27th Australian Total Diet Study

Per- and poly-fluoroalkyl substances

December 2021

Foreword

Food Standards Australia New Zealand (FSANZ) is part of a world class Australian and New Zealand joint Food Regulation System. Our primary role involves developing and reviewing food standards to protect public health and safety, help consumers make informed choices and prevent misleading or deceptive conduct.

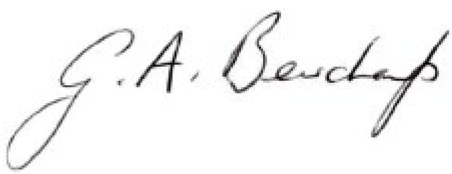
We also monitor the safety of the food supply through our Australian Total Diet Study (ATDS) – one of Australia's most comprehensive food surveys. Run every two to three years, the survey looks at consumers' exposure to a range of chemicals found in food. This information helps us assess where risks to the safety of food may be and how we should respond to and address these risks.

First undertaken in 1970, the ATDS has continued to evolve in its scope and frequency over the past 50 years. This has seen an expansion from a traditional focus on pesticide residues and metal contaminants to a wider range of food chemicals including additives, nutrients, naturally occurring toxins, industrial chemicals, food processing contaminants and food packaging chemicals. The ATDS enables FSANZ to monitor changes to the food supply over time to reflect new scientific information and the evolving nature of food industry and regulatory environments.

The 27th ATDS focuses on a range of per- and poly-fluoroalkyl substances, collectively referred to as PFAS. PFAS are used for industrial purposes and are a concern for regulators due to their environmental mobility, persistence and potential effects on environmental and human health. The 27th ATDS was undertaken on request from the Food Regulation Standing Committee (FRSC) due to concerns in Australia related to contamination of sites where there has been historical use of PFAS-containing firefighting foam. The aim of this study was to obtain data on PFAS levels in the general food supply and to estimate dietary exposures for the general population as this information was previously not available.

Pleasingly, the 27th ATDS confirms the safety of the general Australian food supply with respect to PFAS levels.

I extend my thanks to the staff of FSANZ and partnering agencies who have contributed to the production of this important report and the ongoing monitoring of the Australian food supply, to ensure it continues to be one of the safest food supplies in the world.



Ms Glenys Beauchamp PSM

Chair

Contents

Acronyms and abbreviations

µg	Microgram
ATDS	Australian Total Diet Study
bw	Body weight
EFSA	European Food Safety Authority
FRSC	Food Regulation Standing Committee
FSANZ	Food Standards Australia New Zealand
HED	Human equivalent dose
HRMS	High resolution mass spectrometry
ISO/IEC	International Organisation for Standardisation/International Electrotechnical Commission
ITRC	Interstate Technology Regulatory Council
K	Potassium
kg	Kilogram
LB	Lower bound
Li	Lithium
LOD	Limit of detection
LOR	Limit of reporting
MB	Middle bound
ML	Maximum level
n	Number
NATA	National Association of Testing Authorities
ND	Not-detected
ng	Nanogram
NH_4	Ammonium
NHMRC	National Health and Medical Research Council
NNPAS	Australian National Nutrition and Physical Activity Survey
NOAEL	No observed adverse effect level
P90	90th percentile
PFAA	Perfluoroalkyl acid
PFAS	Per- and poly-fluoroalkyl substances
PFHxS	Perfluorohexane sulfonic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonic acid
TDI	Tolerable Daily Intake
TDS	Total Diet Study

UB	Upper bound
UHPLC	Ultra high performance liquid chromatography

Key findings

Overview

- The 27th Australian Total Diet Study (ATDS) investigated a broad range of Australian foods and beverages for levels of per- and poly-fluoroalkyl substances (PFAS).
- The study found that levels of PFAS in the general Australian food supply are very low.
    - Perfluorooctane sulfonic acid (PFOS) was the only congener detected of 30 different PFAS for which analysis was conducted. PFOS was detected in five of 112 food types and in less than 2% of all samples.
    - Levels of PFAS in Australian foods were consistently lower than those found in overseas studies conducted in Europe, the United States, the United Kingdom and China.
    - Levels of PFAS were well below Australian guidance values including Food Standards Australia New Zealand (FSANZ) trigger points for site investigation and National Health and Medical Research Council (NHMRC) drinking water guidelines.
- The overall dietary exposure to PFOS for the general Australian population is lower than the Tolerable Daily Intake (TDI) indicating no public health and safety concerns.

Conclusions

- The 27th ATDS confirms the safety of the general Australian food supply with regards to levels of PFAS.
- There is no current need to consider establishing food regulatory measures such as maximum levels (MLs) for PFAS in the Australia New Zealand Food Standards Code (the Code).
- FSANZ continues to support Australian government agencies in the investigation and management of localised PFAS contamination where there has been historical use of PFAS-containing firefighting foams.

Highlights

27th Australian Total Diet Study

The 27th ATDS looked at a wide range of Australian foods and beverages for the presence of chemicals known as per- and poly-fluoroalkyl substances (PFAS) Results were used to estimate dietary exposure for Australian consumers.

We tested for **30** types of PFAS.

In **112** commonly eaten foods and beverages and **1,336** composite samples.

Samples were collected from capital cities and regional centres from **all states and territories.** They were taken over **2 seasons** to account for seasonal variations.

Only **1 type of PFAS** was detected - perfluorooctane sulfonic acid (PFOS).
It was found in **less than 2%** of all samples and the overall dietary exposure for the general Australian population is lower than the Tolerable Daily Intake.

Overall, the results indicate:

- PFAS levels in the general food supply are very low
- there are no public health and safety concerns for the general Australian population, and
- there is no current need for additional risk management measures (like maximum levels) in the Australia New Zealand Food Standards Code.

Executive summary

Per- and poly-fluoroalkyl substances (PFAS) are a large group of chemicals used for various industrial purposes due largely to their heat-, stain-, grease- and water-resistant properties. The use of PFAS has been subject to international scrutiny due to their persistence in the environment and potential effects on human health. In Australia, there have been recent concerns regarding contamination of sites where there has been historical use of firefighting foams that contained PFAS.

The 27th Australian Total Diet Study (ATDS) investigated a broad range of Australian foods and beverages for levels of PFAS. Results were used to estimate dietary exposure and assess public health and safety risks for the general Australian population. The outcomes of the risk assessment were used to determine whether risk management measures are required to ensure the continued safety of the general Australian food supply.

A total of 112 commonly consumed foods and beverages were sampled from all Australian states and territories. Samples were collected over two sampling periods from June – September 2019 and January – April 2020. A total of 4,008 primary food samples were purchased from retail outlets and combined into 1,336 composite samples for analysis. Composite samples were analysed for 30 different PFAS including three congeners of primary interest for food safety: perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS) and perfluorohexane sulfonic acid (PFHxS).

The levels of PFAS in the general Australian food supply are very low. PFOS was the only congener detected in five of the 112 food types and in less than 2% of all samples. The mean PFOS levels in these foods (assuming non-detects = 0) were mammalian offal (0.63 µg/kg), canned tuna (0.070 µg/kg), prawns (0.018 µg/kg), saltwater fish fillets (0.011 µg/kg) and chicken eggs (0.0069 µg/kg). There were no detections of the other 29 PFAS analysed including PFOA and PFHxS.

PFAS levels found in the 27th ATDS were consistently lower than reported concentrations in overseas studies conducted in Europe, the United States, the United Kingdom and China. They were also below the current FSANZ (2017c) trigger points for site investigation[1] and Australian drinking water guideline levels (NHMRC, 2019)[2].

Estimated dietary exposure to PFOS for Australian consumers aged two years and above was estimated to be <1 – 13% of the Tolerable Daily Intake (TDI) depending on the scenario modelled. These results indicate there are no public health and safety concerns for the general Australian population.

The results of the 27th ATDS indicate that PFAS levels in the general Australian food supply are as low as reasonably achievable and safe for Australian consumers. Hence, there is no current need for FSANZ to consider food regulatory measures such as maximum levels (MLs) in the Australia New Zealand Food Standards Code (the Code). FSANZ continues to support other Australian government agencies regarding on site measures to assess and

---

[1] Developed to assist authorities analysing PFAS in foods in identifying when further investigation and management may be required.

[2] Developed to assist regulators and authorities determine the quality of Australian drinking water.

manage localised contamination of areas where there has been historical use of PFAS-containing firefighting foams.

1. Introduction

1.1 Background

The ATDS is the one of the most comprehensive monitoring surveys of the Australian food supply. It measures the levels of various substances in a broad range of foods and beverages typical of the Australian diet. These substances include agricultural and veterinary chemicals, contaminants, natural toxicants, nutrients and food additives. The primary purpose of the ATDS is to estimate dietary exposure for the general Australian population to these substances. For this reason, food samples are prepared to a 'ready-to-eat' state prior to analysis to reflect how they are consumed. The ATDS provides valuable information to assess the safety of the food supply and ensure the continued effectiveness of food regulatory measures. Further background information on the ATDS is available on our website (FSANZ, 2021a).

1.2 The 27th ATDS

The 27th ATDS involved the sampling and analysis of 112 different Australian foods and beverages for levels of PFAS. A total of 30 congeners[3] were analysed including three principal congeners that may be found in contaminated food: PFOA, PFOS and PFHxS (FSANZ, 2021b). A full list of substances analysed in the 27th ATDS is provided in Appendix 1.

PFAS are widely used for industrial purposes. Environmental contamination (including foods) is a concern for Australian and overseas regulators. Some PFAS are highly mobile and persistent in the environment. They are potentially toxic and can accumulate in animals which come into contact with them. PFOA and PFOS are listed as persistent organic pollutants (POPs) under the Stockholm Convention in Annex A (elimination) and Annex B (restriction), respectively. PFHxS has also been proposed for listing under the Convention (Stockholm Convention, 2021).

FSANZ (2010 and 2016) previously undertook two surveys of PFAS in the Australian food supply to investigate potential migration from food packaging. These studies found that migration of PFAS from food packaging was very low and posed no public health and safety concerns.

There have been recent concerns in Australia associated with potential contamination of sites where there has been historical use of PFAS-containing firefighting foams. FSANZ continues to support Australia's whole-of- government response to localised PFAS contamination concerns. In 2017, FSANZ completed hazard and dietary exposure assessments and provided advice on risk management options for PFAS in foods (Department of Health, 2021). As part of this work, FSANZ established health-based guidance values in the form of tolerable daily intakes (TDI) for PFOA and PFOS. There was insufficient information to justify establishing a TDI for PFHxS. However it was concluded that using the TDI for PFOS is likely to be a conservative interim measure to protect public health and safety. In practice this means that PFHxS and PFOS exposure should be summed for the purposes of risk assessment. FSANZ also consolidated available information including PFAS occurrence data from various site investigations around Australia. There were

[3] Congeners – related chemical substances, in this case belonging to the group: per- and poly-fluoroalkyl substances (PFAS).

insufficient data to assess PFAS levels in the general food supply or consider the establishment of MLs. To assist with site investigations and management, FSANZ developed non-regulatory trigger points to assist authorities analysing PFAS in foods in identifying when further investigation may be required (FSANZ, 2017c).

In 2017, the Food Regulation Standing Committee (FRSC) concluded that there was no consistent evidence that PFAS causes any adverse health effects in humans. However, it was recommended that PFAS be included in a future ATDS to provide appropriate ongoing monitoring of the general population's dietary exposure (Food Regulation, 2021).

1.3 Per- and poly-fluoroalkyl substances

PFAS are a large and diverse group of manufactured chemicals which are widely used in industrial processes due to their heat-, stain-, grease- and water-resistant properties. The basic chemical structure of PFAS is a fluorinated organic compound, consisting of a chain of carbon and fluorine atoms (tail) and a non-fluorinated functional group (head). The fluorinated tail is very stable due to the strong carbon-fluorine covalent bond making PFAS persistent in the environment. It is hydrophobic and generally lipophobic, with little to no affinity for water or lipids. The non-fluorinated head of the molecule may be charged and bond more readily with other substances (Buck et al, 2011; Wang et al, 2017). Figure 1 provides the general chemical structure of PFAS.

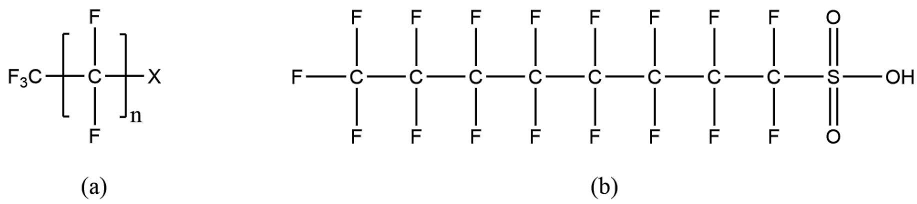


Figure 1: General chemical structure of PFAS (a) and chemical structure of PFOS (b)

There are many different families of PFAS, with unique environmental and biological properties. Some of the most relatively simple and well-studied congeners are perfluoroalkyl acids (PFAAs) which include PFOA, PFOS and PFHxS. These substances are extremely persistent in the environment. Other classes of PFAS are less stable and can break down into simpler PFAS including PFAAs. These include perfluoroalkane sulfonamides, fluorotelomers, perfluoroalkane sulfonamido substances and polymeric PFAS (Buck et al, 2011).

PFAS may occur in various ionic states and structural forms which influence their interaction with the environment and living organisms. They may be anions (negatively charged) or cations (positively charged salts e.g. Li, K, NH_4). Much literature on PFAS focuses on the acid form which is rarely present in the environment. Some PFAS may be both positively and negatively charged dipolar molecules. PFAS can also occur as both linear and branched isomers due to the manufacturing process used (Buck et al, 2011).

1.3.1 Sources of PFAS in the environment and food

The unique properties of PFAS make them useful in a range of industrial applications. These include stain- and water-protection for textiles and leather, paper coating (including food packaging), metal plating and etching, photographic materials, aviation hydraulic fluid, cosmetics and sunscreen, medical devices and as ingredients in firefighting foams (Australian Government, 2021).

Once in the environment, PFAS can be distributed widely through water, soil or air. Some PFAS have the potential to bioaccumulate in animals and biomagnify up the food chain. They have been found at highest levels in the blood, kidney and liver and relatively lower levels in adipose and muscle tissue. As PFAS can have hydrophilic properties, uptake into plants is also possible through contaminated water (ITRC, 2021). The migration of PFAS from food contact materials (including packaging) is considered a potential pathway for contamination of food. However, previous Australian studies have found no public health and safety concerns regarding packaging materials (FSANZ, 2016a). The European Food Safety Authority (EFSA) (2018) concluded that dietary exposure to PFAS from food contact materials is likely to be small compared to other sources.

1.3.2 Regulation of PFAS in foods

For Australian and New Zealand foods, FSANZ sets MLs for specific contaminants in Schedule 19 of Standard 1.4.1 of the Code (FSANZ, 2021c). MLs are only established for contaminants that present a significant risk to public health and safety and in foods that are major contributors to total dietary exposure to those chemicals. MLs are set at levels which are as low as reasonably achievable while reducing dietary exposure to chemicals of public health concern.

There are currently no MLs for PFAS in foods in the Code or overseas regulations. In the absence of MLs, general Code provisions apply including that food must be safe and suitable and levels of PFAS should be kept as low as reasonably achievable.

1.3.3 Australian guidance values for PFAS in foods and drinking water

In 2017, the Department of Health published FSANZ's report 'Perfluorinated Chemicals in Food'. The report included recommended TDIs[4] for PFOA, PFOS and PFHxS, a dietary exposure assessment and risk management advice (FSANZ, 2017a).

FSANZ developed non-regulatory trigger points to assist site investigations and management measures being undertaken by relevant authorities. Trigger points are the maximum concentration level of these chemicals that could be present in individual foods or food groups so even high consumers of these foods would not exceed the relevant TDI. Trigger points were proposed for a range of food commodities which may be sourced on or near potentially contaminated sites including fish and seafood, animal products, fruit and vegetables. They may be used by authorities analysing PFAS in food to indicate when further investigation may be required (FSANZ, 2017c).

The recommended TDIs were used by the National Health and Medical Research Council (NHMRC) to establish health-related guideline values for drinking water. These are established for PFOA and the sum of PFOS and PFHxS at 0.56 µg/L and 0.07 µg/L respectively. While not mandatory standards, they can be used by regulators and authorities to determine the quality of Australian drinking water. They indicate a concentration "that does not result in any significant risk to the health of the consumer over a lifetime of consumption" (NHMRC, 2019).

[4] TDI - a level of daily oral exposure over a lifetime that is considered to be without significant health risk for humans.

2. Survey methods

Food sample purchasing, preparation and analysis were undertaken according to detailed instructions provided in a procedures manual. Details on all food types sampled, together with food preparation procedures, can be found in Appendix 2.

2.1 Food selection and purchasing

The 27th ATDS involved the sampling and analysis of 112 different foods and beverages, including bottled and tap water. A total of 4008 primary samples were collected and combined into 1336 composite samples for analysis. Each composite sample comprised three primary samples of a particular food type from a single state or territory.

Foods were selected according to the following criteria:

a) those which have been shown (through previous investigations) or are suspected to contribute to the dietary exposure of PFAS, and/or
b) represent key food and beverages consumed in Australia.

The food types sampled were classified as either regional or national foods. Regional foods are those that, when sourced from different regions, have the potential to show greater variations in PFAS concentrations. They include fresh meat and meat products, offal, seafood, milk, cheese, fruit, vegetables, bread, takeaway foods and tap water. Higher numbers of regional food samples were collected to account for potential variations in PFAS levels. For each regional food, 16 composite samples were analysed.

National foods are centrally produced and distributed nationwide and therefore are expected to show less variation in PFAS concentrations. These include processed and shelf stable foods such as breakfast cereals, rice, pasta, biscuits, oil, beer, wine, condiments and infant foods. For each national food, eight composite samples were analysed.

Food sample purchasing was undertaken by sampling officers from Australian state and territory food regulatory agencies in capital cities and other metropolitan areas. Sampling took place over two sampling periods to account for the seasonality of some foods. Sampling for phase 1 was conducted from June – September 2019 and for phase 2 from January – April 2020. Food samples were transported to the coordinating analytical laboratory, Symbio Laboratories (Brisbane), as soon as practicable after purchase. Perishable food samples (including fresh meat, seafood, fruit and vegetables) were sent to the laboratory by overnight freight in a chilled or frozen state, reflecting the state these products are in when they arrive at the home of consumers.

2.2 Food sample preparation

On receipt at the laboratory, samples were logged and prepared to a ‘ready-to-eat’ state prior to compositing and analysis. The food preparation reflected how they are typically consumed, with inedible portions removed, and cooking as required. For example, sausages were grilled and eggs were hard boiled before analysis. A number of foods such as bread were already in a ready-to-eat state when purchased, and therefore required no additional preparation. Perishable foods were prepared within 48 hours of purchase whereas frozen and shelf-stable foods were prepared within a week of purchase.

After preparation to a ready-to-eat state, primary samples were homogenised and combined into composite samples for analyses. Further details of the preparation undertaken for each food are available in Appendix 2.

2.3 Food sample analyses

Symbio Laboratories conducted the preparation and analyses of food samples for PFAS. The analyses of samples were conducted in a National Association of Testing Authorities (NATA) accredited facility using a fully validated NATA-accredited method (In-house method CR148 – Ultra High Performance Liquid Chromatography/High Resolution Mass Spectrometry (UHPLC/HRMS)). The results were subject to quality assurance and quality control procedures in accordance ISO/IEC/17025[5] requirements.

The Limits of Reporting (LORs[6]) ranged from 0.001 to 0.005 µg/L for water and 0.050 to 1.0 µg/kg for all other foods depending on the PFAS being measured. Further details on the food sample analyses and analytical limits are provided in Appendix 1.

3. Analytical results

3.1 Treatment of analytical results

Due to their mobility and persistence, PFAS have the potential to be widespread in the environment at very low levels. On this basis it is reasonable to assume they could be present in food when analytical results are less than the LOR. Therefore in cases where an analytical result was reported as ‘not-detected’ (ND) or <LOR, the actual concentration of PFAS in that sample could be anywhere between zero and the LOR. To address this uncertainty, analytical results are presented in three ways, as described below:

a) Lower bound (LB): In this scenario results reported as ND (<LOR) are assigned a concentration of zero.
b) Middle bound (MB): Results reported as ND (<LOR) are assigned a concentration of half the LOR (½LOR).
c) Upper bound (UB): Results reported as ND (<LOR) are assigned a concentration equal to the LOR. The UB represents the ‘worst-case’ scenario regarding the potential presence of PFAS in a sample.

A large proportion of analytical results were NDs. As a consequence, the conservatism of the UB scenarios is considerable and is compounded for the UB values.

3.2 Prevalence and concentrations

Out of 30 different PFAS analysed in this study, PFOS was the only congener detected in five of the 112 food types sampled. Of the 1,336 composite samples analysed, only 22 (<2%) were found to have detectable levels of PFOS above the LOR.

---

[5] International Organisation for Standardisation/International Electrotechnical Commission (ISO/IEC) 17025 – Standard for general requirements for the competence of testing and calibration laboratories.

[6] LOR: The lowest concentration of an analyte reported by the laboratory using a certain analytical procedure.

The food with the highest LB mean PFOS concentration was mammalian offal (0.63 µg/kg), followed by canned tuna (0.070 µg/kg), cooked prawns (0.018 µg/kg), saltwater fish fillets (0.011 µg/kg) and chicken eggs (0.0069 µg/kg). These results are consistent with findings from other studies that PFAS are found more frequently and at higher levels in fish, seafood, meat and meat products. The consistent detections of PFOS in mammalian offal are not unexpected, as PFOS is known to accumulate at relatively higher levels in the liver and kidney, compared to the muscle tissue of animals (FSANZ, 2017d; EFSA, 2020). There were no detections in any other foods, including infant foods, and bottled or tap water.

The concentrations of PFAS found in the 27th ATDS were comfortably below Australian guidance values including FSANZ (2017c) trigger points for site investigation and NHMRC (2019) drinking water guidelines. A summary of results for PFOS in foods with detections is in Table 1 below and Appendix 3. Detailed occurrence data can be found in Appendix 4.

Table 1: Summary of PFOS analytical results for foods with detected concentrations

Sampled food	N#	Congener	Number of detections (% detection rate)	Range (min-max) (µg/kg)	Mean (LB) (µg/kg)	Mean (UB) (µg/kg)	Corresponding 'trigger point' (µg/kg)*
Eggs, chicken	16	PFOS	1 (6%)	<0.050 – 0.11	0.0069	0.054	11 (poultry eggs)
Fish fillets, saltwater	16	PFOS	1 (6%)	<0.050 – 0.18	0.011	0.058	5.2 (finfish)
Liver or other offal, non-poultry	16	PFOS	13 (81%)	<0.050 – 5.5	0.63	0.64	96 (offal mammalian)
Prawns, cooked	16	PFOS	3 (19%)	<0.050 – 0.11	0.018	0.059	65 (crustaceans and molluscs)
Tuna, canned in brine	8	PFOS	4 (50%)	<0.050 – 0.19	0.070	0.095	5.2 (finfish)

#Number of composite samples analysed
*FSANZ (2017c) - developed to assist authorities analysing PFAS in foods in identifying when further investigation and management may be required.

3.3 Comparison of concentration data with other Australian and overseas studies

FSANZ previously investigated the levels of PFAS in packaged foods in two surveys. The FSANZ (2010) survey of chemical migration from food contact packaging materials in Australian foods did not detect 22 different PFAS (including PFOA, PFOS and PFHxS) in any of the 17 foods analysed (FSANZ, 2010). The 24th ATDS phase 2 analysed 50 packaged foods for PFOA and PFOS. There were no detections of PFOA in any of the samples. PFOS was detected in two samples, fish fillets (1.0 µg/kg) and beef sausages (0.2 µg/kg) (FSANZ, 2016b). Food safety risks were considered to be negligible. The 27th ATDS focused on a broader range of foods with considerably more samples. PFAS levels found in the 27th ATDS were consistent with previous FSANZ surveys and other available data indicating PFAS levels in the general Australian food supply are very low.

A comparison of PFAS levels in the 27th ATDS with several overseas studies was undertaken. These include reports from Europe (EFSA, 2020), the United States (USFDA, 2019), the United Kingdom (FERA, 2012) and China (Wang et al, 2019). Foods in which PFOS was detected in the 27th ATDS had consistently lower levels than overseas studies:

- Mean 27th ATDS concentrations of PFOS in mammalian offal ranged between 0.63 (LB) – 0.64 (UB) µg/kg, which are lower than levels reported in Europe (0.87 – 1.18 µg/kg) and the United Kingdom (2.66 µg/kg).
- Mean levels of PFOS in canned tuna (0.070 – 0.095 µg/kg) were lower than those reported in Europe (0.16 – 0.26 µg/kg).
- Mean levels of PFOS in prawns (0.018 – 0.059 µg/kg) were lower than those reported in Europe (0.33 – 0.5 µg/kg).
- Mean levels of PFOS in saltwater fish (0.011 – 0.058 µg/kg) were lower than those reported in Europe (0.47 – 1.05 µg/kg) and the United Kingdom (0.96 µg/kg).
- Mean levels of PFOS in chicken eggs (0.0069 – 0.054 µg/kg) were lower than those reported in Europe (0.27 – 0.35 µg/kg), the United Kingdom (0.31 µg/kg) and China (0.055 µg/kg).
- The 27th ATDS concentrations of PFOS in other foods were all ND (<LOR). These were lower or consistent with overseas studies.

No other PFAS were detected in the 27th ATDS, including PFOA and PFHxS. Overseas studies in Europe, the United Kingdom and China found consistent detections of these congeners in several foods. Overall, results from the 27th ATDS indicate PFAS levels in the general Australian food supply are consistently lower than overseas studies. Further information can be found in Table 2 below.

Table 2: Comparison of 27th ATDS PFOS levels in selected foods with overseas studies

Food category	Australia (this study - 27th ATDS)			EU (EFSA 2020)[1]	US (TDS 2019)[2]	United Kingdom (2012 TDS)[3]	China (5th TDS 2011-2013)[4]
	N	Detection rate	Mean LB – UB concentration (µg/kg)	Mean LB – UB concentration (µg/kg)	Mean LB – UB concentration (µg/kg)	Concentration (µg/kg)[+]	Mean concentration (µg/kg)*
Edible offal	16	13/16 (81%)	0.63 – 0.64 'mammalian offal'	0.87 – 1.18 'edible offal, farmed animals'	-	2.66 'offal'	-
Tuna	8	4/8 (50%)	0.07 – 0.095 'canned tuna'	0.16 – 0.26 'tuna'	-	-	-
Prawns	16	3/16 (19%)	0.018 – 0.059 'cooked prawns'	0.33 – 0.5 'prawns'	-	-	-
Saltwater fish	16	1/16 (6%)	0.011 – 0.058 'saltwater fish fillets'	0.47 – 1.05 'cod and whiting'	-	0.96 'fish'	
Eggs and egg products	16	1/16 (6%)	0.0069 – 0.054 'chicken eggs'	0.27 – 0.35 'eggs and egg products'	-	0.31 'eggs'	0.055 'egg'
Salmon fillets	16	0 (0%)	0 – 0.050 'salmon fillets'	0.31 – 0.83 'salmon and trout'	-	-	-
Seafood	112	8/112 (7%)	0.0092 – 0.056 'seafood'	-	0.085 – 0.085 'tilapia'	-	0.419 'aquatic food'
Meat and meat products	96	0 (0%)	0 – 0.050 'meat and meat products'	0.028 – 0.17 'livestock meat'	0 – 0.082 'meat products'	0.22 'carcass meat'	0.09 'meat'
Poultry	48	0 (0%)	0 – 0.050 'poultry'	0.009 – 0.13 'poultry'	0.043 – 0.084 'turkey, ground'	0.16 'poultry'	-

Food category	Australia (this study - 27th ATDS)			EU (EFSA 2020)[1]	US (TDS 2019)[2]	United Kingdom (2012 TDS)[3]	China (5th TDS 2011-2013)[4]
	N	Detection rate	Mean LB – UB concentration (µg/kg)	Mean LB – UB concentration (µg/kg)	Mean LB – UB concentration (µg/kg)	Concentration (µg/kg)+	Mean concentration (µg/kg)*
Milk	16	0 (0%)	0 – 0.050 'milk'	0.001 – 0.14 'liquid milk'	0 – 0.024 'milk'	0.05 'milk'	-
Milk and dairy products	88	0 (0%)	0 – 0.050 'milk and dairy products'	0.001 – 0.12 'milk and dairy products'	0 – 0.34 'cheese'	0.06 'milk and dairy'	-
Fruit and fruit products	192	0 (0%)	0 – 0.050 'fruit and food products'	0.027 – 0.25 'fruit and fruit products'	-	0.07 'fresh fruits'	-
Vegetables and vegetable products	352	0 (0%)	0 – 0.050 'vegetables and vegetable products'	0.003 – 0.15 'vegetables and vegetable products'	0 – 0.033 'lettuce'	0.1 'green vegetables'	-
Bread	32	0 (0%)	0 – 0.050 'bread'	-	0 – 0.033 'bread'	0.1 'bread'	-
Infant food	24	0 (0%)	0 – 0.050 'infant food'	0 – 0.24 'food for infants and small children'	-	-	-
Drinking water	24	0 (0%)	0 – 0.0010 'drinking water'	0.0001 – 0.003 'drinking water'	0 - 0.0027 'water'	-	-

#Number of composite samples analysed
+results are for composited samples
*results<LOD were substituted by 1/2 LOD
[1]EFSA (2020)
[2]US FDA (2019)
[3]FERA (2012)
[4]Wang et al. (2019)

4. Risk assessment

4.1 Scope of the risk assessment

The risk assessment was only undertaken for PFOS as it was the only congener with detected concentrations above the LOR. This scope was applied to both the hazard assessment and the dietary exposure assessment.

4.2 Hazard characterisation

In 2017, FSANZ established a TDI for PFOS of 20 ng/kg bw/day. This TDI was based on lower parental and offspring body weight gains in a multigeneration reproductive toxicity study in rats. The TDI was derived by applying pharmacokinetic modelling to the serum PFOS concentrations measured in experimental animals at the no observed adverse effect levels (NOAELs) in these and other critical studies, to calculate human equivalent doses (HED). An uncertainty factor of 30 was applied to the HEDs, which comprised a default factor of 3 to account for interspecies differences in toxicodynamics and a default factor of 10 for intraspecies differences in the human population (FSANZ, 2017b).

FSANZ continues to carefully monitor the developing scientific literature on the potential health effects of PFAS. A recent update on the immunomodulatory effects of PFAS can be found on the FSANZ (2021d) website:
https://www.foodstandards.gov.au/publications/Documents/PFAS and Immunomodulatory Review and Update 2021.pdf.

4.3 Dietary exposure assessment

The general dietary exposure assessment methodology used in the ATDS is discussed in detail on the FSANZ website:
https://www.foodstandards.gov.au/science/surveillance/Pages/australiantotaldiets1914.aspx.
Where the methodology used in the 27th ATDS varies from the general ATDS methodology, further details are provided below.

4.3.2 Concentration data used

There were a high number of analytical results for PFOS that were below the LOR and therefore the mean analytical concentration was used for each food in the dietary exposure calculations.

4.3.3 Treatment of analytical results

4.3.3.1 Lower, middle and upper-bound concentrations

Dietary exposures were calculated for three scenarios, using LB, MB and UB mean PFOS concentrations as described in Section 3.1.

4.3.4 Food consumption data used

Food consumption data used in the calculation of PFOS dietary exposures for Australians aged 2 years and above are from the 2011-12 Australian National Nutrition and Physical Activity Survey (NNPAS) component of the 2011-13 Australian Health Survey (ABS, 2014). Only those respondents with two days of food consumption data were considered in this assessment (n=7,735).

4.3.5 Mapping analysed samples to foods eaten

Given that the ATDS cannot survey all foods consumed by the Australian population, mapping is a major step in dietary exposure assessments to ensure that the total diet is captured in the estimates of dietary exposure. Mapping is the process of matching the foods analysed in the ATDS to the foods consumed in the NNPAS. For example, cheddar cheese was analysed and the concentration mapped to all types of hard cheeses (e.g. cheddar, edam, gouda). The mapping used for the 27th ATDS can be found in Appendix 2.

4.3.6 Population groups assessed

The dietary exposure assessment was undertaken for the Australian population group aged 2 years and above (i.e. the whole 2011-12 nutrition survey population). The TDI is established to represent a long term or chronic period of exposure, therefore this was the only population group assessed.

4.3.7 Dietary exposure assessment results

The mean and 90th percentile (P90) dietary exposures to PFOS for Australian consumers aged 2 years and above were estimated in nanogram per kilo of body weight per day (ng/kg bw/day) units as this is consistent with the units for the PFOS TDI. The lower end of the range represents the LB and the upper end of the range represents the UB.

Daily dietary exposures were derived by averaging the exposures for each respondent (n=7,735) based on two days of food consumption data from the 2011-12 NNPAS. The two-day average reflects longer term food consumption patterns and therefore provides a better estimate for dietary exposures when the health based guidance value relates to chronic or long term exposures. Food consumption data for individuals were used in the calculation of dietary exposure, however summary mean food consumption data for food groups for both consumers and respondents, including the proportion of consumers to respondents, can be found in Appendix 5.

Mean and P90 dietary exposures are estimated to be 0.011 – 1.7 ng/kg bw/day and 0.032 – 2.6 ng/kg bw/day, respectively for Australian consumers aged 2 years and above. Further details are provided in Table 3.

Table 3: Estimated mean and 90th percentile (P90) dietary exposures to PFOS for Australian consumers aged 2 years and above

Statistic	Estimated consumer dietary exposure to PFOS* (ng/kg bw/day)		
	Lower Bound	Middle Bound	Upper Bound
Mean	0.011	0.83	1.7
P90	0.032	1.3	2.6

Note: The ratio of consumers to respondents for PFOS is 77% at LB, and 100% at MB and UB.
* Based on the average of two days of consumption data from the 2011-12 NNPAS.

4.3.8 Food contributors

The system used to map the analysed samples to the foods consumed by the Australian population can be found in Appendix 2. All discussion about food contributors to PFOS dietary exposures refers to the food categories that the analysed samples represent (e.g. the sampled food “Cheese, cheddar” represents the food group of “Hard cheeses”). Major contributors are those food categories and food groups that contribute to ≥5% of dietary exposures. The major contributors were derived using the LB scenario to make sure that foods with no detectable concentrations were not captured.

Seventy one percent (71%) of PFOS dietary exposures are from seafood. The major contributing (≥5%) food categories to dietary exposures are tuna (53%), eggs (19%), mammalian offal (except heart) (11%), saltwater fish (no crumbs, batter or coating) (11%) and crustacea (7%). Food contribution results can also be found in Appendix 5.

Table 4: Major contributing food groups for PFOS dietary exposures for Australian consumers aged 2 years and above

Food group	%Contribution*
Tuna	53%
Eggs	19%
Mammalian offal (except heart)	11%
Saltwater fish (no crumbs, batter or coating)	11%
Crustacea	7%

Note: *Based on LB results to include only foods with detectable concentrations.

4.4 Risk characterisation

Mean and P90 dietary exposure estimates for PFOS for consumers aged 2 years and above are below the TDI of 20 ng/kg bw/day (Table 5). Mean and P90 dietary exposure estimates (LB to UB) are <1 – 8% TDI and <1 – 13% TDI, respectively. As the exposures are well below the TDI, FSANZ concludes that there are no food safety concerns associated with current dietary exposures to PFOS. No other PFAS were detected.

It is concluded that there are no public health and safety concerns for Australian consumers from dietary exposures to PFAS.

Table 5: Mean and P90 dietary exposures to PFOS for Australian consumers aged 2 years and above, expressed as a percentage of the tolerable daily intake (TDI)

Statistic	Estimated dietary exposure (%TDI)*		
	Lower Bound	Middle Bound	Upper Bound
Mean	<1	4	8
P90	<1	7	13

*The TDI for PFOS is of 20 ng/kg bw/day (FSANZ, 2017c).

5. Risk management

The results from the 27th ATDS indicate that the levels of PFAS in the general Australian food supply are as low as reasonably achievable and acceptable from a public health and safety perspective for the following reasons:

- Levels of PFAS in the general food supply are very low with PFOS the only congener detected. The vast majority of food samples had no detections of PFAS.
- Levels were consistently lower than overseas studies including those conducted in Europe, the United States, the United Kingdom and China.
- Levels were well below Australian guidance values including FSANZ (2017c) trigger points for site investigations and NHMRC (2019) drinking water guidelines.
- Overall dietary exposure to PFOS for the general Australian population is lower than the TDI established by FSANZ (2017b) indicating no food safety concerns for Australian consumers.

These conclusions indicate there is no current need to consider additional risk management measures to reduce Australian consumer's exposure to PFAS from the general food supply.

6. Conclusions and recommendations

The 27th ATDS confirms the safety of the general Australian food supply for consumers with regard to levels of PFAS. Australia has a strong food regulation system and there is no current requirement for considering additional risk management measures.

Primary concerns in Australia relate to contamination of sites and adjoining areas where there has been historical use of fire-fighting foams which contained PFAS. FSANZ continues to work with Australian government agencies in response to localised PFAS contamination concerns including site assessment and management measures. This work includes the establishment of TDIs (FSANZ, 2017b) and trigger points (FSANZ, 2017c) to support site investigations.

7. References

Australian Government (2021) Per- and Polyfluoroalkyl Substances (PFAS). https://www.pfas.gov.au/. Accessed 11 February 2021.

Australian Bureau of Statistics (ABS) (2014) National Nutrition and Physical Activity Survey, 2011–12, Basic CURF. Australian Government, Canberra. Accessed 2 July 2018. http://www.abs.gov.au/AUSSTATS/abs@.nsf/Latestproducts/4324.0.55.002Main%20Features652011-12?opendocument&tabname=Summary&prodno=4324.0.55.002&issue=2011-12&num=&view=

Buck RC, Franklin J, Berger U, Conder JM, Cousins IT, de Voogt P, Astrup Jensen A, Kannan K, Mabury SA, van Leeuwen SP (2011) Perfluoroalkyl and Polyfluoroalkyl Substances in the Environment: Terminology, Classification and Origins. Integrated Environmental Assessment and Management – Volume 7, Number 4: 513-541.

Department of Health (2021) Health Based Guidance Values for Per- and Poly-Fluoroalkyl substances (PFAS). https://www1.health.gov.au/internet/main/publishing.nsf/Content/ohp-pfas-hbgv.htm. Accessed 2 February 2021.

European Food Safety Authority (EFSA) (2018) Risk to human health related to the presence of perfluorooctane sulfonic acid and perfluorooctanoic acid in food. EFSA Journal 2018;16(12):5194.

EFSA (2020) Risk to human health related to the presence of perfluoroalkyl substances in food. EFSA Journal 2020;18(9):6223.

Food and Environmental Research Agency (FERA) (2012) Organic Environmental Contaminants in the 2012 Total Diet Study Samples. https://www.food.gov.uk/sites/default/files/media/document/research-report-total-diet-study.pdf. Accessed 18 February 2021.

Food Regulation (2021) Per- and poly-fluoroalkyl substances. https://foodregulation.gov.au/internet/fr/publishing.nsf/Content/pfas. Accessed 4 February 2021.

FSANZ (2010) Survey of Chemical Migration from Food Contact Packaging Materials in Australian Food. https://www.foodstandards.gov.au/science/surveillance/pages/surveyofchemicalmigr5148.aspx. Accessed 17 February 2021.

FSANZ (2016a) Proposal P1034 Chemical Migration from Packaging into Food. Supporting Document 3 – Risk Profile. https://www.foodstandards.gov.au/code/proposals/Documents/P1034%20Packaging%201CFS%20SD3%20Risk%20Profile%20Mar2016.pdf. Accessed 12 March 2021.

FSANZ (2016b) 24th ATDS Phase 2. https://www.foodstandards.gov.au/publications/Pages/24th-ATDS-Phase-2.aspx. Accessed 17 February 2021.

FSANZ (2017a) Perfluorinated Chemicals in Food. Consolidated Report https://www1.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA258

0C900817CDC/$File/consolidated-report-perfluorinated-chemicals-food.pdf. Accessed 28 January 2021. Accessed 27 January 2021.

FSANZ (2017b) Perfluorinated Chemicals in Food. Supporting Document 1: Hazard Assessment Report – PFOS, PFOA and PFHxS. https://www1.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/6.sd1-Hazard-assessment-report.pdf. Accessed 27 January 2021.

FSANZ (2017c) Perfluorinated Chemicals in Food. Supporting Document 2: Dietary Exposure Assessment. https://www1.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Dietary-Exposure-Assesment.pdf. Accessed 27 January 2021.

FSANZ (2017d) Perfluorinated Chemicals in Food. Supporting Document 2. Attachment 1: Occurrence and Dietary Exposure Literary Review. https://www1.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Occurrence-Dietary-Exposure-Literature-Reveiw.pdf. Accessed 18 March 2021.

FSANZ (2021a) Australian Total Diet Study. https://www.foodstandards.gov.au/science/surveillance/Pages/australiantotaldiets1914.aspx. Accessed 1 February 2021.

FSANZ (2021b) Perfluorinated compounds. https://www.foodstandards.gov.au/consumer/chemicals/Pages/Perfluorinated-compounds.aspx. Accessed 27 January 2021.

FSANZ (2021c) Food Standards Code. https://www.foodstandards.gov.au/code/Pages/default.aspx. Accessed 12 February 2021.

FSANZ (2021d) PFAS and Immunomodulation Review and Update. https://www.foodstandards.gov.au/publications/Documents/PFAS and Immunomodulatory Review and Update 2021.pdf. Accessed 10 December 2021.

ITRC (2021) PFAS 5 Environmental Fate and Transport Processes. https://pfas-1.itrcweb.org/5-environmental-fate-and-transport-processes. Accessed 11 February 2021.

NHMRC (2019) Australian Drinking Water Guidelines (2011) – Updated May 2019. https://www.nhmrc.gov.au/file/14288/download?token=OPCuW6hp. Accessed 27 January 2021.

Stockholm Convention (2021) The POPs. http://www.pops.int/TheConvention/ThePOPs/tabid/673/Default.aspx. Accessed 2 February 2021.

United States Food & Drug Administration (USFDA) (2019) Testing Results for PFAS in Food from the General Food Supply. https://www.fda.gov/food/chemicals/analytical-results-testing-food-pfas-environmental-contamination. Accessed 18 February 2021.

Wang Z, DeWitt JC, Higgins CP, Cousins IT (2017) A Never-Ending Story of Per- and Polyfluoroalkyl Substances (PFASs)?. Environ. Sci. Technol. 2017, 51: 2508−2518.

Wang Y, Liu J, Li J, Zhao Y, Wu Y (2019) Dietary Exposure of Chinese Adults to Perfluoroalkyl Acids via Animal-Origin Foods: Chinese Total Diet Study (2005 – 2007 and 2011 – 2013). J. Agric. Food Chem. 2019, 67: 6048−6055.

8. Appendices

Appendix 1: Compounds analysed, analytical limits and methods for the 27th ATDS

Appendix 2: Overview of 27th ATDS samples, including food sampling, food preparation instructions and food mapping to total diet

Appendix 1: Summary of PFOS analytical results for 27th ATDS food samples

Appendix 2: Detailed PFAS analytical results for 27th ATDS food samples

Appendix 3: Detailed dietary exposure results for the 27th ATDS