FOOD STANDARDS Australia New Zealand
Te Mana Kounga Kai – Ahitereiria me Aotearoa

26th Australian Total Diet Study

2020

Foreword

For Australians, access to a safe, plentiful and diverse food supply is something that we have come to expect and enjoy. As a vibrant and multicultural society we have access to an ever-increasing variety of foods and ingredients.

As the Australian diet has evolved, so has consumer expectations about the food they eat – this includes sustainability, nutrition content and importantly, the safety of food.

Food Standards Australia New Zealand (FSANZ) has an important role in ensuring the safety of the food supply. We do this by developing and maintaining standards for food including labelling requirements to help consumers make informed choices, and setting limits for certain chemicals in food.

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

2020 is a significant milestone in the history of the ATDS as it marks its 50th anniversary. Over the past 50 years, the ATDS has continued to evolve in its scope and frequency, moving away from a traditional focus on pesticide residues and contaminants to a wider range of food chemicals including additives, nutrients, and food packaging chemicals.

The 26th ATDS has a specific focus on the persistent organic pollutants dioxins and polychlorinated biphenyls (PCBs). These chemicals are of significant global concern as they can accumulate in the body fat of animals and humans for long periods of time and can be harmful.

Pleasingly, the results of this survey indicate dietary exposure to these chemicals through food is low and Australian consumers can continue to be confident that the food we eat is safe. Of note, the concentrations of the chemicals classed as dioxins found in the 26th ATDS were generally comparable with, or lower than those reported in a previous Australian study in 2004.

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.

Mr Steve McCutcheon

Chair (a/g)

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Acknowledgments

FSANZ thanks all staff from state and territory food regulatory agencies for their involvement in this study and, in particular, for assisting with the collection of food samples during the autumn and summer sampling periods, and for forwarding these on to the laboratory for analysis.

Acronyms and abbreviations

2011–12 NNPAS	2011-12 Australian National Nutrition and Physical Activity Survey
AhR	Aryl Hydrocarbon Receptor (AhR)
ATDS	Australian Total Diet Study
bw	Body weight
DAWE	Department of Agriculture, Water and the Environment
DLC	Dioxin and Dioxin-like Compound
DL-PCB	Dioxin-like Polychlorinated Biphenyl
EC-SCF	European Community Scientific Committee on Food
EFSA	European Food Safety Authority
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
FSANZ	Food Standards Australia New Zealand
fw	Fresh Weight
GC/MSMS	Gas Chromatography with Tandem Mass Spectroscopy
HBGV	Health-Based Guidance Value
HRGC	High Resolution Gas Chromatography
HRMS	High Resolution Mass Spectrometry
JECFA	Joint FAO/WHO Expert Committee on Food Additives
LB	Lower Bound
LOD	Limit of Detection
LOQ	Limit of Quantitation
LOR	Limit of Reporting
lw	Lipid Weight
MB	Middle Bound
MED	Minimal Effect Dose
ML	Maximum Level
MOE	Margin of Exposure
NATA	National Association of Testing Authorities, Australia
ND	Not Detected
NDL-PCB	Non-dioxin-like Polychlorinated Biphenyl
NHMRC	National Health and Medical Research Council
NMI	National Measurement Institute
P90	90^{th} percentile
PCB	Polychlorinated Biphenyl

PCDD	Polychlorinated Dibenzo-p-dioxin
PCDF	Polychlorinated Dibenzofuran
POP	Persistent Organic Pollutant
PTMI	Provisional Tolerable Monthly Intake
RASFF	Rapid Alert System for Food and Feed
RfD	Reference Dose
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TEF	Toxic Equivalency Factor
TEQ	Toxic Equivalent
The Code	Australia New Zealand Food Standards Code
TMI	Tolerable Monthly Intake
TSH	Thyroid Stimulating Hormone
TWI	Tolerable Weekly Intake
UB	Upper Bound
USA	United States of America
US EPA	United States Environmental Protection Agency
WHO	World Health Organization

Key findings

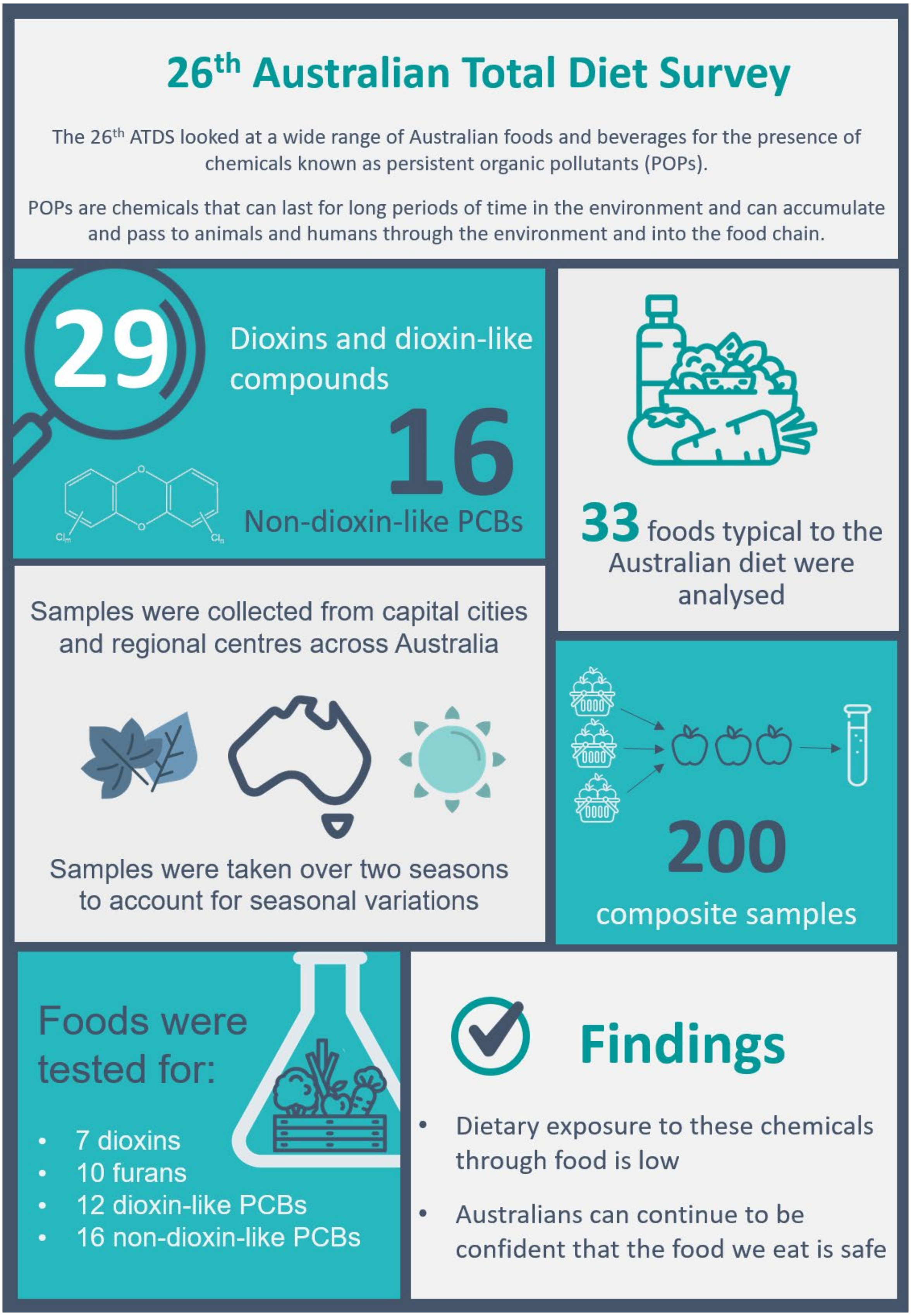
Overview

- The 26th ATDS investigated levels of compounds classified as persistent organic pollutants (POPs) by the Stockholm Convention in a broad range of foods and beverages. The POPs investigated were:
    - Dioxins and dioxin-like compounds (DLCs) (hereafter referred to as 'dioxins'):
        - polychlorinated dibenzo-p-dioxins (PCDDs)
        - polychlorinated dibenzofurans (PCDFs)
        - dioxin-like polychlorinated biphenyls (DL-PCBs) and
    - Non-dioxin-like PCBs (NDL-PCBs).
- The levels of dioxins and NDL-PCBs across all foods were low and did not exceed Australian or European regulatory limits. While salmon fillets had consistently higher levels than other foods owing to their high oil content, the levels were acceptably low and did not raise any concerns.
- A comparison with results from other countries found that levels in Australian foods were generally lower than those reported internationally. Similarly, a comparison of results against those reported in a 2004 FSANZ study indicates that the 26th ATDS results are generally comparable with, or lower than this previous study.
- Dietary exposure estimates for the general Australian population were well below the health-based guidance value or toxicological point of departure for dioxins and NDL-PCBs, respectively, and on this basis did not raise any public health and safety concerns.

Conclusions

- The 26th ATDS confirms the safety of the Australian food supply for the general population in relation to the levels of dioxins and NDL-PCBs present in foods and beverages.
- FSANZ is of the view that current risk management measures, which include maximum levels (MLs) in the Australia New Zealand Food Standards Code (the Code), where appropriate, are effective in ensuring that dioxin and NDL-PCB levels remain as low as reasonably achievable.
- FSANZ will continue to monitor the outcomes of international work by JECFA and other food regulatory agencies on the hazards and risks associated with dioxins and NDL-PCBs, and take appropriate follow-up action to ensure that Australia's food supply remains safe.

Highlights


26th Australian Total Diet Survey
The 26th ATDS looked at a wide range of Australian foods and beverages for the presence of chemicals known as persistent organic pollutants (POPs).
POPs are chemicals that can last for long periods of time in the environment and can accumulate and pass to animals and humans through the environment and into the food chain.
29
Dioxins and dioxin-like compounds
16
Non-dioxin-like PCBs
33 foods typical to the Australian diet were analysed
Samples were collected from capital cities and regional centres across Australia
Samples were taken over two seasons to account for seasonal variations
200
composite samples
Foods were tested for:
• 7 dioxins
• 10 furans
• 12 dioxin-like PCBs
• 16 non-dioxin-like PCBs
Findings
• Dietary exposure to these chemicals through food is low
• Australians can continue to be confident that the food we eat is safe

Executive summary

The ATDS is a large survey undertaken periodically that monitors the levels of various chemicals of public health concern in the Australian food supply. The data collected can be used to assess the dietary exposure of the Australian population to these food chemicals, to confirm that our food supply is safe or that risk management measures are necessary to ensure that our food supply continues to be safe.

The 26th ATDS investigated a wide range of Australian foods and beverages for the presence of compounds classified as persistent organic pollutants (POPs) by the Stockholm Convention. These compounds included 29 dioxins and dioxin-like compounds (DLCs), namely, polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and dioxin-like polychlorinated biphenyls (DL-PCBs). Also included were 16 non-dioxin-like PCBs (NDL-PCBs), including six indicator NDL-PCBs, which are considered representative of the environmental presence of PCBs.

A total of 33 different foods and beverages, typical of the Australian diet, were sampled from all Australian states and territories and forwarded to the National Measurement Institute (NMI) for analysis. Sampling was done over two sampling periods – the first in autumn (April 2017) and the second the following summer (February 2018) – to take account of the seasonality of certain foods. A total of 600 primary samples were collected and combined into 200 composite samples for analysis. Each composite sample was made up of three primary samples from a single state or territory.

Dioxins were detected in 32 of 33 foods sampled, and 190 (95%) of 200 composite samples. This result is not unexpected due to the ubiquitous nature of dioxins.

Foods with the highest mean dioxin levels (assuming non-detections = 0) were salmon fillets (0.28 pg toxic equivalents per gram (TEQ/g)) and fish fillets (lower fat varieties) (0.064 pg TEQ/g). Other foods with detectable levels, in descending order, included crumbed fish portions (0.059 pg TEQ/g), butter (0.048 pg TEQ/g), cheddar cheese (0.028 pg TEQ/g), canned tuna (0.027 pg TEQ/g), and liver pate (0.025 pg TEQ/g). Whilst the Australia New Zealand Food Standards Code (the Code) does not specify MLs for dioxins, a comparison of analytical results with MLs set by the European Union (EU) indicated no exceedances of these European limits.

Of the 16 NDL-PCB congeners analysed, 12 were detected. Of these, one or more were detected in 13 of the 33 sampled foods, and 21 (11%) of 200 composite samples. All six indicator PCBs were detected, with the most frequently detected being PCB28. The highest mean lower bound (LB) levels of PCB28, PCB53 and PCB52 were reported in salmon fillets (0.061, 0.31 and 0.090 µg/kg respectively). Salmon fillets were also found to contain the highest mean LB concentration of total NDL-PCBs (i.e. the sum of 16 congeners analysed) (1.2 µg/kg). This is consistent with international data indicating that fatty fish generally contains the highest concentrations of PCBs. There were no exceedances of the Code or EU MLs for NDL-PCB levels detected in any samples.

A comparison of dioxin results with those reported in an earlier Australian study (FSANZ 2004) indicated that the latest results are generally comparable with, or lower than those reported previously. Dioxin and NDL-PCB levels analysed in the 26th ATDS were also compared to data from the United Kingdom, Europe, Canada and Africa. Overall, levels in Australian foods are generally lower than those reported internationally.

The LB to upper bound (UB) mean and 90th percentile (P90) dietary exposures to dioxins for Australian consumers aged 2 years and above were estimated to be 9 – 25% of the tolerable monthly intake (TMI) (mean) and 15-40% of the TMI (P90). These results indicate that dietary exposures to dioxins for Australian consumers are acceptably low.

Due to the absence of appropriate toxicological data for NDL-PCBs, it is not currently possible to establish health-based guidance values (HBGVs) for these substances. Therefore, margins of exposure (MOEs) were estimated using conservative toxicological reference points to provide guidance on human health risks. MOEs for the NDL-PCBs mean dietary exposures ranged from 53,000 to 22,031,000 at the LB, and from 1,000 to 40,000 at the UB. MOEs for the P90 dietary exposures ranged from 30,000 to 5,996,000 at the LB and from 1,000 to 26,000 at the UB. Given the large size of all MOEs and the conservative nature of the toxicological reference points, these results indicate that dietary exposures to NDL-PCBs for Australian consumers are acceptably low.

The results of the 26th ATDS indicate that levels of dioxins and NDL-PCBs in the Australian food supply are as low as reasonably achievable. Therefore, current risk management measures, which include MLs for PCBs in the Code, where appropriate, are effective in ensuring that food safety risk for all Australians from exposure to dioxins and NDL-PCBs remains low.

FSANZ will continue to monitor the outcomes of international work on the hazards and risks associated with dioxins and NDL-PCBs, including that of JECFA, and take follow-up action as appropriate, to ensure that Australia’s food supply remains safe.

1 Study background

1.1 Introduction to the ATDS

The ATDS is the most comprehensive monitoring survey of the Australian food supply. It measures the levels of various food chemicals in foods and beverages typical of the Australian diet. This includes agricultural and veterinary chemicals, contaminants, nutrients, food packaging chemicals and naturally occurring toxins. The data collected are used to estimate and report on dietary exposure for the general Australian population to these substances. ATDS results are not used as a measure of compliance against regulatory limits such as maximum levels (MLs) or other regulatory requirements enforced by Australian states and territories. Information from the ATDS is used to confirm that the Australian food supply is safe or that additional risk management measures may be needed. Further details regarding the history and purpose of the ATDS is available from our website: https://www.foodstandards.gov.au/science/surveillance/Pages/australiantotaldiets1914.aspx

1.2 Scope of the 26th ATDS

The 26th ATDS involved the sampling and analysis of a broad range of Australian foods and beverages for dioxins and dioxin-like compounds (DLCs). These compounds included polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and dioxin-like PCBs (DL-PCBs). Of the many congeners known to exist, 29 congeners for which toxic equivalency factors (TEFs)[1] have been determined were analysed.

Also included in the 26th ATDS were 16 non-dioxin-like PCBs (NDL-PCBs), including six indicator NDL-PCBs, which are considered representative of PCB contamination. All of these compounds are classified as persistent organic pollutants (POPs) by the Stockholm Convention.

We have previously assessed the risk to human health associated with the dietary exposure of the Australian population to dioxins, with the results of this study published in 2004 (FSANZ 2004). In addition, we have assessed the potential food safety risks from dioxins in seafood caught in Sydney Harbour, with a report published in 2007 (FSANZ 2007). The 26th ATDS represents a direct follow-up to the 2004 study. It is also the first Australian study of specific NDL-PCB congeners[2] in foods and estimate of dietary exposure for the general population.

1.3 Overview of dioxins and PCBs

Dioxins and PCBs are a family of structurally and chemically related toxic organic chemicals. There are several hundred compounds in this family, categorised as follows:

- polychlorinated dibenzo-p-dioxins (PCDDs)
- polychlorinated dibenzofurans (PCDFs)
- polychlorinated biphenyls (PCBs).

PCDDs, PCDFs and certain dioxin-like PCBs (DL-PCBs) share a common mode of toxicity and are hereafter collectively referred to as ‘dioxins’. Other non-dioxin-like PCBs (NDL-

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[1] TEFs are weighting factors applied to individual congeners indicating their toxicity relative to that of the most toxic reference congener.
[2] A congener is a unique and well-defined chemical compound within a group of compounds with similar structures and chemical properties.

PCBs) have different toxicological effects to dioxins. Figure 1 provides the general chemical structures of these substances.

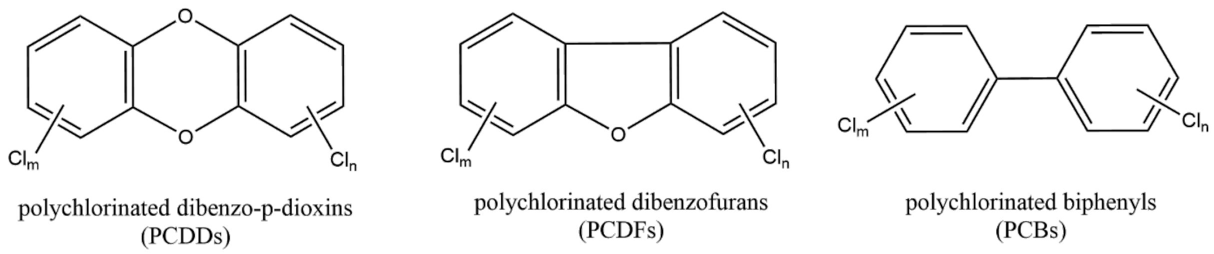


Figure 1: General structures of PCDDs, PCDFs and PCBs

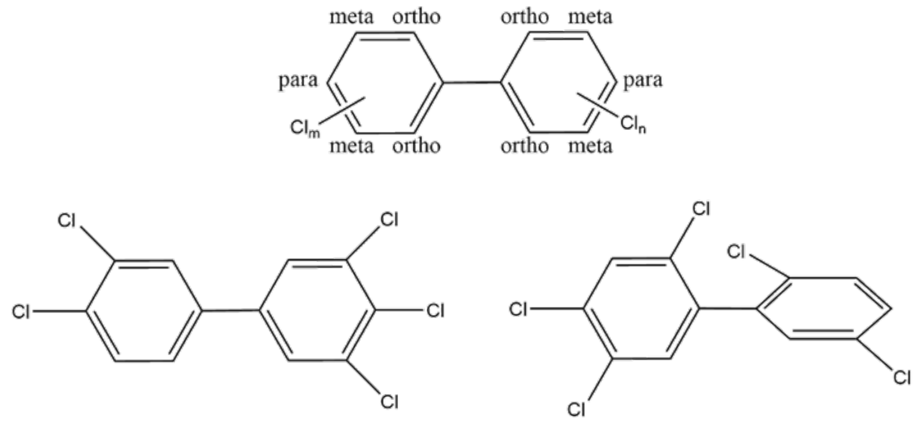
1.3.1 PCDDs and PCDFs

PCDDs and PCDFs are two groups of closely related chlorinated organic compounds that have a triple-ring structure consisting of two benzene rings connected by a third oxygenated ring. For PCDDs, the benzene rings are connected by a pair of oxygen atoms, whereas for PCDFs, they are connected by a single oxygen atom. The number of chlorine substitutions of the hydrogen atoms can vary from one to eight. PCDDs and PCDFs have the same mechanism of toxicity, which involves binding to an aryl hydrocarbon receptor (AhR), a cytosolic receptor protein present in most vertebrate tissues. There are 75 possible different positional congeners of PCDD and 135 possible congeners of PCDF, however only those with chlorine substitution in the 2,3,7 and 8 positions (including seven PCDDs and ten PCDFs), have dioxin-like toxicity (WHO 2016b).

1.3.2 PCBs

PCBs are a class of chemicals that have a biphenyl structure of two linked benzene rings in which one to ten chlorine atoms substitute the hydrogen atoms on the rings. PCBs exhibit different toxicological effects depending on the site of chlorine substitution. There are 209 possible PCB congeners, with 12 exhibiting toxicological properties similar to PCDDs and PCDFs. This is due to their ability to adopt a similar planar structure and bind to the AhR receptor (WHO 2016b). These 12 PCBs are therefore referred to as DL-PCBs. They include congeners with no chlorine substitution in the *ortho* position (non-*ortho*-substituted PCB77, PCB81, PCB126 and PCB169) and congeners with only one *ortho* substitution (mono-*ortho*-substituted PCB105, PCB114, PCB118, PCB123, PCB156, PCB157, PCB167 and PCB189). All 12 have four or more chlorine atoms and are sometimes referred to as coplanar PCBs since their rings can rotate into the same plane (WHO 2016b).

Out of the 209 theoretically possible PCB congeners, 197 are NDL-PCBs. The NDL-PCBs display different toxicological activity than dioxins (PCDD/Fs and DL-PCBs). The EU (1999) has identified seven ‘indicator PCBs’ that can be used to characterise the presence of PCB in food or the environment. Six of these are NDL-PCBs (PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180), and one is a DL-PCB (PCB118). Figure 2 shows the different chlorine substitution positions and difference between DL- and NDL-PCBs.



PCB 126 PCB 101

*Figure 2: General structure of PCBs showing different chlorine substitution positions and examples of a coplanar, non-*ortho*-substituted DL-PCB (PCB126) and a non-planar, di-*ortho*-substituted NDL-PCB (PCB101)*

1.3.3 Toxic equivalency of dioxins

In total, there are seven PCDDs, ten PCDFs, and 12 DL-PCBs that have been classified as dioxins or dioxin-like compounds by the World Health Organization (WHO) (Van den Berg 2006). Within this group, the toxicity of each congener varies according to the degree and position of chlorine substitution. To account for this, WHO developed toxic equivalency factors (TEFs) for human risk assessments of these compounds. TEFs are weighting factors applied to individual congeners indicating their toxicity relative to that of the most toxic reference congener. In this case, the reference congener is the most toxic dioxin, 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), which has a TEF of one. Multiplying the analytical concentration of a particular congener with its TEF gives a concentration that is toxicologically equivalent to TCDD. The total toxic equivalency (TEQ) of a combination of specific dioxins is the sum of each congener concentration multiplied by its TEF.

TEFs were first established by the WHO in 1993, specifically for 2,3,7,8-PCDDs and PCDFs. These were subsequently reviewed in 1997 and the WHO published revised TEFs in 1998 for 29 congeners. In June 2005, a third WHO expert meeting was held to re-evaluate the TEFs. As a result of this third meeting, TEFs for some of the 29 congeners were changed. A comparison of the 1998 and 2005 WHO TEFs can be found in Appendix 2.

1.3.4 Sources of dioxins and PCBs

Dioxins and PCBs are ubiquitous environmental contaminants. Their presence reflects both historical and current emissions and can take many decades to plateau and reach a steady state. They are highly stable in soil, sediment, water and air. As such, they can remain in the environment for many years and be transported large distances.

Dioxins and PCBs have a high affinity for lipids and accumulate in the fatty tissue of living organisms that have been exposed through the environment and the diet. They bioaccumulate through the food chain, concentrating in the lipid tissue when organisms consume contaminated plants or other animals. Predators and other animals at the top of the food chain are most at risk of exposure to dioxins and PCBs. Due to these properties, the presence of dioxins and PCBs at very low levels in the environment and food supply is unavoidable (DAWE 2004a).

PCDDs and PCDFs are not manufactured intentionally. Previous assessment work by the Australian government estimated that uncontrolled combustion, including bushfires, agricultural burning, accidental fires and open waste burning activities contributed approximately 75% of total PCDD and PCDF emissions into the environment. Other sources of emissions were metal production, production of chemicals and consumer goods, power generation and heating, waste disposal and landfill (primarily associated with aquatic contamination), and controlled industrial waste incineration (DAWE 2004b). The role of bushfires in PCDD and PCDF emissions is important, as they are a natural and re-occurring phenomenon in parts of Australia.

Up until the late 1970s, large amounts of PCBs were manufactured in countries other than Australia in the form of various PCB technical mixtures, commonly referred to as Aroclors. PCBs were widely used in electrical appliances, hydraulic fluids, plasticisers and dye carriers. The Australian government banned the importation of PCBs in 1975. Historical releases into the Australian environment are thought to be largely through waste management of materials containing PCBs. They are also produced as unintentional by-products of industrial processes such as chemical manufacturing and incineration (DAWE 2019).

1.3.5 Regulation of dioxins and PCBs in food

For Australian and New Zealand foods, FSANZ sets maximum levels (MLs) for various contaminants for specific foods in Schedule 19 of Standard 1.4.1 of the Australia New Zealand Food Standards Code (the Code) (FSANZ 2020). MLs are only established for contaminants that present a significant risk to human health in those foods that are major contributors to dietary exposure or where there are known high concentrations, where regulations assist in ensuring levels in the food supply are at acceptable levels. MLs are established at levels which are as low as reasonably achievable (ALARA) while achieving food safety objectives.

There are no MLs for PCDDs and PCDFs in the Code. In the absence of MLs, general Code provisions apply including that food must be safe and suitable, for example, the concentration of contaminants should be kept ALARA. The Code specifies MLs for total PCBs in mammalian meat and poultry fat, milk and milk products, and eggs (0.2 mg/kg), and fish (0.5 mg/kg).

There are regulatory limits for dioxins and PCBs set by other countries or regions, namely MLs set by the European Union (EU) under Regulation EC No 1881/2006. For dioxins, these have been set for both the sum of PCDDs and PCDFs (TEQ) and the sum of all dioxins (including PCDDs, PCDFs and DL-PCBs) (TEQ). MLs have also been set for the sum of the six indicator NDL-PCBs (PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180) (EU 2020).

2 26th ATDS methodology

Food sample purchasing, preparation and analysis were undertaken according to detailed instructions provided in a procedures manual supplied to participating jurisdictions and the analytical laboratory. Details on all food types sampled, together with food preparation procedures can be found in Appendix 1 (PDF and Excel versions).

2.1 Food selection and purchasing

A total of 33 foods and beverages, including tap water, were included in the 26th ATDS. For each of the 33 foods, three primary samples (i.e. three purchases) were collected from either four or eight different Australian states and territories. A total of 600 primary samples were collected and combined into 200 composite samples for analysis. Each composite sample was made up of three primary samples from a single state or territory. The construction of state and territory-based composite samples for analysis is shown in Figure *3*.

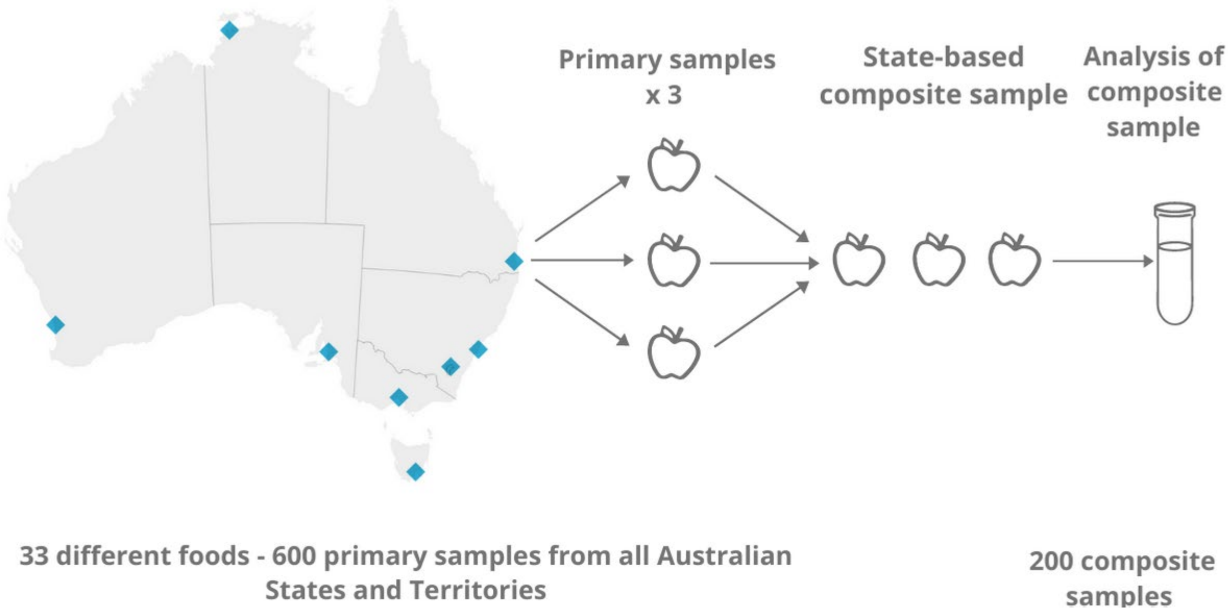


Figure 3*: Construction of state/territory-based composite samples*

Foods were chosen if they either:

- have been shown, through previous investigations, to contribute to the dietary exposure for any of the dioxins or NDL-PCBs analysed, and/or
- represent a food or beverage that is consumed in Australia based on national nutrition survey data.

Foods in the sample list were classified as either regional or national foods. Regional foods are more likely to be sourced from different regions and, as such, may have geographical variations in dioxin and NDL-PCB concentrations. These foods include milk, cheese, eggs, fish, meat and meat products, fruits, vegetables, bread, selected takeaway foods and tap water. Higher numbers of regional food samples were collected to take account of potential variations in concentrations. For each regional food, eight composite samples were analysed, each comprising three primary samples collected from different locations within each Australian state and territory.

National foods are centrally produced and distributed nationwide and therefore are expected to show less variation in dioxin and NDL-PCB concentrations. These include processed foods such as dairy products, fish products, processed meats, infant foods, vegetable oil, rice and a variety of canned and other shelf-stable packaged foods. For each national food, four composite samples were analysed, each comprising three primary samples collected from different locations within four Australian states and territories.

Food purchasing was undertaken by staff from Australian state and territory food regulatory agencies. Sampling took place over two sampling periods, Phase 1 (autumn sampling period) in April 2017 and Phase 2 (summer sampling period) in February 2018. This was done to take account of the seasonality of certain foods. Food samples were dispatched to the coordinating analytical laboratory, the National Measurement Institute (NMI), to its Port Melbourne facility, as soon as practicable after purchase. Perishable food samples (including fruits, vegetables and meat etc.) purchased outside Melbourne were sent to the laboratory by overnight freight in a chilled or frozen state, reflecting the state these products are received by consumers prior to cooking or preparation.

2.2 Food and sample preparation

All primary food samples were prepared to a ready-to-eat state by NMI Port Melbourne. For example, sausages were grilled before analysis. A number of purchased food samples, such as peanut butter and infant desserts, were in a ready-to-eat state when purchased and therefore did not require additional cooking or preparation. Perishable foods were all prepared within 48 hours of purchase. Frozen and shelf-stable foods were prepared as soon as practicable within a week of purchase.

After preparation to a table ready state, a representative portion from each primary sample was taken and combined to form a state/territory-based composite sample for analyses. Samples requiring further transport for analyses by a different laboratory were freighted in a stable frozen state as soon as practicable.

2.3 Food analyses

The NMI Ultra-trace laboratory in Sydney conducted the analyses of food samples for dioxins. NMI Port Melbourne undertook the analyses of food samples for NDL-PCBs. The analyses of samples were conducted in NATA accredited facilities using fully validated NATA accredited methods. The results were also subject to documented quality assurance and quality control procedures.

A summary of the analytical methods used is provided in Table 1. Further details can be found in Appendix 2.

Table 1: Summary of analytical methods used in the 26th ATDS

Compound		Analytical method (reference)	Limit of Reporting (LOR)[3]
Dioxins	PCDD/Fs	HRGC/HRMS (US EPA 1613B)	0.00020 – 1.0 pg/g or ppt
	DL-PCBs	HRGC/HRMS (US EPA 1668A)	0.00030 – 30 pg/g or ppt
NDL- PCBs	NDL-PCBs	GC/MSMS (in-house)	0.050 – 1.0 µg/kg or ppb

Note: pg/g = picogram/gram, ppt = parts per trillion, µg/kg = microgram/kilogram, ppb = parts per billion

[3] LOR: The lowest concentration of an analyte reported by the laboratory using a certain analytical procedure. LORs for different food types (matrices) differ. The range of LORs cover the 33 different food types analysed.

3 Results

3.1 Treatment of analytical results

3.1.1 Lower, middle and upper-bound concentrations

As dioxins are ubiquitous environmental chemicals, it is reasonable to assume they are present in food when analytical results are reported to be less than the limit of reporting (LOR). The LOR for dioxins was equal to the limit of detection (LOD) and the limit of quantification (LOQ). The LOD and LOQ are the lowest concentrations of an analyte that can be reliably detected and quantified by an analytical procedure, respectively, with an acceptable degree of certainty. Therefore, where an analytical result was reported as being 'not-detected' (ND) or below the LOR (<LOR), the actual concentration could be anywhere between zero and the LOR. To address this uncertainty, analytical results for each dioxin congener are presented as a range, as described below:

- The lower bound (LB) of this range was calculated assuming that all results reported as ND (<LOR) were equal to zero.
- The middle bound (MB) of this range was calculated assuming that all results reported as ND (<LOR) were present at half the LOR (½LOR).
- The upper bound (UB) of this range, representing a very conservative 'worst-case' estimate, was calculated assuming that all results reported as ND (<LOR) were present at the LOR.

Similar to dioxins, the presence of NDL-PCBs is widespread in the environment, and low levels of these compounds are expected to be present in food. For this reason, LB, MB and UB scenarios also applied with respect to the LOR. In addition, some analytical results were reported as a trace result (TR). This occurred when individual sample chromatograms had sufficient characteristics to determine the presence of NDL-PCB congeners at concentrations somewhere between the LOD and LOR. The LB, MB and UB results for each NDL-PCB congener are presented as a range, as described below:

- The LB of this range was calculated assuming that all results reported as ND (<LOR) were equal to zero; and results reported as TR were assumed to be equal to the LOD.
- The MB of this range was calculated assuming that all results reported as ND (<LOR) were present at half the LOR (½LOR); and results reported as TR were assumed to be equal to the mid-point between the LOD and the LOR ((LOD + LOR)/2).
- The UB of this range was calculated assuming that all congeners reported as non-detect (<LOR) were present at the LOR; and results reported as TR were assumed to be equal to the LOR.

Total LB, MB and UB dioxin and NDL-PCB concentrations were calculated by summing the concentrations of the 29 individual dioxin congeners (after weighting with the TEF) and 16 NDL-PCB congeners using the assumptions set out above. The majority of analytical results were NDs. As a consequence, the conservatism of the dioxin and NDL-PCB UB concentration scenarios is considerable and is compounded by the summing of the UB values for the relevant congeners. Therefore, in the following section, LB analytical values are presented and discussed.

3.2 Prevalence and concentrations

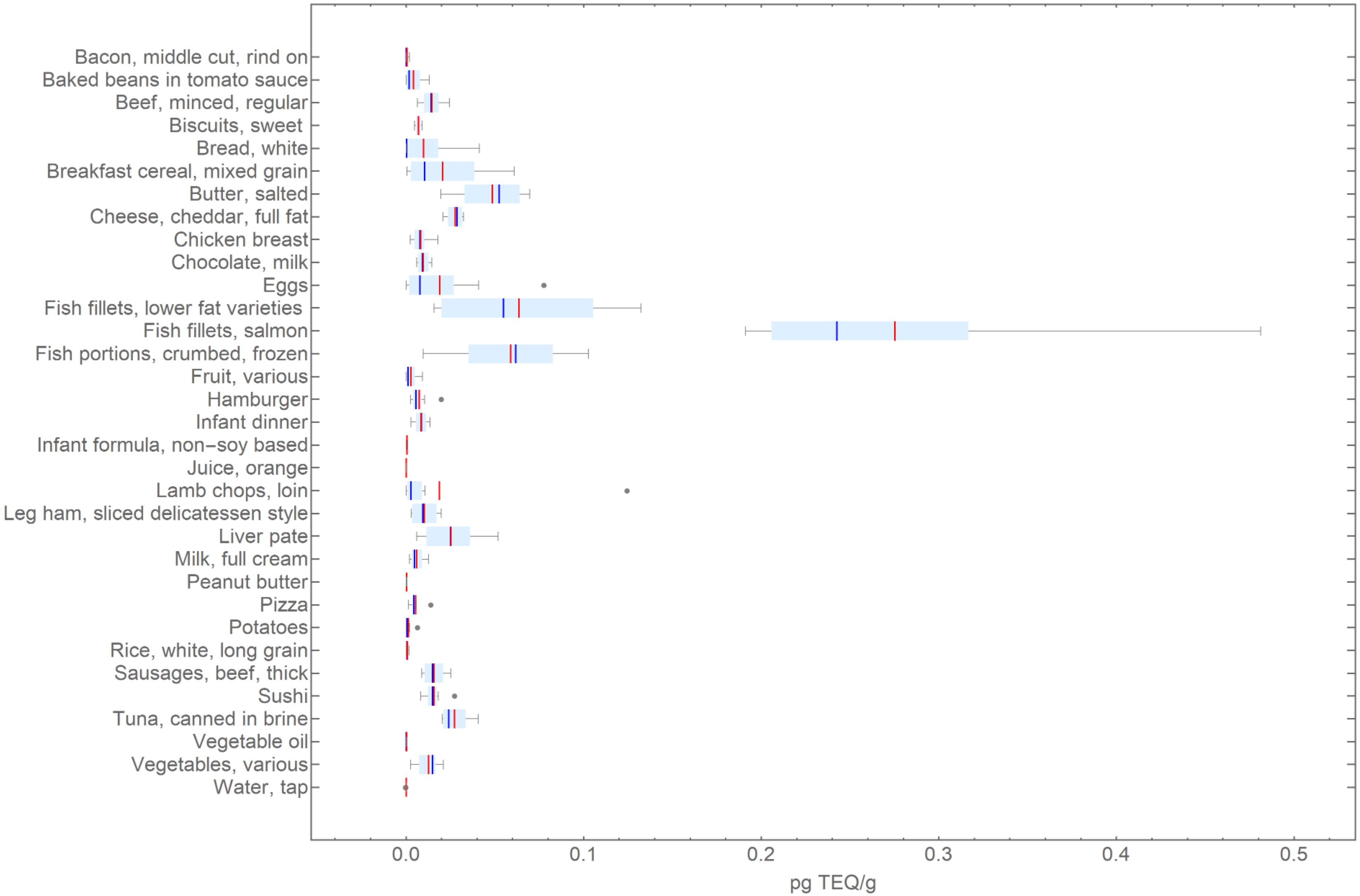
3.2.1 Dioxins

Dioxins were detected in 32 of the 33 foods sampled in the 26th ATDS. Of the 200 composite samples analysed, 190 (95%) had detectable levels of dioxins above the LOR. This result is not unexpected due to the ubiquitous nature of dioxins.

The foods with the highest mean dioxin levels (assuming ND=0) were salmon fillets (0.28 pg TEQ/g) and fish fillets (lower fat varieties) (0.064 pg TEQ/g). Other foods with detectable levels included crumbed fish portions (0.059 pg TEQ/g), butter (0.048 pg TEQ/g), cheddar cheese (0.028 pg TEQ/g), canned tuna (0.027 pg TEQ/g), and liver pate (0.025 pg TEQ/g). For each of these foods, there was a 100% rate of detection (Table 2). The results are consistent with the known potential of dioxins to accumulate at higher levels in fatty foods including fish and dairy. Fish, in particular have been consistently found to have higher levels of dioxins than other food types including dairy, eggs, meat and vegetable products (JECFA, 2002). For salmon fillets, the results likely reflect their relatively high fat content compared to other fish products sampled. Mean dioxin levels for the other foods sampled were less than 0.025 pg TEQ/g. There were no detections in tap water. Looking specifically at infant foods, the mean dioxin levels in infant dinner and infant formula were comparatively low (0.0084 pg TEQ/g and 0.00055 pg TEQ/g, respectively). Refer to Figure 4 and Appendix 4 for further details.

Table 2: Lower bound dioxin concentrations as TEQ for foods surveyed in the 26th ATDS with the highest detected levels

Food	Number of samples	Rate of detection (%) (Detections/ Total samples)	Mean LB concentration (pg TEQ/g)	Range LB concentrations (pg TEQ/g)
Fish fillets, salmon	8	100 (8/8)	0.28	0.19 – 0.48
Fish fillets, lower fat varieties	8	100 (8/8)	0.064	0.016 – 0.13
Fish portions, crumbed, frozen	4	100 (4/4)	0.059	0.010 – 0.10
Butter, salted	4	100 (4/4)	0.048	0.019 – 0.070
Cheese, cheddar, full fat	4	100 (4/4)	0.028	0.021 – 0.032
Tuna, canned in brine	4	100 (4/4)	0.027	0.020 – 0.041
Liver pate	8	100 (8/8)	0.025	0.0060 – 0.052



Note: red line depicts mean concentrations; blue line depicts median concentrations
Comprehensive results are in Appendix 4

Figure 4: Lower bound dioxin concentrations as TEQ for foods surveyed in the 26th ATDS

3.2.2 Non-dioxin-like PCBs

The majority of samples had no detectable levels of NDL-PCBs. Of the 16 NDL-PCB congeners analysed, four were not detected in any foods. Of the 12 that were detected, one or more were detected in 13 of the 33 foods – this equates to detections in 21 (11%) of 200 composite samples.

All six indicator NDL-PCBs, which are considered representative of PCB contamination, were among the 12 congeners detected. The most frequently detected NDL-PCB congeners were PCB28 (detected in 21 of 200 composite samples (11%)), followed by PCB153 (6 of 200 or 4%), PCB138 (6 of 200 or 3%) and PCB52 (6 of 200 or 3%). The remaining congeners were detected in less than 3% of samples. Four NDL-PCBs congeners (PCB8, PCB195, PCB206 and PCB209) were not detected in any samples.

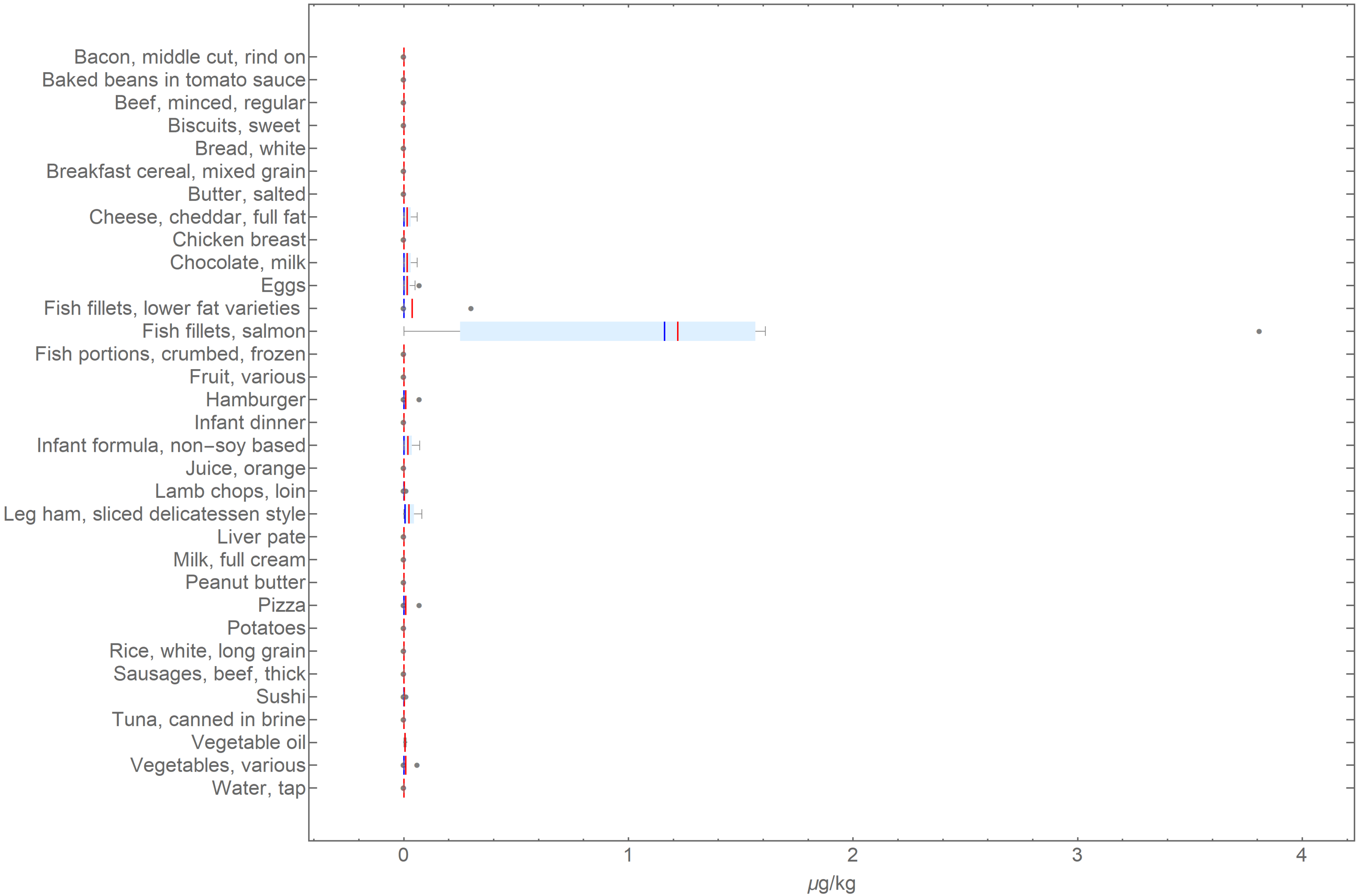
The highest mean LB levels of PCB28 were reported in salmon fillets (0.061 µg/kg), leg ham (0.023 µg/kg) and infant formula (0.018 µg/kg) (whereby PCB28 was the only congener detected in this food). For PCB153, the highest mean LB levels were detected in salmon fillets (0.31 µg/kg) and fish fillets (lower fat varieties) (0.0088 µg/kg). Similarly, the highest mean LB levels of PCB52 were detected in salmon fillets (0.090 µg/kg) and fish fillets (lower fat varieties) (0.0088 µg/kg). PCB101, PCB128 and PCB138 were detected in salmon fillets only, at mean LB levels of 0.13, 0.089 and 0.25 µg/kg respectively.

For total NDL-PCBs (i.e. the sum of the 16 congeners analysed[4]), the food with the highest mean LB concentration was salmon fillets (1.2 µg/kg). This is consistent with international occurrence data indicating that fatty fish generally contain the highest concentrations of PCBs. Reflecting the levels found in individual congeners, total NDL-PCB concentrations for other foods were comparatively lower: fish fillets (lower fat varieties) with a mean LB concentration of 0.038 µg/kg, leg ham (0.023 µg/kg), infant formula (0.018 µg/kg), cheddar cheese (0.015 µg/kg), milk chocolate (0.015 µg/kg) and eggs (0.015 µg/kg). The mean total NDL-PCB levels detected in all other foods were less than 0.0015 µg/kg. Refer to Figure 5 and Appendix 5 for further details.

[4] Of the 16 NDL-PCB congeners analysed, 12 were detected. For the four congeners that were not detected, their contribution to the total mean LB concentration was 0.

Table 3: Lower bound total NDL-PCB concentrations for foods surveyed in the 26th ATDS with the highest detected levels

Food	Number of samples	Rate of detection (%) (Detections/ Total samples)	Mean LB concentration (µg/kg)	Range LB concentrations (µg/kg)
Fish fillets, salmon	8	75 (6/8)	1.2	0 – 3.8
Fish fillets, lower fat varieties	8	13 (1/8)	0.038	0 – 0.30
Leg ham, sliced delicatessen style	4	50 (2/4)	0.023	0 – 0.080
Infant formula, non-soy based	4	25 (1/4)	0.018	0 – 0.070
Cheese, cheddar, full fat	4	25 (1/4)	0.015	0 – 0.060
Chocolate, milk	4	25 (1/4)	0.015	0 – 0.060
Eggs	8	25 (2/8)	0.015	0 – 0.070



Note: red line depicts mean concentrations; blue line depicts median concentrations
Comprehensive results are in Appendix 5

Figure 5: Lower bound total PCB concentrations in foods surveyed in the 26th ATDS

3.3 Comparison with previous Australian concentration data

As part of the Australian National Dioxin Program (2001 to 2004), FSANZ published a report of Australian consumers' dietary exposure to dioxins, including a risk characterisation (FSANZ 2004). Food samples were drawn from those collected and kept in frozen storage as part of the 20th ATDS in 2000-2001. Where there were insufficient samples remaining from the 20th ATDS, additional sampling was undertaken in 2002.

A comparison of the occurrence data reported in the FSANZ (2004) and 26th ATDS studies was conducted to investigate whether there had been any notable changes in dioxin TEQ levels in Australian foods between the two time periods. To facilitate this comparison, FSANZ (2004) results were recalculated to TEQ values using updated WHO (2005) TEFs.

The concentrations of dioxins found in the 26th ATDS were generally comparable with, or lower than those reported in the previous Australian study (2004) (Table 4 and Figure 6). For fish fillets (including salmon), mean UB dioxin TEQ concentrations were 4.9-fold lower than the 2004 levels. Other foods with considerably lower UB TEQ concentrations were infant formula (4.0-fold lower), peanut butter (3.0-fold lower), orange juice (2.3-fold lower) and milk chocolate (2.0-fold lower).

For those foods analysed in the 26th ATDS with dioxin concentrations higher than those analysed in the 2004 survey, the magnitude of the change was not as great; the most significant change in magnitude was observed in fish portions, which showed a 2.2-fold increase (Table 4 and Figure 6).

Table 4: Comparison of mean upper bound TEQ concentrations for dioxins between the 2004 study and the 26th ATDS

Food	Mean UB concentration for dioxins (pg TEQ/g)	
	FSANZ (2004)	26th ATDS
Bacon	0.25	0.14
Baked beans*	0.014	0.012
Beef, minced	0.31	0.32
Bread, white*	0.022	0.029
Butter	0.29	0.25
Chicken breast	0.67	0.59
Chocolate, milk	0.3	0.15
Eggs	0.48	0.41
Fish fillets	9.33	1.9
Fish portions, crumbed	0.26	0.56
Hamburger	0.19	0.27
Infant formula	0.59	0.15
Juice, orange*	0.0067	0.0029
Lamb chops	0.29	0.24
Leg ham	0.41	0.54
Liver pate	0.26	0.28
Milk	0.29	0.33
Peanut butter	0.43	0.14
Potatoes*	0.013	0.0068
Sausage	0.25	0.26
Tuna, canned*	0.038	0.030
Vegetable oil/Margarine	0.069	0.081

Note: all results are expressed in g TEQ/g lipid weight (lw) unless otherwise stated. TEQs for dioxin concentration data from the 2004 study have been recalculated using WHO 2005 TEF values.
*Results are expressed in fresh weight (fw)
#Margarine was analysed in the 2004 study and compared with vegetable oil analysed in the 26th ATDS

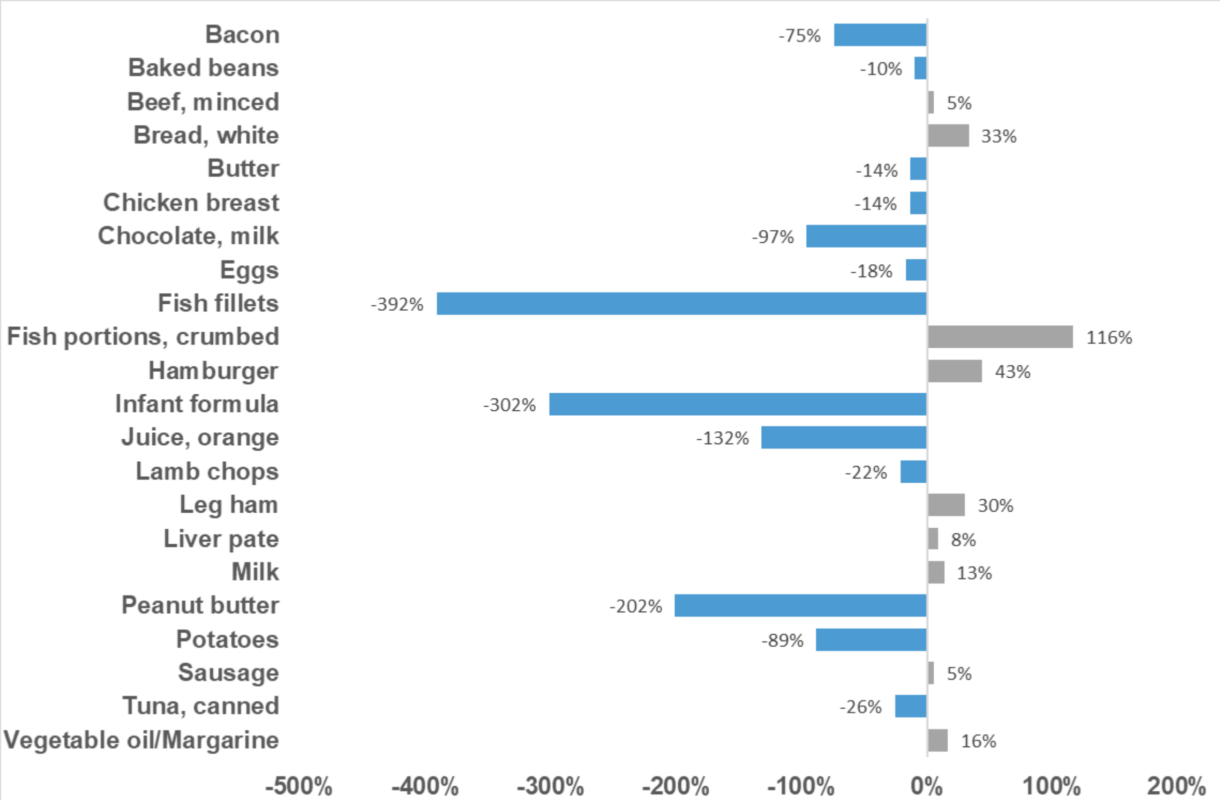


Figure 6: Comparison of mean upper bound TEQ concentrations for dioxins between the 2004 study and the 26th ATDS as relative change (%)

3.4 Comparison of concentrations with international studies

Dioxin and NDL-PCB levels in foods surveyed in the 26th ATDS were compared to a number of international studies. It was necessary to make comparisons on both a lipid weight (lw) and a fresh weight (fw) basis, depending on how the international data were presented. Therefore, in some cases, 26th ATDS results have been presented on a lipid weight basis to match how the international data were reported; this has been clearly indicated in the discussion that follows. Overall, dioxin and NDL-PCB levels in Australian foods are generally lower than those reported internationally.

3.4.1 Dioxins

Dioxin levels determined in the 26th ATDS for those foods that had the highest levels, such as fish, meat and dairy products, were consistently lower than those reported internationally.

For fish, mean 26th ATDS dioxin concentrations ranged between 0.17 – 0.18 pg TEQ/g, which is considerably lower than levels reported in the United Kingdom, France, and Sub-Saharan Africa (0.278 – 0.537 pg TEQ/g). For fish products, mean 26th ATDS results (0.13 – 0.14 pg TEQ/g) also compared favourably to those reported in the EU and Spain (1.55 – 3.09 pg TEQ/g).

The 26th ATDS results for milk and dairy products (0.14 – 0.32 pg TEQ/g on a lw basis) were generally within the range of international studies and considerably lower than those reported by the EU and Spain (0.99 – 1.61 pg/ TEQ/g (lw)).

Similarly, meat and meat product results from the 26th ATDS (0.14 – 0.35 pg TEQ/g (lw)) were generally consistent with international studies and considerably lower than the EU and Spain (0.93 – 3.33 pg TEQ/g (lw)).

The 26th ATDS results for offal were approximately 2 to 17-fold lower than those reported by the United Kingdom, France and the EU.

With respect to infant formula, the levels reported in Australia (0.018 – 0.15 pg TEQ/g (lw)) were under half those reported in the EU (0.36 pg TEQ/g (lw)) and over three-fold less than the maximum levels reported in Canada (0.5387 pg TEQ/g (lw)) (Table 5).

Table 5: Comparison of mean TEQs concentrations for dioxins between the 26th ATDS and international studies

Food group	ER	Australia (26th ATDS) Mean LB – UB (pg TEQ/g)	United Kingdom[1] (2012) UB (pg TEQ/g)	France[2] (2012) Mean (pg TEQ/g)	European Union[3] (2010) Mean (pg TEQ/g)	Canada[4] (2014) Min – Max (pg TEQ/g)	Spain[5] (2011) Mean (pg TEQ/g)	Sub-Saharan Africa[6] (2019) UB (pg TEQ/g)
Eggs	fw	0.019 – 0.034	0.044	0.027				0.046
	lw	0.23 – 0.41			1.71		0.78	
Fish	fw	0.17 – 0.18	0.326	0.537				0.278
Fish and fish products	fw	0.13 – 0.14			3.09		1.55	
Milk	fw	0.0060 – 0.010	0.008	0.013				0.048
Milk and dairy products	fw	0.022 – 0.088	0.105	0.038				
	lw	0.14 – 0.32			1.61	0 – 0.4016	0.99	
Meat	fw	0.014 – 0.035	0.077	0.047				0.03
Meat products	fw	0.011 – 0.038	0.03	0.043				
Meat and meat products	lw	0.14 – 0.35			3.33		0.93	
Poultry	fw	0.0082 – 0.017	0.011	0.025				
	lw	0.28 – 0.59			1			
Offal	fw	0.025 – 0.066	0.191	0.139				
	lw	0.10 – 0.28			4.93			
Vegetable oil	fw	0.00022 – 0.081	0.092	0.049				0.123
	lw	0.00022 – 0.081			0.35	0 – 1.0113	0.37	
Infant formula	lw	0.018 – 0.15			0.36	0 – 0.5387		

Food group	ER	Australia (26th ATDS) Mean LB – UB (pg TEQ/g)	United Kingdom[1] (2012) UB (pg TEQ/g)	France[2] (2012) Mean (pg TEQ/g)	European Union[3] (2010) Mean (pg TEQ/g)	Canada[4] (2014) Min – Max (pg TEQ/g)	Spain[5] (2011) Mean (pg TEQ/g)	Sub-Saharan Africa[6] (2019) UB (pg TEQ/g)
Bread	fw	0.010 – 0.029	0.011					
Cereals	fw	0.021 – 0.040	0.013				0.07	
Vegetables	fw	0.013 – 0.017	0.005	0.005			0.04	
Fruit	fw	0.0026 – 0.010	0.003					
Potatoes	fw	0.0013 – 0.0068	0.01					

ER: expression of results in fresh weight (fw) or lipid weight (lw). All results are in pg TEQ/g.
[1]2012 UK FERA Organic environmental contaminants in the 2012 total diet study samples, [2]2012 Sirot et al. (2nd French TDS), [3]2010 EFSA report on Results of the monitoring of dioxin levels in food and feed, [4]2014 Dioxins and dioxin-like compounds in selected foods, [5]2011 Marin et al. (Occurrence and estimated dietary intake of dioxins and DL-PCBs in foods in Valencia (Spain)), [6]2020 Vaccher et al. (1st Sub-Saharan Africa TDS)

3.4.2 Non-dioxin-like PCBs

A comparison between 26th ATDS NDL-PCB concentration data and data from various international studies is presented in Table 6. The 26th ATDS results for the sum of the 6 indicator NDL-PCBs were consistently lower than those reported by France, Germany, Belgium, Finland and China (EFSA 2016). Indicator NDL-PCB levels reported for Sub-Saharan Africa were consistent and within the range of 26th ATDS results.

For fish, which has the highest levels of NDL-PCBs detected in the 26th ATDS, the sum of indicator NDL-PCBs ranged between 447 – 654 pg/g, which is considerably lower than those reported in several European countries (6,673 – 24,839 pg/g). Levels were slightly lower than Sub-Saharan Africa and similar to those reported in China. The 26th ATDS infant formula results for the sum of indicator NDL-PCBs (0 – 300 pg/g) were generally consistent with international data and considerably lower than those reported in Belgium and Finland (which were analysed as being up to 10,927 pg/g) (Table 6).

Table 6: Comparison of mean concentrations for the sum of 6 indicator NDL-PCBs between 26th ATDS and international studies

Food group	Mean concentration for the sum of six indicator NDL-PCBs (PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180)						
	Australia (26th ATDS)	France[1] (2016)	Germany[1] (2016)	Belgium[1] (2016)	Finland[1] (2016)	China[1] (2016)	Sub-Saharan Africa[2] (2019)
	Mean LB-UB (pg/g)	Mean LB-UB (pg/g)	Mean LB-UB (pg/g)	Mean LB-UB (pg/g)	Mean LB-UB (pg/g)	Mean LB-UB (pg/g)	Mean UB (pg/g)
Eggs	15 – 303	0.6 – 379	1,226 – 1,415	8,095 – 14,031	428 – 428	100 – 101	64
Fish	44 – 654	6,673 – 7,416	777 – 1,380	7,316 – 9,418	24,839 – 24,839	580 – 581	852
Meat	0.4 – 300			338 – 3,671	329 – 329		44
Beef	0 – 300	0.8 – 0.8	216 – 288			29 – 29	
Pork	11 – 304	1 – 1	794 – 795			61 – 61	
Lamb	1 – 300	0.7 – 0.7	174 – 328	317 – 850		0 – 1	
Chicken	0 – 300	10 – 79	5 – 27	53 – 2,712		3 – 5	
Milk	0 – 300	0.1 – 8	23 – 26	2,935 – 6,760		20 – 20	
Dairy products	8 – 301		228 – 255	416 – 766		57 – 57	83
Butter	0 – 300	1,716 – 1,716	3,608 – 3,719	1161 – 10,458			
Vegetable oil	5 – 300	0.2 – 0.2	61,515 – 61,515*	0 – 1,740			23**
Infant food	0 – 300	0.1 – 0.1	253 – 309	0 – 2,875	10,927 – 10,927	43 – 43	

All results are in pg/g fresh weight.

[1]2016 WHO JECFA Safety evaluation of certain food additives and contaminants – Non-dioxin-like polychlorinated biphenyls, [2]2019 Vaccher et al. (1st Sub-Saharan Africa TDS)

*animal or vegetable fats, not elsewhere specified

**oil/fat

3.5 Comparison of concentrations with Australian and international regulatory limits

A comparison of total PCB levels determined in the 26th ATDS against Code MLs was undertaken. ATDS results are not a measure of compliance with the MLs specified in the Code. MLs are applicable to 'food for sale' in Australia and enforcement is the responsibility of state and territory departments, agencies and local councils in Australia and, for food imported into Australia, the Australian Department of Agriculture, Water and the Environment. However, ATDS results can provide a general indication of areas that may warrant follow-up investigation and management by the Food Regulation System.

The PCB profile included in the 26th ATDS is considered to be representative of total PCB contamination as all seven congeners considered relevant for the characterisation of PCB contamination (indicator PCBs) were included in the study (i.e. NDL-PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180, and DL-PCB118). The levels of total PCBs detected in foods for which there are Code MLs were several orders of magnitude below those MLs (Table 7).

Table 7: Comparison of upper bound concentrations for total PCBs between 26th ATDS and Code Maximum Levels

Food group	N	Upper bound concentration for total PCBs* (mg/kg fw)		Code ML** (mg/kg)
		Mean	Range	
Butter, salted	4	0.0046	0.0046 – 0.0046	0.2
Cheese, cheddar, full fat	4	0.0046	0.0046 – 0.0046	0.2
Eggs	8	0.0046	0.0046 – 0.0046	0.2
Milk, full cream	8	0.0046	0.0046 – 0.0046	0.2
Tuna, canned in brine	4	0.0046	0.0046 – 0.0046	0.5
Fish fillets, lower fat varieties	8	0.0047	0.0046 – 0.0048	0.5
Fish fillets, salmon	8	0.0060	0.0048 – 0.0087	0.5
Fish portions, crumbed, frozen	4	0.0047	0.0046 – 0.0047	0.5

*Total PCBs include 12 DL-PCBs and 16 NDL-PCBs analysed in the 26th ATDS
** FSANZ Schedule 19 Maximum levels of contaminants and natural toxicants F2017C00333 registered 18.04.2017. The ML for mammalian fat, poultry fat, milk and milk products, and eggs is 0.2 mg/kg. The ML for fish is 0.5 mg/kg.
N denotes number of composite samples analysed in that food group. All results are expressed in fresh weight (fw).

MLs for dioxins and PCBs have also been set by the EU. Table 8 provides a comparison of dioxin (total PCDDs plus PCDFs, as well total PCDD/Fs plus DL-PCBs) and NDL-PCB concentrations detected in the 26th ATDS against respective EU MLs. The dioxin and NDL-PCB concentrations in the 26th ATDS foods were well below the EU MLs indicating consistency with European regulations.

Table 8: Comparison of minimum and maximum upper bound levels for dioxins and 6 indicator NDL-PCBs between 26th ATDS and EU Maximum Levels (MLs)

Food group	N	ER	Dioxins + Furans (PCDD/Fs)		Total dioxins (PCDD/Fs + DL-PCBs)		Total of 6 indicator NDL-PCBs	
			UB range (pg TEQ/g)	EU ML* (pg/g)	UB range (pg TEQ/g)	EU ML* (pg/g)	UB range (ng/g)	EU ML* (ng/g)
Fish	24	fw	0.0073 – 0.14	3.5	0.02 – 0.48	6.5	0.30 – 2.6	75
Infant food	8	fw	0.0028 – 0.017	0.1	0.003 – 0.018	0.2	0.30 – 0.32	1.0
Liver	8	fw	0.030 – 0.084	0.3	0.04 – 0.09	0.5	0.30 – 0.30	3.0
Milk/Dairy	15	lw	0.13 – 0.44	2.5	0.19 – 0.55	5.5	n/a	40
Eggs	8	lw	0.10 – 0.80	2.5	0.12 – 0.90	5	n/a	40
Vegetable oil	4	lw	0.070 – 0.078	0.75	0.079 – 0.082	1.25	n/a	40
Beef	16	lw	0.14 – 0.59	2.5	0.19 – 0.66	4	n/a	40
Lamb	8	lw	0.093 – 0.43	2.5	0.11 – 0.49	4	n/a	40
Pork	8	lw	0.083 – 0.76	1	0.093 – 0.88	1.25	n/a	40
Chicken	7	lw	0.26 – 0.70	1.75	0.32 – 0.80	3	n/a	40

*Commission Regulation EC No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs with greater than 2% lipid content for those categories where lw applies (version 01.07.2020)
N denotes number of samples in that food group that met the EC critieria
ER: expression of results in fresh weight (fw) or lipid weight (lw)
n/a: not applicable. 26th ATDS analytical results for NDL PCBs were reported by fw only, hence a comparison with EU MLs (based on lw) is not possible
Fish comprised 26th ATDS foods fish fillets of lower fat varieties, salmon fillets, crumbed fish portions and canned tuna
Infant food comprised 26th ATDS foods infant dinner and infant formula
Liver represented by 26th ATDS food liver pate
Milk/Dairy comprised 26th ATDS foods butter, cheddar cheese and milk
Beef comprised 26th ATDS foods minced beef and beef sausages
Pork comprised 26th ATDS foods bacon and leg ham

4 Hazard identification and characterisation

4.1 Dioxins

Dioxins can accumulate in the body fat of animals and humans because they are lipophilic and not metabolised to any significant extent. Adverse effects observed in animal studies include reproductive and developmental effects, alterations in thyroid hormone levels, immune toxicity and several types of cancer. Human studies have reported associations between exposure to dioxins and a range of health effects including impaired semen quality, increased neonatal thyroid stimulating hormone (TSH) and reduced mineralisation of tooth enamel (JECFA 2002; US EPA 2012; EFSA 2018).

In Australia, the National Health and Medical Research Council (NHMRC) has established a tolerable monthly intake (TMI) for dioxins of 70 pg TEQ/kg bw (NHMRC 2002; FSANZ 2004; OCS 2005).

The Australian TMI is based on a review of toxicology and epidemiology studies of dioxin-like compounds, as well as reviews by a range of national and international agencies (OCS 2005). These reviews included three key international evaluations by the World Health Organization European Centre for Environmental Health and International Programme on Chemical Safety, the European Community Scientific Committee on Food (EC-SCF) and Joint FAO/WHO Expert Committee on Food Additives (JECFA).

The Australian review noted that it is difficult to find epidemiological data with sufficient dose-response information to provide reliable risk estimates in exposed human populations (OCS 2005). Evaluation of epidemiology studies is complicated by uncertainties in extrapolating current body burdens of dioxins to past exposure and by the choice of the dose-response model used to fit the data.

The evaluations by the WHO, EC-SCF and JECFA established that hormonal, reproductive and/or developmental effects are the most sensitive indicators of dioxin-related toxicity in experimental animals. Despite some differences in the pivotal studies and in the methodology used to analyse the data, all three evaluations recommended similar health intake standards ranging from 30 – 120 pg TEQ/kg bw/month.

After considering the available reviews, the NHMRC concluded that a tolerable intake could be established for dioxins on the basis that a threshold exists (based on body burden) for all observed adverse effects, including cancer. A TMI for Australians of 70 pg TEQ/kg bw was established, which is the same as the provisional TMI (PTMI) derived by JECFA which was based on reproductive effects in the male offspring of TCDD-treated female rats (JECFA 2002). The tolerable intake was established on a monthly basis to indicate the long-term nature of any potential dioxin toxicity.

The NHMRC and JECFA evaluations concluded that any potential adverse effect associated with dioxin exposure at the levels normally found in food would only be observed following an elevation in dioxin body burden due to long-term exposure (over 40 – 50 years). The JECFA review further noted that the PTMI is not a limit of toxicity and does not represent a boundary between safe intake and intake associated with a significant increase in body burden or risk. Long-term exposure slightly above the PTMI would not necessarily result in adverse health effects but would erode the safety factor built into the calculation of the PTMI (JECFA 2002).

The US Environmental Protection Agency (US EPA) and European Food Safety Authority (EFSA) published risk assessments of dioxins in 2012 and 2018, respectively. Both proposed health-based guidance values (HBGVs) based on human epidemiology data rather than animal studies. The US EPA established an oral reference dose (RfD) for TCDD of 0.7 pg/kg bw/day, while EFSA established a tolerable weekly intake (TWI) for dioxins of 2 pg TEQ/kg bw/week (US EPA 2012; EFSA 2018).

Both EFSA and the US EPA noted that there were significant uncertainties in the exposure measurements made in the epidemiology studies on which these HBGVs are based. For studies of residents in Seveso, Italy, who were exposed to TCDD following an industrial explosion in 1976, it is not certain whether health outcomes may be a result of the initial high peak exposure or from longer-term ongoing exposure. In other cohorts there may be confounding by co-exposure to other organochlorines. EFSA and the US EPA also used different kinetic modelling approaches which involve a number of assumptions and limitations that introduce further uncertainties into the calculation of these HBGVs. In addition, EFSA noted that current TEFs for some compounds may overestimate their potency in humans, and recommended that they are re-evaluated.

Based on an analysis of the available international hazard assessments it is considered that the Australian TMI of 70 pg/kg bw/month should be adequately protective of the general population. Given the uncertainties in the available data the TMI may need to be reviewed following any further assessment by JECFA, noting that dioxins are included on JECFA's priority list for re-evaluation.

4.2 Non-dioxin-like PCBs

The most sensitive effects of NDL-PCBs are toxicity to the liver and thyroid. NDL-PCBs are lipid soluble and readily absorbed via the gastrointestinal tract, following which they are rapidly distributed throughout the body. The highest amounts are typically found in the liver, fat, skin and breast milk (JECFA 2016).

Short-term toxicity studies in rodents are available for four of the six indicator NDL-PCBs (PCB28, PCB52, PCB153 and PCB180) as well as for PCB128. The most sensitive effects in these studies were minimal changes in liver and thyroid histopathology that were of questionable toxicological relevance. Effects on neurodevelopment and immunological parameters were observed at doses higher than those which induced the minimal changes in the liver and thyroid.

PCB153 is the only congener for which a long-term toxicity and carcinogenicity study is available. Effects on the liver and thyroid were similar to those observed in the short term studies. On this basis the 80th JECFA meeting concluded that the liver and thyroid changes observed in the short-term studies with all five NDL-PCBs tested are unlikely to progress to major pathological changes over the long term (JECFA 2016).

Human epidemiological studies have suggested potential health effects associated with exposure to NDL-PCBs, including changes in thyroid hormone homeostasis, neurodevelopmental effects, immunological effects and some types of cancer. Environmental exposure to NDL-PCBs is always accompanied by exposure to dioxin-like PCBs, however, making it difficult to determine the independent effect of NDL-PCBs (JECFA 2016).

JECFA concluded that the available database is not sufficient to allow derivation of HBGVs for any of the NDL-PCBs, or for a group evaluation of these substances. Instead, JECFA used the minimal effect levels for the five NDL-PCBs for which toxicological data are available (Table 9) to estimate margins of exposure (MOEs). These endpoints are considered to be particularly conservative as they are based on minimal liver and thyroid changes that were not clearly of toxicological significance (JECFA 2016).

Because different dosing regimens were used in the toxicity studies, and because NDL-PCBs bioaccumulate, JECFA also calculated minimal effect doses (MEDs) as internal doses, based on concentrations reported in the animal studies (Table 9).

Table 9: Minimal effect doses for NDL-PCBs identified by JECFA (2016)

PCB congener Study duration Mode of administration	Minimal effect dose expressed as external dose (µg/kg bw/day)	Minimal effect dose expressed as body burden (mg/kg bw)[a]
PCB28 **90 days** **Diet**	2.8	0.07
PCB52 **28 days** **Gavage**	Total dose administered over the study: 3.0 mg/kg bw (administered as several loading and maintenance doses at intervals) MOEs calculated based on dose divided by 28 days: 107 µg/kg bw/day	NA
PCB101	NA	NA
PCB128 **90 days** **Diet**	4.2	0.07
PCB138	NA	N/A
PCB153 **105 weeks** **Diet**	7.0	2.0
PCB180 **28 days** **Gavage**	Total dose administered over the study: 3.0 mg/kg bw (administered as several loading and maintenance doses at intervals) MOEs calculated based on dose divided by 28 days: 107 µg/kg bw/day	1.6

[a] body burden based on reported concentration in adipose tissue; 350 g rat with 10% lipid
NA: no data available

For the risk assessment, FSANZ has compared estimated dietary exposures with the external MED levels identified by JECFA for the five NDL-PCBs for which toxicological data are available.

5 Dietary exposure assessment

The general ATDS dietary exposure assessment methodology used is discussed in detail in https://www.foodstandards.gov.au/science/surveillance/Pages/australiantotaldiets1914.aspx. Where the methodology used in the 26th ATDS varies from the general ATDS methodology, further details are provided below.

5.1 Analytical results used

5.1.1 Treatment of analytical results below the Limit of Reporting

Some analytical results for dioxins and NDL-PCBs were 'not detected' (ND), or in other words, were below the LOR for the analytical method. Since dioxins and NDL-PCBs occur in the environment, it is not reasonable to assume that the contaminant is not present in the food when the analytical concentrations are less than the LOR. Actual concentrations below the LOR could in reality be anywhere between zero and the LOR. To allow for this uncertainty, the concentration data were summarised for use in the dietary exposure assessments as outlined in Section 3.1.1. The UB represents a conservative 'worst-case' estimate. As a result of this, the estimates of dietary exposure are presented as a range between the LB and UB.

5.1.2 Concentration data used

There were a high number of analytical results for NDL-PCBs that were below the LOR therefore the mean analytical concentration was used for each analysed sample type in the dietary exposure calculations. Mean analytical concentrations were also used for the dioxins dietary exposure assessment.

5.2 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 2011-12 Australian National Nutrition and Physical Activity Survey (NNPAS). For example, beef sausages were analysed and the concentration mapped to all types of meat sausages and frankfurts. The mapping used for the 26th ATDS can be found in Appendix 1.

5.3 Population groups assessed

As discussed in Section 4.1, any potential adverse effect associated with dioxin exposure at the levels normally found in food would only be observed following an elevation in dioxin body burden due to long-term exposure (over 40 – 50 years). Therefore the only Australian population group assessed was 2 years and above (i.e. the whole 2011-12 nutrition survey population). To enable a comparison against international dietary exposure estimates, data for other age groups were also extracted but are not presented in detail in this report.

5.4 Dietary exposure assessment results

A dietary exposure assessment was conducted for all analysed dioxins (as TEQs), NDL-PCBs and for the sum of the six indicator PCB congeners (see Appendix 2 for further details). Only those substances with a HBGV or a MED are presented in this section of the report: dioxins (n=29 as TEQ), and individually PCB28, PCB52, PCB128, PCB153 and

PCB180. The detailed dietary exposures for all substances, including those listed above, can be found in Appendix 1.

5.4.1 Dioxins dietary exposures

The mean and 90th percentile (P90) dietary exposures to dioxins for Australian consumers aged 2 years and above were estimated in daily and monthly units. 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 daily results were multiplied by 30 in order to obtain monthly dietary exposures to enable a comparison with the TMI.

Daily mean and P90 dietary exposures are estimated to be 0.21 – 0.53 pg TEQ/kg bw/day and 0.37 – 0.89 pg TEQ/kg bw/day, respectively. Monthly mean and P90 dietary exposures are estimated to be 6.3 – 16 pg TEQ/kg bw/month and 11 – 27 pg TEQ/kg bw/month.

For all scenarios examined (LB, MB and UB), all respondents aged 2 years and above are exposed to dioxins (i.e. are consumers). Further details are provided in Table 10 and Figure 7.

Table 10: Estimated mean and P90 dietary exposures to dioxins for Australian consumers aged 2 years and above

Statistic	Scenario	Consumer dietary exposure to dioxins	
		pg TEQ/kg bw/day	pg TEQ/kg bw/month
Mean	Lower Bound	0.21	6.3
	Middle Bound	0.37	11
	Upper Bound	0.53	16
P90	Lower Bound	0.37	11
	Middle Bound	0.63	19
	Upper Bound	0.89	27

Note: the ratio of consumers to respondents for dioxins is 100% at LB, MB and UB

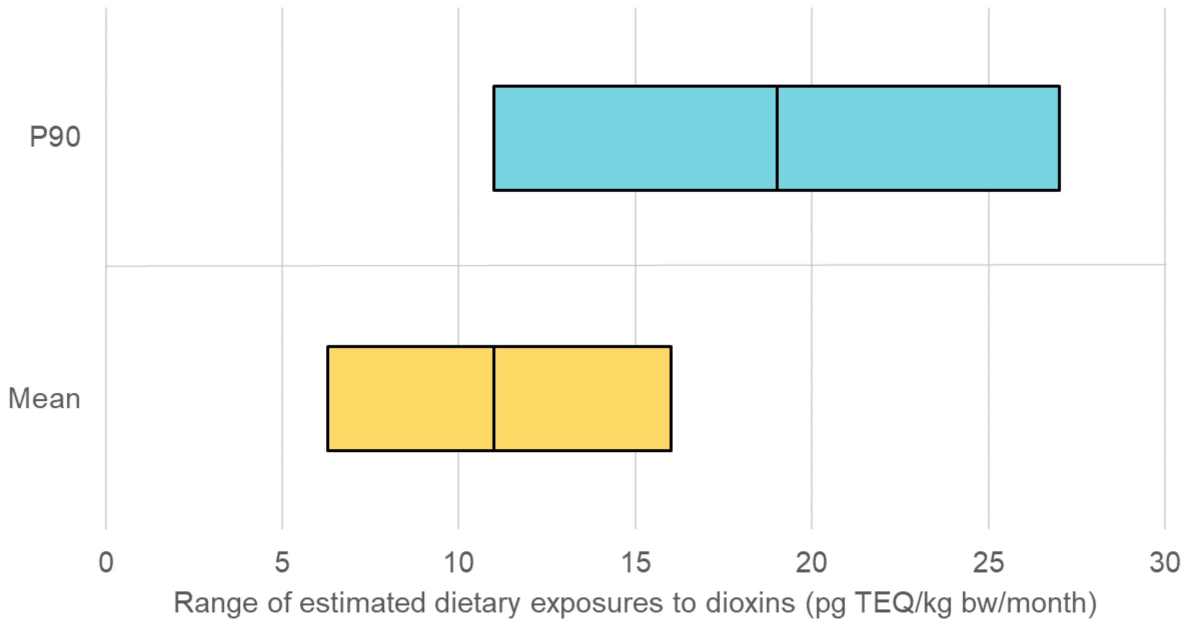


Figure 7: Range of estimated consumer dietary exposure to dioxins (LB to UB) for Australians aged 2 years and above

*(***Note***: the bar in the middle of the range represents the MB)*

5.4.2 Non-dioxin-like PCBs dietary exposures

The estimated mean and P90 dietary exposures to individual NDL-PCBs (PCB28, PCB52, PCB128, PCB153 and PCB180) for Australians aged 2 years and above were estimated in daily units.

The mean and P90 dietary exposures to the five specified NDL-PCBs are the same or similar at both the MB and UB, with only the LB estimates showing any differences between congeners. The LB estimates are reflective of the foods for which there were detectable concentrations. MB means are 1.3 – 1.4 ng/kg bw/day, with UB means at 2.6 – 2.7 ng/kg bw/day. MB P90s are 2.1 ng/kg bw/day, with UB P90s at 4.2 ng/kg bw/day.

At the LB, PCB180 has the lowest mean and P90 dietary exposures (mean 0.0049 ng/kg bw/day; P90 0.018 ng/kg bw/day), followed by PCB52 (mean 0.014 ng/kg bw/day; P90 0.044 ng/kg bw/day) and PCB128 (mean 0.017 ng/kg bw/day; P90 0.063 ng/kg bw/day). The highest exposures are for PCB28 (mean 0.053 ng/kg bw/day; P90 0.095 ng/kg bw/day) and PCB153 (mean 0.043 ng/kg bw/day; P90 0.14 ng/kg bw/day).

For the MB and UB scenarios, all respondents aged 2 years and above are exposed to PCB28, PCB52, PCB128, PCB153 and PCB180 (i.e. are consumers). At the LB, 29.1% of respondents are exposed to PCB28, PCB128 and PCB180, with 43.8% of respondents being exposed to PCB52 and PCB153.

Further details about the estimated dietary exposures to the NDL-PCBs listed above can be found in Table 11 and Figure 8. Details for all NDL-PCBs, including those listed above, can be found in Appendix 7.

Table 11: Mean and P90 consumer dietary exposures to a selection of NDL-PCBs for Australian consumers aged 2 years and above

NDL-PCB	%consumers to respondents*		Consumer dietary exposure (ng/kg bw/day)					
			Mean			90th percentile		
	LB	MB and UB	Lower Bound	Middle Bound	Upper Bound	Lower Bound	Middle Bound	Upper Bound
PCB28	29.1	100	0.053	1.4	2.7	0.095	2.1	4.2
PCB52	43.8	100	0.014	1.3	2.7	0.044	2.1	4.2
PCB128	29.1	100	0.017	1.3	2.6	0.063	2.1	4.2
PCB153	43.8	100	0.043	1.3	2.7	0.040	2.1	4.2
PCB180	29.1	100	0.0049	1.3	2.6	0.018	2.1	4.2

*Total number of respondents = 7,735

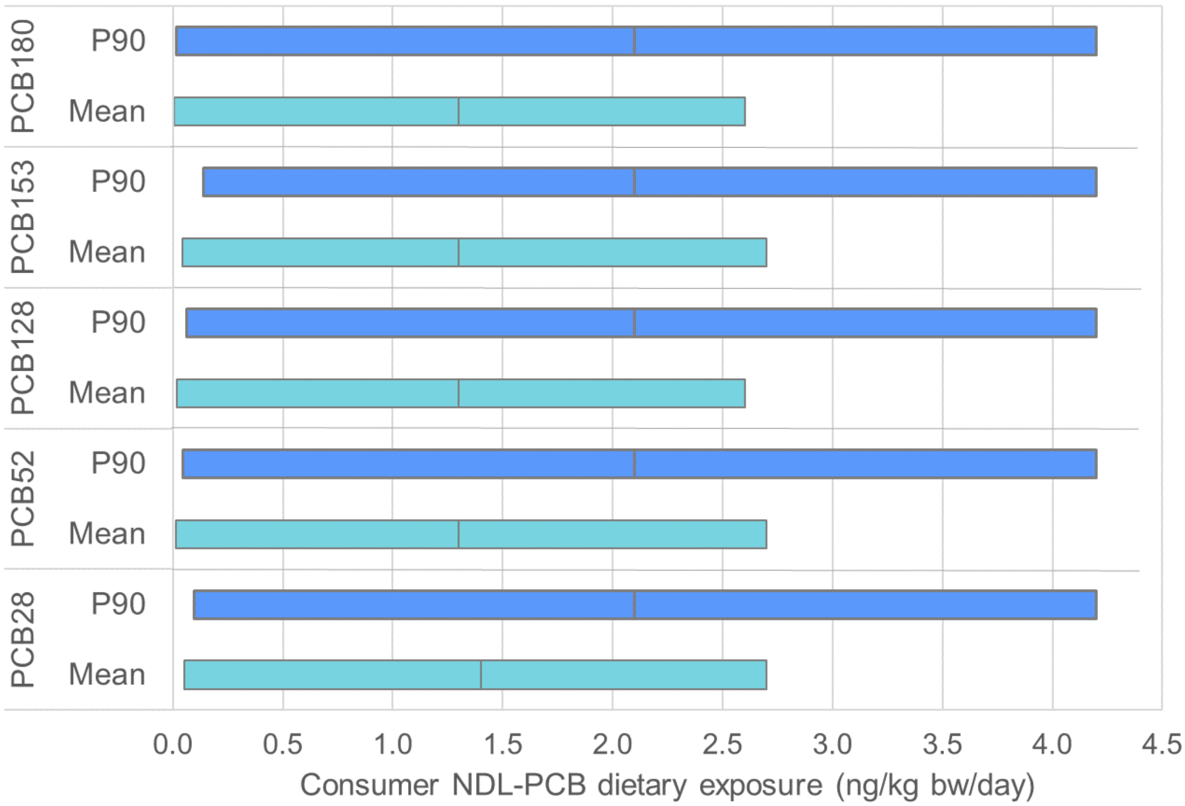


Figure 8: Range of estimated consumer dietary exposures to a selection of NDL-PCBs (LB-UB) for Australians aged 2 years and above

(Note: the bar in the middle of the range represents the MB)

5.5 Food contributors

The system used to map the analysed samples to the foods consumed by the Australian population can be found in Appendix 1. All discussion about food contributors to dioxins and NDL-PCBs dietary exposures refers to the food categories that the analysed samples represent (e.g. the sampled food "Vegetables, various" represents the food group of "Non-starchy vegetables and herbs"). "Food categories" are at a broad level; "food groups" are at a more specific level. 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.

Food consumption data for food categories and food groups for both consumers and respondents, including the proportion of consumers to respondents, can be found in Appendix 7.

5.5.1 Major contributors to dioxins dietary exposures

The major contributing (≥5%) food categories to dioxins dietary exposures are Dairy products (24%), Vegetables (23%), Cereals and cereal products (17%), Seafood (16%) and Meat, poultry and eggs (14%). The major contributing food groups are *Non-starchy vegetables and herbs* (21%), *Dairy milks (including flavoured), creams and yoghurts* (18%), *Breakfast cereals, flours, pasta and noodles (excluding rice based)* (9%), *Oily/ fatty fish (≥5% total fat)* (8%), and *Wheat- and rye-based breads and yeasted bakery products* (7%). Refer to Figure 9 and Appendix 7 for further information.

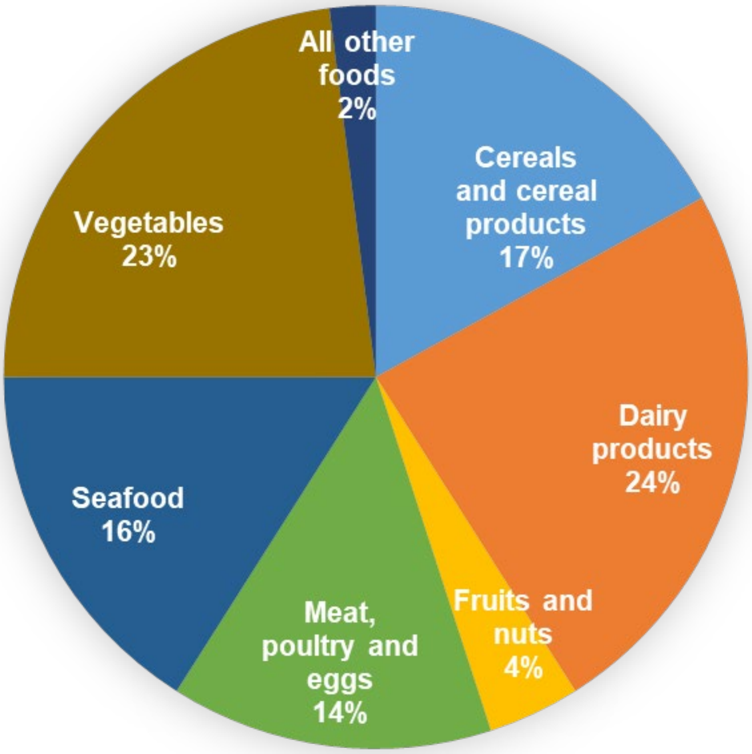


*Figure 9: Food category contributors to dioxins dietary exposures**

* Based on LB results

5.5.2 Major contributors to Non-dioxin-like PCB dietary exposures

5.5.2.1 PCB28

Vegetables (48%), Meat, poultry and eggs (20%), Seafood (10%) and Takeaway foods and Snacks (6%) are the major contributing food categories to PCB28 dietary exposures. *Non-starchy vegetables and herbs* (48%), *Pork (except bacon)* (12%), *Cheeses* (8%), *Eggs* (8%) and *Oily/ fatty fish (≥5% total fat)* (7%) are the major contributing food groups. Refer to Table 12, Table 13 and Appendix 7 for further details.

5.5.2.2 PCB52, PCB128, PCB153 and PCB180

Seafood is the only contributor to dietary exposures to PCB52, PCB128, PCB153 and PCB180. Most or all of this exposure (83 – 100%) is from *Oily/ fatty fish (≥5% total fat)*, with a smaller to no contribution (0 – 17%) from *White flesh/ non-oily fish (<5% total fat), molluscs and crustacea*. Refer to Table 12, Table 13 and Appendix 7 for further details.

Table 12: Major contributing food categories for a selection of NDL-PCBs for Australian consumers aged 2 years and above

Food category	%Contribution*				
	PCB28	PCB52	PCB128	PCB153	PCB180
Dairy products	**8**	0	0	0	0
Meat, poultry and eggs	**20**	0	0	0	0
Seafood	**10**	**100**	**100**	**100**	**100**
Takeaway foods and snacks	**6**	0	0	0	0
Vegetables	**48**	0	0	0	0

Note: only major contributing food categories for one or more NDL-PCB congeners are shown in this table. Comprehensive results are in Appendix 7
* Based on LB results

Table 13: Major contributing food groups to a selection of NDL-PCBs for Australian consumers aged 2 years and above

Food category	Food group	%Contribution*				
		PCB28	PCB52	PCB128	PCB153	PCB180
Dairy Products	Cheeses	**8**	0	0	0	0
Meat, poultry and eggs	Eggs	**8**	0	0	0	0
	Pork (except bacon)	**12**	0	0	0	0
Seafood	Oily/ fatty fish (≥5% total fat)	**7**	**83**	**100**	**94**	**100**
	White flesh/ non oily fish (<5% total fat), molluscs and crustacea	3	**17**	0	**6**	0
Vegetables	Non-starchy vegetables and herbs	**48**	0	0	0	0

Note: only major contributing food groups for one or more NDL-PCB congeners are shown in this table. Comprehensive results in Appendix 7
* Based on LB results

5.6 Comparison with international dietary exposures

When comparing 26th ATDS dietary exposures to dioxins and NDL-PCBs with those from other countries, it is important to recognise that different nutrition surveys, age groups, analytical methodologies and dietary exposure assessment methodologies have been used. These factors should be taken into account when making any comparisons or drawing conclusions from such comparisons. Additional dietary exposure estimates for specific age groups were extracted from the 26th ATDS datasets for the purpose of comparing as closely as possible with JECFA and other countries' estimates. Details of results from these other population sub groups can be found in Appendix 7.

Any dietary exposure assessment results that were not able to be directly compared with the available Australian data were excluded. Reasons for exclusion included: 1) the extrapolation of dietary exposures to a specific chemical from the dietary exposures to a group of chemicals; 2) the use of different TEFs; 3) there were dietary exposures estimated at two different periods of time (only the most recent dataset was used); 4) dietary exposures based on food frequency questionnaires; and/or 5) the use of age groups for which Australia has no national nutrition survey consumption data (e.g. infants).

5.6.1 Dioxins

Estimated mean dietary exposures for Australians aged 2 years and above (6.3 – 16 pg TEQ/kg bw/month) are lower than those for the whole American population (9.6 – 26.8 pg TEQ/kg bw/month) that were estimated using the 2001-2004 American Total Diet Studies (US FDA 2006).

The MB P50 (9.2 pg TEQ/kg bw/month) and P90 (16.3 pg TEQ/kg bw/month) dietary exposures for Australians aged 7-69 years are lower than those for the Dutch population of the same age (P50;15 pg TEQ/kg bw/month; P90; 24 pg TEQ/kg bw/month) (RIVM 2014).

Hong Kong adults aged 20-84 years have a higher mean dietary exposure to dioxins (21.92 pg TEQ/kg bw/month) (Hong Kong Centre for Food Safety 2011) compared to Australians of the same age (5.4 – 13.3 pg TEQ/kg bw/month).

Australia's mean dietary exposures to dioxins are generally lower than or in the lower end of the range of those estimated for Europeans (EFSA 2018). Australia's mean dietary exposures to dioxins for toddlers aged 2 years are 18.0 – 44.0 pg/kg bw/month whereas those for European toddlers aged 1-2 years are 20.4 – 77.1 pg TEQ/kg bw/month. Australian children aged 3-9 years have mean dietary exposures of 11.7 – 31.1 pg/kg bw/month whereas those for European children are 16.8 – 73.5 pg TEQ/kg bw/month. Adolescents aged 10-17 years have mean dietary exposures of 6.6 – 17.9 pg/kg bw/month for Australia while those for European adolescents are 9.0 – 45.0 pg TEQ/kg bw/month. Mean dietary exposures to dioxins for adults aged 18 years and above are 5.4 – 13.3 pg/kg bw/month for Australians and 12.6 – 39.0 pg TEQ/kg bw/month for Europeans.

5.6.2 Non-dioxin-like PCBs

In 2016, the FAO/WHO Joint Expert Committee on Food Additives (JECFA) published national dietary exposure estimates for NDL-PCBs (WHO 2016b). For both adults and children, the range of estimated mean and P90 dietary exposures to PCB28, PCB52, PCB101, PCB153 and PCB180 for Australians were either in the lower half of the range of those published by JECFA or were below the range (WHO 2016b). No comparison has been made between the PCB138 dietary exposures from the 26th ATDS and the JECFA estimates since the JECFA estimates were based on an extrapolation. The 26th ATDS and JECFA estimates for NDL-PCBs are presented in Table 14 for adults and Table 15 for children.

Table 14: Comparison between Australian estimated dietary exposures to NDL-PCBs for adults and national estimates of dietary exposure published by JECFA (WHO 2016b)

NDL-PCB	Country	Age group	Estimated dietary exposure to NDL-PCBs (ng/kg bw/day)	
			Mean♦	P90♦
PCB28	Australia	19 years and above	0.049 – 2.3	0.087 – 3.5
	JECFA	Adults	(0.005 – 0.3) – (0.02 – 4.7)	(0.01 – 2.0) – (0.05 – 9.5)
PCB52	Australia	19 years and above	0.015 – 2.3	0.049 – 3.5
	JECFA	Adults	(0.01 – 1.2) – (0.04 – 4.6)	(0.02 – 2.3) – (0.08 – 9.2)
PCB153	Australia	19 years and above	0.046 – 2.3	0.17 – 3.5
	JECFA	Adults	(0.03 – 3.0) – (0.1 – 5.0)	(0.06 – 6.0) – (0.3 – 9.9)
PCB180	Australia	19 years and above	0.0053 – 2.3	0.019 – 3.5
	JECFA	Adults	(0.01 – 0.7) – (0.07 – 4.7)	(0.03 – 1.5) – (0.1 – 9.4)
PCB101	Australia	19 years and above	0.026 – 2.3	0.096 – 3.5
	JECFA	Adults	(0.01 – 0.7) – (0.05 – 4.8)	(0.03 – 2.0) – (0.1 – 9.5)
PCB138	Australia	19 years and above	0.053 – 2.3	0.9 – 3.5
	JECFA	Adults	(0.03 – 1.7) – (0.1 – 4.7)	(0.06 – 3.5) – (0.3 – 9.3)

♦ The estimates of dietary exposures are LB to UB for Australia; those published by JECFA are presented as (minimum LB – maximum LB estimate) – (minimum UB – maximum UB estimate)

Table 15: Comparison between Australian estimated dietary exposures to NDL-PCBs for children and national estimates of dietary exposure published by JECFA

NDL-PCB	Country	Age group	Estimated dietary exposure to NDL-PCBs (ng/kg bw/day)	
			Mean♦	P90
PCB28	Australia	2 – 17 years	0.070 – 3.9	0.13 – 6.3
	JECFA	Children 0 – 17 years	(0.002 – 1.2) – (0.03 – 17.5)	(0.0004 – 2.5) – (0.05 – 35.1)
PCB52	Australia	2 – 17 years	0.011 – 3.9	0.021 – 6.3
	JECFA	Children 0 – 17 years	(0.0007 – 2.4) – (0.03 – 17.2)	(0.001 – 4.8) – (0.05 – 34.3)
PCB153	Australia	2 – 17 years	0.031 – 3.9	0.034 – 6.3
	JECFA	Children 0 – 17 years	(0.001 – 6.5) – (0.04 – 15.7)	(0.002 – 13.1) – (0.08 – 31.5)
PCB180	Australia	2 – 17 years	0.0032 – 3.9	0.0046 – 6.3
	JECFA	Children 0 – 17 years	(0.001 – 2.0) – (0.03 – 17.3)	(0.002 – 4.1) – (0.05 – 34.5)
PCB101	Australia	2 – 17 years	0.016 – 3.9	0.023 – 6.3
	JECFA	Children 0 – 17 years	(0.0003 – 3.0) – (0.03 – 17.2)	(0.001 – 6.0) – (0.07 – 34.4)
PCB138	Australia	2 – 17 years	0.032 – 3.9	0.046 – 6.3
	JECFA	Children 0 – 17 years	(0.0006 – 4.3) – (0.04 – 17.5)	(0.001 – 8.6) – (0.08 – 35.0)

♦ The estimates of dietary exposures are LB to UB for Australia; those published by JECFA are presented as (minimum LB – maximum LB estimate) – (minimum UB – maximum UB estimate)

6 Risk characterisation

6.1.1 Risk characterisation for dioxins

Given their ubiquitous environmental presence, low levels of dioxins may be detectable in a wide range of foods in the Australian diet and internationally. On this basis some dietary exposure to dioxins would be expected.

Levels of dioxins found in foods sampled in the 26th ATDS are generally comparable to or lower than concentrations found in Australian foods in 2004. Estimated dietary exposures for Australian consumers are also below or in the lower end of the range of those estimated in the USA, EU, the Netherlands and Hong Kong.

A TMI of 70 pg TEQ/kg bw for dioxins has been established independently by the NHMRC and JECFA. Mean and P90 dietary exposure estimates for dioxins for consumers aged 2 years and above are below this TMI (Table 16); mean and P90 dietary exposure estimates (LB to UB) are 9 – 25% TMI and 15 – 40% TMI, respectively.

Given that estimated dietary exposures are below the Australian TMI and below or towards the lower end of those estimated internationally, the ATDS results indicate that dietary exposures to dioxins for Australian consumers are acceptably low.

Table 16: Mean and P90 dietary exposures to dioxins (as TEQs) for Australian consumers aged 2 years and above, expressed as a percentage of the TMI

Estimated dietary exposure (%TMI)					
Mean			P90		
Lower Bound	Middle Bound	Upper Bound	Lower Bound	Middle Bound	Upper Bound
9	15	25	15	25	40

6.1.2 Risk characterisation for non-dioxin-like PCBs

Because the toxicological database for NDL-PCBs is limited, it is not possible to establish HBGVs for these substances. JECFA has identified MEDs for the five NDL-PCBs for which toxicological data are available, for use as reference points in a MOE evaluation. These reference points are particularly conservative as they are based on minimal liver and thyroid changes that were not clearly of toxicological significance.

MOEs based on external dose MEDs and mean estimated dietary exposures ranged from 53,000 to 22,031,000 at the lower bound, and from 1,000 to 40,000 at the upper bound (Table 17) across the five NDL-PCBs assessed. MOEs for the P90 dietary exposures ranged from 30,000 to 5,996,000 at the lower bound and from 1,000 to 26,000 at the upper bound across the five NDL-PCBs assessed. For substances which are not genotoxic and carcinogenic, a MOE ≥ 100 generally indicates a low health concern.

The wide range of the MOEs indicates a considerable amount of uncertainty and that non-detects contributed to the upper bound concentrations and dietary exposure estimates, where they are assigned a value equal to the LOR. In reality, NDL-PCB concentrations and therefore exposures will be somewhere between the lower and upper bound.

Estimated dietary exposures of Australian consumers to the individual indicator NDL-PCBs are either below or in the lower half of the range of international estimates published by JECFA. External dose upper bound MOEs are broadly comparable to those estimated by JECFA for the individual indicator NDL-PCBs for which toxicological data are available. JECFA also calculated internal body burden MOEs based on external doses as well as NDL-PCB levels measured in human milk, and concluded they gave some assurance that dietary exposures to NDL-PCBs are unlikely to be of health concern for adults and children.

PCB28 was detected in only one of four composite samples of infant formula at 0.070 µg/kg. On this basis, the mean LB concentration of PCB28 in all four infant formula samples was 0.018 µg/kg. There were no detections of NDL-PCBs in any other infant foods. The results for infant foods are comparable or lower than international data. A nine month old infant weighing 8.9 kg would need to consume over 345 L per day of made up infant formula containing PCB28 at the maximum concentration detected (0.070 µg/kg) to be exposed at the MED identified by JECFA. This, combined with the large size of the MOEs for PCB28 (1,000 – 53,000), indicate no health concerns for formula-fed infants.

For PCB128, upper bound MOEs for Australian consumers were an order of magnitude lower than those estimated by JECFA (1,000 – 2,000 versus 11,000 – 21,000, respectively), indicating that exposures to this compound in Australia are potentially higher. However, the PCB128 exposure estimates used by JECFA were not based on measured concentrations in food, but on an extrapolation from the exposures to the indicator NDL-PCBs. In the current survey PCB128 was only found in one food source, oily fish, at a mean LB concentration of 0.089 µg/kg and a maximum concentration of 0.30 µg/kg. A 60 kg individual would need to consume over 840 kg of fish per day containing PCB128 at the maximum concentration to be exposed at the MED identified by JECFA. Therefore dietary exposure to PCB128 for Australian consumers is also unlikely to be of health concern.

Given the large size of all MOEs and the conservative nature of the toxicological reference points, these results indicate that dietary exposures to NDL-PCBs for Australian consumers are acceptably low.

Table 17: Mean and P90 dietary exposures to NDL-PCBs for Australian consumers aged 2 years and above, expressed as a Margin of Exposure

NDL-PCB	MED (µg/kg bw/day)	MOE					
		For mean dietary exposure			For P90 dietary exposure		
		Lower Bound	Middle Bound	Upper Bound	Lower Bound	Middle Bound	Upper Bound
PCB28	2.8	53,000	2,000	1,000	30,000	1,000	1,000
PCB52	107	7,567,000	81,000	40,000	2,405,000	51,000	26,000
PCB128	4.2	243,000	3,000	2,000	66,000	2,000	1,000
PCB153	7	163,000	5,000	3,000	48,000	3,000	2,000
PCB180	107	22,031,000	81,000	40,000	5,996,000	51,000	26,000

7 Risk management

The results of the 26th ATDS indicate that levels of dioxins and PCBs in the Australian food supply are ALARA and acceptable from a food safety perspective. Specifically:

- There were no exceedances of Code or EU MLs for the detected levels of dioxins and NDL-PCBs.
- Levels of dioxins in foods are very low in Australia and trending downwards compared to the results of a previous Australian study (FSANZ 2004).
- Levels of dioxins and PCBs in food and dietary exposures for Australian consumers are considerably lower than those reported internationally, reflecting Australia's historically lower emissions and environmental presence.
- Dietary exposure for Australian consumers is considered to be acceptably low.

The conclusions of the 26th ATDS risk assessment indicate existing measures are satisfactory in managing risks associated with dioxins and NDL-PCBs in the Australian food supply. Hence, FSANZ's view is that there is no current need to consider establishing MLs for dioxins or PCBs or reviewing the existing MLs for PCBs. Nor is there any requirement to consider any non-regulatory risk management measures at this time. However, the measures used to ensure that dioxin and NDL-PCB levels in the food supply are kept ALARA should be maintained.

The major contributors to dietary exposure to dioxins and NDL-PCBs for Australian consumers are wide ranging, reflecting the ubiquity of these substances in the environment. The 26th ATDS has confirmed that dioxins and NDL-PCBs tend to accumulate at higher levels in fatty foods such as fish, meat and dairy products. Lower fat foods such as fruit, vegetables and wholegrain cereals generally contain lower levels of dioxins and PCBs. Consumers can keep their dietary exposure to these substances low by following good dietary practices including eating a varied and balanced diet.

8 Conclusions and recommendations

The ATDS is an important national activity that monitors the safety of food typically consumed by Australians, providing current data to support risk assessment activities and risk management decisions for FSANZ and food regulatory agencies in Australia.

- The 26th ATDS confirms the current safety of the Australian food supply for the general population in terms of the levels of dioxins and NDL-PCBs present in foods and beverages available for consumption in Australia.

- Australia has a strong system for managing food safety risks. Current measures are effective in ensuring dioxin and NDL-PCB levels remain ALARA and acceptable from a food safety perspective.

- Food regulators and industry should continue to ensure dioxins and NDL-PCBs remain ALARA in the environment and food supply.

- There are resources to assist industry and regulators manage the presence of dioxins and NDL-PCBs in the environment and food supply. These include the Codex Alimentarius (2018) Code of Practice for the prevention and reduction of dioxins and PCBs in food and feed (CXC 62-2006).

- Consumers can keep their dietary exposure to these substances low by eating a balanced diet including a range of different nutritious foods according to the Australian Dietary Guidelines such as fruit, vegetables and wholegrain cereals, lean meat and fish, and low fat dairy foods.

- FSANZ will continue to monitor the outcomes of international work on the hazards and risks associated with dioxins and NDL-PCBs, including that of JECFA.

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10 Appendices

Appendix 1: Overview of 26th ATDS samples, including Food sampling (Excel), Food preparation instructions (PDF) and Food mapping to total diet (PDF)

Appendix 2: Compounds analysed, WHO derived toxic equivalency factors (TEFs), and analytical methodology (PDF)

Appendix 3: Prevalence and concentrations of dioxins and NDL-PCBs (PDF)

Appendix 4: Individual sample analytical results and mean concentrations for total dioxins (PCDD/Fs + DL-PCBs) (Excel)

Appendix 5: Individual sample analytical results and mean concentrations for total non-dioxin-like PCBs (NDL-PCBs) (Excel)

Appendix 6: Comparison of concentrations of total dioxins (PCDD/Fs + DL-PCBs) in foods analysed in the 2004 FSANZ Dioxins in food study and the 26th ATDS (PDF)

Appendix 7: Detailed dietary exposure results (Excel)