perfluorooctane sulfonamide, EtFOSA = N-ethylperfluorooctane sulfonamide, EtFOSE = N-Ethyl perfluorooctane sulfonamidoethanol, FC-807 = Perfluoroalkyl phosphate

and meat products and to a lesser extent in other food groups. The highest concentrations for the different PFASs were found in edible offal and in particular in liver. Individual quantified values ranged from a low of 0.00034 µg/kg for drinking water to a high of 3480 µg/kg for wild boar liver. However, in general food with the highest concentrations do not have the greatest impact on exposure because the quantities consumed are low (e.g. liver from wild animals). Fish from fresh water was more highly contaminated than marine fish and diadromous fish.

Dietary exposure was calculated using the overall European lower and upper bound mean occurrence of PFASs. The low proportion of quantified results prevented calculation of a more realistic dietary exposure. The upper bound results are highly overestimated, but still the exposure estimates in all age classes and for both mean and 95$^{th}$ percentile consumers were well below the TDIs for PFOS (150 ng/kg b.w. per day) and PFOA (1500 ng/kg b.w. per day) set by the EFSA Scientific Panel on Contaminants in the Food Chain. For PFOS, the highest upper bound mean exposure estimate for the adult population (5.2 ng/kg b.w. per day) represented 3.5 % of the TDI while the highest 95$^{th}$ percentile estimate (10 ng/kg b.w. per day) represented 6.7 % of the TDI. In toddlers, the age class having the highest exposure, the same parameters represented 9.3 % and 19 % of the TDI, respectively.

The highest contributors to dietary PFOS exposure across all age classes were 'Fish and other seafood' (50 to 80 %) followed by 'Fruits and fruit products' (8 to 27 %) and 'Meat and meat products' (5 to 8 %).

For PFOA, the chronic dietary exposure in all age classes and for both average and high consumers were also far below the TDI. For adults, the highest upper bound mean estimate (4.3 ng/kg b.w. per day) represented 0.3 % of the TDI while the highest 95$^{th}$ percentile estimate (7.7 ng/kg b.w. per day) represented 0.5 % of the TDI. In toddlers, the age class having the highest exposure, the highest mean and 95$^{th}$ percentile estimates would represent 1.1 % and 2.1 % of the TDI, respectively. The most important contributors to PFOA exposure in all age classes were 'Fruits and fruit products' (18 to 39 %) and 'Fish and other seafood' (7.6 to 27 %) but high variations were observed in relation to dietary habits.

Based on the available data with a very low proportion of quantified results, the chronic dietary exposure to the other 25 single PFASs is expected to be in the low ng/kg b.w. per day range or even lower. Since no TDIs are available for these PFASs, it was not possible to evaluate the relevance of the dietary exposure for human health.

Based on further results from toxicological evaluations, the relevance of various PFASs to human health could be better established and allow the definition of a set of priority PFASs for future monitoring.

The use of analytical methods with improved sensitivity would be required to monitor such priority PFASs in order to increase the proportion of quantified results and thereby the reliability of exposure assessments.

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## BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

Commission Recommendation 2010/161/EU on the monitoring of perfluoroalkylated substances (PFASs) in food of 17 March 2010 required the Member States to perform during the years 2010 and 2011 monitoring on the presence of perfluoroalkylated substances in food. It also recommended transmitting the data to EFSA on regular basis for compilation into one database, including the data available from previous years, in order to monitor trends in exposure. These data are needed by the Commission as a basis for deciding on any possible risk management measures.

## TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

Both monitoring data and additional data, obtained through the call for data will be collated, analysed and summarised by EFSA. An intermediate report could allow for adjustment of the monitoring performed by the Member States[5]. The final report will provide an overview on PFAS occurrence in food and dietary exposure assessment.

[5] Report published in the EFSA Journal 2011; 9(2):2016. Available at www.efsa.europa.eu/efsajournal.htm

**ASSESSMENT**

## 1. Introduction

Perfluoroalkylated substances (PFASs), whose nomenclature has often been used in a non-harmonised way, are a subset of the large group of perfluorinated compounds (PFCs). Buck et al. (2011) provided an overview on terminology, classification and origin of the perfluoroalkyl and polyfluoroalkyl substances. According to the authors, PFASs are highly fluorinated aliphatic substances that contain one or more C atoms on which all the H substituents have been replaced by F atoms in such a manner that they contain the perfluoroalkyl moiety $C_nF_{2n+1}$- . The nomenclature and acronyms of PFASs discussed in the present report follow the recommendations of Buck et al. (2011).

Due to their thermal and chemical stability and surface activity, PFASs have been used since decades in a range of industrial and chemical applications as processing aids in impregnation agents for textiles, carpets, paper, packaging materials, furniture, shoes, cleaning agents, paint and varnish, wax, floor polishing agents, fire-extinguishing liquids, photo paper, and insecticide formulations (3M Company, 1999; Prevedouros et al., 2006). The wide use of certain PFASs led to their global distribution in the environment including humans. Perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are the most known PFASs. PFOS and its salts were included in 2010 as persistent organic pollutants (POPs) in Annex B of the Stockholm Convention (Stockholm Convention on Persistent Organic Pollutants, 2010) meaning that their use is accepted only for a defined list of applications.

Public health concern towards PFASs was raised after several studies indicated that PFOS and PFOA are present in the environment including the human body. Several adverse health effects e.g. hepatotoxicity, developmental toxicity, neurobehavioral toxicity, immunotoxicity, reproductive toxicity, lung toxicity, hormonal effects, as well as a weak genotoxic and carcinogenic potential have been demonstrated in experimental studies in animals (Lau et al., 2007; Zhang et al., 2008; Shi et al., 2009; Peden-Adams et al., 2009; Eriksen et al., 2010; Pinkas et al., 2010). Recently, an epidemiological study performed on a children cohort in the Faroe Islands indicated that high exposure to PFASs was associated with reduced humoral immune response to immunisations in children (Grandjean et al., 2012).

Many studies have reported the presence of PFASs in food indicating fish and other seafood as the most contaminated commodities (Berger et al., 2009; Delinsky et al., 2009; Haug et al. 2010a; Schuetze et al., 2010). In a study on the dietary exposure of the Dutch population to PFOS and PFOA, (Noorlander et al.,2011) it was reported that drinking water was the main contributor to PFOS and PFOA. However, no information on the actual concentration of PFOS and PFOA in the Dutch drinking water was available so the indicative concentrations used in the EFSA Scientific Opinion (EFSA, 2008) were applied. Dietary exposure has been suggested as the main exposure route to PFASs in the human population. Fish and other seafood were considered as major contributors. Food can be contaminated by accumulation from the environment or by contact with packaging materials and cookware containing PFASs (Gruber et al., 2011; Trier et al., 2011). Besides food (including drinking water), inhalation of outdoor and indoor air may contribute to the overall exposure (Shoeib et al., 2005; EFSA, 2008; Fromme et al., 2009; D'Hollander et al., 2010).

A number of risk assessments have been conducted in recent years to evaluate the level of exposure to PFASs in humans. In 2008, the EFSA Scientific Panel on Contaminants in the Food Chain (CONTAM Panel) performed a risk assessment for PFOS and PFOA concluding that it is unlikely that adverse effects of PFOS and PFOA are occurring in the general population. However, due to lack of data only a limited exposure assessment was possible (EFSA, 2008; Johansson et al. 2009). Based on the limited data available on fish and drinking water and on consumption data from four European countries, the CONTAM Panel estimated an indicative dietary exposure to PFOS of 60 ng/kg b.w. per day for average consumers and 200 ng/kg b.w. per day for high consumers of fish. Indicative dietary exposure to PFOA for the same consumer categories was estimates at 2 ng/kg b.w. per day and 6 ng/kg b.w. per

day, respectively. The CONTAM Panel has also established a tolerable daily intake (TDI) of 150 ng/kg b.w. per day for PFOS and of 1500 ng/kg b.w. per day for PFOA (EFSA, 2008). The CONTAM Panel noted that in the general population the indicative dietary exposure to PFOS and PFOA was below the TDI. The CONTAM Panel acknowledged the limitations of the dietary exposure assessment and recommended that more occurrence data of PFASs in different foodstuffs and biomonitoring data from humans should be collected, particularly with respect to monitoring trends in exposure. As a follow-up of the CONTAM Panel recommendation, the European Commission issued the Commission Recommendation 2010/161/EU on the monitoring of perfluoroalkylated substances in food in the Member States[6]. Member States were recommended to monitor during 2010 and 2011 the presence of PFASs in broad varieties of food. EFSA collected the monitoring data from previous years and issued in 2011 an intermediate report on the presence of PFASs in food in the period 2000-2009 (EFSA, 2011).

The Federal Institute for Risk Assessment in Germany concluded in 2008 that there is no health risk in the German population arising from dietary exposure to PFOS and PFOA at levels found in food. PFOS dietary exposure estimates calculated in lower bound and upper bound scenarios ranged from 2.3 to 3.7 ng/kg b.w. per day in average consumers and from 24 to 26 ng/kg b.w. per day in high consumers ($95^{th}$ percentile occurrence and $95^{th}$ percentile consumption). For PFOA, the dietary exposure estimates ranged from 0.71 to 0.95 ng/kg b.w. per day in average consumers and around 13 ng/kg b.w. per day in high consumers (BfR, 2008).

The Office for Risk Assessment in The Netherlands, in its opinion on the risk assessment on PFASs in Dutch food, concluded that the daily intake of PFOS and PFOA is respectively 200 and 2000 times below the corresponding TDI. Average dietary exposure in the Dutch population was estimated at 0.3 ng PFOS/kg b.w. per day and 0.2 ng PFOA/kg b.w. per day. The highest exposure ($99^{th}$ percentile) for PFOS and PFOA was 0.6 and 0.5 ng/kg b.w. per day, respectively (VWA, 2010; Noorlander et al., 2011). The close to 10-fold lower exposure reported in the Dutch population compared to other studies can be partly explained by the more sensitive analytical methods applied in the analysis of PFASs in food (LODs and LOQs in the low range of pg/kg) thus reducing the influence of the left-censored data on the exposure estimates.

The French Food Safety Agency evaluated in 2009 the potential human health risks related to the residual presence of PFOA in non-stick coatings for cookware. It was concluded that the consumer health risk related to residues of PFOA in non-stick coating for cookware is negligible. Realistic exposure to PFOA via food contact materials would be 2.5 ng/kg b.w. per day and maximum theoretical exposure would be 300 ng/kg b.w. per day (AFSSA, 2009).

Fromme et al. (2009) assessed the overall exposure to PFASs in the general population in western countries taking into consideration all the potential exposure routes. Using a simplified model, the average (and high) level of total exposure in adults was estimated at 1.6 ng/kg b.w. per day (8.8 ng/kg b.w. per day) for PFOS and 2.9 ng/kg b.w. per day (12.6 ng/kg b.w. per day) for PFOA, values which were well below the recommended TDIs.

Several other dietary exposure assessments indicated that exposure to PFOS and PFOA in humans is in the low ng/kg b.w. per day range (Ericson Jogsten et al., 2009; Kärrman et al., 2009; Haug et al., 2010b; Cornelis et al., 2012). Differences in the calculated dietary exposure in the aforementioned assessments are more likely linked to the different assessment methodologies applied, food groups considered in the assessment, origin of samples and different sensitivity of the analytical methods applied.

[6] Commission Recommendation 2010/161/EU of 17 March 2010 on the monitoring of perfluoroalkylated substances in food. OJ, L 68, 18.3.2010, p.22-23.

## 2. Objectives

As requested in the mandate from the European Commission, the report should focus on:

1. Building a database on PFASs in food.
2. Analyse and summarise the collected data.
3. Evaluate the contamination levels of the individual PFASs in food.
4. Evaluate the chronic dietary exposure of the European population to PFASs.

## 3. Material and method

### 3.1. Data collection

Commission Recommendation 2010/161 recommends to the Member States to carry out the analysis of PFASs in accordance with Annex III to Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004[7] on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules by making use of a method of analysis that has been proven to generate reliable results. In 2010, EFSA issued a call for data on PFASs in food with a closing date of 31 January 2012. Thirteen countries have submitted 56,862 analytical results on 27 PFASs in food covering the sampling period 1998 to 2012. In addition, data on PFASs in food from a three-year EU research project (PERFOOD[8]) were submitted to EFSA. As described in section 3.2, data submitted to EFSA underwent several data quality steps and only qualified data were retained for the assessment. The 27 PFASs for which results were provided and the abbreviations used for them throughout the report are presented in Table 1.

Data submitted to EFSA were compliant with the Standard Sample Description (SSD) agreed between EFSA and the EU Member States (EFSA, 2010a).

### 3.2. Data management and validation

For a sound analysis of the background contamination of PFASs in food, a list of validation steps was applied to the initial data set.

*Food classification*
All food samples were classified according to the FoodEx 1 classification system. FoodEx 1 is a provisional food classification system developed by the EFSA's Dietary and Chemical Monitoring Unit in 2009 with the objective to allow the accurate linkage between occurrence and food consumption data when assessing the exposure to hazardous substances. It contains about 1,800 food names or generic food names which can be grouped according to the needs for statistical analysis (EFSA, 2011b).

*Expression of results*
All analytical results were expressed on whole weight basis (w.w.), thus no conversion had to be applied.

[7] Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules. OJ L 191, 28.5.2004, p. 1-59.
[8] PERFOOD is a consortium of several European research institutions which collaborate in a FP7 EU project with the aim to improve the analytical tools for the determination of PFASs in food items, to contribute to the understanding of PFASs transfer from the environment into dietary items and to quantify the possible contribution of food/beverage contact materials and food and water processing to the overall PFASs levels in the diet (www.perfood.eu).

*Sampling year*
Outdated results may not reflect the current contamination therefore only results obtained from samples collected from 2006 onwards (n = 56,222) were retained for further evaluation. However, only a limited number of analytical results (n = 640) was available for the period before 2006 (360 between 1988 and 1996 and 280 between 2000 and 2005).

**Table 1:** List of PFASs for which data were reported.

| PFAS family/substance | Acronyms |
|---|---|
| Perfluoroalkyl carboxylic acids | PFCAs |
| Perfluorobutanoic acid | PFBA |
| Perfluoropentanoic acid | PFPA |
| Perfluorohexanoic acid | PFHxA |
| Perfluoroheptanoic acid | PFHpA |
| Perfluorooctanoic acid | PFOA |
| Perfluorononanoic acid | PFNA |
| Perfluorodecanoic acid | PFDA |
| Perfluoroundecanoic acid | PFUnDA |
| Perfluorododecanoic acid | PFDoDA |
| Perfluorotridecanoic acid | PFTrDA |
| Perfluorotetradecanoic acid | PFTeDA |
| Perfluoropentadecanoic acid | PFPeDA |
| Perfluorohexadecanoic acid | PFHxDA |
| Perfluorooctadecanoic acid | PFODA |
| Perfluoroalkane sulfonic acids | PFSAs |
| Perfluorobutane sulfonic acid | PFBS |
| Perfluorohexane sulfonic acid | PFHxS |
| Perfluoroheptane sulfonic acid | PFHpS |
| Perfluorooctane sulfonic acid | PFOS |
| Perfluorodecane sulfonic acid | PFDS |
| Perfluoroalkane sulfinic acids | PFSIAs |
| Perfluorooctane sulfinic acid | PFOSI |
| (n:2) Fluorotelomer alcohols | (n:2) FTOHs |
| 8:2 Fluorotelomer alcohol | 8:2 FTOH |
| Polyfluoroalkyl phosphoric acid esters | PAPs |
| 8:2 Fluorotelomer posphate monoester | 8:2 monoPAP |
| 8:2 Fluorotelomer posphate diesters | 8:2 diPAP |
| Perfluoroalkane sulfonamides | FASAs |
| Perfluorooctane sulfonamide | FOSA |
| N-ethyl perfluoroalkane sulfonamides | EtFASAs |
| N-ethylperfluorooctane sulfonamide | EtFOSA |
| N-Ethyl perfluoroalkane sulfonamidoethanol | EtFASEs |
| N-Ethyl perfluorooctane sulfonamidoethanol | EtFOSE |
| Perfluoroalkyl phosphate | FC-807 |

*Sampling strategy*
Suspect samples may lead to an overestimation of the contamination levels and therefore they should be treated with extra care when included in the assessment. There were no suspect samples in the PFAS data set. However, it has to be pointed out that some of the samples may have been collected in a more targeted way[9].

*Management of left-censored data*
In the analysis of occurrence data for PFASs in food the left-censored results (results reported either as <LOD or <LOQ) were treated by the substitution method as recommended in the "Principles and Methods for the Risk Assessment of Chemicals in Food" (WHO, 2009). The same method is indicated in the EFSA scientific report "Management of left-censored data in dietary exposure assessment of chemical substances" (EFSA, 2010b) as an option in the treatment of left-censored data. The lower bound (LB) is obtained by assigning a value of zero to all samples reported as left-censored. The upper bound (UB) is obtained by assigning the numerical value of the respective left-censoring limit.

*Left-censoring limits*
Commission Recommendation 2010/161 recommended limits of quantification (LOQ) of 1 µg/kg for the monitoring of PFASs in food. In a preliminary analysis it appeared that the detection capabilities varied with the type of matrix analysed and substance. Notably lower LODs/LOQs were reported for water and alcoholic beverages while higher LODs/LOQs were frequently reported for offal (mainly liver). It appears that analysis of PFASs is still challenging, especially in certain matrices as e.g. liver. In order to reduce the impact of the high left-censoring limits on the occurrence data analysis and on the dietary exposure estimates, but also not to exclude data on certain foods, the following upper limits were applied for the left-censoring of the 16 PFASs for which quantified results were reported (PFPA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFBS, PFHxS, PFHpS, PFOS, PFDS and FOSA):

- 0.02 µg/kg for water and alcoholic beverages;
- 5 µg/kg for edible offal of mammals and fish;
- 3 µg/kg for all other foods.

As no dietary exposure assessment could be carried out for the eleven PFASs where all analytical results were left-censored (PFBA, PFPeDA, PFHxDA, PFODA, PFOSI, 8:2 FTOH, 8:2 monoPAP, 8:2 diPAP, EtFOSA, EtFOSE and FC-807), no exclusion based on the left-censoring limits was applied to them.

Where the reported LODs/LOQs did not comply with the qualifying criteria, the analytical results (n = 2,027) were not included in the assessment regardless of whether they were quantified results or left-censored results. Hence, 99 % of the excluded data were left-censored values. After applying the aforementioned qualifying criteria, the data set included 54,195 observations.

*Sampling programme and sampling method*
Of the 54,195 data, 71 % were obtained on samples collected within official monitoring programs and 29 % on samples from Total Diet Studies (TDS) or other diet studies. With regard to the sampling method, 24 % of data were obtained on pooled samples. Since the level of aggregation for pooled samples matched the level of classification of the individual samples (only similar matrices were pooled together) results on pooled samples were retained for further evaluation.

*Recovery rates*

[9] Targeted samples are taken based on certain sampling criteria e.g. monitor the background contamination in matrices with high accumulation potential, controlling compliance with the maximum levels laid down in the relevant legislation. Suspect samples are samples taken repeatedly from the same site as a consequence of evidence or suspicion of (illegal) contamination. Frequently, suspect samples are taken as a follow-up of demonstrated non-compliance with legislation.

Commission Recommendation 2010/161 recommends to the Member States to apply methods of analysis with recovery rates ideally in the range of 70-120 %. However, recovery rates were reported for only 12 % of the data. In several Member States the data collection system on contaminants does not collect the information on recovery rates as it is expected to be in the recommended ranges. Since recovery rates were not available for the vast majority of results, it was considered that no exclusion could be made on this criterion.

Although recovery rates were reported only for a limited number of data, the analytical results were submitted to EFSA as corrected for recovery in 62.2 % of cases. 28.3 % of results were not corrected for recovery and for 9.5 % of results the correction for recovery was unknown. This aspects contribute to the uncertainty of the assessment.

*Outliers*
Potential outlying values were identified by the Tukey's method (Tukey, 1977) which identifies the values greater than the 75$^{th}$ percentile plus 1.5 times the interquartile distance, or less than the 25$^{th}$ percentile minus 1.5 times the interquartile distance. For a few suspect outlying values, data providers were asked to check the correctness of the transmitted data. In all cases it proved to be an error of the unit of measurement transmitted. The data were corrected accordingly.

The validated data set contained 54,195 observations: 50,420 for the 16 PFASs for which quantified results were reported and 3,775 for the eleven PFASs where all results were left-censored.

### 3.3. Food consumption

During 2010, the EFSA Comprehensive European Food Consumption Database (Comprehensive Database) was built from existing national information on food consumption at a detailed level. Competent organisations in the European Union Member States provided EFSA with data from the most recent national dietary survey in their country at the level of consumption by the individual consumer. Survey results for children were mainly obtained through the EFSA Article 36 project "Individual food consumption data and exposure assessment studies for children" through the EXPOCHI consortium (Huybrechts et al., 2011). Results from a total of 32 different dietary surveys carried out in 22 different Member States covering more than 67,000 individuals are included in the Comprehensive Database version 1 (EFSA, 2011c).

Although the food consumption data in the Comprehensive Database are the most complete and detailed currently available in the EU, it should be pointed out that different methodologies were used between surveys to collect the data and thus direct country-to-country comparisons can be misleading. Only surveys covering more than one day and thus appropriate for calculating chronic exposure were selected as described in Table 2. The 95$^{th}$ percentile exposure estimates were only calculated for surveys that included 60 or more subjects. Individuals were categorised into seven age groups covering infants (<1 year), toddlers (1 to <3 years), other children (3 to <10 years), adolescents (10 to <18 years), adults (18 to <65 years), elderly (65 to <75 years) and the very elderly (≥75 years) (EFSA, 2011c).

### 3.4. Statistical analysis

Frequency tables and summary statistics were produced to describe the PFAS data by substance, sampling year, sampling country and food group. Means were computed for each substance and food group where sufficient data was available. An important number of analytical results were obtained on pooled samples meaning that the result represented the average concentration of a number of samples taken in equal parts from different consignments/batches and pooled together for the laboratory analysis. To ensure a proportionate representation of the individual samples and thus an accurate use of the occurrence data in calculating the dietary exposure, the mean concentrations per food group were calculated by weighting the reported analytical results for the number of samples pooled.

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

**Table 2:** Dietary surveys considered for the chronic dietary exposure assessment and number of subjects in the different age classes.

| Code[(a)] | Country | Dietary survey[(b)] | Method | Days | Year | Age | Number of subjects | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Total | Infants | Toddlers | Other children | Adolescents | Adults | Elderly | Very elderly |
| BE/1 | Belgium | Diet_National_2004 | 24-h dietary recall | 2 | 2004 | 15-105 | 3118 | | | | 584 | 1304 | 518 | 712 |
| BE/2 | Belgium | Regional Flanders | Dietary record | 3 | 2003 | 2-6 | 661 | | 36 [(c)] | 625 | | | | |
| BG | Bulgaria | NUTRICHILD | 24-h dietary recall | 2 | 2007 | 0.1-5 | 1721 | 860 | 428 | 433 | | | | |
| CY | Cyprus | Childhealth | Dietary record | 3 | 2003 | 11-18 | 303 | | | | 303 | | | |
| CZ | Czech Republic | SISP04 | 24-h dietary recall | 2 | 2004 | 4-64 | 2353 | | | 389 | 298 | 1666 | | |
| DE/1 | Germany | DONALD 2006 | Dietary record | 3 | 2006 | 1-10 | 303 | | 92 | 211 | | | | |
| DE/2 | Germany | DONALD 2007 | Dietary record | 3 | 2007 | 1-10 | 311 | | 85 | 226 | | | | |
| DE/3 | Germany | DONALD 2008 | Dietary record | 3 | 2008 | 1-10 | 307 | | 84 | 223 | | | | |
| DE/4 | Germany | National Nutrition Survey II | 24-h dietary recall | 2 | 2006 | 14-80 | 13926 | | | | 1011 | 10419 | 2006 | 490 |
| DK | Denmark | Danish Dietary Survey | Food record | 7 | 2001 | 4-75 | 4120 | | | 490 | 479 | 2822 | 309 | 20[(c)] |
| EL | Greece | Regional Crete | Dietary record | 3 | 2005 | 4-6 | 839 | | | 839 | | | | |
| ES/1 | Spain | AESAN | 24-h dietary recall | 2 | 2009 | 18-60 | 410 | | | | | 410 | | |
| ES/2 | Spain | AESAN FIAB | Dietary record | 3 | 2001 | 17-60 | 1067 | | | | 86 | 981 | | |
| ES/3 | Spain | NUT INK05 | 24-h dietary recall | 2 | 2005 | 4-18 | 1050 | | | 399 | 651 | | | |
| ES/4 | Spain | enKid | 24-h dietary recall | 2 | 2000 | 1-14 | 382 | | 17[(c)] | 156 | 209 | | | |
| FI/1 | Finland | DIPP | Dietary record | 3 | 2005 | 1-6 | 1430 | | 497 | 933 | | | | |
| FI/2 | Finland | FINDIET 2007 | 48-h dietary recall | 2 | 2007 | 25-74 | 2038 | | | | | 1575 | 463 | |
| FI/3 | Finland | STRIP | Dietary record | 4 | 2000 | 7-8 | 250 | | | 250 | | | | |
| FR | France | INCA2 | Dietary record | 7 | 2006 | 3-79 | 4079 | | | 482 | 973 | 2276 | 264 | 84 |
| HU | Hungary | National Repr Survev | Dietary record | 3 | 2003 | 18-96 | 1360 | | | | | 1074 | 206 | 80 |
| IE | Ireland | NSIFCS | Dietary record | 7 | 1998 | 18-64 | 958 | | | | | 958 | | |
| IT | Italy | INRAN SCAI 2005 06 | Dietary record | 3 | 2006 | 0.1-98 | 3323 | 16[(c)] | 36[(c)] | 193 | 247 | 2313 | 290 | 228 |
| LV | Latvia | EFSA TEST | 24-h dietary recall | 2 | 2008 | 7-66 | 1965 | | | 189 | 470 | 1306 | | |
| NL/1 | Netherlands | DNFCS 2003 | 24-h dietary recall | 2 | 2003 | 19-30 | 750 | | | | | 750 | | |
| NL/2 | Netherlands | VCP kids | Dietary record | 3 | 2006 | 2-6 | 1279 | | 322 | 957 | | | | |
| SE/1 | Sweden | Riksmaten 1997-1998 | Dietary record | 7 | 1997 | 18-74 | 1210 | | | | | 1210 | | |
| SE/2 | Sweden | NFAn | 24-h dietary recall | 4 | 2003 | 3-18 | 2491 | | | 1473 | 1018 | | | |
| UK | United Kingdom | NDNS | Dietary record | 7 | 2001 | 19-64 | 1724 | | | | | 1724 | | |

(a): Abbreviations to be used consistently in all tables on exposure assessment; (b): More information on the dietary surveys is given in the Guidance of EFSA "Use of the EFSA Comprehensive European Food Consumption Database in Exposure Assessment" (EFSA, 2011b); (c): 95$^{th}$ percentile calculated over a number of observations lower than 60 are not be statistically robust (EFSA, 2011b) and therefore for these dietary surveys/age classes the 95$^{th}$ percentile estimates will not be presented in the exposure assessment.

## 4. Results and discussion

### 4.1. Overview of the validated data set

The final data set obtained after applying the validation criteria described in section 3.2. included 54,195 observations obtained from 7,560 food samples analysed for a various set of substances from a total of 27 PFASs. Food samples were collected in 13 European countries with most of the data submitted by Norway, Germany and France (Table 3). The data set covers results on samples collected from 2006 to 2012 with the majority of samples taken between 2007 and 2011. As the closing date for the data collection was in early 2012, only a limited number of data was reported for that year.

The sampled food groups and the number of samples by substance and food group are illustrated in Table 4. Most of the results were available for PFOS and PFOA (over 7,500 data each) while results for PFPeDA, 8:2 FTOH, 8:2 monoPAP, 8:2 diPAP, EtFOSA, EtFOSE and FC-807 were very few (between 3 and 18 results) (Table 4).

The most frequently analysed food groups were 'Fish and other seafood' (n = 25,328) and 'Meat and meat products including edible offal' (n = 13,780). A substantial number of data was also available for the food groups 'Milk and dairy products', 'Drinking water', 'Vegetables and vegetable products', 'Starchy roots and tubers' and Grains and grain-based products'. The other food groups were less well represented. The number of data available for a food group was not evenly distributed across the 27 PFASs (Table 4).

**Table 3:** Distribution of analytical results per sampling country and sampling year.

| Country | Sampling year | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | N | % |
| Austria | | | | | 300 | 72 | | 372 | 0.7 |
| Belgium | | | | 351 | 720 | 13 | | 1084 | 2.0 |
| Cyprus | | | | | 26 | | | 26 | 0.05 |
| Czech Republic | | | | | 627 | | | 627 | 1.2 |
| France | | 2125 | 5736 | 904 | | 2310 | | 11075 | 20.4 |
| Germany | 1091 | 4503 | 2200 | 1803 | 3048 | 2766 | 152 | 15563 | 28.7 |
| Greece | | | | | 58 | 98 | 2 | 158 | 0.3 |
| Ireland | 462 | 187 | 451 | | | | | 1100 | 2.0 |
| Italy | | | 130 | 106 | 664 | | | 900 | 1.7 |
| Norway | 720 | 4250 | 2429 | 7007 | 3754 | 1635 | | 19795 | 36.5 |
| Slovenia | | | | | | 299 | | 299 | 0.6 |
| Spain | | 66 | 14 | | | | | 80 | 0.15 |
| United Kingdom | | 2181 | 813 | 122 | | | | 3116 | 5.7 |
| **Total** | 2273 | 13312 | 11773 | 10293 | 9197 | 7193 | 154 | 54195 | 100.0 |

**Table 4:** Number of observations per main food group (FoodEx level 1) and PFAS compound.

| Food group | PFBA | PFPA | PFHxA | PFHpA | PFOA | PFNA | PFDA | PFUnDA | PFDoDA | PFTrDA | PFTeDA | PFPeDA | PFHxDA | PFODA | PFBS | PFHxS | PFHpS | PFOS | PFDS | PFOSI | 8:2 FTOH | 8:2 monoPAP | 8:2 diPAP | FOSA | EtFOSA | EtFOSE | FC-807 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grains and grain-based products | 45 | 45 | 75 | 75 | 79 | 75 | 75 | 74 | 75 | 18 | 18 | | 11 | | 75 | 75 | 45 | 79 | 56 | | | | | 30 | | | | 1025 |
| Vegetables and veg. products | 47 | 78 | 206 | 147 | 285 | 186 | 186 | 147 | 171 | 82 | 82 | | 5 | | 186 | 186 | 47 | 286 | 109 | | 1 | | | 99 | 1 | 1 | | 2538 |
| Starchy roots and tubers | 1 | 55 | 100 | 26 | 303 | 89 | 89 | 26 | 35 | 5 | 4 | | | | 89 | 88 | 1 | 303 | 5 | | | | | 25 | | | | 1244 |
| Legumes, nuts and oilseeds | 9 | 9 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 8 | 8 | | | | 20 | 20 | 9 | 20 | 12 | | | | | 11 | | | | 266 |
| Fruit and fruit products | | | 29 | 28 | 35 | 29 | 29 | 29 | 29 | 25 | 25 | | 1 | | 29 | 29 | | 34 | 25 | | | | | 4 | | | | 380 |
| Meat and meat products | 303 | 473 | 734 | 435 | 3221 | 792 | 793 | 432 | 636 | 219 | 190 | 3 | 23 | 23 | 689 | 683 | 316 | 3215 | 339 | 95 | 10 | 3 | 3 | 127 | 10 | 10 | 3 | 13780 |
| Fish and other seafood | 939 | 1044 | 1381 | 1333 | 2542 | 1813 | 1714 | 1544 | 1254 | 977 | 1368 | | 860 | 860 | 1331 | 1303 | 86 | 2534 | 977 | | 3 | | | 1459 | 3 | 3 | | 25328 |
| Milk and dairy products | 161 | 180 | 239 | 220 | 319 | 239 | 238 | 215 | 203 | 58 | 58 | | 16 | 16 | 239 | 239 | 161 | 318 | 177 | 14 | 2 | | | 61 | 2 | 2 | | 3377 |
| Eggs and egg products | 43 | 68 | 99 | 74 | 138 | 99 | 99 | 70 | 74 | 35 | 35 | | 4 | 4 | 99 | 99 | 43 | 134 | 47 | 27 | 2 | | | 33 | 2 | 2 | | 1330 |
| Sugar and confectionary | 5 | 5 | 10 | 10 | 45 | 10 | 10 | 9 | 10 | 4 | 4 | | 2 | | 10 | 10 | 5 | 45 | 9 | | | | | 2 | | | | 205 |
| Animal and vegetable fats & oils | 28 | 28 | 53 | 53 | 55 | 53 | 53 | 53 | 53 | 38 | 38 | | 38 | 38 | 53 | 53 | 1 | 56 | 39 | | | | | 52 | | | | 835 |
| Fruit and vegetable juices | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | 1 | 1 | | 1 | | | | | | 1 | | | | 11 |
| Alcoholic beverages | | | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | | 6 | 6 | 6 | 6 | | 6 | 6 | | | | | 6 | | | | 96 |
| Drinking water | 6 | 232 | 300 | 6 | 367 | 300 | 300 | 6 | 74 | | | | | | 296 | 300 | 6 | 372 | 6 | | | | | | | | | 2571 |
| Herbs, spices and condiments | 5 | 5 | 8 | 8 | 8 | 8 | 8 | 7 | 8 | 5 | 5 | | 2 | | 8 | 8 | 5 | 8 | 8 | | | | | 2 | | | | 116 |
| Food for infants & young children | 10 | 9 | 10 | 10 | 21 | 10 | 10 | 10 | 10 | 10 | 10 | | | | 10 | 10 | 10 | 21 | 10 | | | 10 | | 10 | 10 | 10 | | 221 |
| Composite food | 24 | 37 | 38 | 25 | 45 | 38 | 38 | 22 | 25 | 5 | 4 | | | | 38 | 38 | 24 | 45 | 24 | | | | | 1 | | | | 471 |
| Snacks, desserts, and other foods | 2 | 39 | 46 | 9 | 46 | 46 | 46 | 9 | 9 | | | | | | 46 | 46 | 2 | 46 | 2 | | | | | 7 | | | | 401 |
| Total | 1628 | 2307 | 3355 | 2486 | 7536 | 3814 | 3715 | 2680 | 2693 | 1495 | 1855 | 3 | 968 | 947 | 3197 | 3222 | 761 | 7523 | 1851 | 136 | 18 | 13 | 3 | 1930 | 28 | 28 | 3 | 54195 |

### 4.2. Performance of analytical methods

Results included in the final data set (n = 54,195) were obtained by LC-MS/MS methods (90.4 %) and GC methods (0.7 %). For 8.9 % of data, the information on the analytical methods applied was not provided.

LODs and LOQs were reported for 85 % and 98 % of results, respectively. Commission Recommendation 2010/161/EC recommended for PFASs monitoring an LOQ below 1 µg/kg. For 77% of the results in the final data set the left-censoring limits were ≤ 1 µg/kg. As pointed out in section 3.2, some of the results obtained for 16 PFASs by analytical methods with high LODs or LOQs were not included in the final dataset. In the subset of the 16 PFASs where quantified results were reported, 80 % of the left-censoring limits were ≤ 1 µg/kg. In the same subset, the left-censoring limits were higher for PFOA, PFTeDA, PFBS, PFDS, and FOSA. The distribution of the left-censoring limits applied (LODs or LOQs depending on how the results were censored) are illustrated in Figure 2 and 3. Across food groups, left-censoring limits > 1 µg/kg were mainly reported in the food groups 'Meat and meat products (especially for offal)', 'Fish and other seafood' and 'Animal and vegetable fats and oils'. For beverages and fruit and fruit products, most of the left-censoring limits were in the range from 0.001 to 0.01 µg/kg.

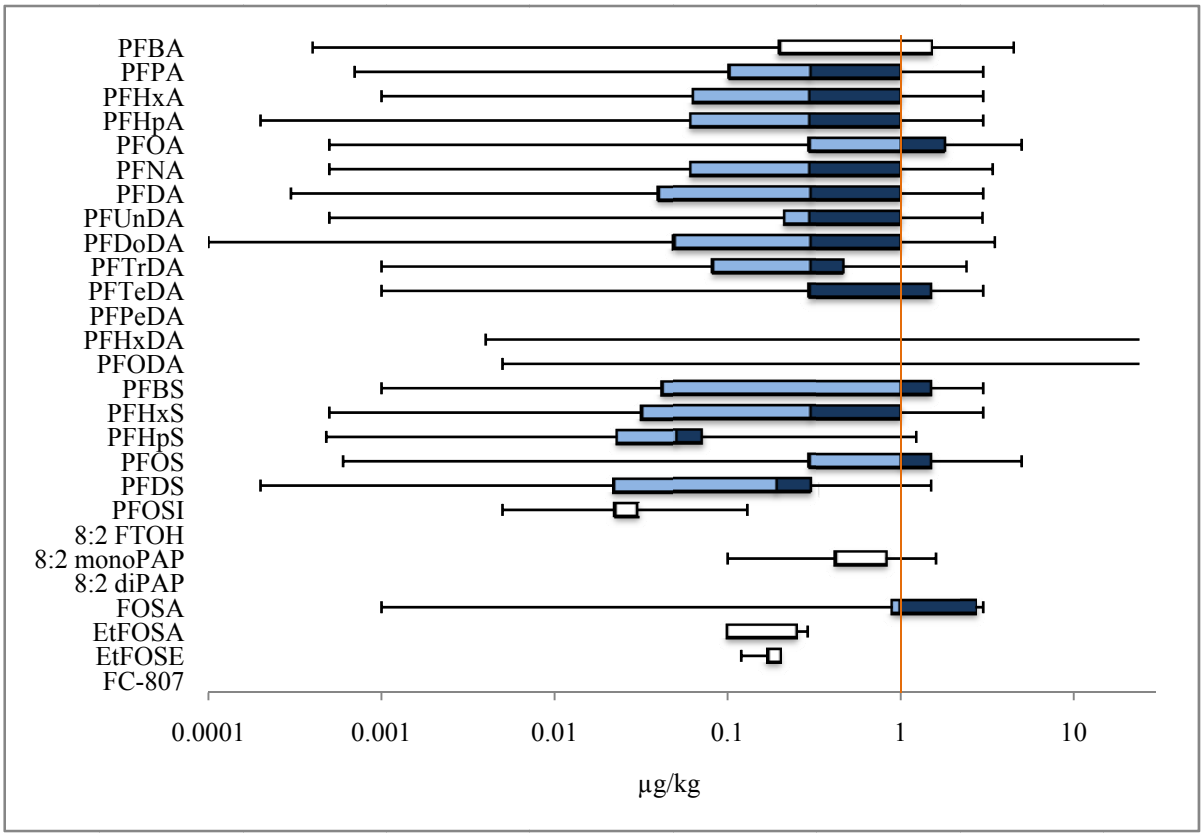


**Figure 1:** Distribution of the left-censoring limits for PFASs after applying the qualifying criteria (Box-plot on logarithmic scale: whiskers at minimum and maximum, box at P25 and P75 with line at P50). In colour the 16 PFAS where quantified results were reported.

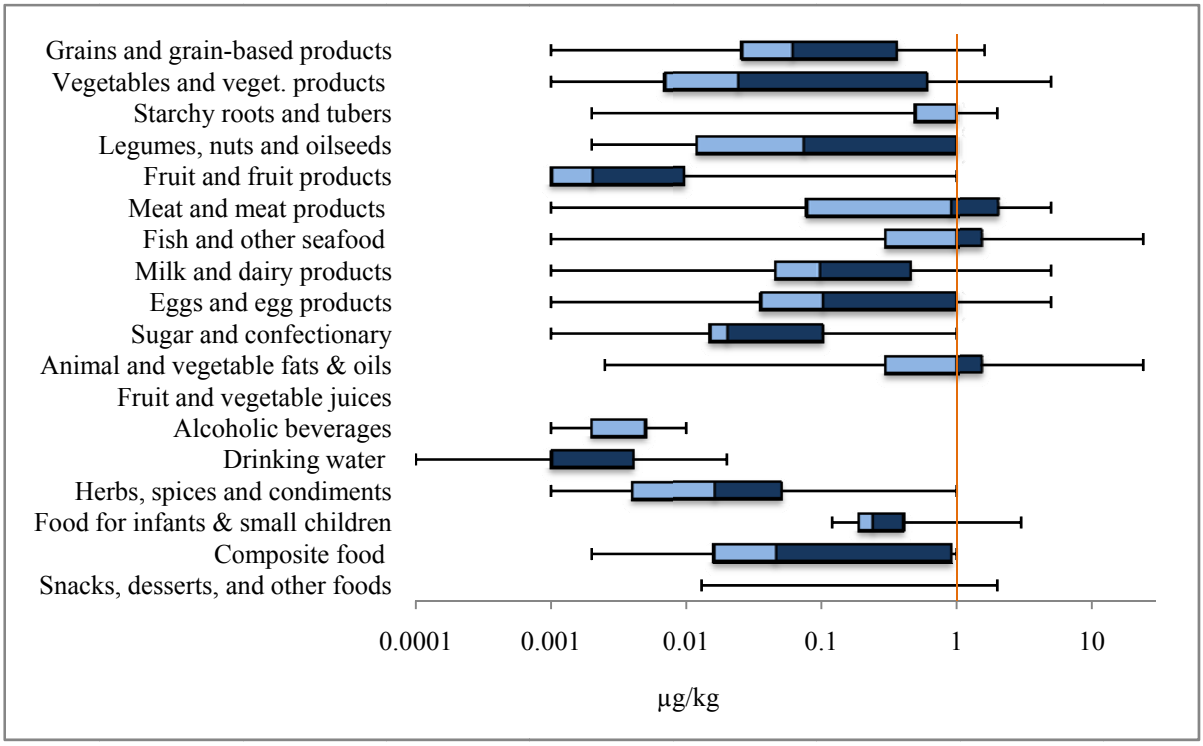


**Figure 2:** Distribution of the left-censoring limits across food groups after applying the qualifying criteria (Box-plot on logarithmic scale: whiskers at minimum and maximum, box at P25 and P75 with line at P50).

### 4.3. Frequency of left-censored data

The frequency of left-censored data (analytical results reported as <LOD or <LOQ) was 92 % out of the 54,195 results across the 27 PFASs. The most frequently found PFASs were PFOS (29 %) followed by PFOA (9 %), FOSA (7 %), PFUnDA (7 %), PFDA (6 %), PFDoDA (6 %), PFTriDA (6 %), PFNA (5 %), PFHxA (4 %), PFPA (3 %), PFHpA (2 %), PFBS (2 %), PFHxS (2 %), PFDS (0.7 %), PFTeDA (0.6 %) and PFHpS (0.1 %). Eleven PFASs (PFBA, PFPeDA, PFHxDA, PFODA, PFOSI, 8:2 FTOH, 8:2 monoPAP, 8:2 diPAP, EtFOSA, EtFOSE and FC-807) were not detected in any of the samples analysed.

The frequency of left-censored data per food groups and PFASs is presented in Table 5. A more detailed discussion on the results within the food groups is given in section 4.4.

**Table 5:** Frequency in percent of left-censored results for the individual PFASs across food groups.

| Food group | PFBA | PFPA | PFHxA | PFHpA | PFOA | PFNA | PFDA | PFUnDA | PFDoDA | PFTrDA | PFTeDA | PFPeDA | PFHxDA | PFODA | PFBS | PFHxS | PFHpS | PFOS | PFDS | PFOSI | 8:2 FTOH | 8:2 monoPAP | 8:2 diPAP | FOSA | EtFOSA | EtFOSE | FC-807 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grains and grain-based products | 100 | 100 | 100 | 99 | 96 | 100 | 97 | 100 | 100 | 100 | 100 | | 100 | | 100 | 100 | 100 | 100 | 98 | | | | | 100 | | | |
| Vegetables and veget. products | 100 | 100 | 91 | 97 | 88 | 96 | 98 | 100 | 99 | 100 | 100 | | 100 | | 97 | 98 | 100 | 90 | 98 | | 100 | | | 100 | 100 | 100 | |
| Starchy roots and tubers | 100 | 100 | 100 | 92 | 99.7 | 99 | 100 | 100 | 97 | 100 | 100 | | | | 98 | 100 | 100 | 99.7 | 100 | | | | | 96 | | | |
| Legumes, nuts and oilseeds | 100 | 100 | 90 | 95 | 90 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 95 | 100 | 100 | 95 | 100 | | | | | 100 | | | |
| Fruit and fruit products | | | 76 | 100 | 54 | 69 | 100 | 100 | 97 | 100 | 96 | | 100 | | 83 | 79 | | 68 | 100 | | | | | 100 | | | |
| Meat and meat products | 100 | 95 | 97 | 99.5 | 86 | 86 | 86 | 97 | 86 | 98 | 99 | 100 | 100 | 100 | 99.6 | 99 | 99.7 | 64 | 100 | 100 | 100 | 100 | 100 | 98 | 100 | 100 | 100 |
| Fish and other seafood | 100 | 99 | 95 | 98 | 95 | 97 | 95 | 88 | 96 | 91 | 99 | | 100 | 100 | 99.7 | 99 | 100 | 63 | 99 | | 100 | | | 91 | 100 | 100 | |
| Milk and dairy products | 100 | 99 | 99.6 | 99.5 | 99 | 99 | 99 | 100 | 100 | 100 | 100 | | 100 | 100 | 99 | 99.6 | 100 | 97 | 98 | 100 | 100 | | | 100 | 100 | 100 | |
| Eggs and egg products | 100 | 100 | 98 | 97 | 89 | 100 | 100 | 99 | 100 | 97 | 100 | | 100 | 100 | 100 | 99 | 100 | 88 | 100 | 100 | 100 | | | 100 | 100 | 100 | |
| Sugar and confectionary | 100 | 100 | 90 | 100 | 91 | 100 | 90 | 100 | 100 | 100 | 100 | | 100 | | 100 | 100 | 100 | 98 | 100 | | | | | 100 | | | |
| Animal and vegetable fats & oils | 100 | 100 | 100 | 100 | 96 | 100 | 98 | 100 | 100 | 100 | 100 | | 100 | 100 | 98 | 98 | 100 | 98 | 100 | | | | | 100 | | | |
| Fruit and vegetable juices | | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | | | | | | 100 | 100 | | 100 | | | | | | 100 | | | |
| Alcoholic beverages | | | 83 | 100 | 83 | 100 | 100 | 100 | 100 | 100 | 100 | | 100 | 100 | 100 | 83 | | 100 | 100 | | | | | 100 | | | |
| Drinking water | 100 | 80 | 98 | 50 | 84 | 99.7 | 100 | 100 | 100 | | | | | | 90 | 88 | 100 | 89 | 100 | | | | | | | | |
| Herbs, spices and condiments | 100 | 100 | 100 | 100 | 100 | 100 | 75 | 100 | 100 | 100 | 100 | | 100 | | 100 | 100 | 100 | 100 | 100 | | | | | 100 | | | |
| Food for infants & small children | 100 | 100 | 100 | 90 | 100 | 90 | 90 | 100 | 90 | 100 | 100 | | | | 100 | 100 | 100 | 100 | 100 | | | 100 | | 100 | 100 | 100 | |
| Composite food | 100 | 100 | 100 | 100 | 98 | 100 | 100 | 100 | 100 | 100 | 100 | | | | 100 | 100 | 100 | 100 | 100 | | | | | 100 | | | |
| Snacks, desserts, and other foods | 100 | 100 | 100 | 89 | 100 | 100 | 100 | 100 | 100 | | | | | | 98 | 100 | 100 | 100 | 100 | | | | | 100 | | | |
| Overall | 100 | 97 | 96 | 98 | 91 | 95 | 94 | 93 | 94 | 94 | 99 | 100 | 100 | 100 | 98 | 98 | 99.9 | 71 | 99 | 100 | 100 | 100 | 100 | 93 | 100 | 100 | 100 |

### 4.4. Occurrence of PFAS in food

Of the 27 PFASs analysed in food, quantified results were obtained for 16 substances (PFPA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFBS, PFHxS, PFHpS, PFOS, PFDS and FOSA). This section details the contamination levels within the FoodEx level 1 groups where quantified data were reported. The FoodEx level 1 food groups where no quantified data were reported are not further discussed in this section. The number of samples analysed for those groups are presented in Table 4. Similarly, the eleven PFASs (PFBA, PFPeDA, PFHxDA, PFODA, PFOSI, 8:2 FTOH, 8:2 monoPAP, 8:2 diPAP, EtFOSA, EtFOSE and FC-807) for which no quantified results were reported in any of the samples analysed are not discussed in this section. The number of samples analysed per food groups for these PFASs is also given in Table 4.

As explained in section 3.4, the mean concentrations were calculated by weighting the analytical results for the number of samples pooled. It should be noted that due to the high proportion of left-censored data in almost all food groups, the UB mean concentrations strongly reflect the left-censoring limits. In the following sub-sections, mean concentrations are presented in Tables 6 to 21 while the ranges of effectively measured concentrations (quantified results) are discussed in the text. For food groups where left-censored data represented 100 % of the results, an indication on the range of LODs/LOQs applied can be appreciated in Figures 1 and 2.

#### 4.4.1. Perfluoropentanoic acid (PFPA)

PFPA was analysed in most of the food groups (Table 4), but quantified results were reported only for 'Meat and meat products', 'Fish and other seafood', 'Milk and dairy products' and 'Drinking water' (Table 6).

**Table 6:** Occurrence of PFPA in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Meat and meat products | 473 (3474) | 95 | 0.018 | 0.17 |
| Meat and meat products (unspecified) | 15 (15) | 100 | 0 | 1.0 |
| Livestock meat | 145 (1255) | 100 | 0 | 0.11 |
| Poultry meat | 119 (676) | 97 | 0.012 | 0.17 |
| Game mammals | 25 (25) | 100 | 0 | 0.71 |
| Game birds | 1 (1) | 100 | 0 | 0.11 |
| Edible offal, farmed animals | 88 (344) | 81 | 0.13 | 0.40 |
| Edible offal, game animals | 3 (3) | 0 | 3.5 | 3.5 |
| Preserved meat | 32 (480) | 100 | 0 | 0.12 |
| Sausages | 31 (465) | 100 | 0 | 0.17 |
| Pastes, pâtés and terrines | 14 (210) | 100 | 0 | 0.11 |
| Fish and other seafood | 1044 (2206) | 99 | 0.0051 | 0.6 |
| Fish and seafood (unspecified) | 2 (2) | 100 | 0 | 1.5 |
| Fish meat | 701 (1345) | 99 | 0.0084 | 0.29 |
| Fish offal | 287(287) | 100 | 0 | 2.9 |
| Crustaceans | 25 (249) | 100 | 0 | 0.19 |
| Water molluscs | 29 (323) | 100 | 0 | 0.16 |
| Milk and dairy products | 180 (2212) | 99 | 0.000002 | 0.16 |
| Milk and dairy products (unspecified) | 13 (13) | 92 | 0.0004 | 0.92 |
| Liquid milk | 58 (592) | 100 | 0 | 0.18 |
| Cream and cream products | 12 (180) | 100 | 0 | 0.18 |
| Fermented milk products | 63 (945) | 100 | 0 | 0.14 |
| Cheese | 34 (482) | 100 | 0 | 0.17 |
| Drinking water | 232 (316) | 80 | 0.0004 | 0.0022 |
| Tap water | 3 (45) | 100 | 0 | 0.0068 |
| Well water | 3 (45) | 100 | 0 | 0.0017 |
| Bottled water | 226 (226) | 80 | 0.0005 | 0.0013 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

The contamination frequency ranged between 1 and 20% across the aforementioned (main) food groups. The highest concentrations were found in edible offal (liver) of game animals and of farmed animals. The quantified results in the two groups of edible offal ranged from 1.6 to 5.3 µg/kg and from 0.3 to 4.5 µg/kg, respectively. Similar concentrations (0.4 to 3.3 µg/kg) were measured in fish meat but the contamination frequency equalled only 1 % of the samples analysed. In the food group 'Milk and dairy products', PFPA was found in only one sample (0.005 µg/kg). In 'Drinking water' PFPA was reported in 20 % of bottled water at concentrations from 0.001 to 0.01 µg/kg.

### 4.4.2. Perfluorohexanoic acid (PFHxA)

Occurrence of PFHxA was reported in several food groups. The frequency of quantified results across FoodEx level 1 groups ranged from 0.10 to 24 % (Table 7). In the food group 'Vegetables and vegetable products', PFHxA was reported in 9 % of the samples. Concentrations ranged from 0.006 to 0.42 µg/kg. In 'Legumes, nuts and oil seeds', PFHxA was found in two samples of green beans with pods in concentration of 0.0037 µg/kg and 0.011 µg/kg, respectively. Of the 29 analysis on 'Fruit and fruit products', PFHxA was found in 7 samples (minimum = 0.012 µg/kg; maximum = 0.17 µg/kg).

The highest concentrations were reported for edible offal of farmed animals (minimum = 0.29 µg/kg; maximum = 3.4 µg/kg) and game animals (liver) (minimum = 1.4 µg/kg; maximum = 2.6 µg/kg). In meat, PFHxA was reported only in one veal sample (0.3 µg/kg) and in one chicken meat sample (0.91 µg/kg). In 'Fish and other seafood', PFHxA was found in 7 % of the fish meat samples (minimum = 1.1 µg/kg; maximum = 23 µg/kg). In 'Milk and dairy products', of the 239 analysis performed for PFHxA only one quantified result was reported (0.006 µg/kg). In 'Eggs and egg products' two quantified results were reported for fresh eggs (0.5 and 1.1 µg/kg). In honey, PFHxA was found in one only sample (0.024 µg/kg).

In the group of 'Alcoholic beverages', PFHxA was quantified in one beer sample (0.023 µg/kg). In 'Drinking water', PFHxA was found in two tap water samples and in 5 bottled water samples at concentrations from 0.0019 µg/kg to 0.02 µg/kg.

**Table 7:** Occurrence of PFHxA in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Vegetables and vegetable products | 206 (1074) | 91 | 0.0016 | 0.10 |
| Root vegetables | 63(205) | 98 | 0.0005 | 0.12 |
| Bulb vegetables | 8 (68) | 75 | 0.0009 | 0.058 |
| Fruiting vegetables | 37 (243) | 86 | 0.0027 | 0.072 |
| Brassica vegetables | 20 (108) | 80 | 0.0010 | 0.10 |
| Leaf vegetables | 24 (200) | 83 | 0.0034 | 0.036 |
| Legume vegetables | 4 (13) | 100 | 0 | 0.043 |
| Stem vegetables | 19 (172) | 95 | 0.0003 | 0.058 |
| Sugar plants | 4 (14) | 100 | 0 | 0.002 |
| Vegetable products | 2 (13) | 100 | 0 | 1.0 |
| Fungi, cultivated | 3 (16) | 67 | 0.0032 | 0.32 |
| Fungi, wild, edible | 22 | 100 | 0 | 0.86 |
| Legumes, nuts and oilseeds | 20 (157) | 90 | 0.0004 | 0.13 |
| Legumes, beans, green, with pods | 5 (12) | 60 | 0.0048 | 0.17 |
| Legumes, beans, dried | 15 (145) | 100 | 0 | 0.13 |
| Fruit and fruit products | 29 (133) | 76 | 0.014 | 0.045 |
| Citrus fruits | 7 (32) | 86 | 0.0012 | 0.003 |
| Pome fruits | 8 (48) | 63 | 0.022 | 0.024 |
| Stone fruits | 4 (25) | 75 | 0.0065 | 0.0078 |
| Berries and small fruits | 7 (20) | 71 | 0.028 | 0.13 |
| Miscellaneous fruits | 1 (6) | 100 | 0 | 0.002 |
| Jam, marmalade and other fruit | 2 (2) | 100 | 0 | 1.0 |

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Meat and meat products | 734 (4007) | 97 | 0.0087 | 0.19 |
| Meat and meat products (unspecified) | 15 (15) | 100 | 0 | 1.0 |
| Livestock meat | 183 (1369) | 99 | 0.0002 | 0.12 |
| Poultry | 136 (721) | 99 | 0.0013 | 0.15 |
| Game mammals | 26 (26) | 100 | 0 | 0.72 |
| Game birds | 1 (1) | 100 | 0 | 0.13 |
| Edible offal, farmed animals | 249 (639) | 94 | 0.046 | 0.46 |
| Edible offal, game animals | 37 (37) | 95 | 0.11 | 1.1 |
| Preserved meat | 36 (515) | 100 | 0 | 0.077 |
| Sausages | 36 (473) | 100 | 0 | 0.11 |
| Pastes, pâtés and terrines | 15 (211) | 100 | 0 | 0.071 |
| Fish and other seafood | 1381 (3242) | 95 | 0.045 | 0.60 |
| Fish and seafood (unspecified) | 5 (20) | 100 | 0 | 0.15 |
| Fish meat | 973 (1969) | 93 | 0.073 | 0.54 |
| Fish offal | 308 (308) | 100 | 0.0016 | 1.4 |
| Crustaceans | 47 (271) | 100 | 0 | 0.22 |
| Water molluscs | 48 (674) | 100 | 0 | 0.57 |
| Milk and dairy products | 239 (2370) | 99.9 | 0.0000025 | 0.15 |
| Milk & dairy products (unspecified) | 28 (28) | 96 | 0.0002 | 0.96 |
| Liquid milk | 76 (646) | 100 | 0 | 0.16 |
| Concentrated milk | 1 (1) | 100 | 0 | 1.0 |
| Cream and cream products | 12 (180) | 100 | 0 | 0.15 |
| Fermented milk products | 69 (951) | 100 | 0 | 0.13 |
| Cheese | 52 (559) | 100 | 0 | 0.12 |
| Milk & milk product imitates | 1 (5) | 100 | 0 | 0.005 |
| Eggs and egg products | 99 (781) | 98 | 0.0020 | 0.54 |
| Eggs and egg products | 37 (233) | 100 | 0 | 0.12 |
| Eggs, fresh | 62 (548) | 97 | 0.0029 | 0.72 |
| Sugar and confectionary | 10 (121) | 90 | 0.002 | 0.065 |
| Chocolate (Cocoa) products | 3 (45) | 100 | 0 | 0.085 |
| Confectionery (non-chocolate) | 2 (30) | 100 | 0 | 0.092 |
| Dessert sauces | 1 (1) | 100 | 0 | 1.0 |
| Honey | 4 (45) | 75 | 0.0052 | 0.0068 |
| Alcoholic beverages | 6 (63) | 83 | 0.0037 | 0.0079 |
| Beer and beer-like beverage | 4 (48) | 75 | 0.0048 | 0.0088 |
| Wine | 2 (15) | 100 | 0 | 0.005 |
| Drinking water | 300 (384) | 98 | 0.001 | 0.0034 |
| Tap water | 71 (113) | 97 | 0.0029 | 0.0086 |
| Well water | 3 (45) | 100 | 0 | 0.0017 |
| Bottled water | 226 (226) | 98 | 0.0002 | 0.0011 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

### 4.4.3. Perfluoroheptanoic acid (PFHpA)

PFHpA was analysed in a large number of food groups (Table 4), but quantified results were reported only sporadically (Table 8). In the groups covering foods of plant origin, PFHpA was quantified in one sample of wheat grain (0.18 µg/kg), in samples of tomatoes, spinach, lettuce, fennel (minimum = 0.0043 µg/kg; maximum = 0.090 µg/kg), in one canned maize sample (0.54 µg/kg), in two samples of potatoes (0.0043 µg/kg and 0.052 µg/kg) and in one sample of green beans with pods (0.0066 µg/kg).

In the food group 'Meat and meat products', quantified results for PFHpA were reported in one sample of pork meat (0.06 µg/kg) and in one sample of meat of game mammals (0.24 µg/kg). In 'Fish and seafood', PFHpA was reported in 6 % of fish meat samples (minimum = 0.3 µg/kg; maximum = 8 µg/kg) and in two oysters samples (1 µg/kg). Other quantified results in foods of animal

origin were reported for one cheese sample (0.61 µg/kg) and for two hen egg samples (0.46 µg/kg; 1.4 µg/kg).

Only a limited number of water samples were analysed for PFHpA: 3 pooled samples of tap water and 3 pooled samples of well water. All three tap water samples gave quantified results between 0.001 and 0.01 µg/kg. In the food group 'Food for infants and young children', there was one quantified result (ready-to-eat meal; 0.38 µg/kg). Among snack food, there was one quantified result for a popcorn sample (1 µg/kg PFHpA).

**Table 8:** Occurrence of PFHpA in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Grains and grain-based products | 75 (774) | 99 | 0.0012 | 0.092 |
| Grains as crops | 12 (71) | 100 | 0 | 0.14 |
| Grains for human consumption | 11 (75) | 91 | 0.0141 | 0.026 |
| Grain milling products | 2 (2) | 100 | 0 | 1.0 |
| Bread and rolls | 12 (114) | 100 | 0 | 0.14 |
| Breakfast cereals | 6 (56) | 100 | 0 | 0.21 |
| Fine bakery wares | 32 (466) | 100 | 0 | 0.064 |
| Vegetables and vegetable products | 147 (224) | 97 | 0.0014 | 0.075 |
| Root vegetables | 25 (167) | 100 | 0 | 0.082 |
| Bulb vegetables | 8 (68) | 100 | 0 | 0.037 |
| Fruiting vegetables | 37 (243) | 95 | 0.0023 | 0.072 |
| Brassica vegetables | 20 (108) | 100 | 0 | 0.094 |
| Leaf vegetables | 25 (210) | 92 | 0.0033 | 0.033 |
| Legume vegetables | 4 (13) | 100 | 0 | 0.033 |
| Stem vegetables | 19 (172) | 95 | 0.001 | 0.043 |
| Sugar plants | 4 (14) | 100 | 0 | 0.0040 |
| Vegetable products | 2 (13) | 100 | 0 | 1.0 |
| Fungi, cultivated | 3 (16) | 100 | 0 | 0.33 |
| Starchy roots and tubers | 26 (62) | 92 | 0.0086 | 0.39 |
| Potatoes and potatoes products | 24 (60) | 92 | 0.0089 | 0.37 |
| Other starchy roots and tubers | 2 (2) | 100 | 0 | 1.0 |
| Legumes, nuts and oilseeds | 20 (157) | 95 | 0.0001 | 0.12 |
| Legumes, beans, green, with pods | 5 (12) | 80 | 0.0017 | 0.19 |
| Legumes, beans, dried | 15 (145) | 100 | 0 | 0.11 |
| Meat and meat products | 435 (3708) | 100 | 0.0003 | 0.13 |
| Livestock meat | 181 (1367) | 99 | 0.0007 | 0.10 |
| Poultry | 77 (662) | 100 | 0 | 0.083 |
| Game mammals | 9 (9) | 89 | 0.026 | 0.17 |
| Game birds | 1 (1) | 100 | 0 | 0.069 |
| Edible offal, farmed animals | 77 (467) | 100 | 0 | 0.42 |
| Edible offal, game animals | 3 (3) | 100 | 0 | 1.0 |
| Preserved meat | 36 (515) | 100 | 0 | 0.065 |
| Sausages | 36 (473) | 100 | 0 | 0.086 |
| Pastes, pâtés and terrines | 15 (211) | 100 | 0 | 0.055 |
| Fish and other seafood | 1333 (3194) | 98 | 0.010 | 0.80 |
| Fish and other seafood (unspecified) | 3 (18) | 100 | 0 | 0.0050 |
| Fish meat | 826 (1822) | 94 | 0.017 | 0.52 |
| Fish offal | 403 (403) | 100 | 0 | 2.8 |
| Crustaceans | 63(287) | 100 | 0 | 0.39 |
| Water molluscs | 38 (664) | 95 | 0.003 | 0.53 |
| Milk and dairy products | 220 (2351) | 100 | 0.0003 | 0.11 |
| Milk and dairy products (unspecified) | 15 (15) | 100 | 0 | 1.0 |
| Liquid milk | 70 (640) | 100 | 0 | 0.12 |
| Concentrated milk | 1 (1) | 100 | 0 | 2.0 |
| Cream and cream products | 12 (180) | 100 | 0 | 0.090 |
| Fermented milk products | 69 (951) | 100 | 0 | 0.096 |
| Cheese | 52 (559) | 98 | 0.0011 | 0.091 |
| Milk and milk product imitates | 1 (5) | 100 | 0 | 0.0050 |

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Eggs and egg products | 74 (756) | 97 | 0.0025 | 0.51 |
| Eggs and egg products (unspecified) | 14 (210) | 100 | 0 | 0.018 |
| Eggs, fresh | 60 (546) | 97 | 0.0034 | 0.70 |
| Drinking water | 6 (90) | 50 | 0.0035 | 0.0038 |
| Tap water | 3 (45) | 0 | 0.007 | 0.007 |
| Well water | 3 (45) | 100 | 0 | 0.0007 |
| Food for infants and young children | 10 (10) | 90 | 0.038 | 0.201 |
| Infant formulae, powder | 3 (3) | 100 | 0 | 0.27 |
| Follow-on formulae, powder | 2 (2) | 100 | 0 | 0.16 |
| Ready-to-eat meal for infants and young children | 5 (5) | 80 | 0.076 | 0.20 |
| Snacks, desserts, and other foods | 9 (37) | 89 | 0.027 | 0.24 |
| Snack food | 7 (7) | 86 | 0.14 | 1.1 |
| Ices and desserts | 2 (30) | 100 | 0 | 0.029 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

### 4.4.4. Perfluorooctanoic acid (PFOA)

PFOA was one of the most analysed PFASs. Special focus was on 'Meat and meat products' and 'Fish and other seafood'. Quantified results were reported across the majority of the food groups with a frequency across FoodEx level 1 food groups from 0.03 to 46 %.

In foods of plant origin PFOA was reported in two wheat grain samples (0.007 µg/kg), one oat sample (0.03 µg/kg), in a range of samples of vegetables at concentrations from 0.0013 to 0.54 µg/kg, in one potato sample (0.031 µg/kg), in one sample of green beans with pods (0.0087 µg/kg) and in one pea sample (0.03 µg/kg). Of the 35 samples of fruit and fruit products, PFOA was found in 16 fruit samples (minimum = 0.001 µg/kg; maximum = 0.15 µg/kg).

In the food group 'Meat and meat products (including offal)', the highest frequency of quantified results (41 %) and the highest concentrations were found in the sub-group 'Edible offal of game animals'. All but one of the quantified results in this sub-group were liver of game mammals with actually 98 % of samples being wild boar liver. Thus, the concentrations reported for this sub-group (20 to 789 µg/kg) were strongly influenced by the results found in the wild boar liver samples. In 'Edible offal of farmed animals', quantified results for PFOA were reported only for 2 % of the samples analysed and in lower concentrations (minimum = 0.25 µg/kg; maximum = 4.6 µg/kg) compared to those reported in 'Edible offal of game animals'. In 'Meat of livestock animals' the quantified results accounted for 5 % of the total (minimum = 0.0075 µg/kg; maximum = 3.3 µg/kg). In 'Meat of game mammals', the quantified results represented 9 % of the data with the majority of them (96 %) being wild boar meat. The concentrations found in this group ranged from 0.28 to 76 µg/kg. The contamination frequency and the concentrations reported for poultry meat were lower (minimum = 0.05 µg/kg; maximum = 1.0 µg/kg) compared to samples of meat from livestock animals.

In the food group 'Fish and other seafood', the highest concentrations were found in fish meat (minimum = 0.0064 µg/kg; maximum = 18.2 µg/kg). There were only four quantified results in 'Fish offal' (minimum = 1.1 µg/kg; maximum = 2.9 µg/kg). PFOA was also found in 30 % of the crustaceans samples (minimum = 0.02 µg/kg; maximum = 8.0 µg/kg) and in 5 % of the water molluscs samples (minimum = 0.03 µg/kg; maximum = 0.98 µg/kg).

In 'Milk and dairy products', of the 319 samples analysed, PFOA was quantified in 4 samples in concentrations from 0.007 to 3.7 µg/kg. In 'Eggs and egg products', PFOA was found in 11 % of the samples analysed, in concentrations from 0.006 to 25.5 µg/kg. Four of the 39 honey samples analysed for PFOA provided quantified results in the range from 0.002 to 0.47 µg/kg. In the group 'Animal and vegetable fat and oils', one butter sample and one margarine sample contained PFOA in concentrations of 0.023 µg/kg and 0.024 µg/kg, respectively.

In 'Alcoholic beverages', only one quantified result was reported for beer (0.054 µg/kg). In 'Drinking water', PFOA was reported in 16 % of the samples (minimum = 0.001 µg/kg; maximum = 0.084 µg/kg). In the food group 'Composite food', there was only one quantified result (0.01 µg/kg) in a salad sample.

**Table 9:** Occurrence of PFOA in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Grains and grain-based products | 79 (778) | 96 | 0.0002 | 0.10 |
| Grains as crops | 12 (71) | 100 | 0 | 0.25 |
| Grains for human consumption | 12 (66) | 75 | 0.002 | 0.016 |
| Grain milling products | 2 (2) | 100 | 0 | 1.0 |
| Bread and rolls | 12 (114) | 100 | 0 | 0.15 |
| Pasta (raw) | 3 (3) | 100 | 0 | 0.23 |
| Breakfast cereals | 6 (56) | 100 | 0 | 0.22 |
| Fine bakery wares | 32 (466) | 100 | 0 | 0.059 |
| Vegetables and vegetable products | 285 (1162) | 88 | 0.0039 | 0.13 |
| Root vegetables | 134 (276) | 97 | 0.0034 | 0.20 |
| Bulb vegetables | 8 (68) | 88 | 0.0022 | 0.040 |
| Fruiting vegetables | 37 (243) | 81 | 0.0045 | 0.067 |
| Brassica vegetables | 23 (111) | 87 | 0.0019 | 0.11 |
| Leaf vegetables | 25 (210) | 64 | 0.0062 | 0.039 |
| Legume vegetables | 4 (13) | 25 | 0.025 | 0.028 |
| Stem vegetables (Fresh) | 23 (176) | 78 | 0.003 | 0.082 |
| Sugar plants | 4 (14) | 50 | 0.0009 | 0.0015 |
| Vegetable products | 2 (13) | 100 | 0 | 1.0 |
| Fungi, cultivated | 3 (16) | 100 | 0 | 0.32 |
| Fungi, wild, edible | 22 (22) | 100 | 0 | 0.89 |
| Starchy roots and tubers | 303 (339) | 99.7 | 0.0009 | 0.64 |
| Potatoes and potatoes products | 299 (335) | 99.7 | 0.0009 | 0.64 |
| Other starchy roots and tubers | 4 (4) | 100 | 0 | 0.75 |
| Legumes, nuts and oilseeds | 20 (157) | 90 | 0.0031 | 0.15 |
| Legumes, beans, green, with pods | 5 (12) | 80 | 0.0029 | 0.17 |
| Legumes, beans, dried | 15 (145) | 93 | 0.0031 | 0.15 |
| Fruit and fruit products | 35 (139) | 54 | 0.0111 | 0.062 |
| Citrus fruits | 7 (32) | 14 | 0.0034 | 0.0035 |
| Pome fruits | 14 (54) | 57 | 0.020 | 0.076 |
| Stone fruits | 4 (25) | 50 | 0.0054 | 0.0059 |
| Berries and small fruits | 7 (20) | 71 | 0.011 | 0.11 |
| Miscellaneous fruits | 1 (6) | 100 | 0 | 0.0010 |
| Jam, marmalade and other fruit spreads | 2 (2) | 100 | 0 | 1.0 |
| Meat and meat products | 3221 (6494) | 86 | 0.78 | 1.6 |
| Meat and meat products (unspecified) | 15 (15) | 100 | 0 | 1.0 |
| Livestock meat | 232 (1418) | 95 | 0.0061 | 0.13 |
| Poultry | 150 (735) | 99 | 0.0024 | 0.14 |
| Game mammals | 572 (572) | 91 | 0.40 | 1.2 |
| Game birds | 9 (9) | 100 | 0 | 0.37 |
| Edible offal, farmed animals | 1265 (1655) | 98 | 0.034 | 1.4 |
| Edible offal, game animals | 881 (881) | 59 | 5.4 | 8.1 |
| Preserved meat | 39 (518) | 97 | 0.0002 | 0.067 |
| Sausages | 43 (480) | 100 | 0 | 0.10 |
| Pastes, pâtés and terrines | 15 (211) | 93 | 0.0085 | 0.069 |
| Fish and other seafood | 2542 (4403) | 95 | 0.082 | 0.69 |
| Fish and other seafood (unspecified) | 6 (21) | 50 | 0.029 | 0.18 |
| Fish meat | 1993 (2989) | 96 | 0.10 | 0.64 |
| Fish offal | 410 (410) | 99 | 0.021 | 1.6 |
| Crustaceans | 73 (297) | 70 | 0.15 | 0.30 |
| Water molluscs | 60 (686) | 95 | 0.0032 | 0.54 |

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Milk and dairy products | 319 (2450) | 99 | 0.0018 | 0.12 |
| Milk and dairy products (unspecified) | 28 (28) | 93 | 0.13 | 1.1 |
| Liquid milk | 152 (722) | 100 | 0 | 0.12 |
| Concentrated milk | 2 (2) | 100 | 0 | 0.57 |
| Cream and cream products | 13 (181) | 100 | 0 | 0.11 |
| Fermented milk products | 71 (953) | 100 | 0 | 0.10 |
| Cheese | 52 (559) | 98 | 0.0014 | 0.091 |
| Milk and milk product imitates | 1 (5) | 0 | 0.0086 | 0.0086 |
| Eggs and egg products | 138 (820) | 89 | 0.066 | 0.58 |
| Eggs and egg products | 39 (235) | 95 | 0.012 | 0.14 |
| Eggs, fresh | 99 (585) | 87 | 0.088 | 0.76 |
| Sugar and confectionary | 45 (156) | 91 | 0.0058 | 0.049 |
| Chocolate (cocoa) products | 3 (15) | 100 | 0 | 0.055 |
| Confectionery (non-chocolate) | 2 (30) | 100 | 0 | 0.037 |
| Dessert sauces | 1 (1) | 100 | 0 | 1.0 |
| Honey | 39 (80) | 90 | 0.011 | 0.038 |
| Animal and vegetable fats and oils | 55 (160) | 96 | 0.0021 | 0.31 |
| Animal fat | 12 (54) | 92 | 0.0017 | 0.13 |
| Fish oil | 30 (30) | 100 | 0 | 1.2 |
| Vegetable oil | 10 (41) | 100 | 0 | 0.16 |
| Margarine and similar products | 3 (35) | 67 | 0.0069 | 0.016 |
| Alcoholic beverages | 6 (63) | 83 | 0.0087 | 0.013 |
| Beer and beer-like beverage | 4 (48) | 75 | 0.011 | 0.015 |
| Wine | 2 (15) | 100 | 0 | 0.0050 |
| Drinking water | 367 (451) | 84 | 0.001 | 0.0027 |
| Tap water | 110 (152) | 92 | 0.0023 | 0.0053 |
| Well water | 3 (45) | 33 | 0.0003 | 0.0006 |
| Bottled water | 254 (254) | 82 | 0.0003 | 0.0016 |
| Composite food | 45 (381) | 98 | 0.0004 | 0.071 |
| Cereal-based dishes | 5 (47) | 100 | 0 | 0.042 |
| Potato based dishes | 5 (47) | 100 | 0 | 0.033 |
| Meat-based meals | 4 (4) | 100 | 0 | 0.66 |
| Egg-based meal | 16 (240) | 100 | 0 | 0.033 |
| Prepared salads | 15 (43) | 93 | 0.0035 | 0.31 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

### 4.4.5. Perfluorononanoic acid (PFNA)

Mean concentrations for PFNA across food groups are presented in Table 10. Among foods of plant origin, PFNA was found with the highest frequency in fruits (31 %) but in relatively low concentrations (minimum = 0.001 µg/kg; maximum = 0.2 µg/kg). However, only a limited number of samples was analysed within this group. In 'Vegetables and vegetable products', 4 % of the samples contained PFNA at quantifiable levels (minimum = 0.0071 µg/kg; maximum = 0.03 µg/kg). Only one quantified result was reported for potatoes (0.01 µg/kg).

In the food group 'Meat and meat products (including edible offal)', the highest contamination frequency (94 %) and the highest concentrations (from 1.0 to 30 µg/kg) were reported in the sub-group 'Edible offal of game animals'. It is important to note that all samples which gave quantified results were liver and all but one were liver of wild boar. Therefore the statistics in this subgroup is highly influenced by the concentrations found in liver of wild boar. Concentrations reported in edible offal of farmed animals were much lower (minimum = 0.005 µg/kg; maximum = 1.9 µg/kg). In meat of livestock animals, the concentrations reported (minimum = 0.006 µg/kg; maximum = 0.31 µg/kg) were lower compared to those found in edible offal.

**Table 10:** Occurrence of PFNA in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Vegetables and vegetable products | 186 (1063) | 96 | 0.0007 | 0.088 |
| Root vegetables | 42 (184) | 100 | 0 | 0.095 |
| Bulb vegetables | 8 (68) | 88 | 0.0004 | 0.038 |
| Fruiting vegetables | 37 (243) | 97 | 0.0004 | 0.063 |
| Brassica vegetables | 20 (108) | 95 | 0.0002 | 0.088 |
| Leaf vegetables | 25 (210) | 88 | 0.0027 | 0.026 |
| Legume vegetables | 4 (13) | 100 | 0 | 0.0075 |
| Stem vegetables | 19 (172) | 95 | 0.0001 | 0.039 |
| Sugar plants | 4 (14) | 100 | 0 | 0.001 |
| Vegetable products | 2 (13) | 100 | 0 | 1.0 |
| Fungi, cultivated | 3 (16) | 67 | 0.0027 | 0.32 |
| Fungi, wild, edible | 22 () | 100 | 0 | 0.86 |
| Starchy roots and tubers | 89 (125) | 99 | 0.0002 | 0.61 |
| Potatoes and potatoes products | 87 (123) | 99 | 0.0002 | 0.61 |
| Other starchy roots and tubers | 2 (2) | 100 | 0 | 1.0 |
| Fruit and fruit products | 29 (133) | 69 | 0.0103 | 0.041 |
| Citrus fruits | 7 (32) | 86 | 0.0016 | 0.0025 |
| Pome fruits | 8 (48) | 38 | 0.024 | 0.025 |
| Stone fruits | 4 (25) | 75 | 0.0043 | 0.005 |
| Berries and small fruits | 7 (20) | 86 | 0.0018 | 0.10 |
| Miscellaneous fruits | 1 (6) | 0 | 0.003 | 0.003 |
| Jam, marmalade and other fruit spreads | 2 (2) | 100 | 0 | 1.0 |
| Meat and meat products | 792 (4065) | 86 | 0.24 | 0.38 |
| Meat and meat products (unspecified) | 15 (15) | 100 | 0 | 1.0 |
| Livestock meat | 183 (1369) | 97 | 0.0004 | 0.092 |
| Poultry | 136 (721) | 100 | 0 | 0.12 |
| Game mammals | 26 (26) | 100 | 0 | 0.71 |
| Game birds | 1 (1) | 100 | 0 | 0.032 |
| Edible offal, farmed animals | 248 (638) | 94 | 0.023 | 0.39 |
| Edible offal, game animals | 96 (96) | 6 | 10.1 | 10.2 |
| Preserved meat | 36 (515) | 100 | 0 | 0.052 |
| Sausages | 36 (473) | 100 | 0 | 0.067 |
| Pastes, pâtés and terrines | 15 (211) | 100 | 0 | 0.062 |
| Fish and other seafood | 1813 (3674) | 97 | 0.015 | 0.64 |
| Fish and other seafood (unspecified) | 5 (20) | 40 | 0.048 | 0.20 |
| Fish meat | 1292 (2288) | 98 | 0.014 | 0.60 |
| Fish offal | 404 (404) | 99 | 0.017 | 1.3 |
| Crustaceans | 63 (287) | 79 | 0.062 | 0.27 |
| Water molluscs | 49 (675) | 100 | 0 | 0.54 |
| Milk and dairy products | 239 (2370) | 99 | 0.0001 | 0.11 |
| Milk and dairy products (unspecified) | 28 (28) | 96 | 0.0003 | 0.96 |
| Liquid milk | 76 (646) | 99 | 0.00008 | 0.094 |
| Concentrated milk | 1 (1) | 100 | 0 | 1.0 |
| Cream and cream products | 12 (180) | 100 | 0 | 0.11 |
| Fermented milk products | 69 (951) | 100 | 0 | 0.10 |
| Cheese | 52 (559) | 98 | 0.0004 | 0.098 |
| Milk and milk product imitates | 1 (5) | 100 | 0 | 0.005 |
| Drinking water | 300 (384) | 99.7 | 0.000008 | 0.0017 |
| Tap water | 71 (113) | 100 | 0 | 0.0033 |
| Well water | 3 (45) | 100 | 0 | 0.001 |
| Bottled water | 226 (226) | 99.6 | 0.000013 | 0.001 |
| Food for infants and young children | 10 (10) | 90 | 0.066 | 0.22 |
| Infant formulae, powder | 3 (3) | 100 | 0 | 0.23 |
| Follow-on formulae, powder | 2 (2) | 100 | 0 | 0.16 |
| Ready-to-eat meal for infants and young children | 5 (5) | 80 | 0.13 | 0.24 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

In 'Fish and other seafood', the highest concentrations were found in fish meat but only 2 % of the samples were contaminated (minimum = 0.008 µg/kg; maximum = 4.5 µg/kg). In 'Fish offal', the concentrations found ranged from 0.87 to 2.6 µg/kg. In 'Crustaceans', PFNA was reported in 21 % of samples (minimum = 0.16 µg/kg; maximum = 3.0 µg/kg). In 'Milk and dairy products', PFNA was quantified in three samples (milk and cheese) in concentrations from 0.005 to 0.02 µg/kg. Of the 300 samples of drinking water analysed for PFNA, only one sample of bottled water gave a quantified result (0.003 µg/kg). In the food group 'Foods for infants and young children' one ready-to-eat meal contained PFNA (0.66 µg/kg).

### 4.4.6. Perfluorodecanoic acid (PFDA)

PFDA was analysed in a broad range of food groups (Table 4). Mean concentrations across food groups are presented in Table 11. In foods of plant origin, PFDA was quantified in two grains samples (wheat and oats) in concentrations of 0.019 and 0.024 µg/kg and in four samples of vegetables at concentrations from 0.0014 to 0.022 µg/kg.

**Table 11:** Occurrence of PFDA in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Grains and grain-based products | 75 (774) | 97 | 0.0001 | 0.073 |
| Grains undefined end-use | 12 (65) | 100 | 0 | 0.167 |
| Grains for human consumption | 11 (65) | 82 | 0.0014 | 0.015 |
| Grain milling products | 2 (2) | 100 | 0 | 1.0 |
| Bread and rolls | 12 (114) | 100 | 0 | 0.11 |
| Breakfast cereals | 6 (56) | 100 | 0 | 0.20 |
| Fine bakery wares | 32 (466) | 100 | 0 | 0.037 |
| Vegetables and vegetable products | 186 (1063) | 98 | 0.0002 | 0.088 |
| Root vegetables | 42 (184) | 100 | 0 | 0.096 |
| Bulb vegetables | 8 (68) | 100 | 0 | 0.037 |
| Fruiting vegetables | 37 (243) | 92 | 0.001 | 0.066 |
| Brassica vegetables | 20 (108) | 100 | 0 | 0.089 |
| Leaf vegetables | 25 (210) | 100 | 0 | 0.025 |
| Legume vegetables | 4 (13) | 100 | 0 | 0.010 |
| Stem vegetables | 19 (172) | 100 | 0 | 0.027 |
| Sugar plants | 4 (14) | 75 | 0.0003 | 0.0034 |
| Vegetable products | 2 (13) | 100 | 0 | 1.0 |
| Fungi, cultivated | 3 (16) | 100 | 0 | 0.32 |
| Fungi, wild, edible | 22 (22) | 100 | 0 | 0.86 |
| Meat and meat products | 793 (4066) | 86 | 0.1496 | 0.28 |
| Meat and meat products (unspecified) | 15 (15) | 100 | 0 | 1.0 |
| Livestock meat | 183 (1369) | 100 | 0 | 0.083 |
| Poultry | 136 (721) | 99 | 0.0002 | 0.11 |
| Game mammals | 26 (26) | 100 | 0 | 0.71 |
| Game birds | 1 (1) | 100 | 0 | 0.12 |
| Edible offal, farmed animals | 249 (639) | 90 | 0.064 | 0.45 |
| Edible offal, game animals | 96 (96) | 8 | 5.9 | 5.9 |
| Preserved meat | 36 (515) | 100 | 0 | 0.041 |
| Sausages | 36 (473) | 100 | 0 | 0.053 |
| Pastes, pâtés and terrines | 15 (211) | 100 | 0 | 0.040 |
| Fish and other seafood | 1714 (3575) | 95 | 0.059 | 0.57 |
| Fish and other seafood (unspecified) | 5 (20) | 40 | 0.40 | 0.55 |
| Fish meat | 1192 (2188) | 95 | 0.064 | 0.55 |
| Fish offal | 404 (404) | 95 | 0.098 | 0.96 |
| Crustaceans | 64 (288) | 80 | 0.081 | 0.26 |
| Water molluscs | 49 (675) | 100 | 0 | 0.53 |
| Milk and dairy products | 238 (2369) | 99 | 0.0001 | 0.078 |
| Milk and dairy products (unspecified) | 28 (28) | 96 | 0.0003 | 0.96 |
| Liquid milk | 76 (646) | 100 | 0 | 0.075 |

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Concentrated milk | 1 (1) | 100 | 0 | 1.0 |
| Cream and cream products | 12 (180) | 100 | 0 | 0.057 |
| Fermented milk products | 69 (951) | 100 | 0 | 0.065 |
| Cheese | 51 (558) | 98 | 0.0005 | 0.066 |
| Milk and milk product imitates | 1 (5) | 100 | 0 | 0.0050 |
| Sugar and confectionary | 10 (121) | 90 | 0.001 | 0.028 |
| Chocolate (cocoa) products | 3 (45) | 100 | 0 | 0.028 |
| Confectionery (non-chocolate) | 2 (30) | 100 | 0 | 0.029 |
| Dessert sauces | 1 (1) | 100 | 0 | 1.0 |
| Honey | 4 (45) | 75 | 0.0027 | 0.0054 |
| Animal and vegetable fats and oils | 53 (158) | 98 | 0.00060 | 0.22 |
| Animal fat | 10 (52) | 90 | 0.0018 | 0.12 |
| Fish oil | 30 (30) | 100 | 0 | 0.71 |
| Vegetable oil | 10 (41) | 100 | 0 | 0.17 |
| Margarine and similar products | 3 (35) | 100 | 0 | 0.025 |
| Herbs, spices and condiments | 8 (101) | 75 | 0.0006 | 0.017 |
| Spices | 2 (30) | 100 | 0 | 0.0095 |
| Seasoning or extracts | 3 (26) | 33 | 0.0025 | 0.0031 |
| Dressing | 1 (15) | 100 | 0 | 0.050 |
| Savoury sauces | 2 (30) | 100 | 0 | 0.019 |
| Food for infants and young children | 10 (10) | 90 | 0.059 | 0.21 |
| Infant formulae, powder | 3 (3) | 100 | 0 | 0.21 |
| Follow-on formulae, powder | 2 (2) | 100 | 0 | 0.15 |
| Ready-to-eat meal for infants and young children | 5 (5) | 80 | 0.118 | 0.23 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

Across foods of animal origin, the highest contamination frequency (92 %) and the highest concentrations (minimum = 1.4 µg/kg; maximum = 14.5 µg/kg) were reported in 'Edible offal of game animals'. Similar to the previously described PFASs, all but one sample with a measurable concentration of PFDA in this subgroup were liver of wild boar. The contamination frequency in edible offal of farmed animals were much lower (10 %) with quantified results between 0.024 and 1.4 µg/kg. In meat of farmed animals, PFDA was found in only one turkey meat sample (0.01 µg/kg).

In 'Fish meat', PFDA was quantified in 5 % of the analysed samples (minimum = 0.02 µg/kg; maximum = 11 µg/kg). In the subgroup 'Fish offal', PFDA was found in 5% of the samples (minimum = 0.6 µg/kg; maximum = 6.9 µg/kg). In 'Crustaceans', 20 % of the samples contained PFDA. Concentrations found ranged from 0.03 to 1.1 µg/kg.

A low contamination frequency was found in 'Milk and dairy products' where only two samples (milk and cheese) provided quantified results at the concentrations of 0.008 and 0.028 µg/kg, respectively. Further, PFDA was quantified in one honey sample (0.008 µg/kg), one butter sample (0.023 µg/kg), two salt samples (0.002 and 0.0036 µg/kg) and in one ready-to-eat-meal for infants (0.59 µg/kg).

### 4.4.7. Perfluoroundecanoic acid (PFUnDA)

Although PFUnDA was analysed in a relatively large number of food categories (Table 4), quantified results were obtained only in the food groups 'Meat and meat products', 'Fish and seafood' and in 'Eggs and egg products' (Table 12).

In the food group 'Meat and meat products (including edible offal)' PFUnDA was measured in 14 % of edible offal of farmed animals (minimum = 0.011 µg/kg; maximum = 0.58 µg/kg), in two samples of livestock meat samples (pork meat) (0.008 µg/kg and 0.163 µg/kg) and in one sample of unspecified meat of game mammals (0.15 µg/kg).

In 'Fish and other seafood', PFUnDA was quantified in 9 % of fish meat samples (minimum = 0.02 µg/kg; maximum = 4.2 µg/kg), in 17 % of fish offal samples (liver) (minimum = 0.66 µg/kg; maximum = 6.3 µg/kg) and in 32 % of the crustaceans samples (minimum = 0.04 µg/kg; maximum = 3.2 µg/kg). In the food group 'Eggs and egg products' one sample of hen eggs was reported as containing quantified amount of PFUnDA (0.024 µg/kg).

**Table 12:** Occurrence of PFUnDA in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Meat and meat products | 432 (3663) | 97 | 0.0019 | 0.29 |
| Livestock meat | 180 (1352) | 99 | 0.0001 | 0.31 |
| Poultry | 76 (64) | 100 | 0 | 0.24 |
| Game mammals | 9 (9) | 89 | 0.017 | 0.19 |
| Game birds | 1 (1) | 100 | 0 | 0.11 |
| Edible offal, farmed animals | 77 (467) | 86 | 0.014 | 0.39 |
| Edible offal, game animals | 3 (3) | 100 | 0 | 1.0 |
| Preserved meat | 35 (500) | 100 | 0 | 0.29 |
| Sausages | 36 (473) | 100 | 0 | 0.29 |
| Pastes, pâtés and terrines | 15 (211) | 100 | 0 | 0.19 |
| Fish and other seafood | 1544 (3405) | 88 | 0.078 | 0.63 |
| Fish and other seafood (unspecified) | 3 (18) | 0 | 0.31 | 0.31 |
| Fish meat | 1036 (2032) | 91 | 0.045 | 0.54 |
| Fish offal | 404 (404) | 83 | 0.35 | 1.5 |
| Crustaceans | 63 (287) | 68 | 0.097 | 0.25 |
| Water molluscs | 38 (664) | 100 | 0 | 0.56 |
| Eggs and egg products | 70 (696) | 99 | 0.0004 | 0.59 |
| Eggs and egg products | 10 (150) | 100 | 0 | 0.16 |
| Eggs, fresh | 60 (546) | 98 | 0.0005 | 0.70 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

### 4.4.8. Perfluorododecanoic acid (PFDoDA)

Mean concentrations in lower bound and upper bound across food groups are presented in Table 13. Across foods of plant origin, PFDoDA was quantified in only a few samples: two carrot samples (2 µg/kg), one potato sample (0.038 µg/kg) and one apple sample (0.002 µg/kg).

Within the food group 'Meat and meat products' (including edible offal), the highest contamination frequency (92 %) and the highest concentrations (minimum = 0.8 µg/kg; maximum = 9.2 µg/kg) were found in 'Edible offal of game animals'. All quantified results in this food sub-group were reported on liver of wild boar. Lower contamination frequency (1 %) and lower concentrations were observed in edible offal of farmed animals (2 liver samples; 0.04 and 0.07 µg/kg). In meat, only one quantified result was reported for pork (0.092 µg/kg).

In the food group 'Fish and other seafood' PFDoDA was found in 'Fish meat' (minimum = 0.014 µg/kg; maximum = 16 µg/kg), in fish offal (minimum = 1.9 µg/kg; maximum = 7.9 µg/kg), in crustaceans (minimum = 0.03 µg/kg; maximum = 2 µg/kg), in water molluscs (minimum = 0.01 µg/kg; maximum = 0.08 µg/kg) and in unspecified seafood samples (minimum = 0.016 µg/kg; maximum = 0.23 µg/kg). Within the food group 'Foods for infants and small children', one sample of ready-to-eat meat based on meat and vegetables contained 1.2 µg/kg PFDoDA.

**Table 13:** Occurrence of PFDoDA in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Vegetables and vegetable products | 171 (1048) | 99 | 0.0038 | 0.082 |
| Root vegetables | 44 (186) | 95 | 0.022 | 0.13 |
| Bulb vegetables | 8 (68) | 100 | 0 | 0.039 |
| Fruiting vegetables | 37 (243) | 100 | 0 | 0.065 |
| Brassica vegetables | 20 (108) | 100 | 0 | 0.090 |
| Leaf vegetables | 25 (210) | 100 | 0 | 0.027 |
| Legume vegetables | 4 (13) | 100 | 0 | 0.0071 |
| Stem vegetables | 19 (172) | 100 | 0 | 0.040 |
| Sugar plants | 4 (14) | 100 | 0 | 0.0010 |
| Vegetable products | 2 (13) | 100 | 0 | 1.0 |
| Fungi, cultivated | 3 (16) | 100 | 0 | 0.32 |
| Fungi, wild, edible | 5 (5) | 100 | 0 | 0.6 |
| Starchy roots and tubers | 35 (71) | 97 | 0.0016 | 0.32 |
| Potatoes and potatoes products | 33 (69) | 97 | 0.0016 | 0.29 |
| Other starchy roots and tubers | 2 (2) | 100 | 0 | 1.0 |
| Fruit and fruit products | 29 (133) | 97 | 0.0001 | 0.031 |
| Citrus fruits | 7 (32) | 100 | 0 | 0.0010 |
| Pome fruits | 8 (48) | 88 | 0.0002 | 0.0011 |
| Stone fruits | 4 (25) | 100 | 0 | 0.0010 |
| Berries and small fruits | 7 (20) | 100 | 0 | 0.10 |
| Miscellaneous fruits | 1 (6) | 100 | 0 | 0.0010 |
| Jam, marmalade and other fruit spreads | 2 (2) | 100 | 0 | 1.0 |
| Meat and meat products | 636 (3909) | 86 | 0.085 | 0.24 |
| Livestock meat | 181 (1367) | 99 | 0.0001 | 0.087 |
| Poultry | 108 (69) | 100 | 0 | 0.090 |
| Game mammals | 9 (9) | 89 | 0.011 | 0.16 |
| Game birds | 1 (1) | 100 | 0 | 0.13 |
| Edible offal, farmed animals | 157 (547) | 99 | 0.0005 | 0.65 |
| Edible offal, game animals | 93 (93) | 8 | 3.6 | 3.7 |
| Preserved meat | 36 (515) | 100 | 0 | 0.046 |
| Sausages | 36 (473) | 100 | 0 | 0.063 |
| Pastes, pâtés and terrines | 15 (211) | 100 | 0 | 0.051 |
| Fish and other seafood | 1254 (3115) | 96 | 0.041 | 0.67 |
| Fish and other seafood (unspecified) | 4 (19) | 25 | 0.095 | 0.20 |
| Fish meat | 853 (1849) | 98 | 0.044 | 0.53 |
| Fish offal | 308 (308) | 97 | 0.093 | 2.3 |
| Crustaceans | 48 (272) | 73 | 0.041 | 0.17 |
| Water molluscs | 41 (667) | 71 | 0.0070 | 0.53 |
| Food for infants and young children | 10 (10) | 90 | 0.12 | 0.29 |
| Infant formulae, powder | 3 (3) | 100 | 0 | 0.20 |
| Follow-on formulae, powder | 2 (2) | 100 | 0 | 0.18 |
| Ready-to-eat meal for infants and young children | 5 (5) | 80 | 0.24 | 0.39 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

### 4.4.9. Perfluorotridecanoic acid (PFTrDA)

The complete list of FoodEx level 1 food groups analysed for PFTrDA is available in Table 4. As presented in Table 14, PFTrDA was found only in a few food groups. Quantified results were reported only for a few samples of meat and meat products: one pork meat sample (0.26 µg/kg), one poultry meat sample (0.0072 µg/kg), one sample of unspecified meat of game mammals (0.28 µg/kg) and one liver sample from unspecified farmed animal (0.026 µg/kg).

In the food group 'Fish and other seafood', PFTrDA was found in fish meat (minimum = 0.015 µg/kg; maximum = 0.51 µg/kg), fish offal (minimum = 0.69 µg/kg; maximum = 8.8 µg/kg), unspecified

seafood (minimum = 0.04 µg/kg; maximum = 0.96 µg/kg), crustaceans (minimum = 0.02 µg/kg; maximum = 1.5 µg/kg) and in water molluscs (minimum = 0.01 µg/kg; maximum = 0.17 µg/kg). In 'Eggs and egg products', only one hen eggs sample provided quantified result (0.021 µg/kg).

**Table 14:** Occurrence of PFTrDA in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Meat and meat products | 219 (1592) | 98 | 0.0004 | 0.21 |
| Livestock meat | 100 (472) | 99 | 0.0005 | 0.25 |
| Poultry | 42 (261) | 98 | 0.0001 | 0.23 |
| Game mammals | 8 (8) | 88 | 0.035 | 0.11 |
| Game birds | 1 (1) | 100 | 0 | 0.14 |
| Edible offal, farmed animals | 30 (298) | 97 | 0.0003 | 0.046 |
| Preserved meat | 16 (222) | 100 | 0 | 0.14 |
| Sausages | 13 (195) | 100 | 0 | 0.38 |
| Pastes, pâtés and terrines | 9 (135) | 100 | 0 | 0.22 |
| Fish and other seafood | 977 (2174) | 91 | 0.078 | 0.46 |
| Fish and other seafood (unspecified) | 3 (18) | 0 | 0.41 | 0.41 |
| Fish meat | 610 (1274) | 96 | 0.022 | 0.18 |
| Fish offal | 308 (308) | 90 | 0.32 | 2.3 |
| Crustaceans | 25 (249) | 28 | 0.10 | 0.11 |
| Water molluscs | 31 (325) | 52 | 0.032 | 0.044 |
| Eggs and egg products | 35 (204) | 97 | 0.0012 | 0.12 |
| Eggs and egg products (unspecified) | 2 (30) | 100 | 0 | 0.43 |
| Eggs, fresh | 33 (174) | 97 | 0.0014 | 0.068 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

### 4.4.10. Perfluorotetradecanoic acid (PFTeDA)

The list of food groups analysed for PFTeDA is available in Table 4. As presented in Table 15, PFTeDA was found only in a very few samples.

Among fruits, there was one apple sample with a quantified result (0.007 µg/kg). Within the food group 'Meat and meat products', one sample of pork meat was found to contain PFTrDA (0.053 µg/kg). Across the foods in the group 'Fish and other seafood', PFTrDA was quantified in 0.4 % of the fish meat samples in concentrations from 0.0056 to 4.8 µg/kg, in one sample of fish liver (1.8 µg/kg), in samples of unspecified seafood (from 0.012 to 0.14 µg/kg) and in one mussel sample (0.1 µg/kg).

**Table 15:** Occurrence of PFTeDA in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Fruit and fruit products | 25 (129) | 96 | 0.0003 | 0.0022 |
| Citrus fruits | 7 (32) | 100 | 0 | 0.0020 |
| Pome fruits | 8 (48) | 88 | 0.0007 | 0.0025 |
| Stone fruits | 4 (25) | 100 | 0 | 0.0020 |
| Berries and small fruits | 5 (18) | 100 | 0 | 0.0020 |
| Miscellaneous fruits | 1 (6) | 100 | 0 | 0.0020 |
| Meat and meat products | 190 (1157) | 99 | 0.00004 | 0.33 |
| Livestock meat | 98 (442) | 99 | 0.0001 | 0.31 |
| Poultry | 39 (216) | 100 | 0 | 0.33 |
| Game mammals | 8 (8) | 100 | 0 | 0.051 |
| Game birds | 1 (1) | 100 | 0 | 0.14 |
| Edible offal, farmed animals | 12 (28) | 100 | 0 | 0.038 |
| Preserved meat | 16 (222) | 100 | 0 | 0.22 |
| Sausages | 13 (195) | 100 | 0 | 0.47 |

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Pastes, pâtés and terrines | 3 (45) | 100 | 0 | 0.72 |
| Fish and other seafood | 1368 (2341) | 99 | 0.004 | 0.74 |
| Fish and other seafood (unspecified) | 3 (18) | 0 | 0.066 | 0.066 |
| Fish meat | 936 (1600) | 99.6 | 0.0031 | 0.55 |
| Fish offal | 383(383) | 99.7 | 0.0047 | 2.1 |
| Crustaceans | 25 (25) | 100 | 0 | 1.1 |
| Water molluscs | 21 (315) | 95 | 0.0048 | 0.043 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

### 4.4.11. Perfluorobutane sulfonic acid (PFBS)

PFBS was analysed in a large number of food groups (Table 4). A summary of the contamination frequencies and the mean concentrations found is presented in Table 16.

In foods of plant origin, PFBS was measured in 3 % of the vegetables analysed (sugar beet, spinach, lettuce, celery) at concentrations from 0.0015 to 0.012 µg/kg, in two potato samples (0.010 and 1.0 µg/kg), in one pea sample (2 µg/kg) and in 17 % of the fruit samples (minimum = 0.0026 µg/kg; maximum = 0.067 µg/kg).

In the food group 'Meat and meat products' (including edible offal), PFBS was quantified only in one liver sample of game animals (1.1 µg/kg) and in two samples of edible offal of farmed animals (0.01 and 2.1 µg/kg) accounting for 0.4 % of the total number of samples analysed in this group.

A very low contamination frequency was also observed in the food group 'Fish meat and other seafood' where PFBS was quantified in 0.3 % of the samples analysed (three fish samples and one unspecified seafood sample in concentrations from 0.01 to 3 µg/kg).

In the food group 'Milk and dairy products' three samples (two cheese samples and one unspecified dairy product) were found to contain PFBS in concentrations from 0.002 to 0.01 µg/kg.

Drinking water was contaminated in a proportion of 10 %. The concentrations measured ranged from 0.001 to 0.24 µg/kg. Further, PBS was found in one margarine sample (0.0041 µg/kg) and in one popcorn sample (2.0 µg/kg).

**Table 16:** Occurrence of PFBS in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Vegetables and vegetable products | 186 (1063) | 97 | 0.0002 | 0.11 |
| Root vegetables | 42 (184) | 100 | 0 | 0.11 |
| Bulb vegetables | 8 (68) | 100 | 0 | 0.072 |
| Fruiting vegetables | 37 (243) | 100 | 0 | 0.069 |
| Brassica vegetables | 20 (108) | 100 | 0 | 0.093 |
| Leaf vegetables | 25 (210) | 92 | 0.0005 | 0.032 |
| Legume vegetables | 4 (13) | 100 | 0 | 0.0027 |
| Stem vegetables | 19 (172) | 95 | 0.0003 | 0.10 |
| Sugar plants | 4 (14) | 50 | 0.0007 | 0.0018 |
| Vegetable products | 2 (13) | 100 | 0 | 1.0 |
| Fungi, cultivated | 3 (16) | 100 | 0 | 0.31 |
| Fungi, wild, edible | 22 (22) | 100 | 0 | 0.89 |
| Starchy roots and tubers | 89 (125) | 98 | 0.0088 | 0.62 |
| Potatoes and potatoes products | 87 (123) | 98 | 0.009 | 0.61 |
| Other starchy roots and tubers | 2 (2) | 100 | 0 | 1.0 |
| Legumes, nuts and oilseeds | 20 (157) | 95 | 0.013 | 0.20 |
| Legumes, beans, green, with pods | 5 (12) | 100 | 0 | 0.18 |

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Legumes, beans, dried | 15 (145) | 93 | 0.014 | 0.20 |
| Fruit and fruit products | 29 (133) | 83 | 0.0042 | 0.036 |
| Citrus fruits | 7 (32) | 86 | 0.0002 | 0.0020 |
| Pome fruits | 8 (48) | 75 | 0.0063 | 0.0079 |
| Stone fruits | 4 (25) | 75 | 0.0018 | 0.0031 |
| Berries and small fruits | 7 (20) | 86 | 0.0101 | 0.11 |
| Miscellaneous fruits | 1 (6) | 100 | 0 | 0.0020 |
| Jam, marmalade and other fruit spreads | 2 (2) | 100 | 0 | 1.0 |
| Meat and meat products | 689 (3934) | 99.6 | 0.0008 | 0.27 |
| Meat and meat products (unspecified) | 15 (15) | 100 | 0 | 1.0 |
| Livestock meat | 183 (1369) | 100 | 0 | 0.14 |
| Poultry | 136 (721) | 100 | 0 | 0.16 |
| Game mammals | 26 (26) | 100 | 0 | 0.70 |
| Game birds | 1 (1) | 100 | 0 | 0.032 |
| Edible offal, farmed animals | 145 (507) | 99 | 0.0043 | 0.78 |
| Edible offal, game animals | 96 (96) | 99 | 0.012 | 1.7 |
| Preserved meat | 36 (515) | 100 | 0 | 0.096 |
| Sausages | 36 (473) | 100 | 0 | 0.16 |
| Pastes, pâtés and terrines | 15 (211) | 100 | 0 | 0.095 |
| Fish and other seafood | 1303 (3164) | 99.7 | 0.0024 | 1.1 |
| Fish and other seafood (unspecified) | 5 (20) | 80 | 0.0029 | 0.15 |
| Fish meat | 929 (1925) | 99.7 | 0.0039 | 0.85 |
| Fish offal | 287(287) | 100 | 0 | 4.4 |
| Crustaceans | 47 (271) | 100 | 0 | 0.19 |
| Water molluscs | 35 (661) | 100 | 0 | 0.56 |
| Milk and dairy products | 239 (2370) | 99 | 0.00005 | 0.14 |
| Milk and dairy products (unspecified) | 28 (28) | 96 | 0.0002 | 0.96 |
| Liquid milk | 76 (646) | 100 | 0 | 0.12 |
| Concentrated milk | 1 (1) | 100 | 0 | 1.0 |
| Cream and cream products | 12 (180) | 100 | 0 | 0.18 |
| Fermented milk products | 69 (951) | 100 | 0 | 0.13 |
| Cheese | 52 (559) | 96 | 0.0002 | 0.14 |
| Milk and milk product imitates | 1 (5) | 100 | 0 | 0.0020 |
| Animal and vegetable fats and oils | 53 (158) | 98 | 0.0003 | 0.36 |
| Animal fat | 10 (52) | 100 | 0 | 0.13 |
| Fish oil | 30 (30) | 100 | 0 | 1.45 |
| Vegetable oil | 10 (41) | 100 | 0 | 0.15 |
| Margarine and similar products | 3 (35) | 67 | 0.0012 | 0.0030 |
| Drinking water | 296 (380) | 90 | 0.0016 | 0.0032 |
| Tap water | 67 (109) | 94 | 0.0045 | 0.0076 |
| Well water | 3 (45) | 100 | 0 | 0.0015 |
| Bottled water | 226 (226) | 88 | 0.0005 | 0.0014 |
| Snacks, desserts, and other foods | 46 (125) | 98 | 0.0088 | 0.62 |
| Snack food | 7 (7) | 86 | 0.29 | 1.1 |
| Ices and desserts | 39 (67) | 100 | 0 | 0.61 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

### 4.4.12. Perfluorohexane sulfonic acid (PFHxS)

PFHxS was analysed in a large number of food groups (Table 4). A summary of the contamination frequencies and mean concentrations found is presented in Table 17.

Among foods of plant origin, PFHxS was quantified in 2 % of the vegetable samples (broccoli, lettuce, melons) at concentrations from minimum = 0.0028 µg/kg to maximum = 0.0038 µg/kg and in 21 % of the fruit samples at concentrations from minimum = 0.008 µg/kg to maximum = 0.20 µg/kg. It should be noted that only a limited number of fruit samples were analysed for PFHxS.

**Table 17:** Occurrence of PFHxS in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Vegetables and vegetable products | 186 (1063) | 98 | 0.0001 | 0.090 |
| Root vegetables | 42 (184) | 100 | 0 | 0.11 |
| Bulb vegetables | 8 (68) | 100 | 0 | 0.037 |
| Fruiting vegetables | 37 (243) | 97 | 0.0001 | 0.062 |
| Brassica vegetables | 20 (108) | 95 | 0.0001 | 0.087 |
| Leaf vegetables | 25 (210) | 96 | 0.0001 | 0.026 |
| Legume vegetables | 4 (13) | 100 | 0 | 0.0026 |
| Stem vegetables | 19 (172) | 100 | 0 | 0.029 |
| Sugar plants | 4 (14) | 100 | 0 | 0.0040 |
| Vegetable products | 2 (13) | 100 | 0 | 1.0 |
| Fungi, cultivated | 3 (16) | 100 | 0 | 0.32 |
| Fungi, wild, edible | 22 () | 100 | 0 | 0.93 |
| Fruit and fruit products | 29 (133) | 79 | 0.013 | 0.046 |
| Citrus fruits | 7 (32) | 86 | 0.0012 | 0.0049 |
| Pome fruits | 8 (48) | 75 | 0.022 | 0.025 |
| Stone fruits | 4 (25) | 75 | 0.0058 | 0.0083 |
| Berries and small fruits | 7 (20) | 86 | 0.019 | 0.12 |
| Miscellaneous fruits | 1 (6) | 0 | 0.008 | 0.0080 |
| Jam, marmalade and other fruit spreads | 2 (2) | 100 | 0 | 1.0 |
| Meat and meat products | 683 (3928) | 99 | 0.0010 | 0.21 |
| Meat & meat products (unspecified) | 15 (15) | 100 | 0 | 1.0 |
| Livestock meat | 183 (1369) | 99 | 0.0002 | 0.081 |
| Poultry | 136 (721) | 100 | 0 | 0.12 |
| Game mammals | 26 (26) | 96 | 0.016 | 0.72 |
| Game birds | 1 (1) | 100 | 0 | 0.053 |
| Edible offal, farmed animals | 145 (507) | 99 | 0.0041 | 0.62 |
| Edible offal, game animals | 90 (90) | 99 | 0.012 | 2.5 |
| Preserved meat | 36 (515) | 100 | 0 | 0.055 |
| Sausages | 36 (473) | 100 | 0 | 0.061 |
| Pastes, pâtés and terrines | 15 (211) | 100 | 0 | 0.041 |
| Fish and other seafood | 1331 (3192) | 99 | 0.0096 | 0.49 |
| Fish and other seafood (unspecified) | 5 (20) | 80 | 0.013 | 0.16 |
| Fish meat | 927 (1923) | 99.9 | 0.00052 | 0.46 |
| Fish offal | 308 (308) | 98 | 0.070 | 0.92 |
| Crustaceans | 43 (267) | 91 | 0.030 | 0.19 |
| Water molluscs | 48 (674) | 100 | 0 | 0.54 |
| Milk and dairy products | 239 (2370) | 99.6 | 0.000002 | 0.077 |
| Milk & dairy products (unspecified) | 28 (28) | 96 | 0.0003 | 0.96 |
| Liquid milk | 76 (646) | 100 | 0 | 0.074 |
| Concentrated milk | 1 (1) | 100 | 0 | 1.0 |
| Cream and cream products | 12 (180) | 100 | 0 | 0.063 |
| Fermented milk products | 69 (951) | 100 | 0 | 0.058 |
| Cheese | 52 (559) | 100 | 0 | 0.071 |
| Milk and milk product imitates | 1 (5) | 100 | 0 | 0.0020 |
| Eggs and egg products | 99 (781) | 99 | 0.0001 | 0.52 |
| Eggs and egg products (unspecified) | 37 (233) | 100 | 0 | 0.11 |
| Eggs, fresh | 62 (548) | 98 | 0.0001 | 0.69 |
| Animal and vegetable fats and oils | 53 (158) | 98 | 0.0003 | 0.21 |
| Animal fat | 10 (52) | 90 | 0.0008 | 0.12 |
| Fish oil | 30 (30) | 100 | 0 | 0.71 |
| Vegetable oil | 10 (41) | 100 | 0 | 0.15 |
| Margarine and similar products | 3 (35) | 100 | 0 | 0.0025 |
| Alcoholic beverages | 6 (63) | 83 | 0.0048 | 0.0065 |
| Beer and beer-like beverage | 4 (48) | 75 | 0.0064 | 0.0079 |
| Wine | 2 (15) | 100 | 0 | 0.002 |

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Drinking water | 300 (384) | 88 | 0.0007 | 0.0021 |
| Tap water | 71 (113) | 93 | 0.0015 | 0.0045 |
| Well water | 3 (45) | 100 | 0 | 0.0007 |
| Bottled water | 226 (226) | 86 | 0.0004 | 0.0013 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

A low contamination frequency (1 %) was observed in the food group 'Meat and meat products' (including edible offal). PFHxS was quantified in one sheep meat sample (0.076 µg/kg), in one sample of unspecified meat of game mammals (0.41 µg/kg), in one sample of giblets of poultry (2.1 µg/kg) and in one sample of liver of unspecified game animal (1.1 µg/kg).

In the food group 'Fish and other seafood', PFHxS was found in 2 % of the fish offal samples in concentrations from minimum = 1.4 µg/kg to maximum = 4.5 µg/kg, in one fish sample (1 µg/kg ), in one unspecified seafood sample (0.043 µg/kg) and in crustaceans (minimum = 0.3 µg/kg; maximum = 4.9 µg/kg). PFHxS was also quantified in a few other samples of food of animal origin: in one sample of unspecified dairy product (0.007 µg/kg), in one butter sample (0.01 µg/kg) and in one sample of hen eggs (0.005 µg/kg).

In 'Drinking water', 12 % of the samples analysed contained PFHxS (minimum = 0.001 µg/kg; maximum = 0.011 µg/kg. Also, one beer sample showed a quantified result (0.030 µg/kg).

### 4.4.13. Perfluoroheptane sulfonic acid (PFHpS)

PFHpS was analysed in samples from different food groups (Table 4). However, it was quantified only in 'Meat and meat products' in one sample of meat of unspecified game mammals (0.037 µg/kg).

**Table 18:** Occurrence of PFHpS in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Meat and meat products | 316 (3289) | 99.7 | 0.00001 | 0.098 |
| Livestock meat | 143 (1253) | 100 | 0 | 0.043 |
| Poultry | 63 (620) | 100 | 0 | 0.038 |
| Game mammals | 8 (8) | 88 | 0.0046 | 0.053 |
| Game birds | 1 (1) | 100 | 0 | 0.13 |
| Edible offal, farmed animals | 24 (252) | 100 | 0 | 0.71 |
| Preserved meat | 32 (480) | 100 | 0 | 0.046 |
| Sausages | 31 (465) | 100 | 0 | 0.046 |
| Pastes, pâtés and terrines | 14 (210) | 100 | 0 | 0.089 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

### 4.4.14. Perfluorooctane sulfonic acid (PFOS)

PFOS was one of the most analysed PFAS across food groups (Table 4). A summary of the contamination frequencies and mean concentrations across food groups are presented in Table 19.

With a few exceptions, PFOS occurrence data were reported without information on the isomer types analysed: linear, branched or both types. Since the linear PFOS has a higher bioaccumulation potential (Chu et al., 2009; O'Brian et al., 2011) it can be assumed that the reported PFOS occurrence data mainly refers to the linear isomer.

**Table 19:** Occurrence of PFOS in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Vegetables and vegetable products | 286 (1163) | 90 | 0.020 | 0.12 |
| Root vegetables | 135 (277) | 97 | 0.0095 | 0.21 |
| Bulb vegetables | 8 (68) | 88 | 0.0022 | 0.0395 |
| Fruiting vegetables | 37 (243) | 95 | 0.0021 | 0.065 |
| Brassica vegetables | 23 (111) | 96 | 0.0012 | 0.099 |
| Leaf vegetables | 25 (210) | 84 | 0.0006 | 0.026 |
| Legume vegetables | 4 (13) | 100 | 0 | 0.0111 |
| Stem vegetables (Fresh) | 23 (176) | 100 | 0 | 0.0466 |
| Sugar plants | 4 (14) | 100 | 0 | 0.002 |
| Vegetable products | 2 (13) | 100 | 0 | 1.0 |
| Fungi, cultivated | 3 (16) | 100 | 0 | 0.32 |
| Fungi, wild, edible | 22 (22) | 27 | 0.90 | 1.1 |
| Starchy roots and tubers | 303 (339) | 99.7 | 0.0035 | 0.63 |
| Potatoes and potatoes products | 299 (335) | 99.7 | 0.0036 | 0.63 |
| Other starchy roots and tubers | 4 (4) | 100 | 0 | 0.75 |
| Legumes, nuts and oilseeds | 20 (157) | 95 | 0.0001 | 0.11 |
| Legumes, beans, green, with pods | 5 (12) | 80 | 0.0016 | 0.17 |
| Legumes, beans, dried | 15 (145) | 100 | 0 | 0.11 |
| Fruit and fruit products | 34 (136) | 68 | 0.032 | 0.085 |
| Citrus fruits | 7 (32) | 71 | 0.0021 | 0.0037 |
| Pome fruits | 13 (51) | 69 | 0.066 | 0.13 |
| Stone fruits | 4 (25) | 50 | 0.0053 | 0.0062 |
| Berries and small fruits | 7 (20) | 71 | 0.038 | 0.14 |
| Miscellaneous fruits[(b)] | 1 (6) | 0 | 0.007 | 0.007 |
| Jam, marmalade and other fruit spreads[(b)] | 2 (2) | 100 | 0 | 1.0 |
| Meat and meat products | 3215 (6460) | 64 | 29.5 | 30 |
| Meat & meat products (unspecified) | 15 (15) | 100 | 0 | 1.0 |
| Livestock meat | 232 (1418) | 91 | 0.0086 | 0.12 |
| Poultry | 150 (735) | 97 | 0.0097 | 0.14 |
| Game mammals | 569 (569) | 71 | 0.87 | 1.5 |
| Game birds | 9 (9) | 100 | 0 | 0.38 |
| Edible offal, farmed animals | 1261 (1623) | 91 | 0.42 | 1.9 |
| Edible offal, game animals | 882 (882) | 4 | 215 | 215 |
| Preserved meat | 39 (518) | 95 | 0.0003 | 0.057 |
| Sausages | 43 (480) | 88 | 0.066 | 0.14 |
| Pastes, pâtés and terrines | 15 (211) | 100 | 0 | 0.050 |
| Fish and other seafood | 2534 (4395) | 63 | 1.99 | 2.4 |
| Fish & other seafood (unspecified) | 6 (21) | 33 | 0.52 | 0.66 |
| Fish meat | 1982 (2978) | 67 | 2.1 | 2.5 |
| Fish offal | 410(410) | 46 | 4.9 | 5.5 |
| Crustaceans | 78 (302) | 32 | 1.5 | 1.5 |
| Water molluscs | 58 (684) | 72 | 0.031 | 0.55 |
| Milk and dairy products | 318 (2449) | 97 | 0.0007 | 0.11 |
| Milk and dairy products (unspecified) | 28 (28) | 93 | 0.043 | 0.97 |
| Liquid milk | 152 (722) | 94 | 0.0009 | 0.12 |
| Concentrated milk | 2 (2) | 100 | 0 | 0.58 |
| Cream and cream products | 13 (181) | 100 | 0 | 0.099 |
| Fermented milk products | 71 (953) | 100 | 0 | 0.080 |
| Cheese | 51 (558) | 100 | 0 | 0.094 |
| Milk and milk product imitates | 1 (5) | 100 | 0 | 0.002 |
| Eggs and egg products | 134 (816) | 88 | 0.034 | 0.54 |
| Eggs and egg products (unspecified) | 39 (235) | 95 | 0.026 | 0.14 |
| Eggs, fresh | 95 (581) | 85 | 0.037 | 0.70 |
| Sugar and confectionary | 45 (156) | 98 | 0.0035 | 0.053 |
| Chocolate (cocoa) products[(c)] | 3 (45) | 100 | 0 | 0.057 |
| Confectionery (non-chocolate) [(c)] | 2 (30) | 100 | 0 | 0.025 |
| Dessert sauces[(c)] | 1 (1) | 100 | 0 | 1.0 |

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Honey | 39 (80) | 97 | 0.0069 | 0.049 |
| Animal and vegetable fats and oils[(d)] | 56 (161) | 98 | 0.28 | 0.56 |
| Animal fat | 13 (55) | 92 | 0.82 | 0.95 |
| Fish oil | 30 (30) | 100 | 0 | 1.1 |
| Vegetable oil | 10 (41) | 100 | 0 | 0.15 |
| Margarine and similar products | 3 (35) | 100 | 0 | 0.006 |
| Drinking water | 372 (456) | 89 | 0.0005 | 0.0025 |
| Tap water | 114 (156) | 91 | 0.0009 | 0.0039 |
| Well water | 3 (45) | 100 | 0 | 0.0017 |
| Bottled water | 255 (255) | 87 | 0.0004 | 0.0017 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples; (b): due to the limited number of samples analysed for this subgroup, the mean concentrations of the FoodEx level 1 group was introduced in the exposure; (c): not included in the exposure assessment as only a few samples were analysed and all were left-censored; (d): not included in the exposure assessment as only one sample of wild boar fat tissue was reported to contain PFOS.

Across foods of plant origin, PFOS was found in vegetables and wild edible fungi in concentrations from 0.0043 to 1.54 µg/kg, in fruits in concentrations from 0.003 to 0.54 µg/kg, in one potato sample (1.2 µg/kg) and in one bean sample (0.0063 µg/kg).

In the food group 'Meat and meat products' (including edible offal) quantified results were obtained in a number of food subgroups: in meat of livestock animals (minimum = 0.0033 µg/kg; maximum = 1.74 µg/kg), in poultry meat (minimum = 0.0046 µg/kg; maximum = 2.8 µg/kg), in meat of game mammals – all quantified results concerned wild boar meat samples – (minimum = 1.1 µg/kg; maximum = 29 µg/kg), in edible offal from farmed animals (minimum = 0.20 µg/kg; maximum = 12.3 µg/kg), in edible offal of game animals (dominated by samples of wild boar liver) (minimum = 0.002 µg/kg; maximum = 3480 µg/kg), in two sample of preserved meat (both in concentration of 0.01 µg/kg) and in sausages (minimum = 0.08 µg/kg; maximum = 16.5 µg/kg).

In 'Fish and other seafood', PFOS was quantified in all subgroups. The highest concentrations were recorded in fish offal (minimum = 1.1 µg/kg; maximum = 310 µg/kg). Lower concentrations were observed in fish meat (minimum = 0.04 µg/kg; maximum = 211 µg/kg), in crustaceans (minimum = 0.09 µg/kg; maximum = 65 µg/kg) and in water molluscs (minimum = 0.02 µg/kg; maximum = 2.9 µg/kg).

In 'Milk and dairy products', the quantified results represented 3 % of the samples analysed. The concentrations measured were between 0.005 and 1.2 µg/kg. In the food group 'Egg and egg products', 12 % of the samples provided quantified results (minimum = 0.0023 µg/kg; maximum = 6.4 µg/kg).

Other quantified results on foods of animal origin were obtained for one honey sample (0.055 µg/kg) and one sample of fat tissue of wild boar (45 µg/kg).

In 'Drinking water', PFOS was found in 11 % of the samples analysed. The concentrations measured ranged from 0.001 to 0.016 µg/kg.

### 4.4.15. Perfluorodecane sulfonic acid (PFDS)

PFDS was analysed in samples from different food groups (Table 4) but the contamination frequency was very low (Table 20). In foods of plant origin, PFDS was quantified in one oats sample (0.016 µg/kg), in one sample of cultivated mushrooms (0.012 µg/kg) and in one spinach sample (0.16 µg/kg). A similarly low contamination frequency was observed in foods of animal origin. PFDS was found in one fish meat sample (0.4 µg/kg), four samples of fish offal (liver) (concentrations from

1.13 to 3.7 µg/kg), two samples of unspecified seafood (0.004 µg/kg) and in three cheese samples (0.004 to 0.005 µg/kg).

**Table 20:** Occurrence of PFDS in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Grains and grain-based products | 56 (740) | 98 | 0.0001 | 0.026 |
| Grains undefined end-use | 4 (60) | 100 | 0 | 0.018 |
| Grains for human consumption | 11 (65) | 91 | 0.0007 | 0.013 |
| Bread and rolls | 7 (105) | 100 | 0 | 0.029 |
| Breakfast cereals | 3 (45) | 100 | 0 | 0.0097 |
| Fine bakery wares | 31 (465) | 100 | 0 | 0.030 |
| Vegetables & vegetable | 109 (963) | 98 | 0.0004 | 0.0079 |
| Root vegetables | 13 (155) | 100 | 0 | 0.0068 |
| Bulb vegetables | 6 (66) | 100 | 0 | 0.011 |
| Fruiting vegetables | 28 (229) | 100 | 0 | 0.0056 |
| Brassica vegetables | 14 (99) | 100 | 0 | 0.0053 |
| Leaf vegetables | 21 (206) | 95 | 0.0015 | 0.0077 |
| Legume vegetables | 4 (13) | 100 | 0 | 0.009 |
| Stem vegetables | 17 (170) | 100 | 0 | 0.013 |
| Sugar plants | 4 (14) | 100 | 0 | 0.001 |
| Fungi, cultivated | 2 (11) | 50 | 0.0067 | 0.011 |
| Fish and other seafood | 977 (2174) | 99 | 0.0052 | 0.23 |
| Fish and other seafood (unspecified) | 3 (18) | 33 | 0.0059 | 0.0065 |
| Fish meat | 610 (1274) | 100 | 0.00031 | 0.16 |
| Fish offal | 308 (308) | 99 | 0.035 | 0.87 |
| Crustaceans | 25 (249) | 100 | 0 | 0.041 |
| Water molluscs | 31 (325) | 100 | 0 | 0.046 |
| Milk and dairy products | 177 (2305) | 98 | 0.000046 | 0.075 |
| Liquid milk | 60 (630) | 100 | 0 | 0.081 |
| Cream and cream products | 12 (180) | 100 | 0 | 0.089 |
| Fermented milk products | 63 (945) | 100 | 0 | 0.075 |
| Cheese | 41 (545) | 93 | 0.0002 | 0.066 |
| Milk and milk product imitates | 1 (5) | 100 | 0 | 0.0020 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

### 4.4.16. Perfluorooctane sulfonamide (FOSA)

FOSA was analysed in foods from different food groups but the main focus was on 'Fish and other seafood' (Table 4). Quantified results were obtained only for foods belonging to three food groups (Table 21).

Across foods of plant origin, FOSA was found in only one potato sample (0.010 µg/kg). In 'Meat and meat products' (including edible offal), FOSA was quantified in two liver samples of farmed animals (0.0021 and 0.038 µg/kg) and in one poultry meat sample (0.0016 µg/kg).

In 'Fish meat', 9 % of the samples analysed contained FOSA (minimum = 0.005 µg/kg; maximum = 27 µg/kg). Higher concentrations were found in fish offal samples (liver) (minimum = 1.15 µg/kg; maximum = 56 µg/kg). Relatively high concentrations were also found in crustaceans (minimum = 0.9 µg/kg; maximum = 59 µg/kg). In water molluscs, the concentrations ranged from 0.7 to 2.1 µg/kg.

**Table 21:** Occurrence of FOSA in food.

| Food group | N | LC % | Mean[(a)] (µg/kg) | |
|---|---|---|---|---|
| | | | LB | UB |
| Starchy roots and tubers | 25 (47) | 96 | 0 | 0.45 |
| Potatoes and potatoes products | 23 (45) | 96 | 0.0023 | 0.43 |
| Other starchy roots and tubers | 2 (2) | 100 | 0 | 1.0 |
| Meat and meat products | 127 (399) | 98 | 0 | 0.72 |
| Meat, livestock animals | 44 (120) | 100 | 0 | 0.59 |
| Meat, poultry | 16 (44) | 94 | 0 | 0.60 |
| Meat, game mammals | 1 (1) | 100 | 0 | 1.0 |
| Edible offal, farmed animals | 53 (187) | 96 | 0 | 0.91 |
| Edible offal, game animals | 3 (3) | 100 | 0 | 1.0 |
| Preserved meat | 4 (35) | 100 | 0 | 0.23 |
| Sausages | 5 (8) | 100 | 0 | 1.0 |
| Pastes, pâtés and terrines | 1 (1) | 100 | 0 | 1.0 |
| Fish and other seafood | 1459 (2158) | 91 | 0.37 | 1.8 |
| Fish and other seafood (unspecified) | 3 (18) | 0 | 0.32 | 0.32 |
| Fish meat | 988 (1340) | 91 | 0.17 | 1.4 |
| Fish offal | 404 (404) | 94 | 0.96 | 3.5 |
| Crustaceans | 47 (47) | 74 | 3.5 | 4.9 |
| Water molluscs | 17 (349) | 65 | 0.02 | 1.0 |

N: number of reported analyses; in brackets, total number of samples taken when considering the pooled samples; LC: proportion of left-censored results calculated on the number of reported analyses; LB: lower bound; UB: upper bound; (a): Means were calculated by weighting the results for the number of pooled samples.

### 4.4.17. Comparison of mean PFASs concentrations in fish

Several studies have indicated that concentrations of PFASs is higher in fish caught from fresh water compared to marine water (Berger et al., 2009; Schuetze et al., 2010). Based on the available occurrence data for 16 PFASs in fish, a comparison of the lower-bound mean concentrations found in fresh water fish, marine fish and diadromous fish was performed. Results showed constantly higher mean concentrations in fish from fresh water. Diadromous fish had mean concentrations slightly higher or similar to the marine fish. Among PFASs, PFOS had the highest mean concentrations in all three fish categories (Figure 3).

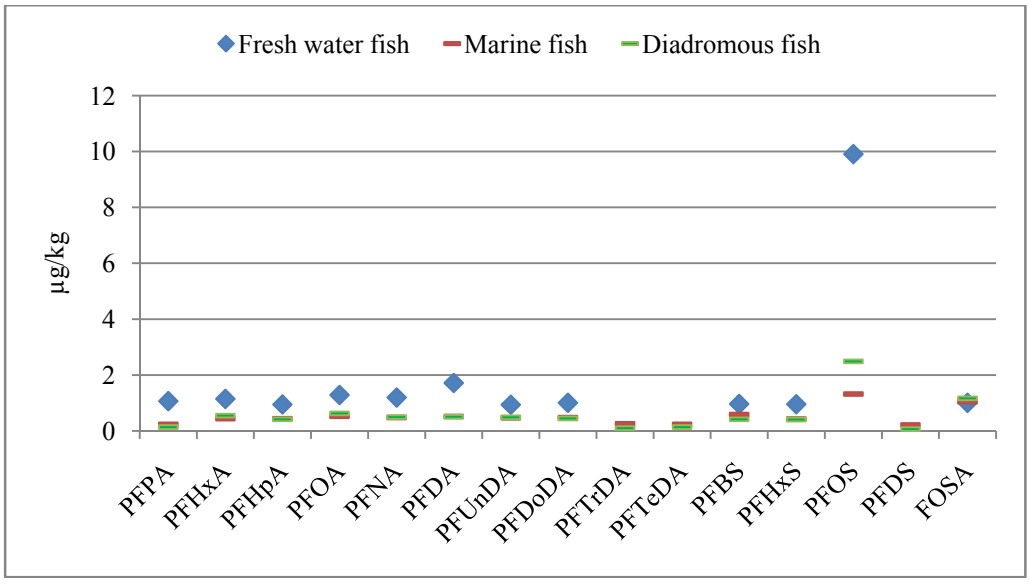


**Figure 3:** Comparison of PFASs lower bound mean concentrations in fish in relation to their aquatic environment. No data on fresh water fish were available for PFTrDA, PFTeDA and PFDS.

### 4.5. Dietary exposure assessment

Among the 27 PFASs, quantified results were reported for 16 substances. According to international guidance (WHO, 2009; EFSA, 2010b), chronic dietary exposure assessment cannot be performed accurately if more than 80 % of results in the food groups are left-censored data. This was the case for most of the PFASs. With a few exceptions, the proportion of left-censored data across food groups was above 90 %. Therefore, the dietary exposure calculated here should only be seen as a rough indication of the range of chronic dietary exposure. The high proportion of left-censored data has a major impact on the calculated dietary exposure. It is anticipated that exposure will be underestimated with the lower bound approach whereas it may be even highly overestimated with the upper bound approach, results just indicating a range within which the real exposure potentially lies.

Because of the different toxicological profiles and the lack of toxicological equivalent factors for PFASs, dietary exposure was calculated for each substance separately.

TDIs are available only for PFOS and PFOA (EFSA, 2008). For these two PFASs, the dietary exposure assessment will be presented in more detail. For the other PFASs, no TDIs are available therefore it is difficult to interpret the exposure estimates.

Dietary exposure was calculated using the overall European lower and upper bound mean occurrence of PFASs at level 2 of the FoodEx food groups as presented in section 4.4. They were matched with survey-specific reported food consumption and body weight at individual level. Some PFAS occurrence results or food consumption amounts were reported only at Level 1 and were matched at that level. In a few dietary surveys, a limited proportion (1 to 10 %) of composite foods was not disaggregated into major ingredients as required for the compilation of the Comprehensive Database. Therefore, composite foods were linked at level 2 with the available occurrence values or, where no occurrence values were available, the mean concentration of the main ingredient food was applied. As example, for 'Fish-based meals' where no occurrence values were available, the mean concentration of 'fish meat' was applied. The other composite foods (meat-based, egg-based, cereal-based, and vegetables-based) were treated similarly. For simplification and consistency, the exposure resulting from composite food was added to the food group of the main ingredient (e.g. 'Fish-based meals' to 'Fish and other seafood', 'Meat-based meals' to 'Meat and other products', 'Egg-based meals' to 'Eggs and egg products, etc.).

Lower bound exposure was used to establish a relative ranking for the contributions of the different food groups in order to exclude the influence of left-censored data and left-censoring limits.

#### 4.5.1. Perfluorooctane sulfonic acid (PFOS)

The detailed results of the chronic dietary exposure calculations for the different dietary surveys and age classes are presented in Table 22. It gives an indication of the range of results for the surveys included with the minimum, median and maximum of mean and 95th percentile exposure estimates across dietary surveys.

*Infants*
Food consumption information for infants was available only from two dietary surveys, one of which included very few survey participants (Table 2). Therefore, the variation between lower bound mean exposure of 0.29 ng/kg b.w. per day and upper bound 95$^{th}$ percentile exposure of 12 ng/kg b.w. per day should be taken only as a rough indication for the chronic dietary exposure in European infants.

*Toddlers*
There were nine surveys available reporting food consumption information for toddlers covering an overall 1,597 survey participants (Table 2). Mean dietary exposure ranged from 0.58 ng/kg b.w. per day (LB) to 14 ng/kg b.w. per day (UB) and 95$^{th}$ percentile exposure ranged from 2.1 ng/kg b.w. per day (LB) to 29 ng/kg b.w. per day (UB).

*Other children*
There were seventeen surveys available reporting food consumption information for other children covering an overall 8,468 survey participants (Table 2). Mean dietary exposure ranged from 0.59 ng/kg b.w. per day (LB) to 10 ng/kg b.w. per day (UB) and 95$^{th}$ percentile exposure. ranged from 2.3 ng/kg b.w. per day (LB) to 19 ng/kg b.w. per day (UB).

*Adolescents*
There were twelve surveys available reporting food consumption information for adolescents covering an overall 6,329 survey participants (Table 2). Mean dietary exposure ranged from 0.32 ng/kg b.w. per day (LB) to 5.3 ng/kg b.w. per day (UB) and 95$^{th}$ percentile exposure ranged from 1.7 ng/kg b.w. per day (LB) to 12 ng/kg b.w. per day (UB).

*Adults*
There were fifteen surveys available reporting food consumption for adults covering an overall 30,788 survey participants (Table 2). Mean dietary exposure ranged from 0.27 ng/kg b.w. per day (LB) to 5.2 ng/kg b.w. per day (UB) and 95$^{th}$ percentile exposure ranged from 1.4 ng/kg b.w. per day (LB) to 10 ng/kg b.w. per day (UB).

*Elderly*
There were seven surveys available reporting food consumption for the elderly covering an overall 4,056 survey participants (Table 2). Mean dietary exposure ranged from 0.41 ng/kg b.w. per day (LB) to 3.7 ng/kg b.w. per day (UB) and 95$^{th}$ percentile exposure ranged from 1.7 ng/kg b.w. per day (LB) to 8.2 ng/kg b.w. per day (UB).

*Very elderly*
There were six surveys available reporting food consumption for the very elderly covering an overall 1,614 survey participants (Table 2). Mean dietary exposure ranged from 0.40 ng/kg b.w. per day (LB) to 4.1 ng/kg b.w. per day (UB) and 95$^{th}$ percentile exposure ranged from 1.5 ng/kg b.w. per day (LB) to 6.7 ng/kg b.w. per day (UB).

The highest exposure estimates across age classes were observed in toddlers and other children. This is related to the higher food consumption per kg b.w. compared to the adult population..

Compared to the TDI set by the EFSA Scientific Panel on Contaminants (150 ng/kg b.w. per day), it should be noted that although the upper bound results are highly overestimated, the exposure estimates in all age classes and for both average consumers and high consumers are well below the TDI. For adults, the highest upper bound mean estimate (5.2 ng/kg b.w. per day) represents 3.5 % of the TDI while the highest upper bound 95$^{th}$ percentile estimate (10 ng/kg b.w. per day) represents 6.7 % of the TDI. In toddlers, the age class having the highest exposure, the same parameters represented 9.3 % and respectively 19 % of the TDI.

The contribution of each of the FoodEx Level 1 food categories to overall PFOS exposure was calculated for each age class and the European population as shown in Figure 4. The highest contributor across all age classes for the lower bound results (less influenced by left-censored data) were 'Fish and other seafood' (50 to 80 %) followed by 'Fruits and fruit products' (8 to 27 %) and 'Meat and meat products' (5 to 8 %). 'Fish meat' had the highest contribution among the food subgroups within 'Fish and other seafood' in all age classes. The contribution of crustaceans and water molluscs was much lower (Figure 5). Even though high PFOS concentrations were found in edible offal of game animals, these types of food are consumed only on rare occasions thus having a very limited contribution to the overall chronic dietary exposure. 'Milk and dairy products' contributed to some extent to exposure in infants (4 %) and toddlers (1.1 %) while in other age classes it contributed only 0.2 to 0.6 %. 'Drinking water' had the highest average contribution in infants (up to 13 %) while in other age classes its average contribution ranged from 0.5 to 1.5 %. Contribution of other food groups was minor.

Based on lower bound estimates PFOS dietary exposure patterns varied considerably across the different surveys even at the broad food category levels. Minimum and maximum contributions of the broad food categories to overall lower bound mean PFOS exposure across the dietary surveys included and for each age group are shown in Table 23.

Compared to the indicative chronic dietary exposure estimated by the EFSA Scientific Panel on Contaminants in 2008, the current results show a 10 to 30 times lower exposure in the adult population. This difference is mainly due to the different mean concentrations of PFOS in fish and other seafood used in the two assessments. In the 2008 assessment, a mean PFOS concentration of 68.1 µg/kg in 'Fish and fishery products' was applied in the exposure calculation whereas in the current assessment the mean concentration for PFOS in 'Fish and other seafood' varied between 2 µg/kg (LB) and 2.4 µg/kg (UB). The high mean PFOS concentration considered in the 2008 assessment can be partly explained by the limited number of analytical results available for fish and fishery products (n = 252; several samples probably taken from highly contaminated areas) compared to the present assessment (n = 4395), and by the less sensitive analytical methods applied in the early 2000's. As fish is clearly the main contributor to PFOS exposure, the 30-fold lower mean PFOS concentration in 'Fish and other seafood' applied in the present assessment explains the difference between the exposure estimates in the two assessments.

The dietary exposure estimates of the present assessment are in line with those reported in recent studies demonstrating that the long term dietary exposure to PFOS is in the low range of ng/kg b.w. per day and does not represent a health risk for consumers (BFR, 2008; Ericson Jogsten et al., 2009; Fromme et al., 2009; Kärrman et al., 2009; Haug et al., 2010b; VWA, 2010; Noorlander et al., 2011; Cornelis et al., 2012).

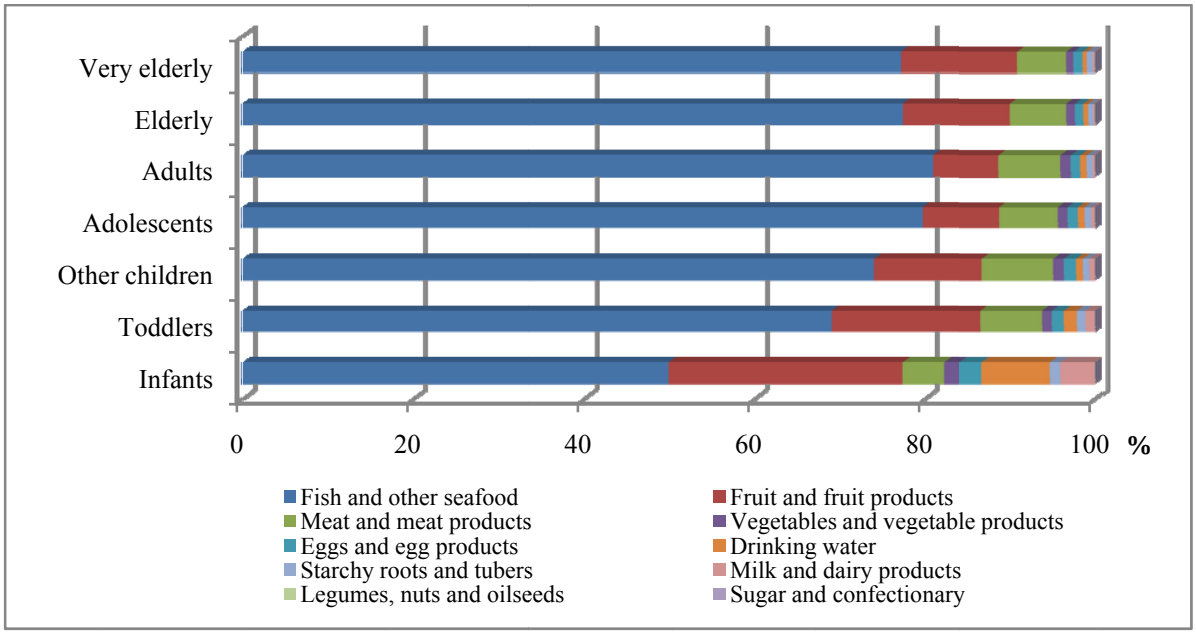


**Figure 4:** Average contribution (in percentage) of broad food groups to overall lower bound mean PFOS exposure per age group.

**Table 22:** Mean and 95th percentile (P95) chronic dietary exposure to PFOS (ng/kg b.w. per day) for total population in lower-bound and upper-bound scenario.

| Code[a] | Range of dietary exposure (LB – UB) (ng/kg b.w. per day) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Infants | | Toddlers | | Other children | | Adolescents | | Adults | | Elderly | | Very elderly | |
| | Mean | P95 | Mean | P95 | Mean | P95 | Mean | P95 | Mean | P95 | Mean | P95 | Mean | P95 |
| **BE/1** | | | | | | | 0.54-2.5 | 2.9-5.7 | 0.8-2.6 | 3.6-6.3 | 0.91-2.9 | 3.7-6.8 | 0.84-2.9 | 3.9-6.7 |
| **BE/2** | | | 1.2-9.1 | -[b] | 1.2-7.4 | 5.5-14 | | | | | | | | |
| **BG** | 0.29-4.0 | 0.7-12 | 1.4-8.5 | 7.8-18 | 1.3-7.2 | 8.3-16 | | | | | | | | |
| **CY** | | | | | | | 0.76-2.8 | 3.2-6.7 | | | | | | |
| **CZ** | | | | | 1.5-6.8 | 7.6-15 | 1.0-4.7 | 5.4-11 | 0.70-2.9 | 3.6-6.8 | | | | |
| **DE/1** | | | 1.2-6.4 | 5.1-13 | 0.95-4.5 | 3.6-9 | | | | | | | | |
| **DE/2** | | | 1-6.7 | 4.1-12 | 0.88-4.5 | 4.0-9 | | | | | | | | |
| **DE/3** | | | 1-6.7 | 4-13 | 1-4.6 | 4.0-10 | | | | | | | | |
| **DE/4** | | | | | | | 0.32-1.8 | 1.7-4.5 | 0.62-2.1 | 3.2-5.5 | 0.8-2.4 | 3.7-6.1 | 0.82-2.5 | 3.6-6.3 |
| **DK** | | | | | 1.8-7.2 | 5-14 | 0.81-3.9 | 2.4-7.3 | 0.77-3.0 | 2.1-5.6 | 1.0-3.7 | 2.2-6.5 | 1.2-4.1 | -[b] |
| **EL** | | | | | 1.5-9.4 | 7.1-18 | | | | | | | | |
| **ES/1** | | | | | | | | | 1.9-4.1 | 5.9-8.9 | | | | |
| **ES/2** | | | | | | | 1.5-4.3 | 4.3-8 | 2.4-5.2 | 6.1-10 | | | | |
| **ES/3** | | | | | 3.2-8.1 | 9.8-17 | 1.9-4.7 | 6.5-10 | | | | | | |
| **ES/4** | | | 4.3-14 | -[b] | 2.5-8.5 | 9.9-18 | 1.9-5.3 | 7.2-12 | | | | | | |
| **FI/1** | | | 2.0-13 | 7.3-29 | 1.8-10 | 6.4-19 | | | | | | | | |
| **FI/2** | | | | | | | | | 1.0-3.3 | 3.9-7.1 | 1.4-3.7 | 4.7-8.2 | | |
| **FI/3** | | | | | 2.0-7.1 | 7.5-15 | | | | | | | | |
| **FR** | | | | | 1.7-6.6 | 4.6-12 | 0.86-3.3 | 2.9-6.7 | 1.0-2.9 | 2.8-5.6 | 1.2-3.4 | 3.0-6.2 | 1.2-3.4 | 2.9-5.6 |
| **HU** | | | | | | | | | 0.55-3.5 | 2.5-7.2 | 0.41-3.1 | 1.7-5.8 | 0.4-3.2 | 1.5-5.7 |
| **IE** | | | | | | | | | 0.78-4.3 | 2.5-8.1 | | | | |
| **IT** | 0.91-11 | -[b] | 5.9-13 | -[b] | 2.7-7.4 | 8.5-16 | 1.5-4.1 | 4.5-9 | 1.4-3.2 | 4.1-6.8 | 1.4-3.2 | 4.3-6.9 | 1.0-2.8 | 3.2-5.6 |
| **LV** | | | | | 0.67-4.4 | 2.9-11 | 0.40-3.2 | 2.1-7.1 | 0.64-2.7 | 2.9-6.2 | | | | |
| **NL/1** | | | | | | | | | 0.27-2.4 | 1.4-4.7 | | | | |
| **NL/2** | | | 0.58-6.4 | 2.1-12 | 0.59-5.0 | 2.3-9.4 | | | | | | | | |
| **SE/1** | | | | | | | | | 1.1-3.6 | 3.1-6.8 | | | | |
| **SE/2** | | | | | 1.6-6.9 | 5.5-14 | 0.80-4.2 | 3.3-8.4 | | | | | | |
| **UK** | | | | | | | | | 0.87-3.0 | 2.6-5.5 | | | | |
| **Minimum** | 0.29-4.0 | 0.7-12 | 0.58-6.4 | 2.1-12 | 0.59-4.4 | 2.3-9.0 | 0.32-1.8 | 1.7-4.5 | 0.27-2.1 | 1.4-4.7 | 0.41-2.4 | 1.7-5.8 | 0.40-2.5 | 1.5-5.6 |
| **Median** | | | 1.2-8.5 | 4.6-13 | 1.5-7.1 | 5.5-14 | 0.84-4.0 | 3.3-7.7 | 0.8-3.0 | 3.1-6.8 | 1.0-3.2 | 3.7-6.5 | 0.92-3.1 | 3.2-5.7 |
| **Maximum** | 0.91-11 | 0.7-12 | 5.9-14 | 7.8-29 | 3.2-10 | 9.9-19 | 1.9-5.3 | 7.2-12 | 2.4-5.2 | 6.1-10 | 1.4-3.7 | 4.7-8.2 | 1.2-4.1 | 3.9-6.7 |

(a): Details on the dietary surveys and the number of subjects are given in Table 2; (b): P95 estimates for dietary surveys/age classes with less than 60 observations are not statistically robust (EFSA, 2011) and therefore not presented.

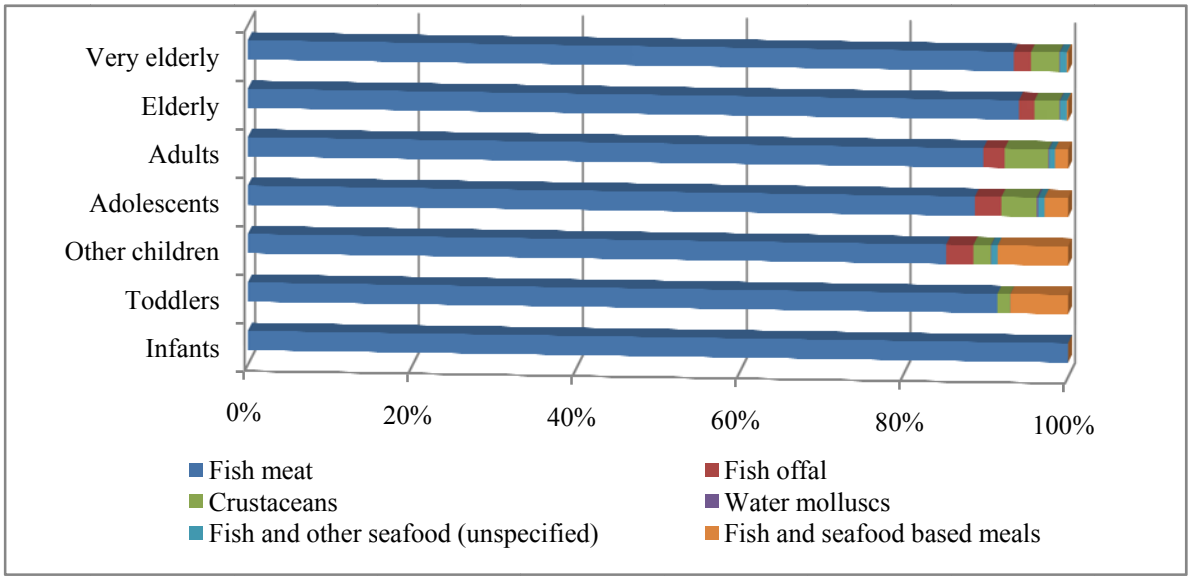


**Figure 5:** Average contribution (in percentage) of FoodEx level 2 subgroups to the lower bound mean PFOS exposure resulting from 'Fish and other seafood'. Note: Fish and seafood based meals which were not disaggregated into its main ingredients represents only a small proportion of the composite foods.

**Table 23:** Minimum and maximum relative contributions in percent of broad food groups to overall lower bound mean PFOS exposure across the surveys included for each age group.

| Food group | Infants | | Toddlers | | Other children | | Adolescents | | Adults | | Elderly | | Very elderly | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| Fish and other seafood | 43 | 57 | 37 | 92 | 48 | 91 | 48 | 91 | 53 | 93 | 41 | 87 | 43 | 87 |
| Fruit and fruit products | 23 | 32 | 5.2 | 41 | 4.0 | 34 | 3.0 | 22 | 3.3 | 20 | 5.5 | 33 | 6.3 | 34 |
| Meat and meat products | 0.47 | 9.2 | 0.56 | 13 | 2.1 | 22 | 2.3 | 20 | 1.9 | 22 | 1.9 | 20 | 2.0 | 17 |
| Vegetables and vegetable products | 0.54 | 3.1 | 0.25 | 1.8 | 0.16 | 3.9 | 0.18 | 4.9 | 0.3 | 3.2 | 0.55 | 1.8 | 0.4 | 1.7 |
| Eggs and egg products | 0.16 | 5.0 | 0.40 | 2.7 | 0.32 | 2.4 | 0.52 | 2.9 | 0.66 | 2.5 | 0.49 | 2.8 | 0.55 | 2.8 |
| Drinking water | 2.8 | 13 | 0.30 | 2.7 | 0.001 | 1.5 | <0.001 | 2.0 | 0.15 | 1.9 | 0.18 | 0.91 | 0.12 | 0.68 |
| Starchy roots and tubers | 0.24 | 2.2 | 0.10 | 1.9 | 0.18 | 1.7 | 0.19 | 2.3 | 0.2 | 2.1 | 0.20 | 1.3 | 0.28 | 1.5 |
| Milk and dairy products | 1.1 | 6.9 | 0.33 | 2.2 | 0.27 | 1.3 | 0.17 | 0.8 | 0.073 | 0.8 | 0.065 | 0.41 | 0.09 | 0.5 |
| Legumes, nuts and oilseeds | <0.010 | 0.10 | <0.001 | 0.054 | <0.001 | 0.072 | <0.001 | 0.067 | <0.001 | 0.05 | <0.001 | 0.064 | 0.001 | 0.052 |
| Sugar and confectionary | <0.001 | 0.013 | <0.001 | 0.023 | 0.001 | 0.050 | 0.001 | 0.039 | 0.002 | 0.040 | 0.002 | 0.055 | 0.002 | 0.051 |

### 4.5.2. Perfluorooctane acid (PFOA)

The detailed results of the chronic dietary exposure calculations for the different dietary surveys and age classes are presented in Table 24. The results are presented as lower bound and upper bound estimates for average consumers and high consumers across dietary surveys.

*Infants*
Food consumption information for infants was available only from two dietary surveys, one of which included very few survey participants (Table 2). Therefore, the variation between the lower bound mean exposure of 0.16 ng/kg b.w. per day and the upper bound 95$^{th}$ percentile exposure of 15 ng/kg b.w. per day should be taken only as a rough indication for the chronic dietary exposure in European infants.

*Toddlers*
Mean dietary exposure ranged from 0.20 ng/kg b.w. per day (LB) to 17 ng/kg b.w. per day (UB) and 95$^{th}$ percentile exposure ranged from 0.44 ng/kg b.w. per day (LB) to 32 ng/kg b.w. per day (UB).

*Other children*
Mean dietary exposure ranged from 0.10 ng/kg b.w. per day (LB) to 13 ng/kg b.w. per day (UB) and 95$^{th}$ percentile exposure ranged from 0.28 ng/kg b.w. per day (LB) to 30 ng/kg b.w. per day (UB).

*Adolescents*
Mean dietary exposure ranged from 0.07 ng/kg b.w. per day (LB) to 5.4 ng/kg b.w. per day (UB) and 95$^{th}$ percentile exposure ranged from 0.20 ng/kg b.w. per day (LB) to 10 ng/kg b.w. per day (UB).

*Adults*
Mean dietary exposure ranged from 0.08 ng/kg b.w. per day (LB) to 4.3 ng/kg b.w. per day (UB) and 95$^{th}$ percentile exposure ranged from 0.22 ng/kg b.w. per day (LB) to 7.7 ng/kg b.w. per day (UB).

*Elderly*
Mean dietary exposure ranged from 0.11 ng/kg b.w. per day (LB) to 4.3 ng/kg b.w. per day (UB) and 95$^{th}$ percentile exposure ranged from 0.21 ng/kg b.w. per day (LB) to 7.2 ng/kg b.w. per day (UB).

*Very elderly*
Mean dietary exposure ranged from 0.10 ng/kg b.w. per day (LB) to 4.1 ng/kg b.w. per day (UB) and 95$^{th}$ percentile exposure ranged from 0.19 ng/kg b.w. per day (LB) to 5.9 ng/kg b.w. per day (UB).

The highest PFOA exposure estimates across age classes were observed in toddlers and other children. This is due to the higher food consumption per kg b.w. of children compared to adults.

Compared to the TDI for PFOA set by the EFSA CONTAM Panel (1500 ng/kg b.w. per day), it can be noted that although the upper bound results are highly overestimated, the chronic dietary exposure in all age classes and for both average and high consumers are well below the TDI. For adults, the highest upper bound mean estimate (4.3 ng/kg b.w. per day) represents 0.3 % of the TDI while the highest 95$^{th}$ percentile estimate (7.7 ng/kg b.w. per day) represents 0.5 % of the TDI. In toddlers, the age class having the highest exposure, the same parameters represents respectively 1.1 % and 2.1 % of the TDI.

The contribution of each of the FoodEx Level 1 food categories to overall PFOA exposure was calculated for each age class and the European population as shown in Figure 6. The highest contributors across all age classes for the lower bound results (less influenced by left-censored data) were 'Fruits and fruit products' (18 to 39 %) and 'Fish and other seafood' (7.6 to 27 %). The high contribution of 'Fruit and fruit products' should be interpreted with caution as only a relatively limited number of data was available for this food group. Average contribution of 'Eggs and egg products' ranged from 10 to 15 % across age classes. 'Meat and meat products' contributed on average with 2.2 to 11 %. Although the highest high PFOA concentrations were found in edible offal of game

animals, due to their rare consumption they have a negligible contribution to the overall chronic dietary exposure. The highest average contribution of 'Drinking water' was in infants (up to 51 %) whereas in other age classes its average contribution ranged from 7 to 16 %. The contribution of 'Vegetables and vegetable products' accounted on average for 4.4 % to 8 % across age classes. Alcoholic beverages' (namely beer) contributed up to 16 % in adults and had a much lower or no contribution at all in children. 'Grains and grains-based products', Legumes nuts and oilseeds', 'Starchy roots and tubers', 'Milk and dairy products', 'Animal and vegetable fats and oils' and 'Sugar and confectionery' had a minor contribution.

Based on lower bound estimates PFOA dietary exposure patterns varied considerably across the different surveys even at broad food category level. Minimum and maximum contributions of the broad food categories to overall lower bound mean PFOA exposure across the dietary surveys and age groups are shown in Table 25.

Compared to the indicative chronic dietary exposure estimated by the EFSA Scientific Panel on Contaminants in 2008, the current results are in the same order of magnitude although a broad list of food groups was considered in the current assessment. This is because the 2008 assessment was based on 'Fish and fishery products' with an average concentration of 2.1 µg/kg and drinking water with a mean concentration of 0.00937 µg/kg while in the present report the mean concentrations for the two food groups were even in the upper bound 3 times lower. In the 2008 assessment, only a limited number of occurrence data were available and they were very likely obtained from more targeted samples.

The dietary exposure estimates of the present assessment are in line with those reported in recent years showing a dietary exposure to PFOS and PFOA in the low ng/kg b.w. per day or even lower (BFR, 2008; AFSSA, 2009; Ericson Jogsten et al., 2009; Fromme et al., 2009; Kärrman et al., 2009; Haug et al., 2010b; VWA, 2010; Cornelis, 2012).

**Table 24:** Mean and 95th percentile (P95) chronic dietary exposure to PFOA (ng/kg b.w. per day) for total population in lower-bound and upper-bound scenario.

| Code[(a)] | Range of dietary exposure (LB – UB) (ng/kg b.w. per day) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Infants | | Toddlers | | Other children | | Adolescents | | Adults | | Elderly | | Very elderly | |
| | Mean | P95 | Mean | P95 | Mean | P95 | Mean | P95 | Mean | P95 | Mean | P95 | Mean | P95 |
| **BE/1** | | | | | | | 0.09-2.8 | 0.23-5.0 | 0.11-2.5 | 0.29-4.7 | 0.12-2.7 | 0.29-4.9 | 0.11-2.7 | 0.26-4.9 |
| **BE/2** | | | 0.22-11 | -[(b)] | 0.18-8.8 | 0.43-15 | | | | | | | | |
| **BG** | 0.19-5.0 | 0.46-15 | 0.31-10 | 0.64-16 | 0.27-8.6 | 0.6-14 | | | | | | | | |
| **CY** | | | | | | | 0.07-2.8 | 0.20-5.2 | | | | | | |
| **CZ** | | | | | 0.27-7.7 | 0.58-14 | 0.18-5.4 | 0.42-10 | 0.17-3.2 | 0.41-5.7 | | | | |
| **DE/1** | | | 0.28-7.1 | 0.67-13 | 0.21-5.1 | 0.42-8.6 | | | | | | | | |
| **DE/2** | | | 0.25-7.5 | 0.49-13 | 0.20-5.4 | 0.44-9.6 | | | | | | | | |
| **DE/3** | | | 0.28-7.5 | 0.51-13 | 0.19-5.3 | 0.44-9.0 | | | | | | | | |
| **DE/4** | | | | | | | 0.07-2.0 | 0.22-4.0 | 0.11-2.0 | 0.28-3.8 | 0.13-2.2 | 0.31-4.1 | 0.12-2.3 | 0.27-4.2 |
| **DK** | | | | | 0.26-8.3 | 0.49-14 | 0.14-4.7 | 0.27-8.0 | 0.15-3.4 | 0.28-5.7 | 0.17-3.7 | 0.31-6.2 | 0.16-4.1 | -[(b)] |
| **EL** | | | | | 0.15-8.7 | 0.40-16 | | | | | | | | |
| **ES/1** | | | | | | | | | 0.19-3.2 | 0.39-5.6 | | | | |
| **ES/2** | | | | | | | 0.19-3.8 | 0.33-6.3 | 0.22-3.8 | 0.41-6.1 | | | | |
| **ES/3** | | | | | 0.25-6.4 | 0.53-10 | 0.15-3.7 | 0.38-6.4 | | | | | | |
| **ES/4** | | | 0.35-11 | -[(b)] | 0.22-7.3 | 0.60-14 | 0.15-4.2 | 0.39-7.8 | | | | | | |
| **FI/1** | | | 0.37-17 | 0.89-32 | 0.28-13 | 0.65-20 | | | | | | | | |
| **FI/2** | | | | | | | | | 0.16-4.2 | 0.43-7.4 | 0.16-4.3 | 0.39-7.2 | | |
| **FI/3** | | | | | 0.29-6.8 | 0.74-10 | | | | | | | | |
| **FR** | | | | | 0.21-6.7 | 0.40-11 | 0.11-3.6 | 0.25-6.4 | 0.12-2.7 | 0.25-4.6 | 0.15-3.0 | 0.29-5.0 | 0.14-3.0 | 0.24-4.9 |
| **HU** | | | | | | | | | 0.12-3.7 | 0.26-6.3 | 0.11-3.3 | 0.21-5.4 | 0.10-3.6 | 0.19-5.9 |
| **IE** | | | | | | | | | 0.13-4.3 | 0.31-7.7 | | | | |
| **IT** | 0.16-11 | -[(b)] | 0.49-11 | -[(b)] | 0.31-7.8 | 0.67-14 | 0.18-4.6 | 0.36-7.6 | 0.15-3.2 | 0.30-5.4 | 0.16-3.0 | 0.32-5.0 | 0.15-2.9 | 0.27-4.5 |
| **LV** | | | | | 0.10-5.1 | 0.28-11 | 0.08-3.7 | 0.22-7.6 | 0.08-2.8 | 0.22-5.4 | | | | |
| **NL/1** | | | | | | | | | 0.09-2.6 | 0.28-4.6 | | | | |
| **NL/2** | | | 0.2-8.2 | 0.44-15 | 0.16-6.3 | 0.38-11 | | | | | | | | |
| **SE/1** | | | | | | | | | 0.14-3.1 | 0.28-5.2 | | | | |
| **SE/2** | | | | | 0.17-6.8 | 0.41-11 | 0.08-4.3 | 0.21-7.7 | | | | | | |
| **UK** | | | | | | | | | 0.13-2.9 | 0.28-4.6 | | | | |
| **Minimum** | 0.16-5.0 | 0.46-15 | 0.2-7.1 | 0.44-13 | 0.10-5.1 | 0.28-8.6 | 0.07-2.0 | 0.20-4.0 | 0.08-2.0 | 0.22-3.8 | 0.11-2.2 | 0.21-4.1 | 0.10-2.3 | 0.19-4.2 |
| **Median** | | | 0.28-10 | 0.58-14 | 0.21-6.8 | 0.44-11 | 0.13-3.8 | 0.26-7.0 | 0.13-3.2 | 0.28-5.4 | 0.15-3.0 | 0.31-5.0 | 0.13-3.0 | 0.26-4.9 |
| **Maximum** | 0.19-11 | 0.46-15 | 0.49-17 | 0.89-32 | 0.31-13 | 0.74-20 | 0.19-5.4 | 0.42-10 | 0.22-4.3 | 0.43-7.7 | 0.17-4.3 | 0.39-7.2 | 0.16-4.1 | 0.27-5.9 |

(a): Details on the dietary surveys and the number of subjects are given in Table 2; (b): P95 estimates for dietary surveys/age classes with less than 60 observations are not statistically robust (EFSA, 2011) and therefore not presented.

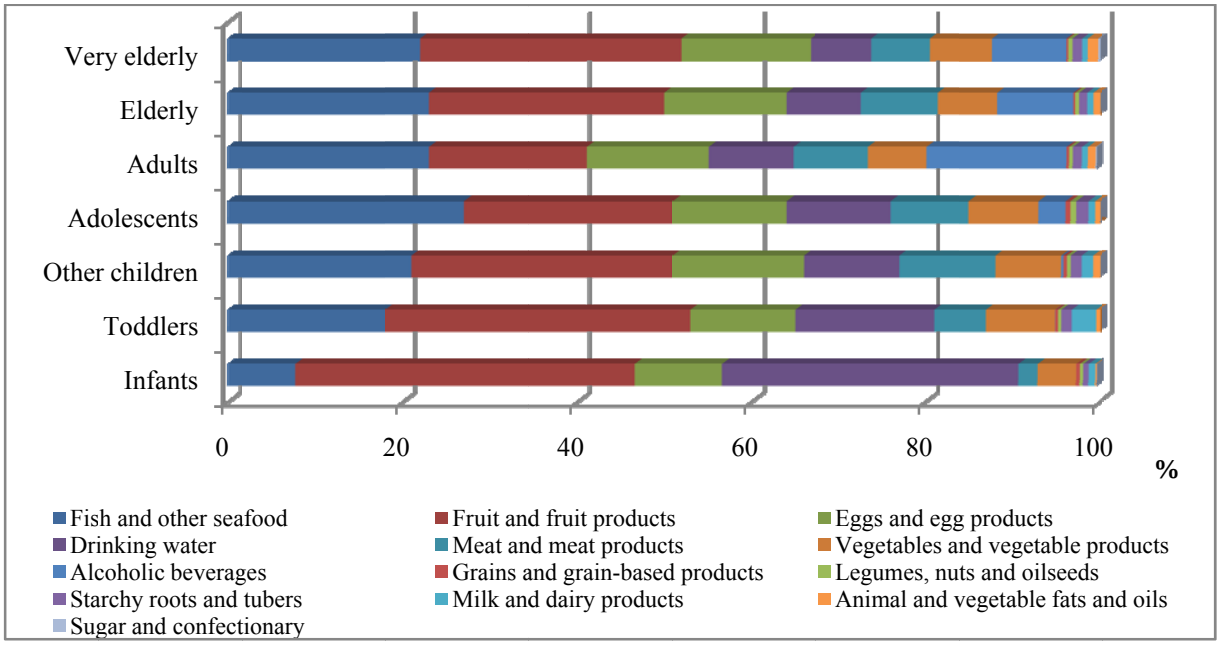


**Figure 6:** Average contribution (in percentage) of broad food groups to overall lower bound mean PFOA exposure per age group.

**Table 25:** Minimum and maximum relative contributions in percent of broad food groups to overall lower bound mean PFOA exposure across the surveys included for each age group.

| Food group | Infants | | Toddlers | | Other children | | Adolescents | | Adults | | Elderly | | Very elderly | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| Fish and other seafood | 2.5 | 13 | 4.2 | 43 | 7.2 | 45 | 9.7 | 48 | 9.0 | 41 | 6.0 | 31 | 6.4 | 31 |
| Fruit and fruit products | 17 | 61 | 21 | 51 | 12 | 49 | 15 | 39 | 12 | 32 | 16 | 41 | 20 | 43 |
| Eggs and egg products | 2.2 | 18 | 0.1 | 28 | 0.1 | 27 | 0.1 | 23 | 6.8 | 28 | 6.4 | 25 | 6.8 | 26 |
| Drinking water | 18 | 51 | 4.1 | 31 | 0.01 | 19 | 0.01 | 21 | 0.59 | 18 | 0.61 | 17 | 0.36 | 11 |
| Meat and meat products | 1.7 | 2.7 | 1.2 | 15 | 2.1 | 58 | 5.6 | 13 | 4.0 | 21 | 4.8 | 22 | 4.1 | 9.3 |
| Vegetables and vegetable products | 3.2 | 5.6 | 5.2 | 12 | 3.0 | 14 | 4.2 | 14 | 3.5 | 11 | 3.7 | 11 | 4.5 | 11 |
| Alcoholic beverages | 0 | 0 | 0 | 0.23[(a)] | 0 | 1.2[(a)] | 0 | 14 | 2.7 | 36 | 0.95 | 18.9 | 0.34 | 21 |
| Grains and grain-based products | 0.33 | 0.51 | 0.01 | 0.57 | 0.03 | 1.1 | 0.17 | 1.6 | 0.13 | 0.57 | 0.06 | 0.37 | 0.06 | 0.38 |
| Legumes, nuts and oilseeds | 0.38 | 0.38 | 0.10 | 1.1 | 0.07 | 1.7 | 0.18 | 1.5 | 0.12 | 1.2 | 0.14 | 1.1 | 0.13 | 1.16 |
| Starchy roots and tubers | 0.4 | 0.89 | 0.33 | 2.7 | 0.56 | 2.9 | 0.62 | 3.0 | 0.4 | 2.4 | 0.46 | 1.4 | 0.52 | 1.6 |
| Milk and dairy products | 0.6 | 0.97 | 0.54 | 14 | 0.27 | 5.9 | 0.21 | 1.4 | 0.22 | 1.3 | 0.36 | 1.2 | 0.27 | 1 |
| Animal and vegetable fats and oils | 0.01 | 0.34 | 0.04 | 2.2 | 0.06 | 2.3 | 0.05 | 1.9 | 0.05 | 2.0 | 0.05 | 2.5 | 0.06 | 2.8 |
| Sugar and confectionary | 0.01 | 0.03 | 0.01 | 0.32 | 0.02 | 0.51 | 0.01 | 0.32 | 0.01 | 0.37 | 0.02 | 0.58 | 0.03 | 0.59 |

(a): mainly due to consumption of alcohol-free bier and bier-like beverages (malt drink).

### 4.5.3. Other PFASs

Considering the high proportion of left-censored data (93 to 99.9 %) and the limited number of food groups with quantified results in the data sets of the remaining 14 PFASs (PFPA, PFHxA, PFHpA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA, PFBS, PFHxS, PFHpS, PFDS and FOSA), the upper bound scenario has to be regarded as a very conservative approach. The calculated estimates aim to give a rough idea about the range of chronic dietary exposure.

Based on the available data with high proportion of left-censored results, the chronic dietary exposure to the 14 individual PFASs is expected to be at the level of a few ng/kg b.w. at the highest. By analogy, for the eleven PFAS where no quantified results were reported by applying analytical methods with similar detection capabilities, the chronic dietary exposure should be even lower. In the case toxicological data would demonstrate the necessity for a more refined dietary exposure assessment, data obtained by more sensitive analytical methods would be needed in order to increase the proportion of quantified results and thus increase the accuracy of the dietary exposure assessment.

**Table 26:** Indicative mean and 95$^{th}$ percentile (P95) chronic dietary exposure to PFASs (ng/kg b.w. per day) for adults in lower-bound (LB) and upper-bound (UB) scenarios.

| PFAS | Range of indicative dietary exposure in adults (LB – UB) (ng/kg b.w. per day) | | | | | |
|---|---|---|---|---|---|---|
| | Average consumers | | | High consumers | | |
| | Minimum | Median | Maximum | Minimum | Median | Maximum |
| PFPA | 0.01-0.73 | 0.01-1.1 | 0.03-2.1 | 0.02-1.79 | 0.03-2.12 | 0.11-3.63 |
| PFHxA | 0.05-1.18 | 0.07-1.65 | 0.12-2.65 | 0.14-2.56 | 0.18-2.94 | 0.26-4.41 |
| PFHpA | 0.02-1.74 | 0.07-2.6 | 0.11-3.77 | 0.06-3.61 | 0.18-4.39 | 0.26-6.76 |
| PFNA | 0.02-1.49 | 0.03-1.95 | 0.05-3.18 | 0.06-3.12 | 0.09-3.84 | 0.13-6.22 |
| PFDA | 0.01-0.99 | 0.02-1.34 | 0.07-2.82 | 0.04-2.03 | 0.09-2.38 | 0.18-4.98 |
| PFUnDA | 0.01-0.61 | 0.03-0.92 | 0.09-1.81 | 0.05-1.48 | 0.12-1.79 | 0.23-3.09 |
| PFDoDA | 0.01-0.89 | 0.03-1.13 | 0.05-1.73 | 0.04-1.93 | 0.07-2.35 | 0.13-3.57 |
| PFTrDA | 0.01-0.51 | 0.03-0.68 | 0.08-1.22 | 0.05-1.02 | 0.10-1.3 | 0.21-2.21 |
| PFTeDA | <0.01-0.67 | <0.01-0.94 | <0.01-1.69 | <0.01-1.4 | 0.01-1.85 | 0.01-3.12 |
| PFBS | 0.03-1.89 | 0.07-2.55 | 0.10-3.72 | 0.08-3.88 | 0.18-4.67 | 0.25-6.91 |
| PFHxS | 0.03-0.91 | 0.05-1.22 | 0.08-1.93 | 0.11-1.83 | 0.13-2.25 | 0.18-3.63 |
| PFHpS | <0.01-0.08 | <0.01-0.11 | <0.01-0.21 | <0.01-0.18 | <0.01-0.25 | <0.01-0.69 |
| PFDS | <0.01-0.29 | <0.01-0.45 | 0.01-0.80 | 0.01-0.77 | 0.01-0.89 | 0.02-1.48 |
| FOSA | 0.03-1.69 | 0.19-2.45 | 0.58-4.19 | 0.23-4.03 | 0.67-5.4 | 2.21-7.7 |

### 4.6. Uncertainties

In Table 27, a summary of the uncertainty evaluation is presented, highlighting the main sources of uncertainty and indicating an estimate of whether the respective source of uncertainty might have led to an over- or underestimation of the mean contamination levels or the calculated dietary exposure.

**Table 27:** Summary of qualitative evaluation of the impact of uncertainties on the dietary exposure to PFASs.

| Sources of uncertainty | Direction [(a)] |
|---|---|
| Uncertainty of the analytical measurements | +/- |
| Sampling strategy: random/targeted | + |
| Occurrence data on food available from a limited number of countries | +/- |
| Limited occurrence data for a number of PFASs (e.g. PAPs) | - |
| Use of LB occurrence data in the exposure estimations | - |
| Use of UB occurrence data in the exposure estimations | + |
| Limited food consumption data on infants | +/- |

(a): + = uncertainty with potential to cause overestimation of exposure; - = uncertainty with potential to cause underestimation of exposure

The PFASs occurrence data were submitted by 13 European countries with the vast majority (86%) of data originating from three countries. Thus, the occurrence data have only a limited representativeness for Europe. Also, part of he sampling may have been focused on contaminated areas thus leading to an overestimation of the exposure estimates. The use of the UB approach for occurrence data sets with high percentage of results < LODs/LOQs is conservative, i.e. it represents a clear overestimation of exposure. There was a lack of dietary surveys reporting consumption data for children younger than 1 year, which led to an even higher uncertainty in this area.

## CONCLUSIONS AND RECOMMENDATIONS

### CONCLUSIONS

- The present assessment is based on 54,195 observations obtained on 7,560 food samples collected in the period 2006 – 2012 from 13 European countries. Samples were analysed for various sets of PFASs covering in total 27 substances.

- Overall, the proportion of quantified results was low. The most frequently found PFASs were PFOS (29 %) followed by PFOA (9 %), FOSA (7 %), PFUnDA (7 %), PFDA (6 %), PFDoDA (6 %), PFTriDA (6 %), PFNA (5 %), PFHxA (4 %), PFPA (3 %), PFHpA (2 %), PFBS (2 %), PFHxS (2 %), PFDS (0.7 %), PFTeDA (0.6 %) and PFHpS (0.1 %). No quantified results were reported for PFBA, PFPeDA, PFHxDA, PFODA, PFOSI, 8:2 FTOH, 8:2 monoPAP, 8:2 diPAP, EtFOSA, EtFOSE and FC-807.

- PFASs were reported more frequently in fish and other seafood, in meat and meat products and with less extent in fruits and fruit products, vegetables and drinking water. The highest concentrations for the different PFASs were found in edible offal and in particular in liver.

- Chronic dietary exposure was calculated using overall European lower and upper bound mean occurrence of PFASs. The low proportion of quantified results was a limiting factor in performing the exposure assessment. Therefore, the upper bound results are highly overestimated and they should be regarded as very conservative estimates.

- The EFSA Scientific Panel on Contaminants (CONTAM) established in 2008 TDIs for PFOS (150 ng/kg b.w. per day) and PFOA (1500 ng/kg b.w. per day), thus the exposure assessment was focused on the two substances. The chronic dietary exposure to PFOS and PFOA was in all age classes and for both average and high consumers well below the TDI.

- For PFOS, the highest upper bound mean exposure estimates for the adult population (5.2 ng/kg b.w. per day) represented 3.5 % of the TDI while the highest 95$^{th}$ percentile estimate (10 ng/kg b.w. per day) represented 6.7 % of the TDI. In toddlers, the age class having the highest exposure, the same parameters represented 9.3 % and 19 % of the TDI, respectively.

- For PFOA, the highest upper bound mean exposure estimates for the adult population (4.3 ng/kg b.w. per day) represented 0.3 % of the TDI while the highest 95$^{th}$ percentile estimate (7.7 ng/kg b.w. per day) represented 0.5 % of the TDI. In toddlers, the age class having the highest exposure, the same parameters represented 1.1 % and 2.1 % of the TDI, respectively.

- Main contributors to dietary exposure to PFOS and PFOA were fish and other seafood, fruits and fruit products and meat and meat products but high variation in contribution was observed across dietary studies and age classes reflecting differences in dietary patterns.

- Based on the available data with only very few quantified results, the chronic dietary exposure to other 25 single PFASs is expected to be in low ng/kg b.w. per day range or even lower. Since no TDIs are available for those PFASs, it was not possible to evaluate the relevance of the dietary exposure for human health.

## RECOMMENDATIONS

- Based on further results from toxicological evaluations, the relevance of various PFASs to human health could be better established and allow the definition of a set of priority PFASs for future monitoring.

- The use of analytical methods with improved sensitivity would be required to monitor such priority PFASs in order to increase the proportion of quantified results and thereby the reliability of exposure assessments.

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## ABBREVIATIONS

| | |
|---|---|
| (n:2) FTOHs | (n:2) Fluorotelomer alcohols |
| 8:2 diPAP | 8:2 fluorotelomer posphate diesters |
| 8:2 monoPAP | 8:2 fluorotelomer posphate monoester |
| 8-2 FTOH | 8:2 Fluorotelomer alcohol |
| b.w. | Body weight |
| EFSA | European Food Safety Authority |
| EtFASAs | Perfluoroalkane sulfonamides |
| EtFASEs | N-Ethyl perfluoroalkane sulfonamidoethanol |
| EtFOSA | N-ethylperfluorooctane sulfonamide |
| EtFOSE | N-Ethyl perfluorooctane sulfonamidoethanol |
| FASAs | Perfluoroalkane sulfonamides |
| FC-807 | Perfluoroalkyl phosphate |
| FoodEx | Food classification system developed by EFSA for undertaking |
| FOSA | Perfluorooctane sulfonamide |
| LB | Lower bound - left-censored result entered as zero |
| LC | Left-censored result - results below the respective analytical limit |
| LOD | Limit of detection |
| LOQ | Limit of quantification |
| PAPs | Polyfluoroalkyl phosphoric acid esters |
| PFASs | Perfluoroalkylated substances |
| PFBA | Perfluorobutanoic acid |
| PFBS | Perfluorobutane sulfonic acid |
| PFCAs | Perfluoroalkyl carboxylic acids |
| PFDA | Perfluorodecanoic acid |
| PFDoDA | Perfluorododecanoic acid |
| PFDS | Perfluorodecane sulfonic acid |
| PFHpA | Perfluoroheptanoic acid |
| PFHpS | Perfluoroheptane sulfonic acid |
| PFHxA | Perfluorohexanoic acid |
| PFHxDA | Perfluorohexadecanoic acid |
| PFHxS | Perfluorohexane sulfonic acid |
| PFNA | Perfluorononanoic acid |
| PFOA | Perfluorooctanoic acid |
| PFODA | Perfluorooctadecanoic acid |
| PFOS | Perfluorooctane sulfonic acid |
| PFOSI | Perfluorooctane sulfinic acid |
| PFPA | Perfluoropentanoic acid |
| PFPeDA | Perfluoropentadecanoic acid |
| PFSAs | Perfluoroalkane sulfonic acids |
| PFSIAs | Perfluoroalkane sulfinic acids |
| PFTeDA | Perfluorotetradecanoic acid |
| PFTrDA | Perfluorotridecanoic acid |
| PFUnDA | Perfluoroundecanoic acid |
| TDI | Tolerable Daily Intake |
| UB | Upper bound – left-censored result entered at the respective analytical limit |