New Zealand Food Safety

Haumaru Kai Aotearoa



2016 New Zealand **Total Diet Study**

Ministry for Primary Industries

Manatū Ahu Matua

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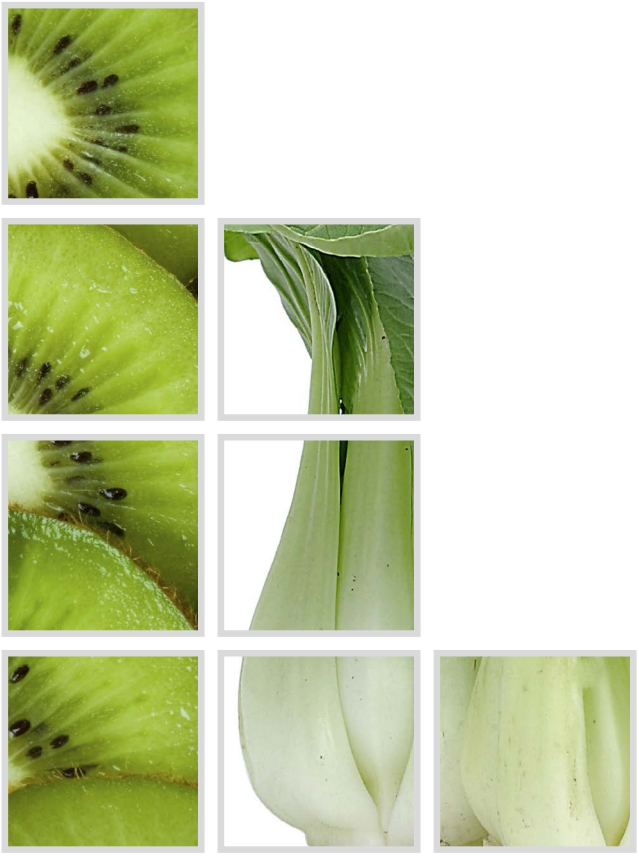
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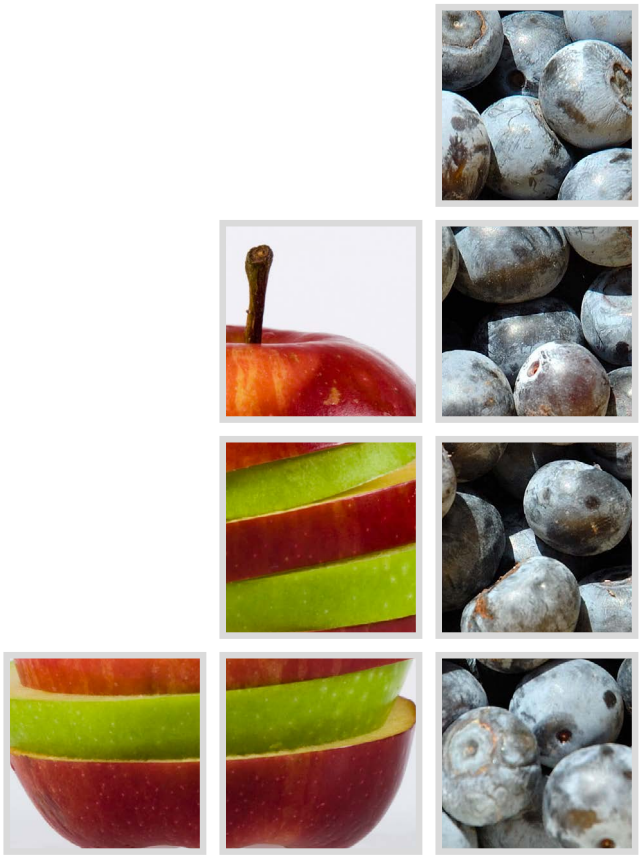
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Executive summary

The 2016 New Zealand Total Diet Study (2016 NZTDS) was a large-scale food survey undertaken over the 2016 calendar year. The 2016 NZTDS involved the analysis of 1056 composite food samples, with eight samples taken of 132 different food types. The selected food types represent the most commonly consumed foods for the majority of New Zealanders. Changes to the sampled foods in the 2016 NZTDS included the addition of tofu, canned coconut cream and sushi.

Samples were collected quarterly: 62 different regional food types were sampled in January/February and July/August 2016 and 70 different national foods collected in April/May and October/November 2016. Regional foods, those foods that may expect to show regional variation due to local production, were sampled from food retail outlets in Auckland, Christchurch, Napier and Dunedin. National foods, those foods expected to be consistent across the country due to centralised distribution, or resulting from an imported source, were all sampled in Christchurch. All samples were prepared using common food preparation and cooking methods to reflect the way these foods are usually consumed.

All 1056 of the collected samples were analysed for 301 agricultural chemical analytes, six contaminant elements (aluminium, arsenic, cadmium, lead, mercury and tin) and four nutrient elements (iodine, selenium, sodium and zinc). Sub-groupings of foods were analysed for further analytes, including a marker for dithiocarbamate fungicides, 21 herbicides, the contaminants inorganic arsenic and methylmercury, and the nutrient fluoride. All results had been previously published in quarterly reports. Using simulated diets developed for 10 New Zealand population cohorts, including for the first time in the NZTDS two Pacific Island ethnicity adult cohorts, the dietary exposures/intakes for all of the tested analytes have been estimated. The resulting deterministic exposure/intake estimates have been characterised against health based guidance values or nutrient reference values to establish if there is a public health concern.

None of the estimated dietary exposures to agricultural chemicals represented a risk to health, with the highest dietary exposure reflecting only 2.9% of the respective health based guidance value. The majority of the agricultural chemicals analysed were not detected and therefore calculated to have a zero exposure. A new addition to the NZTDS in 2016 was the assessment of the cumulative dietary exposure to three groupings of agricultural chemicals having common modes of action. The conclusions of this cumulative dietary exposure modelling were that there was not a risk to health, for any of the10 New Zealand population cohorts, for the three chemical groups analysed.

Aluminium has been analysed for the first time in the New Zealand diet in the 2016 NZTDS. Estimates of exposure to aluminium indicate potential concern over younger population cohorts (teenage girls, children, toddlers and infants) exceeding the health based guidance value. The aluminium exposure is largely a result of high concentrations detected in some baked goods (muffins and scones, and cakes and slices).

The form of arsenic of most interest for human exposure is inorganic arsenic. Analysis of inorganic arsenic concentrations in samples with appreciable total arsenic has allowed for refinement in the estimates of dietary exposure for arsenic. Neither inorganic arsenic nor lead have health based guidance values and an alternative method to characterise risk was used. Although the levels of exposure to inorganic arsenic or lead are such that adverse health impacts cannot be ruled out, there is no trend of increase in the diet, and estimated dietary exposure to lead has decreased, compared with reported exposures in the 2009 NZTDS.



Dietary exposure estimates for the other contaminant elements analysed (cadmium, inorganic mercury, methylmercury and tin) are below levels that would represent a health concern.

Dietary intake estimates for the nutrient element iodine show large increases for all of the population cohorts, compared with previous NZTDSs. The increase reflects the mandatory fortification of bread with iodine, through the replacement of non-iodised salt with iodised salt. All population cohorts, apart from infants, are deemed to be at or above the level of dietary iodine intake necessary to avoid dietary deficiency.

The estimated dietary intakes of the nutrients selenium and zinc are also considered to be sufficient to meet nutritional requirements for all of the population cohorts. Zinc dietary intakes appear to have decreased, compared with previous estimates of intakes from the 1990s. In contrast, selenium intakes have seen a small increase over those reported in the 2009 NZTDS, largely due to increased consumption of selenium rich foods in the simulated diets.

Dietary intakes of sodium have seen little change from previously reported values in the 2009 NZTDS and continue to exceed dietary targets and upper levels of intake for all of the population cohorts. An adverse health impact from excess dietary sodium cannot be excluded.

Finally, fluoride concentrations and intakes have been reported from all plant-based foods and beverages. Tea has been identified as a major source of fluoride contribution to adult dietary intakes. Because the analytical method for fluoride only allowed testing of a proportion of the foods sampled in the 2016 NZTDS, a full dietary intake estimate for fluoride cannot be made. As a result, characterising whether dietary needs of fluoride are met, or excessive intake is occurring, in the New Zealand population is not possible.



Introduction

What is a total diet study?

A total diet study (TDS) is a large-scale project that examines patterns of intake and exposure to different chemicals across the diet of a population. It is internationally recognised as a robust yet cost-effective way to estimate a population's dietary exposure while having the flexibility to investigate risks specific to the country conducting the study.

The chemical screening in a TDS is not fixed but will be designed to fit priority chemical issues known or suspected to be present in a food supply. This can include residues from chemicals used in agriculture, contaminants from the environment or processing, and major organic and inorganic nutrients. Such an approach contrasts with monitoring or surveillance programmes that tend to look at a specific chemical or group of chemicals in a small number of foods. Because a TDS will look at food from across the diet it best suits the analysis of chemicals ubiquitous in foods or the environment, or widely used in the food supply. By obtaining concentrations for these chemicals in a large proportion of the diet it is then possible to obtain realistic estimates for the intake of these chemicals by a population.

Typically, a TDS will be run using the following principles:

1. A range of different food types, making up a large proportion of the population diet, will be selected for testing.
2. The foods to be tested in a TDS tend to be sampled at retail outlets; off the shop shelf or market stall.
3. Food samples are prepared in the laboratory how they would be in a home kitchen, this will include being cooked if that is how the food is normally eaten.
4. Samples are tested for a range of priority chemicals. Some chemicals may not be tested in all foods if they are not expected to be present.
5. A mean concentration for each chemical in each food type will be calculated.
6. A model of the amount of each food different cohorts of the population (ages, ethnicities and gender) eat over a time period will be derived from nutrition surveys.
7. Using the model diets, the amount of each chemical that the population cohort is typically exposed to will be estimated.
8. Using health based guidance values or nutrient reference values, the chemicals in the diet can be checked to see if they present any health concerns, or in the case of some of the nutrients, if intakes are sufficient to meet nutritional requirements.

The frequency of a TDS differs between countries, with some choosing to undertake a large-scale project every few years, while other countries choose more frequent testing but may focus on more targeted analysis of priority chemicals.

New Zealand Total Diet Study

History of the NZTDS

Prior to the present study, the 2016 NZTDS, seven editions of the NZTDS have been published. The details of these, and how they are referred to and cited throughout this report, are:

- *The 1974/75 New Zealand Total Diet Survey* (1974/75 NZTDS; Dick et al., 1978, 1978a)
- *The 1982 New Zealand Total Diet Survey* (1982 NZTDS; Pickston et al., 1985)
- *The 1987/88 New Zealand Total Diet Survey* (1987/88 NZTDS; ESR & MOH, 1994)
- *The 1990/91 New Zealand Total Diet Survey* (Hannah et al., 1995; Pickston & Vannoort, 1995; 1990/91 NZTDS; Vannoort et al., 1995; Vannoort et al., 1995).
- *The 1997/98 New Zealand Total Diet Survey* (1997/98 NZTDS; Cressey et al., 2000; Vannoort et al., 2000).
- *The 2003/04 New Zealand Total Diet Survey* (2003/04 NZTDS; Vannoort & Thomson, 2005)
- *The 2009 New Zealand Total Diet Study* (2009 NZTDS; Vannoort & Thomson, 2011).

Many aspects of the NZTDS methodologies have largely remained consistent over time, for example, samples from four regional centres have always been taken and foods have been analysed for key chemical elements and agricultural chemicals. As methodology has advanced and more resources become available, the scale of the NZTDS has increased, for example, the number of food types sampled has increased in every NZTDS edition (Figure 1).

The consistency of undertaking the NZTDS over the previous 32 years has allowed detailed dietary exposure trends of many agricultural chemicals, contaminants and nutrients to be obtained for the New Zealand population. As a result, temporal observations, such as the decrease in iodine intakes and in lead contamination levels, have been able to be recorded and have allowed appropriate risk management measures to be implemented.

A detailed history of the NZTDS editions and changing methodology from the 1974/75 to 2003/03 NZTDS are reported on in the 2009 NZTDS (Vannoort & Thomson, 2011). Because the 2016 NZTDS has been largely undertaken following the agreed principles in the 2009 NZTDS, the comparisons to trends in the NZTDS studies undertaken before this can be made without major qualification.

Goals of the 2016 NZTDS

The overarching goal for the 2016 NZTDS is to contribute to the maintenance of food security in New Zealand. The Food and Agricultural Organization (FAO) of the United Nations defines food security as the following (FAO, IFAD & WFP, 2015):

> *A situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.*

Accurately measuring the levels of nutrients and contaminants in the diet and estimating the impacts of these levels on public health are essential to establish if the New Zealand population has safe and nutritious food that meets its dietary needs. The chemical analyses and dietary exposure assessments in the NZTDS hence represent a key component in ensuring food security for New Zealanders.

Specifically, in undertaking the 2016 study, the following goals were agreed in advance (MPI, 2016):

1. Determine the estimated dietary exposure for selected agricultural compounds, contaminants and nutrient elements in the New Zealand food supply through collecting and analysing foods that represent the diet of New Zealanders.
2. Compare estimated dietary exposure with internationally recognised acceptable or tolerable exposures or recommended intakes.
3. Identify dietary exposure trends in New Zealand over time and compare New Zealand estimates with those in other countries.
4. Implement appropriate risk management measures if any potential dietary risks to human health are identified.
5. Where appropriate, provide data on selected agricultural compounds, contaminants and nutrient elements for incorporation into other databases including the World Health Organization (WHO) Global Environmental Monitoring System.
6. Engage with key stakeholders in the development of methodology, and communicate findings to interested parties in a timely and transparent manner.

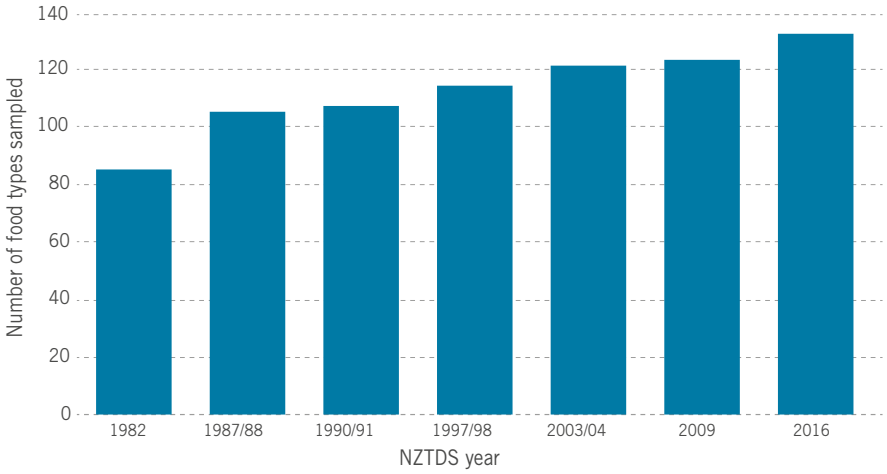
The objective of this final report of the 2016 NZTDS is to present the final deliverables for goals 1–3 and 6. Goals 4 and 5 will be undertaken subsequent to the publication of the 2016 NZTDS. The 2016 NZTDS was undertaken by the Ministry for Primary Industries, and the Institute of Environmental Science and Research Ltd was contracted for technical input and operational management.

Comparison of the 2016 NZTDS and 2009 NZTDS

The 2016 NZTDS has largely followed the methodology and principles established in the 2009 NZTDS. In particular:

- Eight composite samples were taken of each food.
- Sampling was broken down into regional and national samples.
- Regional samples were collected from Auckland, Christchurch, Dunedin and Napier.
- Samples were collected quarterly and prepared "as consumed" before analysis.
- All raw analytical data was released in quarterly reports.
- Dietary intake/exposure assessments have been conducted using simulated diets.
- Where available, intakes and exposures are compared with appropriate nutrient reference values or health based guidance values.

Figure 1: Trend in number of food types sampled in the NZTDS (1982–2016)



However, a number of additional features have been incorporated into the methodology for the 2016 NZTDS. These include:

- an increase in the number of sampled foods to 132 different food types, including additional food types such as coconut cream, simmer sauce and tofu (123 foods in 2009);
- the increase in the number of agricultural chemical analytes screened up to 323 chemicals, including a separate screen for herbicide chemicals (240 in 2009);
- addition of aluminium, inorganic arsenic, fluoride, tin and zinc to the chemical element analysis. All elements analysed in 2009 were also retained;
- consideration of two additional simulated diets, accounting for adult females and males of Pacific Island ethnicity;
- cumulative dietary exposure assessment of selected agricultural chemical groupings;
- adoption of methodology to characterise the risk of chemicals without health based guidance values.

Other reports of the 2016 NZTDS

All individual analytical data generated in the 2016 NZTDS has been published previously in a series of four quarterly reports (Pearson, 2016, 2016a, 2016b, 2017).

Separate reports have also been published on consultation regarding the methodology of the 2016 NZTDS, details of responses to submissions and to present the agreed project outline (MPI, 2015, 2015a, 2016).

Structure of this report

This is the main report of the 2016 NZTDS. It provides a collation of raw data presented in the quarterly report series and presents the key findings for New Zealand dietary exposure to agricultural chemicals and elemental contaminants, as well as the dietary intake of selected nutrient elements.

The report consists of three main sections focusing separately on agricultural chemicals, contaminant elements and nutrient elements. Each section is structured to include an overall introduction to the topic, followed by specific discussion on each element or agricultural chemical group. Following the risk appraisal framework, each element or chemical group discussion follows the same format of hazard identification, hazard characterisation, dietary exposure assessment and risk characterisation. Prefacing the discussion sections is an overview of the methodology used in the 2016 NZTDS, including details on the overseas TDSs used for comparisons. Finally, the key findings are summarised in a conclusion at the end of the main report.

The second half of the 2016 NZTDS report consists of 15 appendices containing:

- the food list (Appendix 1);
- methodology details (Appendices 2, 4, 5 and 6);
- simulate diets (Appendix 3);
- tables of collated analytical results (Appendices 7, 8, 11 and 13);
- hazard characterisation values (Appendix 9);
- dietary exposure and intake estimates (Appendices 10, 12 and 14);
- a glossary of terms (Appendix 15).





Methods used in the 2016 NZTDS

Food selection, sampling and preparation

The selection of foods for the 2016 NZTDS was based on those of the 2009 NZTDS, with some additions and alterations (Appendix 1: National and regional foods sampled in the 2016 NZTDS). The 2016 NZTDS sampled 132 foods, which predominantly represent the most commonly consumed foods in New Zealand. It should be noted that some foods in the list (such as oysters and liver) are consumed only in very small amounts by a limited number of age-gender population groups, but were included as they are known sources of contaminants or agricultural compounds. Other foods were included as they are popular foods for specific sub-populations, especially children, such as infant foods and flavoured milk.

The following categories and numbers of contributing foods were selected: Additional meat and shellfish (4), Beverages, alcoholic (3), Beverages, non-alcoholic (11), Butter and table spreads (2), Chicken, eggs, fish and meat (14), Composite foods (8), Dairy products (7), Dairy substitutes (1), Fruits (16), Grains (18), Infant foods (4), Nuts (4), Oil (1), Savoury sauces, condiments and other (5), Snack foods (3), Spreads and sweets (5), Vegetables (26). A full list of individual foods can be found in Appendix 1.

Foods were further classified as follows.
National foods (72), which are uniformly available throughout New Zealand, such as processed foods and commodity products, which are imported into New Zealand and distributed nationally, such as bananas. National foods were sampled in a single location (Christchurch) over six weeks during two separate sampling periods (April/May 2016 and October/November/December 2016). Multiple purchases of four leading brands, selected on the basis of sales data, were made in each sampling period. Foods were prepared and analysed as composites of individual brands per sampling period to give a total of four analyses for each food for each of the two sampling periods.

Regional foods (60), which have potential to demonstrate variation in agricultural compound, contaminant or nutrient content levels depending on the location in which the food was produced. Regional foods are most likely to be produced near to the consumption centre, such as fresh fruit and vegetables, fresh meat and fresh milk products. Regional foods were sampled in Auckland, Napier, Christchurch and Dunedin over five weeks during two separate sampling periods (January/February 2016 and July/August 2016). Multiple purchases of each food were made in each region in each sampling period from at least two different retail outlets where possible; a supermarket and one other relevant shop (such as green grocer, butchery, bakery). Foods were prepared and analysed as composites of individual regions per sampling period to give a total of four analyses for each food for each of the two sampling periods.

All foods in the 2016 NZTDS had eight different samples analysed. Foods were prepared to a "table ready" state before analysis. For example, meats and potatoes were cooked, while fruits that are consumed without peel, such as bananas, were peeled. All water used in food preparation was distilled. A summary of food preparation for each food type is given in Appendix 2.

Food consumption data

Food consumption information was derived from 14-day simulated typical diets for different age–gender cohorts in the New Zealand population. Similar age and gender cohorts were used to those used in 2003/04 and 2009. Additionally, simulated typical diets for adult males and females of Pacific Island ethnicity (15 years and above) were included. In relation to including simulated diets for Māori, it was reported in *A Focus on Māori Nutrition* (MOH, 2012) that there were no differences in intakes of micronutrients between Māori and non-Māori. Additionally, with regard to dietary habits, in comparison with notable differences observed for Pacific Island ethnicities, there were few differences observed between Māori and non-Māori ethnicity groups. As a result, it was considered unlikely that the diet of Māori would provide a sufficiently different exposure assessment from the other general population age and gender cohorts in the 2016 NZTDS.

Overall, simulated diets for 10 age and gender cohorts were included in the 2016 NZTDS, these are referred to throughout the report in the following format:

Adult diets:

1. Adult females (25 years and over)
2. Adult females of Pacific Island ethnicity (15 years and over)
3. Adult males (25 years and over)
4. Adult males of Pacific Island ethnicity (15 years and over)
5. Young adult males (19–24 years)

Infant, child and teenage diets:

6. Teenage boys (11–14 years)
7. Teenage girls (11–14 years)
8. Children (5–6 years)
9. Toddlers (1–3 years)
10. Infants (6–12 months)

For the 2016 NZTDS, a comprehensive review of the simulated diets was completed by the University of Otago (Smith et al., 2017). The 2008/09 New Zealand Adult National Nutrition Survey is the most recent nutrition survey data available for adults (University of Otago & MOH, 2009). Due to the timing of the survey, these survey data were unable to be included in the 2009 NZTDS. The availability of the 2008/09 data meant

that a comprehensive review of the adult diets, as well as the construction of the Pacific Island ethnicity diets, could be undertaken.

The most recent New Zealand Children's Nutrition Survey was conducted in 2002 (MOH, 2003). As such, a literature review was conducted to determine whether there was sufficient evidence to support a change to the 2009 simulated diets for the infant, child and teenage age groups, these being infants (6–12 months), toddlers (1–3 years) and children (5–6 years) and teenagers (11–14 years of age). Due to the lack of new evidence, simulated diets for children 5–6 years and teenagers 11–14 years of age remained similar to that of 2009. The main change was to incorporate the relevant new food types added to the food list since 2009. Access to two key sources of new information was provided by Dr Anne-Louise Heath from the University of Otago to inform a review of the simulated diets for toddlers 1–3 years of age and infants 6–12 months of age. This was data from the Baby Led Introduction to Solids (BLISS) study published in 2015 and the Eating Assessment in Toddlers (EAT) study conducted between 2011 and 2012 (Mills et al., 2015; Watson et al., 2015; Williams-Erickson, 2017).

The simulated diets are intended to represent an average consumer in each of the cohorts and include all appropriate foods from the key foods list (for example, children's diets do not include alcohol). The daily average weights of each individual food consumed by each age–gender cohort in the 2016 NZTDS are listed in Appendix 3. The mean energy and macronutrient composition of the 2016 NZTDS simulated diets for all of the population cohorts considered are presented in tables 1 and 2.

Analytes

Three groups of analytes were included in the 2016 NZTDS: agricultural chemicals, contaminant elements and nutrient elements. The analytical scope is consistent with that undertaken in the 2009 NZTDS, however, several additional analytes were included.

Agricultural chemicals

All 2016 NZTDS sampled foods were analysed for 301 agricultural chemical residues, through the use of the agricultural chemical multi-screen. This multi-screen included a number of new analytes, compared with the method used in the 2009 NZTDS, including quaternary ammonium compounds (QACs). In addition, all fruit, vegetables and grains were analysed for carbon disulphide (CS_2), a common chemical marker for the dithiocarbamate fungicide group. Finally all vegetables and grains were analysed for 21 additional herbicide residues, encompassing phenoxy and aromatic acid herbicide compounds.

Details on the analytical testing methods for the agricultural chemicals are provided in Appendix 4.

The analytical limits of reporting (LORs), the lowest concentration that can be confidently reported by the laboratory, for the agricultural chemical elements tested in the 2016 NZTDS are detailed in Appendix 5.

Contaminant elements

The contaminant elements aluminium, arsenic (total), cadmium, lead, mercury (total) and tin were analysed in all of the sampled 2016 NZTDS foods. With the exception of aluminium and tin, these contaminant elements were analysed in the 2009 NZTDS. Where total arsenic concentrations exceeded 0.02 milligrams per kilogram (mg/kg), the samples were separately analysed for inorganic arsenic. Finally all seafood samples were further analysed for methylmercury.

Details on the analytical testing methods for the contaminant elements are provided in Appendix 4.

The LORs for the contaminant elements tested in the 2016 NZTDS are detailed in Appendix 5.

Nutrient elements

The nutrient elements fluoride, iodine, selenium, sodium and zinc were also analysed in 2016 NZTDS foods. Iodine, selenium and sodium had all been analysed for previously in the 2009 NZTDS. While iodine, selenium, sodium and zinc were measured in all foods, fluoride was mainly measured in cereals and cereal products, vegetables, fruits, alcoholic and non-alcoholic beverages, nuts and dairy substitutes. Animal-based foods, and high fat foods such as chocolate, were not able to be analysed for fluoride with the method available.

Details on the analytical testing methods for the nutrient elements are provided in Appendix 4.

The LORs for the nutrient elements tested in the 2016 NZTDS are detailed in Appendix 5.

Calculating mean concentration data

The most suitable concentration value from the NZTDS for assessing the extent of long-term (chronic) dietary exposure is the arithmetic mean concentration. While individual purchases of a food may have higher and lower concentrations, over time these variations will "average out" to the mean concentration.

A difficulty in calculating the mean concentration in the NZTDS is that for many food and chemical combinations the result of analysis will be too low to be reported (less than (<) LOR), this is termed left-censoring of results. A concentration below the LOR could be interpreted as a trace concentration or could be assumed to be a true zero concentration. To address this uncertainty, different methods are used in the NZTDS for the agricultural chemicals and the contaminant and nutrient elements.

Because the use of agricultural chemicals, and thus the presence of residues, is part of a deliberate agricultural practice, it is considered unlikely that when a crop and

chemical combination has a result below the LOR that the chemical is present at all. In the 2016 NZTDS, the mean concentration of an agricultural chemical used for dietary exposure assessment was calculated assuming that any result below the LOR represents a true zero concentration. The resulting calculated mean is termed the lower-bound estimate of the mean. This approach is consistent with the approach used historically in the NZTDS and allows for consistent trend analysis of dietary exposures.

In contrast, for the nutrient and contaminant elements, concentrations in foods will reflect environmental levels of the chemical and the same assumption of zero concentration is unlikely to be valid. It is likely that trace levels of the element will be present in the food even if not able to be quantified.

While the exact level present cannot be measured it is possible to provide a range, within which the concentration will fall. The lower-bound mean as described above is the lower limit of this range, and the higher limit is calculated by assuming that all values below the LOR are present at a concentration equal to the LOR value. This is termed the upper-bound estimate of the mean. As a reference point within this range, to allow trend analysis, a third mean value is calculated by replacing all values below the LOR with a value half the concentration of the LOR, the mid-bound mean. Again, this maintains consistency with the approach of previous NZTDSs allowing useful comparisons for trend analysis.

All of the calculated arithmetic means were used for dietary exposure calculation without rounding.

Table 1: Mean energy and macronutrient composition of the simulated diets for adult population cohorts, per day

Composition	Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Energy (kJ)	7,960	8,770	11,086	11,169	12,613
Protein (g)	78	82	101	106	116
Protein (% energy)	16	15	15	15	15
Fat (g)	76	87	107	105	118
Fat (% energy)	35	37	36	35	35
Saturated fat (g)	30	36	43	42	47
Saturated fat (% energy)	14	15	14	14	14
Carbohydrates (g)	220	244	303	307	353
Carbohydrates (% energy)	47	47	46	47	48

Table 2: Mean energy and macronutrient composition of the simulated diets for infant, child and teenage population cohorts, per day

Composition	Teenage boys	Teenage girls	Children	Toddlers	Infants
Energy (kJ)	10,527	8,645	7,207	5,474	4,156
Protein (g)	101.6	77.7	63.3	48.0	33.1
Protein (% energy)	15.4	14.4	14.0	14.0	12.7
Fat (g)	101	83	64	51	42
Fat (% energy)	35.5	35.4	33.1	34.4	37.5
Saturated fat (g)	43	35	28	23	16
Saturated fat (% energy)	15.2	15.1	14.2	15.8	14.5
Carbohydrates (g)	305	257	226	167	123
Carbohydrates (% energy)	49.2	50.5	53.2	51.9	50.1
Calcium (mg)	860	755	670	765	550
Iron (mg)	19.5	12.5	10.9	8.4	7.6

Estimating dietary intakes and exposures in the 2016 NZTDS

The estimates of dietary intakes and exposures in the 2016 NZTDS were calculated using a standard deterministic approach, consistent with the methodology of previous NZTDS years.

The arithmetic mean concentration of the detected agricultural compound, contaminant element or nutrient element (in mg/kg) in food was multiplied by the daily consumption of that food in grams (g) from the simulated diets for each population cohort. The result is an estimate of dietary exposure to the chemical of interest from consumption of the food. Dietary exposure contribution for all foods was then summed to provide a total dietary exposure or intake estimate.

For agricultural compounds, the estimated mean dietary exposure for each population cohort (in mg/day) was divided by the mean body weight (bw; Appendix 3.1) for the cohort to present dietary exposures on a µg/kg bw/day basis. This allowed the estimates to be characterised against the health based guidance values (HBGV). All exposure estimates were rounded to two significant figures and values less than 0.0001 µg/kg bw/day expressed as <0.0001 µg/kg bw/day.

For the contaminant elements, the estimated daily mean exposure for each population cohort was divided by the mean body weight for the cohort and then multiplied by seven or 30.42 (equivalent to days in a week or the average days a month per year) to express the exposures on a µg/kg bw/week or month basis. This allowed the values to be characterised against the HBGV. Aluminium and tin were converted to mg/kg bw/week by dividing by 1000, to allow characterisation against the HBGV.

For the nutrient elements, daily intakes are not divided by body weight, so are expressed in µg/person/day or mg/person/day.

Risk characterisation in the 2016 NZTDS

Health based guidance values

In most cases, analyte dietary intakes or exposures have been characterised as a percentage of an appropriate reference value. For the agricultural chemicals this is an HBGV selected from New Zealand or international toxicology risk assessments. The selected HBGV for each agricultural chemical is presented in Appendix 8. The term HBGV replaces the use of Acceptable Daily Intakes from previous NZTDSs as other types of risk characterisation values are also used.

In the case of contaminants, exposures have been characterised against the HBGVs established by the Joint FAO and WHO Expert Committee on Food Additives (JECFA). The selected HBGV for each contaminant element is presented in Appendix 12.

Finally, all nutrient intakes have been compared with relevant nutrient reference values (NRVs) established for Australia and New Zealand by the Australian National Health and Medical Research Council and New Zealand Ministry of Health. The selected NRVs for each nutrient element are presented in Appendix 14.

Margin of exposure

In several cases, such as for the agricultural chemical residue propham, or the contaminant element inorganic arsenic, no HBGV is available to directly characterise the exposure risk. As an alternative in these cases the Margin of Exposure (MOE) approach has been used to characterise the dietary exposure risk. Calculating the MOE involves selection of a toxicological point of departure, either the lowest dose in an animal study with reported adverse effects, termed a lowest observed adverse effect level, or more preferably the next dosing level down where no adverse health effects are reported, termed a no observed adverse effect level. A final reference point may be a benchmark dose level, which is the statistically modelled dose with a certain percentage elevated risk of an adverse health effect.

The toxicological point of departure is then divided by the estimated dietary exposure of the specific chemical to derive the margin between the two. This value is the MOE.

For a non-carcinogenic chemical, an MOE greater than 100 is deemed sufficiently protective of human health. Whereas for a carcinogenic chemical, an MOE of greater than 10,000 is considered to represent a negligible health risk.

Agricultural chemicals

Introduction

Agricultural chemicals are currently a core input in conventional agriculture and horticulture. In addition, some agricultural chemicals have been certified for use in modern organic agriculture (BioGro, 2009). The use of agricultural chemicals is important in protecting crops from damage and loss, which allows yields to be maintained (Cooper & Dobson, 2007). This in turn enables greater assurances that foods and animal feeds will be available, increasing food security. Chemical protection from diseases and pest damage may also limit the presence of plant produced toxins, mycotoxins from fungal disease, or contamination with toxic weed species, which can be detrimental to human health. Finally, some agricultural chemicals may increase the time that foods can be safely stored, leading to availability through the year and decreased food wastage due to oversupplies in production around harvesting (Cooper & Dobson, 2007).

A range of agricultural chemicals, covering different use situations, is used in modern agriculture. These may be grouped according to the type of pest under control: insecticides, fungicides, herbicides and bactericides/sanitisers. The types of agricultural chemicals in use include inorganic chemicals, plant extracts, bacterial fermentation products and fully synthetic organic chemicals. The agricultural chemicals in use can also vary in how they are applied, including soil treatments, fumigation, post-harvest dipping and broadcast spraying.

While agricultural chemicals fulfil important roles in many forms of modern agriculture, they can also represent a hazard to users and the general public (WHO, 2010). If exposure to agricultural chemicals is high enough, there is the potential to cause short- or long-term harm to human health. For this reason, the manufacture and use of agricultural chemicals is highly regulated. In agricultural applications they are used only in minimum amounts required to achieve the greatest effect, while not leading to residues in food that would be of harm to consumers; a concept called good agricultural practice. To ensure good agricultural practice is being correctly followed, concentration limits are set for each agricultural chemical in the produced agricultural commodity. These limits are called Maximum Residue Levels. When Maximum Residue Levels are exceeded, it usually indicates the food producer has not followed good agricultural practice.

Most, if not all, countries with significant agricultural production use agricultural chemicals as part of their primary production systems. Because pest pressures, crop types, growing conditions and availability of chemicals can differ between countries, the residue amounts and types of agricultural chemicals in imported food can also differ from those in domestically produced foods. If a chemical is not approved in New Zealand, it does not necessarily mean it is not approved for use elsewhere.

Interpreting the 2016 NZTDS agricultural chemical residues results

Active ingredient

A commercial product can consist solely of the active ingredient or, more usually, contain a range of other proprietary ingredients, termed excipients. The excipients perform a number of chemical functions within the commercial product, including as stabilisers, preservatives, dyes and bittering agents. The target analytes in the 2016 NZTDS analysis of agricultural chemical residues are the active ingredient(s) of commercial products. The active ingredient is the component of the commercial product intended to be biologically active.

Concentration data

All of the residues results in the 2016 NZTDS have been reported as part of the quarterly reporting (Pearson, 2016, 2016a, 2016b, 2017). In addition, appendices 7 and 8 provide a summary of the results, sorted respectively, alphabetically by chemical name or by the food type that they were detected in.

Comparison of 2016 NZTDS concentration and exposure results with previous years

In contrast to the nutrient and contaminant elements, making an analysis of the trends over time of agricultural chemical residues in the NZTDS is problematic. Compared with elements, where environmental sources are usually consistent, the availability and use of the agricultural chemicals can vary considerably from year to year. This may be driven by market need, updates to newer chemicals, new or increased pest pressures and changes to good agricultural practice (GAP).

Within the NZTDS methodology, the range of agricultural chemical residues assessed can also change, as new products are approved or old products become redundant. A further change should be noted from the 2009 NZTDS and the current study. The agricultural chemical analytical method available for the current study did not achieve the sensitivity of the method used in the previous NZTDS and, consequently, very low concentrations of agricultural chemicals detected in the 2009 NZTDS may not have been detected in the 2016 NZTDS. However, the agricultural chemical analytical method was still considered fit for purpose as the sensitivity was sufficient to identify any exposures from these chemicals that would present a potential risk.

To place the 2016 NZTDS in context with previous studies, some general trends in concentrations of agricultural chemicals for certain food types have been made where possible.

Comparison of 2016 NZTDS exposure results with overseas data

The agricultural chemical dietary exposures estimated in the 2016 NZTDS have been compared with estimates from three recent overseas TDSs where agricultural chemical exposure has been assessed. In all cases, dietary exposure estimates from the overseas TDSs were expressed as a proportion of the relevant HBGV, used for risk characterisation of the New Zealand exposures, and comparisons conducted for the most relevant population cohorts. The studies and methods used for comparison are:

- *The 23rd Australian Total Diet Study* (ATDS; FSANZ, 2011). In the ATDS, lower-bound mean exposure estimates for agricultural chemicals are reported in µg/day. For infants (9 months) and all adults (17 years and above), the reported exposures were divided by body weights of 8.9 kg and 74 kg, respectively, to obtain dietary exposure estimates expressed in µg/kg bw/day. Comparisons were made to the 2016 NZTDS dietary exposures, as %HBGV, for infants (6–12 months) and adults (25 years and above).
- *The Second French Total Diet Study* (FTDS; ANSES, 2011). In the FTDS, lower-bound mean dietary exposure estimates for agricultural chemicals are reported in µg/kg bw/day for adults (18–79 years). Comparisons were made with adults (25 years and over) from the 2016 NZTDS.
- *The French Infant Total Diet Study* (FITDS; ANSES, 2016). In the FITDS, lower-bound mean dietary exposure estimates for agricultural chemicals are reported in µg/kg bw/day. The dietary exposures for infants of 7–12 months age were compared with the 2016 NZTDS estimated dietary exposures for infants (6–12 months).

Chemical groupings

Most agricultural chemicals use in New Zealand falls within three functional classes: insecticides, fungicides and herbicides. Within these major groupings, further classes of structurally related chemicals can also be considered. These structurally related classes usually share a similar mode of action against the target pest or disease, and may also have similar hazard characteristics for humans. For a more detailed analysis of dietary exposures and trends it is therefore useful to focus discussion on specific classes of chemicals.

The following major groupings and specific classes of agricultural chemicals are considered together in the current report:

- **Insecticides:**
  - Organochlorine insecticides;
  - Organophosphate and carbamate insecticides;
  - Neonicotinoid insecticides;
  - Pyrethrin and pyrethroid insecticides;
  - Other insecticides.
- **Fungicides:**
  - Triazole and imidazole fungicides;
  - Carbon disulphide and the dithiocarbamate fungicides;
  - Strobilurin fungicides;
  - Other fungicides.
- **Herbicides**.

In addition, the following two minor groupings of agricultural chemicals are considered together in the current report:

- **QACs;**
- **Sprout and scald inhibitors**.

Agricultural chemical residue discussion

A full summary of the estimated dietary exposures to the agricultural chemical residues detected in the 2016 NZTDS for all population cohorts considered is provided in Appendix 10.

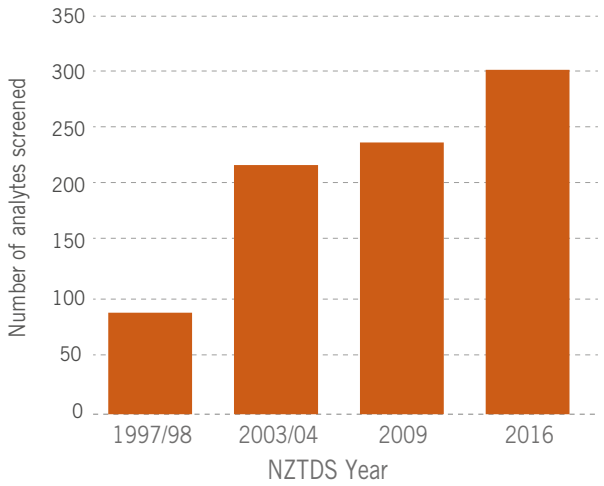
Prevalence and concentrations

In total, 1056 food samples were analysed for 301 agricultural chemical analytes in the multi-screen method. From this total, 406 (39%) food samples contained detectable residues.

The proportion of samples with detectable residues continues a trend of decreasing residue prevalence observed from the 1997/98 NTZDS (59%) and 2003/04 NZTDS (50%). While the trend also appears to decrease against the 2009 NZTDS (45%), the values are not directly comparable because a proportion of the detections of agricultural chemicals in the 2009 NZTDS were below the LORs in use for the 2016 NZTDS. When the residue prevalence in the 2009 NZTDS is recalculated to account for the reduced analytical sensitivity in the 2016 NZTDS, 242 (25%) food samples contained detectable residues.

There has been a consistent trend of increase in the number of agricultural chemical residues included in the multi-

Figure 2: Trend in the number of analytes screened for, in the agricultural chemical multi-screen, in the NZTDS (1997/98–2016)



screen analysis (Figure 2). In the 2016 NZTDS, 66 agricultural chemicals were added to the multi-screen and six were removed from those analysed in the 2009 NZTDS. Out of the six chemicals removed only a single detection had been reported in the 2009 NZTDS (flamprop-methyl in potatoes), so the omission in the 2016 NZTDS was unlikely to lead to a notable difference in the results. From the agricultural chemical residues detected in the 2016 NZTDS, 32 analytes, detected in 191 food samples, were of chemicals added to the multi-screen for the 2016 NZTDS and would not have been detected in previous studies (Table 3). When the number of samples containing residues of these newly added analytes was omitted, to allow a more direct comparison with previous NZTDS values, the number of samples with detected residues dropped considerably to 314 (30%).

A small number of the agricultural chemicals within the multi-screen and herbicide residue screen in the 2016 NZTDS had multiple marker analytes. These can reflect different metabolites in crops, or manufacturing impurities, of an individual agricultural chemical active ingredient. For example, there are three marker analytes for the insecticide endosulfan (endosulfan I, endosulfan II and endosulfan sulfate). When multiple marker analytes are accounted for, the 2016 NZTDS multi-screen and herbicide screen provide results for 293 active ingredients of commercial agricultural chemicals. The analysis for CS_2 is a marker for the potential presence of nine individual dithiocarbamate fungicides and it is possible that a single detection of CS_2 may represent the presence of several dithiocarbamate fungicides in the sample. Several of the agricultural chemical residues detected in the 2016 NZTDS, for example, benzalkonium chloride and spirotetramat, had multiple marker analytes. The relevant compounds are recorded in Appendix 5.

In addition to the multi-screen method, 52 food types were analysed for CS_2, a chemical marker for nine dithiocarbamate fungicides, and 48 food types were analysed for 21 herbicide residues. A total of 323 agricultural chemical analytes were analysed in the 2016 NZTDS, from which 92 analytes were detected.

The food types containing the greatest number of different agricultural chemical residues were: raisins/sultanas (33 different agricultural chemicals), grapes (23), strawberries (18), bran flake cereal (16), nectarines (11) and frozen mixed berries (10); although for each food type these were not all present in any single composite sample. There were also 33 food types sampled in the 2016 NZTDS in which no agricultural chemical residues were detected.

The individual composite samples containing the greatest number of agricultural chemical residues were in the raisins/sultanas food types, with two individual samples containing 26 and 23 different agricultural chemical residues, respectively. Because raisins/sultanas are dried, any residues remaining from agricultural chemicals used in cultivation become concentrated, this can result in very small amounts of agricultural chemicals being concentrated to a level where they can be detected.

The resulting rate of detection for agricultural chemical residues was 0.3%; 991 detects out of a total of 326,321 individual assay results generated in the 2016 NZTDS. This consisted of 905 detected results in the agricultural chemical multi-screen, 50 detected results in the herbicide screen and 36 detected results in the analysis for CS_2. As with the samples with detected residues, the proportion of analyses resulting in detection of residues continues to decrease, from 1.4% in 1997/98 (397 out of a total of approximately 29,000 individual assay results generated) to 0.5% in 2003/04 (997 out of a total of 199,100) to 0.4% in the 2009 NZTDS (910 out of a total of 236,662).

Ten agricultural chemicals accounted for just over half (507; 51%) of the 991 detections in the 2016 NZTDS. The 10 agricultural chemicals, and the change in prevalence since the 2009 NZTDS, are presented in Table 4.

Overall, in the 2016 NZTDS, insecticides (380 detections) and fungicides (371 detections) accounted for the majority of the agricultural chemical residues detected (38% each; Figure 3). QACs, which were a new addition to the 2016 NZTDS, represented 14% of the total residue detections in the current study.

Table 3: Detected agricultural chemical analytes added to the multi-screen in the 2016 NZTDS

Acetamiprid	Fenhexamid	Spirotetramat-cis-enol
Benzalkonium chloride (C12)	Fenpyroximate	Spirotetramat-cis-keto-hydroxy
Benzalkonium chloride (C14)	Flufenoxuron	Spirotetramat-enol-glucoside
Benzalkonium chloride (C16)	Imidacloprid	Sulfoxaflor
Boscalid	Lufenuron	Tebufenozide
Carbendazim (including benomyl and thiophanate)	Methomyl	Tetraconazole
Chlorantraniliprole	Methoxyfenozide	Thiacloprid
Cyflufenamid	Pyraclostrobin	Thiamethoxam
Didecyldimethylammonium chloride (DDAC)	Spinetoram	Thiophanate-methyl
Dodine	Spinosad	Triadimenol
Etoxazole	Spiromesifen	

Table 4: Ten most frequently detected agricultural chemical residues in 2016 NZTDS and comparison with detection frequency in 2009 NZTDS

Agricultural chemical residue	Detections in 2016	Detections in 2009
Benzalkonium chloride	118 (71[a])	Not analysed
Pirimiphos-methyl	89	120
Piperonyl-butoxide	50	108
Iprodione	46	29
Clopyralid	44	Not analysed
Chlorpyrifos-methyl	37	19
Carbon disulphide[b]	36	138 (131[c])
Pyrimethanil	30	42
Spirotetramat (sum of isomers)	29 (26[a])	Not analysed
Captan	28	11

[a] Benzalkonium chloride and spirotetramat have multiple marker analytes (Appendix 5). The number in brackets is the individual food samples with detected residues because some food samples contained multiple marker analytes.
[b] Carbon disulphide (CS_2) was the marker residue for nine individual dithiocarbamate fungicides (Appendix 5).
[c] The type of food categories tested for CS_2 differed in the 2016 NZTDS, compared with the 2009 NZTDS. The number in brackets is the equivalent number of detections excluding categories not tested in the 2016 NZTDS.



Dietary exposures and risk characterisation

Accounting for the agricultural chemicals with multiple marker analytes, dietary exposure estimates could potentially be derived for 293 agricultural chemical residues and 10 population cohorts, to give a total of 2930 dietary exposure estimates. The majority of the potential dietary exposure estimates (71%) are zero exposures, being for agricultural chemicals that were not detected in any food in the 2016 NZTDS. In addition, 0.7% of the exposures reflected agricultural chemicals that were detected but were not consumed by a particular population cohort, resulting in zero exposure for that cohort. For example, a residue only detected in coffee would not result in dietary exposure for the infant cohort as this food is not expected to be consumed by infants.

Of all of the dietary exposure estimates, 15% (430 results) were less than 0.01% of the HBGV, 8% (245 results) were between 0.011–0.1% of the HBGV, 4% (127 results) were between 0.11–1.0% of the HBGV and 0.7% (19 results) greater than or equal to 1.1% of the HBGV (Figure 4). The dithiocarbamate fungicides had the highest dietary exposure estimated for an agricultural chemical in the 2016 NZTDS, relative to the HBGV, at 2.9% of the HBGV.

Only one agricultural chemical residue (propham; sprout inhibitor) detected in the 2016 NZTDS had no HBGV. An alternative method was used to characterise the dietary risk for propham. This alternative method is described within the sprout and scald inhibitor section.

In the 2009 NZTDS, seven of the detected agricultural chemicals were not able to be assigned an HBGV. In the foods sampled in the 2016 NZTDS, only one agricultural chemical residue was not able to be assigned an HBGV (propham).

The magnitude and order of the agricultural chemicals dietary exposures in the top 18 differ slightly between age groups, as presented in figures 5–7. Of the 18 agricultural chemicals with the highest mean dietary exposures, relative to their HBGVs, averaging across all the population cohorts there were two organochlorine insecticide compounds (dichlorodiphenyl trichloroethane (DDT) and dieldrin), six organophosphate insecticides (acephate, chlorpyrifos, chlorpyrifos-methyl, dimethoate/omethoate, methamidophos and pirimiphos-methyl), six fungicides (boscalid, captan, dithiocarbamate fungicides, cyprodinil, imazalil and iprodione), two herbicides (fluazifop/fluazifop-butyl and haloxyfop), one QAC (benzalkonium chloride; BAC) and a sprout inhibitor (chlorpropham).

Figure 3: Proportion of residue analyte detections in the 2016 NZTDS sampled foods within different agricultural use groups

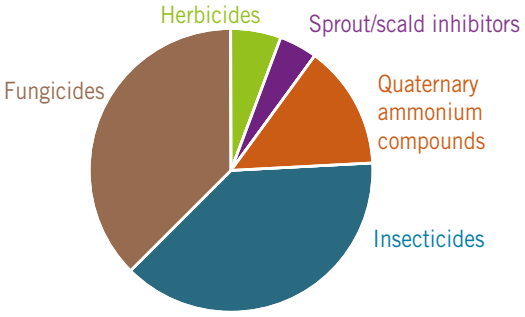


Figure 4: Dietary exposures estimate for all population cohorts to agricultural chemical residues in the 2016 NZTDS, expressed as a percentage of the health based guidance value

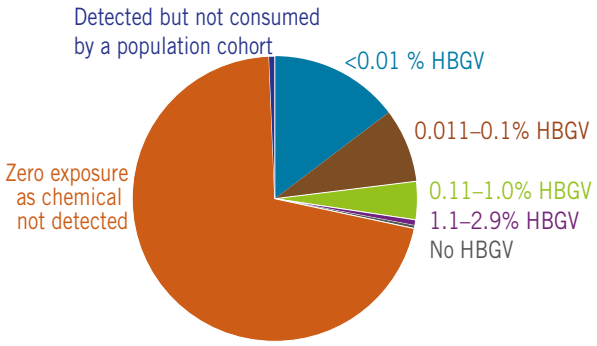


Figure 5: Top 18 dietary exposures for adult males (25 years and above), as a proportion of the health based guidance value, for agricultural chemicals analysed in the 2016 NZTDS

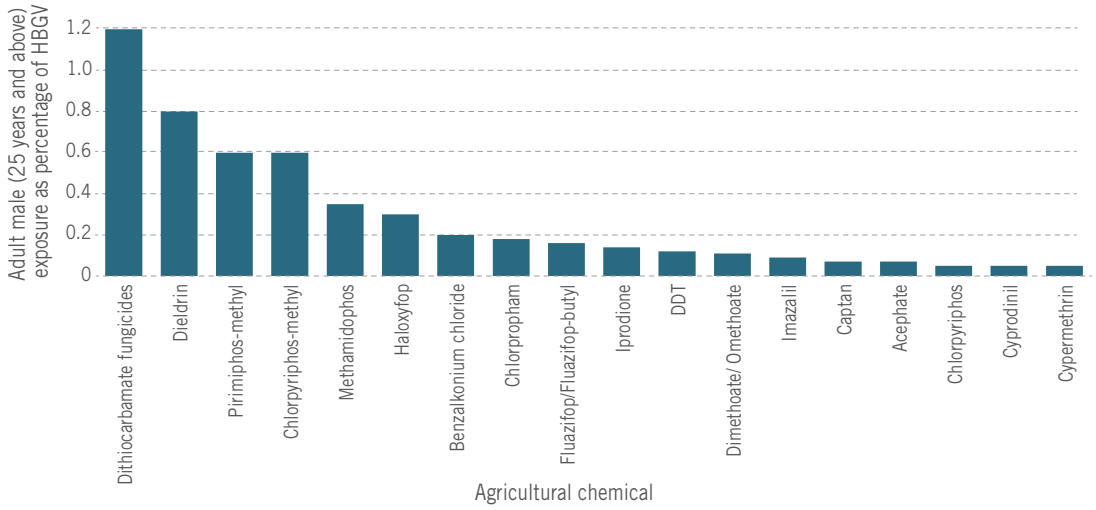


Figure 6: Top 18 dietary exposures for children (5–6 years), as a proportion of the health based guidance value, for agricultural chemicals analysed in the 2016 NZTDS

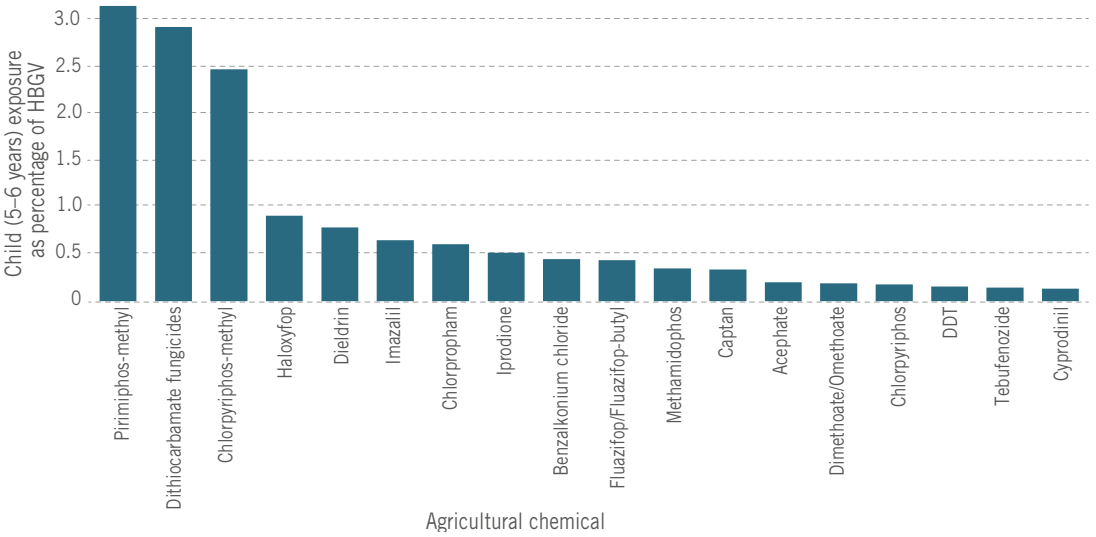
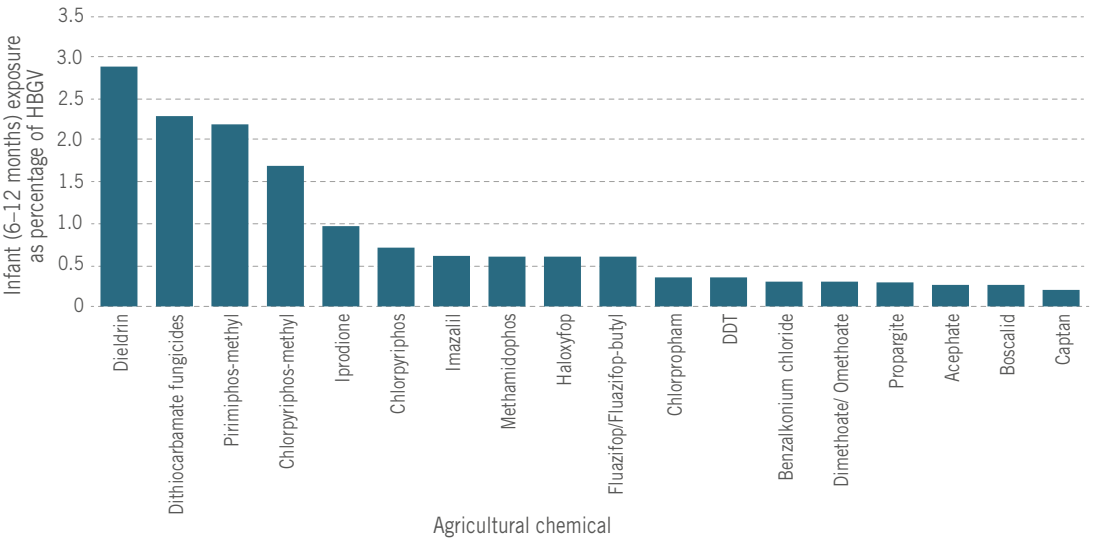


Figure 7: Top 18 dietary exposures for infants (6–12 months), as a proportion of the health based guidance value, for agricultural chemicals analysed in the 2016 NZTDS



Insecticides

Overview

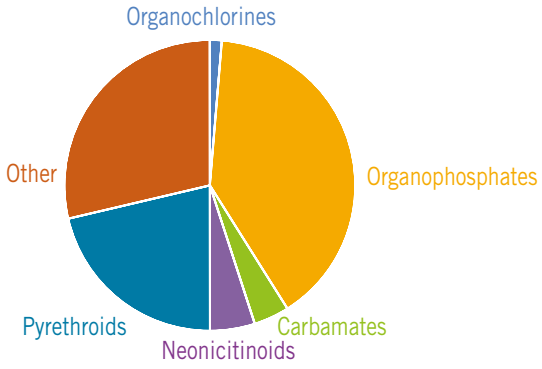
Insecticides are chemicals designed to control insect pests. In addition, compounds that target mites (acaricides) and molluscs (molluscicides) are often included within this group. The insecticides represented slightly over a third (38%; 380 out of 991) of the agricultural chemical residue detections in the 2016 NZTDS. The insecticides also had the largest number of different analytes detected (46 different analytes out of 158 analysed). When considered by insecticide classes (structurally related groups), the organophosphates represent the largest proportion of the insecticide detections in the 2016 NZTDS (Figure 8).

Organochlorine insecticides

Organochlorine insecticides are a group of agricultural chemicals that once formed a key component of pest control in New Zealand. Most of the organochlorines, such as DDT and dieldrin, were banned from use in New Zealand in the 1980s. The key reason for this ban was the extreme persistence and high potential for bioaccumulation of these chemicals. A later generation organochlorine insecticide, endosulfan, which had much lower environmental persistence, remained in use until January 2009 (ERMA, 2008).

Analysis for organochlorine insecticides has been a key component of the NZTDS since the 1974/75 NZTDS. Although the organochlorine insecticides are all now banned from use in New Zealand, their persistence in the environment means residues of organochlorine insecticides are still found occasionally in food samples.

Figure 8: Breakdown by chemical classes of the insecticide detections in the 2016 NZTDS



Hazard identification

Short-term exposure to organochlorine insecticides causes toxicity to the nervous system. For example, DDT delays the closing of sodium channels in nerves and increases the potential for rapid nerve pulses firing (Klaassen, 2008). Symptoms of an acute poisoning would manifest as increased sensitivity in the mouth and around the face, followed by pins and needles in this area and on the tongue, then tremors, vomiting and confusion. Organochlorines are also highly fat soluble, so accumulate in the fats of humans and livestock, which may lead to chronic exposure. Chronic effects of dieldrin and DDT include enlargement and toxicity of the liver (Klaassen, 2008).

Hazard characterisation

HBGVs have been established for the two organochlorine insecticides detected, which enabled the dietary exposures to be characterised (Appendix 9). The HBGVs are 0.1 µg/kg bw/day for dieldrin and 10 µg/kg bw/day for total DDT.

Prevalence and concentrations

The concentrations of the organochlorine insecticides in individual foods of the 2016 NZTDS have been previously presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in appendices 7 and 8, with minimum, maximum and arithmetic mean concentrations calculated for these agricultural chemicals in each food type.

Two organochlorine insecticide residues were detected in foods sampled in the 2016 NZTDS out the 23 organochlorine analytes tested for. These are 4,4-Dichlorodiphenyldichloroethylene (4,4-DDE), with three detections, and dieldrin, with two detections. 4,4-DDE is the major metabolite of DDT, which persists in the environment. For risk assessment purposes, parent DDT and all metabolites are considered to be of equal toxicity and their concentrations are added together to give a concentration of "total DDT".

The 4,4-DDE residues detected were all in animal products (minced beef, butter and lamb and mutton). This is consistent with the pattern of occurrence of 4,4-DDE observed in the 2009 NZTDS and other NZTDSs. The detections likely represent the accumulation over time in fatty animal tissues from 4,4-DDE that still persists in New Zealand soils decades after the banning of DDT.

Dieldrin was detected in one sample each of courgettes and pumpkin. A consistent pattern of dieldrin occurrence in cucurbit crops was also reported in previous NZTDSs, although the result of 0.04 mg/kg in the pumpkin sample in 2016 NZTDS was higher than the results reported for dieldrin in 2009 or 2003/04 NZTDS. The occurrence of a dieldrin residue in the pumpkin sample is consistent with reports of cucurbit species showing high uptake of dieldrin from soil (Donnarumma et al., 2009).

In contrast to the 2009 NZTDS, where 8% of all the residues detected resulted from organochlorine insecticides, only 0.5% of all residues detected in the 2016 NZTDS were from organochlorine insecticides. The decrease is primarily a result of the reduced LOR for 4,4-DDE because many of the detections reported in the 2009 NZTDS were below the LORs available in the 2016 NZTDS. Occasional detections of organochlorines may still occur in the future, due to environmental persistence in some locations. However, with the use of organochlorine insecticides now banned, the expected trend is for concentrations to continue to decrease in New Zealand foods.

Dietary exposure assessment

Estimated daily dietary exposures to dieldrin and total DDT for each of the population cohorts in the 2016 NZTDS are detailed in Appendix 10. Each of the dietary exposure estimates is given in µg/kg bw/day and is also reported as a percentage of the HBGV.

Dietary exposure to total DDT has demonstrated a consistent downward trend over time. This trend continued in the 2016 NZTDS, as presented for young adult males and toddlers, and reflects the gradual breakdown of DDT in the environment following its banning from use in the 1980s (Figure 9).

The contribution to total DDT exposure for most of the population cohorts is approximately evenly split between the three foods in which residues were detected. The simulated diet for young adult males included greater consumption of lamb than other cohorts, resulting in lamb being the major (58%) contributor to dietary total DDT exposure for this cohort. Similarly, minced beef contributes about half (49%) of the total DDT dietary exposure for teenage boys.

Estimated dietary exposures to dieldrin for the population cohorts in 2016 have increased, compared with estimates in the 2009 NZTDS. For the infant cohort, the estimated dietary exposure is 32 times higher in 2016 than it was in 2009. The single result of 0.04 mg/kg in a pumpkin sample accounts for the majority of the exposure (>90% for all population cohorts) and is the reason for the large increase in dietary dieldrin exposure since the previous NZTDS.

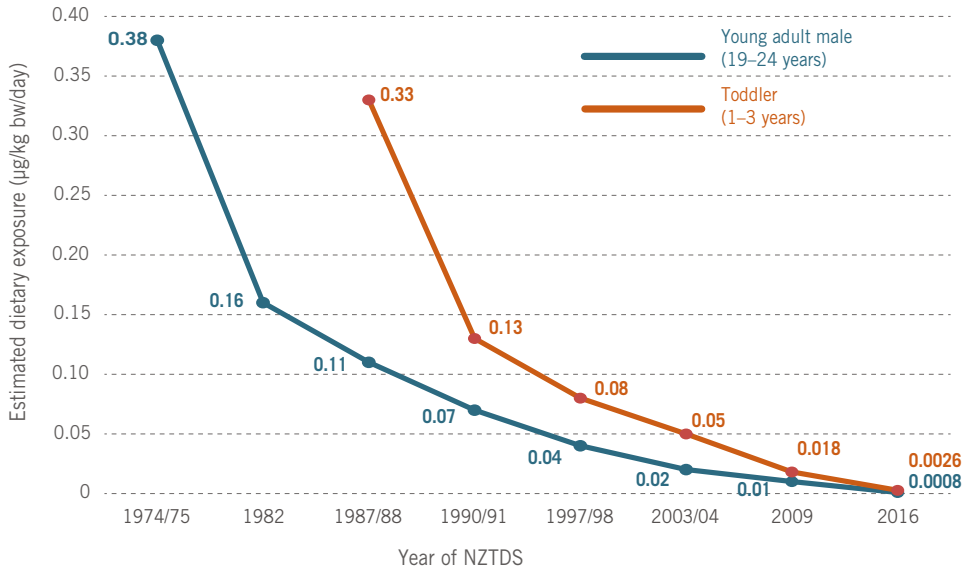
Because no other organochlorine insecticide residues were detected in any food, no dietary exposure estimates have been derived for these compounds.

Risk characterisation

The estimated dietary exposures to the two organochlorine insecticides detected in the 2016 NZTDS are well below the established HBGVs for these compounds (0.4–2.9% of HBGV for dieldrin and 0.01–0.03% of HBGV for DDT). The continuing trend for the decrease in total DDT exposure suggests any dietary risk will continue to decrease as the compounds in the environment gradually degrade.

The increase in the estimated exposure to dieldrin was driven by a single analytical result for this compound in pumpkins. Comparable occurrence of dieldrin was reported in the ATDS (FSANZ, 2011), where a single residue detection of 0.04 mg/kg in pumpkin was reported. The dietary exposure estimates for dieldrin in the ATDS were equivalent to 2–9% of the New Zealand HBGV, although much higher consumption values for pumpkin were used in the ATDS than in the 2016 NZTDS simulated diets. The Hong Kong Total Diet Study also reported similar adult dietary exposure estimates for dieldrin of between 0.3-5.9% the HBGV (CFS, 2014).

Figure 9: Dietary exposure trends for total DDT in the NZTDS (1974/75–2016) for young adult males (19–24 years) and toddlers (1–3 years)



Organophosphate and carbamate insecticides

The organophosphate insecticides are a large group of agricultural chemicals. The first organophosphate insecticides were commercialised in the 1940s–1950s and development of further chemicals from the group continued throughout later decades. Use of organophosphate insecticides became widespread as they replaced organochlorine insecticides when these were banned from use. For a long period of time organophosphates were the mainstay of insect control in New Zealand agriculture. Concerns over the hazard profile of organophosphate insecticides have resulted in many of the commonly used compounds being phased out of use in New Zealand (Figure 10).

The carbamate insecticides were initially developed in the late 1950s. The carbamates act in a similar way to the organophosphate insecticides. Both groups of insecticide rapidly kill target insects, providing a knock-down effect on insect populations. They are also both broad spectrum, so can control a range of insect species. Because their toxicity hazard in humans is similar, organophosphate and carbamate insecticides are commonly grouped together for assessing risk.

There are some organophosphates and carbamates used as herbicides and fungicides, these are not covered within this section.

Hazard identification

The organophosphate and carbamate insecticide groups contain many chemicals ranked as extremely or highly hazardous for acute exposure (WHO Classes Ia and Ib; WHO, 2010). The toxicity of the organophosphate and carbamate insecticides derives from their activity as acetylcholinesterase inhibitors, as they inhibit the enzyme that breaks down the neurotransmitter acetylcholine. This inhibition results in a build up of the neurotransmitter to toxic levels, with poisoning manifesting in symptoms ranging from cramps, vomiting, sweating, excess salivation and tremors, to paralysis, convulsions, coma and respiratory failure (Klaassen, 2008).

Organophosphate and carbamate insecticides differ in that the former irreversibly binds to acetylcholinesterase, whereas the latter will show reversible binding and generally lower toxicity (WHO, 1986).

Hazard characterisation

There were HBGVs available for all of the organophosphates and carbamates detected in the 2016 NZTDS (Appendix 9). The HBGVs range from 0.1 µg/kg bw/day for methamidophos to 35 µg/kg bw/day for pirimicarb. Methamidophos, jointly with dieldrin, had the lowest HBGV of the agricultural chemicals detected in the 2016 NZTDS.

Prevalence and concentrations

The concentrations of the organophosphates and carbamate insecticides in individual foods of the 2016 NZTDS have been previously presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in appendices 7 and 8, with minimum, maximum and arithmetic mean concentrations calculated for these agricultural chemicals in each food type.

From the 55 organophosphate insecticides analysed for, eight organophosphate insecticides were detected in the foods sampled in the 2016 NZTDS. The detected residues were acephate, chlorpyrifos, chlorpyrifos-methyl, dimethoate/omethoate, malathion (also termed maldison in New Zealand), methamidophos, phosmet, and pirimiphos-methyl. The number of different compounds detected was less than a third (8 compared with 30) of the different organophosphate insecticides detected in the 2009 NZTDS. The organophosphate insecticides represented 15% of all residues detected in the 2016 NZTDS (151 out of a total of 991), compared with 27% in the 2009 NZTDS.

The most frequently detected organophosphate insecticide was pirimiphos-methyl (89 detections). Pirimiphos-methyl, chlorpyrifos-methyl (37 detections) and malathion (1 detection) were only found in foods containing cereal grain ingredients, such as bread, muffins and pizza. Both pirimiphos-methyl and chlorpyrifos-methyl are used as fumigants in grain storage silos. Acephate, dimethoate/omethoate, methamidophos and phosmet were all detected infrequently in fruit and vegetables. Chlorpyrifos was detected in foods containing or derived from berries (bran flake cereals with berry ingredients, mixed frozen berries and raisins/sultanas) and peanuts.

Fenitrothion was detected in 24 samples of cereal products in the 2009 NZTDS, or 17 samples, accounting for the reduced sensitivity on the multi-screen in the 2016 NZTDS. However, use of this insecticide was phased out in New Zealand in 2016

Figure 10: Recent and future phase out of organophosphates in New Zealand 2005–2028



Sources: EPA, 2013; ERMA, 2008a, 2009.

and fenitrothion was not detected in any food in the 2016 NZTDS.

Occurrence of chlorpyrifos-methyl and pirimiphos-methyl residues in bread (mixed grain, white and wheatmeal; Table 5) were found to be dependent on either sampling season or region. Chlorpyrifos-methyl concentrations varied between sampling seasons, but not sampling region. While chlorpyrifos-methyl is not used in New Zealand, residues may be present due to fumigation of stored grain in exporting countries. Most wheat imported into New Zealand is from Australia and wheat available in winter is likely to have been stored. The presence of chlorpyrifos-methyl in most regional samples in July and August 2016 indicates that during winter months a higher proportion of imported grain is used across the country to bake bread. In contrast, pirimiphos-methyl residues varied between the regional samples, but not between the sampling seasons. Pirimiphos-methyl is used in stored grain in New Zealand. New Zealand-grown wheat is predominantly used for bread making in the South Island.

Three carbamate insecticides were detected in the foods sampled in the 2016 NZTDS out of the 17 carbamate residue analytes tested for. These were carbaryl (3 detections), methomyl (9 detections) and pirimicarb (3 detections). Methomyl had not previously been tested for in the NZTDS. However, carbaryl and pirimicarb were reported in the 2009 NZTDS (9 and 4 detections, respectively). In the current study, carbaryl was only detected in nectarines and pirmicarb in nectarines and strawberries. Methomyl was detected in capsicums, courgettes, grapes and strawberries. A further 10 carbamate insecticides were analysed for in the sampled foods, but were not detected.

Estimated dietary exposure

Estimated daily dietary exposures to the organophosphate and carbamate insecticides for each of the population cohorts in the 2016 NZTDS are detailed in Appendix 10. Each exposure is given in µg/kg bw/day and also reported as a percentage of the HBGV. The estimated dietary exposures in the 2016 NZTDS for the adult male population cohort were compared against previous NZTDS exposure estimates for selected organophosphate and carbamate insecticides (Table 6).

The highest exposure to an organophosphate or carbamate insecticide in the 2016 NZTDS was for pirimiphos-methyl (5–6 year-old children: 0.55 µg/kg bw/day). Bread was the largest contributor (53%) to pirimiphos-methyl exposures for the 5–6 year-old child population cohort.

Large decreases in estimated exposure were evident for carbaryl, dimethoate/omethoate and methamidophos. Only chlorpyrifos-methyl showed a notable increase in exposure from the dietary exposure estimates in the 2009 NZTDS. The highest dietary exposure to chlorpyrifos-methyl was for 5–6 year-old children (0.22 µg/kg bw/day, compared to

Table 5: Seasonal and regional comparisons of chlorpyrifos-methyl and pirimiphos-methyl residues

		Number of residue detections in bread (mixed grain, white, wheatmeal)			
		Seasonal comparison		**Regional comparison**	
Compound	**Total detections**	**Summer January/February 2016** (mean mg/kg)	**Winter July/August 2016** (mean mg/kg)	**Auckland and Napier** (mean mg/kg)	**Christchurch and Dunedin** (mean mg/kg)
Chlorpyrifos-methyl	13	1 (0.01)	12 (0.11)	7 (0.08)	6 (0.14)
Pirimiphos-methyl	18	9 (0.09)	9 (0.07)	6 (0.03)	12 (0.10)

Table 6: Dietary exposure trends in the NZTDS (1990/91–2016) for organophosphate and carbamate insecticides for adult males (25 years and above)

	Estimated dietary exposure (µg/kg bw/day)				
Compound	**1990/91**	**1997/98**	**2003/04**	**2009**	**2016**
Acephate	Not analysed	Not analysed	Not detected	0.0004	0.001
Carbaryl	Not analysed	Not analysed	0.056	0.013	0.002
Chlorpyrifos	0.033	0.006	0.004	0.002	0.001
Chlorpyrifos-methyl	0.011	0.10	0.040	0.006	0.058
Dimethoate/Omethoate	Not detected	0.013	0.031	0.020	0.001
Malathion	0.010	Not detected	0.002	0.003	0.0002
Methamidophos	Not analysed	Not analysed	Not analysed	0.005	0.0003
Phosmet	0.001	Not detected	0.019	Not detected	0.0002
Pirimicarb	Not detected	Not detected	0.027	0.002	0.001
Pirimiphos-methyl	0.23	0.24	0.24	0.11	0.12

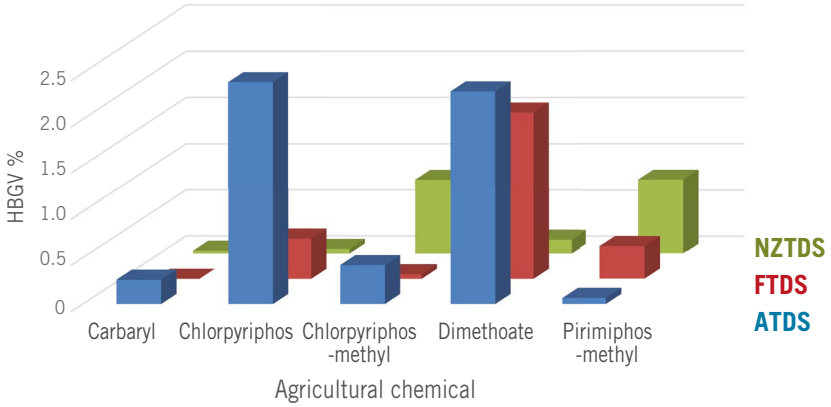
0.017 mg/kg bw/day in the 2009 NZTDS) with the increase a result of the detection of chlorpyrifos-methyl residues in bread (4 out of 8 samples of white and mixed-grain bread and 5 out of 8 samples of wheatmeal bread). This differed from the 2009 NZTDS where residues of chlorpyrifos-methyl were not detected in bread.

Risk characterisation

All estimated dietary exposures to the organophosphate and carbamate insecticides detected in the 2016 NZTDS have been calculated as a percentage of the HBGV and are summarised in Appendix 10. Dietary exposure estimates for all population cohorts for all organophosphate and carbamate insecticides did not exceed 2.8% of the respective HBGVs. This outcome is similar to the 2009 NZTDS, in which all dietary exposure estimates for these insecticides ranged up to 2.2% of the HBGV. While dietary exposure to chlorpyrifos-methyl has significantly increased, compared with the 2009 NZTDS, the exposure for all population cohorts was still far below the HBGV.

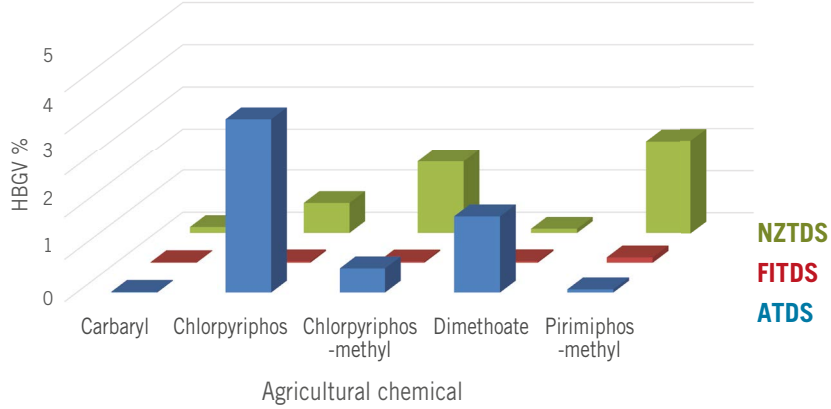
The 2016 NZTDS dietary exposure estimates for organophosphate and carbamate insecticides, as a percentage of the HBGV, are generally comparable to the ATDS (FSANZ, 2011) and FTDS/FITDS (ANSES, 2011; ANSES, 2016) for adults (Figure 11) and infants (Figure 12). Dietary exposures to chlorpyrifos-methyl and pirimiphos-methyl residues, which were present predominantly in grains, were higher in the 2016 NZTDS than the other referenced studies. In contrast, organophosphate and carbamate insecticides used in horticulture (carbaryl, chlorpyrifos and dimethoate) resulted in equivalent or lower dietary exposures for New Zealand, compared with estimates from Australia and France.

Figure 11: Comparative dietary exposures for adults to selected organophosphate and carbamate insecticides, as a percentage of the health based guidance value



ATDS: Australian Total Diet Study (FSANZ, 2011); FTDS: French Total Diet Study (ANSES, 2011).

Figure 12: Comparative dietary exposures to infants (6–12 months) for selected organophosphate and carbamate insecticides, as a percentage of the health based guidance value



ATDS: Australian Total Diet Study (FSANZ, 2011); FITDS: French Infant Total Diet Study (ANSES, 2016).

Risk characterisation of cumulative dietary exposure

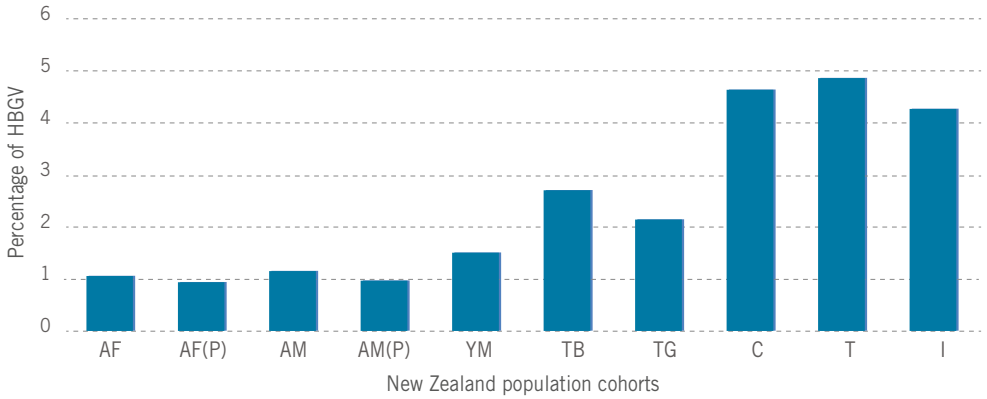
The organophosphate and carbamate insecticides are all categorised as sharing a common toxicological mode of action; the inhibition of acetylcholinesterase. The cumulative impact of all organophosphate and carbamate insecticides present in the diet can be estimated using an additive approach. Although the organophosphate and carbamate insecticides act through the same mechanism of action, the potency of each compound can differ considerably based on various toxicokinetic factors. For example, different rates of absorption from the gastrointestinal tract and efficiency of metabolism in the liver. Specifically for these classes of insecticides, toxicity depends on whether inhibition of acetylcholinesterase is reversible or irreversible. To reflect the different potencies, dietary exposure to each of the organophosphate and carbamate insecticides was weighted, relative to a representative or index compound, based on the comparative potency of the acetylcholinesterase inhibition (Appendix 9). This weighting is referred to as a relative potency factor (RPF). By adding the weighted exposures, it was possible to characterise the risk due to cumulative dietary exposure to all detected organophosphate and carbamate insecticides. Table 7 presents the methodology used for estimating the cumulative exposure in adult females (25 years and above).

Through weighting the individual organophosphate and carbamate insecticide dietary exposures for each population group, and calculating the sum of the individual weighted exposures, the cumulative exposure to the acetylcholinesterase inhibition mode of action can been calculated (Appendix 10). This has been illustrated as a percent of the HBGV for chlorpyrifos (Figure 13).

Table 7: Adult female (25 years and above) cumulative dietary exposure to organophosphates and carbamates, as weighted against relative potency factors (RPF) for chlorpyrifos

Compound	RPF against chlorpyrifos	Adult female (25 years and over) exposure (µg/kg bw/day)	Weighted adult female (25 years and over) exposure (µg/kg bw/day)
Chlorpyrifos	1	0.0010	0.0010
Dimethoate/Omethoate	0.75	0.0015	0.0011
Chlorpyrifos-methyl	0.3	0.0538	0.0162
Methamidophos	0.3	0.0004	0.0001
Acephate	0.12	0.0007	0.00008
Pirimiphos-methyl	0.12	0.1125	0.0135
Phosmet	0.1	0.0001	0.00001
Malathion	0.01	0.0003	$3x10^{-6}$
Methomyl	0.003	0.0018	0.00001
Carbaryl	0.003	0.0028	0.00001
Pirimicarb	0.003	0.0030	0.00001
Total		**0.178**	**0.032**

Figure 13: Cumulative dietary exposures to organophosphate and carbamate insecticides in the 2016 NZTDS, expressed as a percentage of the health based guidance value for chlorpyrifos



AF: Adult Female (25 years and over); AF(P): Adult Female – Pacific Island ethnicity (15 years and over); AM: Adult Male (25 years and over); AM(P): Adult Male – Pacific Island ethnicity (15 years and over); YM: Young Adult Male (19–24 years); TB: Teenage Boy (11–14 years); TG: Teenage Girl (11–14 years); C: Child (5–6 years); T: Toddler (1–3 years); I: Infant (6–12 months).

Neonicotinoid insecticides

The neonicotinoid insecticides are a group of chemicals related to the natural plant toxin nicotine. Neonicotinoids were developed during the 1980s and 1990s and are now one of the more commonly used insecticide groups. They are used widely in horticulture, arable farming, and pet and livestock treatments.

Hazard identification

The neonicotinoid insecticides act on the nervous system through stimulation of the nicotinic acetylcholine receptor. The neonicotinoid insecticides show similar effects to nicotine but with much lower toxicity in vertebrates (Klaassen, 2008). Poisoning symptoms after intentional ingestion have included nausea, muscle weakness, headaches and drowsiness (Roberts & Reigart, 2013). Separate to the human health hazard, the neonicotinoid insecticides have seen international scrutiny in relation to their role in mortality events for pollinators, such as honey bees (EFSA, 2012).

Hazard characterisation

Appropriate HBGVs were available for all of the neonicotinoid insecticides detected in the 2016 NZTDS (Appendix 9). The HBGVs ranged from 10 µg/kg bw/day for thiacloprid, to 80 µg/kg bw/day for thiamethoxam.

Prevalence and concentrations

The concentrations of the neonicotinoid insecticides in individual foods of the 2016 NZTDS have been previously presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in appendices 7 and 8, with minimum, maximum and arithmetic mean concentrations calculated for these agricultural chemicals in each food type.

All four neonicotinoid insecticides tested for in the 2016 NZTDS were detected in the sampled foods. Single detections were made of acetamiprid (raisins/sultanas), thiacloprid (tomato) and thiamethoxam (courgette). Imidacloprid was detected in 16 samples, including capsicums, celery, courgettes, grapes, lettuce, raisins/sultanas and tomatoes. Neonicotinoids were not analysed for in previous NZTDSs, therefore, trends and comparisons cannot be made.

Estimated dietary exposure

Estimated daily dietary exposures to the neonicotinoid insecticides for each of the population cohorts in the 2016 NZTDS are detailed in Appendix 10. Each exposure is given in µg/kg bw/day and also reported as a percentage of the HBGV.

The highest estimate of exposure to neonicotinoid insecticides was for imidacloprid (0.011 µg/kg bw/day for toddlers). Grapes and raisins/sultanas were the foods contributing the majority (63% combined) of this dietary exposure. In contrast, for adult males, capsicum and tomato contributed the most (63% combined) to the estimated dietary exposure. Dietary exposures for the other three neonicotinoids did not exceed 0.002 µg/kg bw/day for any cohort.

Risk characterisation

All estimated dietary exposures to the neonicotinoid insecticides detected in the 2016 NZTDS have been calculated as a percentage of the HBGV (Appendix 10). All population cohort dietary exposure estimates were below 0.02% of the respective HBGVs for the four neonicotinoids detected.

Of the comparator overseas studies, only the ATDS (FSANZ, 2011) included exposure assessments for a neonicotinoid insecticide. The lower-bound mean dietary exposure estimates for imidacloprid were 0.0019 µg/kg bw/day for 9-month-old infants (NZTDS infants 6–12 months: 0.0069 µg/kg bw/day) and 0.0069 µg/kg bw/day for adults 17 years and over (NZTDS Adult females: 0.0034 µg/kg bw/day).



Pyrethrin and pyrethroid insecticides

The pyrethroid insecticides are a grouping of compounds similar to the natural plant toxins produced by chrysanthemum plants, termed pyrethrins. The knowledge of the insecticidal properties of these plants dates far back in history. The development of synthetic pyrethroids as insecticides commenced in the 1960s, with a second generation of pyrethroid insecticides being developed in the 1970s. Natural pyrethrins and synthetic pyrethroids may be used directly as agricultural chemicals, often in fly sprays and in combination with the synergist piperonyl-butoxide. Because natural pyrethrins are short lived in the environment, the presence of residues of the synergist is often the only indication that they have been used. Fifteen synthetic pyrethroid insecticides were analysed in the 2016 NZTDS.

Hazard identification

Pyrethrins and the pyrethroid insecticides all act on the nervous system, specifically through binding to the sodium channels in nerves and delaying their opening and closing. The disruption to the sodium channels causes repetitive and prolonged firing of nerve pulses, which for many of the synthetic pyrethroids (termed type II compounds) progresses to full depolarisation and blocking of the nerve pulse (Klaassen, 2008). Symptoms of toxicity when consumed include a sore throat, vomiting and abdominal cramps, followed by dizziness, headaches and, in high doses, convulsions; although human poisonings are rare (Bradberry et al., 2005).

The synergist piperonyl-butoxide works through preventing the metabolic system of the insect from breaking down the pyrethrin and pyrethroid and allows toxic levels of these compounds to concentrate. In humans, piperonyl-butoxide has been assessed to be of very low toxicity (JMPR, 1995).

Hazard characterisation

Pyrethrin and all of the pyrethroid insecticides detected in the 2016 NZTDS have established HBGVs (Appendix 9). The HBGVs for the pyrethroid insecticides range from 10 µg/kg bw/day for bifenthrin to 30 µg/kg bw/day for fenpropathrin. Natural pyrethrin has an HBGV of 40 µg/kg bw/day. An HBGV was also available for the synergist piperonyl-butoxide of 200 µg/kg bw/day.

Prevalence and concentrations

The concentrations of pyrethrin and the pyrethroid insecticides in individual foods of the 2016 NZTDS have been previously presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in appendices 7 and 8, with minimum, maximum and arithmetic mean concentrations calculated for these agricultural chemicals in each food type.

Six pyrethroid insecticides, from the 15 tested for, were detected in the foods sampled in the 2016 NZTDS, with 20 samples containing residues of a pyrethroid insecticide. The pyrethroid insecticides detected were cypermethrin (9 samples), bifenthrin (5 samples), cyhalothrin (4 samples), deltamethrin (6 samples), fenpropathrin (1 sample) and fenvalerate (2 samples). Four raisins/sultanas samples out of eight analysed contained multiple residues of pyrethroids. Two raisins/sultanas samples contained residues of two different pyrethroid insecticides, and two samples contained three and four pyrethroid residues, respectively.

The pyrethroid deltamethrin was primarily detected in cereal grain-based foods, such as cracker biscuits and bran flake cereals. The other pyrethroids were detected on a range of foods, including fruit and vegetables, and cereal products. Notably, cypermethrin was also present in three oil samples and two table spread samples, out of the eight samples of each food. The presence of cypermethrin in oil-based foods reflects its common use on oilseed crops. In addition to the synthetic pyrethroids, the natural compound pyrethrin was detected in three out of eight almond samples. Pyrethrin was analysed for, but not detected, in the 2009 NZTDS, however, almonds were not included in the sampled foods of the 2009 NZTDS.

Piperonyl-butoxide was detected in 5% (50 out of 1056) of the food samples in the 2016 NZTDS. Ten of the samples with detected residues of piperonyl-butoxide also had a detected residue of pyrethrin or a pyrethroid insecticide. Because piperonyl-butoxide is used as a synergist with pyrethrin- or pyrethroid-based insecticides, it is highly likely the other 40 samples were also treated with a pyrethrin- or pyrethroid-based insecticide. Piperonyl-butoxide was detected in 27 different food types; including fresh fruit and vegetables, seafood, meat and cereal products. In the 2009 NZTDS, 11% (108 out of 982) of samples had detected residues of piperonyl-butoxide, although this reduces to 6% (61 out of 991) when results below the LORs of the 2016 NZTDS are excluded, suggesting the prevalence has remained largely consistent.

Pyrethrin, synthetic pyrethroids and piperonyl-butoxide residues accounted for 8% (81 out of 991) of the total agricultural chemical detections in the 2016 NZTDS.

Estimated dietary exposure

Estimated daily dietary exposures to the pyrethroid insecticides for each of the population cohorts in the 2016 NZTDS are detailed in Appendix 10. Each exposure is given in µg/kg bw/day and also reported as a percentage of the HBGV.

The highest estimated exposure for the pyrethroids was for cypermethrin (0.023 µg/kg bw/day for toddlers). For all the population cohorts, except infants, oil made the largest contribution to synthetic pyrethroid dietary exposure (54–86%). For infants, the main food that contributed to dietary exposure was raisins/sultanas (56%).

Exposure to piperonyl-butoxide was highest in toddlers and infants (0.097 µg/kg bw/day). A large proportion of the piperonyl-butoxide exposure (Toddlers: 33%; Infants: 24%) resulted from consumption of the other breakfast cereals food type. Exposures to piperonyl-butoxide in the adult population cohorts were lower than for toddlers and infants (0.030–0.041

µg/kg bw/day) and were generally contributed to evenly by the 27 food types with detected residues. The estimated dietary exposures for piperonyl-butoxide in the 2016 NZTDS have decreased considerably, down to 27–33% of those reported for the equivalent population cohorts in 2009.

Trends in estimated exposures for adult males for the pyrethroid insecticides tested in prior NZTDSs have been compiled in Table 8.

Risk characterisation

All estimated dietary exposures to the pyrethroid insecticides detected in the 2016 NZTDS have been calculated as a percentage of the HBGV (Appendix 10). The highest estimated exposure was for cypermethrin for both adult population cohorts (0.03–0.06%) and the infant, child and adolescent population cohorts (0.03–0.12%). None of the dietary exposures to the pyrethroid insecticides exceed 0.5% of the HBGV. Piperonyl-butoxide dietary exposures did not exceed 0.05% of the HBGV.

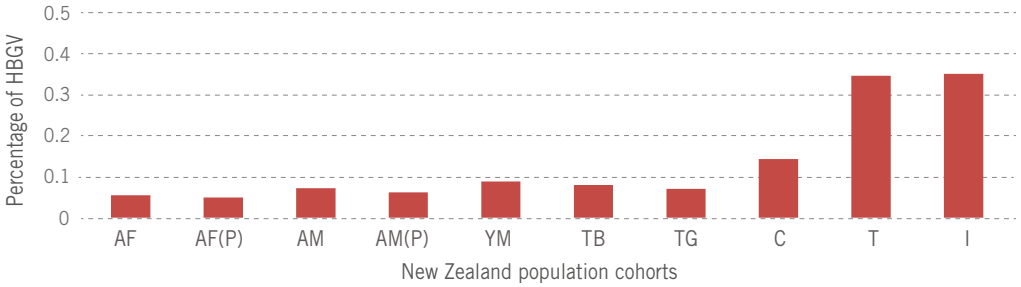
For adults, the number of comparable exposures from overseas data to the pyrethroid insecticides in the 2016 NZTDS was limited. The ATDS (FSANZ, 2011) reported an exposure of 0.0378 µg/kg bw/day for bifenthrin (New Zealand adults: 0.0003–0.0004 µg/kg bw/day). The FTDS (ANSES, 2011) recorded an exposure of 0.1% of the HBGV for piperonyl-butoxide for adults and children (New Zealand range: 0.01–0.05% of the HBGV). For infants, the ATDS (FSANZ, 2011) reported an exposure of 0.0007 µg/kg bw/day for bifenthrin (New Zealand infants: 0.005 µg/kg bw/day). While deltamethrin in the FITDS (ANSES, 2016) was reported at 0.01% of the HBGV (New Zealand infants: 0.09% of the HBGV).

Risk characterisation of cumulative dietary exposure

The pyrethrin and pyrethroid insecticides have been identified as sharing a common mechanism of action on the sodium channels in nerves (US EPA, 2011). To account for potential additive exposure in the diet, a cumulative dietary exposure assessment was undertaken. The approach used was similar to that used for the cumulative assessment for organophosphates and carbamate insecticides. RPFs were derived by assessing neurotoxicity endpoints for pyrethrin and the pyrethroid insecticides against the toxicity of deltamethrin (Appendix 9). Piperonyl-butoxide was omitted from the cumulative dietary expose because it does not share a common mode of action with pyrethrin and the pyrethroid insecticides.

The dietary exposure estimates for the individual pyrethrin and pyrethroid insecticides for each population group were multiplied by the RPF for the insecticide and summed to give a cumulative exposure to "deltamethrin equivalents" (Appendix 10). The risk associated with this cumulative exposure was characterised against the HBGV for deltamethrin (Figure 14). None of the exposure calculations exceeded the HBGV for deltamethrin indicating that the risk of cumulative exposure to pyrethrin and the pyrethroid insecticides is negligible for New Zealand population cohorts.

Figure 14: Cumulative dietary exposure to pyrethrin and the pyrethroid insecticides in the 2016 NZTDS, expressed as a percentage of the health based guidance value for deltamethrin



AF: Adult Female (25 years and over); AF(P): Adult Female – Pacific Island ethnicity (15 years and over); AM: Adult Male (25 years and over); AM(P): Adult Male – Pacific Island ethnicity (15 years and over); YM: Young Adult Male (19–24 years); TB: Teenage Boy (11–14 years); TG: Teenage Girl (11–14 years); C: Child (5–6 years); T: Toddler (1–3 years); I: Infant (6–12 months).

Table 8: Dietary exposure trends in the NZTDS (1990/91–2016) for pyrethroids and piperonyl-butoxide for adult males (25 years and above)

	Estimated daily dietary exposure (µg/kg bw/day)				
Compound	**1990/91**	**1997/98**	**2003/04**	**2009**	**2016**
Bifenthrin	Not analysed	Not analysed	0.0004	0.0001	0.0003
Cypermethrin	Not detected	Not detected	0.002	<0.0001	0.010
Deltamethrin	Not detected	Not detected	Not detected	0.020	0.002
Fenpropathrin	Not analysed	Not analysed	0.0002	0.0002	0.0002
Fenvalerate	Not detected	Not detected	0.0004	Not detected	0.0001
Piperonyl-butoxide	0.006	0.061	0.010	0.12	0.035

Other insecticides

A number of other insecticide chemical types were analysed for within the 2016 NZTDS. These include some more recently developed groups of insecticides, such as the diamides (chlorantraniliprole), spinosyns (spinosad and spinetoram), tetronic (spiromesifen) and tetramic acids (spirotetramat), and sulfoximine (sulfoxaflor) insecticides. In addition, it also covered the insect and mite growth regulators buprofezin and etoxazole. In total, 37 other insecticide analytes were tested for in the 2016 NZTDS.

Many of the other insecticide chemicals tend to be highly selective to particular insect pests under control. With more specificity for insect pests they can also be applied at much lower concentrations than the older insecticide groups.

Hazard identification

The other insecticides cover a range of different hazards and toxicological modes of action. These include buprofezin and spinosad, which cause cellular changes in the thyroid (JMPR, 2001a, 2008); and chlorantraniliprole, which showed very few symptoms of toxicity in a range of animal studies using high doses (JMPR, 2009).

Hazard characterisation

All of the other insecticides detected in the 2016 NZTDS had established HBGVs (Appendix 9). Most of the other insecticides had HBGVs in the range of 9–42 µg/kg bw/day. The exceptions were methoxyfenozide (100 µg/kg bw/day) and chlorantraniliprole (1580 µg/kg bw/day).

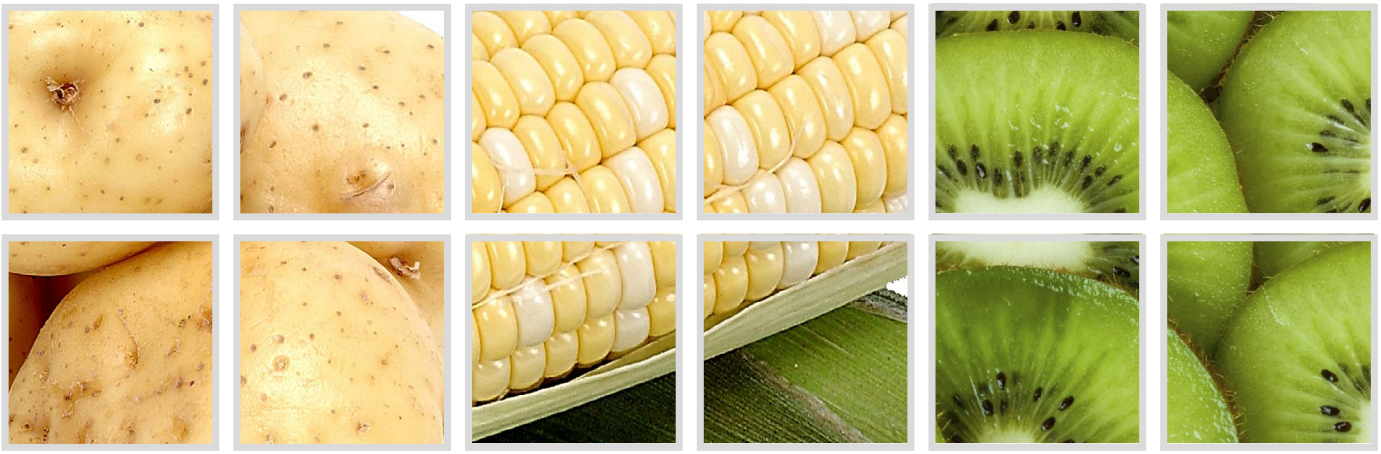
Prevalence and concentrations

The concentrations of other insecticides in individual foods of the 2016 NZTDS have been previously presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in appendices 7 and 8, with minimum, maximum and arithmetic mean concentrations calculated for these agricultural chemicals in each food type.

Seventeen other insecticides were detected in the foods sampled in the 2016 NZTDS, with 7% (74 out of 1056) of the food samples analysed having detected concentrations of one or more of the other insecticides. Grapes and raisins/sultanas were notable for having multiple other insecticides detected, with samples containing up to five detected residues of the other insecticides. The frequency of the detected concentrations of the other insecticides, and the food types where they were detected most often, is presented in Table 9.

Fruits and vegetables most frequently contained residues of the other insecticides, and of this group raisins/sultanas had 23 detections and grapes had 16 detections. Spinosad was only present in cereal grain-based foods (bread, bran flake and wheat biscuit cereal), and propargite, a miticide, was only detected in two of the infant weaning foods and raisins/sultanas.

Many of the other insecticides had not previously been analysed for in NZTDSs, reflecting their relatively recent development and commercialisation in global agriculture. For the other insecticides that had been analysed previously, the frequency of detection was generally lower or equal in the 2016 NZTDS when compared with the 2009 NZTDS. For example, buprofezin had eight detections in the 2009 NZTDS, but was only detected in two grape samples in the 2016 NZTDS. Tebufenpyrad was detected in a single pear sample in the 2009 NZTDS and in a single raisins/sultanas sample in the 2016 NZTDS. Only the prevalence of indoxacarb residues increased, from two samples with detected residues in the 2009 NZTDS to eight samples in the 2016 NZTDS.



Detections of the other insecticides accounted for 11% (109 out of 991) of the agricultural chemical detections in the 2016 NZTDS. In terms of the total insecticide detections, the other insecticides made up 29% (109 out of 380) of the findings (Figure 8).

Estimated dietary exposure

Estimated daily dietary exposures to the other insecticides for each of the population cohorts in the 2016 NZTDS are detailed in Appendix 10. Each exposure is given in µg/kg bw/day and also reported as a percentage of the HBGV.

Spirotetramat had the highest dietary exposures of the other insecticides detected (0.061 µg/kg bw/day for toddlers). The main contributing foods to this exposure in toddlers were potato hot chips (41%) and raisins/sultanas (35%). Propargite dietary exposure for infants was 0.029 µg/kg bw/day, with most of this exposure (94%) resulting from the detection of residues in the custard/fruit-based and cereal grain-based infant weaning foods. Tebufenozide exposure for 5–6-year-old children was 0.026 µg/kg bw/day, almost all of which (98%) was contributed to by the consumption of apples.

Trends in estimated dietary exposures for adult males for the other insecticides tested in prior NZTDSs are presented in Figure 15. However, because many of the other insecticides have not been analysed for in previous NZTDSs, no exposure trends for these chemicals are possible.

Risk characterisation

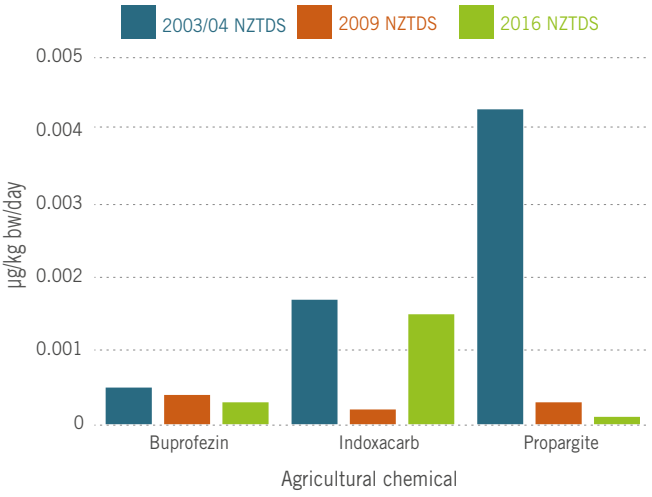
All estimated dietary exposures to the other insecticides detected in the 2016 NZTDS have been calculated as a percentage of the HBGV in Appendix 10. None of the exposures for the other insecticides exceed 0.5% of the HBGV. The highest exposure for the adult population cohorts was for spirotetramat (0.03–0.05%). In the infant, child and adolescent population cohorts, the highest exposures were for tebufenozide (0.13% for 5–6-year-old children), propargite (0.29% for infants) and spirotetramat (0.06–0.15% for adolescents).

The number of comparable estimates of dietary exposures to the other insecticides from overseas studies was limited. For adults, the ATDS (FSANZ, 2011) reported dietary exposures of 0.0047 µg/kg bw/day for spinosad (New Zealand adults: 0.0032–0.0062 µg/kg bw/day) and 0.0216 µg/kg bw/day for tebufenpyrad (New Zealand adults: 0.00005–0.0001 µg/kg bw/day). While for infants, the reported dietary exposures in the ATDS (FSANZ, 2011) were 0.0009 µg/kg bw/day for spinosad (New Zealand infants: 0.017 µg/kg bw/day) and 0.0236 µg/kg bw/day for tebufenpyrad (New Zealand infants: 0.0012 µg/kg bw/day).

Table 9: Other insecticide compounds detected in the 2016 NZTDS, with total number of detections and food type in which the compounds were most frequently detected (key food type)

Agricultural chemical	Total number of detections	Key food type
Buprofezin	2	Grape
Chlorantraniliprole	7	Grape
Etoxazole	3	Grape
Fenpyroximate	2	Raisins/sultanas
Flufenoxuron	1	Raisins/sultanas
Hexythiazox	2	Raisins/sultanas, prune
Indoxacarb	8	Raisins/sultanas
Lufenuron	1	Capsicum
Methoxyfenozide	18	Raisins/sultanas
Propargite	5	Infant weaning food, cereal-based
Spinetoram	4	Nectarines
Spinosad	12	Bread, wheatmeal
Spiromesifen	3	Tomato
Spirotetramat	26	Potato, hot chips
Sulfoxaflor	6	Tomato
Tebufenozide	5	Apple
Tebufenpyrad	1	Raisins/sultanas

Figure 15: Dietary exposure trends in the NZTDS (2003/04–2009) of the other insecticides for adult males (25 years and above)



Fungicides

Overview

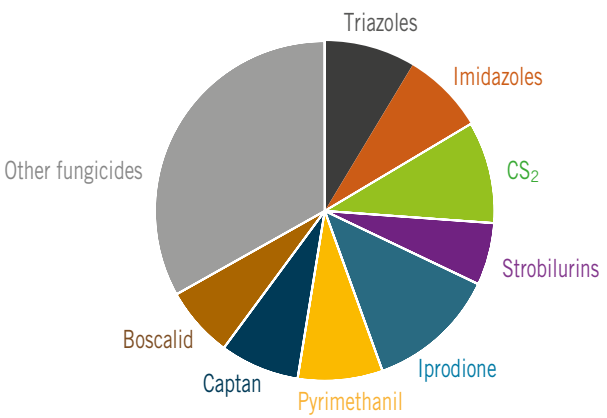
Fungicides are chemicals used in the control of moulds and yeasts. The fungicide group of agricultural chemical represented the second most common detection in the 2016 NZTDS. From the 372 analytical detections (out of 991 total detections) for a fungicide in the 2016 NZTDS, there was a wide spread of chemistry present and no group or individual chemical represented a majority of detections (Figure 16). The method of analysis for the dithiocarbamate fungicides breaks the various chemical structures down to the common marker CS_2.

Triazole and imidazole fungicides

The triazole fungicides contain a five member ring, comprising two carbon and three nitrogen atoms, while the imidazole fungicides contain a five member ring with three carbon and two nitrogen atoms. Triazoles are an important group of fungicides in agriculture and are also used in human medicines as antifungal drugs. Both triazole and imidazole fungicides act to inhibit ergosterol biosynthesis, which inhibits fungal growth. Both triazole and imidazole fungicides are often collectively referred to as demethylation inhibitors (DMI) or DMI fungicides.

The first triazole and imidazole fungicides came into use in the 1970s, with development continuing on other triazole fungicides in subsequent decades, to provide compounds with increasing efficacy. One imidazole and three triazole fungicide analytes were initially added to the NZTDS in 1997/98, although these were not detected in the foods sampled in that year. Further triazole and imidazole fungicides were included in subsequent NZTDS years.

Figure 16: Breakdown of fungicide detections in the 2016 NZTDS by chemical class, or individual compounds, with greater than 25 detections



Hazard identification

The triazole and imidazole fungicides cover a range of different hazards and toxicological modes of action. The critical adverse effect for the triazole tebuconazole, for example, is on the adrenal glands (JMPR, 2010). The imidazole fungicide prochloraz, however, acts upon the liver in animal studies and is very potent at inducing metabolic enzymes (JMPR, 2001a). The triazoles present a specific hazard in that they share common toxic metabolites, so cumulative exposure to triazoles across the diet could result in an additive effect (EFSA, 2009).

Hazard characterisation

Suitable HBGVs were available for all of the triazole and imidazole fungicides detected in the 2016 NZTDS (Appendix 9). The established HBGVs for the triazoles and imidazole ranged between 4 µg/kg bw/day for tebuconazole and 70 µg/kg bw/day for propiconazole.

Prevalence and concentrations

The concentrations of the triazole and imidazole fungicides in individual foods of the 2016 NZTDS have been previously presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in appendices 7 and 8, with minimum, maximum and arithmetic mean concentrations calculated for these agricultural chemicals in each food type.

Out of the 15 triazole fungicides analysed for, eight triazole fungicides were detected in the foods sampled in the 2016 NZTDS. Triazole fungicides were detected in 23 samples, including three samples (grapes and raisins/sultanas) with two triazole fungicides present, and two samples (raisins/sultanas) with four triazole fungicides present. The compounds detected were myclobutanil (9 samples), difenoconazole and tebuconazole (8 samples each), triadimenol (3 samples), and hexaconazole, penconazole, propiconazole and tetraconazole (1 sample each). Fruit (grapes, nectarines, raisins/sultanas and strawberries) samples contained the majority of detections (71%) for triazole fungicides. However, difenoconazole was also found in samples of broccoli/cauliflower, celery, hummus, sushi and a noodle dish. The single result for hexaconazole in taro was the only reported agricultural chemical detected in the 2016 NZTDS for this food type.

Two imidazole fungicides were analysed for in the 2016 NZTDS. A total of 29 food samples had detected levels of either imazalil (23 samples) or prochloraz (6 samples). The detections of imazalil were mostly found in fruit (bananas, mandarins, oranges, pears) or foods that may contain fruit (infant weaning food, custard/fruit dish). Prochloraz is used in mushroom cultivation and was detected in five of the eight mushroom samples.

The triazole fungicides accounted for 3.2% (32 out 991) of the agricultural chemical residue detections in the 2016 NZTDS. Compared with the 2009 NZTDS, where 2.9% (27 out of 910) of detections of triazole fungicides were reported, there has been a slight increase in prevalence in the 2016 NZTDS. However, in the 2009 NZTDS, a different array of triazole fungicides was detected (azaconazole, cyproconazole and triadimefon), which were not detected in 2016. While there were 10 detections for a triazole fungicide in raisins/sultanas samples in the 2016 NZTDS, no triazoles were detected in this food in 2009. Prevalence of individual triazole fungicide residues varied slightly between the 2009 and 2016 NZTDSs, with difenoconazole and tebuconazole both increasing from four to eight detections, respectively.

The imidazole fungicides accounted for 2.9% (29 out 991) of the agricultural chemical residue detections in the 2016 NZTDS, with the combined DMI fungicides accounting for 6.2% (61 out of 991) of agricultural chemical residue detections. The number of detections for imazalil has increased from 11 in the 2009 NZTDS to 23 in the 2016 NZTDS. Prochloraz was not detected in the 2009 NZTDS.

Dietary exposure estimates

Estimated daily dietary exposures to the triazole and imidazole fungicides for each of the population cohorts in the 2016 NZTDS are detailed in Appendix 10. Each exposure is given in µg/kg bw/day and as a percentage of the respective HBGVs.

The highest dietary exposure estimated for a triazole fungicide was for tebuconazole (0.021 µg/kg bw/day for infants). The exposure to tebuconazole for infants was mainly due to residues detected in nectarines (85% of dietary exposure). Difenoconazole and hexaconazole were notable amongst the agricultural chemicals; adult population cohorts had greater dietary exposures than infant, child and adolescent cohorts. Exposure to difenoconazole was highest in the young adult male population group, of which 81% of exposure resulted from the detection of this compound in a single sample of a noodle dish. Hexaconazole was the only agricultural chemical where the two Pacific Island ethnicity adult cohorts showed an appreciably greater level of exposure (approximately tenfold) over the general population, due to the detection of this triazole fungicide in taro.

For the two imidazole fungicides, the estimated exposure to imazalil was greatest in the toddler age group (0.19 µg/kg bw/day), and prochloraz exposure greatest in the infant age group (0.0017 µg/kg bw/day). Imazalil dietary exposure for the infant, child and adolescent population cohorts was driven largely by the residues present in fresh oranges (33–76%), and to a lesser extent pears (14–26%) and bananas (5–20%). A similar pattern was evident in the adult population cohorts, where the three fruits together contributed more than 90% of the dietary exposure.

The estimated daily dietary exposures to the selected triazole and imidazole fungicides for adult males in the 2016 NZTDS are compared against previous NZTDS exposure estimates in Table 10.

Risk characterisation

All estimated dietary exposures to the triazole and imidazole fungicides detected in the 2016 NZTDS have been calculated as a percentage of the HBGV in Appendix 10. None of the estimated exposures for the triazole and imidazole fungicides exceeded 1% of the HBGV. The highest estimated dietary exposure was for imazalil (0.63% for toddlers 1–3 years). The only other chemical within these groups to have exposures exceeding 0.05% of the HBGV was tebuconazole in children (5–6 years; 0.06%) and infant (6–12 months; 0.07%) age groups.

Table 10: Dietary exposure trends in the NZTDS (2003/04–2016) for triazole and imidazole fungicides for adult males (25 years and above)

	Estimated daily dietary exposure (µg/kg bw/day)		
Compound	**2003/04**	**2009**	**2016**
Difenoconazole	0.0008	0.0012	0.004
Imazalil	Not analysed	0.043	0.026
Myclobutanil	Not analysed	0.0005	0.0009
Penconazole	<0.0001	<0.0001	<0.0001
Propiconazole	0.0003	0.0007	0[a]
Tebuconazole	0.0003	0.0011	0.004
Triadimenol	<0.0001	Not detected	0.0006

[a] In 2016, propiconazole was only detected in a food type only consumed by infants so no adult exposure was estimated.

Triazoles and imidazole fungicides were infrequently detected in the ATDS (FSANZ, 2011) and FTDS (ANSES, 2011). Imazalil was detected in both overseas studies and lower-bound mean dietary exposures reported for adult cohorts (ATDS: 0.072 µg/kg bw/day; FTDS: 0.112 µg/kg bw/day) that were greater than in the 2016 NZTDS adult population cohorts (0.022–0.035 µg/kg bw/day). However, all of the studies reported dietary exposure less than 0.5% of the HBGV. The ATDS also reported dietary exposure estimates for prochloraz (0.41% of the HBGV) and myclobutanil (0.01% of the HBGV), which were slightly greater than the estimated dietary exposure to these compounds in the 2016 NZTDS (0.002–0.008%). Comparable estimates for infant dietary exposure to triazole and imidazole fungicides were available (Figure 17).

Estimated cumulative dietary exposure

The triazole fungicides share a common target organ, the liver (EFSA, 2009). As a result, it was possible to characterise the risk of cumulative dietary exposure to this chemical group. Liver toxicity (hepatotoxicity) is evidenced through increasing enzyme induction and increased organ weight. For the two imidazole fungicides detected, the liver was also a target organ. Consequently, the two imidazole fungicides were conservatively considered to exert their toxicity through the same mode of action as the triazole fungicides.

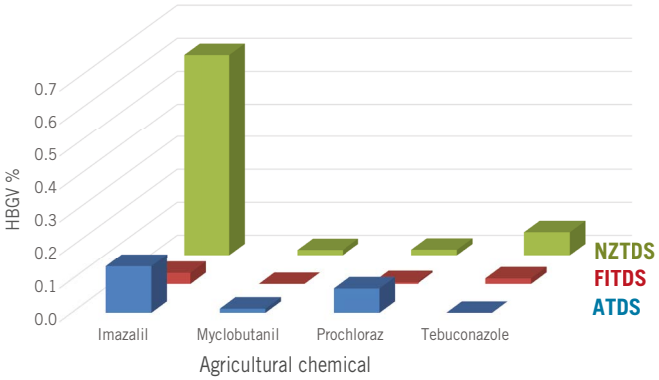
The cumulative impact of all triazole and imidazole fungicide exposures across the diet was estimated using an additive model. The same methodology has been used for cumulative dietary exposure assessment for organophosphates and carbamate insecticides. RPFs were derived by assessing the hepatotoxicity of each triazole and imidazole fungicide against the toxicity of tetraconazole (Appendix 9).

The dietary exposure estimates for the individual triazole and imidazole fungicides for each population group were multiplied by the RPF for the fungicide and summed to give a cumulative exposure to "tetraconazole equivalents" (Appendix 10). The risk associated with this cumulative exposure was characterised against the HBGV for tetraconazole (Figure 18). None of the population cohorts had exposures that exceeded the HBGV for tetraconazole; as a result, the risks from cumulative exposure to triazole and imidazole fungicides are considered negligible.

Carbon disulphide and the dithiocarbamate fungicides

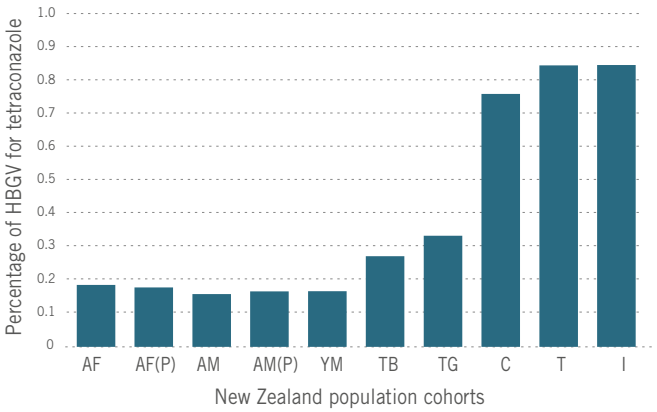
CS_2 is a small organic molecule that is highly volatile at room temperature. CS_2 was one of the first agricultural fumigants, however, because of its flammability and explosive nature, it has largely been phased out of agricultural use. While residues of CS_2 could be present from direct use of the chemical, it is primarily tested in the NZTDS as a marker for the presence of dithiocarbamate fungicides. The common method of analysis for the dithiocarbamate fungicides breaks the various chemical structures down to CS_2. However, in this method, CS_2 is not exclusively formed by dithiocarbamates. CS_2 can also be generated by the breakdown of certain natural plant chemicals, which are most commonly found in brassica vegetables (Perz et al., 2000).

Figure 17: Comparative dietary exposures for infants (6–12 months) to triazole and imidazole fungicides, as a percentage of the health based guidance value



ATDS (FSANZ, 2011); FITDS (ANSES, 2016).

Figure 18: Cumulative dietary exposure to triazole and imidazole fungicides in the 2016 NZTDS, expressed as a percentage of the health based guidance value for tetraconazole



AF: Adult Female (25 years and over); AF(P): Adult Female – Pacific Island ethnicity (15 years and over); AM: Adult Male (25 years and over); AM(P): Adult Male – Pacific Island ethnicity (15 years and over); YM: Young Adult Male (19–24 years); TB: Teenage Boy (11–14 years); TG: Teenage Girl (11–14 years); C: Child (5–6 years); T: Toddler (1–3 years); I: Infant (6–12 months).

The dithiocarbamates were the first major group of fungicides developed, being commercialised during the 1940–60s. Prior to this, only inorganic fungicide chemicals, such as copper and sulphur, had been widely used in agriculture. Analysis for CS_2 has been undertaken in the NZTDS since 1990/91 and results interpreted in terms of exposure to dithiocarbamate fungicide residues.

Hazard identification

The molecule CS_2 itself is a hazardous solvent, however, exposure to CS_2 directly is highly unlikely outside of industrial settings (Klaassen, 2008). The residues of CS_2 in foods analysed for dithiocarbamate fungicides are generated by the testing method so do not reflect on the levels of CS_2 normally in the diet, although some CS_2 can be liberated in the body when dithiocarbamates are metabolised (Nelson, 2003). In contrast to CS_2, the dithiocarbamate fungicides are low in acute toxicity but can cause chronic effects on the thyroid through metabolism to a toxic metabolite (Klaassen, 2008). A potential effect from dithiocarbamates is the inhibition of alcohol metabolism, leading to cramps, vomiting, tremors and potentially more severe toxicity and collapse if alcohol is consumed after exposure (Nelson, 2003; Roberts & Reigart, 2013).

Hazard characterisation

The individual dithiocarbamate fungicides have different toxicological potencies and are grouped under three different HBGVs. These are 3 µg/kg bw/day for ferbam, thiram and ziram; 7 µg/kg bw/day for propineb; and 30 µg/kg bw/day for mancozeb, maneb, metiram and zineb (Appendix 9). In New Zealand, because mancozeb, metiram, thiram and ziram are all in use, it was considered conservative to assume that any reported residue of CS_2 resulted from the most toxic of the dithiocarbamates. As a result, the HBGV of 3 µg/kg bw/day was applied to characterise the risk of the estimated dietary exposure to dithiocarbamate fungicides. Any CS_2 originating from natural plant chemicals is also characterised against this HBGV, although the human health hazard is unlikely to be of the same magnitude as the dithiocarbamate fungicides.

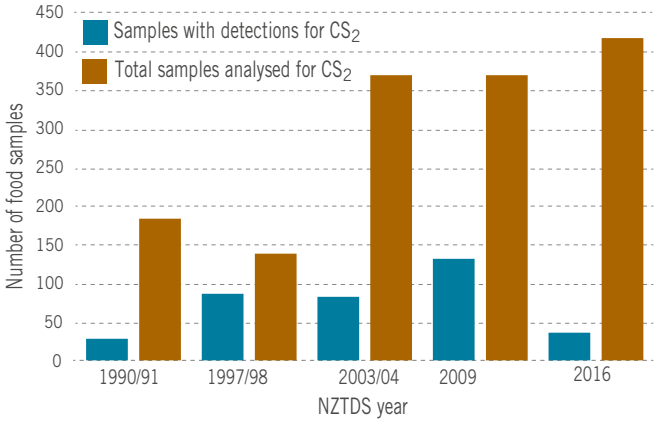
Prevalence and concentrations

The concentrations of CS_2 in individual foods of the 2016 NZTDS have been previously presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in appendices 7 and 8, with minimum, maximum and arithmetic mean concentrations calculated for these agricultural chemicals in each food type.

In the 2016 NZTDS, CS_2 residues were detected in 36 food samples from 16 different food types. The foods with CS_2 residue detections included all eight samples of cabbage and three broccoli/cauliflower samples. For the brassica vegetables, the CS_2 residues have the potential to have been generated from the breakdown of natural chemicals in the plant (Perz et al., 2000). The other foods with detections for CS_2 are mostly fruits, where dithiocarbamate fungicide use was the likely origin. These fruits included strawberries (4 samples), avocados and grapes (3 samples each). Dithiocarbamate fungicide residues are not generally stable in food preparation because they are broken down by natural food acids. Consequently, many of the processed food types were not analysed for CS_2 in the 2016 NTZDS. From the limited processed fruit and vegetable-based foods that were analysed, single detections for CS_2 were reported in one sample of each of apple and orange juices, and hot potato chips; and two detections in tomato sauce.

The prevalence of CS_2 residues detected has decreased sharply compared with the 2009 NZTDS, in which 138 detections for CS_2 were reported. While the range of foods included in the two NZTDSs differs, if only the foods tested in the 2016 NZTDS are considered, the number of detections of CS_2 residues in the 2009 NZTDS would decrease to 131 detections. Comparatively, the 2016 NZTDS results represented a 72% decrease in prevalence of CS_2 residues in the sampled foods. The 2016 NZTDS has the lowest number of CS_2 detections since the 1990/91 NZTDS. However, it is important to note that in the 1990/91 NZTDS the detection limit for CS_2 was 95 times greater than in the current study. The 2016 NZTDS also had the greatest number of individual samples tested for CS_2 (Figure 19).

Figure 19: Trends for carbon disulphide (CS_2) in the NZTDS (1990/91–2016[a]) of total samples analysed and samples with detections



[a] The detection limit in the 1990/91 NZTDS for CS_2 was 0.95 mg/kg. For all other years it was 0.01 mg/kg.

Dietary exposure estimates

Estimated daily dietary exposures to the dithiocarbamate fungicides, based on CS_2 determination, for each of the population cohorts in the 2016 NZTDS, are detailed in Appendix 10. Each exposure is given in µg/kg bw/day.

In previous NZTDSs, dietary exposures to dithiocarbamate fungicides have consistently been the highest of any of the agricultural chemicals considered. A similar trend was evident in the 2016 NZTDS, with dithiocarbamate fungicide dietary exposure estimates for the adult population cohorts representing one of the highest of all the agricultural chemicals considered. The main foods contributing to the estimated dietary exposure to dithiocarbamate fungicides in the adult population cohorts were cabbage (28–40%) and strawberries (32–46 %). As noted above, the cabbage CS_2 residue values are likely to be at least partly a result of natural compounds in the plant rather than of dithiocarbamate fungicide origin (Perz et al., 2000). Consequently, the contribution of cabbage to the dithiocarbamate fungicide dietary exposure is likely to be an overestimate. The highest exposure for the dithiocarbamate fungicides was in the toddler age group (0.082 µg/kg bw/day). Strawberries (31%), apple-based juice (18%) and cabbage (16%) were all major foods contributing to the exposure in toddlers.

Estimated dietary exposures to dithiocarbamate fungicides have decreased considerably, compared with previous NZTDSs. The estimated dietary exposures for dithiocarbamate fungicides in adults were approximately an order of magnitude below those of all the previous NZTDSs (Figure 20).

Risk characterisation

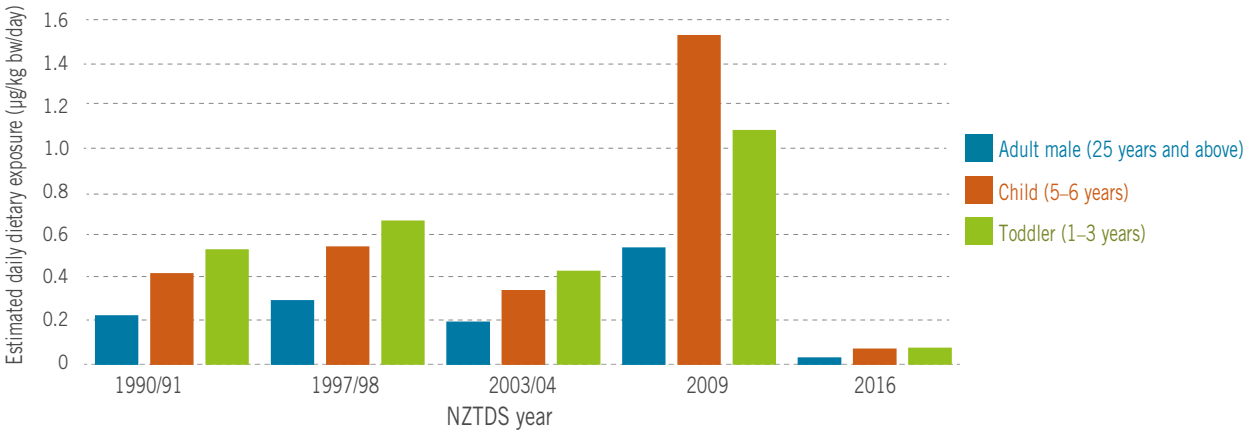
All estimated dietary exposures to the dithiocarbamate fungicides detected in the 2016 NZTDS are summarised as a percentage of the HBGV in Appendix 10.

In previous NZTDS years, the exposure to dithiocarbamate fungicides as a percentage of the HBGV was markedly higher than the remainder of the agricultural chemical residues found. For example, in the 2009 NZTDS, the exposure of adult males to dithiocarbamate fungicides was 18 times higher than any other agricultural chemical. In the 2016 NZTDS, dietary exposure estimates for dithiocarbamate fungicides dropped to 0.8–2.8% of the HBGV across the population cohorts considered and dietary exposure to dithiocarbamate fungicides is now similar to many other agricultural chemicals. In fact, for some population cohorts (children and infants), the estimated dietary exposure for the dithiocarbamate fungicides was lower than for some other agricultural chemicals.

It was considered likely that the apparent CS_2 residues in the brassica vegetables, broccoli/cauliflower and cabbage, resulted at least partly from natural plant chemicals generating CS_2 during extraction. As a result, the risks characterised for the dithiocarbamate fungicides are likely to be an overestimate. By removing the exposure contribution from broccoli/cauliflower and cabbage, the dietary exposure to dithiocarbamates decreased to 0.4–2.1% of the HBGV across the population cohorts.

Dietary exposure estimates determined in the FTDS and ATDS, for dithiocarbamate fungicides, were commonly reported as one of the higher values for agricultural chemicals (ANSES, 2011; FSANZ, 2011).

Figure 20: Dietary exposure trends in the NZTDS (1990/91–2016) for dithiocarbamate fungicides for adult males, children and toddlers



Strobilurin fungicides

The strobilurin fungicides are a more recent fungicide development, with commercialisation in the 1990s. The strobilurin fungicides are based on the structure of a naturally bioactive chemical isolated from the fungal species *Strobilurus tenacellus*. The strobilurin fungicides are now one of the most commonly used fungicide groups globally and are used for disease protection and control in a wide variety of crops.

Hazard identification

There is little information available on the hazards of the strobilurin fungicides to humans, with cases of poisoning in the United States only reported from dermal contact and inhalation of pyraclostrobin (Roberts & Reigart, 2013). The liver is the target organ for chronic toxicity in laboratory animals for the strobilurin fungicide azoxystrobin (JMPR, 2009).

Hazard characterisation

All of the strobilurin fungicides have suitable HBGVs established to characterise the human health hazard (Appendix 9). The HBGVs ranged from 30 µg/kg bw/day for pyraclostrobin to 252 µg/kg bw/day for kresoxim-methyl.

Prevalence and concentrations

The concentrations of the strobilurin fungicides in individual foods of the 2016 NZTDS have been previously presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in appendices 7 and 8, with minimum, maximum and arithmetic mean concentrations calculated for these agricultural chemicals in each food type.

All four strobilurin fungicide residues analysed for in the 2016 NZTDS were detected, being present in seven different food types. One sample each of grape and raisins/sultanas contained two different strobilurin fungicide residues. One other grape sample contained all four different strobilurin residues. The 22 detections of the four strobilurin fungicides included azoxystrobin and pyraclostrobin (7 samples each), trifloxystrobin (6 samples) and kresoxim-methyl (2 samples). All of the samples with a detected residue of pyraclostrobin also contained another detected fungicide, boscalid. These agricultural chemicals are often formulated together in one agricultural product.

Compared with the 2009 NZTDS, where only two samples had azoxystrobin residues and five samples had trifloxystrobin residues, the number of strobilurin fungicide residue detections doubled in the 2016 NZTDS. Similarly, only eight detections of strobilurin fungicide residues had been made in the 2003/04 NZTDS. Pyraclostrobin is a new addition to the analytical agricultural chemical multi-screen for 2016. All of the detections, except a single detection of trifloxystrobin in an oil sample, were found in fruit or foods likely to contain fruit, such as muesli and bran flakes. Small fruits most frequently contained residues of the strobilurin fungicides (17 detections in total), with ten in grapes, five in raisins/sultanas and two in strawberries.

Dietary exposure estimates

Estimated daily dietary exposures to strobilurin fungicides for each of the population cohorts in the 2016 NZTDS are detailed in Appendix 10. Each exposure is given in µg/kg bw/day and as a percentage of the respective HBGVs.

Strobilurin fungicide dietary exposures for adults ranged from 0.0001 µg/kg bw/day for kresoxim-methyl to 0.0015 µg/kg bw/day for azoxystrobin. Azoxystrobin also had the highest estimated exposure of the strobilurin fungicides (0.018 µg/kg bw/day for both toddlers and infants). Estimated azoxystrobin exposure was almost all (96–98%) due to residues detected in raisins/sultanas.

The dietary exposures to azoxystrobin were consistent with those estimated in the 2003/04 and 2009 NZTDSs (Table 11). Trifloxystrobin, however, has seen an increase in the estimated dietary exposure, compared with the two previous NZTDS studies.

Risk characterisation

All estimated dietary exposures to the strobilurin fungicides detected in the 2016 NZTDS have been calculated as a percentage of the HBGV in Appendix 10.

Exposures for the strobilurin fungicides were all below 0.05% of the HBGV. The highest exposure estimate was for pyraclostrobin (0.024% for toddlers 1–3 years). As a result, it is unlikely that the increased prevalence of strobilurin residues seen in the 2016 NZTDS present a public health concern.

Table 11: Dietary exposure trends in the NZTDS (2003/04–2016) for strobilurin fungicides for young adult males (19–24 years)

	Estimated daily dietary exposure (µg/kg bw/day)		
Compound	**2003/04**	**2009**	**2016**
Azoxystrobin	0.0010	0.0015	0.0011
Kresoxim-methyl	0.00002	Not detected	0.001
Trifloxystrobin	0.0001	0.0002	0.0015

Other fungicides

A range of other fungicides have been included in the 2016 NZTDS. These other fungicides include a wide variety of chemical structural groups but usually with only a few chemicals in use within each group. As a result, the remainder of the fungicide chemicals tested are reported on in a single section. This grouping includes older fungicides, such as phthalimide (captan), nitroanaline (dicloran), phthalonitrile (chlorothalonil) and benzimidazole (carbendazim and thiophanate-methyl). More modern fungicide groupings are also included, such as anilinopyrimidines (cyprodinil and pyrimethanil). Forty-four other fungicide analytes were tested for in total in the 2016 NZTDS.

The other fungicides iprodione and procymidone were first included in the agricultural chemical screen in 1987/88. In contrast, a number of fungicides, including bixafen, boscalid and fluxapyroxad, are new additions to the NZTDS agricultural chemical screen in 2016.

Hazard identification

The other fungicides vary considerably in their human health hazards and toxicological mechanisms of action, although there are few reported cases of human poisonings (Roberts & Reigart, 2013). Dicloran was reported to cause no adverse effects in male volunteers when ingested at 10 mg/day (JMPR, 1999). Effects in animal studies include toxicity to the liver for cyprodinil and to the liver and thyroid for pyrimethanil (JMPR, 2004, 2008).

The significant health hazards that chlorothalonil presents to users from inhalation have recently been considered sufficient to revoke its non-agricultural use permissions in New Zealand (EPA, 2017).

Hazard characterisation

All of the other fungicides detected in the 2016 NZTDS have suitable HBGVs established (Appendix 9). The HBGVs ranged from 10 µg/kg bw/day for dicloran to 590 µg/kg bw/day for fludioxonil.

Prevalence and concentrations

The concentrations of the other fungicides in individual foods of the 2016 NZTDS have been previously presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in appendices 7 and 8, with minimum, maximum and arithmetic mean concentrations calculated for these agricultural chemicals in each food type.

Sixteen other fungicide compounds were detected in the 2016 NZTDS, being present in 137 different food samples (Table 12). Seven individual analytes from the other fungicides group were present in two samples of raisins/sultanas and one sample of bran flake cereal.

Of the other fungicides detected, six (boscalid, carbendazim/thiophanate-methyl, cyflufenamid, dodine, fenhexamid and propamocarb) had not been previously analysed for in the NZTDS. For the other fungicides that had been previously analysed in the NZTDS only dimethomorph was not detected in prior studies (Figure 21).

The majority of the other fungicides detected were in grapes and berry fruits, and foods containing these as ingredients. These foods were: strawberries (34 detections), raisins/sultanas (31 detections), bran flake cereal (25 detections), grapes (16 detections), frozen mixed berries (10 detections) and wine (5 detections). Other fruits also showed consistent patterns of residues of the other fungicides. For example, all

Table 12: Other fungicide compounds detected in the 2016 NZTDS, with total number of detections and food type in which the compound was most frequently detected (key food type)

Agricultural chemical	Total number of detections	Key food type
Boscalid	25	Grape, raisins/sultanas
Captan	28	Apple, strawberry
Carbendazim/thiophanate-methyl	23	Simmer sauce
Chlorothalonil	10	Celery
Cyflufenamid	3	Grape
Cyprodinil	20	Raisins/sultanas
Dicloran	11	Kumara
Dimethomorph	3	Raisins/sultanas
Dodine	3	Pear
Fenhexamid	5	Strawberry
Fludioxonil	21	Strawberry
Iprodione	46	Raisins/sultanas
Metalaxyl	9	Bran flake cereal
Procymidone	11	Pumpkin, simmer sauce, tomato
Propamocarb	4	Cucumber
Pyrimethanil	30	Bran flake cereal, muesli

of the apple samples and seven out of eight pear samples contained detected captan residues. Iprodione residues were also detected widely in fruits. In contrast, the fungicide procymidone was present only in vegetables, or foods containing vegetables, and propamocarb was only detected in cucumbers. Dicloran was also notable in being detected in all eight kumara samples. Finally, six out of the eight bottled simmer sauce samples had a residue of carbendazim/thiophanate-methyl present. The tomato base in the simmer sauces was considered the likely source, given this fungicide was also found in whole tomatoes and other tomato-based foods.

Residues of the other fungicides accounted for 25% (252 out of 991) of the analytical agricultural chemical detections in the 2016 NZTDS.

Dietary exposure estimates

Estimated daily dietary exposures to the other fungicides for each of the population cohorts in the 2016 NZTDS are detailed in Appendix 10. Each exposure is given in µg/kg bw/day.

Amongst the other fungicides, captan, iprodione and pyrimethanil had dietary exposures >0.2 mg/kg bw/day for at least one population cohort. The highest dietary exposure was for iprodione (0.55 µg/kg bw/day for infants), which was predominantly (45%) due to nectarine consumption. Captan dietary exposure was highest for the child (5–6 years) cohort (0.31 µg/kg bw/day). Two-thirds (66%) of the captan exposure in this population cohort resulted from the detection of residues in apples, with strawberries also contributing 22% of the dietary exposure. Estimated dietary exposure to pyrimethanil for the toddler and infant age groups (0.20–0.21 µg/kg bw/day) was almost tenfold higher than for adult age groups. The residues of pyrimethanil in raisins/sultanas contributed 72–86% of the dietary exposure. Consequently, consumption of greater amounts of raisins/sultanas in the youngest age groups resulted in the large difference in exposure.

Dietary exposures to the other fungicides are largely similar to previous NZTDSs (Table 13). Cyprodinil has shown a consistent increase in dietary exposure since its first inclusion in the 2003/04 NZTDS. Iprodione dietary exposure peaked in the 1997/98 NZTDS and has decreased to below 0.1 µg/kg bw/day in the latest two NZTDSs.

Figure 21: Residue detection trends in the NZTDS (2003/04–2016) for other fungicides

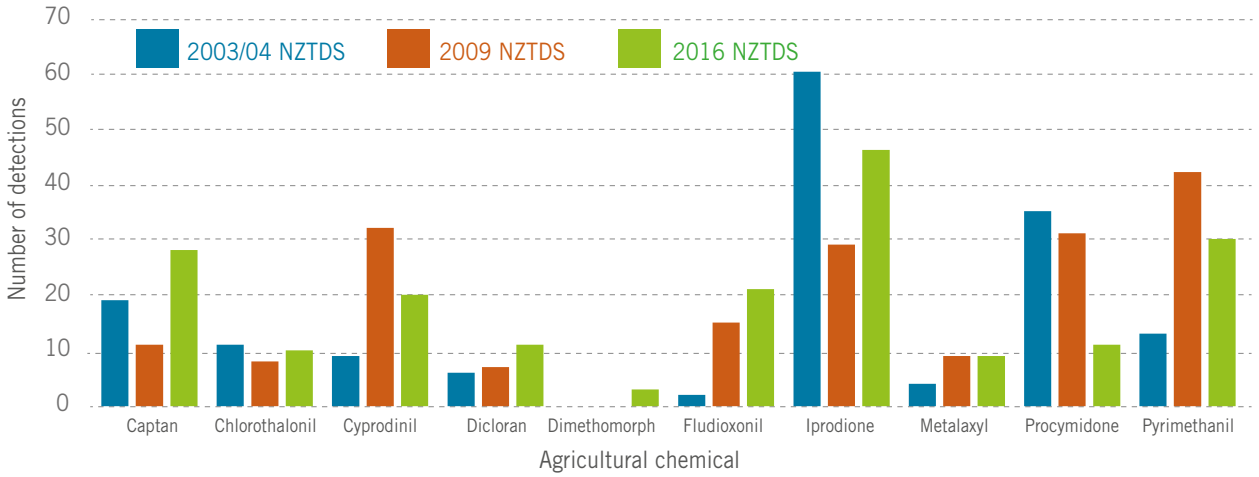


Table 13: Dietary exposure trends in the NZTDS (1990/91–2016) for other fungicides for adult males (25 years and above)

	Estimated daily dietary exposure (µg/kg bw/day)				
Compound	**1990/91**	**1997/98**	**2003/04**	**2009**	**2016**
Captan	0.013	Not detected	0.058	0.030	0.065
Chlorothalonil	0.020	0.002	0.002	0.002	0.003
Cyprodinil	Not analysed	Not analysed	0.002	0.007	0.014
Dicloran	Not analysed	0.011	0.004	0.002	0.012
Fludioxonil	Not analysed	Not analysed	0.001	0.040	0.027
Iprodione	0.184	0.483	0.175	0.067	0.083
Metalaxyl	Not detected	Not detected	0.001	0.005	0.001
Procymidone	0.052	0.008	0.018	0.008	0.010
Pyrimethanil	Not analysed	Not analysed	0.033	0.018	0.025

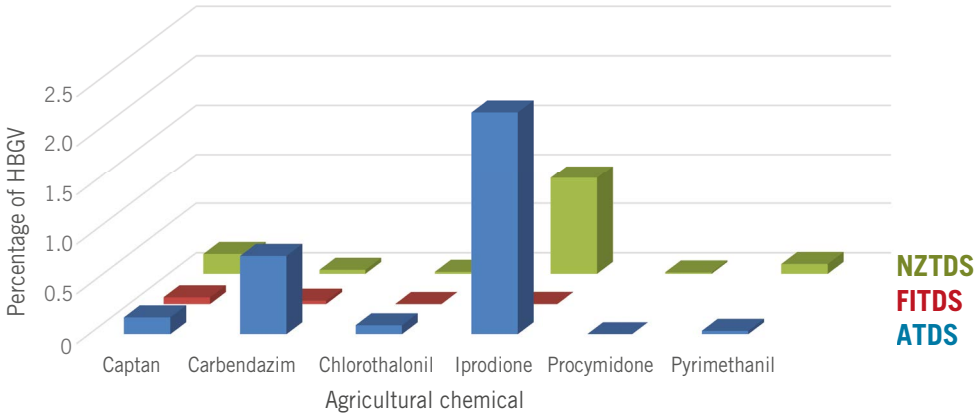
Risk characterisation

All estimated dietary exposures to the other fungicides detected in the 2016 NZTDS have been calculated as a percentage of the respective HBGVs in Appendix 10.

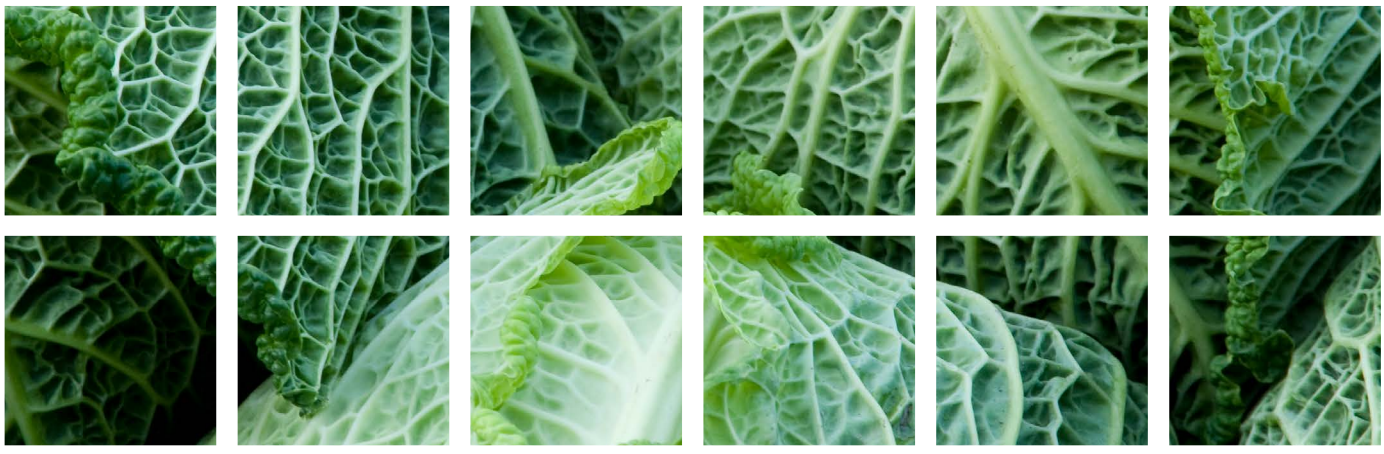
For the other fungicides, the estimated dietary exposures for the population cohorts all fell below 1% of the HBGV.

Comparison of the dietary exposure estimates for the 2016 NZTDS with those determined in the FTDS and ATDS shows similar patterns of exposure to the other fungicides (ANSES, 2011; FSANZ, 2011). Dietary exposure to iprodione, chlorothalonil and carbendazim in the adult diet in the ATDS and FTDS all fell below 1% of the HBGV. A similar situation was reported for infants for a range of other fungicides, with the estimated iprodione exposures being very similar for this age group in both Australia and New Zealand (Figure 22).

Figure 22: Comparative dietary exposures for infants (6–12 months) for other fungicides, as a percentage of the health based guidance value



ATDS: Australian Total Diet Study (FSANZ, 2011); FITDS: French Infant Total Diet Study (ANSES, 2016).



Herbicides

Herbicides are chemicals used to control plant pests in agriculture. Herbicides may be non-selective, causing damage to most plant types, or selective, targeting control to specific weed species. Because non-selective herbicides will damage crop plants, they will rarely be sprayed onto the crop itself. More commonly, they are applied as targeted spot sprays or to open fields before crop seeds germinate. Because crops are not directly treated, residues of non-selective herbicides in food are unlikely. In contrast, selective herbicides can be applied to tolerant crop types and residues may result in the produced food.

A wide range of herbicide types are in use in New Zealand agriculture. The group first commercialised in the 1940s was the "phenoxy" herbicides (referring to the phenoxyacetic, phenoxypropionic or phenoxybutyric chemical structure). This group includes 2,4-dichlorophenoxyacetic acid (2,4-D) and 2-methyl-4-chlorophenoxyacetic acid (MCPA), which are both used for selective control of weeds in cereals. Later compounds developed from this group were fluazifop/fluazifop-butyl and haloxyfop, which are used against grassy weeds in many types of vegetable crops. Other common herbicide groups in use are the pyridines, including the selective herbicides clopyralid and triclopyr, and the triazines, including atrazine and non-selective simazine.

Sixty-three herbicide residue analytes are tested for in the agricultural chemical multi-screen employed in the NZTDS, including atrazine and linuron. However, the chemistry of some of the herbicide groups means they are not amenable to inclusion in agricultural chemical multi-screens and specialised methods have to be employed to detect them. In the 2016 NZTDS, the phenoxy and aromatic acid herbicides screen had been added to the testing methodology, to enable a further 21 additional herbicide residues to be detected. Other groups of herbicides, such as the sulfonylureas, phosphonomethyl and bipyridil herbicides, also require specialised methods but were not included in the 2016 NZTDS.

Hazard identification

As with the fungicides, the herbicides present a variety of different hazard types and mechanisms of toxicity. The mechanisms of action of herbicides target aspects of plant metabolism, as a result, systemic toxicity in humans (or other mammals) is unlikely without consuming excessive amounts (Roberts & Reigart, 2013). In the majority of reviewed cases of intentional ingestion of MCPA, there were minimal symptoms of poisoning, however, cases of intentional ingestion of 2,4-D have led to fatalities following kidney failure, acidosis and multiple organ failure (Roberts & Reigart, 2013). For many of the other herbicides, such as linuron and diuron, limited information on adverse human effects is available. In animals, the kidney is the target organ in both acute and chronic exposure for 2,4-D (JMPR, 1997). The contemporary herbicide aminopyralid has a much lower toxic potency, with the critical effect over the short term being on cells in the stomach lining (JMPR, 2008).

Hazard characterisation

Suitable HBGVs were available for all of the herbicides detected in the 2016 NZTDS (Appendix 9). Haloxyfop has a very low HBGV, at 0.7 µg/kg bw/day. In contrast, clopyralid has an HBGV more than 100 times higher (105 µg/kg bw/day).

Prevalence and concentrations

The concentrations of herbicides in individual foods of the 2016 NZTDS have been previously presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in appendices 7 and 8, with minimum, maximum and arithmetic mean concentrations presented for these agricultural chemicals in each food type.

Residues of seven different herbicide compounds were detected in the foods sampled in the 2016 NZTDS. Clopyralid was the most prevalent, with 44 samples containing a detected residue. The remaining detections were for fluazifop/fluazifop-butyl (4 samples), haloxyfop and metribuzin (3 samples each) and diuron, linuron and tri-allate (1 sample each). A single onion sample had more than one herbicide residue present – containing both clopyralid and haloxyfop. The herbicides diuron (9 samples), linuron (4 samples) and haloxyfop (1 sample) were previously detected in the 2009 NZTDS. The herbicides alachlor and flamprop-methyl were detected in the 2009 NZTDS but not in the 2016 NZTDS. The 2003/04 NZTDS was the last study year in which clopyralid was analysed for, as a specific herbicide screen was included in the methods. In the 2003/04 NZTDS, there were no detections of clopyralid or the other 17 herbicides tested for. The increase in prevalence of clopyralid residues in a number of foods included in the 2016 NZTDS suggests its use in agriculture has changed or become more widespread over the past 12 years.

Most of the bread samples analysed in the 2016 NZTDS contained residues of clopyralid, with residues detected in 8 out of 8 wheatmeal bread samples, and 7 out of 8 mixed grain and white bread types. Detected residues for clopyralid were also reported in other cereal grain-based foods, such as bran flakes, rolled oats and pasta. An unexpected finding was the presence of clopyralid in all of the mushroom samples from Quarter 1. Commercial mushroom cultivation occurs indoors under tightly controlled conditions so herbicide use would not be necessary or expected. It is believed the clopyralid residues may have originated from the growing media and/or compost the mushrooms were cultivated in. Clopyralid is reported to be resistant to breakdown in cut grass clippings (ERMA, 2007). If contaminated clippings were used in compost production, there is the potential that residues would result in mushrooms subsequently cultivated on the compost.

The remaining herbicides were most frequently detected in vegetables, with celery, onions and potato-based foods all containing detectable residues. Two seafood products also had two herbicide residues present. The detection of diuron in prawns and shrimps is likely due to the use of this compound as an anti-fouling treatment on boats and marine structures. However, the detection of tri-allate in mussels is less clearly attributable to a known use pattern. It is not expected that

tri-allate would be used in, or close to, any aquaculture. A potential explanation for the residue is that this herbicide is present in oils and other minor ingredients used to marinate pre-cooked mussels sampled within this category.

With a prevalence of 6% (57 out of 991 total analyte detections), the herbicides were a minor proportion of the total agricultural chemical residue detections in the 2016 NZTDS food samples.

Dietary exposure estimates

Estimated daily dietary exposures to herbicides for each of the population cohorts in the 2016 NZTDS are detailed in Appendix 10. Each exposure is given in µg/kg bw/day and as a percentage of the respective HBGVs.

Clopyralid was the most prevalent herbicide detected in the food supply, therefore, it is unsurprising that this herbicide has the highest dietary exposure. Clopyralid dietary exposures ranged between 0.025 µg/kg bw/day in the diet of adult females of Pacific Island ethnicity to 0.1 µg/kg bw/day in the diet of children. Bread was the main contributing food to this exposure (as presented for children 5–6 years in Figure 23) for all the population cohorts, except for infants.

Of the remaining herbicides detected in the 2016 NZTDS, the highest estimated dietary exposure was for fluazifop/fluazifop-butyl (0.025 µg/kg bw/day for toddlers). All the other herbicide compounds detected had estimated dietary exposures below 0.0033 µg/kg bw/day, approximately an order of magnitude below that of fluazifop/fluazifop-butyl.

Of the herbicides residues detected in the 2016 NZTDS, only linuron had been detected prior to the 2009 NZTDS (Figure 24). Linuron was included in the agricultural chemical multi-screen in the 1997/98 NZTDS and was first detected in the 2003/04 NZTDS, in a single sample. Linuron dietary exposure has decreased considerably in the 2016 NZTDS, compared with previous exposure estimates. Haloxyfop, in contrast, has shown an increase in exposure for all population cohorts in the 2016 NZTDS, compared with the 2009 NZTDS.

Risk characterisation

All estimated dietary exposures to the herbicides detected in the 2016 NZTDS have been calculated as a percentage of the respective HBGVs (Appendix 10).

Both haloxyfop and fluazifop/fluazifop-butyl have relatively low HBGVs on the scale of all of the agricultural chemicals detected in the 2016 NZTDS. This resulted in both herbicides having estimated dietary exposures for all but one of the population cohorts of 0.1–1% the HBGV. The exception was for adult females of Pacific Island ethnicity, with a dietary exposure less than 0.1% of the HBGV for fluazifop/fluazifop-butyl. In contrast, all of the estimated clopyralid exposures were within the range of 0.01–0.1% of the HBGV, despite the wider prevalence of clopyralid in the diet. Dietary exposures to the remaining herbicides detected in samples of the 2016 NZTDS were all below 0.01% of the HBGV.

There are few comparable dietary exposure estimates for the herbicides detected in the 2016 NZTDS in the overseas TDSs. Clopyralid, diuron, fluazifop, haloxyfop, linuron and metribuzin were all analysed for in the ATDS (FSANZ, 2011). However, of these herbicides, only haloxyfop was detected in a single sample of canned pineapple. The resulting estimated exposures to haloxyfop in the ATDS are similar to those estimated in the 2016 NZTDS, at approximately 1% of the New Zealand HBGV. Dietary exposure of infants to linuron was also estimated in the FITDS (ANSES, 2016). However, because linuron was only detected in the 2016 NZTDS in a food infants were not expected to consume (celery), no New Zealand infant exposure estimate was calculated.

Figure 23: Major clopyralid contributing food types in the 2016 NZTDS for children (5–6 years)

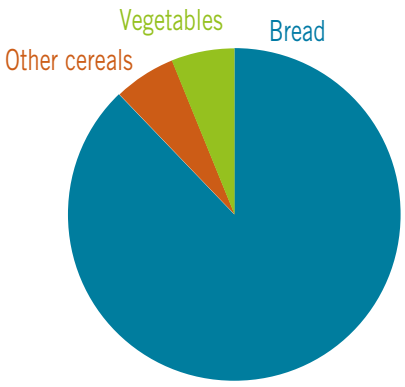
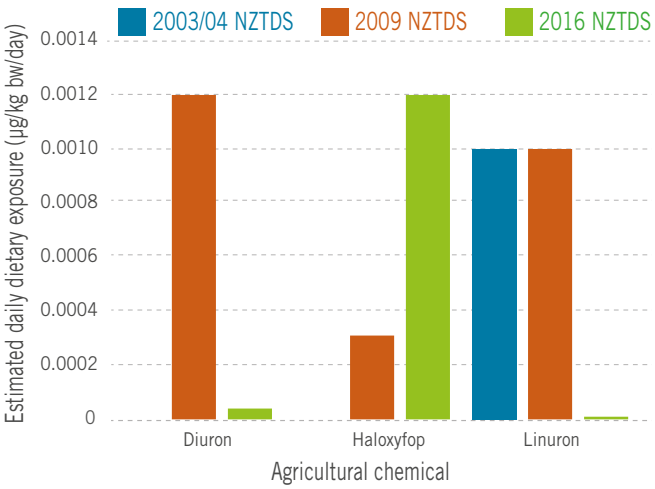


Figure 24: Dietary exposure trends in the NZTDS (2003/04–2016) for adult males (25 years and above) for herbicides



Quaternary ammonium compounds

QACs are a group of chemicals analysed for the first time in 2016 NZTDS. The QACs are used as disinfectants throughout the food industry and are also present in many household products.

The QACs are reported within the agricultural chemical section of the NZTDS because they also have uses in agriculture, primarily in post-harvest washing of fruit and vegetables to control storage infections and rots. However, the use of QACs to sanitise surfaces in the food processing industry is likely to be a key source of any residues found.

There are two types of QAC in common use in New Zealand, both of which have been analysed for in the 2016 NZTDS. The first is benzalkonium chloride (BAC), which consists of a mixture of different even-length alkyl chains. The 2016 NZTDS agricultural chemical multi-screen analysed samples separately for the three most common chain lengths (12, 14 and 16 carbon chain length). The second QAC type in use is didecyldimethylammonium chloride (DDAC). DDAC is also a mixture of different even-length alkyl chains (8, 10 and 12 carbon chain length), but is reported on in the 2016 NZTDS agricultural chemical multi-screen as a single summed concentration.

Hazard identification

When present in concentrated solutions, the QACs are irritant and corrosive, causing symptoms such as vomiting, cramps and burns to the gastrointestinal tract when ingested (Roberts & Reigart, 2013). Poisonings have resulted when QACs have been stored in drink containers and accidentally consumed (Arugonda, 1999). The health hazard reduces when QACs are diluted, and they are used safely in a range of household products at lower dilutions. Longer term effects on food intake and weight gain have been reported in animal studies for BAC (BFR, 2012)

Hazard characterisation

Both BAC and DDAC have been assigned HBGVs of 100 µg/kg bw/day (Appendix 9).

Prevalence and concentrations

The concentrations of QACs in individual foods of the 2016 NZTDS have been previously presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in appendices 7 and 8, with minimum, maximum and arithmetic mean concentrations calculated for these agricultural chemicals in each food type.

BAC was one of the most commonly detected agricultural chemicals in the 2016 NZTDS. Seventy-one out of the 1056 food samples had a detection for at least one of the three BAC analytes, and there were 118 detections in total for the BAC analytes out of a total of 991 agricultural chemical detections (12%). The 16 carbon chain length was detected least frequently of the three BAC analytes, being detected in only six samples. The 12 carbon chain length was the most frequently detected, accounting for 62 of the detections. Only three samples had all three BAC analytes present. DDAC was detected in 22 samples, eight of which also contained BAC. In a single sample of fresh fish, residues of all four QACs were present.

The QAC detections occurred across all of the food groups tested in the 2016 NZTDS. BAC residues were commonly detected in frozen fruit and vegetables; such as corn (7 out of 8 samples), mixed berries (5 samples), mixed vegetables (1 sample) and peas (2 samples). An agricultural use of BAC could have been the origin of these residues, although use as a surface sanitiser in the food processing and freezing facility could also be a source. DDAC was only detected on a single sample of a horticultural product (strawberry). However, DDAC residues were present in 6 out of the 8 tofu samples. QAC detections also occurred in ham (5 out of 8 samples), mussels (4 samples), bacon (4 samples), fresh fish (3 samples) and sausages (2 samples). The presence of BAC and DDAC across a wide range of seafood and meat products is highly likely to be from disinfectant use in food processing facilities.

Dietary exposure estimates

Estimated daily dietary exposures to the QACs for each of the population cohorts in the 2016 NZTDS are detailed in Appendix 10. Each exposure is given in µg/kg bw/day and as a percentage of the respective HBGVs.

The widespread prevalence of BAC across the foods sampled in the 2016 NZTDS results in one of the larger estimated dietary exposures of the agricultural chemicals detected. This ranged from 0.15 µg/kg bw/day in the diet of adult females to 0.50 µg/kg bw/day in the diet of toddlers. The estimated exposure to BAC in each of the population cohort diets results from similar contributions by all of the food types. Only in the toddler diet did one food type stand out, with an estimated contribution of 29% of total BAC exposure resulting from milk (3.25% fat).

Exposures to DDAC were an order of magnitude lower than for BAC. The highest estimated dietary exposure was 0.038 µg/kg bw/day for 5–6-year-old children. Major contributors to the dietary exposure to DDAC in children were chicken (31%), tofu (17%) and fresh fish (15%). The infant and toddler diets presented the lowest exposure estimates to DDAC amongst the population cohorts (0.017–0.021 µg/kg bw/day).

Because BAC and DDAC have not been previously analysed in the NZTDS, it was not possible to derive any trends in exposure.

Risk characterisation

The estimated dietary exposures to BAC and DDAC in the 2016 NZTDS have been calculated as a percentage of the HBGV in Appendix 10.

Exposures for BAC ranged between 0.2–0.5% of the HBGV for the different population cohorts and between 0.02–0.04% of the HBGV for DDAC. Notwithstanding the widespread prevalence of both compounds across the food supply, the risk characterisation indicates that they present a low dietary risk.

QACs have not been measured in the overseas TDSs. However, monitoring data for BAC across the European food supply has been assessed for dietary exposure by the German Federal Institute for Risk Assessment (BFR, 2012). Exposures in the German population ranged between 6% of the HBGV for adults (14–80 years of age) and 10% of the HBGV for toddlers/children (2–4 years of age). More broadly, for the European population, exposures of up to 7% of the HBGV were estimated for the Swedish general population and up to 15% of the HBGV for United Kingdom infants. The HBGV selected to characterise the risk was the same used in the 2016 NZTDS.

Sprout and scald inhibitors

The final minor grouping of agricultural chemicals analysed for in the 2016 NZTDS is the two sprout inhibitors, chlorpropham and propham, and the scald inhibitor diphenylamine. Sprout inhibitors are used to prevent potatoes forming sprouts when they are stored. While scald inhibitors are used to prevent apples and pears suffering surface browning and injury, termed scald, during storage. Both types of inhibitors are applied to the crops after they have been harvested.

Propham and diphenylamine were added to the NZTDS agricultural chemical screening in the 1987/88 NZTDS, chlorpropham was included in the 2003/04 NZTDS.

Hazard identification

The scald inhibitor diphenylamine is classified as being of low acute toxicity (US EPA, 1998). Similarly, the sprout inhibitors chlorpropham and propham are both classified as unlikely to present an acute hazard (WHO, 2010). A case of human poisoning from industrial diphenylamine has been recorded, which identified symptoms on the bladder, high blood pressure and eczema (NIOSH, 2011). Longer term dosing studies in animals identified that chlorpropham can cause effects on the thyroid (JMPR, 2005). Chronic exposure to diphenylamine can lead to anaemia through damage to blood cells (JMPR, 1999).

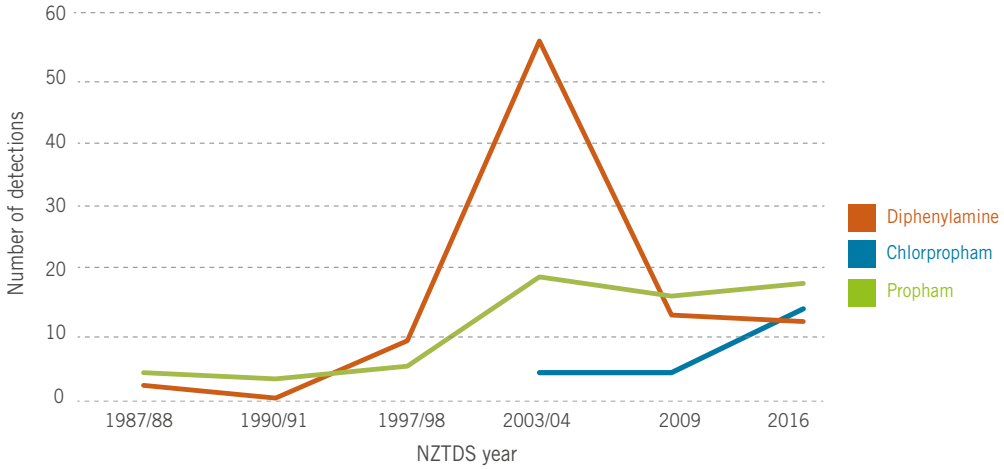
Hazard characterisation

Suitable HBGVs were available for chlorpropham (50 µg/kg bw/day) and diphenylamine (80 µg/kg bw/day; Appendix 9). However, no established HBGV from which to characterise risk was available for propham. As an alternative, it was possible to calculate the MOE from the key toxicological endpoint for a potential health concern. For propham, the selected toxicological endpoint was a No Observable Adverse Effect Level of 5700 µg/kg bw/day, derived from an intake level below that in which haematological effects were seen in male rats in a two year feeding study (JMPR, 1993). The MOE can be calculated by dividing the toxicological endpoint by the level of dietary exposure. This MOE value can characterise how many orders of magnitude the intake differs from the level reported to lead to adverse health impacts. For propham, which is a non-genotoxic chemical, a difference of at least two orders of magnitude (100x) is considered to represent a negligible dietary risk.

Prevalence and concentrations

The concentrations of sprout and scald inhibitors in individual foods of the 2016 NZTDS have been previously presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in appendices 7 and 8, with minimum, maximum and arithmetic mean concentrations calculated for these agricultural chemicals in each food type.

Figure 25: Trends in the number of detections in the NZTDS (1987/88–2016) for the sprout and scald inhibitors



From the 1056 food samples analysed in the 2016 NZTDS, propham was detected in 18 samples, chlorpropham in 14 samples and diphenylamine in 12 samples. The prevalence of propham and diphenylamine residues in the 2016 NZTDS was similar to the prevalence in the 2009 NZTDS. However, the number of detections of chlorpropham increased, compared with the 2009 NZTDS (Figure 25). In the 2003/04 NZTDS, the detections of diphenylamine were widespread across sampled foods, with 56 detections being reported. Interpreting trends back to the 1987/88 NZTDS and 1990/91 NZTDS, for propham and diphenylamine, is difficult because the analytical methodology has increased in sensitivity with time. In the 1997/98 NZTDS, the detection sensitivity for propham and diphenylamine improved by 45 times and 30 times, respectively.

For chlorpropham, residues were only detected in potatoes or foods with a potato ingredient. This included all 8 of the potato hot chip samples and 3 out of the 8 samples of fish cakes. There was also a single detection of chlorpropham in a meat pie sample, likely from the potato in potato-topped pies included within this composite sample. Propham was also commonly detected in potatoes, peeled potatoes (4 out of 8 samples) and those with skin (5 samples), as well as potato crisps (4 samples). In addition, propham was detected in two samples each of apples and pears. Because propham has no direct use in fruit, it is likely that these residues result from cross contamination of the fruit from storage containers previously used to store potatoes. A similar finding of propham in fruit was reported in the 2009 NZTDS.

Two samples of potato crisps and one of potato hot chips had detections for both sprout inhibitor chemicals. This is most likely a reflection of the inclusion of different batches of potatoes in further potato processing and/or the different crisp and hot chip batches comprising the NZTDS composite samples.

Diphenylamine was detected in 5 out of 8 of the pear samples, as well as a single apple sample. Diphenylamine was also detected in 3 of the cereal grain-based and 2 of the custard/fruit-based infant weaning foods. The residues in these infant foods could be from the presence of apple and/or pears as an ingredient; or alternatively diphenylamine is known to migrate into food from other sources in the environment and from food contact materials. For example, in the 2003/04 NZTDS, diphenylamine was detected in a wide variety of foods, including chocolate biscuits, wheatmeal bread, caffeinated beverages, ice-cream and peanut butter. These foods are unlikely to have an apple or pear ingredient, or need a diphenylamine treatment, supporting that there are other sources of food residues.

Dietary exposure estimates

Estimated daily dietary exposures to the sprout and scald inhibitors for each of the population cohorts in the 2016 NZTDS are detailed in Appendix 10. Each exposure is given in µg/kg bw/day and as a percentage of the respective HBGVs.

Propham had the largest calculated dietary exposures for any of the agricultural chemicals detected in the 2016 NZTDS. The exposures to propham ranged from 0.23 µg/kg bw/day in adult females of Pacific Island ethnicity up to 1.25 µg/kg bw/day for toddlers. Greater than 90% of the exposure in all of the population cohorts resulted from consumption of peeled potatoes and potatoes with skin. In contrast, apples and pears contributed less than 5% of the exposure. Chlorpropham exposure was estimated to be less than that of propham. The highest estimated exposure for chlorpropham was 0.30 µg/kg bw/day for toddlers. Consumption of potato hot chips resulted in 88–96% of the estimated exposure across the population cohorts to chlorpropham.

Diphenylamine exposures were the lowest of the three compounds and ranged over an order of magnitude (0.012 µg/kg bw/day for adult males of Pacific Island ethnicity up to 0.127 µg/kg bw/day infants). For infants, the weaning foods contributed almost two-thirds (63%) of the dietary exposure, compared with a third (37%) from the fresh apples and pears. For the adult population cohorts, where apples and pears were the only dietary contributors, the exposure was predominantly from pears (>80%).

The historical trends of dietary exposure in the NZTDS for young adult males and toddlers to the sprout and scald

Table 14: Dietary exposure trends for sprout and scald inhibitors in the NZTDS (1987/88–2016) for young adult males (19–24 years) and toddlers (1–3 years)

	Estimated daily dietary exposure (µg/kg bw/day)					
Compound	**1987/88**	**1990/91**	**1997/98**	**2003/04**	**2009**	**2016**
Young adult males						
Chlorpropham	Not analysed	Not analysed	Not analysed	0.02	0.07	0.16
Diphenylamine	0.49	Not detected	0.07	0.11	0.02	0.02
Propham	1.60	1.16	0.62	0.26	0.14	0.53
Toddlers						
Chlorpropham	Not analysed	Not analysed	Not analysed	0.03	0.10	0.30
Diphenylamine	1.79	Not detected	0.12	0.30	0.07	0.09
Propham	1.79	0.84	0.69	0.36	0.21	1.25

inhibitors are presented in Table 14. The population dietary exposures for diphenylamine are consistent with the estimates from the 2009 NZTDS. Chlorpropham exposures have continued to increase for the different population cohorts since first being analysed in 2003/04. For propham, the 2016 NZTDS exposure departed from the decreasing trend of exposure reported up to the 2009 NZTDS.

The increase in dietary exposure estimates for propham appears to be due to increased residue concentrations, rather than changes in the consumption of potatoes. For example, the mean propham residues in potatoes with skin were 0.22 mg/kg in 2003/04, 0.09 mg/kg in 2009 and 0.56 mg/kg in 2016. Similarly, for the peeled potatoes, mean residues were 0.13 mg/kg in 2003/04, 0.10 mg/kg in 2009 and 0.35 mg/kg in 2016. All but a single detection for propham in peeled potatoes and potatoes with skin were from samples collected in the winter sampling quarter (July/August 2016). Therefore, the increased residues may be due to greater sampling of stored potatoes. Reasons for this could include an unfavourable growing season, leading to the need to use more potatoes from storage to fulfil retail shelf demand. Alternatively, different potato varieties may have been sampled, with more storage-suitable ones selected in 2016.

Risk characterisation

The estimated dietary exposures to chlorpropham and diphenylamine in the 2016 NZTDS have been summarised as a percentage of the respective HBGVs in Appendix 10.

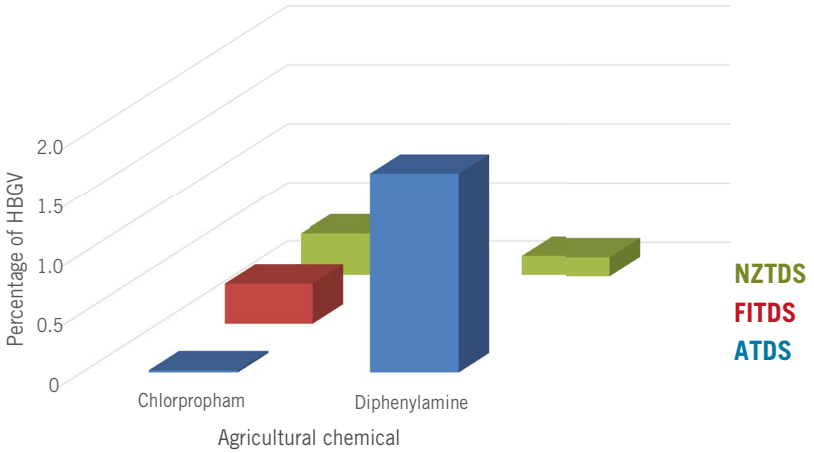
Propham is the only agricultural chemical detected in the 2016 NZTDS that does not have an established HBGV. An alternative method, involving calculation of an MOE, has been used, as described in the hazard characterisation section above. The MOE value for each population cohort is reported in Appendix 9.

The calculated exposures for chlorpropham ranged between 0.14% and 0.60% of the HBGV, and those for diphenylamine between 0.02% and 0.16%.

The estimated MOEs for propham ranged considerably for the different population cohorts (MOE of 4500 in toddlers to 25,000 for adult females of Pacific Island ethnicity). The calculated MOEs indicate it is unlikely there is a health concern due to exposure to propham.

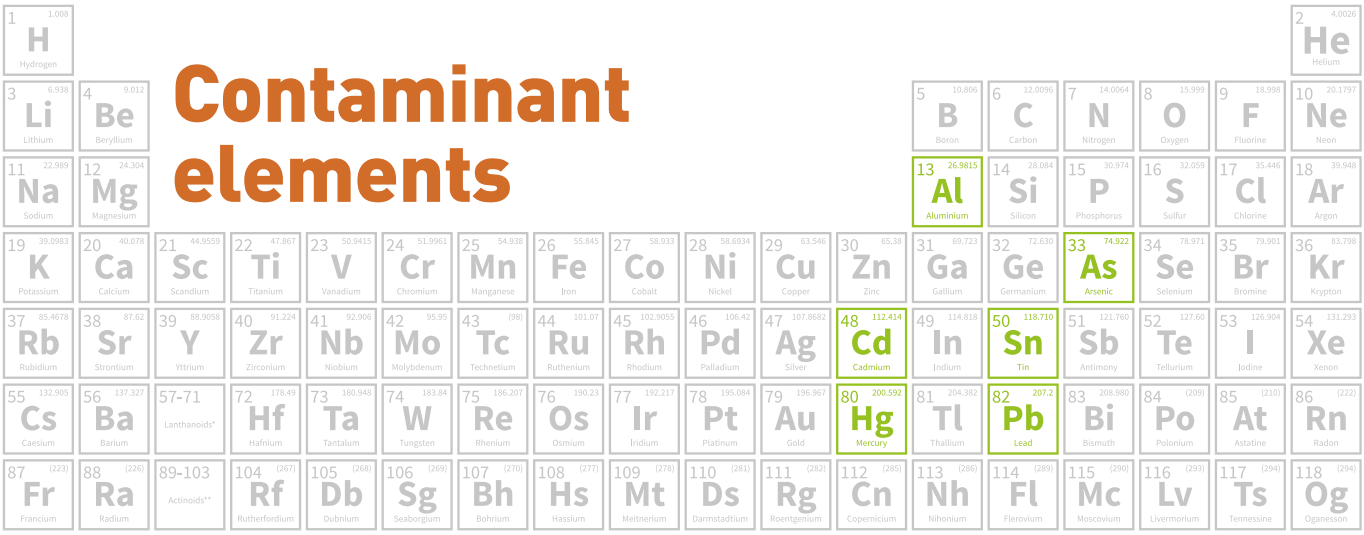
Dietary exposures for chlorpropham and diphenylamine are comparable to those reported in the ATDS and FTDS. In the ATDS, the adult exposure to chlorpropham was 0.10% of the HBGV (2016 NZTDS adult range: 0.13–0.32%; FSANZ, 2011). The lower-bound mean exposure for adults in the FTDS for diphenylamine was reported as 0.1% of the HBGV used in that study (75 µg/kg bw/day; ANSES, 2011), all of the NZTDS adult cohorts had a mean exposure equivalent to 0.02% of the HBGV. The calculated exposure values for infants in the ATDS and FITDS to both of these compounds were similar to those in the 2016 NZTDS (Figure 26).

Figure 26: Comparative dietary exposures for infants (6–12 months) to chlorpropham and diphenylamine, as a percentage of the health based guidance value



ATDS: Australian Total Diet Study (FSANZ, 2011); FITDS: French Infant Total Diet Study (ANSES, 2016).

Contaminant elements



Introduction

Contaminant elements occur naturally in the environment, either ubiquitously distributed in soils, sediments and water or transported from geological deposits by natural processes, such as volcanic eruptions. Human activities also lead to concentration and distribution of contaminant elements into the environment and, subsequently, the food chain. Finally, some elements have properties, such as durability and low densities, that make them suitable for use in food containers or utensils, from which some migration into the diet can occur.

In the 2016 NZTDS, six contaminant elements were prioritised for investigation. These were aluminium, arsenic, cadmium, lead, mercury and tin. Arsenic, cadmium, lead and mercury have been included in every NZTDS since the programme began in 1974/74. Tin was included in the NZTDS up until the 1997/98 NZTDS, but has not been analysed for in the previous two NZTDSs (2003/04 and 2009).

Arsenic, cadmium, lead and mercury are all considered priority contaminants globally. Ensuring that exposure levels for these four contaminant elements are not increasing in the New Zealand diet is a key role of the NZTDS.

Arsenic and mercury can each be present in different chemical forms with differing toxicities. Inorganic arsenic, which is the most toxic form of arsenic, was tested for in foods containing greater than 0.02 mg/kg of total arsenic. Because the risk characterisation for arsenic is specific to inorganic arsenic, obtaining inorganic arsenic exposures allows refinement of the exposure estimates and foods contributing to exposure. Continuing from its initial testing in the 2009 NZTDS, methylmercury, the form of mercury associated with seafood, was also included in the 2016 NZTDS. Methylmercury represents a specific health concern to the developing foetus, through exposure of the mother. The HBGV for mercury is expressed in terms of methylmercury, and the addition of methylmercury allows the exposure estimates to be directly compared to the HBGV.

In addition to the four contaminant elements previously analysed for in the NZTDS, aluminium has been included in the NZTDS for the first time. Aluminium has been raised as a food contaminant of potential concern for dietary exposure, based on results from overseas TDSs (ANSES, 2011; FSANZ, 2014). Aluminium has therefore been added to the NZTDS to allow assessment of current dietary exposures and begin to establish dietary trends. Finally, the contaminant element tin, which was last included in the 1997/98 NZTDS, has been reintroduced in the analysis of the sampled foods. Obtaining current tin concentration values allows long-term trends in foods to be tracked, in particular, any trends of increases in migration into canned foods from tin-plate cans.

Interpreting the contaminant element results

Concentration data

All of the reported contaminant results in the 2016 NZTDS have been released as part of the quarterly reporting (Pearson, 2016, 2016a, 2016b, 2017). In addition, Appendix 11 provides a summary table for each of the contaminant elements, sorted alphabetically by the food type analysed in the NZTDS.

Comparison of 2016 NZTDS concentration and exposure results with previous NZTDS years

The analysis of trends in contaminant element concentrations in certain foods and exposures for each population cohort against previous NZTDSs provides a valuable insight into the behaviour of the contaminant in the food supply. Analysis of the trends can identify food and foods types of current or developing concern for exposure, or confirm if mitigation methods in certain foods are taking effect. Except for aluminium, which is analysed for the first time, trends across the NZTDS years have been presented.

In interpreting any trends, it is important to note that some minor methodological differences are evident between different NZTDS years. These may include differences in LOR, with a general trend for these to improve in the more recent studies. In addition, some food types may have changed over the course of the study, for example, the battered fish

samples in the 2016 NZTDS were previously sampled as fish and chips in the 1990/91 NZTDS. Where these changes have an implication for interpreting the trends in concentrations or exposures these have been noted.

Comparison of 2016 NZTDS results with overseas data

The contaminant dietary exposures estimated in the 2016 NZTDS have been compared with estimates from a number of overseas TDSs. In all cases, dietary exposure estimates have been expressed in the same unit as the New Zealand dietary exposure estimates, for comparison purposes. The studies and methods used for comparison are:

- *The 23rd Australian Total Diet Study* (ATDS; FSANZ, 2011, 2016): In the ATDS, the range of lower-bound to upper-bound mean exposure estimates is reported in mg/day. For all adults (17 years and above; 74 kg), children (2–5 years; 18 kg) and infants (9 months; 8.9 kg) the reported exposures were divided by mean cohort body weights to obtain dietary exposure estimates expressed in µg/kg bw/day (arsenic, cadmium, lead and mercury) or mg/kg bw/day (aluminium). The resulting value was converted to a weekly (7 days) or monthly (30.42 days) value, depending on the contaminant. Comparisons were made to the 2016 NZTDS dietary exposures for infants (6–12 months), children (5–6 years), and for adult females and males (25 years and above).
- *The 24th Australian Total Diet Study* (ATDS; FSANZ, 2016): Specific analysis for aluminium was undertaken in the 24th ATDS to examine high contributing foods in more detail. The aluminium dietary exposure was adjusted as per the calculation for the 23rd ATDS and is also used for comparison to the 2016 NZTDS dietary exposures for children (5–6 years) and the range for all adults (25 years and above).
- *The French Infant Total Diet Study* (FITDS; ANSES, 2016a): In the FITDS, the range of lower-bound to upper-bound mean dietary exposure estimates for contaminants is reported in µg/kg bw/day for infants (7–12 months). These values have been converted to a weekly (7 days) or monthly (30.42 days) value, depending on the contaminant. Comparisons were made to the 2016 NZTDS dietary exposures for Infants (6–12 months).
- *The 2nd French Total Diet Study* (FTDS; ANSES, 2011a): In the FTDS, mid-bound mean dietary exposure estimates for contaminants are reported in µg/kg bw/day for children (3–6 years), women of childbearing age (18–45 years) and all adults (18–79 years). These values have been converted to a weekly (7 days) or monthly (30.42 days) value, depending on the contaminant. Comparisons were made to the 2016 NZTDS dietary exposures for children (5–6 years) and for adult females and males (25 years and above).
- *The 1st Hong Kong Total Diet Study* (HKTDS; CFS, 2012, 2013): In the HKTDS, mid-bound mean dietary exposure estimates for contaminants are reported in µg/kg bw/week or month (arsenic, cadmium, lead and mercury) or mg/kg bw/week (aluminium) for adult females (20–84 years) and adult males (20–84 years). In addition, the range of lower-bound to upper-bound mean exposure estimates for tin is reported in mg/kg bw/week for adult females (20–84 years) and adult males (20–84 years). Comparisons were made to the 2016 NZTDS dietary exposures for adult females and males (25 years and above).
- *The 2012–2014 Irish Total Diet Study* (ITDS; FSAI, 2016): In the ITDS, the range of lower-bound to upper-bound mean exposure estimates are reported in µg/kg bw/day or week (arsenic, cadmium, lead and mercury) or mg/kg bw/week (aluminium and tin) for all adults (18 years and above) and children (5–12 years). Cadmium values were converted to a monthly (30.42 days) intake and arsenic and lead to weekly (7 days) intakes. Comparisons were made to the 2016 NZTDS dietary exposures for children (5–6 years), and adult females and males (25 years and above).

Aluminium

Aluminium is a very common light metallic element and the third most common element in the earth's crust. Aluminium is also the most common mineral in soils, although the majority of it is present in unreactive and insoluble forms.

A cheap refining process for aluminium ore (bauxite) was developed in 1886, called the Hall-Héroult process. Following this development, aluminium metal has been available for use in a range of applications where a lightweight, corrosion resistant and strong material is needed. Aluminium metal is frequently used in food contact materials such as containers, cooking equipment and foils. The salts of aluminium also see a number of food supply uses: aluminium phosphide and fosetyl-aluminium are used as agricultural chemicals, and aluminium hydroxide is used in water purification. Aluminium-based food additives are also approved for use in certain foods in New Zealand.

Hazard identification

Aluminium in its metallic form, with an inert surface coating of aluminium oxide, presents a minimal health hazard (Krewski et al., 2007). Because of the widespread use of aluminium in society, most individuals come in contact with it daily without any adverse health impacts.

Specific forms of aluminium, for example, the fumigant aluminium phosphide, can present a significant hazard. However, the hazard results from the highly toxic phosphine gas formed in the decomposition of aluminium phosphide and not the aluminium directly.

Aluminium is also likely to be a natural component of the diet, although it is not known to fulfil any beneficial or nutritional role. The form of the aluminium present can make a big difference to its health impacts. Most forms of consumed aluminium readily bind to phosphorus in ingested food to form an insoluble salt (Drüeke, 2002; Liamis et al., 2010).

Consequently, most of the aluminium we ingest does not get absorbed. In contrast, very soluble salts of aluminium, like aluminium citrate, are readily taken in by the body. The small proportion of aluminium (usually less than 0.5%) that is absorbed can present a hazard in excess (WHO, 2007). This hazard is greater in people with reduced kidney function, in which case the body is not able to rapidly excrete the aluminium (Drüeke, 2002).

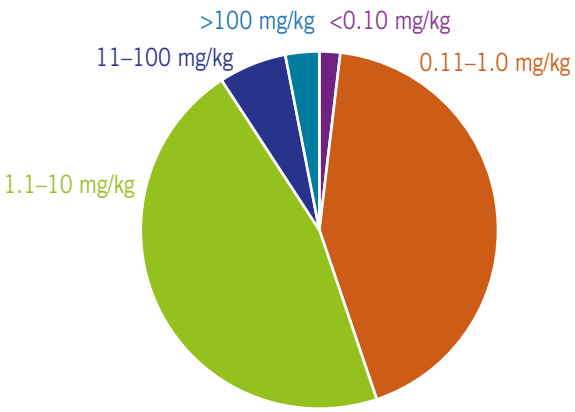
Elevated levels of absorbed aluminium cause damage and obstruction to the kidneys (WHO, 2011). Animal studies also observed impacts on the developing brain when animals were exposed in the womb and during lactation (WHO, 2011). Long-term exposure to high levels of aluminium in the diet could lead to phosphorus deficiency. A historical example of acute aluminium poisoning was reported in the condition dialysis encephalopathy syndrome. This condition, a form of dementia, occurred in kidney dialysis patients prior to the 1980s, caused by high aluminium concentrations in the dialysis fluid (Rob et al., 2001).

An association between aluminium in drinking water and Alzheimer's disease has been hypothesised (Flaten, 2001). However, no mechanism of action for aluminium in causing Alzheimer's disease has been established (Gupta et al., 2005). The WHO has recorded strong reservations regarding the validity of a causal relationship between aluminium in drinking water and Alzheimer's disease (WHO, 1997).

Hazard characterisation

A suitable HBGV was available to characterise the risk from dietary exposure to aluminium. The selected HBGV was the provisional tolerable weekly intake of 2 mg/kg bw/week established by the JJECFA in 2011 (WHO, 2011a). The provisional tolerable weekly intake was derived from the no observed adverse effect level for renal damage in rats following long-term dosing with aluminium citrate in drinking water. The provisional tolerable weekly intake has been established for hazard characterisation of both natural and added sources of aluminium in the diet.

Figure 27: Ranges of aluminium concentrations in sampled foods of the 2016 NZTDS



Prevalence and concentrations

The concentrations of aluminium in individual foods of the 2016 NZTDS have been presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in Appendix 11, with minimum, maximum and arithmetic mean concentrations calculated for aluminium in each food type.

Detected concentrations of aluminium were reported in 56% (587 out of 1056) of the composite food samples tested in the 2016 NZTDS. Aluminium was present in most of the 132 food types tested, with only 28 food types having no detected concentrations. Foods with no aluminium present included apples, beer, chicken, milk (0.5% and 3.25% fat), oil, pork roast and white rice.

For the foods containing detected levels of aluminium, the average concentration was 17.2 mg/kg. However, this average was skewed by the presence of a small number of food samples with high aluminium concentrations. Only 9% of the sampled foods had aluminium levels above 10 mg/kg (Figure 27). For foods with aluminium present at concentrations below 10 mg/kg, the source is likely natural or inadvertent contamination, such as transfer from aluminium utensils and vessels in manufacturing and cooking.

The mean aluminium content of mussels (58.1 mg/kg) and oysters (31.5 mg/kg), while elevated over many foods, was also likely to be of natural origin and reflects the known ability of filter-feeding molluscs to accumulate environmental contaminants. All the samples of cakes and slices and muffins and scones had aluminium concentrations far greater than the other sampled foods. The flour used to bake these foods would likely contain an aluminium based raising agent. As a result, aluminium levels are significantly elevated over those naturally present in a grain-based food. Other foods containing flour as an ingredient, such as the batter in battered fish and the bases of pizzas, also had appreciable concentrations of aluminium.

Variability between the aluminium concentrations across the eight samples taken of each food in the 2016 NZTDS was considerable. For example, flavoured snacks ranged in aluminium concentration between <1 and 29.5 mg/kg, while silverbeet ranged between 1.3 and 26.5 mg/kg.

Aluminium has not previously been analysed for in the NZTDS, and no trend analysis is possible. However, many of the aluminium concentrations reported are comparable to those reported overseas. Aluminium was analysed broadly across the food supply in the 23rd ATDS and in targeted foods in the

24th ATDS (FSANZ, 2011, 2014). The 23rd ATDS reported the majority of foods to have <10 mg/kg aluminium and, similarly to the 2016 NZTDS, many samples contained <1 mg/kg aluminium. Higher aluminium in the 23rd ATDS concentrations were reported for beef sausage (10 samples, mean: 15.6 mg/kg), fancy bread (8 samples, mean: 41.2 mg/kg), takeaway battered fish (10 samples, mean: 18.9 mg/kg) and frozen fish portions (4 samples, mean: 24.9 mg/kg; FSANZ, 2011). The 24th ATDS focused on foods associated with use of aluminium-containing additives, with concentrations of up to 610 mg/kg in sponge cake. Results consistent with those in the 2016 NZTDS were also seen in other flour-based foods, such as pancake mixture and crumpets.

The FTDS reported analysis of aluminium in a range of foods (ANSES, 2011). The highest mean aluminium levels were reported in shellfish and crustaceans (21.1 mg/kg) and chocolate (15.6 mg/kg), with all other foods reporting less than 6 mg/kg. It was reported that aluminium levels had increased in many foods over that of the previous FTDS. It was hypothesised that a move to aluminium-based cookware and utensils in the food preparation methods of the study was the source of the increase.

The HKTDS also analysed for aluminium in 600 composite food samples (CFS, 2013). Elevated aluminium concentrations reported in steamed buns (mean: 170 mg/kg) and deep-fried dough (mean: 250 mg/kg) were associated with aluminium additive use. Whereas, the concentrations in oysters (mean: 62 mg/kg) were believed to be from natural processes.

Dietary exposure estimates

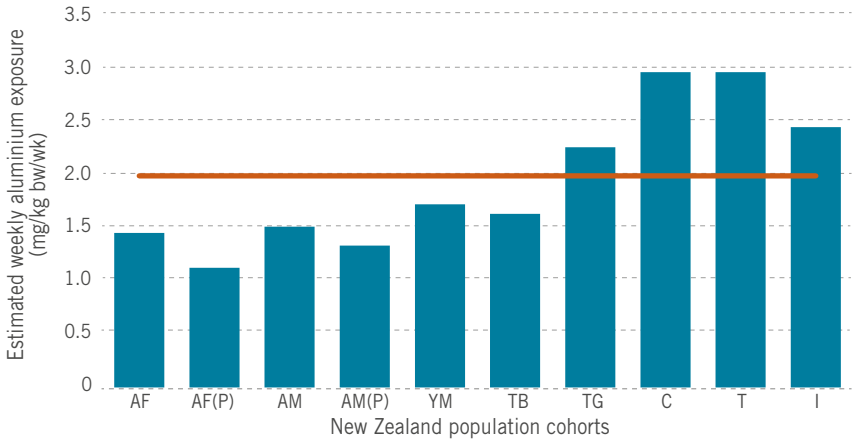
Dietary exposure estimates for aluminium exposure at lower-bound, mid-bound and upper-bound means for all the population cohorts have been summarised in Appendix 12. Exposures are expressed in mg/kg bw/week, and as a percentage of the provisional tolerable weekly intake (PTWI). Mid-bound mean estimates of weekly aluminium exposures from the 2016 NZTDS are also presented in Figure 28.

Aluminium dietary exposures were greatest in the child and toddler population cohorts (mid-bound mean for both cohorts: 3 mg/kg bw/week). Dietary exposures for the infant and adolescent population cohorts were also elevated, compared with the adult cohort dietary exposures, with the exception of the teenage boy cohort. The Pacific Island ethnicity adult cohorts had the lowest estimates of dietary exposure.

There was little difference between lower-bound and upper-bound estimates of mean dietary exposure in most of the population cohorts (less than 5% variation), indicating the low impact from samples in which aluminium was not detected. The sole exception was the estimate for infant exposure where a larger variation (16%) between the lower-bound and upper-bound exposures resulted from the absence of measurable aluminium in infant formula.

The key contributing foods for aluminium dietary exposure for children and toddlers were muffins and scones (72% for children, 64% toddlers), and cakes and slices (10% for children, 18% toddlers; Figure 29). The highest individual contributors to dietary exposure, by foods without a suspected additive presence, were 1–2% for chocolate beverages and peeled potatoes.

Figure 28: Estimated weekly aluminium exposures (mid-bound mean) in the 2016 NZTDS, characterised against the health based guidance value[a]



AF: Adult Female (25 years and over); AF(P): Adult Female – Pacific Island ethnicity (15 years and over); AM: Adult Male (25 years and over); AM(P): Adult Male – Pacific Island ethnicity (15 years and over); YM: Young Adult Male (19–24 years); TB: Teenage Boy (11–14 years); TG: Teenage Girl (11–14 years); C: Child (5–6 years); T: Toddler (1–3 years); I: Infant (6–12 months).
[a] JECFA provisional tolerable weekly intake of 2 mg/kg bw/week (WHO, 2011a).

For adults, the same bakery goods were also major contributors to dietary exposure (34% from each food for adult males). However, other foods were also notable sources of dietary exposure, including tea (3–21%) and to a much lesser extent chicken takeaways (1–2%).

Very similar patterns of exposure were reported in the 24th ATDS Phase 1 report (FSANZ, 2014): with between 32% and 48% of exposure resulting from cakes and biscuits, and in the adult population cohort, 27% resulting from tea intake.

Because aluminium has not previously been analysed in the NZTDS, it is not possible to present trends of dietary exposure.

Risk characterisation

The estimated weekly dietary exposures to aluminium for all of the New Zealand population cohorts have been characterised against the HBGV in Appendix 12. Figure 28 compares the levels of aluminium estimated to be consumed over a week against the HBGV. The infant, toddler, child and teenage girl cohorts are estimated to have dietary exposure to aluminium in excess of the HBGV (113–149%). For the adult and teenage boy population cohorts the estimated exposures are all within the HBGV. The estimated weekly exposures in the NZTDS are also notably greater than those reported in overseas TDS reports (Table 15).

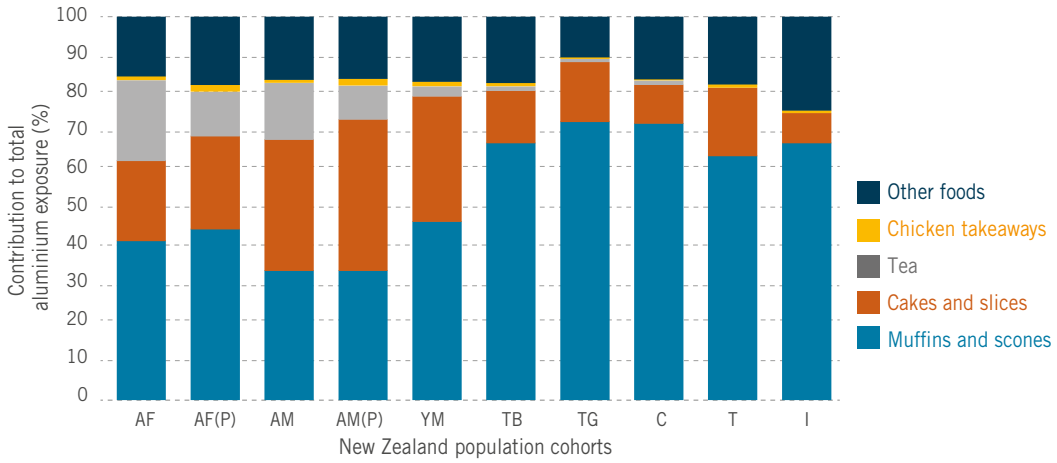
The elevated dietary exposure in the NZTDS results predominantly from the high concentrations of aluminium reported in muffins and scones. The mean concentration of 704 mg/kg in this food type was above that of comparable foods in the overseas studies, such as the 395 mg/kg in sponge cake in the 24th ATDS, or the 5 mg/kg in pastries and cakes of the FTDS (ANSES, 2011a; FSANZ, 2014).

Table 15: Comparative dietary exposures to aluminium for adult females and males (25 years and above), and children (5–6 years)

	Estimated weekly mean exposure (mg/kg bw/week) (lower-bound–[mid-bound]–upper-bound)				
Population cohort	**NZTDS**	**ATDS[a]**	**FTDS[b]**	**HKTDS[c]**	**ITDS[d]**
Adult females	1.4–[1.5]–1.5	0.3/0.4[e]	[0.3]	[0.6]	0.4[b]
Adult males	1.5[f]		[0.4]	[0.6]	
Children	2.9–[3.0]–3.0	0.5[f]/0.8–0.9[e]	[0.6]	Not determined	0.4[b]

[a] ATDS: Australian Total Diet Study (FSANZ, 2011; FSANZ, 2014).
[b] FTDS: French Total Diet Study (ANSES, 2011a).
[c] HKTDS: Hong Kong Total Diet Study (CFS, 2013).
[d] ITDS: Irish Total Diet Study (FSAI, 2016).
[e] 23rd ATDS/24th ATDS.
[f] Lower-bound and upper-bound mean values derive the same rounded concentration.

Figure 29: Major aluminium (mid-bound mean) contributing food groups in the 2016 NZTDS



AF: Adult Female (25 years and over); AF(P): Adult Female – Pacific Island ethnicity (15 years and over); AM: Adult Male (25 years and over); AM(P): Adult Male – Pacific Island ethnicity (15 years and over); YM: Young Adult Male (19–24 years); TB: Teenage Boy (11–14 years); TG: Teenage Girl (11–14 years); C: Child (5–6 years); T: Toddler (1–3 years); I: Infant (6–12 months).

Arsenic

Arsenic is a metalloid that is naturally distributed throughout the environment. It occurs in many mineral forms in rocks and soils and is also released into the atmosphere through volcanic emissions (WHO, 2011). Arsenic concentrations in New Zealand soils tend to be in the range 1–10 mg/kg (Cavanagh et al., 2015), however, some contaminated sites can have levels considerably higher. For example, prior to remediation, the processing of arsenic rich rock for gold extraction resulted in soils on the Prohibition mine site on the West Coast of the South Island in New Zealand with up to 40% (400 g/kg) arsenic (Haffert & Craw, 2009).

In the 19th century, arsenic was widely used as a medicine, a rat poison and in pigments for fabrics and wallpaper (Hughes et al., 2011). Arsenic was also used as an insecticide and herbicide in agriculture and applied directly to soils and crops, although the majority of uses of arsenic were subsequently phased out because of its hazard to health. With the discontinuation of agricultural and household uses of arsenic, natural levels and sites with historical contamination are expected to be the predominant source of current arsenic occurrence in the food supply. Arsenic enters the food chain through accumulation in marine species and through uptake from soils or arsenic-contaminated groundwater into plants. Arsenic has been a core analyte in the NZTDS since the first study in 1974/75.

Hazard identification

Arsenic is infamous for its toxicity, being a highly potent acute toxin and utilised throughout history as a poison for homicide (Hughes et al., 2011). Arsenic can occur in a range of forms (termed chemical species), depending on the nature of the chemicals it binds with and the oxidation state of the atoms (Apostoli et al., 2006). The inorganic species of arsenic are considerably more toxic than organic forms. Short-term exposure to large doses of inorganic arsenic can lead to gastrointestinal symptoms, impacts on the cardiovascular and nervous systems, and finally death, if untreated (Bendetti, 1999). Longer-term exposure to inorganic arsenic, particularly through high levels in drinking water, causes tumours of the skin, bladder, kidney and lungs (WHO, 2011).

Contrasting with the high toxicity of inorganic species of arsenic, organic arsenic species are of relatively low toxicity. Some organic arsenic species, such as arsenobetaine, are considered largely non-toxic because they are rapidly excreted from the body after ingestion (WHO, 2011).

There is evidence that, in some mammal species, trace levels of arsenic may be essential for nutrition (Uthus, 2003). For example, in rats, an arsenic-free diet resulted in stunted growth. It is unknown if arsenic is essential in humans.

Hazard characterisation

Historically, the hazard that dietary arsenic presents has been characterised initially through an HBGV for daily exposure (50 µg/kg bw/day for total arsenic; WHO, 1967), which was withdrawn in 1983. A provisional tolerable weekly intake was then established in 1989 for inorganic arsenic species only (15 µg/kg bw/week; WHO, 1989), however, this value was also withdrawn in 2010 due to concerns that the level presented an elevated risk of lung cancer. Consequently, no HBGV for arsenic in organic or inorganic forms was available to allow the risk of arsenic exposure to be characterised in the 2016 NZTDS.

For the purposes of the NZTDS, the risk of inorganic arsenic dietary exposure can be characterised through the use of a margin or exposure approach, comparing dietary exposure to a benchmark dose level. A benchmark dose is derived from fitting a dose-response curve from toxicological or epidemiological studies to calculate a dose level at which there is a specific elevation in the risk of incidence for a toxicological end-point. In the case of inorganic arsenic, a benchmark dose level has been set at 3.0 µg/kg bw/day for a 0.5% increase in the incidence of lung cancer ($BMDL_{0.5}$), equivalent to a dietary exposure of 21 µg/kg bw/week (WHO, 2011).

No HBGV or benchmark dose is available to characterise risk associated with dietary exposure to the organic forms of arsenic. However, for the purposes of the 2016 NZTDS, where organic arsenic species were found predominantly in seafood, it was judged that arsenobetaine was the most probable species present. Because arsenobetaine has been assessed to be largely non-toxic, no dietary risk assessment was necessary (WHO, 2011).

Prevalence and concentrations

The concentrations of total arsenic and inorganic arsenic in individual foods of the 2016 NZTDS have been presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in Appendix 11, with minimum, maximum and arithmetic mean concentrations calculated for total arsenic and inorganic arsenic in each food type.

Detected concentrations of total arsenic were present in 36% (380 out of 1056) of the sampled foods in the 2016 NZTDS. Most of the foods with detected total arsenic contained concentrations below 0.01 mg/kg. All the analysed seafood had detected levels of total arsenic, with concentrations ranging between 0.1 and 10.1 mg/kg. Mushrooms, cereal-based foods (other breakfast cereal, biscuits and rice) and yeast extract contained total arsenic concentrations between 0.01 and 0.2 mg/kg.

Arsenic concentrations in the sampled foods of the 2016 NZTDS were generally consistent with results for previous NZTDS years (Table 16).

Foods with total arsenic concentrations greater than 0.02 mg/kg were further tested for the inorganic arsenic content. This included all the collected samples of seafood, white rice and rice dishes. Mushrooms were also tested for inorganic arsenic, as well as a proportion of some of the cereal grain-based foods and the yeast extracts. The inorganic arsenic

content of seafood was a minor proportion of the total arsenic (1–3%), consistent with the known speciation of arsenic in marine species as predominantly the organic form arsenobetaine (Table 17; WHO, 2011). However, for white rice and the yeast extract, the inorganic arsenic was the major component. The high proportion of inorganic arsenic in rice is consistent with findings in the scientific literature (Lynch et al., 2014). No inorganic arsenic was detected in the mushroom samples, indicating it represented less than a quarter of total arsenic. The speciation of arsenic in mushrooms differs depending on the species and the media they are cultured on, however, research on common button mushrooms *(Agaricus bisporus)* has identified that the organic form, arsenobetaine, is commonly the major species of arsenic present (Nearing et al., 2014).

Dietary exposure estimates

Dietary exposure estimates for total arsenic and inorganic arsenic exposure at lower-bound, mid-bound and upper-bound means for all the population cohorts have been summarised in Appendix 12. To enable comparison to previous NZTDS estimates, the dietary exposures are expressed in µg/kg bw/week.

For total arsenic, the highest exposure was estimated to be in the adult male of Pacific Island ethnicity population cohort (mid-bound mean exposure: 13.3 µg/kg bw/week). This dietary exposure estimate was largely due to seafood consumption. Fresh and battered fish, and mussels contributed 80% to the estimated dietary exposure to total arsenic in this population cohort.

Estimates of exposure to total arsenic were reasonably similar for all other population cohorts (10.3–13.0 µg/kg bw/week), with the exception being the estimate of dietary exposure for the teenage girl cohort, which was approximately half that of the other cohorts (5.9 µg/kg bw/week). This difference is due to much lower seafood consumption by this population cohort, although fresh and battered fish still contributed 80% of the estimated dietary exposure.

For inorganic arsenic, the highest exposure estimate was for infants (mid-bound mean exposure: 3.6 µg/kg bw/week). There was a wide range between the lower-bound and upper-bound exposure estimates (1.0–5.5 µg/kg bw/week), due to the number of foods in which inorganic arsenic was not detected. From the mid-bound mean estimate, infant formula contributed 48% of the dietary exposure for infants, although no inorganic arsenic was detected in this food. In adult population cohorts dietary exposure was made up of contributions from various food types, although white rice and fresh fish were notable contributors to dietary exposure (14% from white rice and 9% from fresh fish in adult males).

The estimated dietary exposures to inorganic arsenic were all markedly lower than equivalent dietary exposure estimates for total arsenic, ranging between 6% and 27% of the total arsenic exposure. This indicates that the majority of arsenic dietary exposure is due to lower toxicity organic arsenic species, predominantly consumed through seafood.

Table 16: Trends of total arsenic concentrations (mid-bound mean) in the NZTDS (1987/88–2016)

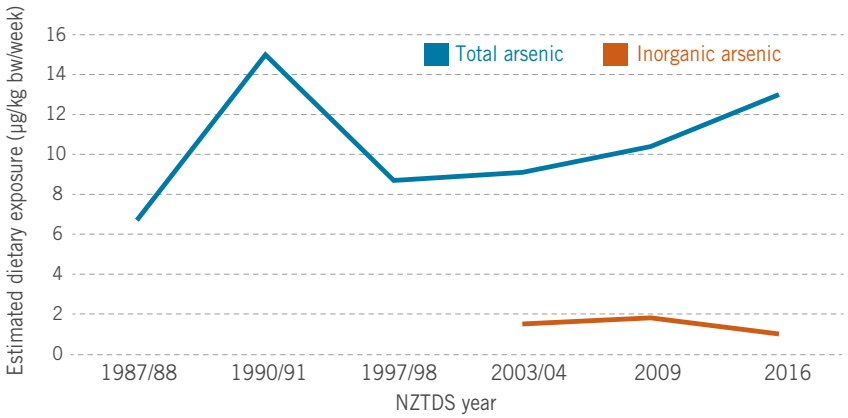
	Mid-bound mean total arsenic concentration (mg/kg)					
Food	**1987/88**	**1990/91**	**1997/98**	**2003/04**	**2009**	**2016**
Noodles	0.040	<0.007	0.004	0.003	0.002	0.002
Oysters	0.66	1.96	2.61	1.92	2.39	2.69
Pork	<0.020	0.350	0.040	0.005	0.004	0.002
White rice	<0.020	0.029	0.009	0.060	0.033	0.031

Table 17: Comparison of inorganic arsenic and total arsenic concentrations in selected foods samples of the 2016 NZTDS

Food	**Mean total arsenic** (mg/kg)	**Mean inorganic arsenic** (mg/kg)	**Percent inorganic arsenic** (%)
Fresh fish	4.33	0.06	1
Mushrooms	0.075	0.01/0.02[a]	13–27
Mussels	3.43	0.1	3
Oysters	2.69	0.06	2
White rice	0.038	0.031	82
Yeast extract	0.053	0.046	87

[a] Mid-bound mean/upper-bound mean.

Figure 30: Dietary arsenic (total and inorganic[a]) exposure (mid-bound mean) trends in the NZTDS (1987/88–2016) for young adult males (19–24 years)



[a] 2003/04 NZTDS and 2009 NZTDS inorganic arsenic estimates based on seafood containing 10% inorganic arsenic and other foods 100%.

Table 18: Comparative estimated dietary arsenic (total and inorganic) exposures for adult males (25 years and above)

Element (species)	Estimated weekly mean exposure (µg/kg bw/week) (lower-bound–[mid-bound]–upper-bound)				
	NZTDS	ATDS[a,b]	FTDS[a,c]	HKTDS[d]	ITDS[a,e]
Arsenic (total)	12.2–[12.4]–12.7	2.8–3.9	[5.5]	Not estimated	4.9–6.3
Arsenic (inorganic)	0.6–[0.9]–1.2	Not estimated	[1.7–2.0][f]	[1.6]	0.1[g]

[a] Exposure estimated for all adult population.
[b] ATDS: Australian Total Diet Study (FSANZ, 2011).
[c] FTDS: French Total Diet Study (ANSES, 2011a).
[d] HKTDS: Hong Kong Total Diet Study (CFS, 2012).
[e] ITDS: Irish Total Diet Study (FSAI, 2016).
[f] A range for inorganic arsenic was estimated based on two scenarios of the inorganic arsenic proportion to total arsenic being low or high.
[g] Lower-bound and upper-bound mean values derive the same rounded concentration.

Table 19: Comparative estimated dietary arsenic (total and inorganic) exposures for infants (6–12 months)

Element (species)	Estimated weekly mean exposure (µg/kg bw/week) (lower-bound–[mid-bound]–upper-bound)		
	NZTDS	ATDS[a]	FITDS[b]
Arsenic (total)	9.8–[12.0]–12.5	4.4–6.9	4.1–4.7
Arsenic (inorganic)	1.0–[3.3]–5.5	Not estimated	2.2–2.7

[a] ATDS: Australian Total Diet Study (FSANZ, 2011).
[b] FITDS: French Infant Total Diet Study (ANSES, 2016).

Arsenic dietary exposure over time in the NZTDS has remained consistent, as demonstrated for young adult males (Figure 30). While a slight increase, since the 1997/98 NZTDS, in total arsenic exposure is evident, the analysis in the 2016 NZTDS for inorganic arsenic has allowed the exposure estimate for this arsenic species to be refined. This shows no apparent elevation resulting over the estimates from the 2003/04 and 2009 NZTDSs.

Risk characterisation

Due to the carcinogenicity of arsenic, no HBGV was available from which to characterise the dietary risk of total and inorganic arsenic. In the absence of an HBGV, the mid-bound mean dietary exposures to inorganic arsenic for the population cohorts have been compared against the benchmark dose level and MOEs derived. For a dietary carcinogen, an MOE of 10,000 or greater is targeted, to be able to establish a negligible dietary risk.

The calculated MOEs for inorganic arsenic range from 6 to 27 in the New Zealand population cohorts. The calculated MOEs for arsenic are therefore insufficient to exclude any dietary risk.

The risk management principle for dietary carcinogens is to reduce levels to as low as reasonably achievable. However, maintenance of food security is also important, given that processes to fully remove the contaminant may not be possible, or economically feasible; and full exclusion of contributing foods from the diet may remove an important source of nutrition. Because there is no indication that the dietary exposures to inorganic arsenic are increasing in the New Zealand diet, it is likely that dietary sources are already as low as reasonably achievable considering arsenic is ubiquitous in the environment. As a result, there is no elevated health risk from arsenic over that which has been present through the natural occurrence of arsenic in food throughout the history of the NZTDS.

The estimated exposures to inorganic arsenic are comparable with those reported in overseas TDSs (Table 18 and Table 19). Notably, in the HKTDS, MOEs of 9–32 were calculated for inorganic dietary exposure for mean adult consumers, which are very similar to those estimated for the 2016 NZTDS (CFS, 2012).

Cadmium

Cadmium is a metal element. The name cadmium originates from cadmia, the Latin term for the mineral calamine (zinc carbonate) out of which cadmium was first extracted as an impurity (Emsley, 2001). Cadmium is naturally distributed in the environment, although most New Zealand soils have levels below 1 mg/kg (MAF, 2008). Cadmium concentrations can be elevated in certain minerals, such as shales and phosphate and zinc ores (Liu et al., 2017; Roberts, 2014; Schwartz, 2010). The processing and use of these can lead to cadmium entering the environment, either from atmospheric release, leaching from old mine sites or as an impurity in phosphate fertilisers.

Cadmium was historically used as a pigment, cadmium yellow, which was added to paints and a range of other materials, and had a number of minor industrial uses, such as in electroplating steel (Alloway & Steinnes, 1999). Due to the toxicity of cadmium, many uses have been phased out, however, cadmium is still used in batteries. No direct agriculture uses for cadmium exist in New Zealand so the main source is from historical build up from use of fertilisers (MAF, 2008). Cadmium is readily taken up from soils into many ground crops. Cadmium may also enter livestock, through uptake into feed and direct consumption of soil, where it concentrates in the liver and kidneys (MAF, 2008; WHO, 2010a).

Because build up of cadmium in soil is a long-term risk for public health, risk management measures have been established in New Zealand to limit this. This includes a voluntary limit on the cadmium impurity in fertilisers as well as a soil management system to restrict cadmium levels building up to levels that may present a concern (FANZ, 2013; MAF, 2011). The NZTDS fulfils a critical part of this risk management by monitoring the trends of dietary cadmium exposure in the New Zealand population.

Hazard identification

Short-term toxicity to cadmium is very rare outside of industrial exposure conditions. Cadmium can be toxic at high levels to crops so the amount entering the diet at one time is usually limited.

Cadmium presents a high hazard because the human body is very poor at removing it, as a result, levels build up to those that are detrimental to health. Most of the cadmium in the diet passes through the body without being absorbed, but up to 10% of ingested cadmium may be absorbed and can take decades to clear from the body (WHO, 2010a). Once in the body, the majority of cadmium accumulates in the kidneys, where it causes damage to the renal tubules, leading to loss of kidney function and significant tissue damage (WHO, 2010a). The loss of kidney function is also believed to reduce how efficiently calcium is retained in the body, with resulting effects on bone density and bone reabsorption leading to conditions such as osteoporosis (WHO, 2010a).

Cadmium has been classified by the International Agency for Research on Cancer as a proven lung carcinogen when it is inhaled (IARC, 2012). There is limited evidence for the role of cadmium in the formation of other tumors, but the association of these to dietary exposure has not been confirmed.

Hazard characterisation

Cadmium was last reviewed by JECFA in 2010 (WHO, 2010a). JECFA reviewed a meta-analysis of the urinary cadmium levels to identify the highest concentration that was not associated with elevated levels of a urinary marker of kidney damage. A model was then developed to associate levels of dietary exposure to levels of this urinary marker, from which the intake level of 0.8 µg/kg bw was selected. As a chronic toxicant, daily fluctuations in cadmium exposure make little overall impact on long-term exposure. As a result, a provisional monthly tolerable daily intake of 25 µg/kg bw was established to better characterise longer term levels of exposure. The provisional monthly tolerable daily has been selected to characterise the dietary risk of cadmium in the 2016 NZTDS (Appendix 12).

Prevalence and concentrations

The concentrations of cadmium in individual foods of the 2016 NZTDS have been presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in Appendix 11, with minimum, maximum and arithmetic mean concentrations calculated for cadmium in each food type.

Cadmium was widespread in the tested foods in the 2016 NZTDS, with 68% (722 out of 1056) of the samples having a detected concentration (Figure 31). However, almost two-thirds (62%) of the samples with detected cadmium had concentrations less than 0.01 mg/kg.

Six food types made up all of the samples with greater than 0.1 mg/kg cadmium, these were oysters, mussels, lamb's liver, peanut butter, whole peanuts and potato crisps. Cadmium concentrations in sampled food of the NZTDS have largely remained consistent over time (Figure 32), although a slight trend of increase is evident in potato crisps. Because this increasing trend is not reflected in the other potato-based foods, the source of increase may be a result of differences in manufacture, or differing proportions of New Zealand origin potato crisps to imported potato crisps. Concentrations of cadmium in the other ground crops, such as carrots and onions, and in the grain-based foods, have remained unchanged over the past 30 years.

Consistent with previous NZTDSs, the cadmium concentrations in oysters and mussels are far greater than terrestrial and other marine-based foods. However, concentrations of cadmium in oysters can vary considerably depending on the proportion of Bluff (dredge) oysters to Pacific or imported oysters present in the sampling.

Dietary exposure estimates

Dietary exposure estimates for cadmium exposure at lower-bound, mid-bound and upper-bound means for all the population cohorts have been summarised in Appendix 12. These values are expressed in µg/kg bw/month.

For all population cohorts, the range from lower-bound to upper-bound mean shows little variation, which reflects the lower influence that foods with no detections of cadmium make upon the overall dietary exposure. The highest cadmium exposures are estimated in the child and toddler age groups (12.2 and 12.5 µg/kg bw/month, respectively). The predominant contributors to cadmium exposure in these groups came from the vegetable group (Figure 33), in particular, potatoes, potato crisps and potato fries (37–38% of exposure in both cohorts). For 5–6-year-old children, mixed-grain bread (7%) and white bread (8%) were also notable sources of exposure, with the grains food group being an important contributor to total cadmium exposure for all the infant, child and teenage cohorts.

For the adult cohorts, the contribution from the vegetables food group was similar to that for younger cohorts (Figure 33), however, shellfish were also an important contributor to exposure, with oysters contributing from 14% of dietary exposure for young adult males to 27% for adult males and adult males of Pacific Island ethnicity. Mussels also contributed 7–8% of the adult dietary exposures to cadmium.

Dietary exposure estimates in the 2016 NZTDS remained largely consistent with the 2009 NZTDS. This is demonstrated for young adult males and children in Table 20. Because habitual oyster consumption is likely to be uncommon, a dietary exposure estimate for young adult males excluding oysters has also been determined.

Risk characterisation

The estimated monthly dietary exposures to cadmium for all of the New Zealand population cohorts have been characterised against the HBGV in Appendix 12. The estimated dietary exposures range between 18% of the HBGV for adult females of Pacific Island ethnicity to 50% of the HBGV for toddlers. Dietary cadmium exposures have largely remained consistent with the ranges reported in the 1997/98 NZTDS and subsequent NZTDSs. There is no evidence of an increase in cadmium exposure through the diet and no consequent elevation in dietary risk.

Estimates of dietary cadmium exposure from the 2016 NZTDS are within the range reported in overseas TDSs (tables 21 and 22). Estimates for adult males are double those published for adults in Australia, however, they more closely align to the exposure estimates for Irish adults and are below those reported in Hong Kong (CFS, 2013; FSAI, 2016; FSANZ, 2011).

Figure 31: Ranges of cadmium concentrations in sampled foods of the 2016 NZTDS

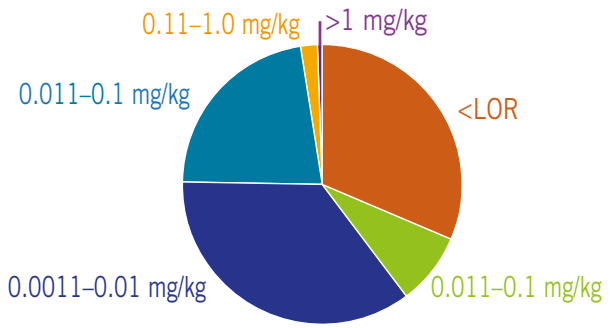


Figure 32: Cadmium concentration (mid-bound mean) trends in selected foods of the NZTDS (1987/88–2016)

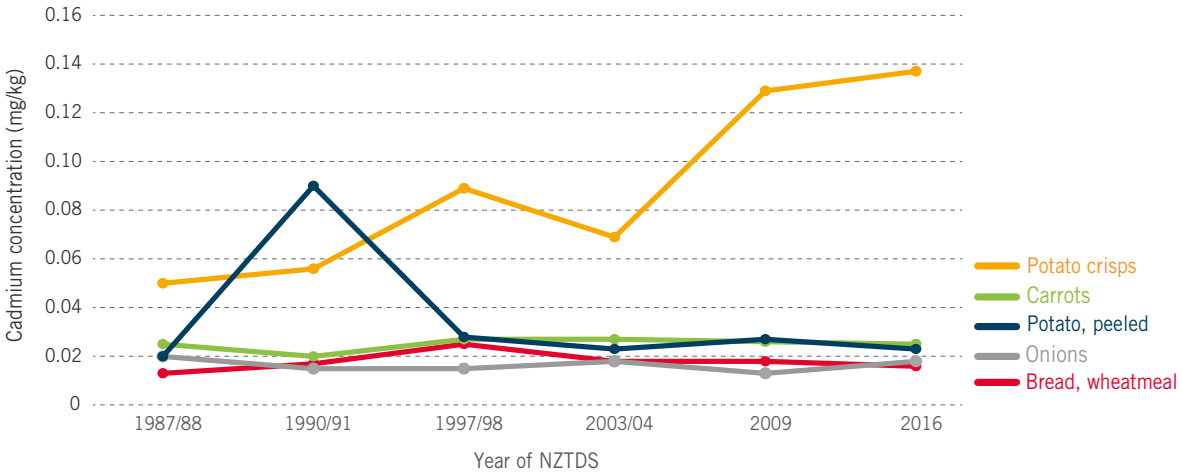
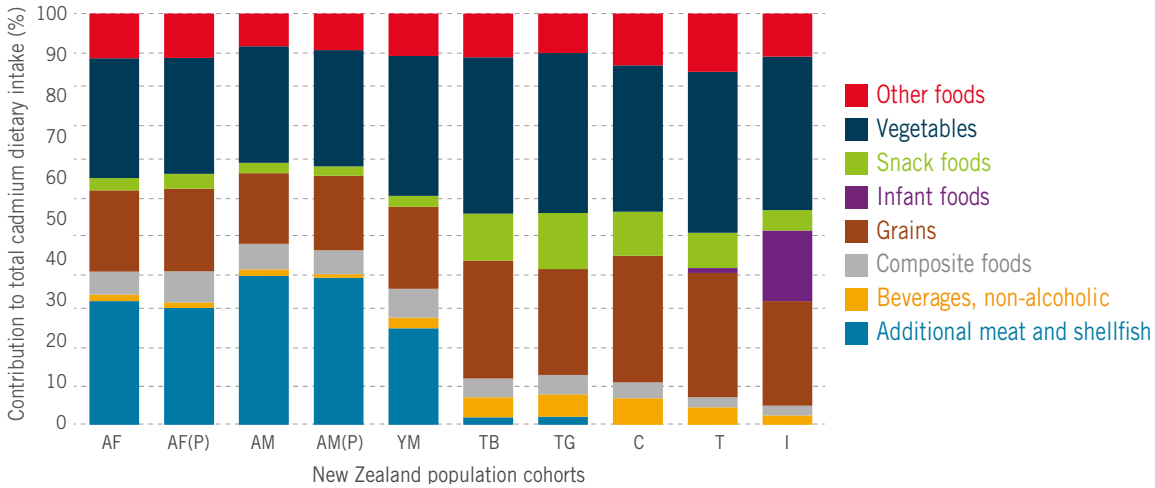


Figure 33: Major cadmium (mid-bound mean exposure) contributing food groups in the 2016 NZTDS



AF: Adult Female (25 years and over); AF(P): Adult Female – Pacific Island ethnicity (15 years and over); AM: Adult Male (25 years and over); AM(P): Adult Male – Pacific Island ethnicity (15 years and over); YM: Young Adult Male (19–24 years); TB: Teenage Boy (11–14 years); TG: Teenage Girl (11–14 years); C: Child (5–6 years); T: Toddler (1–3 years); I: Infant (6–12 months).

Table 20: Dietary cadmium exposure (mid-bound mean) trends in the NZTDS (1987/88–2016) for young adult males (19–24 years) and children (5–6 years)

	Estimated mid-bound mean monthly dietary exposure (µg/kg bw/month)					
Element	**1987/88**	**1990/91**	**1997/98**	**2003/04**	**2009**	**2016**
Young Adult Males						
Cadmium (diet including oysters)	35.5	12.1	12.1	7.8	6.9	6.9
% PTMI	142%	49%	49%	31%	28%	28%
Cadmium (diet excluding oysters)	17.3	10.0	7.4	5.6	5.8	5.9
% PTMI	69%	40%	29%	23%	23%	24%
Children						
Cadmium	26.6	12.3	12.0	11.4	11.5	12.2
% PTMI	106%	49%	48%	46%	46%	49%

PTMI: provisional tolerable monthly intake.

Table 21: Comparative dietary exposures to cadmium for adult females and males (25 years and over)

	Estimated monthly mean dietary exposure (µg/kg bw/month) (lower-bound–[mid-bound]–upper-bound)				
Population cohort	**NZTDS**	**ATDS[a]**	**FTDS[b]**	**HKTDS[c]**	**ITDS[d]**
Adult females	5.1–[5.2]–5.3	2.5–3.0[e]	[4.6]	[8.7]	4.9–6.7[e]
Adult males	6.5–[6.6]–6.7		[4. 8]	[7.9]	

[a] ATDS: Australian Total Diet Study (FSANZ, 2011).
[b] FTDS: French Total Diet Study (ANSES, 2011a).
[c] HKTDS: Hong Kong Total Diet Study (CFS, 2013).
[d] ITDS: Irish Total Diet Study (FSAI, 2016).
[e] Exposure estimated for all adult population.

Table 22: Comparative dietary exposures to cadmium for children (5–6 years) and infants (6–12 months)

	Estimated monthly mean dietary exposure (µg/kg bw/month) (lower-bound–[mid-bound]–upper-bound)				
Population cohort	**NZTDS**	**ATDS[a]**	**FITDS[b]**	**FTDS[c]**	**ITDS[d]**
Children	12.0–[12.2]–12.4	8.3–9.6	Not calculated	[11.7]	7.3–9.7
Infants	9.5–[11.0]–12.6	4.8–6.5	9.8–10.5	Not calculated	Not calculated

[a] ATDS: Australian Total Diet Study (FSANZ, 2011).
[b] FITDS: French Infant Total Diet Study (ANSES, 2016).
[c] FTDS: French Total Diet Study (ANSES, 2011a).
[d] ITDS: Irish Total Diet Study (FSAI, 2016).

Lead

Lead is a metal element that may have been in use by humans since antiquity, with the name having originated as the Anglo-Saxon word for the metal (Emsley, 2001). Lead is ubiquitous in the environment. Lead has had a range of uses in human society, including in paints, water pipes and cookware; lead arsenate was also used as an insecticide (Hernberg, 2000). Historically, lead was also present in the solder used to seal tin cans, which resulted in elevated lead levels in food (Jorhem & Slorach, 1987). One of the biggest contributions to lead in the food supply was the use of leaded additives in fuels, with the resulting emissions from car exhausts distributing lead into the environment (Tong et al., 2000). In many countries where leaded fuel has been phased out, lead levels in the environment, particularly areas adjacent to roads, have been consistently decreasing (WHO, 2011).

Hazard identification

Most forms of lead are low in acute toxicity. Except for occupational exposure, lead toxicity is almost exclusively a result of accumulation in the body over a period of time (Flora et al., 2012; WHO, 2011). In the body, lead interferes with synthesis of the haem component of blood. It also causes damage to the male reproductive system and the kidneys (WHO, 2011). Chronic lead poisoning may cause symptoms such as irritation of the gastrointestinal tract and effects on sleep, mood and memory (WHO, 2011).

A particular hazard of lead is its effects on the central nervous system, particularly that in the developing foetus, infants and children. In population studies, elevation in blood lead levels has been causally associated with effects on neurodevelopment, including decreases in Intelligence Quotient (IQ) (WHO, 2011).

Hazard characterisation

Historically, it was considered that there was an exposure threshold to the toxic effect of dietary lead. This threshold was characterised through a provisional tolerable weekly intake, set in 2000 at a level of 25 µg/kg bw/week (WHO, 2000). In 2010, this value was reviewed in light of new information. At an exposure equalling the provisional tolerable weekly intake there was an association with a decrease in IQ by three points in children and an increase in blood pressure in adults and it was concluded that no threshold for these effects could be determined. As a result, the provisional tolerable weekly intake was withdrawn and no other HBGV is currently specified (WHO, 2011).

As with arsenic, the risk due to lead exposure can be assessed by use of MOEs against the toxicological effects reported in humans. For children, the dose-response model derived by JECFA established a dose of 0.6 µg/kg bw/day (4.2 µg/kg bw/week), which was associated with a decrease in IQ of one point (WHO, 2011). In relation to the hazard for adults, the dose-response modelling established that a dose of 1.3 µg/kg bw/day (9.1 µg/kg bw/week) would result in elevation in systolic blood pressure by 1 millimetre of mercury (mmHg) (WHO, 2011).

Prevalence and concentrations

The concentrations of lead in individual foods of the 2016 NZTDS have been presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in Appendix 11, with minimum, maximum and arithmetic mean concentrations calculated for lead in each food type.

Lead was detected in approximately one-third of the analysed food samples (32%; 339 samples out of 1056). This was a large reduction over the 53% of foods with a detected lead concentration in the 2009 NTZDS, and the 52% of foods in the 2003/04 NZTDS. As with cadmium, the majority (74%) of the detections for lead were below 0.01 mg/kg.

Foods with consistently higher concentrations of lead were mussels (0.08–0.23 mg/kg), oysters (0.03–0.14 mg/kg) and lamb's liver (0.01–0.05 mg/kg). Individual canned samples also had higher lead levels, such as canned peaches (0.12 mg/kg) and pineapples (0.03 mg/kg), as did other food types such as sugar (0.04 mg/kg) and chocolate biscuits (0.13 mg/kg).

Lead concentrations in foods were consistent with those reported in the past two NZTDSs. There is a notable decrease in concentrations from studies prior to 2000, most likely reflecting the banning of leaded fuel additives in New Zealand in 1996 (Figure 34).

Dietary exposure estimates

Dietary exposure estimates for lead at lower-bound, mid-bound and upper-bound means for all the population cohorts have been summarised in Appendix 12. For consistency with reporting in previous NZTDS years, these values are expressed in µg/kg bw/week.

The highest estimated dietary exposure for lead is in the infant age group (2.9 µg/kg bw/week). For this age group, there is a large variation between the lower-bound and upper-bound values, which indicates that estimating exposure in foods where lead was not detected has a large influence on the total exposure. For example, lead was not detected in any samples of infant and follow-on formula, but these foods still contributed 54% of the dietary exposure for the infant cohort. This variation between lower-bound and upper-bound mean dietary exposure estimates reduced in older age groups and was much less evident in adults.

For adult cohorts, the mid-bound exposures ranged from 0.42 µg/kg bw/week for adult females of Pacific Island ethnicity to 0.61 µg/kg bw/week for young adult males. A wide variety of foods contributed to adult dietary exposures to lead, reflecting the ubiquitous presence of lead in the environment. The only notable food source was mussels, which contributed 10–12% of the dietary lead exposure for the adult diets.

With the reduction in lead concentrations in sampled foods, the dietary exposures to lead decrease sharply during the period 1982–1998. The 1997/98 and subsequent NZTDSs suggested that dietary exposure to lead had reached a plateau that may reflect the residual or natural background of lead in the diet. The 2016 NZTDS recorded a further slight reduction in dietary lead exposures over those estimated in the 2003/04 NZTDS and 2009 NZTDS (Figure 35). This may reflect the reducing prevalence of lead detections in the sampled food and suggest that potentially further reductions in dietary lead exposures could still occur, although these would not be of the magnitude of decreases seen in the 1980s and 1990s.

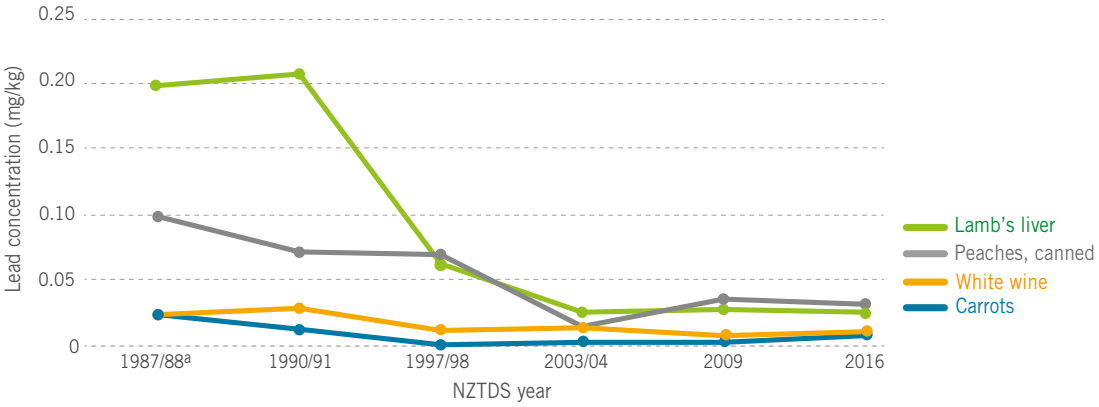
Risk characterisation

Due to the lack of an effect threshold, no HBGV was available from which to characterise the dietary risk of lead. In the absence of an HBGV, the mid-bound mean dietary exposures to lead for the population cohorts have been compared against toxicological reference points (benchmark doses) determined by JECFA for children and adults.

For a non-carcinogenic health effect, an MOE of 100 or greater is considered to indicate a negligible dietary risk. Margins of exposure for the adult dietary exposures to lead were calculated using a toxicological reference point of 9.1 µg/kg bw/week. The calculated MOEs for adults were in the range 15–22. Margins of exposure for the child exposures to lead were calculated using a toxicological reference point of 4.2 µg/kg bw/week. The calculated MOEs for children were in the range 1.5–9. A similar conclusion was reached in the FITDS, where MOEs of less than 10 were estimated for infants (ANSES, 2016).

While the calculated MOEs for adults and children are not at a magnitude that would indicate that dietary lead exposure was a negligible health concern, it is important to place the values in context. First, the majority of the population cohorts have shown a further decrease in exposure since the 2009 NZTDS. In addition, the levels of lead for many foods are likely approaching the natural background for the food supply. Comparison with overseas TDSs indicates that many of the New Zealand dietary exposures are on the lower bound of the international ranges (tables 23 and 24).

Figure 34: Lead concentration (mid-bound mean) trends in selected foods of the NZTDS (1987/88–2016)



[a] The LOR for lead was higher in the 1987/88 NZTDS, at 0.05 mg/kg, no detections were present in carrots and white wine so half the LOR has been used for these commodities.

Figure 35: Dietary exposure (mid-bound mean) trends for lead in the NZTDS (1982–2016) for young adult males (19–24 years)

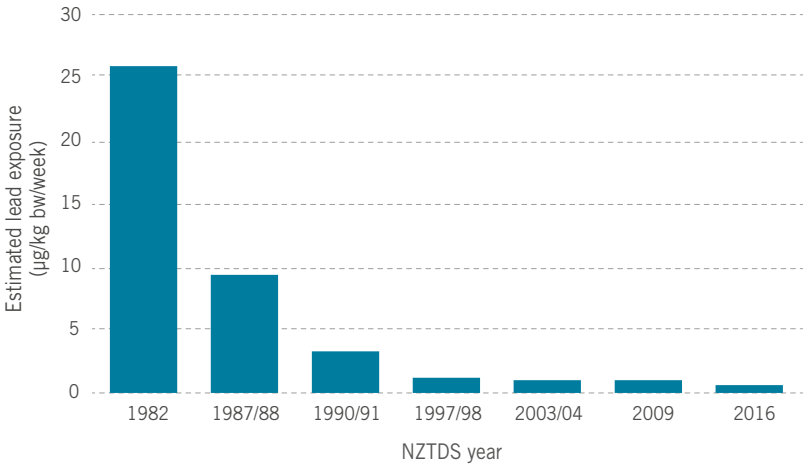


Table 23: Comparative lead exposures for adult females and males (25 years and over)

	Estimated weekly exposure (µg/kg bw/week) (lower-bound–[mid-bound]–upper-bound)				
Population cohort	**NZTDS**	**ATDS[a,b]**	**FTDS[c]**	**HKTDS[d]**	**ITDS[a,e]**
Adult females	0.27–[0.52]–0.76	0.87–0.93	[1.29][f]	[1.54]	0.28–0.84[f]
Adult males	0.29–[0.55]–0.81		[1.41][a]	[1.47]	

[a] Exposure estimated for all adult population.
[b] ATDS: Australian Total Diet Study (FSANZ, 2011).
[c] FTDS: French Total Diet Study (ANSES, 2011a).
[d] HKTDS: Hong Kong Total Diet Study (CFS, 2013).
[e] ITDS: Irish Total Diet Study (FSAI, 2016).
[f] Exposure estimated for women of childbearing age (18–45 years).

Table 24: Comparative lead exposures for children (5–6 years) and infants (6–12 months)

	Estimated weekly exposure (µg/kg bw/week) (lower-bound–[mid-bound]–upper-bound)				
Population cohort	**NZTDS**	**ATDS[a]**	**FITDS[b]**	**FTDS[c]**	**ITDS[d]**
Children	0.53–[1.13]–1.73	1.79–1.91	Not calculated	[2.77]	0.28–1.19
Infants	0.76–[2.91]–5.05	1.57–1.65	1.25–1.37	Not calculated	Not calculated

[a] ATDS: Australian Total Diet Study (FSANZ, 2011).
[b] FITDS: French Infant Total Diet Study (ANSES, 2016).
[c] FTDS: French Total Diet Study (ANSES, 2011a).
[f] ITDS: Irish Total Diet Study (FSAI, 2016).

Mercury

Mercury is a highly toxic metal element. Metallic mercury is a liquid at room temperatures. Mercury has been in use since antiquity, with its naming originating from the Roman god Mercury (Emsley, 2001). Inorganic forms of mercury, such as cinnabar (mercury sulphide), are largely insoluble in water so act as sinks for the metal. As a result, mercury tends to concentrate into rich deposits (MfE, 2009). A key natural input to environmental mercury for New Zealand is volcanic and geothermal activity, which redistributes deep mercury deposits to the surface (MfE, 2009). Mercury has historically, and in some cases continues to be, used for a wide range of industrial, medical and household applications (WHO, 1991, 2011).

In the past, mercury has been used in ways that have led to contamination of food. Organic mercury compounds were used in agriculture as seed treatments and fungicides. Unintended consumption of treated seed led to several incidents of widespread poisonings, and this use of mercury compounds has been discontinued (Klaassen, 2008). Atmospheric pollution and industrial run-off have also led to mercury entering soils and water bodies (Klaassen, 2008). The signing of the international Minamata Convention on Mercury in 2013 is intended to support the reduction of mercury releases into the environment, which will lead to continued reductions in soil and marine contamination (MfE, 2016).

In the marine environment, mercury is converted to an organic form, methylmercury, predominantly by bacteria (WHO, 1991). Methylmercury presents a specific risk because it bioaccumulates through marine food chains, meaning that large predatory fish can contain very high levels of the element.

Hazard identification

Mercury can present an acute health concern at higher levels, causing damage to the heart and blood supply, the kidneys and the gastrointestinal tract (WHO, 2011). However, the potent chronic toxicity of mercury is most relevant to public health. Chronic poisoning with inorganic mercury usually manifests as tremors, usually beginning in the hands but that can intensify to more violent involuntary movements; neuropsychiatric effects, such as delirium, impacts on emotions, insomnia and memory loss; and inflammation and lesions forming in the mouth and on the gums (WHO, 2011).

The impacts of chronic exposure to mercury on the nervous system and brain function have been reported throughout history (Rice et al., 2014). The use of mercury in hat making resulted in poisoning, with symptoms of emotional lability and dementia, resulting in the historical phrase "as mad as a hatter".

In direct contrast to arsenic, it is the organic form of mercury, methylmercury, rather than its inorganic salts that presents the greater health hazard (WHO, 2007). Methylmercury is more readily absorbed from the diet and, unlike inorganic mercury, can readily cross the placental barrier to the developing foetus. Methylmercury exposure in the foetus is associated with developmental delays after birth, including potentially permanent impacts on motor skills, attention and cognition (WHO, 2007).

Hazard characterisation

Separate HBGVs are derived for inorganic mercury and methylmercury. In 2007, JECFA established a PTW intake of 1.6 µg/kg bw/week for methylmercury, based upon protecting the developing foetus (WHO, 2007). This provisional

tolerable weekly intake is primarily intended to be applied to methylmercury exposure in women of childbearing age, but is also considered to be protective of neurotoxicity effects in infants and children, as well as the general adult population.

In 2010, JECFA established a provisional tolerable weekly intake of 4 µg/kg bw/week for inorganic mercury. Unless there is evidence of methylmercury exposure, this provisional tolerable weekly intake is applicable to characterising the risk of total mercury in foods of terrestrial origin (WHO, 2011).

Prevalence and concentrations

The concentrations of total mercury and methylmercury in individual foods of the 2016 NZTDS have been presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in Appendix 11, with minimum, maximum and arithmetic mean concentrations calculated for total mercury and methylmercury in each food type.

Total mercury was detected infrequently in food samples analysed in the 2016 NZTDS. Only 8% of samples (88 out of 1056) had detected concentrations of total mercury. This is consistent with the 8% of samples containing detected concentrations in the 2009 NZTDS (63 out of 752). High-fat foods were not analysed for total mercury in the 2009 NZTDS. Of the 2016 NZTDS food samples with detected total mercury concentrations, 70 were seafood, leaving only 18 food samples of terrestrial origin with detected concentrations of total mercury. The number of terrestrial origin samples with total mercury has remained consistent, with 15 reported in the 2009 NZTDS.

The five terrestrial origin foods with detected total mercury concentrations were lamb's liver (6 samples), pork roast (6), mushrooms (4), sausage (1) and cabbage (1). The range of detected concentrations was narrow, from 0.0021 mg/kg to 0.0071mg/kg. Total mercury in terrestrial foods is usually considered to be in an inorganic form.

In the seafood samples, only a single sample of each of mussel and oyster did not contain detected concentrations of total mercury. Because mercury in marine organisms is usually present as methylmercury, all of the seafood samples in the 2016 NZTDS were further analysed for methylmercury. Of the 70 seafood samples with reported concentrations of total mercury, 55 (79%) were also positive for the presence of methylmercury. All of the finfish or finfish-based foods except sushi had detected concentrations of methylmercury. The proportion of methylmercury in the sushi was likely reduced from samples containing chicken and vegetable ingredients, forming part of the composite samples. The calculated ratios of methylmercury to total mercury in the seafood samples are presented in Table 25. The form of mercury present in finfish and prawns and shrimp is predominantly methylmercury, however, in the mussel and oyster sample the proportion of methylmercury was between one-fifth and one-third of total mercury.

The highest concentration of methylmercury was in a sample of battered fish (0.40 mg/kg). This is a decrease from the highest value of 0.48 mg/kg reported in the 2009 NZTDS. However, the reported methylmercury concentrations in the different finfish and finfish-based food types have remained consistent with previous reporting, showing small year to year fluctuations (Figure 36). A notable trend is the reduction in the total mercury concentration in battered fish since the 1997/98 NZTDS. Prior to 1997/98, this NZTDS food type included chips and the mercury concentration of the fish would have been diluted by the lower concentrations in the chips. This downward trend may result from the use of different fish species in the fillet over time, moving away from higher mercury species, such as shark.

Table 25: Comparisons of total and methylmercury concentrations in different food types of the 2016 NZTDS

Food	Mean total mercury (mg/kg)[a]	Mean methylmercury (mg/kg) [no of samples <LOR]	Mean methylmercury to total mercury (%) [range]
Battered fish	0.15	0.13 [0]	92 [38–121]
Canned fish	0.04	0.04 [0]	90 [53–105]
Fish cakes	0.03	0.03 [0]	97 [76–116]
Fish fingers	0.06	0.06 [0]	101 [82–128]
Fresh fish	0.16	0.15 [0]	101 [57–119]
Sushi	0.02	0.008 [6]	68 [67–69]
Total finfish	**0.09**	**0.08 [6]**	**95 [38–128]**
Mussels	0.02	0.007 [5]	34 [29–36]
Oysters	0.04	0.008 [4]	20 [19–23]
Total molluscs	**0.03**	**0.008 [9]**	**26 [19–36]**
Prawns and shrimps	0.007	0.007 [0]	101 [79–126]

[a] Mean total mercury in samples containing reported methylmercury only.

Dietary exposure estimates

Dietary exposure estimates for inorganic mercury and methylmercury exposure at lower-bound, mid-bound and upper-bound means for all the population cohorts have been summarised in Appendix 12. For consistency with reporting in previous NZTDS years, these values are expressed in µg/kg bw/week.

Inorganic mercury dietary exposure was calculated by excluding all finfish and shrimp and prawn intakes. Additionally, the concentration of total mercury in the oyster and mussel samples was reduced to 74%, to reflect the mean ratio of methylmercury to total mercury in these foods. Methylmercury dietary exposure was calculated from the methylmercury concentrations in seafood only.

The highest estimate of dietary exposure to inorganic mercury was in the infant population cohort (2.5 µg/kg bw/week). However, as with lead, there was a large range between the lower-bound and upper-bound means due to the influence of foods without detected total mercury. Infant and follow-on formula constituted 68% of the mid-bound mean exposure for infants, however, mercury was not detected in this food type (all samples <0.01 mg/kg). Food types with appreciable inorganic mercury concentrations are not a large part of the diet for infants and, as such, this exposure is likely to be an overestimate.

Inorganic mercury dietary exposure in the adult and teenage population cohorts was very similar, ranging from 0.25-0.43 µg/kg bw/week. However, as with the infant estimates, the dietary exposure is still dominated by foods with no detected concentrations of total mercury (bread, pasta and white rice).

Estimated dietary exposure to methylmercury through seafood consumption was very similar for all the population cohorts (0.40 to 0.49 µg/kg bw/week), apart from teenage girls (0.25 µg/kg bw/week). Because the majority of the seafood samples had detected concentrations of methylmercury, there was little difference between lower-bound and upper-bound mean estimates. Fresh and battered fish were the main contributors to dietary exposure for all of the population cohorts, reflecting that they contained the highest concentrations of methylmercury.

Dietary exposure to inorganic mercury and methylmercury has varied little over the course of the NZTDS (Figure 37).

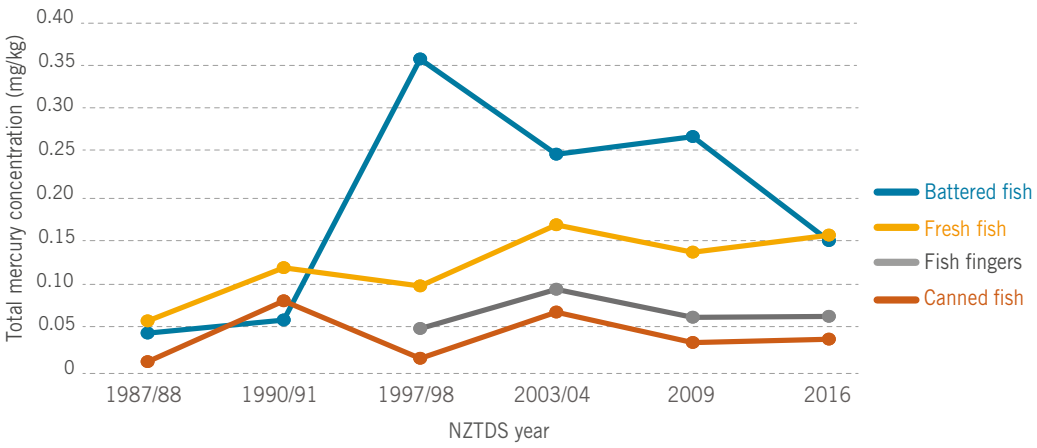
Risk characterisation

The estimated weekly dietary exposures to inorganic mercury and methylmercury for all of the New Zealand population cohorts have been characterised against respective HBGVs in Appendix 12. Adult dietary exposures to inorganic mercury were in the range 6–9% of the HBGV. For the infant, child and teenage population cohorts, the estimated dietary exposures ranged between 9% of the HBGV for teenage girls and 58% of the HBGV for infants.

For methylmercury, the most sensitive population is women of childbearing age, due to impacts on the developing foetus. The estimated mean dietary exposure to methylmercury for adult females was 28% of the PTWI, while for adult females of Pacific Island ethnicity it was 30%. All of the other population cohorts have similar levels of exposures, with the exception of the teenage girl population cohort for which methylmercury dietary exposure was only 13% of the PTWI. The lower methylmercury dietary exposure for this population cohort reflects the lower consumption of seafood in comparison with other cohorts.

That all the exposures for both inorganic mercury and methylmercury are below the PTWI suggests that normal dietary practices are unlikely to result in adverse health impacts from mercury. Because seafood consumption practices can differ considerably across the population, the levels of methylmercury present in finfish, particularly

Figure 36: Trends of finfish total mercury concentrations (mid-bound mean) in the NZTDS (1987/88–2016[a])



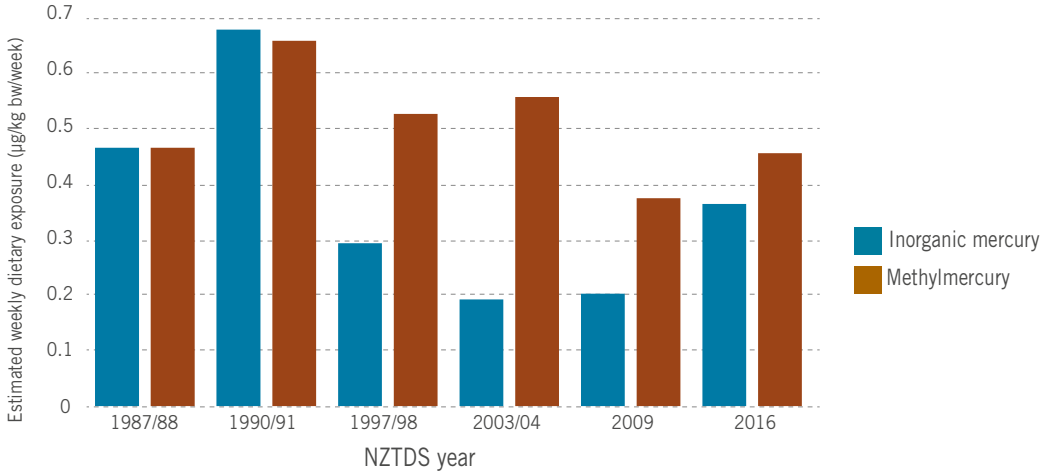
[a] Canned fish was recorded as canned salmon, and fresh fish as terakihi fillets in the 1987/88, 1990/91 and 1997/98 NZTDS years; battered fish samples also contained potato hot chips in the 1987/88 and 1990/91 NZTDS years.

predatory species, may still represent a health risk for some high consumers of finfish. Seafood is also an important dietary source of omega fatty acids, such as docosahexaenoic acid, and other beneficial nutrients (FAO/WHO, 2011). Balancing the potential risks from the methylmercury content of seafood with the health benefits is important, to maintain good consumer health.

The Ministry for Primary Industries has published seafood consumption advice for pregnant women, to provide information on the risks common fish species present from mercury, and a recommendation of how frequently different fish types should be consumed (MPI, 2015b).

The estimated weekly dietary exposures to inorganic mercury and methylmercury are within the ranges reported in overseas TDSs (tables 26, 27 and 28). A key determinant of the level of dietary exposure to methylmercury is the level of seafood consumption in the population. Populations in landlocked countries generally have lower dietary exposure to mercury, because the availability of seafood is limited.

Figure 37: Dietary inorganic mercury[a] and methylmercury[b] exposure trends in the NZTDS (1987/88–2016) for young adult males (19–24 years)



[a] Inorganic mercury: 1987/88 to 2003/04 NZTDS: total mercury intake excluding all fish products; 2009 NZTDS: total mercury intake excluding all fish and shellfish; 2016 NZTDS: total mercury intake excluding all fish and shrimp and using 74% of total mercury intake from shellfish.
[b] Methylmercury: 1987/88 to 2003/04 NZTDS: extrapolated from total mercury intake through all fish products; 2009 and 2016 NZTDSs from direct analysis of methylmercury in seafood.

Table 26: Comparative mercury dietary exposures for adult females (AF; 25 years and above) and adult females of Pacific Island ethnicity (AF(P); 15 years and above)

	Estimated weekly exposure (µg/kg bw/week) (lower-bound–[mid-bound]–upper-bound)					
Element (species)	**NZTDS AF**	**NZTDS AF(P)**	**ATDS[a,b]**	**FTDS[c]**	**HKTDS[d]**	**ITDS[a,e]**
Mercury (inorganic)	0.01–[0.30]–0.58	0.01–[0.25]–0.48	0.20–0.33	0.17–1.44[f]	Not estimated	Not estimated
Mercury (methylmercury)	0.43[g]	0.47[g]	0.45[g]		[0.77]	0.17–0.84

[a] Exposure estimated for all adult population.
[b] ATDS: Australian Total Diet Study (FSANZ, 2011).
[c] FTDS: French Total Diet Study (ANSES, 2011a).
[d] HKTDS: Hong Kong Total Diet Study (CFS, 2013).
[e] ITDS: Irish Total Diet Study (FSAI, 2016).
[f] The FTDS calculated lower-bound and upper-bound mean exposures to total mercury for women of childbearing age (18–45 years).
[g] Lower-bound and upper-bound means round to the same value.

Table 27: Comparative mercury dietary exposures for children (5–6 years)

	Estimated weekly exposure (µg/kg bw/week) (lower-bound–[mid-bound]–upper-bound)			
Element (species)	**NZTDS**	**ATDS[a]**	**FTDS[b]**	**ITDS[c]**
Mercury (inorganic)	0.01–[0.75]–1.50	0.62–0.89	0.41–2.92[d]	Not estimated
Mercury (methylmercury)	0.45[e]	0.58[e]		0.14–1.19

[a] ATDS: Australian Total Diet Study (FSANZ, 2011).
[b] FTDS: French Total Diet Study (ANSES, 2011a).
[c] ITDS: Irish Total Diet Study (FSAI, 2016).
[d] The FTDS calculated lower-bound and upper-bound mean exposures to total mercury.
[e] Lower-bound and upper-bound means round to the same value.

Table 28: Comparative mercury dietary exposures for infants (6–12 months)

	Estimated weekly exposure (µg/kg bw/week) (lower-bound–[mid-bound]–upper-bound)		
Element (species)	**NZTDS**	**ATDS[a]**	**FITDS[b]**
Mercury (inorganic)	0.01–[2.30]–4.60	0.51–0.79	0.05–0.46
Mercury (methylmercury)	0.47[c]	0.09[c]	0.04–0.05

[a] ATDS: Australian Total Diet Study (FSANZ, 2011).
[b] FITDS: French Infant Total Diet Study (ANSES, 2016).
[c] Lower-bound and upper-bound means round to the same value.

Tin

Tin is an easily worked and largely water insoluble metal, in use since antiquity. Originally used in making bronze alloys (Muhly, 1985), more recent applications include use in glass making, pigments and generating organotin compounds (Evans, 1998). The most important use of tin in the food supply is in making tin-plate, whereby tin is bonded to steel cans to form a protective layer and allow food to be stored for long periods of time. This technology was first developed in the late 19th century (Emsley, 2001). Other packaging materials have subsequently been developed, but tin cans are still widely used.

Tin-plate is the main route of entry of tin into the food supply (WHO, 2006). Long-term storage in cans, particularly of acidic foods or foods with high nitrate levels, can lead to slow leaching of the tin into the food. Because tin is present in the environment, some uptake to food sources could occur, although uptake through the food chain is expected to be low (WHO, 2006). Organotin compounds, such as tributyltin, have been used for anti-fouling on shipping and other marine structures, resulting in transfer into the marine food chain (EFSA, 2004).

Hazard identification

Acute exposure to inorganic tin may cause irritation of the gastrointestinal tract, leading to vomiting, abdominal pain and diarrhoea. Chronic health impacts are less well characterised, although it is considered likely that tin may interact in the body with essential trace elements such as iron, zinc and calcium (ATSDR, 2005). Animal studies have demonstrated impacts on haemoglobin in the blood and on bone strength, however, no associations have been identified for health effects from long-term exposure to inorganic tin.

The long-term hazards of the organotins, such as tributyltin, are better characterised. The most sensitive effect from exposure to the organotins is damage to the thymus, which leads to depression of the immune system (EFSA, 2004).

Hazard characterisation

In 1988, JECFA established an HBGV for chronic exposure to inorganic tin, with a PTWI of 14 mg/kg bw/day (WHO, 2006; Appendix 12). A specific HBGV for the acute impacts of tin has not been set, however, studies in humans indicate that gastrointestinal irritation is unlikely at levels below 150 mg/kg in canned beverages and 250 mg/kg in canned foods (Boogard et al., 2003).

For the reported tin in seafood species (with the exception of canned fish) it was considered that hazard could have resulted from organotin compounds. To characterise this risk, the European Food Safety Authority tolerable daily intake of 0.25 µg/kg bw/day for organotins, adjusted to 0.1 µg/kg bw/day to account for conversion to inorganic tin, has been used as an HBGV (EFSA, 2004).

Prevalence and concentrations

The concentrations of tin in individual foods of the 2016 NZTDS have been presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in Appendix 11; with minimum, maximum and arithmetic mean concentrations calculated for tin in each food type.

Tin was detected in 13% (144 out of 1056) of the samples analysed in the 2016 NZTDS. Tin was predominantly detected in canned food samples, and prepared foods that may have contained a canned ingredient. Sixty of the sampled foods with detected tin had concentrations above 1 mg/kg, with this largely reflecting the canned foods. Three samples of canned pineapple and two of canned tomatoes had tin concentrations between 100 mg/kg and 162 mg/kg. The samples with detected tin below 1 mg/kg covered a wide range of food types, including bananas, frozen corn, minced beef, taro and wine. The origin of tin in these foods may be environmental levels or transfer during manufacturing.

Tin has not been analysed in the NZTDS since the 1997/98 NZTDS, when it was only analysed for in 15 food types, mainly canned foods. Both the 1987/88 NZTDS and 1990/91 NZTDS analysed for tin in a wider range of foods, but had limits of reporting of 1 mg/kg so many foods did not have reported detections. For the canned foods in the 2016 NZTDS, there is generally consistency in the tin concentrations with the results found in these previous NZTDS years (Table 29).

Except canned fish, where the tin may have resulted from migration out of the can, seven samples of seafood had detected tin concentrations all falling within the range of 0.01–0.06 mg/kg. It was considered that this tin could have resulted from organotins used in the marine environment.

Dietary exposure estimates

Dietary exposure estimates for tin at lower-bound, mid-bound and upper-bound means for all the population cohorts have been summarised in Appendix 12. Dietary exposures are expressed in mg/kg bw/week, and as a percentage of the HBGV.

The estimated dietary exposures to tin ranged from 0.12 mg/kg bw/week in adult females of Pacific Island ethnicity, to 1.3 mg/kg bw/week for infants. For all population cohorts, the range between lower-bound and upper-bound was minimal, indicating that the exposure was primarily driven by foods with detected tin concentrations. Analysis of the contributors to dietary exposure confirm that tin exposure is primarily from consumption of canned foods, with little contribution from the remainder of the diet (figures 38 and 39).

The estimated dietary exposures to tin show a slight decrease compared with those reported in the 1997/98 NZTDS. The tin, dietary exposures in the 1997/87 NZTDS ranged between 0.5 mg/kg bw/week for adult males and 1.6 mg/kg bw/week for toddlers. Because the same food types contributed to the exposures, and there has been limited change in the tin concentrations, the decrease likely results from changes in consumption practices.

In addition to the estimates for inorganic tin, exposure estimates were made for the potential that the tin concentrations detected in seafood could be as a result of organotin presence. The estimated mid-bound daily dietary exposures ranged between 0.002 µg/kg bw/day in the teenage girl cohort and 0.007 µg/kg bw/day for toddlers.

Risk characterisation

The estimated weekly dietary exposures to tin for all of the New Zealand population cohorts have been characterised against the HBGV in Appendix 12.

None of the tin results in canned foods exceeded 250 mg/kg, the level associated with acute gastrointestinal effects in humans (WHO, 2006), with the highest reported tin result being 162 mg/kg. As a result, there is unlikely to be a significant risk of acute toxicity from tin in recently purchased cans. Because cans are stored over the long term, the potential for a loss in integrity, and migration of tin, could increase. Ensuring canned foods are consumed within recommend shelf-lives is important to prevent an elevated risk of tin toxicity.

In terms of chronic exposure to tin, the estimated weekly dietary exposures ranged between 1% and 9% of the HBGV. As a result, the current exposures to dietary tin are unlikely to present a risk to health. Tin exposures have remained consistent since the 1982 NZTDS with no associated health impacts on the population likely. The benefit of allowing long-term storage of foods, and limiting the growth of spoilage microorganisms is suggested to far outweigh any risk present by the migration of tin into the canned food.

New Zealand estimated exposures to tin are five to six times greater than in the TDSs for other countries (Table 30). However, given the negligible risk from the dietary exposures to tin present, this is not a significant concern.

Because tin concentrations in marine species could potentially be in the form of organotins, exposure estimates for seafood were also characterised against an HBGV for organotins. The mid-bound mean estimated exposures resulting from the tin concentrations detected in seafood (excluding canned fish) ranged from 2% to 6% of the HBGV. As a result, if the tin concentrations present in seafood were in an organotin form, the levels of exposure would not present a risk to health.

Table 29: Tin concentration (mid-bound mean) trends in canned foods in the NZTDS (1987/88–1997/98 and 2016)

	Mid-bound mean tin concentration (mg/kg)			
Canned food	**1987/88**	**1990/91**	**1997/98**	**2016**
Baked beans	53.00	6.50	51.35	25.31
Beetroot	14.00	30.50	3.25	1.31
Fish	<1.00/<1.00[a]	1.86/2.86[a]	0.52[a]	0.02
Peach	96.00	44.20	52.85	52.16
Pineapple	66.00	43.80	74.66	95.78
Spaghetti	73.00	13.00	76.05	34.65
Tomatoes in juice	29.00	27.50	49.40	47.31

[a] Two forms of canned fish were tested in the 1987/88 and 1990/91 NZTDS: canned salmon/canned tuna. In the 1997/98 NZTDS, only canned salmon was tested.

Table 30: Comparative tin dietary exposures for adult females and males (25 years and above)

	Estimated weekly exposure (mg/kg bw/week) (lower-bound–[mid-bound]–upper-bound)			
Population cohort	**NZTDS**	**FTDS[a]**	**HKTDS[b]**	**ITDS[c]**
Adult females	0.18[d]	[0.02][e]	0.04[d]	0.03–0.04[f]
Adult males	0.18[d]	[0.03]	0.02[d]	

[a] FTDS: French Total Diet Study (ANSES, 2011a).
[b] HKTDS: Hong Kong Total Diet Study (CFS, 2013).
[c] ITDS: Irish Total Diet Study (FSAI, 2016).
[d] Lower-bound and upper-bound means derive the same rounded value.
[e] Women of childbearing age (18–45 years).
[f] All adults (18 years and above).

Figure 38: Major tin contributing food types (mid-bound mean exposure) in the 2016 NZTDS for adult males (25 years and above)

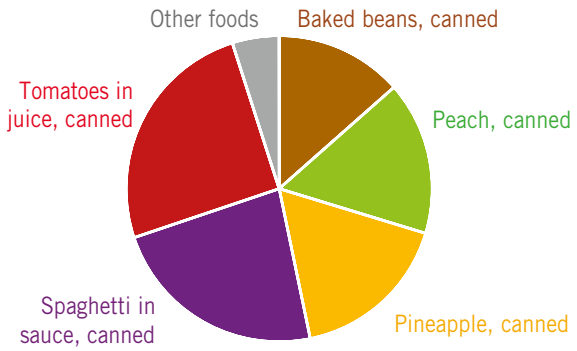
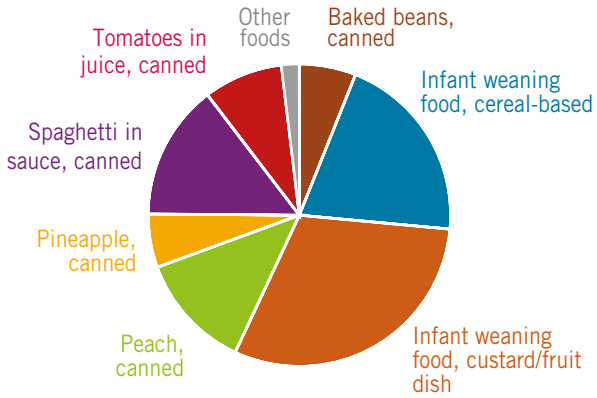
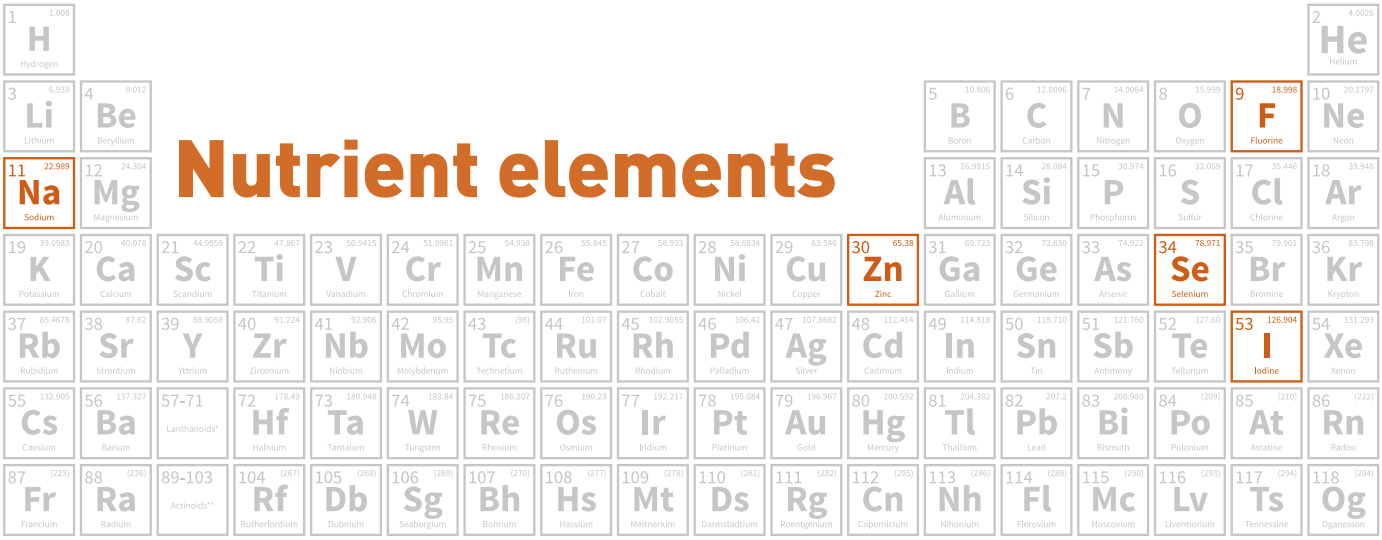


Figure 39: Major tin contributing food types (mid-bound mean exposure) in the 2016 NZTDS for infants (6-12 months)







Introduction

Nutrient elements are present in varying amounts in the foods we eat and are essential for the body to maintain normal, healthy functions. Some of these nutrients are considered to be trace elements and are required in very small amounts. Nutrient deficiency occurs where an individual, including a growing foetus, is not receiving sufficient intakes of a nutrient, and this can lead to adverse impacts on health, normal growth and development. However, excess intake of a nutrient element can lead to toxicity in a similar manner as for the contaminant elements. For some elements, the margin between the recommended dietary intake and toxicity can be quite small.

Five nutrient elements: fluoride, iodine, selenium, sodium and zinc were included in the 2016 NZTDS. Iodine has been included since 1987/88 and selenium since 1997/98, allowing temporal trends to be determined. Fluoride and zinc were included in the 1987/88 and 1990/91 NZTDSs, but have not been included since that time. Sodium has been included since 2003/04.

Iodine is an essential trace element required for the synthesis of the thyroid hormones. Iodine plays a critical role in the normal growth and development of tissues (Gibson, 2005; NHMRC & Ministry of Health, 2006). Selenium is found in all tissues and has an essential role in several important metabolic processes, including antioxidant activities and thyroid hormone metabolism. Sodium is an essential nutrient necessary for the maintenance of key physiological activities such as extracellular fluid volume and cellular membrane potential.

Fluoride is a normal constituent of the human body, and approximately 99% of fluoride is strongly associated with calcified tissue (i.e., bone and teeth). Inadequate fluoride intakes are associated with increased tooth decay and excessive intakes with damage to tooth enamel or, in extreme cases, bones. While there have been improvements in the oral health of New Zealanders in the past 20 years, New Zealanders continue to have a comparatively high rate of tooth decay, and health disparities continue to exist (MOH, 2010).

Zinc is an essential trace mineral and is the second most abundant in the human body (King, 1999). Zinc has an important role in normal growth and development, including normal metabolism and immune system function.

Iodine and selenium are a priority because there are ongoing concerns that intake levels in the New Zealand diet are inadequate, or are approaching inadequate levels. In contrast, although sodium is an essential nutrient, New Zealanders consume far in excess of what is required (McLean et al., 2012; MOH, 2015). High sodium intakes are associated with elevated blood pressure, which can lead to cardiovascular disease, stroke and renal disease (NHMRC, 2017; WHO, 2012).

While iodine, selenium, sodium and zinc were measured in all foods, due to methodological limitations, fluoride was only measured in cereals and cereal products, vegetables, fruits, alcoholic and non-alcoholic beverages, nuts and dairy substitutes.

Interpreting the nutrient element results

Concentration data

All of the reported nutrient results in the 2016 NZTDS have been reported as part of the quarterly reporting (Pearson, 2016, 2016a, 2016b, 2017). In addition, Appendix 13 provides a summary table for each of the nutrient elements, sorted alphabetically by the food type analysed in the NZTDS.

Nutrient reference values

In contrast to the agricultural chemicals and contaminant elements, where HBGVs are used, nutrient reference values (NRVs) are used for the characterisation of intakes of nutrient elements. NRVs encompass two sets of values relevant for the nutrients. The first is the intake level required to meet nutritional requirements and prevent a deficiency in the diet from which adverse health effects could occur. The second is the intake level above which there is anexcess of the nutrient being consumed, with potential for toxicity or interference of uptake of other nutrients.

Comparison of 2016 NZTDS results with previous NZTDS years

As for the agricultural chemicals and contaminant elements, the analysis of trends in nutrient concentrations in certain foods can identify areas of potential concern or whether mitigation methods in certain foods are taking effect. As a result, where possible for the nutrient elements, except fluoride, trends across the NZTDS years have been collated. Fluoride results from the 1990/91 NZTDS have not been compared against those from the current study because, given the methodological limitations in the samples that could be analysed in the 2016 NZTDS, a direct comparison is not reliable.

In interpreting any trends, it is important to note that some minor methodological differences are evident between NZTDS years, these may include differences in LOR, with a general trend for these to improve in the more recent studies. In addition, some food types may have changed over the course of the study, for example, eggs in the 1987/88 and 1990/91 NZTDS were sampled separately as boiled and poached eggs. Where these changes have an implication for interpreting the trends in concentrations or exposures, these have been recorded in a footnote.

Comparison of 2016 NZTDS results with overseas data

The nutrient dietary intakes estimated in the 2016 NZTDS have been compared with estimates from overseas TDSs. In all cases, dietary intake estimates have been expressed in the same unit as the New Zealand estimates and comparisons conducted on that basis. The studies and methods used for comparison are:

- The 23rd Australian Total Diet Study (ATDS; FSANZ, 2011) – In the ATDS, mean intake estimates are reported in mg/day (fluoride and zinc) or µg/kg bw/day (selenium) for different age groups in the female and male adult population (19-29 years, 30–49 years, 50–69 years and 70 years and over), and for male and female children (4–6 years). The range of intakes for all female and male adult age groups and the male and female child intake were selected as points for comparison. Comparisons were made to the 2016 NZTDS dietary intakes for children (5–6 years) and adult females and adult males (25 years and above).
- The First Brazilian Total Diet Study (BTDS; Avegliano et al., 2011) – In the BTDS, mean intake estimates are reported in mg/day for the full population. Comparisons were made to the 2016 NZTDS dietary intakes for children (5–6 years), and adult females and adult males (25 years and above).
- The Second French Total Diet Study (FTDS; ANSES, 2011a) – In the FTDS, mid-bound mean dietary intake estimates for nutrients are reported in µg/day for children (3–6 years), adult females of childbearing age (18–45 years) and all adults (18–79 years). Comparisons were made to the 2016 NZTDS dietary intakes for children (5–6 years) and adult females and adult males (25 years and above).
- The First Hong Kong Total Diet Study (HKTDS; CFS, 2014a) – In the HKTDS, mid-bound mean dietary intake estimates for nutrients are reported in µg/day (selenium), mg/day (zinc) and g/day (sodium) for adult females and males (20–84 years). Comparisons were made to the 2016 NZTDS dietary exposures for adult females and adult males (25 years and above).
- The 2012–2014 Irish Total Diet Study (ITDS; FSAI, 2016) – In the ITDS, the range of lower-bound to upper-bound mean intake estimates are reported in µg/day for all adults (18 years and above) and children (5–12 years). Comparisons were made to the 2016 NZTDS dietary exposures for children (5–6 years) and for adult females and adult males (25 years and above).

Fluoride

Fluoride is the negative ion of the element fluorine. Pure fluorine is highly reactive and in the environment it is predominantly present as fluoride minerals. Fluoride is relatively common in rocks and soil. As a result, it is an element that is naturally present in food and drink, although naturally occurring levels of fluoride vary considerably geographically. In New Zealand, a key environmental source of fluoride is volcanic ash. Livestock consuming too much ash after an eruption can be stricken with acute fluoride poisoning (Cronin et al., 2003).

Fluoride's positive role in the diet relates to its protective effect against tooth decay. Fluoridation of water is the controlled process of deliberately adjusting the natural level of fluoride to levels that provide optimal protection against tooth decay (between 0.7 mg/L and 1.0 mg/L) (RSNZ, 2014). Currently, local authorities are responsible for fluoridation of water supplies in New Zealand. Approximately 2.1 million (56% of the population) New Zealanders receive fluoridated water through public water supplies (Sapare Research Group, 2015).

Nutrient identification

Fluoride is a normal constituent of the human body, and approximately 99% of fluoride is strongly associated with calcified tissue (i.e., bone and teeth). Water-soluble fluoride is almost completely absorbed, however, the bioavailability may be impaired by calcium, magnesium and aluminium (NHMRC, 2017a).

Although it is not considered essential for growth and development, fluoride has been known for more than a hundred years to be useful in the prevention and control of tooth decay (dental caries). Fluoride can assist in the prevention of dental caries in a number of ways. In infants and young children, fluoride is incorporated into the developing enamel of teeth as fluorapatite, which strengthens the teeth enabling them to be more resistant to decay (NHMRC, 2017; RSNZ, 2014). The consumption of fluoride increases the concentration of fluoride in saliva and plaque fluid. This can reduce the rate of enamel demineralisation and can promote remineralisation of early stages of tooth decay (NHMRC, 2017; RSNZ, 2014).

While there have been improvements in the oral health of New Zealanders in the past 20 years, New Zealanders continue to have a comparatively high rate of tooth decay, and health disparities continue to exist (MOH, 2010). The New Zealand Ministry of Health continue to support councils in promoting water fluoridation and has pursued a public health policy to improve oral health at the population level.

Both inadequate and excessive fluoride intakes can affect dental health. Inadequate intakes are associated with increased tooth decay and excessive intakes with damage to tooth enamel (dental fluorosis). Prolonged exposure to excessive intakes of fluoride can result in skeletal fluorosis and bone fractures. Moderate or severe dental fluorosis is uncommon in New Zealand (NHMRC, 2017).

Nutrient characterisation

NRVs for the Australian and New Zealand population were initially established for fluoride in 2006 (NHMRC & Ministry of Health, 2006). In March 2017, the NRVs for fluoride were revised for infants and young children aged 0–8 years old (NHMRC, 2017a; Appendix 14.).

The adequate intake levels for all population groups are based on studies that have demonstrated that near optimal caries prevention is achieved when mean daily dietary intakes of fluoride are approximately 0.05 mg/kg bw/day (NHMRC & Ministry of Health, 2006; NHMRC, 2017a). Intakes of 3–4 mg/day for adults, and intakes of 2–3 mg per day for children aged 9–18 years are assumed to be adequate. In the 2017 Australian National Health and Medical Research Council review, a fluoride intake of 0.05 mg/kg bw/day was reaffirmed as applicable to the 0–8 year age group, but applied to updated reference body weight values. No adequate intake level has been established for infants aged 0–6 months because no preventative effect has been seen in the first six months of life (NHMRC, 2017a).

The upper levels of intake for adults and children aged 9 years and over were not reviewed in 2017. The upper level of intake for these age groups is set at 10 mg/day and is based on moderate enamel fluorosis. A No Observable Adverse Effect Level has been set at 10 mg/day based on data on the relationship between fluoride intake and skeletal fluorosis (NHMRC, 2017a). The revised upper levels of intake for children aged 0–8 years range between 1.2 mg/day and 4.4 mg/day. These upper levels of intake are derived from a level of 0.2 mg/kg bw/day, which is the identified endpoint for enamel pitting or loss, which is visible as severe dental fluorosis (NHMRC, 2017a).

Prevalence and concentrations

The concentrations of fluoride in individual foods of the 2016 NZTDS have been presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in Appendix 13, with minimum, maximum and arithmetic mean concentrations calculated for fluoride in each food type.

Slightly over half the samples from the 2016 NZTDS were analysed for fluoride (57%); plant-based foods and beverages were targeted for analysis. From the 600 food samples analysed for fluoride, detected concentrations were reported in 77 samples (13%). For high fat and high sugar/carbohydrate foods, the extraction of fluoride from the food matrix is challenging; this resulted in the LORs for fluoride in these food types being above 1 mg/kg. The consequence of this was that the results for fluoride were largely non-detect values and fluoride was probably present in more samples from the 2016 NZTDS but at levels below the LOR.

All eight samples of tap water contained fluoride, however, there was a noted difference in levels between the regions undertaking fluoridation (0.73–0.76 mg/L) and those not (0.08-0.16 mg/L). Three bottled water samples also had detections of fluoride at 0.06 mg/L, likely reflecting

background levels in aquifers. Fluoride concentrations were also reported in other beverages at levels similar to those in fluoridated water, including beer (8 detections; range 0.4–0.5 mg/L), caffeinated beverage (3 detections; range 0.5–0.6 mg/L) and orange juice (2 detections; 0.7 mg/L). Fluoride was also present in all of the tea samples, but at greater concentrations than the other beverages and water (range: 1.1–6.5 mg/L). In the NZTDS food preparation, the tea samples were brewed with deionised water so the fluoride originates only from the tea leaves. The tea plant is reported to naturally accumulate fluoride from the soil, leading to the brewed tea being fluoride rich (Cai et al., 2016).

Fluoride was reported at similar concentration in both soya milk and tofu (0.6–1.5 mg/kg). These values closely match the 0.6–1.8 mg/kg range reported in soya beverages in the ATDS (FSANZ, 2011). They also show similarity to a study of commercially available soya milk in the United Kingdom that identified fluoride concentrations of up to 0.96 mg/L (Lal et al., 2014). The highest concentrations of fluoride were reported in almonds (range 2.4–14.2 mg/kg), all the samples of which were of imported origin. Presence of fluoride in almonds is speculated to result from the use of the fumigant sulfuryl fluoride in the exporting country, which is reported to leave some residual fluoride on the food (JMPR, 2005).

Dietary intake estimates

Estimates for dietary fluoride intake at lower-bound, mid-bound and upper-bound means for all the population cohorts have been summarised in Appendix 14. The intakes are expressed as mg/person/day. Due to methodological limitations, animal-based foods were not able to be analysed for fluoride, and the dietary intakes from these foods are not accounted for. A further consideration is that for foods with water as an ingredient, such as coffee and tea, these have been prepared in the laboratory with deionised water, in which there is no fluoride. Consequently, the fluoride introduced from adding water to a prepared food, either at natural fluoride levels or elevated through fluoridation, is not accounted for. Additionally, the simulated dietary intake from tap and bottled water includes only that consumed directly and not as a water ingredient in a prepared food. As a result, it is not possible to accurately estimate the influence that fluoridation of water has on total fluoride intakes because only the contribution from directly consumed water is accounted for. Finally, the high LORs for solid foods analysed for fluoride signify that upper-bound, and possibly mid-bound, mean estimates of dietary intake may be highly conservative.

The highest estimated mid-bound mean fluoride intakes were in adult females (2.0 mg/day), closely followed by adult males (1.9 mg/day). For both Pacific Island adult ethnicity cohorts, estimates of fluoride intake were lower than for the general population (1.2–1.3 mg/day). This difference largely results from the difference in estimated intake of tea in the Pacific Island ethnicity diets, with this approximately half the value estimated for the general adult population. For all the adult diets (except young adult males), tea still makes up the largest source of fluoride intake, contributing 60–80% to total intake.

Estimated fluoride intakes for infant, child and adolescent population cohorts are much lower than those for adult cohorts, ranging from 0.12 mg/day for infants to 0.5 mg/day for teenage boys. Despite the high concentrations of fluoride in almonds, they do not contribute more than 1% of the estimated fluoride dietary intake for any of the population cohorts.

As consumption values for tea are much lower in the infant, child and teenage diets, the contribution to fluoride intake from directly imbibed tap water is more evident. Tap water contributes 47% to the estimated fluoride intake for infants. For the adult diets, fluoride from tap water contributes a much lower proportion of fluoride intake, given there are other key dietary sources, such as tea. A similar trend is reported in the ATDS where infant, child and teenage groups all had greater than 30% of fluoride intake from non-bottled water (FSANZ, 2011). However, the contribution to fluoride intake from water decreased in adult groups, in particular, for age groups above 50 years of age, where tea becomes the predominant contributor (FSANZ, 2011).

Risk characterisation

The estimated fluoride intakes from beverages and plant-based foods for the population cohorts in the 2016 NZTDS have been characterised against the NRVs for each age and gender group in Appendix 14.

Because fluoride analysis was only undertaken on a part of the diet, any conclusions on whether intakes fulfil nutritional requirements should be treated with caution. From beverage and plant-based foods only, the mean fluoride intakes for all the population cohorts are estimated to be below the adequate level of intake. Animal-derived foods, and water as a food ingredient, would also contribute to dietary intakes of fluoride and may provide sufficient intakes to achieve the adequate level of intake. Of the reported fluoride intakes from animal-based foods in the ATDS, the beef, veal and venison food group was reported to contribute 5–6% to the total intake for adult males (17–49 years of age) and infant formula 20% of the total intake for the infant age group (FSANZ, 2011).

The estimated fluoride intakes in the 2016 NZTDS from beverage and plant-based foods were all below the upper levels of intake for each population cohort. The highest mean fluoride intake was 18% of the upper level of intake for children and 17% of the upper level of intake for toddlers. However, because the consumption of animal-based foods as well as exclusive use of a fluoridated water source would further contribute to fluoride intakes, a definitive conclusion on intakes relative to the upper levels of intake cannot be made.

The only fluoride intake estimate in a TDS is from the ATDS, with estimated fluoride mean intakes between 2.5–3.4 mg/day for the different age and gender group bandings of the general adult population, and 0.7–2.7 mg/day for infants, children and teenagers (FSANZ, 2011).

Iodine

Iodine is an essential trace mineral found in food and water predominantly in the form of iodide and iodate. The concentrations of iodine in food and water are highly variable and largely reflect the iodine content in agricultural soils, influenced by natural geology and human factors such as irrigation and fertilisers (NHMRC & Ministry of Health, 2006). In New Zealand, soils are relatively low in iodine and as a result New Zealanders have been predisposed to mild to moderate iodine deficiency disorders.

Foods of marine origin, such as fish, shellfish and seaweed, contain the highest dietary concentrations of iodine, followed by other animal-derived foods and foods containing iodised salt. The iodine content of dairy products varies considerably depending on the concentration of iodine in animal feed, and the use of iodine containing disinfectants (iodophors) by the dairy industry (NHMRC & Ministry of Health, 2006).

Absorption of iodine in the stomach and intestines is considered to be relatively high (approximately 90%). Dietary goitrogens, such as those found in cabbage, broccoli, cauliflower and cassava, can interfere with iodine metabolism by inhibiting the production of thyroid hormones (NHMRC & Ministry of Health, 2006).

Nutrient identification

Iodine is an essential trace element that is required for the synthesis of the thyroid hormones. The thyroid hormones play a critical role in growth and development of tissues, such as the central nervous system, and also regulate basal metabolic rate and macronutrient metabolism (Gibson, 2005; NHMRC & Ministry of Health, 2006).

Deficiency can lead to a range of disorders termed iodine deficiency disorders, including goitre, hypothyroidism, cretinism, and physical impairment. At all ages, the most visible effect of iodine deficiency is goitre, an enlarged thyroid. However, the most serious effect of iodine deficiency is on cognitive impairment. Iodine requirements are highest for pregnant and lactating women, and an inadequate supply during this critical time can have serious consequences for brain development in the foetus or infant (NHMRC & Ministry of Health, 2006; Zimmerman, 2015).

Iodisation of salt was first introduced in 1924 and dramatically reduced the rate of goitre, from 30% of schoolchildren to less than 1% (Mann, 2003). In the past 20 years, several studies have indicated a re-emergence of mild iodine deficiency in New Zealand (MOH, 2003, 2011; Skeaff, 2002). This led to the mandatory fortification of bread with iodine, through the replacement of non-iodised salt with iodised salt, in New Zealand from September 2009. Representative surveys of the iodine status of New Zealand adults have shown significant improvements since the introduction of mandatory fortification of bread. Adults in a regional 2014/15 survey had a median urinary iodine concentration of 103 µg/L, in comparison to 53 µg/L in the 2008/09 Adult Nutrition Survey (ANS; MPI, 2016a).

Thyroid dysfunction also occurs with excessive intakes of iodine. Excessive iodine intake can result in enlargement of the thyroid gland and elevated production of thyroid-stimulating hormone (NHMRC & Ministry of Health, 2006; Zimmerman & Boelaert, 2015).

Nutrient characterisation

In 2006, the Australian National Health and Medical Research Council and the New Zealand Ministry of Health established NRVs for iodine intakes in the Australian and New Zealand population (NHMRC & Ministry of Health, 2006).

The estimated average requirement for iodine in adults is 100 µg/day and is based on studies indicating that iodine balance is achieved at intakes over 100 µg/day but not below 40 µg/day (NHMRC & Ministry of Health, 2006). For children and teenagers, the estimated average requirements for iodine are also based on balance studies and extrapolated data from adult populations using metabolic body weight ratios (NHMRC & Ministry of Health, 2006). Adequate intake levels were established for infants based on the average intake of iodine from breast milk (NHMRC & Ministry of Health, 2006).

Upper levels of intake for iodine are based on elevated thyroid stimulating hormone concentrations, which are the first sign of iodine excess (NHMRC & Ministry of Health, 2006). An upper level of intake of 1100 µg/day was established for adults, derived from the lowest observed adverse effect level of iodine on adult thyroid stimulating hormone concentrations of 1700 µg/day and an uncertainty factor of 1.5 (NHMRC & Ministry of Health, 2006). Upper levels of intake for teenagers and children were extrapolated from this finding based on metabolic body weight (NHMRC & Ministry of Health, 2006).

Prevalence and concentrations

The concentrations of iodine in individual foods of the 2016 NZTDS have been presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in Appendix 13, with minimum, maximum and arithmetic mean concentrations calculated for iodine in each food type.

Iodine concentrations were detected in 61% (640 out of 1056) of the foods sampled in the 2016 NZTDS. Because the 2016 NZTDS had comparable LORs to those used in the 2009 NZTDS, the reported prevalence of iodine can be considered to be similar to that of 2009 NZTDS , where 66% (643 out of 982) of the food samples had detected iodine concentrations. Iodine was widespread across the food types sampled in the 2016 NZTDS, however, the majority of foods (498) had concentrations of less than 0.1 mg/kg iodine. The highest concentrations for iodine were in oysters (0.8–1.8 mg/kg) and mussels (0.9–3.1 mg/kg).

A high concentration of iodine (2.3 mg/kg) was detected in a single lamb-mutton composite sample. This concentration was above the reported range for iodine in this food type from the previous NZTDSs. Sheep may receive iodine supplementation by intramuscular injection into the neck, but

meat from this area is rarely taken for human consumption. It is possible that the composite sample included meat from near the injection site or from the site of an incorrectly administered injection of a recently supplemented animal.

The impact of mandatory fortification of bread with iodine is evident in the large increase in iodine concentrations in bread in the 2016 NZTDS, compared with previous NZTDSs (Figure 40). Of the foods newly included in the 2016 NZTDS simulated diets, sushi shows appreciable iodine concentrations (range 0.18–0.76 mg/kg). This range is higher than that reported in fresh fish (0.15–0.26 mg/kg), rice (0.01 mg/kg) and chicken (0.004–0.01 mg/kg), which are the main ingredients of the samples. The elevated iodine concentration is expected to result from the use in the sushi wraps of seaweed (nori), a natural iodine accumulator that is reported to contain 29–46 mg/kg iodine (Yeh et al., 2014). A notable finding was that the four tap water samples sampled from the North Island contained detected concentrations of iodine (range 0.003–0.011 mg/L). However, the South Island tap water samples did not contain detected levels of iodine.

Dietary intake estimates

Estimates of dietary iodine intake at lower-bound, mid-bound and upper-bound means for all population cohorts have been summarised in Appendix 14. The intakes are expressed as µg/person/day. An adjusted estimate was made to exclude the unexpected iodine concentration in a single lamb-mutton sample, to identify the contribution this unexpected result made to overall intake. It is important to note that the iodine intake estimates do not account for any intake through the use of discretionary iodised salt. Discretionary salt may increase intakes of iodine, if the salt is iodised, however, this will also increase sodium intakes as discussed within the sodium section.

The highest unadjusted mean dietary iodine intake was estimated in the young adult male population cohort (155 µg/day). However, upon excluding the unexpected iodine result in the lamb-mutton intake for this population cohort, it reduced to 133 µg/day. Intakes in all population cohorts reduced slightly as a result of omitting the unexpected lamb result; lamb consumption contributed 1–6% of total dietary iodine intake. This contribution reduced to below 0.2% for all age groups

Figure 40: Iodine concentration (mid-bound mean) trends in the NZTDS (1987/88–2016)

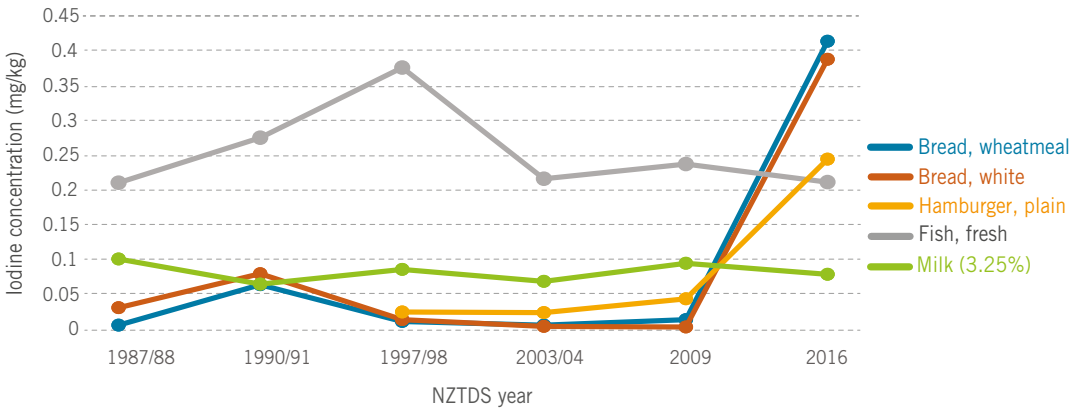
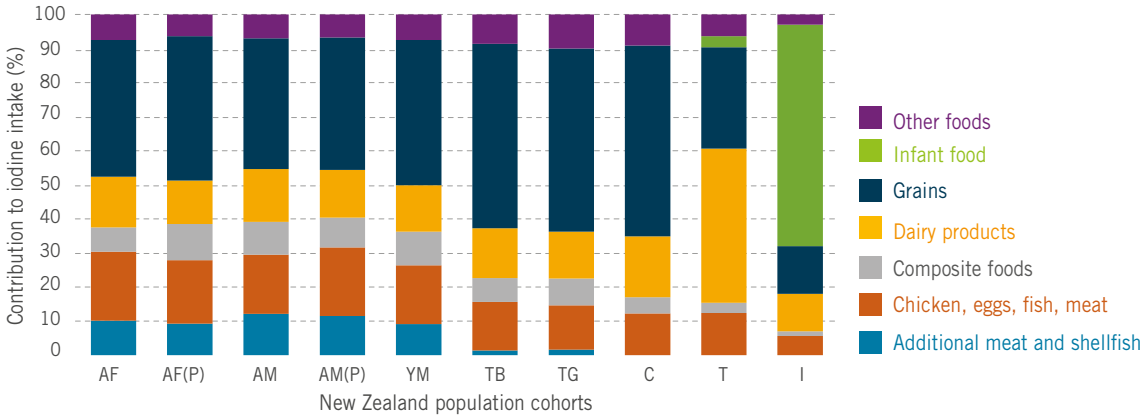


Figure 41: Major iodine contributing food groups (mid-bound mean intake) in the 2016 NZTDS



AF: Adult Female (25 years and over); AF(P): Adult Female – Pacific Island ethnicity (15 years and over); AM: Adult Male (25 years and over); AM(P): Adult Male – Pacific Island ethnicity (15 years and over); YM: Young Adult Male (19–24 years); TB: Teenage Boy (11–14 years); TG: Teenage Girl (11–14 years); C: Child (5–6 years); T: Toddler (1–3 years); I: Infant (6–12 months).

when the unexpected result was omitted. Iodine intakes for adult females were the lowest of the adult population cohorts, with an adjusted estimated dietary intake of 100 µg/day. For all the adult age groups, the largest contribution to iodine intakes was from cereal grain-based foods, with dairy and fish, meat and eggs also major contributors (Figure 41). Mandatory fortification of bread with iodine has markedly increased the contribution of cereal-based foods to total iodine intake (Figure 42). While dairy products have historically been the largest source of iodine intake in the New Zealand diet, bread was the primary dietary source of iodine in the 2016 NZTDS.

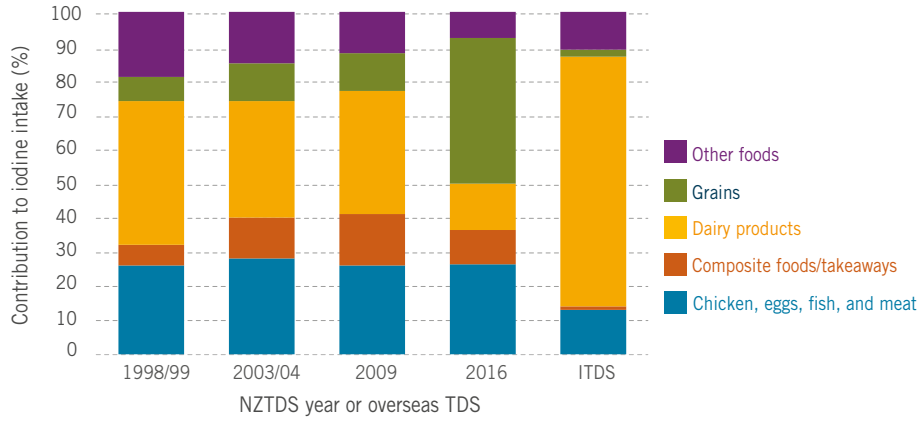
In the child and teenage cohorts, the estimated iodine intakes ranged from 70 µg/day for toddlers to 133 µg/day for teenage boys. The child and teenage population cohorts showed a similar high contribution from grains in the diet, as for the adult cohorts. For the infant and toddler age groups, grain products made a lower contribution to overall iodine intake, with dairy products being the most important source for toddlers and dairy-based infant formula for infants. This is more consistent with the 2009 NZTDS, in which dairy products contributed 66% of the iodine intake for toddlers, and infant formula 72% of the intake for infants. Because these two age groups consume much less grain-based foods than the other population cohorts, the influence of the mandatory fortification of bread with iodine is less.

Risk characterisation

The estimated dietary iodine intakes for the population cohorts in the 2016 NZTDS have been characterised against the NRV for each age and gender group in Appendix 14.

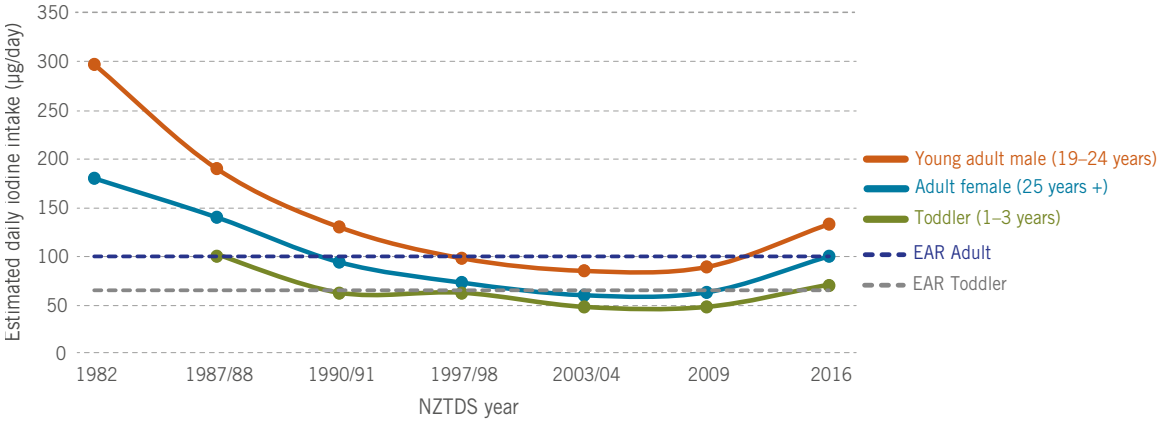
The increase in iodine intake evident since the previous 2009 NZTDS meant that all of the population cohorts met or exceeded the estimated average requirements for iodine. Because an estimated average requirement value is not available for infants, the estimated iodine intake for this age group was characterised against an adequate intake value instead. The dietary iodine intake for infants was 76% of the adequate intake.

Figure 42: Major iodine contributing food group (mid-bound mean intake) trends in the NZTDS (1997/98–2016) for young adult males (19–24 years) and comparison to iodine contributing food groups in the Irish adult diet (2012/14 ITDS[a])



[a] ITDS: Irish Total Diet Study (FSAI, 2016).

Figure 43: Dietary iodine intake (mid-bound mean) trends in the NZTDS (1982–2016) for adult females (25 years and above), young adult males (19–24 years) and toddlers (1–3 years), characterised against the estimated average requirements (EARs)[a]



[a] Adult EAR: 100 µg/day; Toddler EAR: 65 µg/day (NHMRC & Ministry of Health, 2006).

The increase in dietary iodine intakes across the population cohorts in the 2016 NZTDS is a large change from the plateau in iodine intakes since the 1997/98 NZTDS and the large decrease noted in the NZTDS studies before this (Figure 43). As a result of mandatory fortification of bread with iodine, all of the population cohorts, except infants, are now receiving dietary iodine intakes sufficient to meet nutritional requirements. This has not been achieved in most of the population cohorts since the early 1990s.

The mean dietary iodine intake estimates for all of the population cohorts are far below the upper levels of intake, with the toddler age group having the highest dietary iodine intakes at 35% of the upper level of intake. As a result, it was considered that a dietary risk from excess iodine was highly unlikely.

Few overseas TDSs analyse for iodine, as many nations' soils naturally contain iodine concentrations sufficient to contribute to dietary intakes. The ITDS reported higher dietary intakes of iodine for all of its age groups, compared with the 2016 NZTDS (Table 31; FSAI, 2016). In the ITDS, dairy products were the major contributors to dietary iodine intake.

Table 31: Comparative dietary iodine intakes for adults (15 years and above) and children (5–6 years)

	Estimated daily iodine intake (µg/day)			
Element	NZTDS All adults	ITDS[a] All adults	NZTDS Child 5–6 years	ITDS[a] All children
Iodine	100–140[b]	147–153[c]	92	162–167[c]

[a] ITDS: Irish Total Diet Study (FSAI, 2016).
[b] Mid-bound mean intake range for all adult population cohorts.
[c] Lower-bound to upper-bound mean intake range.



Selenium

Selenium is an essential dietary trace non-metal element. The selenium content of soil varies geographically and impacts on the selenium content of the food supply (Mehdi et al., 2013). In New Zealand, the selenium content of the soil is low, particularly in the South Island (Thomson, 2007).

The selenium content of grains and vegetables is reflective of the selenium content of the soil from which they are grown. Some plant sources can accumulate selenium to a greater extent than others. Brazil nuts and vegetables from the brassica (e.g., broccoli and cauliflower) and allium (e.g., garlic and onion) families are known selenium accumulators (Mehdi et al., 2013). The selenium content of foods from animal sources will also vary depending on the selenium content of their diet (Mehdi et al., 2013).

Important food sources of selenium include seafood, meat (muscle and organ) and eggs. The 2008/09 ANS found that bread, fish, seafood and poultry were the main sources of selenium in the diet (MOH, 2015). Previous surveys have shown regional variation in the selenium content of bread available in the North Island and South Island (Vannoort, 2005), with the higher selenium concentrations in North Island bread largely attributed to the importation of Australian wheat for bread baking (Thomson, 2007).

The absorption of selenium from food is generally high and occurs primarily in the small intestine. Selenium is equally well absorbed by selenium deficient and replete individuals (NHMRC & Ministry of Health, 2006).

Nutrient identification

Selenium occurs in all tissues and has an essential role in several important metabolic processes, including antioxidant activities and thyroid hormone metabolism. It is mainly present as selenomethionine incorporated into several selenoproteins. The most important of these are glutathione peroxidase, selenoprotein P, iodothyronine 5'-deiodinase and thioredoxin reductase (Mehdi et al., 2013; NHMRC & Ministry of Health, 2006).

In severe cases, selenium deficiency can lead to the onset of disease. Two diseases are linked to severe endemic deficiency: a cardiomyopathy (Keshan disease) and a chondrodysystrophy (Kashin-Beck disease). Keshan disease has been observed in areas of China where selenium intakes are very low (<20 µg/day). Keshan disease can lead to cardiac enlargement, arrhythmias, heart failure and premature death and has been found to be responsive to selenium supplementation. Kashin-Beck disease, a cartilage condition, may also occur in selenium-deficient areas, and manifests as enlarged joints, shortened fingers, toes and extremities and, in severe cases, dwarfism. Kashin-Beck disease has also been observed in low selenium areas in China, however, the disease does not respond to selenium supplementation. Selenium deficiency in conjunction with iodine deficiency has been reported to increase the risk of cretinism (NHMRC & Ministry of Health, 2006).

No clinical signs of selenium deficiency have been identified in New Zealanders, however, multiple studies indicate that the selenium status of New Zealand residents is low, particularly in the South Island (Thomson, 2004; Thomson, 2007; Thomson, 2012). The 2008/09 ANS found that selenium intakes had increased from 1997 to 2008/09, but were still inadequate for about a third of adult males and half of adult females (MOH, 2015).

Symptoms of selenium toxicity are brittleness and loss of hair and nails, gastrointestinal disturbance, skin rash, fatigue, irritability and nervous system abnormalities (NHMRC & Ministry of Health, 2006).

Nutrient characterisation

The recommended NRVs for selenium in the Australian and New Zealand population were established in 2006 by the Australian National Health and Medical Research Council (Appendix 14).

Selenium requirements were determined for optimum plasma glutathione peroxidase activity (NHMRC & Ministry of Health, 2006). Sufficient data was available to establish estimated average requirements based on experimental data on the efficiency of the selenoproteins, selenium-dependent glutathione peroxidase at varying intakes of selenium from supplements (Duffield, 1999; Xia, 2005). The findings were then applied to the reference adult body weights (NHMRC & Ministry of Health, 2006). The estimated average requirements for adult males and females are 60 µg and 50 µg/day, respectively. The estimated average requirements for children and teenagers were extrapolated from the adult data on a metabolic weight basis and rounded to the nearest 5 µg (NHMRC & Ministry of Health, 2006). Adequate intake levels were established for infants based on the average intakes of selenium from breast milk (NHMRC & Ministry of Health, 2006).

Selenium toxicity is rare and there is limited data to establish an upper level of intake. The National Health and Medical Research Council established an upper level of intake for all adults of 400 µg/day from food and supplements. The upper level of intake is based on a study showing a possible increased risk of cancer from supplements of 200 µg/day (Duffield-Lillico, 2003) with an uncertainty factor of two to allow for knowledge and data gaps (NHMRC & Ministry of Health, 2006).

Prevalence and concentrations

The concentrations of selenium in individual foods of the 2016 NZTDS have been presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in Appendix 13, with minimum, maximum and arithmetic mean concentrations calculated for selenium in each food type.

Selenium concentrations were detected in just over half (51%; 534 out of 1056) of the samples analysed in the 2016 NZTDS; nearly identical to that reported in the 2009 NZTDS (52%; 495

out of 958). Most of the foods with detected selenium had concentrations between 0.01 mg/kg and 0.1 mg/kg; the foods being predominantly cereal grain, dairy or meat based. The highest concentrations of selenium were detected in mussels (0.44–0.81 mg/kg), oysters (0.33–0.72 mg/kg) and fresh and canned fish (0.23–0.78 mg/kg). The other seafood commodities also had above-average levels of selenium. For non-seafood commodities, mushrooms (0.25–0.43 mg/kg) and eggs (0.25–0.32 mg/kg) also had appreciable concentrations of selenium.

Selenium concentrations across the four most recent NZTDSs have largely remained consistent, however, a large decrease in the selenium concentration in oysters was reported after the 1997/98 NZTDS (Table 32).

As reported in previous NZTDSs, there was a notable difference in selenium concentrations in bread from the North Island and South Island sampling locations (Figure 44). This difference contrasts to other food types where this geographical disparity is not evident. The North Island predominantly uses wheat imported from Australia, which is grown in more selenium-enriched soils. The South Island is virtually self-sufficient in providing its wheat needs from domestic arable farms, which leads to a reduced concentration of selenium in the grain-based foods, and therefore lower selenium intakes.

Dietary intake estimates

Dietary selenium intake estimates at lower-bound, mid-bound and upper-bound means for all population cohorts have been summarised in Appendix 14. The intakes are expressed for each population cohort in µg/day.

Within the adult cohorts, dietary selenium intakes were greatest in the adult male of Pacific Island ethnicity population cohort (109 µg/day) and least in the adult female cohort (68 µg/day). For the infant, child and teenage groups, teenage boys had the highest selenium intake (72 µg/day) and infants the lowest (24 µg/day).

The predominant dietary contributors to selenium intake for most of the population cohorts were fish, chicken, meat and eggs (Figure 45), with grain-based foods also being an important source of dietary intake, particularly in the infant, child and teenagers diets. For infants, a key dietary source of selenium was infant and follow-on formula. Contributions from the different food types to selenium intake have changed little over the past three NZTDSs (Figure 46). In addition, accounting for a difference in allocation of foods to certain groups, the NZTDS results compare well with the contributions to intake reported in the ITDS.

Given the consistency of selenium concentrations with those of previous NZTDS years, it was expected that the dietary

Table 32: Selenium concentration (mid-bound mean) trends in the NZTDS (1997/98–2016)

	Mid-bound mean selenium concentration (mg/kg)			
Food type	**1997/98**	**2003/04**	**2009**	**2016**
Chicken	0.208	0.199	0.340	0.254
Eggs	0.391	0.269	0.240	0.272
Fish fingers	0.253	0.255	0.285	0.237
Milk, 3.25% fat	0.014	0.007	0.006	0.008
Oysters	1.422	0.412	0.453	0.487
Peanuts, whole	0.105	0.063	0.083	0.097
Pizza	0.164	0.065	0.085	0.070

Figure 44: Seasonal and regional comparisons of selenium concentrations in selected food samples of the 2016 NZTDS

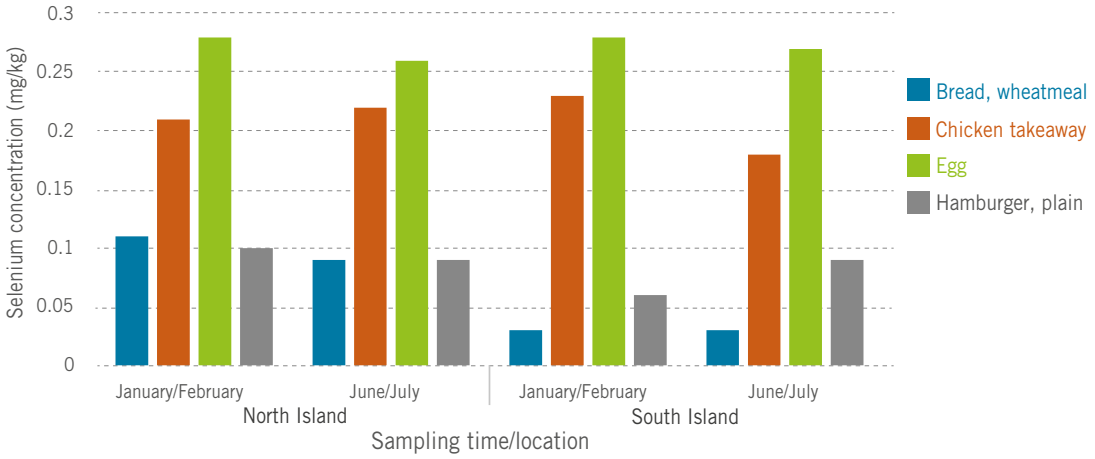
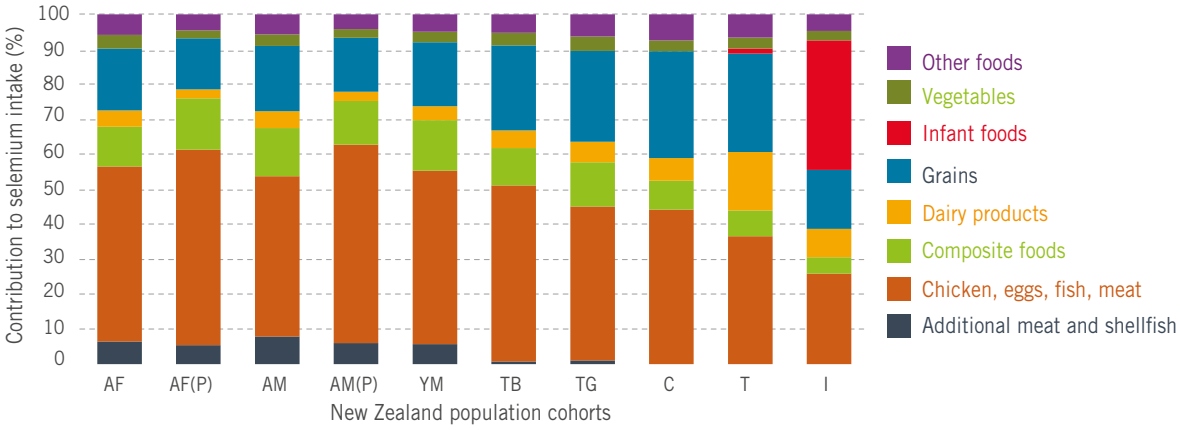
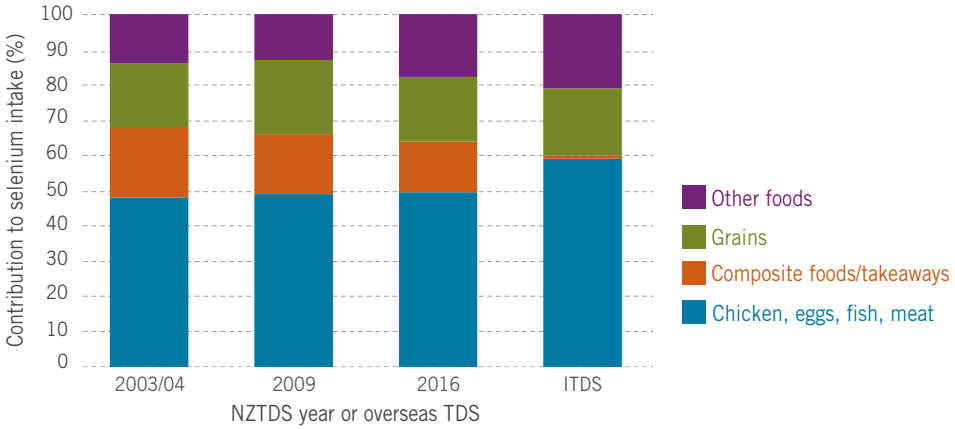


Figure 45: Major selenium contributing food groups (mid-bound mean intake) in the 2016 NZTDS



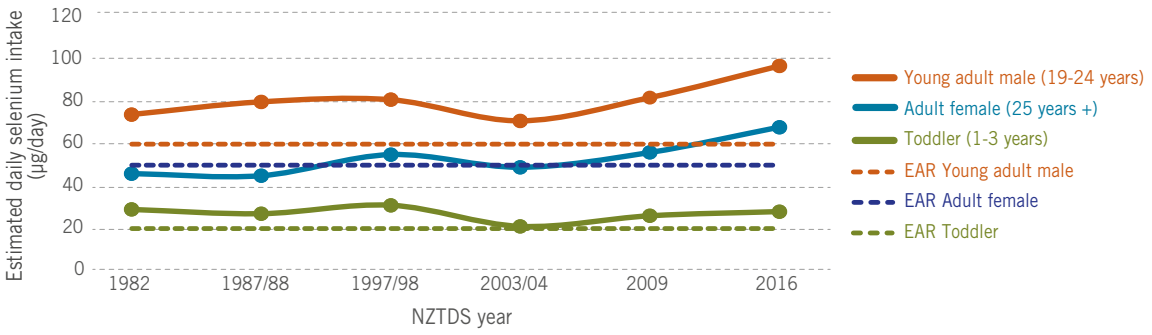
AF: Adult Female (25 years and over); AF(P): Adult Female – Pacific Island ethnicity (15 years and over); AM: Adult Male (25 years and over); AM(P): Adult Male – Pacific Island ethnicity (15 years and over); YM: Young Adult Male (19–24 years); TB: Teenage Boy (11–14 years); TG: Teenage Girl (11–14 years); C: Child (5–6 years); T: Toddler (1–3 years); I: Infant (6–12 months).

Figure 46: Trends in major selenium contributing food groups (mid-bound mean intake) in the NZTDS (2003/04–2016) for young adult males (19–24 years) and comparison to selenium contributing food groups in the Irish adult diet (2012/14 ITDS[a])



[a] ITDS: Irish Total Diet Study (FSAI, 2016).

Figure 47: Selenium intake trends in the NZTDS (1982–1987/88 and 1997/98–2016) for adult females (25 years and above), young adult males (19–24 years) and toddlers (1–3 years), with characterisation against estimated average requirements (EARs)[a]



[a] Adult female EAR: 50 µg/day; Adult male EAR: 60 µg/day; Toddler EAR: 20 µg/day (NHMRC & Ministry of Health, 2006).

intakes would also be relatively consistent. However, a slight increasing trend is evident for adult females and young adult males (Figure 47). While the selenium concentrations have not changed in key contributors, consumption of the foods has increased. For example, in the young adult male simulated diet, the estimated daily consumption of chicken has increased from 47 g in the 2009 NZTDS to 58 g in the 2016 NZTDS. A consequence of changes in consumption patterns is that the estimated selenium intake in many of the adult age groups has increased.

Risk characterisation

The estimated intakes for selenium for the population cohorts in the 2016 NZTDS have been characterised against the NRV for each age and gender group in Appendix 14.

All of the population cohorts had sufficient intakes of selenium, as characterised by the estimated dietary intakes all falling within 135–182% of the estimated average requirement values.

In addition, none of the population cohorts had estimated mean dietary intakes close to the upper level of intake for selenium, indicating that the risk of selenium toxicity is highly unlikely.

The New Zealand diet is therefore currently providing sufficient dietary selenium to meet the nutritional needs of the population. Minor changes in consumption of key contributing foods have resulted in increases to the daily intake of selenium. New Zealand intakes for selenium are within the range reported in overseas studies, but are considerably below dietary intakes in Hong Kong and Australia (Table 33; CFS, 2014a; FSANZ, 2011). The contrast in dietary intakes between the 2016 NZTDS and the ATDS is notable, given that when this comparison was made in the 2009 NZTDS (against the 2004 ATDS), the estimated dietary intakes were near equal for many of the population cohorts.

Table 33: Comparative dietary selenium intakes for adult females and adult males (25 years and above) and children (5–6 years)

	Estimated daily selenium intake (µg/day)				
Population cohort	**NZTDS**	**ATDS[a]**	**FTDS[b]**	**HKTDS[c]**	**ITDS[d]**
Adult females	68	97–111[e]	58[f]	130	58–68 (All adults)[g]
Adult males	83	130–171[e]	64 (All adults)	160	
Children	42	87/98[h]	35[i]	Not calculated	35–39[g]

[a] ATDS: Australian Total Diet Study (FSANZ, 2011).
[b] FTDS: French Total Diet Study (ANSES, 2011a).
[c] HKTDS: Hong Kong Total Diet Study (CFS, 2014a).
[d] ITDS: Irish Total Diet Study (FSAI, 2016).
[e] The intake range is for different age groups in the adult population, includes 19–29 years, 30–49 years, 50–69 years and 70 years and over.
[f] Women of childbearing age (18–45 years).
[g] Lower-bound to upper-bound mean intakes.
[h] Female child/male child (both ages 4–8 years).
[i] Children 3–6 years.



Sodium

Sodium is a very common alkali metal that is present in many regularly consumed foods in New Zealand. Salt (sodium chloride) had been traded since antiquity, but it was not until the 19th century that sodium was chemically isolated.

Sodium is naturally present in all foods, but most dietary sodium is added to foods (McLean et al., 2012). Sodium is added to foods to enhance flavour, preserve food and improve processing. It can be added as sodium chloride (salt), sodium bicarbonate, monosodium glutamate, sodium phosphate, sodium carbonate and sodium benzoate (McLean et al., 2012).

Most dietary sodium comes from salt in packaged foods, while about 10–20% comes from salt added during cooking or at the table (Brown et al., 2009). The food industry has been reducing salt in many products to bring down sodium levels. The NZTDS has been used to monitor sodium concentrations in foods since the 2003/04 NZTDS.

Nutrient identification

Sodium is an essential nutrient necessary for the maintenance of key physiological activities such as extracellular fluid volume and cellular membrane potential. It is the principal cation in human extracellular fluid and is necessary for the maintenance of plasma volume, acid-base balance, transmission of nerve impulse and normal cell function (NHMRC, 2017a; WHO, 2012). Sodium levels in the body are maintained by the kidneys with approximately 90% of ingested sodium excreted in urine (He et al., 2014).

Although sodium is an essential nutrient, New Zealanders consume far in excess of what is required (McLean, 2012; MOH, 2015). High sodium intakes are associated with elevated blood pressure, which can lead to cardiovascular disease, stroke and renal disease (NHMRC, 2017a; WHO, 2012). In New Zealand, a substantial proportion of the population have high blood pressure. In the 2008/09 ANS, 15% of adults 15 years and above reported taking medication to lower blood pressure, and 31% could be defined as having hypertension (McLean et al., 2013).

Reducing sodium intakes in the population has been recognised as a significant public health issue due to its effect on reducing blood pressure and risk of cardiovascular disease – a major cause of premature death in the New Zealand population (MOH 2015; NHMRC 2017a; WHO 2012).

Nutrient characterisation

In September 2017, the Australian National Health and Medical Research Council revised the suggested dietary target and upper level of intake for sodium (NHMRC, 2017a). These values were reviewed as a public health priority given the high-quality evidence that sodium intakes are associated with blood pressure. Because the revised suggested dietary target and upper level of intake values were established during the course of the 2016 NZTDS, analysis was conducted using both the 2006 and 2017 NRVs (Appendix 14).

In the absence of sufficient data to set estimated average requirement values for sodium, an adequate intake of 460-920 mg/day was set for adults to ensure basic requirements are met and to allow adequate intakes of other nutrients. The adequate intake levels for children and teenagers were derived from adult values, with adjustment for relative energy intakes (NHMRC & Ministry of Health, 2006). The adequate intakes for children, teenagers and adults were not reviewed in 2017 (NHMRC, 2017a).

In 2006, the National Health and Medical Research Council set an upper level of intake for sodium of 2300 mg/day based on population studies showing low levels of hypertension in communities with dietary sodium intakes at this level (NHMRC & Ministry of Health, 2006). Because the relationship between dietary sodium intakes and blood pressure is continuous, it was noted in the 2006 review that accurately establishing an upper level of intake is difficult. In the most recent review of the evidence, it was concluded that an upper level of intake should not be established for adults. This is because no single identifiable point at which higher dietary sodium intakes were not associated with higher blood pressure could be determined in the analysis (NHMRC, 2017a). This approach is in alignment with that taken by other international authorities, including the WHO (WHO, 2012).

The suggested dietary target is the daily mean dietary intake of a nutrient that may help in the prevention of chronic disease. The purpose of the sodium suggested dietary target is to assist in the prevention of high blood pressure. In 2006, the suggested dietary target was set at 1600 mg/day. This level was established based on a review of the evidence that demonstrated that further lowering sodium intakes to 1600 mg/day could result in further reducing the risk of chronic disease. In the 2017 National Health and Medical Research Council review, the suggested dietary target was revised to 2000 mg/day. This level was based on the feasibility of meeting all nutrient recommendations given the current food supply, and would result in a reduction in systolic blood pressure of approximately 2 millimetre of mercury (NHMRC, 2017a). The suggested dietary target is consistent with the 2012 WHO sodium guidelines, which strongly recommend that adults reduce their dietary sodium intake to less than 2000 mg/day (WHO, 2012).

Prevalence and concentrations

The concentrations of sodium in individual foods in the 2016 NZTDS have been presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in Appendix 13, with minimum, maximum and arithmetic mean concentrations calculated for sodium in each food type.

The majority (81%: 852 out of 1056) of the foods analysed in the 2016 NZTDS contained a detected sodium concentration. Food types notable for the absence of sodium included a number of fruits and vegetables, such as bananas, capsicum, strawberries and pumpkin, as well as coffee and tea. For foods with detected sodium concentrations, there was a

wide range in the concentrations detected, from 0.18 mg/L in bottled water to 49,300 mg/kg in yeast extract. The highest sodium concentrations were in yeast extract samples (34,000–49,000 mg/kg), followed by bacon (15,000–18,000 mg/kg) and ham (9000–15,000 mg/kg). The remainder of the sodium concentrations above 1000 mg/kg were found in processed foods, such as sausages, bread, condiments, breakfast cereals, takeaway foods and snack foods. Most seafood samples also had greater than 1000 mg/kg sodium, the exception being fresh fish with all samples having 700–1000 mg/kg. Many vegetables, such as carrot, celery and kumara, had sodium concentrations between 100–1000 mg/kg, as did milk (0.5% and 3.25% fat). Sodium was detected at low concentrations in all of the bottled and tap water samples (0.18–24 mg/L), with the four South Island tap water samples (4–7 mg/L) having approximately half the sodium content of the North Island samples (10–16 mg/L).

The addition of sodium during food manufacture is evident through comparisons of unprocessed foods and processed foods. For example, the mean concentrations of sodium in tomato sauce (5000–10,000 mg/kg) were more than 100 times those in fresh tomatoes (12–34 mg/kg).

Sodium concentrations in processed foods have remained largely unchanged across NZTDSs, although some decrease is evident in pizza and flavoured snacks (Table 34).

Dietary intake estimates

Dietary sodium intake estimates at lower-bound, mid-bound and upper-bound means for all population cohorts have been summarised in Appendix 14. The intakes are expressed for each population cohort in mg/day.

Within the adult population cohorts, the young adult male group had the highest mean daily sodium intakes (3470 mg/day) and the adult female group the lowest (2068 mg/day). For infant, child and teenager population cohorts, infants had the lowest sodium intake (842 mg/day) and teenage boys the highest (2877 mg/day). For all population cohorts, there was minimal difference between lower-bound and upper-bound mean values, indicating that the small proportion of foods without detectable sodium had little influence on dietary intakes. The contributors to dietary intake are largely consistent across all population cohorts, with the exception that infant and follow-on formula are an appreciable source of sodium in the infant group (12%). The key contributing food types are composite foods and grains (Figure 48). The chicken, eggs, fish and meat group also makes a notable contribution to dietary intake, largely as a result of the high sodium concentration in bacon. Bacon alone made up 11% of the total dietary sodium intake for young adult males. The contribution of different foods to total dietary sodium intake in each of the population cohorts was similar to the 2009 NZTDS. For example, grain products were estimated to collectively

Table 34: Sodium concentration (mid-bound mean) trends in the NZTDS (2003/04–2016)

	Mean sodium concentration (mg/kg)[a]		
Food type	**2003/04**	**2009**	**2016**
Bacon	15,000	17,000	16,000
Baked beans	4,300	4,300	4,300
Biscuits, crackers	4,600	6,400	6,900
Bran flake cereal	3,100	3,300	2,800
Fish fingers	3,800	4,000	3,900
Peanut butter	4,100	4,500	4,100
Pizza	5,900	5,200	4,800
Snacks, flavoured	12,000	7,000	6,600
Tomato sauce	7,100	8,300	7,300

[a] Concentrations rounded to two significant figures.

Table 35: Comparative dietary sodium intakes for adult females and adult males (25 years and above) and children (5–6 years)

	Estimated daily dietary sodium intake (mg/day)			
Population cohort	**NZTDS**	**BTDS[a]**	**FTDS[b]**	**HKTDS[c]**
Adult females	2,067	1,928 (All population)	2,167[e]	2,400
Adult males	2,899		2,653[f]	2,800
Children	1,920		1,520[g]	Not calculated

[a] BTDS: Brazilian Total Diet Study (Avegliano et al., 2011).
[b] FTDS: French Total Diet Study (ANSES, 2011a).
[c] HKTDS: Hong Kong Total Diet Study (CFS, 2014a).
[e] Women of childbearing age (18–45 years).
[f] All adult population.
[g] Children 3–6 years.

provide 27–48% of the total dietary sodium intake in the 2009 NZTDS, and in the 2016 NZTDS they were estimated to provide 29–45%.

Dietary sodium intake estimates have decreased gradually or remained constant since the late 1980s. Dietary sodium intakes in the 2016 NZTDS represent a slight increase over the 2009 NZTDS estimates (Figure 49). The lack of a continual decrease reflects the lack of any substantial changes in the key variables: sodium concentrations and key food consumption. For example, bacon consumption has largely remained unchanged between the 2009 NZTDS (6 g/day for young adult males) and the 2016 NZTDS (7 g/day).

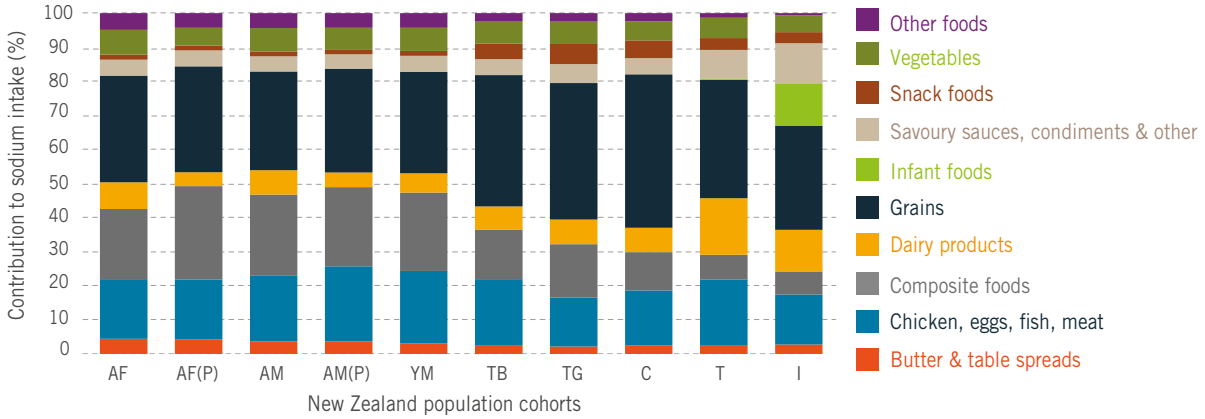
Risk characterisation

The estimated dietary sodium intakes for population cohorts in the 2016 NZTDS have been characterised against the NRV for each age and gender group in Appendix 14. For the characterisation of excess intake in the adult population cohorts, both the pre-2017 upper level of intake and the 2017 suggested dietary target have been referred to (because the change in value occurred during the course of reporting the outcomes of the 2016 NZTDS). For the infant, child and teenager diets only, the upper level of intake has been used because suggested dietary targets are yet to be derived.

All of the population cohorts receive sufficient sodium to fully meet nutritional needs, with dietary intakes 2.5 to 7.5 times the adequate intake reference values for each age group. However, for most of the groups, dietary sodium intakes exceed the relevant upper level of intake and the suggested dietary target values that have been established to identify excess dietary sodium intake. Dietary sodium intake was within the targeted range for adult females only, at 90% of the upper level of intake and 103% of the suggested dietary target.

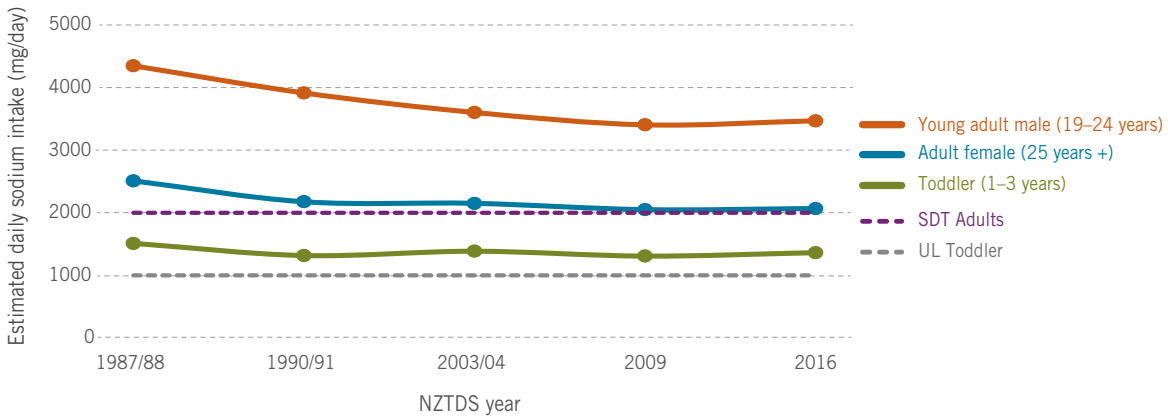
For all the remaining population cohorts, except infants, where an adequate intake or suggested dietary target value has not been established, dietary intakes of sodium were in excess of recommend daily maximums. These ranged from 104% of the upper level of intake for adult females of Pacific Island ethnicity, to 151% of the upper level of intake for young adult males. For the adult population cohorts,

Figure 48: Major sodium (mid-bound mean intake) contributing food groups in the 2016 NZTDS



AF: Adult Female (25 years and over); AF(P): Adult Female – Pacific Island ethnicity (15 years and over); AM: Adult Male (25 years and over); AM(P): Adult Male – Pacific Island ethnicity (15 years and over); YM: Young Adult Male (19–24 years); TB: Teenage Boy (11–14 years); TG: Teenage Girl (11–14 years); C: Child (5–6 years); T: Toddler (1–3 years); I: Infant (6–12 months).

Figure 49: Dietary sodium intake (mid-bound mean) trends in the NZTDS for adult females (25 years and above), young adult males (19–24 years) and toddlers (1–3 years), characterised against the adult suggested dietary target (SDT) and toddler upper level of intake (UL)[a]



[a] Adult SDT: 2000 mg/day; Toddler UL: 1000 mg/day (NHMRC & Ministry of Health, 2006; NHMRC, 2017a).

dietary sodium intakes also exceed the 2017 suggested dietary target, with the male groupings in particular having dietary intakes considerably above the dietary target (145–174% of the suggested dietary target).

The upper level of intake and suggested dietary target values were established to provide dietary targets to limit the adverse effects of excess sodium on blood pressure within a population. For most of the population cohorts, mean dietary intakes exceed the upper level of intake or suggested dietary target values indicating that there are potential risks of adverse health outcomes from excess dietary sodium. Additionally, the NZTDS does not model for discretionary salt used at the table and in cooking, which could further elevate sodium intakes.

New Zealand adult male dietary sodium intakes are estimated to be above those of Brazil, France and Hong Kong (Table 35). Notably, for the young adult male (19–24 years) population cohort the dietary intake from the 2016 NZTDS (3470 mg/day at the mid-bound mean) greatly exceeded the intake of 2700 mg/day estimated for a similar male age group (20–29 years) in the HKTDS (CFS, 2014a).

Zinc

Zinc is an essential trace mineral and is the second most abundant trace mineral in the human body (King, 1999). Zinc is widely distributed in foods. Meats, fish and poultry are the major contributors to dietary intake, but cereals and dairy foods also contribute substantial amounts (King, 1999; NHMRC & Ministry of Health, 2006). The level of zinc in soils is known to affect the concentration of zinc in cereals. The application of zinc fertilisers can enhance the zinc content of cereal crops through biofortification (Roohani et al., 2013).

Zinc is found in food as a complex rather than as free ions. Dietary factors can greatly affect the bioavailability of zinc by limiting its solubility and absorption of zinc in the gut (NHMRC & Ministry of Health, 2006). Phytic acid, which is present in nuts, grains and legumes, is the principal dietary component known to affect the absorption of zinc (NHMRC & Ministry of Health, 2006; Roohani et al., 2013). The type and amount of protein present in the diet has also been shown to impact on the absorption of zinc, with greater absorption in diets rich in animal protein. High intakes of iron from supplements may decrease zinc absorption (NHMRC & Ministry of Health, 2006; Roohani et al., 2013).

Nutrient identification

Zinc has a wide array of vital physiological functions and is found in every cell in the body. It is necessary for growth and development and its function can be broadly classed in three general categories: catalytic, structural and regulatory. It is an essential part of more than 100 enzymes and is involved in the metabolism of protein, carbohydrate and fat; protein structure maintenance and gene expression regulation; and the normal function of the immune system (NHMRC & Ministry of Health, 2006).

Despite extensive study, there has been difficulty in establishing and understanding the link between zinc deficiency and specific phenotypic features (EFSA, 2014a; Roohani et al. 2013). This is attributed to the numerous biological functions for which zinc is essential and its ubiquity in the human body. Although not unique to zinc, mild zinc deficiency is characterised by impaired linear growth and immune responses. Impairment is most marked during periods of rapid growth when zinc requirements are highest, such as pregnancy, infancy and puberty. Cases of severe deficiency can result in growth retardation, delayed sexual maturation, hair loss, eye and skin lesions, diarrhoea and impaired appetite (Gibson, 2005; NHMRC & Ministry of Health, 2006; Roohani et al., 2013).

There are no reported cases of toxicity from naturally occurring zinc in food, and the risk of excessive dietary intake is considered low. Acute toxicity can arise from excessive zinc intakes from dietary supplements or through exposure to very high levels of contaminant zinc.

Adverse effects of excessive intakes from supplements include suppression of immune response, impaired copper metabolism and a decrease in high-density lipoprotein (HDL) cholesterol (NHMRC & Ministry of Health, 2006; Gibson, 2005).

In the 2008/09 ANS, a decrease in estimated dietary zinc intakes was observed, compared with previous national nutrition surveys. One in four adults (24.7%) were reported to have an inadequate dietary intake of zinc, compared with 1.2% in 1997 (MOH, 1999, 2015). The main dietary sources of zinc were beef and veal (10%), bread (10%) and grains and pasta (10%) (MOH, 2015). In the 2002 National Children's Nutrition Survey (2002 CNS), 16% of children had low serum zinc status (MOH, 2003). Data from the 2002 CNS has suggested that selenium status was associated with zinc status (Houghton, 2016).

Nutrient characterisation

The recommended NRVs for zinc in the Australian and New Zealand population were established in 2006 by the Australian National Health and Medical Research Council. Estimated average requirements have been established for older infants, children, teenagers and adults. The estimated average requirements were calculated using a factorial approach, whereby requirements are estimated based on the minimum amount of absorbed zinc necessary to match total daily excretion of endogenous zinc (NHMRC & Ministry of Health, 2006). The calculations used by the National Health and Medical Research Council were based on diets in which the bioavailability of zinc was likely to be similar to a New Zealand diet (NHMRC & Ministry of Health, 2006). The estimated average requirements were established as 6.5 mg/day for adult women and 12 mg/day for adult men (NHMRC & Ministry of Health, 2006).

An upper level of intake of 40 mg/day was established for adults aged 19 years and over. The upper level of intake applies to total zinc intake from food, water and supplements.

It is based on the effect of zinc intakes on copper metabolism, using erythrocyte copper-zinc superoxide dismutase activity as a marker of copper status, where the lowest observed adverse effect level was seen at intakes of 60 mg/day. An upper level of intake of 4 mg/day was established for infants aged 0–6 months, based on a study in which no adverse effects were observed with intakes of 4.5 mg/day (NHMRC & Ministry of Health, 2006; Walravens, 1976). Because no data was available for older children or teenagers, the upper level of intake for young infants was adjusted on a body-weight basis for these age groups (NHMRC & Ministry of Health, 2006). However, recently published research (Foster, 2017) indicates that intakes of zinc above the upper level of intake (at least in healthy adults) appear to have minimal effects on erythrocyte copper-zinc superoxide dismutase activity and other markers of copper metabolism. This would indicate that the upper level of intake for zinc may be quite conservative.

Prevalence and concentrations

The concentrations of zinc in individual foods of the 2016 NZTDS have been presented in the quarterly reports (Pearson, 2016, 2016a, 2016b, 2017). The consolidated results are also presented in Appendix 13, with minimum, maximum and arithmetic mean concentrations calculated for zinc in each food type.

Zinc was widespread across the analysed foods in the 2016 NZTDS, with 90% of samples (945 out of 1056) containing a detected concentration of zinc. Zinc was absent from many of the beverages, including beer, coffee (instant and roast), caffeinated beverages and the carbonated drinks. When zinc was detected in beverages, the concentrations were in the lower range of those detected in all foods. Over half the foods (554 samples) with detected zinc concentrations had levels between 1–10 mg/kg.

The highest zinc concentrations were detected in oysters (56–300 mg/kg). Zinc concentrations in mammalian meat products were also high, with beef mince (72–90 mg/kg), beef rump (55–68 mg/kg) and lamb's liver (54–84 mg/kg) having appreciable zinc levels. Almonds and peanuts also had nearly identical ranges for zinc at above-average levels (26–39 mg/kg).

Zinc was last analysed for in the 1997/98 NZTDS. Comparison with concentrations reported in the 1987/88, 1990/91 and 1997/98 NZTDSs and the 2016 NZTDS indicates little difference in many of the foods (Table 36). Zinc concentrations in beef mince and lamb's liver have trended upwards over the course of the NZTDS, whilst the zinc content of bran flake cereal has decreased. The noted increase in the animal tissues may be the result of increased zinc use as a veterinary medicine to protect against facial eczema in grazing livestock.

Dietary intake estimates

Dietary estimates for zinc intake at lower-bound, mid-bound and upper-bound means for all population cohorts have been summarised in Appendix 14. The dietary intakes for each population cohort are expressed in mg/day.

The range between lower-bound and upper-bound mean dietary intakes for zinc was small, no greater than 0.2 mg/day. Because most foods had detected zinc concentrations, the influence from estimating concentrations in foods without any detected zinc was minimal. The highest dietary zinc intake in the adult population cohort was estimated for adult males of Pacific Island ethnicity, largely due to the higher estimated intake of lamb and mutton (30 g/day, compared with 8–16g/day for the other cohorts). As a result, lamb and mutton contributed 11% to the total dietary zinc intake for adult males of Pacific Island ethnicity but 4–9% for the other adult cohorts. Adult females had the lowest dietary zinc intake of the adult population cohort, at 9.3 mg/day. For all the adult population cohorts, meat and seafood food types were the most important

Table 36: Zinc concentration (mid-bound mean) trends in the NZTDS (1987/88–1997/98 and 2016)

	Mid-Bound mean zinc concentration (mg/kg)			
Food type	**1987/88**	**1990/91**	**1997/98**	**2016**
Beef, mince	53.6	45.9	55.7	76.6
Bran flake cereal	70.3	50.6	47.7	36.9
Chocolate, milk	15.5	9.9	12.8	12.8
Egg	15.4/19.7[a]	8.4/9.1[a]	13.3	13.8
Lamb's liver	33.7	33.3	49.7	63.3
Meat pie	12.0	9.3	16.6	15.6
Milk, 3.25% fat	3.8	4.4	3.1	3.3
Oyster	43.8	143.6	103.0	147.4
Peach, canned	0.8	0.5	0.7	0.5
Potato crisps	8.6	10.8	9.7	11.8
Wine, still white	0.9	2.6	0.7	0.8

[a] Eggs in the 1987/88 and 1990/91 NZTDSs were reported as boiled eggs/poached eggs.

contributors to total dietary zinc intake, although grains, composite foods and dairy products were also notable sources (Figure 50). Similar patterns of zinc intake for adults to the 2016 NZTDS were reported in the HKTDS, with meat-based foods estimated to contribute 35% to total dietary zinc intake and grains 28% (CFS, 2014a).

For the infant, child and teenage population cohorts, the teenage boys had the highest dietary zinc intake (12.5 mg/day). Intakes for the younger age groups were lower, with the infant age group having the lowest zinc intake (5.8 mg/day). Meat and seafood were also primary contributors to dietary zinc intakes for these cohorts. However, grains and dairy product were also important, particularly in the toddler age group. For infants, 40% of zinc intake came from consumption of infant and follow-on formula.

Consistent patterns of contribution to total dietary zinc intake are seen between the 2016 NZTDS and the 1990/91 NZTDS. Animal products made up 41% of the dietary intake for young adult males, and dairy made up 38% of the total dietary intake for toddlers.

Analysis of trends in dietary zinc intake since the NZTDSs undertaken in the 1980s and early 1990s show a gradual decreasing trend in adults (Figure 51). However, zinc intake from the toddler diet appears consistent with previous estimates. Changes in dietary zinc intake result from reductions in red meat consumption by New Zealanders. For example, daily consumption of beef mince in the simulated diet for young adult males has decreased from 11 g/day in the 1990/91 NZTDS to 5 g/day in the 2016 NZTDS. Similarly, the estimated consumption of beef rump steak has decreased in the simulated diet for the adult female population cohort from 12 g/day in the 1990/91 NZTDS to 8 g/day in the 2016 NZTDS. As a result, despite the noted increases in zinc in animal tissues in the 2016 NZTDS, the overall trend is for a decrease in dietary zinc intakes. It was not possible to establish any trends in zinc intakes for the infant diet as this age group was not considered in the NZTDS prior to the 2003/04 study.

Risk characterisation

The estimated dietary intakes for zinc for the population cohorts in the 2016 NZTDS have been characterised against the NRV for each age and gender group in Appendix 14.

All of the population cohorts in the 2016 NZTDS have sufficient dietary zinc intakes to meet nutritional needs. The estimated dietary intakes for the infant, child and teenage population cohorts were over twice the relevant estimated average requirement values. Intakes for the adult population cohorts had a lower margin above the estimated average requirements, with the adult male cohort only slightly exceeding the specific estimated average requirement for that age group (106% of the estimated average requirement of 12 mg/day). Nutritional needs for zinc are estimated to be greater in males because it is not absorbed as efficiently from the gastrointestinal tract as it is in females (NHMRC & Ministry of Health, 2006).

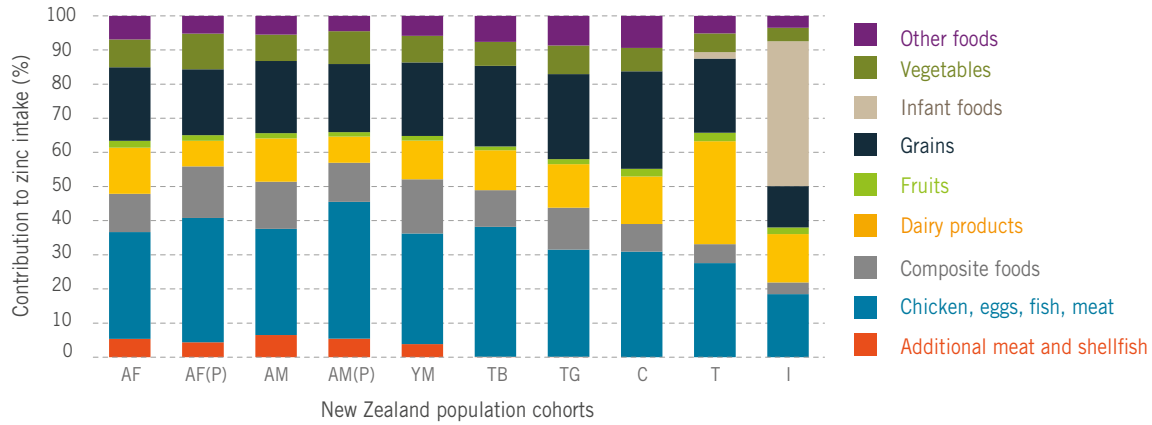
The adult female dietary intake of zinc (9.3 mg/day) are estimated to be well above the estimated average requirement for the general adult female population (6.5 mg/day). However, estimated average requirements for adult females who are pregnant (9 mg/day) or lactating (10 mg/day) are higher than that for the general population meaning that additional sources of dietary zinc may be necessary for these specific nutritional needs (NHMRC & Ministry of Health, 2006).

An additional factor to be considered in interpreting the dietary zinc intakes is that animal-based sources of zinc are more efficiently absorbed than plant-based sources (King & Keen, 1999). Many plant-based sources of zinc contain phytic acid, which decreases zinc absorption (Roohani et al., 2013). Research has been inconclusive as to whether diets excluding animal products result in an increase prevalence of zinc deficiency (Foster & Samman, 2015). However, because meat, dairy and seafood contribute over 50% of dietary zinc intake for most of the population cohorts, a vegetarian or vegan individual may need to consume more alternative high zinc containing foods, such as nuts, to meet nutritional needs.

In relation to characterisation of excessive intakes of dietary zinc, all population cohorts in the NZTDS, except the infant group, had dietary zinc intakes below the upper levels of intake. Dietary zinc intakes in the infant population cohort slightly exceeded (116%) the upper level of intake of 5 mg/day for infants aged 7–12 months. Excessive zinc may interfere with copper metabolism, and the upper level of intake is based on the level in a survey of infants that did not cause any impact on copper status (Walravens & Hambridge, 1976). Adverse effects of zinc intakes at 10 mg/day on copper levels in infants were reported in a single study (Bhandari et al., 2002). However, recent research questions whether intakes significantly higher than the upper level of intake in adults have any adverse effects on copper status and superoxide dismutase function (Foster et al., 2017). Because the dietary estimate in the 2016 NZTDS is still a large margin below 10 mg/day, the slight exceedance of the upper level of intake is unlikely to present a significant risk to infants. Analysis of the Australian National Children's Nutrition and Physical Activity survey (Rangan & Samman, 2012) indicated that 79% of children aged 2–3 years consumed more than the upper level of intake for zinc, with no apparent or reported adverse effects.

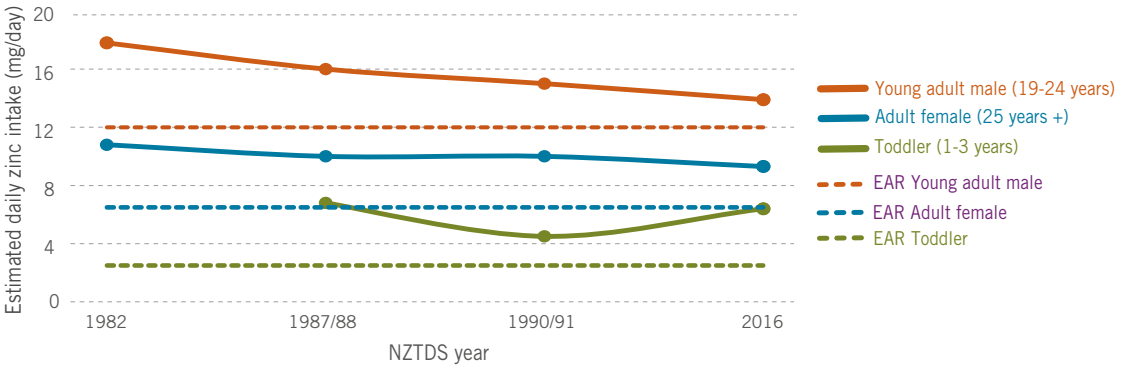
The 2016 NZTDS dietary intakes of zinc are higher than the equivalent intakes estimated in the ATDS (Table 37; FSANZ 2011). Other comparator countries have reported even lower dietary zinc intakes, in particular, intakes in the BTDS are considerably lower than those of the population cohorts in the 2016 NZTDS (Avegliano et al., 2011).

Figure 50: Major zinc (mid-bound mean intake) contributing food groups in the 2016 NZTDS



AF: Adult Female (25 years and over); AF(P): Adult Female – Pacific Island ethnicity (15 years and over); AM: Adult Male (25 years and over); AM(P): Adult Male – Pacific Island ethnicity (15 years and over); YM: Young Adult Male (19–24 years); TB: Teenage Boy (11–14 years); TG: Teenage Girl (11–14 years); C: Child (5–6 years); T: Toddler (1–3 years); I: Infant (6–12 months).

Figure 51: Dietary zinc intake (mid-bound mean) trends in the NZTDS (1982–1990/91 and 2016[a]) for adult females (25 years and above), young adult males (19–24 years) and toddlers (1–3 years), characterised against the estimated average requirements (EARs)[b]



[a] Zinc concentrations were measured in the 1997/98 NZTDS but intakes were not reported.
[b] Adult female EAR: 6.5 mg/day; Adult male EAR: 12 mg/day; Toddler EAR: 2.5 mg/day (NHMRC & Ministry of Health, 2006).

Table 37: Comparative daily dietary zinc intakes for adult females and adult males (25 years and above) and children (5–6 years)

	Estimated daily zinc intake (mg/day)				
Population cohort	**NZTDS**	**ATDS[a]**	**BTDS[b]**	**FTDS[c]**	**HKTDS[d]**
Adult females	9.3	7.8–9.4[e]	4.25 (All population)	6.6[f]	7.9
Adult males	12.7	11.0–14.8[e]		7.9 (All adults)	11.0
Children	8.0	7.2/8.4[g]		5.2[h]	Not calculated

[a] ATDS: Australian Total Diet Study (FSANZ, 2011).
[b] BTDS: Brazilian Total Diet Study (Avegliano et al., 2011).
[c] FTDS: French Total Diet Study (ANSES, 2011a).
[d] HKTDS: Hong Kong Total Diet Study (CFS, 2014a).
[e] The intake range is for different age bandings in the adult population, includes 19–29 years, 30–49 years, 50–69 years and 70 years and over.
[f] Women of childbearing age (18–45 years).
[g] Female child/male child (both ages 4–8 years).
[h] Children 3–6 years.

Conclusions

The final report of the 2016 NZTDS details the outcomes of the study against the following objectives:

- Determine the estimated dietary exposure for selected agricultural compounds, contaminants and nutrient elements in the New Zealand food supply through collecting and analysing foods that represent the diet of New Zealanders.
- Compare estimated dietary exposure with internationally recognised acceptable exposures or recommended levels.
- Identify dietary exposure trends in New Zealand over time and compare these estimates with those in other countries.

In undertaking the 2016 NZTDS, 1056 food samples were analysed for 301 agricultural chemicals and 10 elements. Specific groups of food types were also analysed for carbon disulphide, 21 herbicide analytes, the contaminant species inorganic arsenic and methylmercury and the nutrient element fluoride. Analytical results were combined with food consumption information from simulated diets for 10 population cohorts to establish dietary exposure or daily nutrient intakes. The estimated exposures and intakes were characterised against nutrient reference values (NRVs) or health based guidance values (HBGVs).

All of the estimated dietary exposures for the agricultural chemicals are well within the HBGVs. The 2016 NZTDS also carried out cumulative dietary exposure assessment for groups of agricultural chemicals sharing common modes of toxicity. The cumulative dietary exposure estimates also do not present a public health concern. The conclusion regarding the dietary exposure to agricultural residues is that they do not present a concern for any age or gender group in the New Zealand population.

Dietary exposures to the contaminant elements cadmium, inorganic mercury, methylmercury and tin all fall below the established HBGVs. Dietary exposure trends for cadmium, inorganic mercury and methylmercury show no consistent pattern that would reflect an increasing level of contamination in the food supply.

The dietary exposure to arsenic has been refined by analysing any foods with significant concentrations (greater than 0.02 mg/kg) for the more toxic inorganic arsenic. Neither inorganic arsenic nor lead have HBGVs and an alternative method of risk characterisation has been used. While the levels of exposure to inorganic arsenic or lead are such that adverse health impacts cannot be ruled out, there is no trend of increase in the diet. Lead dietary exposure has seen a notable decrease for most population cohorts, compared with the 2009 NZTDS. The dietary exposure to inorganic arsenic and lead is probably as low as reasonably achievable.

The contaminant element aluminium was analysed for the first time in the 2016 NZTDS. As a result of very high levels of aluminium in muffins and scones and cakes and slices, the estimated dietary exposure to aluminium exceeds the HBGV for teenage girls, children, toddlers and infants.

Daily dietary intakes of iodine have shown a remarkable improvement against the 2009 NZTDS, largely as a result of the mandatory fortification of bread with iodine. The daily dietary intakes for iodine for all population cohorts, apart from infants, now meet or exceed the relevant NRVs, reversing the decline seen since the mid-1990s.

Daily intakes of selenium and zinc across the New Zealand population are also estimated to meet the relevant NRVs for each age and gender group.

The daily intake estimates for fluoride from plant-based foods and beverages are below the adequate intakes and upper levels of intake for all population cohorts. Methodological limitations mean animal-based food sources were not accounted for and, as a result, no conclusion is made on whether total dietary fluoride is sufficient or exceeds nutritional requirements.

Dietary sodium intakes have largely remained unchanged from the 2009 NZTDS and continue to exceed dietary targets and upper levels of intake for all population cohorts.

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Appendices

Appendix 1: National (N) and regional (R) foods sampled in the 2016 NZTDS

2016 NZTDS Food	R/N	2016 NZTDS Food	R/N
Additional meat and shellfish		**Grains**	
Lambs liver	R	Biscuit, chocolate	N
Mussels	R	Biscuit, cracker	N
Oyster	R	Biscuit, plain sweet	N
Prawn/shrimp [b]	N	Bran flake cereal	N
Beverages, alcoholic		Bread, mixed grain	R
Beer	N	Bread, wheatmeal	R
Wine, still red	N	Bread, white	R
Wine, still white	N	Cakes and slices [b]	R
Beverages, non-alcoholic		Cornflakes	N
Apple-based juice	N	Muesli	N
Caffeinated beverage	N	Muffins and scones [b]	R
Carbonated drink	N	Noodles, instant	N
Chocolate beverage	N	Oats, rolled	N
Coffee, instant	N	Other cereals [b]	N
Coffee beans, ground	R	Pasta, dried	N
Fruit drink	N	Rice, white	N
Orange juice	N	Spaghetti in sauce, canned	N
Tea	N	Wheat biscuit cereals	N
Water, bottled	N	**Infant foods**	
Water, tap	R	Infant/follow-on formula	N
Butter and table spread [a]		Infant weaning food, cereal based	N
Butter	R	Infant weaning food, custard/fruit dish	N
Table spread [b]	N	Infant weaning food, savoury dish	N
Chicken, egg, fish, and meat		**Nuts**	
Bacon	R	Almond [b]	N
Beef, mince	R	Coconut cream, canned [b]	N
Beef, rump	R	Peanut butter	N
Chicken	N	Peanut	N
Corned beef	R	**Oil**	
Egg	R	Oil	N
Fish, battered	R	**Savoury sauces, condiments and other** [a]	
Fish, canned	N	Hummus [b]	N
Fish fingers	N	Salad dressing	N
Fish, fresh	R	Simmer sauce, bottled [b]	N
Ham	R	Tomato sauce	N
Lamb/mutton	R	Yeast extract	N
Pork roast [b]	R	**Snack foods** [a]	
Sausages	R	Potato crisps	N
Composite Foods[a]		Snack bar	N
Chicken takeaway	R	Snacks, flavoured	N
Fish cakes [b]	R	**Spreads and sweets** [a]	
Hamburger, plain	R	Milk chocolate	N
Meat pie	R	Confectionery	N

2016 NZTDS Food	R/N	2016 NZTDS Food	R/N
Noodle dish [b]	R	Jam	N
Pizza	R	Honey	N
Rice dish [b]	R	Sugar	N
Sushi [b]	R	**Vegetables**	
Dairy products		Baked beans	N
Cheese	R	Beetroot, canned	N
Dairy dessert	N	Broccoli/cauliflower	R
Ice cream	N	Cabbage	R
Milk, 0.5% fat	R	Capsicum	R
Milk, 3.25% fat	R	Carrot	R
Milk, flavoured	R	Celery	R
Yoghurt	N	Corn, frozen [b]	N
Dairy substitute [a]		Courgette (zucchini)	R
Soya milk	N	Cucumber	R
Fruits		Kumara	R
Apple	R	Lettuce	R
Avocado	R	Mixed vegetables, frozen [b]	N
Banana	N	Mushrooms	R
Grape	R	Onions	R
Kiwifruit	R	Peas, frozen	N
Mandarin [b]	R	Potato, hot chips	R
Melon	R	Potato, peeled	R
Mixed berries, frozen [b]	N	Potato, with skin	R
Nectarine	R	Pumpkin	R
Orange	R	Silverbeet	R
Peach, canned	N	Soup, vegetable [b]	N
Pear	R	Taro [c]	N
Pineapple, canned	N	Tofu [b]	R
Prune	N	Tomatoes, in juice	N
Raisins/sultanas	N	Tomato	R
Strawberry	R		

Notes

[a] New or amended categories for the 2016 NZTDS.
[b] New or amended food for the 2016 NZTDS.
[c] Taro was changed from a regional food to a national food in the 2016 NZTDS, recognising that as an imported food, taro is unlikely to exhibit any regional variability. However, due to the limited availability of taro in Christchurch, six taro samples were purchased in Wellington.

Appendix 2: Preparation instructions for foods sampled in the 2016 NZTDS

Glossary of terms

In order for foods to be prepared in a consistent and unambiguous manner, it is important that the terms used in the preparation instructions are clearly defined.

Homogenise

Samples are put into the food processor and blended until a homogenised mixture is attained.

Mix

When the preparation instructions state 'mix' or 'mix thoroughly' then the following meanings apply to these respective types of foods:

For dry foods (such as flour) or semi-dry foods (such as cooked chopped meat):

- form the food into a cone or pile
- flatten the cone slightly and separate into four equal segments
- pull the segments apart so that four separate piles are formed
- combine diagonally opposite piles and mix together thoroughly
- this process should be repeated until thorough mixing of the foods has been achieved

For foods containing juice (e.g. nectarines)

- if possible, the food being prepared should be chopped in a large glass or stainless steel bowl so that all the juice is collected.
- mixing of the chopped pieces is then carried out in the bowl using gloved hands or stainless steel cutlery and should be mixed as thoroughly as possible.
- unless cooking instructions state that the food must be drained, any juice must be regarded as an integral part of the food being prepared for analysis
- a proportional amount of juice and seeds must be included in all sample containers

For liquid samples (e.g. oils and beer)

- liquids are to be measured into a large receptacle such as a bowl or jug made of stainless steel, glass or Pyrex. Plastic containers are to be avoided.
- the total volume added to the receptacle should be thoroughly stirred with a stainless steel utensil before being poured into the sample containers

Regional and brand samples are kept separate.

Composite

Compositing involves thorough homogenising of equal weights of the indicated samples.

Food preparation equipment

Selection of appropriate sample preparation equipment is a vital component of the contamination control procedures.

Gloves

Gloves are to be worn whenever the food being prepared could come into contact with hands. Non-lubricated surgical-style gloves should be used.

Utensils

- stainless steel knives
- wooden (good quality, smooth, crack free), polypropylene or glass chopping boards
- stainless steel, silicone or teflon-coated utensils. Glass equipment can also be used provided it is Pyrex.
- large stainless steel, glass or Pyrex receptacle (jug or bowl) for mixing liquids
- ceramic and enamel ware should be avoided at all times, as these may leach traces of lead or cadmium.

Appliances

- domestic oven, with hotplates (electric)
- food processors, high density plastic with stainless steel blades

Cookware

- fry-pans (Teflon-coated)
- large stainless steel pots
- baking trays

Containers

- For GC-MS, GC-MS/MS, LC-MS/MS, inorganic arsenic, fluoride, CS2, and methylmercury (refer to Appendix 4 for further details) analysis: 250mL polycarbonate (PC) natural polypropylene (PP) screw cap round autoclaveable (Labserve LBS32258).
- For ICP-OES/MS (refer to Appendix 4 for further details) analysis: 60 ml Polystyrene (PS) plastic specimen containers, with unlined yellow screw on polyethylene lids (Labserve LBS28002).

Food preparation procedures

A key feature of a TDS is that foods are prepared as for normal consumption.

The following table summarises the procedures used to prepare food samples received by the food preparation laboratory. Foods are sorted alphabetically. All water used in food preparation was distilled.

Appendix 2.1: Summarised food preparation methods used in the 2016 NZTDS by food sample type

2016 NZTDS food	Food preparation method
Almond	Mixed and homogenised
Apple	Cored, chopped, homogenised, not peeled
Apple-based juice	Mixed
Avocado	Flesh chopped and homogenised
Bacon	Fat and rind trimmed, then dry fried for 3 minutes each side, and homogenised
Baked beans	Mixed and homogenised
Banana	Skin discarded, homogenised
Beef, mince	Dry fried for 15 minutes till cooked, homogenised
Beef, rump	Fat trimmed, dry fried for 5 minutes each side till cooked, chopped, mixed and homogenised
Beer	Mixed
Beetroot, canned	Mixed and homogenised
Biscuit, chocolate	Mixed and homogenised
Biscuit, cracker	Mixed and homogenised
Biscuit, plain sweet	Mixed and homogenised
Bran flake cereal	Mixed and homogenised
Bread, mixed grain	Mixed and homogenised
Bread, wheatmeal	Mixed and homogenised
Bread, white	Mixed and homogenised
Broccoli/ cauliflower	Rinsed, cut into florets, boiled for 5 minutes till cooked, homogenised
Butter	Chopped, mixed and homogenised
Cabbage	Outer leaves discarded, rinsed, chopped and homogenised
Caffeinated beverage	Mixed
Cakes and slices	Chopped, mixed and homogenised
Capsicum	Stem and seeds discarded, chopped, mixed and homogenised
Carbonated drink	Mixed
Carrot	Ends discarded, peeled, rinsed, chopped and homogenised
Celery	Roots and leaves discarded, rinsed, chopped and homogenised
Cheese	Chopped, mixed and homogenised
Chicken	Roasted at 160°C for 40–60 minutes till cooked, bones discarded, chopped and homogenised
Chicken takeaway	Bones discarded, mixed and homogenised
Chocolate beverage	Mixed
Coconut cream, canned	Contents stirred thoroughly, mixed
Coffee beans, ground	3 tablespoons in 750 ml boiling water, brewed in plunger for 4 minutes, plunged and mixed
Coffee, instant	3 teaspoons in 750 ml boiling water and mixed
Confectionery	Mixed and homogenised
Corn, frozen	Boiled for 5 minutes, drained, mixed and homogenised
Corned beef	Mixed and homogenised
Cornflakes	Mixed and homogenised
Courgette (zucchini)	Ends discarded, rinsed, sliced into approximately 5 mm thick rounds, dry fried for 3-5 minutes till tender, homogenised
Cucumber	Ends discarded, chopped and homogenised
Dairy dessert	Mixed and homogenised

2016 NZTDS food	Food preparation method
Egg	Boiled for 5 minutes, cooled, peeled, mixed and homogenised
Fish cakes	Prepared as per label instructions for cooking in the oven, homogenised
Fish fingers	Prepared as per label instructions for cooking in the oven, homogenised
Fish, battered	Chopped and homogenised
Fish, canned	Brine or oil drained and discarded, mixed and homogenise
Fish, fresh	Dry fry for 3 minutes each side until cooked, mixed and homogenised
Fruit drink	Prepared as per label instructions and mixed
Grape	Stems discarded, and homogenised
Ham	Mixed and homogenised
Hamburger, plain	Chopped, mixed and homogenised
Honey	Mixed and homogenised
Hummus	Mixed and homogenised
Ice cream	Mixed and homogenised
Infant weaning food, cereal based	Prepared as per label instructions (if necessary) with water and mixed
Infant weaning food, custard/fruit dish	Prepared as per label instructions (if necessary) with water and mixed
Infant weaning food, savoury dish	Prepared as per label instructions (if necessary) with water and mixed
Infant/follow-on formula	Prepared as per label instructions with boiling water
Jam	Mixed and homogenised
Kiwifruit	Flesh scooped out and homogenised
Kumara	Peeled, rinsed, cut into approximately 2.5 cm chunks, dry roasted at 180–200°C for 35–45 minutes until tender and homogenised
Lamb/mutton	Mutton chops: dry fried for 5–8 minutes each side Lamb roast: roast in 180°C for 20–25 minutes per 500g Chopped, combined, mixed and homogenised
Lambs liver	Sliced into 1 cm thick slices, dry fried for 3 minutes each side until cooked, mixed and homogenised
Lettuce	Inner leaves rinsed and homogenised
Mandarin	Peeled, seeds removed, mixed and homogenised
Meat pie	Prepared as per label instructions for cooking in the oven (if frozen), chopped, mixed and homogenised
Melon	Rind and seeds discarded, flesh homogenised
Milk chocolate	Chopped, mixed and homogenised
Milk, 0.5% fat	Mixed
Milk, 3.25% fat	Mixed
Milk, flavoured	Mixed
Mixed berries, frozen	Mixed and homogenised
Mixed vegetables, frozen	Boiled for 5 minutes, drained, mixed and homogenised
Muesli	Mixed and homogenised
Muffins and scones	Chopped, mixed and homogenised
Mushroom	Cap and stalk wiped with paper towel if dirty, sliced into approximately 5 mm thick slices, dry fried for 8–10 minutes, homogenised
Mussels	Fresh mussels: Steamed in 2 cm of boiling water in a pot, mussels that remain closed are discarded, flesh scooped out, shells discarded Packaged mussels: Drained Combined, mixed and homogenised
Nectarine	Stones discarded and flesh homogenised with skin on
Noodle dish	Mixed and homogenised
Noodles, instant	Prepared as per label instructions, flavour sachet added, mixed and homogenised

2016 NZTDS food	Food preparation method
Oats, rolled	Prepared as per label instructions with water, mixed and homogenised
Oil	Mixed
Onion	Peeled, sliced into approximately 5mm thick half rounds, dry fried for 5 minutes, homogenised
Orange juice	Mixed
Orange	Skin and seeds discarded, flesh homogenised
Other cereals	Mixed and homogenised
Oyster	Flesh mixed and homogenised
Pasta, dried	Boiled in unsalted water for 11 minutes until cooked, mixed and homogenised
Peach, canned	Drained, mixed and homogenised
Peanut butter	Mixed and homogenised
Peanut	Mixed and homogenised
Pear	Cored, chopped, homogenised, not peeled
Peas, frozen	Boiled for 5 minutes, drained, mixed and homogenised
Pineapple, canned	Drained, mixed and homogenised
Pizza	If frozen, prepared as per label instructions for cooking in the oven, mixed and homogenised
Pork roast	Roasted at 160°C for 30–40 minutes (per 500 g) till cooked, cooled, flesh removed, mixed and homogenised
Potato crisps	Mixed and homogenised
Potato, hot chips	Mixed and homogenised
Potato, peeled	Peeled, rinsed, cut into approximately 2.5 cm cubes, boiled for 20 minutes and homogenised
Potato, with skin	Scrubbed, baked at 200°C for 50-60 minutes until soft and homogenised
Prawn/shrimp	Defrosted, (if uncooked) dry fried for 3–5 minutes until pink then cooled, heads and shells removed, homogenised
Prune	Mixed and homogenised
Pumpkin	Flesh cut into approximately 2.5 cm cubes, roasted at 180–200°C for 40–45 minutes until tender and homogenised
Raisins/sultanas	Mixed and homogenised
Rice dish	Mixed and homogenised
Rice, white	3 cups of rice in 6 cups of water, boiled until cooked and homogenised
Salad dressing	Mixed
Sausage	Dry fried for 5 minutes on each side until cooked, chopped, mixed and homogenised
Silverbeet	Stem trimmed, rinsed, chopped, boiled for 5 minutes, drained and homogenised
Simmer sauce, bottled	For powders or concentrates: Mixed with boiling water as per label instructions For ready-to-use: stirred well Mixed and homogenised
Snack bar	Mixed and homogenised
Snacks, flavoured	Mixed and homogenised
Soup, vegetable	For instant soups or concentrates prepared as per label instructions, ready-to-eat soups analysed cold, mixed and homogenised
Soya milk	Mixed
Spaghetti in sauce, canned	Mixed and homogenised
Strawberry	Stems and leaves discarded, mixed and homogenised
Sugar	Mixed and homogenised
Sushi	Mixed (including condiments such as soy sauce, pickled ginger and wasabi) and homogenised
Table spread	Mixed and homogenised
Taro	Peeled, rinsed and boiled for 20 minutes until cooked, drained and homogenised

2016 NZTDS food	Food preparation method
Tea	Brewed (200ml boiling water per tea bag) for 5 minutes and mixed
Tofu	Cut into approximately 2 cm cubes, dry fried for 3–5 minutes and homogenised
Tomato	Stalk discarded, rinsed, chopped and homogenised
Tomato sauce	Mixed
Tomatoes, in juice	Mixed and homogenised
Water, bottled	Mixed
Water, tap	Mixed
Wheat biscuit cereals	Mixed and homogenised
Wine, still red	Mixed
Wine, still white	Mixed
Yeast extract	Mixed and homogenised
Yoghurt	Mixed and homogenised

Appendix 3: Population cohorts and simulated diets of the 2016 NZTDS

Appendix 3.1: Population cohorts of the 2016 NZTDS

Grouping	Population cohort	Age range	Average body weight (kg)
Adults	Adult females	25 years and over	73.3
	Adult females of Pacific Island ethnicity	15 years and over	88.1
	Adult males	25 years and over	86.7
	Adult males of Pacific Island ethnicity	15 years and over	98.1
	Young adult males	19–24 years	79.5
Infant, child and teenagers	Teenage boys	11–14 years	54
	Teenage girls	11–14 years	54
	Children	5–6 years	23
	Toddlers	1–3 years	13
	Infants	6–12 months	9

Appendix 3.2: Mean daily food consumption (g) of simulated typical diet for adults in the 2016 NZTDS, excludes four infant foods

2016 NZTDS food	Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Almond	2	2	2	2	2
Apple	32	32	42	42	40
Apple-based juice	19	19	19	19	19
Avocado	7	4	4	4	4
Bacon	3	3	6	6	7
Baked beans	6	6	12	12	12
Banana	34	46	39	39	39
Beef, mince	6	6	9	6	5
Beef, rump	8	8	12	12	12
Beer	32	25	237	237	309
Beetroot, canned	2	2	4	4	3
Biscuit, chocolate	3	6	5	5	5
Biscuit, cracker	3	3	3	3	3
Biscuit, plain sweet	4	3	4	4	3
Bran flake cereal, mixed	2	2	4	2	4
Bread, mixed grain	40	20	44	36	31
Bread, wheatmeal	11	11	11	14	15
Bread, white	33	58	53	46	86
Broccoli/cauliflower	9	5	11	11	11
Butter	9	9	10	10	7
Cabbage	4	5	8	10	8
Caffeinated beverage	19	19	19	19	51
Cakes and slices	13	14	26	30	26
Capsicum	3	3	3	3	3
Carbonated drink	75	107	107	126	297
Carrot	13	10	16	16	12
Celery	2	2	1	1	1
Cheese	13	4	16	5	14
Chicken	33	60	31	90	58
Chicken takeaway	13	20	13	27	20
Chocolate beverage	9	9	18	9	38
Coconut cream, canned	0	24	0	24	0
Coffee beans, ground	38	17	45	17	28
Coffee, instant	414	277	555	277	277
Confectionery	4	4	4	4	4
Corn, frozen	2	2	4	4	4
Corned beef	6	14	9	19	10
Cornflakes	4	4	5	5	5
Courgette (Zucchini)	4	3	3	3	3
Cucumber	3	3	3	3	2
Dairy dessert	11	11	11	11	11
Egg	20	12	29	19	22
Fish cakes	4	7	7	7	4
Fish fingers	2	2	2	2	2

2016 NZTDS food	Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Fish, battered	14	15	15	15	15
Fish, canned	7	11	7	14	7
Fish, fresh	14	21	17	23	17
Fruit drink	19	19	39	29	127
Grape	4	4	2	2	2
Ham	6	3	8	5	17
Hamburger, plain	7	17	17	17	25
Honey	2	2	5	3	4
Hummus	2	2	3	3	3
Ice cream	9	11	14	14	21
Jam	6	4	5	4	5
Kiwifruit	9	9	9	9	9
Kumara	6	8	8	8	8
Lamb/mutton	8	18	10	30	14
Lambs liver	2	2	2	2	2
Lettuce	9	5	9	9	7
Mandarin	6	3	10	3	6
Meat pie	12	25	25	12	29
Melon	2	2	3	3	9
Milk chocolate	6	3	7	7	13
Milk, 0.5% fat	74	47	100	100	63
Milk, 3.25% fat	60	85	106	106	124
Milk, flavoured	25	25	26	26	45
Mixed berries, frozen	2	2	3	3	3
Mixed vegetables, frozen	14	7	13	13	14
Muesli	4	9	11	11	5
Muffins and scones	9	9	9	9	13
Mushroom	4	2	3	3	3
Mussels	4	4	6	6	6
Nectarine	8	8	8	8	5
Noodle dish	31	44	56	58	53
Noodles, instant	14	28	14	42	27
Oats, rolled	4	7	7	7	4
Oil	8	8	13	13	15
Onion	7	5	9	9	8
Orange juice	19	19	19	37	19
Orange	19	13	13	13	13
Other cereals	3	3	4	4	4
Oyster	2	2	4	4	2
Pasta, dried	32	21	32	32	32
Peach, canned	8	7	7	7	7
Peanut butter	1	2	1	2	2
Peanut	3	3	3	3	3
Pear	12	12	12	12	12
Peas, frozen	4	1	6	6	6
Pineapple, canned	4	4	4	4	4

2016 NZTDS food	Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Pizza	11	11	14	14	18
Pork roast	6	11	8	14	9
Potato crisps	2	3	3	3	3
Potato, hot chips	18	23	31	31	51
Potato, peeled	37	31	61	51	66
Potato, with skin	18	15	30	25	32
Prawn/shrimp	3	3	3	3	3
Prune	1	1	3	3	1
Pumpkin	13	7	13	13	8
Raisins/sultanas	1	1	2	2	2
Rice dish	15	20	20	20	29
Rice, white	39	39	48	78	57
Salad dressing	1	1	2	2	2
Sausage	7	7	17	17	20
Silverbeet	4	3	7	7	6
Simmer sauce, bottled	6	6	7	7	7
Snack bar	5	3	3	1	4
Snacks, flavoured	2	2	3	3	4
Soup, vegetable	24	11	18	18	18
Soya milk	8	3	3	3	3
Spaghetti in sauce, canned	10	10	15	15	15
Strawberry	4	4	6	6	9
Sugar	11	10	14	14	10
Sushi	3	3	5	3	3
Table spread	12	15	15	16	19
Taro	3	32	3	29	3
Tea	399	206	346	206	64
Tofu	4	4	4	4	6
Tomato	19	14	20	20	13
Tomato sauce	2	4	4	4	9
Tomatoes in juice, canned	10	4	12	9	8
Water, bottled	25	25	25	25	31
Water, tap	271	271	193	193	180
Wheat biscuit cereal	6	4	9	9	12
Wine, still red	21	11	21	21	11
Wine, still white	29	14	21	21	14
Yeast extract	1	1	1	1	1
Yoghurt	29	13	21	11	21

Appendix 3.3: Mean daily food consumption (g) for simulated typical diets for infants, children and teenagers, in the 2016 NZTDS, excludes three alcoholic beverages

2016 NZTDS food	Teenage boys	Teenage girls	Children	Toddlers	Infants
Almond	1	1	1	0	0
Apple	69	72	82	25	19
Apple-based juice	4	6	6	27	9
Avocado	2	2	1	4	2
Bacon	3	1	1	2	1
Baked beans	7	6	6	7	4
Banana	26	19	30	38	33
Beef, mince	20	10	11	9	6
Beef, rump	14	11	6	4	2
Beetroot, canned	2	2	1	0	0
Biscuit, chocolate	20	15	12	8	3
Biscuit, cracker	5	5	5	4	4
Biscuit, plain sweet	6	6	6	12	5
Bran flake cereal, mixed	3	3	1	2	1
Bread, mixed grain	54	43	44	12	0
Bread, wheatmeal	21	13	11	8	5
Bread, white	84	60	61	20	19
Broccoli/cauliflower	9	6	6	5	3
Butter	7	5	5	4	3
Cabbage	10	7	4	1	1
Caffeinated beverage	14	11	0	0	0
Cakes and slices	7	11	4	4	1
Capsicum	3	3	1	1	0
Carbonated drink	98	82	41	21	0
Carrot	13	11	11	8	5
Celery	4	2	1	1	0
Cheese	15	15	7	10	8
Chicken	48	31	24	4	3
Chicken takeaway	9	7	3	4	2
Chocolate beverage	64	64	57	21	7
Coconut cream, canned	0	0	0	0	0
Coffee beans, ground	0	0	0	0	0
Coffee, instant	7	11	0	0	0
Confectionery	14	9	7	3	1
Corn, frozen	0	5	6	2	2
Corned beef	6	4	4	3	2
Cornflakes	5	3	6	4	2
Courgette (zucchini)	3	1	1	1	1
Cucumber	3	1	1	1	1
Dairy dessert	5	9	21	33	9
Egg	16	14	11	8	4
Fish cakes	4	4	0	0	0
Fish fingers	1	2	3	3	2
Fish, battered	7	4	6	3	2
Fish, canned	3	3	1	1	2
Fish, fresh	12	5	3	2	1
Fruit drink	69	50	86	59	25

2016 NZTDS food	Teenage boys	Teenage girls	Children	Toddlers	Infants
Grape	1	2	3	3	1
Ham	13	7	5	5	1
Hamburger, plain	21	19	7	6	3
Honey	3	2	3	1	1
Hummus	1	1	1	1	1
Ice cream	34	26	26	11	6
Infant/follow-on formula	0	0	0	14	400
Infant weaning food, cereal based	0	0	0	0	19
Infant weaning food, custard/fruit dish	0	0	0	9	26
Infant weaning food, savoury dish	0	0	0	9	24
Jam	3	2	2	1	1
Kiwifruit	1	3	6	6	1
Kumara	2	5	1	3	3
Lamb/mutton	7	6	3	3	2
Lambs liver	0	0	0	0	0
Lettuce	14	9	2	1	0
Mandarin	6	6	6	3	3
Meat pie	26	23	14	6	4
Melon	1	2	3	2	2
Milk chocolate	13	9	7	1	1
Milk, 0.5% fat	23	21	16	18	0
Milk, 3.25% fat	164	111	114	307	69
Milk, flavoured	14	14	11	9	0
Mixed berries, frozen	1	1	1	1	1
Mixed vegetables, frozen	2	2	2	1	0
Muesli	3	3	1	1	0
Muffins and scones	12	18	10	5	3
Mushroom	4	3	1	1	1
Mussels	1	1	0	0	0
Nectarine	7	6	9	2	4
Noodle dish	9	7	7	0	0
Noodles, instant	21	33	21	11	4
Oats, rolled	5	6	5	9	5
Oil	6	4	3	3	1
Onion	9	6	5	1	1
Orange juice	4	6	6	20	8
Orange	31	44	44	19	8
Other cereals	3	3	5	4	2
Oyster	0	0	0	0	0
Pasta, dried	28	19	16	11	8
Peach, canned	2	3	4	4	4
Peanut butter	5	3	4	1	0
Peanut	1	1	1	0	0
Pear	9	11	9	10	4
Peas, frozen	12	9	6	4	3
Pineapple, canned	2	2	5	1	1
Pizza	11	13	9	5	3
Pork roast	8	6	3	1	1
Potato crisps	10	11	6	3	1

2016 NZTDS food	Teenage boys	Teenage girls	Children	Toddlers	Infants
Potato, hot chips	50	40	23	15	6
Potato, peeled	51	48	39	17	11
Potato with skin	26	32	20	17	11
Prawn/shrimp	0	0	0	0	0
Prune	1	1	1	1	1
Pumpkin	4	4	3	6	5
Raisins/sultanas	2	2	2	7	5
Rice dish	9	7	5	0	0
Rice, white	26	14	16	4	2
Salad dressing	2	2	1	0	0
Sausage	21	14	14	11	5
Silverbeet	3	2	2	1	1
Simmer sauce, bottled	4	4	4	0	0
Snack bar	9	8	8	2	1
Snacks, flavoured	9	10	8	4	3
Soup, vegetable	11	11	7	4	2
Soya milk	21	18	11	7	0
Spaghetti in sauce, canned	14	11	9	11	7
Strawberry	1	3	4	2	1
Sugar	7	7	4	2	1
Sushi	3	3	3	0	0
Table spread	9	7	6	3	2
Taro	3	3	1	0	0
Tea	18	18	14	0	0
Tofu	1	3	3	0	0
Tomato	17	20	6	5	3
Tomato sauce	8	8	3	4	2
Tomatoes in juice, canned	8	5	4	3	3
Water, bottled	45	45	48	33	5
Water, tap	302	303	322	218	129
Wheat biscuit cereal	14	7	11	13	5
Yeast extract	1	1	1	2	2
Yoghurt	21	21	21	64	56

Appendix 4: Analytical methodology used in the 2016 NZTDS

Agricultural chemicals

All of the collected and prepared food samples (1056 samples) were analysed by the agricultural chemical multi-screen. Samples underwent a clean-up phase, a chemical extraction with acetonitrile and purification, before being analysed separately by liquid chromatography tandem mass spectrometry (LC-MS/MS) and gas chromatography tandem mass spectrometry (GC-MS/MS). This method detected and quantified for the presence of 301 separate agricultural chemical analytes.

When categorised into analytes of different chemical groups this included: 158 insecticides, 73 fungicides, 63 herbicides, 4 quaternary ammonium compounds, and 3 sprout/scald inhibitors.

In addition, sub-samples from all of the fruit, nut and vegetable samples (416 samples) were analysed for CS2. Samples were decomposed in acidic stannous chloride to form CS_2 which was then extracted in solvent. The isolate CS_2 was detected and quantified by gas chromatography mass spectrometry (GC-MS) with selected ion monitoring.

Finally, sub-samples from all of the cereal and vegetable samples (384 samples) were analysed for the phenoxy and aromatic acid herbicides. Samples were extracted with alkaline methanol, before clean-up, and finally analysis with LC-MS/MS

Limits of reporting (LOR) for all of the agricultural chemicals analysed in the 2016 NZTDS are detailed in Appendix 5.

Contaminant elements and nutrients

All of the collected and prepared food samples (1056 samples) were analysed using standard methodology to quantify the levels of trace elements.

With the exception of analysis for total arsenic, inorganic arsenic, methylmercury, fluoride, iodine and selenium the samples were acid digested to release the element from the food matrix.

The arsenic, iodine and selenium analysis involved digesting the samples in the alkaline tetramethylammonium hydroxide, and the use of an enzyme digestion for the high starch food types. All the digested samples were then filtered before the elements were quantified using Inductively Coupled Plasma - Mass Spectrometry (ICP-MS), or in the case of sodium Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES).

Sub-samples of all of the collected and prepared seafood samples (60 samples) were analysed for methylmercury. The samples were extracted using sodium hydroxide, before the methylmercury was isolated using a derivitising agent. The methylmercury was then quantified using a headspace solid phase microextraction and GC-MS.

For samples containing total arsenic concentrations greater than 0.02 mg/kg sub-samples were further analysed for inorganic arsenic. The samples were acid digested, followed by chemical reduction of the arsenic to its trivalent state with hydrobromic acid and hydrazine sulphate. The samples was then solvent extracted and the inorganic arsenic quantified by ICP-MS.

Fluoride was analysed in samples of all beverage and plant-based foods. In solid foods, fluoride was extracted using 0.1M perchloric acid. The levels of fluoride were quantified in all foods using an ion-specific electrode.

Appendix 5: List of agricultural chemical analytes screened for in the 2016 NZTDS and their limits of reporting

Appendix 5.1: Agricultural chemical analytes in the multi-screen and limits of reporting (LOR) in different food matrix types

Analyte	Limit of reporting in different food types (mg/kg)		
	Fruit and vegetables	High carbohydrate	High fat
2,4' - DDD	0.005	0.01	0.02
2,4' - DDE	0.005	0.01	0.02
2,4' - DDT	0.005	0.01	0.02
4,4' - DDD	0.005	0.01	0.02
4,4' - DDE	0.005	0.01	0.02
4,4' - DDT	0.005	0.01	0.02
Abamectin	0.01	0.02	0.1
Acephate	0.01	0.03	0.08
Acetamiprid	0.01	0.01	0.01
Acetochlor	0.01	0.01	0.02
Acrinathrin	0.01	0.04	0.08
Alachlor	0.01	0.01	0.02
Aldicarb sulfone	0.01	0.01	0.02
Aldicarb sulfoxide	0.01	0.01	0.02
Aldicarb	0.01	0.01	0.02
Aldrin	0.005	0.02	0.04
alpha-BHC	0.005	0.01	0.04
Ametryn	0.01	0.01	0.02
Anilazine	0.02	0.05	1
Atrazine - desethyl	0.01	0.01	0.01
Atrazine - desisopropyl	0.01	0.02	0.2
Atrazine	0.01	0.01	0.01
Azaconazole	0.01	0.01	0.01
Azinphos-methyl	0.01	0.01	0.02
Azoxystrobin	0.01	0.01	0.01
Benalaxyl	0.01	0.01	0.02
Bendiocarb	0.01	0.01	0.01
Benodanil	0.01	0.01	0.01
Benoxacor	0.01	0.01	0.02
Benzalkonium chloride (C12)	0.01	0.05	0.2
Benzalkonium chloride (C14)	0.01	0.05	0.2
Benzalkonium chloride (C16)	0.01	0.02	0.09
beta-BHC	0.005	0.01	0.04
Bifenox	0.01	0.01	0.02
Bifenthrin	0.01	0.01	0.02
Bitertanol	0.01	0.01	0.02
Bixafen	0.01	0.01	0.01
Boscalid	0.01	0.01	0.05
Bromacil	0.01	0.01	0.03
Bromophos-ethyl	0.01	0.01	0.02
Bromopropylate	0.01	0.01	0.02

Analyte	Limit of reporting in different food types (mg/kg)		
	Fruit and vegetables	High carbohydrate	High fat
Bupirimate	0.01	0.01	0.02
Buprofezin	0.01	0.01	0.01
Butachlor	0.01	0.01	0.01
Butamifos	0.01	0.01	0.02
Cadusafos	0.01	0.01	0.01
Captafol	0.01	0.3	0.5
Captan	0.01	0.05	0.1
Carbaryl	0.01	0.01	0.01
Carbendazim (incl. benomyl and thiophanate)	0.01	0.01	0.01
Carbofenothion	0.01	0.01	0.02
Carbofuran	0.01	0.01	0.01
Carboxin	0.01	0.01	0.02
Carfentrazone-ethyl	0.01	0.01	0.04
Chlorantraniliprole	0.01	0.01	0.01
Chlorfenapyr	0.01	0.01	0.03
Chlorfenvinphos	0.01	0.01	0.01
Chlorfluazuron	0.01	0.01	0.03
Chloridazon	0.01	0.01	0.04
Chlorobenzilate	0.01	0.01	0.02
Chlorothalonil	0.01	0.05	0.1
Chlorpropham	0.01	0.01	0.07
Chlorpyrifos	0.01	0.01	0.01
Chlorpyrifos-methyl	0.01	0.01	0.02
Chlorthal-dimethyl	0.01	0.01	0.02
Chlortoluron	0.01	0.01	0.01
Chlozolinate	0.01	0.01	0.02
cis-Chlordane	0.005	0.01	0.02
Clethodim	0.01	0.01	0.02
Clofentezine	0.01	0.01	0.2
Clomazone	0.01	0.01	0.01
Coumaphos	0.01	0.01	0.04
Cyanazine	0.01	0.01	0.03
Cyanophos	0.01	0.01	0.04
Cyantraniliprole	0.01	0.03	0.01
Cyflufenamid	0.01	0.01	0.01
Cyfluthrin	0.01	0.01	0.02
Cyhalothrin	0.01	0.01	0.02
Cypermethrin	0.01	0.01	0.02
Cyproconazole	0.01	0.01	0.02
Cyprodinil	0.01	0.01	0.04
delta-BHC	0.005	0.01	0.04
Deltamethrin (including tralomethrin)	0.01	0.02	0.05
Demeton-S-methyl	0.01	0.01	0.01
Diazinon	0.01	0.01	0.02
Dichlobenil	0.01	0.05	0.1
Dichlofenthion	0.01	0.01	0.02

Analyte	Limit of reporting in different food types (mg/kg)		
	Fruit and vegetables	High carbohydrate	High fat
Dichlofluanid	0.01	0.01	0.05
Dichlorvos	0.01	0.05	0.1
Dicloran	0.01	0.01	0.02
Dicofol	0.01	0.1	0.2
Dicrotophos	0.01	0.01	0.01
Didecyldimethylammonium chloride (DDAC)	0.01	0.03	0.1
Dieldrin	0.005	0.01	0.02
Diethofencarb	0.01	0.01	0.02
Difenoconazole	0.01	0.01	0.02
Diflubenzuron	0.01	0.03	0.2
Diflufenican	0.01	0.01	0.02
Dimethenamid	0.01	0.01	0.01
Dimethoate	0.01	0.01	0.01
Dimethylvinphos	0.01	0.01	0.02
Dimethomorph	0.01	0.01	0.02
Dioxabenzofos	0.01	0.01	0.04
Diphenylamine	0.01	0.01	0.04
Disulfoton	0.01	0.01	0.03
Diuron	0.01	0.01	0.03
Dodine	0.01	0.08	0.7
Edifenphos	0.01	0.01	0.01
Emamectin	0.01	0.03	0.3
Empenthrin	0.03	0.3	2
Endosulfan I	0.005	0.01	0.04
Endosulfan II	0.005	0.01	0.02
Endosulfan sulfate	0.005	0.02	0.06
Endrin aldehyde	0.005	0.02	0.07
Endrin ketone	0.005	0.01	0.02
Endrin	0.005	0.01	0.04
EPN	0.01	0.02	0.02
Epoxiconazole	0.01	0.01	0.02
EPTC	0.01	0.02	0.1
Esprocarb	0.01	0.01	0.02
Ethion	0.01	0.01	0.02
Ethoprophos	0.01	0.01	0.02
Etoxazole	0.01	0.01	0.01
Etridiazole	0.02	0.2	0.4
Etrimfos	0.01	0.01	0.02
Famphur	0.01	0.01	0.02
Fenamiphos	0.01	0.01	0.01
Fenarimol	0.01	0.01	0.02
Fenchlorphos	0.01	0.01	0.02
Fenhexamid	0.01	0.04	0.3
Fenitrothion	0.01	0.05	0.1
Fenobucarb	0.01	0.01	0.01
Fenoxaprop-ethyl	0.01	0.01	0.02

Analyte	Limit of reporting in different food types (mg/kg)		
	Fruit and vegetables	High carbohydrate	High fat
Fenoxycarb	0.01	0.01	0.01
Fenpiclonil	0.01	0.01	0.02
Fenpropathrin	0.01	0.01	0.02
Fenpropimorph	0.01	0.01	0.02
Fenpyroximate	0.01	0.01	0.01
Fensulfothion	0.01	0.01	0.01
Fenthion	0.01	0.01	0.02
Fenvalerate (including esfenvalerate)	0.01	0.01	0.07
Fipronil	0.01	0.01	0.03
Fluazifop-butyl	0.01	0.01	0.01
Flucythrinate	0.01	0.01	0.02
Fludioxonil	0.01	0.01	0.02
Flufenoxuron	0.01	0.01	0.02
Flumioxazin	0.01	0.02	0.1
Fluometuron	0.01	0.01	0.02
Flusilazole	0.01	0.01	0.01
Flutolanil	0.01	0.01	0.01
Flutriafol	0.01	0.05	0.1
Fluvalinate	0.01	0.01	0.03
Fluxapyroxad	0.01	0.01	0.02
Folpet	0.01	0.05	0.1
Fonofos	0.01	0.01	0.03
Furalaxyl	0.01	0.01	0.01
Furathiocarb	0.01	0.01	0.01
gamma-BHC	0.005	0.01	0.04
Halfenprox	0.01	0.01	0.02
Haloxyfop-methyl	0.01	0.01	0.01
Heptachlor epoxide	0.005	0.01	0.04
Heptachlor	0.005	0.02	0.04
Hexachlorobenzene	0.005	0.01	0.04
Hexaconazole	0.01	0.01	0.02
Hexazinone	0.01	0.01	0.01
Hexythiazox	0.01	0.01	0.01
Imazalil	0.01	0.01	0.02
Imidacloprid	0.01	0.01	0.03
Indoxacarb	0.01	0.01	0.03
Iodofenphos	0.01	0.01	0.02
Iprobenfos	0.01	0.01	0.01
Iprodione	0.01	0.01	0.03
Isazophos	0.01	0.01	0.02
Isofenphos	0.01	0.01	0.01
Isoprocarb	0.01	0.01	0.01
Kresoxim-methyl	0.01	0.01	0.02
Leptophos	0.01	0.01	0.02
Linuron	0.01	0.01	0.01
Lufenuron	0.01	0.1	0.7
Malathion	0.01	0.01	0.02

Analyte	Limit of reporting in different food types (mg/kg)		
	Fruit and vegetables	High carbohydrate	High fat
Mepronil	0.01	0.01	0.01
Metalaxyl	0.01	0.01	0.01
Metconazole	0.01	0.01	0.02
Methabenzthiazuron	0.01	0.01	0.03
Methacrifos	0.01	0.05	0.1
Methamidophos	0.01	0.01	0.1
Methidathion	0.01	0.01	0.02
Methiocarb	0.01	0.01	0.02
Methomyl	0.01	0.01	0.02
Methoxychlor	0.005	0.01	0.02
Methoxyfenozide	0.01	0.01	0.01
Metolachlor	0.01	0.01	0.01
Metribuzin	0.01	0.01	0.03
Mevinphos	0.01	0.01	0.02
Milbemectin	0.01	0.03	0.2
Molinate	0.01	0.05	0.1
Monocrotophos	0.01	0.01	0.01
Myclobutanil	0.01	0.01	0.02
Naled	0.01	0.04	0.4
Napropamide	0.01	0.01	0.01
Nitrofen	0.01	0.01	0.04
Nitrothal-isopropyl	0.01	0.01	0.02
Norflurazon	0.01	0.01	0.02
Omethoate	0.01	0.01	0.01
Oryzalin	0.02	0.02	0.08
Oxadiazon	0.01	0.01	0.02
Oxadixyl	0.01	0.01	0.02
Oxamyl	0.01	0.01	0.01
Oxychlordane	0.005	0.02	0.04
Oxyfluorfen	0.01	0.01	0.02
Paclobutrazol	0.01	0.01	0.02
Parathion-ethyl	0.01	0.01	0.02
Parathion-methyl	0.01	0.05	0.1
Penconazole	0.01	0.01	0.01
Pencycuron	0.01	0.03	0.2
Pendimethalin	0.01	0.01	0.02
Permethrin	0.01	0.01	0.02
Phenthoate	0.01	0.01	0.01
Phorate	0.01	0.01	0.04
Phosalone	0.01	0.01	0.02
Phosmet	0.01	0.01	0.03
Phosphamidon	0.01	0.01	0.02
Piperonyl-butoxide	0.01	0.01	0.02
Pirimicarb	0.01	0.01	0.01
Pirimiphos-methyl	0.01	0.01	0.01
Prochloraz	0.01	0.02	0.04
Procymidone	0.01	0.01	0.02

Analyte	Limit of reporting in different food types (mg/kg)		
	Fruit and vegetables	High carbohydrate	High fat
Profenofos	0.01	0.01	0.02
Prometryn	0.01	0.01	0.02
Propachlor	0.01	0.01	0.01
Propamocarb	0.01	0.01	0.02
Propanil	0.01	0.01	0.02
Propaphos	0.01	0.01	0.01
Propargite	0.01	0.01	0.01
Propazine	0.01	0.01	0.01
Propetamphos	0.01	0.01	0.02
Propham	0.01	0.05	0.1
Propiconazole	0.01	0.01	0.04
Propoxur	0.01	0.01	0.01
Propyzamide	0.01	0.01	0.02
Prothiofos	0.01	0.01	0.02
Pyraclofos	0.01	0.01	0.03
Pyraclostrobin	0.01	0.01	0.01
Pyrazophos	0.01	0.01	0.02
Pyrazoxyfen	0.01	0.01	0.06
Pyrethrin	0.01	0.04	0.25
Pyridaphenthion	0.01	0.01	0.01
Pyrifenox	0.01	0.01	0.02
Pyrimethanil	0.01	0.01	0.02
Pyriproxyfen	0.01	0.01	0.02
Quinalphos	0.01	0.01	0.01
Quintozene	0.01	0.01	0.04
Quizalofop-ethyl	0.01	0.01	0.02
Sethoxydim	0.01	0.01	0.02
Simazine	0.01	0.01	0.01
Simetryn	0.01	0.01	0.01
Spinetoram	0.01	0.01	0.05
Spinosad	0.01	0.01	0.02
Spiromesifen	0.01	0.01	0.01
Spirotetramat	0.01	0.01	0.01
Spirotetramat-cis-enol	0.01	0.01	0.01
Spirotetramat-cis-keto-hydroxy	0.01	0.01	0.04
Spirotetramat-enol-glucoside	0.01	0.01	0.06
Spirotetramat-mono-hydroxy	0.01	0.01	0.05
Sulfentrazone	0.01	0.01	0.04
Sulfotep	0.01	0.01	0.01
Sulfoxaflor	0.01	0.01	0.01
Tebuconazole	0.01	0.01	0.02
Tebufenozide	0.01	0.01	0.01
Tebufenpyrad	0.01	0.01	0.02
Teflubenzuron	0.02	0.04	0.2
Tefluthrin	0.01	0.01	0.03
Terbacil	0.01	0.1	0.3
Terbufos	0.01	0.01	0.04

Analyte	Limit of reporting in different food types (mg/kg)		
	Fruit and vegetables	High carbohydrate	High fat
Terbumeton	0.01	0.01	0.02
Terbuthylazine	0.01	0.01	0.06
Terbuthylazine-desethyl	0.01	0.01	0.02
Terbutryn	0.01	0.01	0.03
Tetrachlorvinphos	0.01	0.01	0.02
Tetraconazole	0.01	0.01	0.04
Tetradifon	0.01	0.01	0.02
Thenylchlor	0.01	0.01	0.01
Thiacloprid	0.01	0.01	0.02
Thiamethoxam	0.01	0.01	0.02
Thifluzamide	0.01	0.01	0.03
Thiobencarb	0.01	0.01	0.02
Thiometon	0.01	0.01	0.02
Thiophanate-methyl	0.01	0.01	0.05
Tolclofos-methyl	0.01	0.01	0.02
Tolylfluanid	0.01	0.01	0.02
Trans-chlordane	0.005	0.01	0.02
Triadimefon	0.01	0.01	0.02
Triadimenol	0.01	0.01	0.15
Tri-allate	0.01	0.01	0.02
Triazophos	0.01	0.01	0.02
Trichlorfon	0.01	0.01	0.05
Trifloxystrobin	0.01	0.01	0.01
Triflumuron	0.01	0.01	0.03
Trifluralin	0.01	0.05	0.1
Uniconazole	0.01	0.01	0.05
Vinclozolin	0.01	0.01	0.02

Appendix 5.2: Dithiocarbamate fungicides and natural compounds detected in the CS_2 residue screen. LOR for fruit and vegetables = 0.02 mg/kg

Agricultural chemicals	Natural compounds
Ferbam	Isothiocyanates (Perz et al., 2000)
Mancozeb	
Maneb	
Metiram	
Nabam	
Propineb	
Thiram	
Zineb	
Ziram	

Appendix 5.3: Phenoxy and aromatic acid herbicides and LORs for cereals and vegetables

Analyte	Limit of reporting for cereals and vegetables (mg/kg)
1-Naphthylacetic acid (NAA)	0.03
2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)	0.01
2,4,5-Trichlorophenoxypropionic acid (2,4,5-TP)	0.01
2,4-Dichlorophenoxyacetic acid (2,4-D)	0.01
4-Chlorophenoxyacetic acid (4-CPA)	0.01
Acibenzolar acid	0.01
Aminopyralid	0.01
Bentazone	0.01
Clopyralid	0.01
Dicamba	0.01
Dichlorprop	0.01
Fluazifop	0.01
Fluroxypyr	0.01
Haloxyfop	0.01
Ioxynil	0.01
MCPA	0.01
MCPB	0.01
Mecoprop	0.01
Picloram	0.02
Quizalofop	0.01
Triclopyr	0.01

Appendix 5.4: Agricultural chemicals detected in the 2016 NZTDS with multiple marker analytes

Agricultural chemical	Associated marker analytes detected in 2016
Benzalkonium chloride	Benzalkonium chloride (C12) Benzalkonium chloride (C14) Benzalkonium chloride (C16)
Carbendazim (incl. thiophanate-methyl)	Carbendazim (including benomyl and thiophanate) Thiophanate-methyl
Dimethoate/omethoate	Dimethoate Omethoate
Fluazifop/fluazifop-butyl	Fluazifop Fluazifop-butyl
Spirotetramat	Spirotetramat-cis-enol Spirotetramat-cis-keto-hydroxy Spirotetramat-enol-glucoside

Appendix 6: Elements analysed in the 2016 NZTDS and their limits of reporting (LOR)

Element	Limit of reporting (mg/kg) by different food matrix[a]				
	Water	Beverages	Fruit and vegetables	High carbohydrate	High fat
Aluminium	0.003	0.1	0.2	1	1
Arsenic – inorganic			0.02[b]		
Arsenic – total	0.001	0.001	0.002	0.01	0.01
Cadmium	0.00005	0.0002	0.0004	0.002	0.002
Fluoride	0.05–0.1	0.18–0.2	0.2–0.25	1.0–1.2	0.2–0.25[c]
Iodine	0.001	0.001	0.002	0.01	0.01
Lead	0.0001	0.001	0.002	0.01	0.01
Mercury[d]	0.0001	0.001	0.002	0.01	0.01
Selenium	0.001	0.002	0.004	0.02	0.02
Sodium	0.02	5	10	50	50
Tin	0.0005	0.005	0.01	0.05	0.05
Zinc	0.001	0.1	0.2	1	1

[a] LORs are general for those food matrices, some small variation occurs within categories. Full LORs for each sample have been published in the 2016 NZTDS Quarterly reports.
[b] A screening level of 0.02 mg/kg total arsenic was used for undertaking further analysis for inorganic arsenic.
[c] Avocado was the only high fat food that was analysed for fluoride.
[d] The LORs are for total mercury, only seafood was analysed for methylmercury with an LOR of 0.0043 mg/kg.

Appendix 7: Agricultural chemical residues and 2016 NZTDS foods in which they were detected

Appendix 7.1: Agricultural chemical residues and 2016 NZTDS foods in which they were detected

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
2,4-D	Not detected in any foods of 2016 NZTDS				
2,4,5-T	Not detected in any foods of 2016 NZTDS				
2,4,5-TP	Not detected in any foods of 2016 NZTDS				
4-CPA	Not detected in any foods of 2016 NZTDS				
Abamectin	Not detected in any foods of 2016 NZTDS				
Acephate	Capsicum	2	0.005	Not detected	0.02
	Mandarin	1	0.002	Not detected	0.02
	Melon	1	0.011	Not detected	0.09
Acetamiprid	Raisins/sultanas	1	0.002	Not detected	0.02
Acetochlor	Not detected in any foods of 2016 NZTDS				
Acibenzolar acid	Not detected in any foods of 2016 NZTDS				
Acrinathrin	Not detected in any foods of 2016 NZTDS				
Alachlor	Not detected in any foods of 2016 NZTDS				
Aldicarb	Not detected in any foods of 2016 NZTDS				
Aldrin	Not detected in any foods of 2016 NZTDS				
alpha-BHC	Not detected in any foods of 2016 NZTDS				
Ametryn	Not detected in any foods of 2016 NZTDS				
Aminopyralid	Not detected in any foods of 2016 NZTDS				
Anilazine	Not detected in any foods of 2016 NZTDS				
Atrazine	Not detected in any foods of 2016 NZTDS				
Azaconazole	Not detected in any foods of 2016 NZTDS				
Azinphos-methyl	Not detected in any foods of 2016 NZTDS				
Azoxystrobin	Bran flake cereal, mixed	1	0.001	Not detected	0.01
	Grape	1	0.001	Not detected	0.01
	Muesli	2	0.004	Not detected	0.02
	Raisins/sultanas	3	0.032	Not detected	0.15
Benalaxyl	Not detected in any foods of 2016 NZTDS				
Bendiocarb	Not detected in any foods of 2016 NZTDS				
Benodanil	Not detected in any foods of 2016 NZTDS				
Benoxacor	Not detected in any foods of 2016 NZTDS				
Bentazone	Not detected in any foods of 2016 NZTDS				
Benzalkonium chloride (Sum C12-C16)	Bacon	3	0.033	Not detected	0.13
	Beef, mince	3	0.084	Not detected	0.24
	Beef, rump	1	0.009	Not detected	0.07
	Beetroot, canned	1	0.006	Not detected	0.04
	Chicken	1	0.016	Not detected	0.13
	Chicken takeaway	3	0.068	Not detected	0.22
	Chocolate beverage	1	0.007	Not detected	0.05
	Corn, frozen	7	0.054	Not detected	0.15
	Fish, battered	1	0.011	Not detected	0.09

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
	Fish, fresh	3	0.080	Not detected	0.30
	Ham	5	0.072	Not detected	0.27
	Hamburger, plain	2	0.034	Not detected	0.22
	Hummus	4	0.411	Not detected	1.91
	Lamb/mutton	1	0.007	Not detected	0.06
	Meat pie	1	0.040	Not detected	0.32
	Milk Chocolate	1	0.114	Not detected	0.91
	Milk, 3.25% fat	2	0.006	Not detected	0.04
	Mixed berries, frozen	5	0.024	Not detected	0.06
	Mixed vegetables, frozen	1	0.006	Not detected	0.05
	Mussel	4	0.069	Not detected	0.26
	Noodle dish	1	0.041	Not detected	0.33
	Orange juice	2	0.038	Not detected	0.17
	Oyster	1	0.266	Not detected	2.13
	Peas, frozen	2	0.026	Not detected	0.17
	Pineapple, canned	1	0.016	Not detected	0.13
	Potato, hot chips	1	0.020	Not detected	0.16
	Prawn/shrimp	2	0.039	Not detected	0.17
	Rice dish	1	0.010	Not detected	0.08
	Salad dressing	1	0.013	Not detected	0.10
	Sausage	2	0.030	Not detected	0.13
	Snacks, flavoured	1	0.007	Not detected	0.06
	Soup, vegetable	1	0.002	Not detected	0.02
	Sushi	1	0.011	Not detected	0.09
	Tofu	1	0.110	Not detected	0.88
	Tomato sauce	2	0.027	Not detected	0.15
beta-BHC	Not detected in any foods of 2016 NZTDS				
Bifenox	Not detected in any foods of 2016 NZTDS				
Bifenthrin	Courgette (zucchini)	1	0.002	Not detected	0.01
	Infant weaning food, cereal based	1	0.002	Not detected	0.01
	Mixed berries, frozen	1	0.004	Not detected	0.03
	Muffins and scones	1	0.001	Not detected	0.01
	Raisins/sultanas	1	0.001	Not detected	0.01
Bitertanol	Not detected in any foods of 2016 NZTDS				
Bixafen	Not detected in any foods of 2016 NZTDS				
Boscalid	Bran flake cereal, mixed	5	0.045	Not detected	0.21
	Grape	6	0.040	Not detected	0.09
	Mixed berries, frozen	3	0.015	Not detected	0.05
	Muesli	2	0.007	Not detected	0.03
	Muffins and scones	2	0.003	Not detected	0.02
	Prune	1	0.011	Not detected	0.09
	Raisins/sultanas	6	0.106	Not detected	0.49
Bromacil	Not detected in any foods of 2016 NZTDS				
Bromophos-ethyl	Not detected in any foods of 2016 NZTDS				
Bromopropylate	Not detected in any foods of 2016 NZTDS				
Bupirimate	Not detected in any foods of 2016 NZTDS				

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
Buprofezin	Grape	2	0.012	Not detected	0.05
Butachlor	Not detected in any foods of 2016 NZTDS				
Butamifos	Not detected in any foods of 2016 NZTDS				
Cadusafos	Not detected in any foods of 2016 NZTDS				
Captafol	Not detected in any foods of 2016 NZTDS				
Captan	Apple	8	0.057	0.023	0.14
	Mixed berries, frozen	1	0.012	Not detected	0.10
	Nectarine	4	0.043	Not detected	0.15
	Pear	7	0.047	Not detected	0.10
	Strawberry	8	0.391	0.02	0.98
Carbaryl	Nectarine	3	0.025	Not detected	0.14
Carbendazim (incl. thiophanate-methyl)	Broccoli/cauliflower	1	0.005	Not detected	0.04
	Capsicum	2	0.006	Not detected	0.03
	Mixed berries, frozen	2	0.004	Not detected	0.02
	Mushroom	4	0.025	Not detected	0.10
	Pear	1	0.004	Not detected	0.03
	Pizza	1	0.001	Not detected	0.01
	Rice dish	1	0.002	Not detected	0.01
	Simmer sauce, bottled	6	0.043	Not detected	0.08
	Strawberry	1	0.011	Not detected	0.09
	Tomato	3	0.008	Not detected	0.03
	Tomato sauce	1	0.004	Not detected	0.03
Carbofenothion	Not detected in any foods of 2016 NZTDS				
Carbofuran	Not detected in any foods of 2016 NZTDS				
Carboxin	Not detected in any foods of 2016 NZTDS				
Carfentrazone-ethyl	Not detected in any foods of 2016 NZTDS				
Chlorantraniliprole	Grape	3	0.013	Not detected	0.04
	Raisins/sultanas	2	0.006	Not detected	0.03
	Strawberry	2	0.005	Not detected	0.02
Chlorfenapyr	Not detected in any foods of 2016 NZTDS				
Chlorfenvinphos	Not detected in any foods of 2016 NZTDS				
Chlorfluazuron	Not detected in any foods of 2016 NZTDS				
Chloridazon	Not detected in any foods of 2016 NZTDS				
Chlorobenzilate	Not detected in any foods of 2016 NZTDS				
Chlorothalonil	Capsicum	1	0.001	Not detected	0.01
	Celery	4	0.011	Not detected	0.03
	Cucumber	2	0.007	Not detected	0.04
	Lettuce	1	0.008	Not detected	0.07
	Mixed berries, frozen	1	0.006	Not detected	0.05
	Tomato	1	0.006	Not detected	0.05
Chlorpropham	Fish cakes	3	0.014	Not detected	0.06
	Meat pie	1	0.003	Not detected	0.02
	Potato crisps	2	0.109	Not detected	0.67
	Potato, hot chips	8	0.239	0.09	0.39

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
Chlorpyrifos	Bran flake cereal, mixed	3	0.004	Not detected	0.01
	Mixed berries, frozen	1	0.001	Not detected	0.01
	Peanut butter	1	0.006	Not detected	0.04
	Peanut	2	0.006	Not detected	0.03
	Raisins/sultanas	3	0.037	Not detected	0.13
Chlorpyrifos-methyl	Biscuit, cracker	3	0.035	Not detected	0.13
	Bran flake cereal, mixed	2	0.016	Not detected	0.06
	Bread, mixed grain	4	0.025	Not detected	0.06
	Bread, wheatmeal	5	0.110	Not detected	0.36
	Bread, white	4	0.033	Not detected	0.08
	Fish cakes	1	0.002	Not detected	0.02
	Fish fingers	1	0.001	Not detected	0.01
	Hamburger, plain	3	0.009	Not detected	0.04
	Meat Pie	2	0.005	Not detected	0.03
	Muesli	3	0.009	Not detected	0.05
	Muffins and scones	1	0.002	Not detected	0.02
	Other cereals	1	0.052	Not detected	0.42
	Pizza	3	0.011	Not detected	0.05
	Snacks, flavoured	1	0.003	Not detected	0.02
	Wheat biscuit cereal	3	0.006	Not detected	0.03
Chlorthal-dimethyl	Not detected in any foods of 2016 NZTDS				
Chlortoluron	Not detected in any foods of 2016 NZTDS				
Chlozolinate	Not detected in any foods of 2016 NZTDS				
cis-Chlordane	Not detected in any foods of 2016 NZTDS				
Clethodim	Not detected in any foods of 2016 NZTDS				
Clofentezine	Not detected in any foods of 2016 NZTDS				
Clomazone	Not detected in any foods of 2016 NZTDS				
Clopyralid	Baked beans	1	0.010	Not detected	0.08
	Bran flake cereal, mixed	5	0.012	Not detected	0.04
	Bread, mixed grain	7	0.023	Not detected	0.07
	Bread, wheatmeal	8	0.029	0.02	0.05
	Bread, white	7	0.014	Not detected	0.02
	Corn, frozen	2	0.005	Not detected	0.02
	Kumara	2	0.027	Not detected	0.18
	Mixed vegetables, frozen	1	0.003	Not detected	0.02
	Muesli	1	0.004	Not detected	0.03
	Mushroom	4	0.022	Not detected	0.07
	Oats, rolled	3	0.006	Not detected	0.02
	Onion	1	0.002	Not detected	0.02
	Pasta, dried	2	0.007	Not detected	0.04
Coumaphos	Not detected in any foods of 2016 NZTDS				
CS_2	Apple-based juice	1	0.007	Not detected	0.06
	Avocado	3	0.010	Not detected	0.03
	Broccoli/cauliflower	3	0.012	Not detected	0.04
	Cabbage	8	0.165	0.05	0.29
	Coconut cream, canned	1	0.003	Not detected	0.02

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
	Cucumber	2	0.010	Not detected	0.06
	Grape	3	0.018	Not detected	0.05
	Mandarin	1	0.003	Not detected	0.02
	Nectarine	2	0.006	Not detected	0.03
	Onion	1	0.003	Not detected	0.02
	Orange juice	1	0.003	Not detected	0.02
	Potato, hot chips	1	0.005	Not detected	0.04
	Pumpkin	1	0.003	Not detected	0.02
	Silverbeet	2	0.015	Not detected	0.08
	Strawberry	4	0.166	Not detected	0.74
	Tomato sauce	2	0.008	Not detected	0.04
Cyanazine	Not detected in any foods of 2016 NZTDS				
Cyanophos	Not detected in any foods of 2016 NZTDS				
Cyantraniliprole	Not detected in any foods of 2016 NZTDS				
Cyflufenamid	Grape	2	0.003	Not detected	0.01
	Raisins/sultanas	1	0.002	Not detected	0.01
Cyfluthrin	Not detected in any foods of 2016 NZTDS				
Cyhalothrin	Raisins/sultanas	4	0.011	Not detected	0.02
Cypermethrin	Oil	3	0.056	Not detected	0.16
	Raisins/sultanas	4	0.017	Not detected	0.06
	Table spread	2	0.005	Not detected	0.02
Cyproconazole	Not detected in any foods of 2016 NZTDS				
Cyprodinil	Bran flake cereal, mixed	4	0.017	Not detected	0.08
	Grape	3	0.018	Not detected	0.09
	Muesli	1	0.003	Not detected	0.02
	Raisins/sultanas	6	0.061	Not detected	0.18
	Strawberry	5	0.160	Not detected	0.44
	Wine, still red	1	0.001	Not detected	0.01
DDAC	Chicken	1	0.011	Not detected	0.09
	Chicken takeaway	1	0.007	Not detected	0.05
	Confectionery	1	0.013	Not detected	0.10
	Fish cakes	1	0.009	Not detected	0.07
	Fish, fresh	3	0.044	Not detected	0.18
	Ham	1	0.005	Not detected	0.04
	Hummus	1	0.026	Not detected	0.21
	Mussels	2	0.029	Not detected	0.12
	Rice dish	1	0.005	Not detected	0.04
	Snack bar	1	0.012	Not detected	0.10
	Strawberry	1	0.004	Not detected	0.03
	Sushi	2	0.009	Not detected	0.04
	Tofu	6	0.048	Not detected	0.14
DDT (4,4'-DDE)	Beef, mince	1	0.002	Not detected	0.01
	Butter	1	0.003	Not detected	0.02
	Lamb/mutton	1	0.003	Not detected	0.02
delta-BHC	Not detected in any foods of 2016 NZTDS				

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
Deltamethrin (including tralomethrin)	Biscuit, cracker	3	0.012	Not detected	0.05
	Bran flake cereal, mixed	1	0.005	Not detected	0.04
	Hamburger, plain	1	0.003	Not detected	0.02
	Other cereals	1	0.010	Not detected	0.08
Demeton-S-methyl	Not detected in any foods of 2016 NZTDS				
Diazinon	Not detected in any foods of 2016 NZTDS				
Dicamba	Not detected in any foods of 2016 NZTDS				
Dichlobenil	Not detected in any foods of 2016 NZTDS				
Dichlofenthion	Not detected in any foods of 2016 NZTDS				
Dichlofluanid	Not detected in any foods of 2016 NZTDS				
Dichlorprop	Not detected in any foods of 2016 NZTDS				
Dichlorvos	Not detected in any foods of 2016 NZTDS				
Dicloran	Kumara	8	0.083	0.01	0.32
	Strawberry	3	0.061	Not detected	0.37
Dicofol	Not detected in any foods of 2016 NZTDS				
Dicrotophos	Not detected in any foods of 2016 NZTDS				
Dieldrin	Courgette (zucchini)	1	0.001	Not detected	0.01
	Pumpkin	1	0.005	Not detected	0.04
Diethofencarb	Not detected in any foods of 2016 NZTDS				
Difenoconazole	Broccoli/cauliflower	1	0.003	Not detected	0.03
	Celery	2	0.009	Not detected	0.04
	Hummus	1	0.001	Not detected	0.01
	Noodle dish	1	0.005	Not detected	0.04
	Raisins/sultanas	2	0.004	Not detected	0.02
	Sushi	1	0.003	Not detected	0.02
Diflubenzuron	Not detected in any foods of 2016 NZTDS				
Diflufenican	Not detected in any foods of 2016 NZTDS				
Dimethenamid	Not detected in any foods of 2016 NZTDS				
Dimethoate/omethoate	Courgette (zucchini)	3	0.023	Not detected	0.09
	Strawberry	1	0.004	Not detected	0.03
Dimethylvinphos	Not detected in any foods of 2016 NZTDS				
Dimethomorph	Bran flake cereal, mixed	1	0.002	Not detected	0.01
	Raisins/sultanas	2	0.007	Not detected	0.04
Dioxabenzofos	Not detected in any foods of 2016 NZTDS				
Diphenylamine	Apple	1	0.005	Not detected	0.04
	Infant weaning food, cereal based	3	0.009	Not detected	0.04
	Infant weaning food, custard/fruit dish	2	0.021	Not detected	0.11
	Pear	5	0.082	Not detected	0.23
Disulfoton	Not detected in any foods of 2016 NZTDS				
Diuron	Prawn/shrimp	1	0.001	Not detected	0.01
Dodine	Apple	1	0.001	Not detected	0.01
	Pear	2	0.015	Not detected	0.07
Edifenphos	Not detected in any foods of 2016 NZTDS				
Emamectin	Not detected in any foods of 2016 NZTDS				
Empenthrin	Not detected in any foods of 2016 NZTDS				

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
Endosulfan	Not detected in any foods of 2016 NZTDS				
Endrin	Not detected in any foods of 2016 NZTDS				
EPN	Not detected in any foods of 2016 NZTDS				
Epoxiconazole	Not detected in any foods of 2016 NZTDS				
EPTC	Not detected in any foods of 2016 NZTDS				
Esprocarb	Not detected in any foods of 2016 NZTDS				
Ethion	Not detected in any foods of 2016 NZTDS				
Ethoprophos	Not detected in any foods of 2016 NZTDS				
Etoxazole	Grape	3	0.002	Not detected	0.03
Etridiazole	Not detected in any foods of 2016 NZTDS				
Etrimfos	Not detected in any foods of 2016 NZTDS				
Famphur	Not detected in any foods of 2016 NZTDS				
Fenamiphos	Not detected in any foods of 2016 NZTDS				
Fenarimol	Not detected in any foods of 2016 NZTDS				
Fenchlorphos	Not detected in any foods of 2016 NZTDS				
Fenhexamid	Grape	1	0.032	Not detected	0.26
	Strawberry	4	0.095	Not detected	0.36
Fenitrothion	Not detected in any foods of 2016 NZTDS				
Fenobucarb	Not detected in any foods of 2016 NZTDS				
Fenoxaprop-ethyl	Not detected in any foods of 2016 NZTDS				
Fenoxycarb	Not detected in any foods of 2016 NZTDS				
Fenpiclonil	Not detected in any foods of 2016 NZTDS				
Fenpropathrin	Grape	1	0.008	Not detected	0.06
Fenpropimorph	Not detected in any foods of 2016 NZTDS				
Fenpyroximate	Raisins/sultanas	2	0.004	Not detected	0.02
Fensulfothion	Not detected in any foods of 2016 NZTDS				
Fenthion	Not detected in any foods of 2016 NZTDS				
Fenvalerate (including esfenvalerate)	Raisins/sultanas	2	0.005	Not detected	0.02
Fipronil	Not detected in any foods of 2016 NZTDS				
Fluazifop/fluazifop-butyl	Mixed vegetables, frozen	1	0.001	Not detected	0.01
	Potato, peeled	1	0.003	Not detected	0.02
	Potato, with skin	1	0.011	Not detected	0.09
	Raisins/sultanas	1	0.013	Not detected	0.10
Flucythrinate	Not detected in any foods of 2016 NZTDS				
Fludioxonil	Apple-based juice	1	0.002	Not detected	0.02
	Bran flake cereal, mixed	1	0.002	Not detected	0.02
	Grape	1	0.002	Not detected	0.01
	Infant weaning food, cereal based	1	0.007	Not detected	0.06
	Infant weaning food, custard/fruit dish	2	0.010	Not detected	0.06
	Mixed berries, frozen	1	0.003	Not detected	0.03
	Nectarine	4	0.173	Not detected	0.49
	Pear	2	0.015	Not detected	0.06
	Raisins/sultanas	3	0.009	Not detected	0.04
	Strawberry	5	0.114	Not detected	0.30
Flufenoxuron	Raisins/sultanas	1	0.001	Not detected	0.01

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
Flumioxazin	Not detected in any foods of 2016 NZTDS				
Fluometuron	Not detected in any foods of 2016 NZTDS				
Fluroxypyr	Not detected in any foods of 2016 NZTDS				
Flusilazole	Not detected in any foods of 2016 NZTDS				
Flutolanil	Not detected in any foods of 2016 NZTDS				
Flutriafol	Not detected in any foods of 2016 NZTDS				
Fluvalinate	Not detected in any foods of 2016 NZTDS				
Fluxapyroxad	Not detected in any foods of 2016 NZTDS				
Folpet	Not detected in any foods of 2016 NZTDS				
Fonofos	Not detected in any foods of 2016 NZTDS				
Furalaxyl	Not detected in any foods of 2016 NZTDS				
Furathiocarb	Not detected in any foods of 2016 NZTDS				
gamma-BHC	Not detected in any foods of 2016 NZTDS				
Halfenprox	Not detected in any foods of 2016 NZTDS				
Haloxyfop/haloxyfop-methyl	Onion	1	0.004	Not detected	0.03
	Peas, frozen	1	0.002	Not detected	0.02
	Potato, hot chips	1	0.002	Not detected	0.02
Heptachlor	Not detected in any foods of 2016 NZTDS				
Hexachlorobenzene	Not detected in any foods of 2016 NZTDS				
Hexaconazole	Taro	1	0.006	Not detected	0.04
Hexazinone	Not detected in any foods of 2016 NZTDS				
Hexythiazox	Prunes	1	0.003	Not detected	0.03
	Raisins/sultanas	1	0.001	Not detected	0.01
Imazalil	Banana	2	0.010	Not detected	0.07
	Hummus	2	0.004	Not detected	0.02
	Infant weaning food, cereal based	2	0.019	Not detected	0.13
	Infant weaning food, custard/fruit dish	2	0.004	Not detected	0.02
	Mandarin	2	0.014	Not detected	0.09
	Orange juice	1	0.002	Not detected	0.02
	Orange	7	0.069	Not detected	0.21
	Pear	5	0.064	Not detected	0.14
Imidacloprid	Capsicum	7	0.024	Not detected	0.06
	Celery	1	0.002	Not detected	0.01
	Courgette (zucchini)	1	0.003	Not detected	0.02
	Grape	1	0.012	Not detected	0.10
	Lettuce	2	0.004	Not detected	0.02
	Raisins/sultanas	3	0.007	Not detected	0.03
	Tomato	1	0.004	Not detected	0.03
Indoxacarb	Nectarine	1	0.002	Not detected	0.01
	Raisins/sultanas	4	0.010	Not detected	0.02
	Strawberry	3	0.016	Not detected	0.05
Iodofenphos	Not detected in any foods of 2016 NZTDS				
Ioxynil	Not detected in any foods of 2016 NZTDS				
Iprobenfos	Not detected in any foods of 2016 NZTDS				
Iprodione	Almond	1	0.002	Not detected	0.02
	Apple-based juice	1	0.002	Not detected	0.01

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
	Bran flake cereal, mixed	2	0.003	Not detected	0.06
	Cucumber	1	0.002	Not detected	0.02
	Hummus	1	0.002	Not detected	0.10
	Infant weaning food, cereal based	1	0.001	Not detected	0.07
	Infant weaning food, custard/fruit dish	2	0.043	Not detected	0.27
	Mixed berries, frozen	2	0.015	Not detected	0.10
	Muesli	3	0.013	Not detected	0.05
	Nectarine	4	0.477	Not detected	1.26
	Peach, canned	2	0.003	Not detected	0.02
	Pear	5	0.052	Not detected	0.14
	Raisins/sultanas	6	0.144	Not detected	0.59
	Snack bar	1	0.001	Not detected	0.01
	Strawberry	4	0.261	Not detected	1.08
	Tomato	1	0.007	Not detected	0.05
	Wine, still red	1	0.001	Not detected	0.01
	Wine, still white	2	0.009	Not detected	0.06
Isazophos	Not detected in any foods of 2016 NZTDS				
Isofenphos	Not detected in any foods of 2016 NZTDS				
Isoprocarb	Not detected in any foods of 2016 NZTDS				
Kresoxim-methyl	Grape	2	0.004	Not detected	0.02
Leptophos	Not detected in any foods of 2016 NZTDS				
Linuron	Celery	1	0.002	Not detected	0.01
Lufenuron	Capsicum	1	0.002	Not detected	0.02
Malathion	Bread, wheatmeal	1	0.002	Not detected	0.01
MCPA	Not detected in any foods of 2016 NZTDS				
MCPB	Not detected in any foods of 2016 NZTDS				
Mecoprop	Not detected in any foods of 2016 NZTDS				
Mepronil	Not detected in any foods of 2016 NZTDS				
Metalaxyl	Bran flake cereal, mixed	4	0.007	Not detected	0.02
	Cucumber	1	0.002	Not detected	0.02
	Raisins/sultanas	3	0.019	Not detected	0.07
	Wine, still red	1	0.003	Not detected	0.02
Metconazole	Not detected in any foods of 2016 NZTDS				
Methabenzthiazuron	Not detected in any foods of 2016 NZTDS				
Methacrifos	Not detected in any foods of 2016 NZTDS				
Methamidophos	Capsicum	1	0.005	Not detected	0.04
	Kumara	1	0.002	Not detected	0.01
Methidathion	Not detected in any foods of 2016 NZTDS				
Methiocarb	Not detected in any foods of 2016 NZTDS				
Methomyl	Capsicum	1	0.002	Not detected	0.02
	Courgette (zucchini)	3	0.012	Not detected	0.06
	Grape	3	0.011	Not detected	0.05
	Strawberry	2	0.010	Not detected	0.06
Methoxychlor	Not detected in any foods of 2016 NZTDS				
Methoxyfenozide	Bran flake cereal, mixed	4	0.008	Not detected	0.02
	Grape	2	0.003	Not detected	0.01

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
	Muesli	2	0.003	Not detected	0.02
	Nectarine	1	0.002	Not detected	0.02
	Raisins/sultanas	8	0.050	0.01	0.10
	Wine, still white	1	0.001	Not detected	0.01
Metolachlor	Not detected in any foods of 2016 NZTDS				
Metribuzin	Potato crisps	3	0.005	Not detected	0.02
Mevinphos	Not detected in any foods of 2016 NZTDS				
Milbemectin	Not detected in any foods of 2016 NZTDS				
Molinate	Not detected in any foods of 2016 NZTDS				
Monocrotophos	Not detected in any foods of 2016 NZTDS				
Myclobutanil	Grape	3	0.006	Not detected	0.02
	Raisins/sultanas	3	0.005	Not detected	0.02
	Strawberry	3	0.009	Not detected	0.03
NAA	Not detected in any foods of 2016 NZTDS				
Naled	Not detected in any foods of 2016 NZTDS				
Napropamide	Not detected in any foods of 2016 NZTDS				
Nitrofen	Not detected in any foods of 2016 NZTDS				
Nitrothal-isopropyl	Not detected in any foods of 2016 NZTDS				
Norflurazon	Not detected in any foods of 2016 NZTDS				
Oryzalin	Not detected in any foods of 2016 NZTDS				
Oxadiazon	Not detected in any foods of 2016 NZTDS				
Oxadixyl	Not detected in any foods of 2016 NZTDS				
Oxamyl	Not detected in any foods of 2016 NZTDS				
Oxychlordane	Not detected in any foods of 2016 NZTDS				
Oxyfluorfen	Not detected in any foods of 2016 NZTDS				
Paclobutrazol	Not detected in any foods of 2016 NZTDS				
Parathion-ethyl	Not detected in any foods of 2016 NZTDS				
Parathion-methyl	Not detected in any foods of 2016 NZTDS				
Penconazole	Raisins/sultanas	1	0.002	Not detected	0.02
Pencycuron	Not detected in any foods of 2016 NZTDS				
Pendimethalin	Not detected in any foods of 2016 NZTDS				
Permethrin	Not detected in any foods of 2016 NZTDS				
Phenthoate	Not detected in any foods of 2016 NZTDS				
Phorate	Not detected in any foods of 2016 NZTDS				
Phosalone	Not detected in any foods of 2016 NZTDS				
Phosmet	Mixed berries, frozen	2	0.004	Not detected	0.02
Phosphamidon	Not detected in any foods of 2016 NZTDS				
Picloram	Not detected in any foods of 2016 NZTDS				
Piperonyl-butoxide	Almond	7	0.109	Not detected	0.27
	Biscuits, cracker	3	0.043	Not detected	0.14
	Bran flake cereal, mixed	6	0.057	Not detected	0.15
	Bread, mixed grain	1	0.001	Not detected	0.01
	Bread, wheatmeal	2	0.006	Not detected	0.03
	Chicken takeaway	2	0.003	Not detected	0.01
	Cornflakes	1	0.012	Not detected	0.10
	Fish cakes	3	0.008	Not detected	0.02

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
	Fish fingers	1	0.001	Not detected	0.01
	Fish, battered	1	0.004	Not detected	0.03
	Fish, fresh	1	0.002	Not detected	0.02
	Grape	1	0.001	Not detected	0.01
	Hamburger, plain	2	0.026	Not detected	0.17
	Infant weaning food, cereal based	1	0.006	Not detected	0.05
	Meat pie	2	0.010	Not detected	0.04
	Muffins and scones	2	0.013	Not detected	0.08
	Mushroom	2	0.008	Not detected	0.04
	Nectarine	1	0.001	Not detected	0.01
	Noodle dish	1	0.007	Not detected	0.06
	Other cereals	3	0.104	Not detected	0.81
	Peanut	1	0.001	Not detected	0.01
	Pizza	1	0.010	Not detected	0.08
	Prune	1	0.004	Not detected	0.03
	Snack bar	1	0.002	Not detected	0.02
	Soup, vegetable	1	0.004	Not detected	0.04
	Sushi	1	0.003	Not detected	0.02
	Tomato	1	0.009	Not detected	0.08
Pirimicarb	Nectarine	1	0.002	Not detected	0.02
	Strawberry	2	0.014	Not detected	0.10
Pirimiphos-methyl	Biscuit, chocolate	6	0.080	Not detected	0.22
	Biscuit, cracker	3	0.066	Not detected	0.24
	Biscuit, plain sweet	7	0.145	Not detected	0.37
	Bran flake cereal, mixed	3	0.019	Not detected	0.07
	Bread, mixed grain	8	0.067	0.03	0.11
	Bread, wheatmeal	5	0.067	Not detected	0.16
	Bread, white	5	0.050	Not detected	0.12
	Cakes and slices	6	0.024	Not detected	0.06
	Cornflakes	2	0.010	Not detected	0.07
	Fish fingers	5	0.040	Not detected	0.11
	Fish, battered	3	0.007	Not detected	0.02
	Hamburger, plain	4	0.014	Not detected	0.04
	Meat pie	2	0.003	Not detected	0.01
	Muffins and scones	8	0.023	0.01	0.04
	Noodle dish	2	0.003	Not detected	0.01
	Oats, rolled	1	0.002	Not detected	0.01
	Pasta, dried	1	0.002	Not detected	0.02
	Pizza	6	0.034	Not detected	0.08
	Sausage	1	0.006	Not detected	0.05
	Snack bar	5	0.007	Not detected	0.01
	Snacks, flavoured	6	0.324	Not detected	2.12
Prochloraz	Mushroom	5	0.013	Not detected	0.05
	Strawberry	1	0.002	Not detected	0.01
Procymidone	Cucumber	1	0.003	Not detected	0.02
	Mixed vegetables, frozen	1	0.002	Not detected	0.01

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
	Noodle dish	1	0.002	Not detected	0.01
	Pumpkin	2	0.005	Not detected	0.02
	Simmer sauce, bottled	2	0.008	Not detected	0.05
	Spaghetti in sauce, canned	1	0.003	Not detected	0.02
	Tomato	2	0.027	Not detected	0.17
	Tomatoes in juice, canned	1	0.002	Not detected	0.02
Profenofos	Not detected in any foods of 2016 NZTDS				
Prometryn	Not detected in any foods of 2016 NZTDS				
Propachlor	Not detected in any foods of 2016 NZTDS				
Propamocarb	Cucumber	4	0.023	Not detected	0.07
Propanil	Not detected in any foods of 2016 NZTDS				
Propaphos	Not detected in any foods of 2016 NZTDS				
Propargite	Infant weaning food, cereal based	3	0.009	Not detected	0.04
	Infant weaning food, custard/fruit dish	1	0.003	Not detected	0.02
	Raisins/sultanas	1	0.003	Not detected	0.03
Propazine	Not detected in any foods of 2016 NZTDS				
Propetamphos	Not detected in any foods of 2016 NZTDS				
Propham	Apple	2	0.010	Not detected	0.07
	Pear	2	0.005	Not detected	0.03
	Potato crisps	4	0.101	Not detected	0.52
	Potato, hot chips	1	0.014	Not detected	0.11
	Potato, with skin	5	0.556	Not detected	2.08
	Potato, peeled	4	0.348	Not detected	1.59
Propiconazole	Infant weaning food, cereal based	1	0.002	Not detected	0.02
Propoxur	Not detected in any foods of 2016 NZTDS				
Propyzamide	Not detected in any foods of 2016 NZTDS				
Prothiofos	Not detected in any foods of 2016 NZTDS				
Pyraclofos	Not detected in any foods of 2016 NZTDS				
Pyraclostrobin	Grape	4	0.009	Not detected	0.02
	Prune	1	0.006	Not detected	0.05
	Raisins/sultanas	2	0.009	Not detected	0.06
Pyrazophos	Not detected in any foods of 2016 NZTDS				
Pyrazoxyfen	Not detected in any foods of 2016 NZTDS				
Pyrethrin	Almond	3	0.021	Not detected	0.07
Pyridaphenthion	Not detected in any foods of 2016 NZTDS				
Pyrifenox	Not detected in any foods of 2016 NZTDS				
Pyrimethanil	Bran flake cereal, mixed	6	0.066	Not detected	0.20
	Grape	3	0.035	Not detected	0.13
	Hummus	2	0.003	Not detected	0.02
	Muesli	6	0.019	Not detected	0.04
	Muffins and scones	1	0.002	Not detected	0.01
	Peach, canned	1	0.014	Not detected	0.11
	Raisins/sultanas	4	0.293	Not detected	0.88
	Snack bar	3	0.015	Not detected	0.06
	Strawberry	4	0.144	Not detected	0.76
Pyriproxyfen	Not detected in any foods of 2016 NZTDS				

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
Quinalphos	Not detected in any foods of 2016 NZTDS				
Quintozene	Not detected in any foods of 2016 NZTDS				
Quizalofop/Quizalofop-ethyl	Not detected in any foods of 2016 NZTDS				
Sethoxydim	Not detected in any foods of 2016 NZTDS				
Simazine	Not detected in any foods of 2016 NZTDS				
Simetryn	Not detected in any foods of 2016 NZTDS				
Spinetoram	Capsicum	1	0.002	Not detected	0.01
	Nectarine	3	0.005	Not detected	0.01
Spinosad	Bran flake cereal, mixed	2	0.008	Not detected	0.04
	Bread, mixed grain	1	0.001	Not detected	0.01
	Bread, wheatmeal	4	0.009	Not detected	0.02
	Bread, white	1	0.001	Not detected	0.01
	Other cereals	1	0.002	Not detected	0.02
	Wheat biscuit cereal	3	0.014	Not detected	0.06
Spiromesifen	Tomato	3	0.008	Not detected	0.03
Spirotetramat	Grape	6	0.024	Not detected	0.05
	Orange	1	0.001	Not detected	0.01
	Potato crisps	3	0.005	Not detected	0.02
	Potato, hot chips	7	0.022	Not detected	0.05
	Potato, peeled	1	0.002	Not detected	0.01
	Potato, with skin	2	0.003	Not detected	0.01
	Raisins/sultanas	6	0.040	Not detected	0.11
Sulfentrazone	Not detected in any foods of 2016 NZTDS				
Sulfotep	Not detected in any foods of 2016 NZTDS				
Sulfoxaflor	Cucumber	1	0.006	Not detected	0.05
	Tomato	5	0.014	Not detected	0.04
Tebuconazole	Grape	3	0.013	Not detected	0.05
	Nectarine	3	0.039	Not detected	0.20
	Raisins/sultanas	2	0.003	Not detected	0.02
Tebufenozide	Apple	4	0.007	Not detected	0.02
	Pear	1	0.001	Not detected	0.01
Tebufenpyrad	Raisins/sultanas	1	0.002	Not detected	0.02
Teflubenzuron	Not detected in any foods of 2016 NZTDS				
Tefluthrin	Not detected in any foods of 2016 NZTDS				
Terbacil	Not detected in any foods of 2016 NZTDS				
Terbufos	Not detected in any foods of 2016 NZTDS				
Terbumeton	Not detected in any foods of 2016 NZTDS				
Terbuthylazine	Not detected in any foods of 2016 NZTDS				
Terbutryn	Not detected in any foods of 2016 NZTDS				
Tetrachlorvinphos	Not detected in any foods of 2016 NZTDS				
Tetraconazole	Raisins/sultanas	1	0.001	Not detected	0.01
Tetradifon	Not detected in any foods of 2016 NZTDS				
Thenylchlor	Not detected in any foods of 2016 NZTDS				
Thiacloprid	Tomato	1	0.001	Not detected	0.01
Thiamethoxam	Courgette (zucchini)	1	0.002	Not detected	0.02
Thifluzamide	Not detected in any foods of 2016 NZTDS				

Agricultural chemical	Food	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
Thiobencarb	Not detected in any foods of 2016 NZTDS				
Thiometon	Not detected in any foods of 2016 NZTDS				
Tolclofos-methyl	Not detected in any foods of 2016 NZTDS				
Tolylfluanid	Not detected in any foods of 2016 NZTDS				
Trans-chlordane	Not detected in any foods of 2016 NZTDS				
Triadimefon	Not detected in any foods of 2016 NZTDS				
Triadimenol	Grape	1	0.002	Not detected	0.02
	Raisins/sultanas	1	0.009	Not detected	0.07
	Rice dish	1	0.002	Not detected	0.01
Tri-allate	Mussels	1	0.002	Not detected	0.01
Triazophos	Not detected in any foods of 2016 NZTDS				
Trichlorfon	Not detected in any foods of 2016 NZTDS				
Triclopyr	Not detected in any foods of 2016 NZTDS				
Trifloxystrobin	Grape	3	0.005	Not detected	0.02
	Oil	1	0.003	Not detected	0.02
	Strawberry	2	0.008	Not detected	0.04
Triflumuron	Not detected in any foods of 2016 NZTDS				
Trifluralin	Not detected in any foods of 2016 NZTDS				
Uniconazole	Not detected in any foods of 2016 NZTDS				
Vinclozolin	Not detected in any foods of 2016 NZTDS				

[a] Lower bound (LB) mean: not detected results = zero.

Appendix 8: Foods of the 2016 NZTDS and agricultural chemical residues detected

Appendix 8.1: Foods of the 2016 NZTDS and agricultural chemical residues detected

2016 NZTDS food	Agricultural chemical detected	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
Almond	Iprodione	1	0.002	Not detected	0.02
	Piperonyl-butoxide	7	0.109	Not detected	0.27
	Pyrethrin	3	0.021	Not detected	0.07
Apple	Captan	8	0.056	0.02	0.14
	Diphenylamine	1	0.005	Not detected	0.04
	Dodine	1	0.001	Not detected	0.01
	Propham	2	0.010	Not detected	0.07
	Tebufenozide	4	0.007	Not detected	0.02
Apple-based juice	CS_2	1	0.007	Not detected	0.06
	Fludioxonil	1	0.002	Not detected	0.02
	Iprodione	1	0.002	Not detected	0.01
Avocado	CS_2	3	0.010	Not detected	0.03
Bacon	Benzalkonium chloride	3	0.033	Not detected	0.13
Baked beans	Clopyralid	1	0.010	Not detected	0.08
Banana	Imazalil	2	0.010	Not detected	0.07
Beef, mince	Benzalkonium chloride	3	0.084	Not detected	0.24
	DDT (4,4'-DDE)	1	0.002	Not detected	0.01
Beef, rump	Benzalkonium chloride	1	0.009	Not detected	0.07
Beer		0	No agricultural chemical residues detected		
Beetroot, canned	Benzalkonium chloride	1	0.006	Not detected	0.04
Biscuit, chocolate	Pirimiphos-methyl	6	0.080	Not detected	0.22
Biscuit, cracker	Chlorpyrifos-methyl	3	0.035	Not detected	0.13
	Deltamethrin (including tralomethrin)	3	0.012	Not detected	0.05
	Piperonyl-butoxide	3	0.043	Not detected	0.14
	Pirimiphos-methyl	3	0.066	Not detected	0.24
Biscuit, plain sweet	Pirimiphos-methyl	7	0.145	Not detected	0.37
Bran flake cereal, mixed	Azoxystrobin	1	0.001	Not detected	0.01
	Boscalid	5	0.045	Not detected	0.21
	Chlorpyrifos	3	0.004	Not detected	0.01
	Chlorpyrifos-methyl	2	0.016	Not detected	0.06
	Clopyralid	5	0.012	Not detected	0.04
	Cyprodinil	4	0.017	Not detected	0.08
	Deltamethrin (including tralomethrin)	1	0.005	Not detected	0.04
	Dimethomorph	1	0.002	Not detected	0.01
	Fludioxonil	1	0.002	Not detected	0.02
	Iprodione	2	0.003	Not detected	0.06
	Metalaxyl	4	0.007	Not detected	0.02
	Methoxyfenozide	4	0.008	Not detected	0.02
	Piperonyl-butoxide	6	0.057	Not detected	0.15

2016 NZTDS food	Agricultural chemical detected	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
	Pirimiphos-methyl	3	0.019	Not detected	0.07
	Pyrimethanil	6	0.069	Not detected	0.20
	Spinosad	2	0.008	Not detected	0.04
Bread, mixed grain	Chlorpyrifos-methyl	4	0.025	Not detected	0.06
	Clopyralid	7	0.023	Not detected	0.07
	Piperonyl-butoxide	1	0.001	Not detected	0.01
	Pirimiphos-methyl	8	0.067	0.03	0.11
	Spinosad	1	0.001	Not detected	0.01
Bread, wheatmeal	Chlorpyrifos-methyl	5	0.110	Not detected	0.36
	Clopyralid	8	0.029	0.02	0.05
	Malathion	1	0.002	Not detected	0.01
	Piperonyl-butoxide	2	0.006	Not detected	0.03
	Pirimiphos-methyl	5	0.067	Not detected	0.16
	Spinosad	4	0.009	Not detected	0.02
Bread, white	Chlorpyrifos-methyl	4	0.033	Not detected	0.08
	Clopyralid	7	0.014	Not detected	0.02
	Pirimiphos-methyl	5	0.050	Not detected	0.12
	Spinosad	1	0.001	Not detected	0.01
Broccoli/cauliflower	Carbendazim (incl. thiophanate-methyl)	1	0.005	Not detected	0.04
	CS_2	3	0.012	Not detected	0.04
	Difenoconazole	1	0.003	Not detected	0.03
Butter	DDT (4,4'-DDE)	1	0.003	Not detected	0.02
Cabbage	CS_2	8	0.165	0.05	0.29
Caffeinated beverage		0	No agricultural chemical residues detected		
Cakes and slices	Pirimiphos-methyl	6	0.024	Not detected	0.06
Capsicum	Acephate	2	0.005	Not detected	0.02
	Carbendazim (incl. thiophanate-methyl)	2	0.006	Not detected	0.03
	Chlorothalonil	1	0.001	Not detected	0.01
	Imidacloprid	7	0.024	Not detected	0.06
	Lufenuron	1	0.002	Not detected	0.02
	Methamidophos	1	0.005	Not detected	0.04
	Methomyl	1	0.002	Not detected	0.02
	Spinetoram	1	0.002	Not detected	0.01
Carbonated drink		0	No agricultural chemical residues detected		
Carrot		0	No agricultural chemical residues detected		
Celery	Chlorothalonil	4	0.011	Not detected	0.03
	Difenoconazole	2	0.009	Not detected	0.04
	Imidacloprid	1	0.002	Not detected	0.01
	Linuron	1	0.002	Not detected	0.01
Cheese		0	No agricultural chemical residues detected		
Chicken	Benzalkonium chloride	1	0.016	Not detected	0.13
	DDAC	1	0.011	Not detected	0.09
Chicken takeaway	Benzalkonium chloride	3	0.068	Not detected	0.22
	DDAC	1	0.007	Not detected	0.05
	Piperonyl-butoxide	2	0.003	Not detected	0.01
Chocolate beverage	Benzalkonium chloride	1	0.007	Not detected	0.05

2016 NZTDS food	Agricultural chemical detected	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
Coconut cream, canned	CS_2	1	0.003	Not detected	0.02
Coffee beans, ground		0	No agricultural chemical residues detected		
Coffee, instant		0	No agricultural chemical residues detected		
Confectionery	DDAC	1	0.013	Not detected	0.10
Corn, frozen	Benzalkonium chloride	7	0.054	Not detected	0.15
	Clopyralid	2	0.005	Not detected	0.02
Corned beef		0	No agricultural chemical residues detected		
Cornflakes	Piperonyl-butoxide	1	0.012	Not detected	0.10
	Pirimiphos-methyl	2	0.010	Not detected	0.07
Courgette (zucchini)	Bifenthrin	1	0.002	Not detected	0.01
	Dieldrin	1	0.001	Not detected	0.01
	Dimethoate/omethoate	3	0.023	Not detected	0.09
	Imidacloprid	1	0.003	Not detected	0.02
	Methomyl	3	0.012	Not detected	0.06
	Thiamethoxam	1	0.002	Not detected	0.02
Cucumber	Chlorothalonil	2	0.007	Not detected	0.04
	CS_2	2	0.010	Not detected	0.06
	Iprodione	1	0.002	Not detected	0.02
	Metalaxyl	1	0.002	Not detected	0.02
	Procymidone	1	0.003	Not detected	0.02
	Propamocarb	4	0.023	Not detected	0.07
	Sulfoxaflor	1	0.006	Not detected	0.05
Dairy dessert		0	No agricultural chemical residues detected		
Egg		0	No agricultural chemical residues detected		
Fish cakes	Chlorpropham	3	0.014	Not detected	0.06
	Chlorpyrifos-methyl	1	0.002	Not detected	0.02
	DDAC	1	0.009	Not detected	0.07
	Piperonyl-butoxide	3	0.008	Not detected	0.02
Fish fingers	Chlorpyrifos-methyl	1	0.001	Not detected	0.01
	Piperonyl-butoxide	1	0.001	Not detected	0.01
	Pirimiphos-methyl	5	0.040	Not detected	0.11
Fish, battered	Benzalkonium chloride	1	0.011	Not detected	0.09
	Piperonyl-butoxide	1	0.004	Not detected	0.03
	Pirimiphos-methyl	3	0.007	Not detected	0.02
Fish, canned		0	No agricultural chemical residues detected		
Fish, fresh	Benzalkonium chloride	3	0.080	Not detected	0.30
	DDAC	3	0.044	Not detected	0.18
	Piperonyl-butoxide	1	0.002	Not detected	0.02
Fruit drink		0	No agricultural chemical residues detected		
Grape	Azoxystrobin	*1*	0.001	Not detected	0.01
	Boscalid	*6*	0.040	Not detected	0.09
	Buprofezin	*2*	0.012	Not detected	0.05
	Chlorantraniliprole	*3*	0.013	Not detected	0.04
	CS_2	3	0.018	Not detected	0.05
	Cyflufenamid	2	0.003	Not detected	0.01
	Cyprodinil	3	0.018	Not detected	0.09
	Etoxazole	3	0.007	Not detected	0.03
	Fenhexamid	1	0.032	Not detected	0.26

2016 NZTDS food	Agricultural chemical detected	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
	Fenpropathrin	1	0.008	Not detected	0.06
	Fludioxonil	1	0.002	Not detected	0.01
	Imidacloprid	1	0.012	Not detected	0.10
	Kresoxim-methyl	2	0.004	Not detected	0.02
	Methomyl	3	0.011	Not detected	0.05
	Methoxyfenozide	2	0.003	Not detected	0.01
	Myclobutanil	3	0.006	Not detected	0.02
	Piperonyl-butoxide	1	0.001	Not detected	0.01
	Pyraclostrobin	4	0.009	Not detected	0.02
	Pyrimethanil	3	0.035	Not detected	0.13
	Spirotetramat	6	0.024	Not detected	0.05
	Tebuconazole	3	0.013	Not detected	0.05
	Triadimenol	1	0.002	Not detected	0.02
	Trifloxystrobin	3	0.005	Not detected	0.02
Ham	Benzalkonium chloride	5	0.072	Not detected	0.27
	DDAC	1	0.005	Not detected	0.04
Hamburger, plain	Benzalkonium chloride	2	0.034	Not detected	0.22
	Chlorpyrifos-methyl	3	0.009	Not detected	0.04
	Deltamethrin (including tralomethrin)	1	0.003	Not detected	0.02
	Piperonyl-butoxide	2	0.026	Not detected	0.17
	Pirimiphos-methyl	4	0.014	Not detected	0.04
Honey		0	No agricultural chemical residues detected		
Hummus	Benzalkonium chloride	4	0.411	Not detected	1.91
	DDAC	1	0.026	Not detected	0.21
	Difenoconazole	1	0.001	Not detected	0.01
	Imazalil	2	0.004	Not detected	0.02
	Iprodione	1	0.002	Not detected	0.10
	Pyrimethanil	2	0.003	Not detected	0.02
Ice cream		0	No agricultural chemical residues detected		
Infant/follow-on formula		0	No agricultural chemical residues detected		
Infant weaning food, cereal-based	Bifenthrin	1	0.002	Not detected	0.01
	Diphenylamine	3	0.009	Not detected	0.04
	Fludioxonil	1	0.007	Not detected	0.06
	Imazalil	2	0.019	Not detected	0.13
	Iprodione	1	0.001	Not detected	0.07
	Piperonyl-butoxide	1	0.006	Not detected	0.05
	Propargite	3	0.009	Not detected	0.04
	Propiconazole	1	0.002	Not detected	0.02
Infant weaning food, custard/fruit dish	Diphenylamine	2	0.021	Not detected	0.11
	Fludioxonil	2	0.010	Not detected	0.06
	Imazalil	2	0.004	Not detected	0.02
	Iprodione	2	0.043	Not detected	0.27
	Propargite	1	0.003	Not detected	0.02
Infant weaning food, savoury dish		0	No agricultural chemical residues detected		
Jam		0	No agricultural chemical residues detected		
Kiwifruit		0	No agricultural chemical residues detected		

2016 NZTDS food	Agricultural chemical detected	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
Kumara	Clopyralid	2	0.027	Not detected	0.18
	Dicloran	8	0.083	0.01	0.32
	Methamidophos	1	0.002	Not detected	0.01
Lamb/mutton	Benzalkonium chloride	1	0.007	Not detected	0.06
	DDT (4,4'-DDE)	1	0.003	Not detected	0.02
Lambs liver		0	No agricultural chemical residues detected		
Lettuce	Chlorothalonil	1	0.008	Not detected	0.07
	Imidacloprid	2	0.004	Not detected	0.02
Mandarin	Acephate	1	0.002	Not detected	0.02
	CS_2	1	0.003	Not detected	0.02
	Imazalil	2	0.014	Not detected	0.09
Meat pie	Benzalkonium chloride	1	0.040	Not detected	0.32
	Chlorpropham	1	0.003	Not detected	0.02
	Chlorpyrifos-methyl	2	0.005	Not detected	0.03
	Piperonyl-butoxide	2	0.010	Not detected	0.04
	Pirimiphos-methyl	2	0.003	Not detected	0.01
Melon	Acephate	1	0.011	Not detected	0.09
Milk chocolate	Benzalkonium chloride	1	0.114	Not detected	0.91
Milk, 0.5% fat		0	No agricultural chemical residues detected		
Milk, 3.25% fat	Benzalkonium chloride	2	0.006	Not detected	0.04
Milk, flavoured		0	No agricultural chemical residues detected		
Mixed berries, frozen	Benzalkonium chloride	5	0.024	Not detected	0.06
	Bifenthrin	1	0.004	Not detected	0.03
	Boscalid	3	0.015	Not detected	0.06
	Captan	1	0.012	Not detected	0.10
	Carbendazim (incl. thiophanate-methyl)	2	0.004	Not detected	0.02
	Chlorothalonil	1	0.006	Not detected	0.05
	Chlorpyrifos	1	0.001	Not detected	0.01
	Fludioxonil	1	0.003	Not detected	0.03
	Iprodione	2	0.015	Not detected	0.10
	Phosmet	2	0.005	Not detected	0.02
Mixed vegetables, frozen	Benzalkonium cloride	1	0.006	Not detected	0.05
	Clopyralid	1	0.003	Not detected	0.02
	Fluazifop/fluazifop-butyl	1	0.001	Not detected	0.01
	Procymidone	1	0.002	Not detected	0.01
Muesli	Azoxystrobin	2	0.004	Not detected	0.02
	Boscalid	2	0.007	Not detected	0.03
	Chlorpyrifos-methyl	3	0.009	Not detected	0.05
	Clopyralid	1	0.004	Not detected	0.03
	Cyprodinil	1	0.003	Not detected	0.02
	Iprodione	3	0.013	Not detected	0.05
	Methoxyfenozide	2	0.003	Not detected	0.02
	Pyrimethanil	6	0.019	Not detected	0.04
Muffins and scones	Bifenthrin	1	0.001	Not detected	0.01
	Boscalid	2	0.003	Not detected	0.02
	Chlorpyrifos-methyl	1	0.002	Not detected	0.02
	Piperonyl-butoxide	2	0.013	Not detected	0.08

2016 NZTDS food	Agricultural chemical detected	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
	Pirimiphos-methyl	8	0.023	0.01	0.04
	Pyrimethanil	1	0.002	Not detected	0.01
Mushroom	Carbendazim (incl. thiophanate-methyl)	4	0.025	Not detected	0.10
	Clopyralid	4	0.022	Not detected	0.07
	Piperonyl-butoxide	2	0.008	Not detected	0.04
	Prochloraz	5	0.013	Not detected	0.05
Mussels	Benzalkonium chloride	4	0.069	Not detected	0.26
	DDAC	2	0.029	Not detected	0.12
	Tri-allate	1	0.002	Not detected	0.01
Nectarine	Captan	4	0.043	Not detected	0.15
	Carbaryl	3	0.025	Not detected	0.14
	CS_2	2	0.006	Not detected	0.03
	Fludioxonil	4	0.173	Not detected	0.49
	Indoxacarb	1	0.002	Not detected	0.01
	Iprodione	4	0.477	Not detected	1.26
	Methoxyfenozide	1	0.002	Not detected	0.02
	Piperonyl-butoxide	1	0.001	Not detected	0.01
	Pirimicarb	1	0.002	Not detected	0.02
	Spinetoram	3	0.005	Not detected	0.01
	Tebuconazole	3	0.039	Not detected	0.20
Noodle dish	Benzalkonium chloride	1	0.041	Not detected	0.33
	Difenoconazole	1	0.005	Not detected	0.04
	Piperonyl-butoxide	1	0.007	Not detected	0.06
	Pirimiphos-methyl	2	0.003	Not detected	0.01
	Procymidone	1	0.002	Not detected	0.01
Noodles, instant		0	No agricultural chemical residues detected		
Oats, rolled	Clopyralid	3	0.006	Not detected	0.02
	Pirimiphos-methyl	1	0.002	Not detected	0.01
Oil	Cypermethrin	3	0.056	Not detected	0.16
	Trifloxystrobin	1	0.003	Not detected	0.02
Onion	Clopyralid	1	0.002	Not detected	0.02
	CS_2	1	0.003	Not detected	0.02
	Haloxyfop	1	0.004	Not detected	0.03
Orange juice	Benzalkonium chloride	2	0.038	Not detected	0.17
	CS_2	1	0.003	Not detected	0.02
	Imazalil	1	0.002	Not detected	0.02
Orange	Imazalil	7	0.069	Not detected	0.21
	Spirotetramat	1	0.001	Not detected	0.01
Other cereals	Chlorpyrifos-methyl	1	0.052	Not detected	0.42
	Deltamethrin (including tralomethrin)	1	0.010	Not detected	0.08
	Piperonyl-butoxide	3	0.104	Not detected	0.81
	Spinosad	1	0.002	Not detected	0.02
Oyster	Benzalkonium chloride	1	0.266	Not detected	2.13
Pasta, dried	Clopyralid	2	0.007	Not detected	0.04
	Pirimiphos-methyl	1	0.002	Not detected	0.02
Peach, canned	Iprodione	2	0.003	Not detected	0.02

2016 NZTDS food	Agricultural chemical detected	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
	Pyrimethanil	1	0.014	Not detected	0.11
Peanut butter	Chlorpyrifos	1	0.006	Not detected	0.04
Peanut	Chlorpyrifos	2	0.006	Not detected	0.03
	Piperonyl-butoxide	1	0.001	Not detected	0.01
Pear	Captan	7	0.047	Not detected	0.10
	Carbendazim (incl. thiophanate-methyl)	1	0.004	Not detected	0.03
	Diphenylamine	5	0.082	Not detected	0.23
	Dodine	2	0.015	Not detected	0.07
	Fludioxonil	2	0.015	Not detected	0.06
	Imazalil	5	0.064	Not detected	0.14
	Iprodione	5	0.052	Not detected	0.14
	Propham	2	0.005	Not detected	0.03
	Tebufenozide	1	0.001	Not detected	0.01
Peas, frozen	Benzalkonium chloride	2	0.026	Not detected	0.17
	Haloxyfop/Haloxyfop-methyl	1	0.002	Not detected	0.02
Pineapple, canned	Benzalkonium Chloride	1	0.016	Not detected	0.13
Pizza	Carbendazim (incl. thiophanate-methyl)	1	0.001	Not detected	0.01
	Chlorpyrifos-methyl	3	0.011	Not detected	0.05
	Piperonyl-butoxide	1	0.010	Not detected	0.08
	Pirimiphos-methyl	6	0.034	Not detected	0.08
Pork roast		0	No agricultural chemical residues detected		
Potato crisps	Chlorpropham	2	0.109	Not detected	0.67
	Metribuzin	3	0.005	Not detected	0.02
	Propham	1	0.014	Not detected	0.11
	Spirotetramat	3	0.005	Not detected	0.02
Potato, hot chips	Benzalkonium chloride	1	0.020	Not detected	0.16
	Chlorpropham	8	0.239	0.09	0.39
	Haloxyfop/Haloxyfop-methyl	1	0.002	Not detected	0.02
	Propham	5	0.556	Not detected	2.08
	Spirotetramat	7	0.022	Not detected	0.05
Potato, peeled	Fluazifop/Fluazifop-butyl	1	0.003	Not detected	0.02
	Propham	4	0.348	Not detected	1.59
	Spirotetramat	1	0.002	Not detected	0.01
Potato, with skin	Fluazifop/Fluazifop-butyl	1	0.011	Not detected	0.09
	Propham	5	0.556	Not detected	2.08
	Spirotetramat	2	0.003	Not detected	0.01
Prawn/shrimp	Benzalkonium chloride	2	0.039	Not detected	0.17
	Diuron	1	0.001	Not detected	0.01
Prune	Boscalid	1	0.011	Not detected	0.09
	Hexythiazox	1	0.003	Not detected	0.03
	Piperonyl-butoxide	1	0.004	Not detected	0.03
	Pyraclostrobin	1	0.006	Not detected	0.05
Pumpkin	CS_2	1	0.003	Not detected	0.02
	Dieldrin	1	0.005	Not detected	0.04
	Procymidone	2	0.005	Not detected	0.02
Raisins/sultanas	Acetamiprid	1	0.002	Not detected	0.02

2016 NZTDS food	Agricultural chemical detected	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
	Azoxystrobin	3	0.032	Not detected	0.15
	Bifenthrin	1	0.001	Not detected	0.01
	Boscalid	6	0.106	Not detected	0.49
	Chlorantraniliprole	2	0.006	Not detected	0.03
	Chlorpyrifos	3	0.037	Not detected	0.13
	Cyflufenamid	1	0.002	Not detected	0.01
	Cyhalothrin	4	0.011	Not detected	0.02
	Cypermethrin	4	0.017	Not detected	0.06
	Cyprodinil	6	0.061	Not detected	0.18
	Difenoconazole	2	0.004	Not detected	0.02
	Dimethomorph	2	0.007	Not detected	0.04
	Fenpyroximate	2	0.004	Not detected	0.02
	Fenvalerate (including esfenvalerate)	2	0.005	Not detected	0.02
	Fluazifop/Fluazifop-butyl	1	0.013	Not detected	0.10
	Fludioxonil	3	0.009	Not detected	0.04
	Flufenoxuron	1	0.001	Not detected	0.01
	Hexythiazox	1	0.001	Not detected	0.01
	Imidacloprid	3	0.007	Not detected	0.03
	Indoxacarb	4	0.010	Not detected	0.02
	Iprodione	6	0.144	Not detected	0.59
	Metalaxyl	3	0.019	Not detected	0.07
	Methoxyfenozide	8	0.050	0.01	0.10
	Myclobutanil	3	0.005	Not detected	0.02
	Penconazole	1	0.002	Not detected	0.02
	Propargite	1	0.003	Not detected	0.03
	Pyraclostrobin	2	0.009	Not detected	0.06
	Pyrimethanil	4	0.293	Not detected	0.88
	Spirotetramat	6	0.040	Not detected	0.11
	Tebuconazole	2	0.003	Not detected	0.02
	Tebufenpyrad	1	0.002	Not detected	0.02
	Tetraconazole	1	0.001	Not detected	0.01
	Triadimenol	1	0.009	Not detected	0.07
Rice dish	Benzalkonium chloride	1	0.010	Not detected	0.08
	Carbendazim (incl. thiophanate-methyl)	1	0.002	Not detected	0.01
	DDAC	1	0.005	Not detected	0.04
	Triadimenol	1	0.002	Not detected	0.01
Rice, white		0	No agricultural chemical residues detected		
Salad dressing	Benzalkonium chloride	1	0.013	Not detected	0.10
Sausage	Benzalkonium chloride	2	0.030	Not detected	0.13
	Pirimiphos-methyl	1	0.006	Not detected	0.05
Silverbeet	CS_2	2	0.015	Not detected	0.08
Simmer sauce, bottled	Carbendazim (incl. thiophanate-methyl)	6	0.043	Not detected	0.08
	Procymidone	2	0.008	Not detected	0.05
Snack bar	DDAC	1	0.012	Not detected	0.10
	Iprodione	1	0.001	Not detected	0.01
	Piperonyl-butoxide	1	0.002	Not detected	0.02

2016 NZTDS food	Agricultural chemical detected	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
	Pirimiphos-methyl	5	0.007	Not detected	0.01
	Pyrimethanil	3	0.015	Not detected	0.06
Snacks, flavoured	Benzalkonium chloride	1	0.007	Not detected	0.06
	Chlorpyrifos-methyl	1	0.003	Not detected	0.02
	Pirimiphos-methyl	6	0.324	Not detected	2.12
Soup, vegetable	Benzalkonium chloride	1	0.002	Not detected	0.02
	Piperonyl-butoxide	1	0.004	Not detected	0.04
Soya milk		0	No agricultural chemical residues detected		
Spaghetti in sauce, canned	Procymidone	1	0.003	Not detected	0.02
Strawberry	Captan	8	0.391	0.018	0.98
	Carbendazim (incl. thiophanate-methyl)	1	0.011	Not detected	0.09
	CS_2	4	0.166	Not detected	0.74
	Chlorantraniliprole	2	0.005	Not detected	0.02
	Cyprodinil	5	0.160	Not detected	0.44
	Dicloran	3	0.061	Not detected	0.37
	DDAC	1	0.004	Not detected	0.03
	Dimethoate/Omethoate	1	0.004	Not detected	0.03
	Fenhexamid	4	0.095	Not detected	0.36
	Fludioxonil	5	0.114	Not detected	0.30
	Indoxacarb	3	0.016	Not detected	0.05
	Iprodione	4	0.261	Not detected	1.08
	Methomyl	2	0.010	Not detected	0.06
	Myclobutanil	3	0.009	Not detected	0.03
	Pirimicarb	2	0.014	Not detected	0.10
	Prochloraz	1	0.002	Not detected	0.01
	Pyrimethanil	4	0.144	Not detected	0.76
	Trifloxystrobin	2	0.008	Not detected	0.04
Sugar		0	No agricultural chemical residues detected		
Sushi	Benzalkonium chloride	1	0.011	Not detected	0.09
	DDAC	2	0.009	Not detected	0.04
	Difenoconazole	1	0.003	Not detected	0.02
	Piperonyl-butoxide	1	0.003	Not detected	0.02
Table spread	Cypermethrin	2	0.005	Not detected	0.02
Taro	Hexaconazole	1	0.006	Not detected	0.04
Tea		0	No agricultural chemical residues detected		
Tofu	Benzalkonium chloride	1	0.110	Not detected	0.88
	DDAC	6	0.048	Not detected	0.14
Tomato	Carbendazim (incl. thiophanate-methyl)	3	0.008	Not detected	0.03
	Chlorothalonil	1	0.006	Not detected	0.05
	Imidacloprid	1	0.004	Not detected	0.03
	Iprodione	1	0.007	Not detected	0.05
	Piperonyl-butoxide	1	0.009	Not detected	0.08
	Procymidone	2	0.027	Not detected	0.17
	Spiromesifen	3	0.008	Not detected	0.03
	Sulfoxaflor	5	0.014	Not detected	0.04
	Thiacloprid	1	0.001	Not detected	0.01

2016 NZTDS food	Agricultural chemical detected	No of samples with residues	Mean (mg/kg)[a]	Minimum (mg/kg)	Maximum (mg/kg)
Tomato sauce	Benzalkonium chloride	2	0.027	Not detected	0.15
	Carbendazim (incl. thiophanate-methyl)	1	0.004	Not detected	0.03
	CS_2	2	0.008	Not detected	0.04
Tomatoes in juice, canned	Procymidone	1	0.002	Not detected	0.02
Water, bottled		0	No agricultural chemical residues detected		
Water, tap		0	No agricultural chemical residues detected		
Wheat biscuit cereal	Chlorpyrifos-methyl	3	0.006	Not detected	0.03
	Spinosad	3	0.014	Not detected	0.06
Wine, still red	Cyprodinil	1	0.001	Not detected	0.01
	Iprodione	1	0.001	Not detected	0.01
	Metalaxyl	1	0.003	Not detected	0.02
Wine, still white	Iprodione	2	0.009	Not detected	0.06
	Methoxyfenozide	1	0.001	Not detected	0.01
Yeast extract		0	No agricultural chemical residues detected		
Yoghurt		0	No agricultural chemical residues detected		

[a] Lower bound (LB) mean: not detected results = zero.

Appendix 9: Hazard characterisation of agricultural chemicals detected in foods of the 2016 NZTDS

Hazard characterisation of an agricultural chemical most commonly occurs through the derivation of health based guidance values (HBGVs). Health based guidance values are set from reviewing toxicological end-points from laboratory animal studies. Most commonly the lowest no observed adverse effect level (NOAEL) from a chronic toxicity study is selected. Safety factors are then applied to the toxicological end-point to reflect potential differences between laboratory species and humans, and any differences between individuals in a population. The resulting values is the health based guidance value, reflecting a level at below which the dietary exposure to an agricultural chemical can be considered a negligible health concern.

Three types of HBGV have been referenced in the hazard characterisation of agricultural chemicals in the 2016 NZTDS. These are:

- **ADI: Acceptable Daily Intake.** The most common international HBGVs.
- **PDE(food): Potential Daily Exposure through the diet.** This value adjusts the health based guidance value to reflect that a small proportion of daily exposure could occur through drinking water, skin contact and/or inhalation. PDE(food) are only set in New Zealand.
- **PTDI: Provisional Tolerable Daily Intake**. This value is used only for DDT and its metabolites. It fulfils the role of an ADI but reflects that DDT is no longer in common agricultural use and occurs predominantly as an environmental contaminant.

Some differences can result in setting HBGVs between countries. As a result selecting appropriate HBGVs for each of the agricultural chemicals detected in the 2016 NZTDS was prioritised using the following schedule:

1. A PDE(food), or an ADI, established by the New Zealand Environmental Protection Authority (EPA), or its predecessor the Environmental Risk Management Authority (ERMA).
2. An ADI established by the Joint Meeting of the FAO Panel of Experts on Pesticide Residues in Food and the Environment and a WHO Core Assessment Group on Pesticide Residues (JMPR).
3. An ADI established by the European Food Safety Authority (EFSA)
4. An ADI set by any other national regulatory body.

Appendix 9.1: List of agricultural chemicals detected in sampled foods of the 2016 NZTDS and the associated Health Based Guidance Value (HBGV)

Agricultural chemical	**HBGV** (µg/kg/bw/day)	Reference
Acephate	ADI: 1.2	EPA, 2013
Acetamiprid	ADI: 70	JMPR, 2012
Azoxystrobin	ADI: 20	JMPR, 2009
Benzalkonium Chloride	ADI: 100	BFR, 2012
Bifenthrin	ADI: 10	JMPR, 2010
Boscalid	PDE_{food}: 28	ERMA, 2006
Buprofezin	ADI: 9	JMPR, 2009
Captan	ADI: 100	JMPR, 2008
Carbaryl	ADI: 8	EPA, 2013
Carbendazim/ Thiophanate-methyl	ADI: 30	JMPR, 2005
Chlorantraniliprole	PDE_{food}: 1580	ERMA, 2008b
Chlorothalonil	ADI: 20	JMPR, 2010
Chlorpropham	ADI: 50	JMPR, 2005
Chlorpyrifos	ADI: 3	EPA, 2013
Chlorpyrifos-methyl	ADI: 10	JMPR, 2010
Clopyralid	PDE_{food}: 105	ERMA, 2007
Cyflufenamid	PDE_{food}: 30	EPA, 2013a
Cyhalothrin	ADI: 20	JMPR, 2008

Cypermethrin	ADI: 20	JMPR, 2007
Cyprodinil	ADI: 30	JMPR, 2004
Agricultural chemical	**HBGV** (µg/kg/bw/day)	**Reference**
DDAC	ADI: 100	BFR, 2012a
DDT	PTDI: 10	JMPR, 2001
Deltamethrin	ADI: 10	JMPR, 2001
Dicloran	ADI: 10	JMPR, 1999
Dieldrin	ADI: 0.1	JMPR, 1994
Difenoconazole	ADI: 10	JMPR, 2008
Dimethoate/Omethoate	ADI: 1	EPA, 2013
Dimethomorph	ADI: 200	JMPR, 2008
Diphenylamine	ADI: 80	JMPR, 1999
Dithiocarbamate fungicides	ADI: 3-30	JMPR, 1993; 1997
Diuron	ADI: 7	EFSA, 2005
Dodine	ADI: 100	JMPR, 2001
Etoxazole	PDE_{food}: 42	ERMA, 2011
Fenhexamid	ADI: 200	JMPR, 2005
Fenpropathrin	ADI: 30	JMPR, 2013
Fenpyroximate	ADI: 10	JMPR, 2004a
Fenvalerate	ADI: 20	JMPR, 2013
Fluazifop/Fluazifop-butyl	ADI: 4	JMPR, 2016
Fludioxonil	ADE: 590	EPA, 2016
Flufenoxuron	ADI: 40	JMPR, 2015
Haloxyfop	ADI: 0.7	JMPR, 2007
Hexaconazole	ADI: 5	JMPR, 1990
Hexythiazox	ADI: 30	JMPR, 2009
Imazalil	ADI: 30	JMPR, 2001
Imidacloprid	ADI: 60	JMPR, 2001a
Indoxacarb	ADI: 10	JMPR, 2005
Iprodione	ADI: 60	JMPR, 1996
Kresoxim-methyl	PDE_{food}: 252	ERMA, 2006
Linuron	ADI: 3	EFSA, 2016
Lufenuron	ADI: 20	JMPR, 2015a
Malathion	ADI: 20	EPA, 2013
Metalaxyl	ADI: 80	JMPR, 2002
Methamidophos	ADI: 0.1	EPA, 2013
Methomyl	ADI: 10	EPA, 2013
Methoxyfenozide	ADI: 100	JMPR, 2004
Metribuzin	ADI: 13	EFSA, 2006
Myclobutanil	ADI: 30	JMPR, 2015
Penconazole	ADI: 30	JMPR, 2015a
Phosmet	ADI: 10	JMPR, 2004
Piperonyl-butoxide	ADI: 200	JMPR, 1996
Pirimicarb	ADI: 35	EPA, 2013
Pirimiphos-methyl	ADI: 20	EPA, 2013
Prochloraz	ADI: 10	JMPR, 2001a
Procymidone	ADI: 100	JMPR, 2008
Propargite	ADI: 10	JMPR, 1999

Propham	No HBGV	
Propiconazole	ADI: 70	JMPR, 2004a
Agricultural chemical	**HBGV** (µg/kg/bw/day)	**Reference**
Pyraclostrobin	ADI: 30	JMPR, 2004
Pyrethrin	ADI: 40	JMPR, 2004
Pyrimethanil	ADI: 200	JMPR, 2008
Spinetoram	PDE_{food}: 17	EPA, 2016a
Spinosad	ADI: 20	JMPR, 2001a
Spiromesifen	PDE_{food}: 21	ERMA, 2006a
Spirotetramat	PDE_{food}: 40	ERMA, 2011a
Sulfoxaflor	PDE_{food}: 28	EPA, 2013b
Tebuconazole	ADI: 30	JMPR, 2010
Tebufenozide	ADI: 20	JMPR, 2004
Tebufenpyrad	ADI: 10	EFSA, 2008a
Tetraconazole	ADI: 4	EFSA, 2008
Thiacloprid	ADI: 10	JMPR, 2007
Thiamethoxam	ADI: 80	JMPR, 2010
Triadimenol	ADI: 40	ERMA, 2006b
Tri-allate	ADI: 25	EFSA, 2008b
Trifloxystrobin	ADI: 40	JMPR, 2004a

Appendix 9.2: No observable adverse effect levels (NOAELs) and relative potency factors (RPF) for acetylcholinesterase (AChE) inhibition in the organophosphate and carbamate chemical group, as weighted against chlorpyrifos

Compound	**NOAEL for AChE inhibition** (mg/kg bw/day)	**RPF against chlorpyrifos**
Chlorpyrifos	0.03[a]	1
Dimethoate/Omethoate	0.04[a]	0.75
Chlorpyrifos-methyl	0.1[a]	0.3
Methamidophos	0.1[b]	0.3
Acephate	0.25[b]	0.12
Pirimiphos-methyl	0.25[a]	0.12
Phosmet	0.3[c]	0.1
Malathion	3[a]	0.01
Methomyl	9[a]	0.003
Carbaryl	10[b]	0.003
Pirimicarb	10[a]	0.003

[a] Referenced from brain and erythrocyte AChE inhibition NOAEL values in the inhibition of AChE common action group (EFSA, 2014).
[b] Referenced from brain and erythrocyte AChE inhibition NOAEL values in the JMPR toxicity assessments (JMPR, 1997; JMPR, 2002; JMPR, 2005).
[c] Referenced from brain AChE inhibition LOAEL values in the inhibition of AChE common action group with a 3 fold safety factor to convert to NOAEL (EFSA, 2014).

Appendix 9.3: No observable adverse effect levels (NOAELs) and relative potency factors (RPF) for neurotoxicity in the pyrethrin and the pyrethroid insecticide group as weighted against deltamethrin

Compound	NOAEL for neurotoxicity (mg/kg bw/day)[a]	RPF against deltamethrin
Bifenthrin	1	1
Cyhalothrin	0.5	2
Cypermethrin	2.2	0.46
Deltamethrin	1	1
Fenpropathrin	3.1	0.32
Fenvalerate	15	0.07
Pyrethrin	20	0.05

[a] Referenced from neurotoxicity NOAEL values in the JMPR toxicity assessments (JMPR, 1999; JMPR, 2001; JMPR, 2002; JMPR, 2008; JMPR, 2010; JMPR, 2013).

Appendix 9.4: No observable adverse effect levels (NOAELs) and relative potency factors (RPF) for hepatotoxicity in the triazole and imidazole fungicide group as weighted against tetraconazole

Compound	NOAEL for hepatotoxicity (mg/kg bw/day)	RPF against tetraconazole
Tetraconazole	0.4[a]	1
Hexaconazole	0.5[b]	0.8
Prochloraz	0.9[b]	0.44
Difenoconazole	1[c]	0.4
Imazalil	2.5[b]	0.16
Penconazole	3[b]	0.13
Propiconazole	3.6[c]	0.11
Triadimenol	5[c]	0.08
Tebuconazole	16[c]	0.03
Myclobutanil	39[c]	0.01

[a] Referenced from hepatotoxicity NOAEL value from a two year rat study in the EFSA conclusion on the peer review of tetraconazole (EFSA, 2008).
[b] Referenced from hepatotoxicity NOAEL values in the JMPR toxicity assessments (JMPR, 1990; JMPR, 1992; JMPR, 2001; JMPR, 2001a).
[c] Referenced from hepatotoxicity NOAEL values in the triazole common target group. (EFSA, 2009).

Appendix 10: Summary of estimated mean dietary exposures to agricultural chemical residues by population cohort and as a percentage of the health based guidance value in the 2016 NZTDS

Appendix 10.1: Estimated mean dietary exposures to agricultural chemical residues for adult cohorts and as a percentage of the health based guidance value (HBGV) in the 2016 NZTDS

Rounded to two significant figures.

Compound (and form of HBGV used)	HBGV (µg/kg bw/day)	Daily dietary exposure (µg/kg bw/day and % of HBGV)				
		Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Acephate	1.2	0.0007	0.0005	0.0008	0.0005	0.0016
% ADI		0.06	0.04	0.07	0.05	0.13
Acetamiprid	70	<0.0001	<0.0001	0.0001	<0.0001	0.0001
% ADI		<0.0001	<0.0001	0.0001	<0.0001	0.0001
Azoxystrobin	200	0.0007	0.0007	0.0013	0.0012	0.0011
% ADI		0.0004	0.0004	0.0006	0.0006	0.0006
BAC	100	0.15	0.16	0.19	0.19	0.24
%ADI		0.2	0.2	0.2	0.2	0.2
Bifenthrin	10	0.0003	0.0003	0.0003	0.0003	0.0004
%ADI		0.003	0.003	0.003	0.003	0.004
Boscalid	28	0.0061	0.0053	0.0075	0.0058	0.0076
$\%PDE_{food}$		0.02	0.02	0.03	0.02	0.03
Buprofezin	9	0.0006	0.0005	0.0003	0.0002	0.0003
%ADI		0.007	0.006	0.003	0.003	0.003
Captan	100	0.059	0.049	0.065	0.058	0.083
%ADI		0.06	0.05	0.07	0.06	0.08
Carbaryl	8	0.0028	0.0023	0.0023	0.0021	0.0016
%ADI		0.03	0.03	0.03	0.03	0.02
Carbendazim (incl Thiophanate-Me)	30	0.0097	0.0070	0.0091	0.0081	0.0100
%ADI		0.03	0.02	0.03	0.03	0.03
Chlorantraniliprole	1580	0.001	0.0009	0.0008	0.0007	0.001
$\%PDE_{food}$		0.0001	0.0001	<0.0001	<0.0001	0.0001
Chlorothalonil	20	0.0033	0.0020	0.0028	0.0025	0.0023
%ADI		0.02	0.01	0.01	0.01	0.01
Chlorpropham	50	0.063	0.068	0.091	0.08	0.16
%ADI		0.13	0.14	0.18	0.16	0.32
Chlorpyrifos	3	0.001	0.0009	0.0014	0.0012	0.0016
%ADI		0.03	0.03	0.05	0.04	0.05
Chlorpyrifos-Me	10	0.054	0.050	0.059	0.050	0.080
%ADI		0.5	0.5	0.6	0.5	0.8
Clopyralid	105	0.032	0.025	0.033	0.027	0.040
$\%PDE_{food}$		0.03	0.02	0.03	0.03	0.04
Cyflufenamid	30	0.0002	0.0002	0.0001	0.0001	0.0001
$\%PDE_{food}$		0.0006	0.0005	0.0004	0.0003	0.0004
Cyhalothrin	20	0.0002	0.0001	0.0003	0.0002	0.0003
%ADI		0.001	0.001	0.001	0.001	0.001
Cypermethrin	20	0.0072	0.0062	0.0097	0.0086	0.012
%ADI		0.04	0.03	0.05	0.04	0.06

Compound (and form of HBGV used)	HBGV (µg/kg bw/day)	Daily dietary exposure (µg/kg bw/day and % of HBGV)				
		Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Cyprodinil	30	0.012	0.010	0.014	0.012	0.021
%ADI		0.04	0.03	0.05	0.04	0.07
Deltamethrin	10	0.0013	0.0014	0.0017	0.0014	0.0021
%ADI		0.01	0.01	0.02	0.01	0.02
Dicloran	10	0.01	0.01	0.012	0.011	0.015
%ADI		0.10	0.10	0.12	0.11	0.15
DDAC	100	0.023	0.027	0.023	0.030	0.031
%ADI		0.02	0.03	0.02	0.03	0.03
DDT(DDE)	10	0.0007	0.0009	0.0008	0.0012	0.0008
%PTDI		0.01	0.01	0.01	0.01	0.01
Dieldrin	0.1	0.0009	0.0004	0.0008	0.0007	0.0005
%PTDI		0.9	0.4	0.8	0.7	0.5
Difenoconazole	10	0.0029	0.0030	0.0040	0.0036	0.0041
%ADI		0.03	0.03	0.04	0.04	0.04
Dimethoate/Omethoate	1	0.0015	0.0010	0.0011	0.0010	0.0014
%ADI		0.15	0.10	0.11	0.10	0.14
Dimethomorph	200	0.0001	0.0001	0.0002	0.0002	0.0003
%ADI		0.0001	0.0001	0.0001	0.0001	0.0001
Diphenylamine	80	0.016	0.013	0.014	0.012	0.015
%ADI		0.02	0.02	0.02	0.02	0.02
Dithiocarbamate fungicides (as CS_2)	3	0.028	0.025	0.036	0.037	0.047
%ADI		0.9	0.8	1.2	1.2	1.6
Diuron	7	0.0001	<0.0001	<0.0001	<0.0001	0.0001
%ADI		0.0008	0.0006	0.0006	0.0006	0.0007
Dodine	100	0.0030	0.0025	0.0027	0.0024	0.0029
%ADI		0.003	0.002	0.003	0.002	0.003
Etoxazole	42	0.0004	0.0003	0.0002	0.0001	0.0002
$\%PDE_{food}$		0.0009	0.0008	0.0004	0.0003	0.0004
Fenhexamid	20	0.0070	0.0058	0.0073	0.0065	0.012
%ADI		0.03	0.03	0.04	0.03	0.06
Fenpropathrin	30	0.0004	0.0004	0.0002	0.0002	0.0002
%ADI		0.0014	0.0012	0.0006	0.0005	0.0007
Fenpyroximate	10	0.0001	<0.0001	0.0001	0.0001	0.0001
%ADI		0.0005	0.0004	0.0009	0.0008	0.0010
Fenvalerate	20	0.0001	0.0001	0.0001	0.0001	0.0002
%ADI		0.0006	0.0005	0.0003	0.0003	0.0008
Fluazifop/Fluazifop-butyl	4	0.0046	0.0031	0.0063	0.0047	0.0074
%ADI		0.11	0.08	0.16	0.12	0.18
Fludioxonil	590	0.028	0.024	0.027	0.024	0.027
%ADE		0.005	0.004	0.005	0.004	0.005
Flufenoxuron	40	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
%ADI		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Haloxyfop	0.7	0.0009	0.0007	0.0012	0.0011	0.0017
%ADI		0.23	0.18	0.30	0.27	0.44

Compound (and form of HBGV used)	HBGV (µg/kg bw/day)	Daily dietary exposure (µg/kg bw/day and % of HBGV)				
		Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Hexaconazole	5	0.0002	0.0020	0.0002	0.0016	0.0002
%ADI		0.004	0.040	0.004	0.032	0.004
Hexythiazox	30	0.0001	0.0001	0.0001	0.0001	0.0001
%ADI		0.0002	0.0002	0.0005	0.0004	0.0003
Imazalil	30	0.035	0.025	0.026	0.022	0.028
%ADI		0.12	0.08	0.09	0.07	0.09
Imidacloprid	60	0.0034	0.0024	0.0027	0.0024	0.0025
%ADI		0.006	0.004	0.004	0.004	0.004
Indoxacarb	10	0.0012	0.0010	0.0015	0.0013	0.0022
%ADI		0.01	0.01	0.02	0.01	0.02
Iprodione	60	0.088	0.072	0.083	0.073	0.080
%ADI		0.15	0.12	0.14	0.12	0.13
Kresoxim-methyl	252	0.0002	0.0002	0.0001	0.0001	0.0001
$\%PDE_{food}$		0.0001	0.0001	<0.0001	<0.0001	<0.0001
Linuron	3	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
%ADI		0.0015	0.0013	0.0006	0.0006	0.0007
Lufenuron	20	0.0001	0.0001	0.0001	0.0001	0.0001
%ADI		0.0004	0.0003	0.0003	0.0003	0.0004
Malathion	20	0.0003	0.0002	0.0002	0.0002	0.0003
%ADI		0.001	0.001	0.001	0.001	0.002
Metalaxyl	80	0.0012	0.0007	0.0014	0.0011	0.0012
%ADI		0.0015	0.0009	0.0018	0.0014	0.0015
Methamidophos	0.1	0.0004	0.0003	0.0003	0.0003	0.0004
%ADI		0.36	0.34	0.35	0.31	0.38
Methomyl	10	0.0018	0.0014	0.0014	0.0012	0.0019
%ADI		0.02	0.01	0.01	0.01	0.02
Methoxyfenozide	100	0.0020	0.0015	0.0025	0.0021	0.0023
%ADI		0.002	0.002	0.002	0.002	0.002
Metribuzin	13	0.0001	0.0002	0.0002	0.0001	0.0002
%ADI		0.001	0.001	0.001	0.001	0.001
Myclobutanil	30	0.0009	0.0007	0.0009	0.0008	0.0013
%ADI		0.003	0.002	0.003	0.003	0.004
Penconazole	30	<0.0001	<0.0001	0.0001	<0.0001	0.0001
%ADI		0.0001	0.0001	0.0002	0.0002	0.0002
Phosmet	10	0.0001	0.0001	0.0002	0.0001	0.0002
%ADI		0.001	0.001	0.002	0.001	0.002
Piperonyl-butoxide	200	0.030	0.030	0.035	0.029	0.041
%ADI		0.02	0.01	0.02	0.01	0.02
Pirimicarb	35	0.0010	0.0008	0.0011	0.0010	0.0017
%ADI		0.003	0.002	0.003	0.003	0.005
Pirimiphos-methyl	20	0.11	0.096	0.12	0.10	0.16
%ADI		0.6	0.5	0.6	0.5	0.8
Prochloraz	10	0.0008	0.0004	0.0006	0.0005	0.0007
%ADI		0.008	0.004	0.006	0.005	0.007
Procymidone	100	0.010	0.0065	0.0096	0.0084	0.0076
%ADI		0.010	0.007	0.010	0.008	0.008

Compound (and form of HBGV used)	HBGV (µg/kg bw/day)	Daily dietary exposure (µg/kg bw/day and % of HBGV)				
		Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Propamocarb	400	0.0010	0.0008	0.0008	0.0007	0.0006
%ADI		0.0002	0.0002	0.0002	0.0002	0.0001
Propargite	10	<0.0001	<0.0001	0.0001	0.0001	0.0001
%ADI		0.0005	0.0004	0.0008	0.0007	0.0009
Propham	5700[a]	0.32	0.23	0.45	0.34	0.53
MOE[b]		18,000	25,000	13,000	17,000	11,000
Propiconazole	70	0	0	0	0	0
%ADI		0	0	0	0	0
Pyraclostrobin	30	0.0007	0.0006	0.0006	0.0005	0.0005
%ADI		0.002	0.002	0.002	0.002	0.002
Pyrethrin	40	0.0006	0.0005	0.0005	0.0004	0.0005
%ADI		0.001	0.001	0.001	0.001	0.001
Pyrimethanil	200	0.019	0.016	0.025	0.021	0.031
%ADI		0.010	0.008	0.012	0.010	0.016
Spinetoram	17	0.0006	0.0005	0.0005	0.0005	0.0004
$\%PDE_{food}$		0.004	0.003	0.003	0.003	0.002
Spinosad	20	0.0041	0.0032	0.0045	0.0039	0.0062
%ADI		0.02	0.02	0.02	0.02	0.03
Spiromesifen	21	0.0021	0.0013	0.0019	0.0017	0.0014
$\%PDE_{food}$		0.010	0.006	0.009	0.008	0.006
Spirotetramat	40	0.0091	0.0085	0.012	0.0099	0.018
$\%PDE_{food}$		0.02	0.02	0.03	0.02	0.05
Sulfoxaflor	28	0.0038	0.0024	0.0034	0.0030	0.0024
$\%PDE_{food}$		0.014	0.009	0.012	0.011	0.009
Tebuconazole	30	0.0050	0.0042	0.0040	0.0035	0.0029
%ADI		0.02	0.01	0.01	0.01	0.01
Tebufenozide	20	0.0033	0.0027	0.0036	0.0032	0.0037
%ADI		0.02	0.01	0.02	0.02	0.02
Tebufenpyrad	10	<0.0001	<0.0001	0.0001	<0.0001	0.0001
%ADI		0.0003	0.0003	0.0005	0.0005	0.0006
Tetraconazole	4	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
%ADI		0.0005	0.0004	0.0008	0.0007	0.0008
Thiacloprid	10	0.0003	0.0002	0.0003	0.0003	0.0002
%ADI		0.003	0.002	0.003	0.003	0.002
Thiamethoxam	80	0.0001	0.0001	0.0001	0.0001	0.0001
%ADI		0.0001	0.0001	0.0001	0.0001	0.0001
Triadimenol	40	0.0005	0.0005	0.0006	0.0005	0.0009
$\%PDE_{food}$		0.001	0.001	0.002	0.001	0.002
Tri-allate	25	0.0001	0.0001	0.0001	0.0001	0.0001
%ADI		0.0003	0.0003	0.0004	0.0004	0.0005
Trifloxystrobin	40	0.0010	0.0008	0.0010	0.0009	0.0015
%ADI		0.002	0.002	0.003	0.002	0.004

[a] No HBGV is available for propham, the stated value is the No Observed Adverse Effect Level (NOAEL) from a two year toxicity study in rats.
[b] The margin of exposure (MOE) is used to calculate the orders of magnitude between propham exposure and the stated NOAEL.

Appendix 10.2: Cumulative exposure assessments for adult cohorts to common action groups of agricultural chemicals

Rounded to two significant figures.

Chemical group	Daily dietary exposure (µg/kg bw/day and % of HBGV)				
	Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Organophosphate and carbamate insecticides (weighted against chlorpyrifos)	0.032	0.028	0.035	0.029	0.045
% chlorpyrifos ADI (3 µg/kg bw/day)	1.1	0.9	1.2	1.0	1.5
Pyrethrin and pyrethroid insecticides (weighted against deltamethrin)	0.0055	0.0049	0.0072	0.0061	0.0088
% deltamethrin ADI (10 µg/kg/bw/day)	0.05	0.05	0.07	0.06	0.09
Triazole and imidazole fungicides (weighted against tetraconazole)	0.0075	0.0072	0.0064	0.0067	0.0067
% tetraconazole ADI (4 µg/kg/bw/day)	0.19	0.18	0.16	0.17	0.17

Appendix 10.3: Estimated dietary exposures to agricultural chemical residues for infant, child and teenage cohorts and as a percentage of the health based guidance value (HBGV) in the 2016 NZTDS

Compound (and form of HBGV used)	HBGV (µg/kg bw/day)	Daily dietary exposure (µg/kg bw/day and % of HBGV)				
		Teenage boys	Teenage girls	Children	Toddlers	Infants
Acephate	1.2	0.0007	0.0009	0.0022	0.0025	0.0032
% ADI		0.06	0.08	0.18	0.21	0.26
Acetamiprid	70	<0.0001	<0.0001	0.0002	0.0012	0.0012
% ADI		0.0001	0.0001	0.0003	0.0017	0.0017
Azoxystrobin	200	0.0015	0.0015	0.0032	0.018	0.018
% ADI		0.0007	0.0008	0.0016	0.0090	0.0090
BAC	100	0.25	0.19	0.35	0.50	0.34
%ADI		0.3	0.2	0.4	0.5	0.3
Bifenthrin	10	0.0005	0.0006	0.0009	0.0017	0.0054
%ADI		0.005	0.006	0.009	0.017	0.054
Boscalid	28	0.0087	0.0098	0.0192	0.077	0.072
%PDEfood		0.03	0.04	0.07	0.27	0.26
Buprofezin	9	0.0002	0.0004	0.0015	0.0027	0.0013
%ADI		0.002	0.005	0.017	0.030	0.015
Captan	100	0.093	0.11	0.31	0.21	0.20
%ADI		0.09	0.11	0.30	0.21	0.20
Carbaryl	8	0.0033	0.0028	0.0099	0.0039	0.011
%ADI		0.04	0.04	0.12	0.05	0.14
Carbendazim (incl Thiophanate-Me)	30	0.011	0.011	0.017	0.014	0.012
%ADI		0.04	0.04	0.06	0.05	0.04
Chlorantraniliprole	1580	0.0006	0.0010	0.0030	0.0071	0.0054
$\%PDE_{food}$		<0.0001	0.0001	0.0002	0.0004	0.0003
Chlorothalonil	20	0.0053	0.0042	0.0033	0.0048	0.0034
%ADI		0.03	0.02	0.02	0.02	0.02
Chlorpropham	50	0.24	0.20	0.27	0.30	0.17
%ADI		0.49	0.40	0.54	0.60	0.35

Compound (and form of HBGV used)	HBGV (µg/kg bw/day)	Daily dietary exposure (µg/kg bw/day and % of HBGV)				
		Teenage boys	Teenage girls	Children	Toddlers	Infants
Chlorpyrifos	3	0.0023	0.0021	0.0047	0.021	0.021
%ADI		0.08	0.07	0.16	0.71	0.71
Chlorpyrifos-Me	10	0.14	0.10	0.22	0.19	0.17
%ADI		1.4	1.0	2.2	1.9	1.7
Clopyralid	105	0.066	0.051	0.11	0.087	0.074
$\%PDE_{food}$		0.06	0.05	0.10	0.08	0.07
Cyflufenamid	30	0.0001	0.0002	0.0005	0.0016	0.0012
$\%PDE_{food}$		0.0004	0.0006	0.0017	0.0052	0.0042
Cyhalothrin	20	0.0004	0.0004	0.0010	0.0062	0.0064
%ADI		0.002	0.002	0.005	0.031	0.032
Cypermethrin	20	0.0077	0.0055	0.010	0.023	0.017
%ADI		0.04	0.03	0.05	0.12	0.08
Cyprodinil	30	0.0067	0.013	0.036	0.065	0.056
%ADI		0.02	0.04	0.12	0.22	0.19
Deltamethrin	10	0.0030	0.0029	0.0058	0.0088	0.0090
%ADI		0.03	0.03	0.06	0.09	0.09
Dicloran	10	0.0042	0.011	0.014	0.029	0.035
%ADI		0.04	0.11	0.14	0.29	0.35
DDAC	100	0.031	0.022	0.038	0.021	0.017
%ADI		0.03	0.02	0.04	0.02	0.02
DDT(DDE)	10	0.0013	0.0008	0.0017	0.0026	0.0026
%PTDI		0.01	0.01	0.02	0.03	0.03
Dieldrin	0.1	0.0004	0.0004	0.0007	0.0024	0.0029
%PTDI		0.4	0.4	0.7	2.4	2.9
Difenoconazole	10	0.0023	0.0016	0.0035	0.0040	0.0033
%ADI		0.02	0.02	0.03	0.04	0.03
Dimethoate/Omethoate	1	0.0014	0.0007	0.0017	0.0024	0.0030
%ADI		0.14	0.07	0.17	0.24	0.30
Dimethomorph	200	0.0004	0.0004	0.0007	0.0040	0.0040
%ADI		0.0002	0.0002	0.0003	0.0020	0.0020
Diphenylamine	80	0.020	0.023	0.049	0.087	0.13
%ADI		0.02	0.03	0.06	0.11	0.16
Dithiocarbamate fungicides (as CS_2)	3	0.046	0.041	0.077	0.082	0.068
%ADI		1.5	1.4	2.6	2.7	2.3
Diuron	7	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
%ADI		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Dodine	100	0.0041	0.0047	0.010	0.014	0.0093
%ADI		0.004	0.005	0.010	0.014	0.009
Etoxazole	42	0.0001	0.0003	0.0009	0.0017	0.0008
$\%PDE_{food}$		0.0003	0.0006	0.0022	0.0039	0.0019
Fenhexamid	20	0.0024	0.0065	0.021	0.022	0.014
%ADI		0.01	0.03	0.10	0.11	0.07
Fenpropathrin	30	0.0001	0.0003	0.0010	0.0018	0.0009
%ADI		0.0005	0.0010	0.0034	0.0060	0.0029
Fenpyroximate	10	0.0001	0.0001	0.0003	0.0021	0.0021
%ADI		0.0014	0.0014	0.0033	0.021	0.021

Compound (and form of HBGV used)	HBGV (µg/kg bw/day)	Daily dietary exposure (µg/kg bw/day and % of HBGV)				
		Teenage boys	Teenage girls	Children	Toddlers	Infants
Fenvalerate	20	0.0002	0.0004	0.0025	0.0025	0.0001
%ADI		0.0008	0.0020	0.012	0.013	0.0003
Fluazifop / Fluazifop-butyl	4	0.0086	0.0096	0.016	0.025	0.024
%ADI		0.21	0.24	0.39	0.63	0.60
Fludioxonil	590	0.028	0.029	0.095	0.072	0.15
%ADE		0.005	0.005	0.016	0.012	0.025
Flufenoxuron	40	<0.0001	<0.0001	0.0001	0.0007	0.0007
%ADI		0.0001	0.0001	0.0003	0.0018	0.0018
Haloxyfop	0.7	0.0029	0.0022	0.0033	0.0032	0.0024
%ADI		0.71	0.55	0.81	0.79	0.60
Hexaconazole	5	0.0003	0.0003	0.0002	0	0
%ADI		0.006	0.006	0.005	0	0
Hexythiazox	30	0.0001	0.0001	0.0003	0.0010	0.0011
%ADI		0.0004	0.0004	0.0009	0.0032	0.0037
Imazalil	30	0.057	0.074	0.17	0.19	0.18
%ADI		0.19	0.25	0.58	0.63	0.61
Imidacloprid	60	0.0043	0.0042	0.0048	0.011	0.0069
%ADI		0.007	0.007	0.008	0.018	0.012
Indoxacarb	10	0.0009	0.0015	0.0043	0.0082	0.0082
%ADI		0.01	0.01	0.04	0.08	0.08
Iprodione	60	0.087	0.091	0.27	0.30	0.58
%ADI		0.15	0.15	0.46	0.49	0.97
Kresoxim-methyl	252	0.0001	0.0001	0.0005	0.0008	0.0004
$\%PDE_{food}$		<0.0001	0.0001	0.0002	0.0003	0.0002
Linuron	3	0.0001	0.0001	0.0001	0.0001	0
%ADI		0.0041	0.0021	0.0024	0.0043	0
Lufenuron	20	0.0001	0.0001	0.0001	0.0002	0
%ADI		0.0005	0.0005	0.0004	0.0008	0
Malathion	20	0.0007	0.0004	0.0008	0.0011	0.0010
%ADI		0.003	0.002	0.004	0.005	0.005
Metalaxyl	80	0.0012	0.0011	0.0020	0.011	0.011
%ADI		0.0015	0.0014	0.0025	0.014	0.014
Methamidophos	0.1	0.0004	0.0005	0.0003	0.0008	0.0006
%ADI		0.36	0.46	0.31	0.82	0.60
Methomyl	10	0.0011	0.0013	0.0037	0.0050	0.0036
%ADI		0.01	0.01	0.04	0.05	0.04
Methoxyfenozide	100	0.0028	0.0028	0.0060	0.029	0.030
%ADI		0.003	0.003	0.006	0.029	0.030
Metribuzin	13	0.0009	0.0010	0.0012	0.0011	0.0005
%ADI		0.007	0.007	0.009	0.008	0.004
Myclobutanil	30	0.0005	0.0009	0.0028	0.0057	0.0047
%ADI		0.002	0.003	0.009	0.019	0.016
Penconazole	30	0.0001	0.0001	0.0002	0.0012	0.0013
%ADI		0.0003	0.0003	0.0007	0.0041	0.0043
Phosmet	10	0.0001	0.0001	0.0002	0.0003	0.0005
%ADI		0.001	0.001	0.002	0.003	0.005

Compound (and form of HBGV used)	HBGV (µg/kg bw/day)	Daily dietary exposure (µg/kg bw/day and % of HBGV)				
		Teenage boys	Teenage girls	Children	Toddlers	Infants
Piperonyl-butoxide	200	0.048	0.046	0.081	0.097	0.097
%ADI		0.02	0.02	0.04	0.05	0.05
Pirimicarb	35	0.0005	0.0010	0.0032	0.0024	0.0025
%ADI		0.002	0.003	0.009	0.007	0.007
Pirimiphos-methyl	20	0.31	0.26	0.55	0.55	0.44
%ADI		1.5	1.3	2.8	2.7	2.2
Prochloraz	10	0.0010	0.0008	0.0009	0.0013	0.0017
%ADI		0.010	0.008	0.009	0.013	0.017
Procymidone	100	0.011	0.012	0.011	0.016	0.015
%ADI		0.011	0.012	0.011	0.016	0.015
Propamocarb	400	0.0013	0.0004	0.0010	0.0018	0.0026
%ADI		0.0003	0.0001	0.0003	0.0004	0.0006
Propargite	10	0.0001	0.0001	0.0003	0.0039	0.029
%ADI		0.0013	0.0013	0.0029	0.039	0.29
Propham	5700[a]	0.64	0.69	1.2	1.3	1.2
MOE[b]		8900	8300	4900	4600	5000
Propiconazole	70	0	0	0	0	0.0042
%ADI		0	0	0	0	0.006
Pyraclostrobin	30	0.0006	0.0008	0.0021	0.0072	0.0065
%ADI		0.002	0.003	0.007	0.024	0.022
Pyrethrin	40	0.0004	0.0004	0.0009	0	0
%ADI		0.001	0.001	0.002	0	0
Pyrimethanil	200	0.022	0.029	0.067	0.21	0.20
%ADI		0.011	0.014	0.034	0.10	0.099
Spinetoram	17	0.0007	0.0006	0.0020	0.0009	0.0022
$\%PDE_{food}$		0.004	0.004	0.012	0.005	0.013
Spinosad	20	0.011	0.0070	0.018	0.025	0.017
%ADI		0.06	0.04	0.09	0.12	0.08
Spiromesifen	21	0.0026	0.0031	0.0022	0.0032	0.0028
$\%PDE_{food}$		0.012	0.015	0.010	0.015	0.013
Spirotetramat	40	0.026	0.024	0.037	0.061	0.046
$\%PDE_{food}$		0.07	0.06	0.09	0.15	0.12
Sulfoxaflor	28	0.0047	0.0052	0.0039	0.0058	0.0053
$\%PDE_{food}$		0.017	0.019	0.014	0.021	0.019
Tebuconazole	30	0.0054	0.0050	0.017	0.011	0.021
%ADI		0.02	0.02	0.06	0.04	0.07
Tebufenozide	20	0.0092	0.0097	0.026	0.015	0.016
%ADI		0.05	0.05	0.13	0.07	0.08
Tebufenpyrad	10	0.0001	0.0001	0.0002	0.0012	0.0012
%ADI		0.0008	0.0008	0.0019	0.012	0.012
Tetraconazole	4	<0.0001	<0.0001	0.0001	0.0007	0.0007
%ADI		0.0012	0.0012	0.0029	0.018	0.019
Thiacloprid	10	0.0004	0.0005	0.0003	0.0005	0.0004
%ADI		0.004	0.005	0.003	0.005	0.004
Thiamethoxam	80	0.0001	0.0000	0.0001	0.0001	0.0002
%ADI		0.0001	0.0000	0.0001	0.0002	0.0003

Compound (and form of HBGV used)	HBGV (µg/kg bw/day)	Daily dietary exposure (µg/kg bw/day and % of HBGV)				
		Teenage boys	Teenage girls	Children	Toddlers	Infants
Triadimenol	40	0.0006	0.0006	0.0013	0.0050	0.0049
$\%PDE_{food}$		0.002	0.001	0.003	0.013	0.012
Tri-allate	25	0.0000	0.0000	0	0	0
%ADI		0.0001	0.0001	0	0	0
Trifloxystrobin	40	0.0005	0.0008	0.0024	0.0030	0.0017
%ADI		0.001	0.002	0.006	0.008	0.004

[a] No HBGV is available for propham, the stated value is the No Observed Adverse Effect Level (NOAEL) from a two year toxicity study in rats.
[b] The margin of exposure (MOE) is used to calculate the orders of magnitude between propham exposure and the stated NOAEL.

Appendix 10.4: Cumulative exposure assessments for infant, child and teenage cohorts to common action groups of agricultural chemicals

Chemical group	Daily dietary exposure (µg/kg bw/day and % of HBGV)				
	Teenage boys	Teenage girls	Children	Toddlers	Infants
Organophosphate and carbamate insecticides (weighted against chlorpyrifos)	0.081	0.065	0.14	0.15	0.13
% chlorpyrifos ADI (3 µg/kg bw/day)	2.7	2.2	4.6	4.9	4.3
Pyrethrin and pyrethroid insecticides (weighted against deltamethrin)	0.0079	0.0070	0.014	0.035	0.035
% deltamethrin ADI (10 µg/kg/bw/day)	0.08	0.07	0.14	0.35	0.35
Triazole and imidazole fungicides (weighted against tetraconazole)	0.011	0.013	0.031	0.034	0.034
% tetraconazole ADI (4 µg/kg/bw/day)	0.27	0.34	0.76	0.85	0.85

Appendix 11: Contaminant elements – aluminium, arsenic (total and inorganic), cadmium, lead, mercury (total and methylmercury) and tin in the 2016 NZTDS

Appendix 11.1: Aluminium concentrations (mg/kg) in foods of the 2016 NZTDS

Food	No of samples > LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Almond	8	4.1	4.1	4.1	3.2	5.4
Apple	0	0	0.1	0.2	<0.2	<0.2
Apple-based juice	4	0.2	0.2	0.2	<0.1	0.6
Avocado	0	0	0.5	1.0	<1.0	1.0
Bacon	7	0.3	0.3	0.3	<0.2	0.5
Baked beans	6	0.3	0.4	0.4	<0.2	0.7
Banana	2	0.1	0.2	0.3	<0.2	0.6
Beef, mince	6	0.2	0.2	0.2	<0.2	0.3
Beef, rump	4	0.1	0.2	0.2	<0.2	0.4
Beer	0	0.0	0.1	0.1	<0.1	<0.1
Beetroot, canned	0	0	0.1	0.2	<0.2	<0.2
Biscuit, chocolate	8	3.7	3.7	3.7	2.1	5.8
Biscuit, cracker	5	3.5	3.7	3.9	<1.0	21.5
Biscuit, plain sweet	0	0	0.5	1.0	<1.0	<1.0
Bran flake cereal, mixed	8	2.4	2.4	2.4	1.3	3.7
Bread, mixed grain	3	0.4	0.7	1.0	<1.0	1.1
Bread, wheatmeal	7	1.1	1.1	1.2	<1.0	1.7
Bread, white	5	0.9	1.1	1.3	<1.0	1.7
Broccoli/cauliflower	5	0.4	0.5	0.5	<0.2	1.8
Butter	0	0	0.5	1.0	<1.0	<1.0
Cabbage	2	0.1	0.1	0.2	<0.2	0.3
Caffeinated beverage	5	0.2	0.2	0.2	<0.1	0.3
Cakes and slices	8	247.5	247.5	247.5	119.5	359.0
Capsicum	1	0.1	0.2	0.3	<0.2	0.7
Carbonated drink	2	0	0.1	0.1	<0.1	0.1
Carrot	0	0	0.1	0.2	<0.2	<0.2
Celery	7	0.3	0.3	0.4	<0.2	0.6
Cheese	0	0	0.5	1.0	<1.0	<1.0
Chicken	0	0	0.1	0.2	<0.2	<0.2
Chicken takeaway	8	12.9	12.9	12.9	2.2	48.1
Chocolate beverage	8	2.6	2.6	2.6	1.2	4.8
Coconut cream, canned	0	0	0.5	1.0	<1.0	<1.0
Coffee beans, ground	0	0	0.1	0.1	<0.1	<0.1
Coffee, instant	2	0	0.1	0.1	<0.1	0.1
Confectionery	3	2.7	3.0	3.3	<1.0	8.5
Corn, frozen	0	0	0.1	0.2	<0.2	<0.2
Corned beef	6	0.3	0.3	0.3	<0.2	0.5
Cornflakes	0	0	0.5	1.0	<1.0	<1.0

Food	No of samples > LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Courgette (zucchini)	4	0.3	0.3	0.4	<0.2	1.2
Cucumber	0	0	0.1	0.2	<0.2	<0.2
Dairy dessert	8	1.0	1.0	1.0	0.4	1.4
Egg	1	0.4	0.5	0.6	<0.2	3.1
Fish cakes	8	1.2	1.2	1.2	0.5	3.1
Fish fingers	5	1.2	1.2	1.2	<0.2	2.9
Fish, battered	8	62.3	62.3	62.3	0.2	155.6
Fish, canned	6	1.7	1.7	1.7	<0.2	5.2
Fish, fresh	0	0	0.1	0.2	<0.2	<0.2
Fruit drink	2	0.3	0.3	0.3	<0.1	1.3
Grape	8	1.5	1.5	1.5	1.0	1.8
Ham	8	1.7	1.7	1.7	0.3	4.8
Hamburger, plain	8	5.8	5.8	5.8	0.8	13.8
Honey	4	2.1	2.3	2.6	<1.0	8.9
Hummus	7	1.1	1.1	1.1	<0.2	2.3
Ice cream	0	0	0.1	0.2	<0.2	0.2
Infant/follow-on formula	0	0	0.5	1.0	<1.0	1.0
Infant weaning food, cereal based	7	0.3	0.4	0.4	<0.2	0.6
Infant weaning food, custard/fruit dish	4	0.2	0.3	0.3	<0.2	0.8
Infant weaning food, savoury dish	6	0.4	0.4	0.4	<0.2	1.0
Jam	4	0.7	1.0	1.2	<1.0	1.7
Kiwifruit	8	1.8	1.8	1.8	0.3	3.0
Kumara	7	0.3	0.3	0.3	<0.2	0.4
Lamb/mutton	0	0	0.1	0.2	<0.2	<0.2
Lambs liver	5	0.7	0.7	0.7	<0.2	3.1
Lettuce	3	0.4	0.4	0.5	<0.2	2.0
Mandarin	0	0	0.1	0.2	<0.2	<0.2
Meat pie	8	2.7	2.7	2.7	<0.4	14.4
Melon	1	0	0.1	0.2	<0.2	0.2
Milk chocolate	5	1.9	2.1	2.3	<1.0	3.9
Milk, 0.5% fat	0	0	0.1	0.1	<0.1	<0.1
Milk, 3.25% fat	0	0	0.1	0.1	<0.1	<0.1
Milk, flavoured	8	0.6	0.6	0.6	0.4	0.9
Mixed berries, frozen	8	2.3	2.3	2.3	0.4	3.4
Mixed vegetables, frozen	7	0.5	0.5	0.6	<0.2	0.9
Muesli	4	0.8	1.0	1.3	<1.0	2.6
Muffins and scones	8	704.5	704.5	704.5	497.0	926.7
Mushroom	7	0.5	0.5	0.5	<0.2	1.5
Mussels	8	58.1	58.1	58.1	18.7	89.1
Nectarine	1	0	0.1	0.2	<0.2	0.2
Noodle dish	8	2.3	2.3	2.3	0.3	10.3
Noodles, instant	7	0.8	0.8	0.8	<0.2	1.7
Oats, rolled	0	0	0.3	0.6	<0.2	<1.0

Food	No of samples > LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Oil	0	0	0.5	1.0	<1.0	<1.0
Onion	5	0.2	0.3	0.3	<0.2	0.5
Orange juice	1	0.1	0.1	0.1	<0.1	0.2
Orange	0	0	0.1	0.2	<0.2	0.2
Other cereals	6	2.5	2.6	2.7	<1.0	7.0
Oyster	8	31.5	31.5	31.5	12.0	54.4
Pasta, dried	2	1.3	1.6	2.0	<1.0	9.0
Peach, canned	0	0	0.1	0.2	<0.2	<0.2
Peanut butter	5	1.8	1.9	2.1	<1.0	8.1
Peanut	4	2.3	2.5	2.8	<1.0	6.0
Pear	5	0.3	0.4	0.4	<0.2	1.7
Peas, frozen	8	2.3	2.3	2.3	0.7	7.5
Pineapple, canned	1	0.1	0.2	0.3	<0.2	1.1
Pizza	8	18.0	18.0	18.0	1.1	57.4
Pork roast	0	0	0.1	0.2	<0.2	<0.2
Potato crisps	5	6.1	6.3	6.5	<1.0	22.9
Potato, hot chips	4	0.1	0.2	0.2	<0.2	0.3
Potato, peeled	4	0.3	0.3	0.4	<0.2	0.8
Potato, with skin	8	3.1	3.1	3.1	0.4	7.6
Prawn/shrimp	8	3.0	3.0	3.0	0.6	10.3
Prune	2	1.2	1.6	2.0	<1.0	5.3
Pumpkin	1	0	0.1	0.2	<0.2	0.2
Raisins/sultanas	8	3.6	3.6	3.6	1.9	4.8
Rice dish	8	1.9	1.9	1.9	0.6	4.1
Rice, white	0	0	0.5	1.0	<1.0	<1.0
Salad dressing	1	0.2	0.6	1.0	<1.0	1.4
Sausage	8	3.2	3.2	3.2	0.8	16.4
Silverbeet	8	5.8	5.8	5.8	1.3	26.5
Simmer sauce, bottled	8	2.4	2.4	2.4	1.7	3.8
Snack bar	7	2.2	2.2	2.3	<1.0	4.7
Snacks, flavoured	4	4.6	4.9	5.1	<1.0	29.5
Soup, vegetable	7	0.5	0.5	0.5	<0.1	1.6
Soya milk	8	0.5	0.5	0.5	0.2	1.1
Spaghetti in sauce, canned	8	1.1	1.1	1.1	0.3	2.6
Strawberry	7	0.4	0.4	0.4	<0.2	0.6
Sugar	0	0	0.5	1.0	<1.0	<1.0
Sushi	8	1.0	1.0	1.0	0.4	2.6
Table spread	0	0	0.5	1.0	<1.0	<1.0
Taro	4	0.3	0.3	0.4	<0.2	1.0
Tea	8	8.0	8.0	8.0	3.8	11.2
Tofu	8	1.7	1.7	1.7	1.3	2.2
Tomato	0	0	0.1	0.2	<0.2	<0.2
Tomato sauce	8	1.5	1.5	1.5	0.5	4.1

Food	No of samples > LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Tomatoes in juice, canned	7	1.3	1.3	1.3	<0.2	3.6
Water, bottled	4	0.003	0.003	0.004	<0.003	0.009
Water, tap	5	0.010	0.010	0.011	<0.003	0.023
Wheat biscuit cereal	5	1.5	1.6	1.8	<1.0	2.9
Wine, still red	8	0.4	0.4	0.4	0.2	0.9
Wine, still white	8	1.0	1.0	1.0	0.4	1.9
Yeast extract	8	2.6	2.6	2.6	1.0	5.4
Yoghurt	8	0.4	0.4	0.4	0.3	0.5

[a] Lower-bound (LB; not detected result = zero), mid-bound (MB; not detected = 50% the LOR) and upper-bound (UB; not detected = 100% LOR) mean concentrations. All mean values rounded to one decimal place, except for water (bottled and tap) which is rounded to three decimal places.

Appendix 11.2: Arsenic (total and inorganic (iAs)) concentrations (mg/kg) in foods of the 2016 NZTDS

Food	No of samples >LOR	Mean concentration (mg/kg)[b]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Almond	2	0.003	0.007	0.011	<0.010	0.013
Apple	5	0.002	0.002	0.003	<0.002	0.005
Apple-based juice	5	0.004	0.004	0.004	<0.001	0.019
Avocado	0	0	0.005	0.010	<0.009	<0.010
Bacon	1	0.001	0.003	0.006	<0.002	0.010
Baked beans	0	0	0.001	0.002	<0.002	<0.002
Banana	1	0.001	0.001	0.002	<0.002	0.002
Beef, mince	8	0.005	0.005	0.005	0.004	0.007
Beef, rump	8	0.007	0.007	0.007	0.003	0.010
Beer	3	0.001	0.001	0.002	<0.001	0.004
Beetroot, canned	0	0	0.001	0.002	<0.002	<0.002
Biscuit, chocolate	0	0	0.005	0.010	<0.010	<0.010
Biscuit, cracker	3	0.028	0.031	0.035	<0.010	0.119
Biscuit, cracker (iAs)	2 (2)[a]	0.015	0.018	0.021	<0.010	0.060
Biscuit, plain sweet	0	0	0.005	0.010	<0.010	<0.010
Bran flake cereal, mixed	7	0.017	0.018	0.018	0.010	0.033
Bran flake cereal, mixed (iAs)	0 (2)[a]	0.010	0.013	0.016	<0.010	<0.020
Bread, mixed grain	0	0	0.005	0.010	<0.010	<0.010
Bread, wheatmeal	2	0.003	0.007	0.011	<0.010	0.016
Bread, white	0	0	0.005	0.010	<0.010	<0.010
Broccoli/cauliflower	0	0	0.001	0.002	<0.002	<0.002
Butter	2	0.004	0.007	0.011	<0.010	0.015
Cabbage	0	0	0.001	0.002	<0.002	<0.002
Caffeinated beverage	5	0.001	0.001	0.001	<0.001	0.002
Cakes and slices	1	0.001	0.006	0.010	<0.010	0.011
Capsicum	0	0	0.001	0.002	<0.002	<0.002
Carbonated drink	3	0.001	0.001	0.001	<0.001	0.001

Food	No of samples >LOR	Mean concentration (mg/kg)[b]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Carrot	4	0.002	0.003	0.003	<0.002	0.006
Celery	4	0.001	0.002	0.002	<0.002	0.003
Cheese	0	0	0.005	0.010	<0.009	<0.010
Chicken	0	0	0.005	0.011	<0.002	<0.020
Chicken takeaway	3	0.004	0.007	0.010	<0.009	0.011
Chocolate beverage	5	0.001	0.001	0.001	<0.001	0.002
Coconut cream, canned	0	0	0.005	0.009	<0.009	<0.010
Coffee beans, ground	0	0	0.001	0.001	<0.001	<0.001
Coffee, instant	0	0	0.001	0.001	<0.001	<0.001
Confectionery	0	0	0.005	0.010	<0.010	<0.010
Corn, frozen	2	0.001	0.001	0.002	<0.002	0.003
Corned beef	8	0.004	0.004	0.004	0.002	0.005
Cornflakes	0	0	0.005	0.010	<0.010	<0.010
Courgette (zucchini)	0	0	0.001	0.002	<0.002	<0.002
Cucumber	5	0.002	0.002	0.003	<0.002	0.005
Dairy dessert	1	0.001	0.001	0.002	<0.002	0.002
Egg	6	0.006	0.006	0.006	<0.002	0.011
Fish cakes	8	0.520	0.520	0.520	0.197	1.396
Fish cakes (iAs)	1 (8)[a]	0.004	0.013	0.021	<0.020	0.030
Fish fingers	8	0.887	0.887	0.887	0.511	1.311
Fish fingers (iAs)	3 (8)[a]	0.011	0.018	0.024	<0.020	0.040
Fish, battered	8	1.819	1.819	1.819	0.784	3.451
Fish, battered (iAs)	2 (8)[a]	0.011	0.026	0.041	<0.020	0.050
Fish, canned	8	0.682	0.682	0.682	0.232	1.560
Fish, canned (iAs)	3 (8)[a]	0.009	0.015	0.021	<0.020	0.030
Fish, fresh	8	4.334	4.334	4.334	1.734	10.125
Fish, fresh (iAs)	8 (8)[a]	0.059	0.059	0.059	0.030	0.170
Fruit drink	2	0.002	0.003	0.003	<0.001	0.009
Grape	8	0.003	0.003	0.003	0.002	0.005
Ham	7	0.004	0.004	0.004	<0.002	0.010
Hamburger, plain	8	0.006	0.006	0.006	0.005	0.007
Honey	0	0	0.005	0.010	<0.010	<0.010
Hummus	1	0.001	0.007	0.013	<0.002	<0.040
Ice cream	3	0.001	0.002	0.002	<0.002	0.003
Infant/follow-on formula	0	0	0.005	0.010	<0.010	<0.010
Infant weaning food, cereal based	3	0.004	0.006	0.008	<0.002	0.018
Infant weaning food, custard/fruit dish	1	0	0.001	0.002	<0.002	0.003
Infant weaning food, savoury dish	3	0.004	0.006	0.008	<0.002	0.016
Jam	0	0	0.005	0.010	<0.010	<0.010
Kiwifruit	0	0	0.001	0.002	<0.002	<0.002
Kumara	1	0.001	0.001	0.002	<0.002	0.002
Lamb/mutton	0	0	0.003	0.006	<0.002	<0.010
Lambs liver	5	0.005	0.007	0.009	<0.003	0.012

Food	No of samples >LOR	Mean concentration (mg/kg)[b]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Lettuce	0	0	0.001	0.002	<0.002	<0.002
Mandarins	0	0	0.001	0.002	<0.002	<0.002
Meat pie	8	0.005	0.005	0.005	0.003	0.007
Melon	0	0	0.001	0.002	<0.002	<0.002
Milk chocolate	0	0	0.005	0.010	<0.010	<0.010
Milk, 0.5% fat	0	0	0.001	0.001	<0.001	<0.001
Milk, 3.25% fat	0	0	0.001	0.001	<0.001	<0.001
Milk, flavoured	0	0	0.001	0.001	<0.001	<0.001
Mixed berries, frozen	5	0.002	0.003	0.003	<0.002	0.005
Mixed vegetables, frozen	1	0.001	0.001	0.002	<0.002	0.002
Muesli	0	0	0.005	0.010	<0.010	<0.010
Muffins and scones	4	0.006	0.008	0.011	<0.010	0.013
Mushroom	8	0.075	0.075	0.075	0.022	0.176
Mushroom (iAs)	0 (8)[a]	0	0.010	0.020	<0.020	<0.020
Mussels	8	3.431	3.431	3.431	2.077	6.674
Mussels (iAs)	8 (8)[a]	0.096	0.096	0.096	0.050	0.210
Nectarine	5	0.003	0.003	0.003	<0.002	0.005
Noodle dish	8	0.013	0.013	0.013	0.004	0.033
Noodles, instant	3	0.001	0.002	0.002	<0.002	0.003
Oats, rolled	0	0	0.003	0.006	<0.002	<0.010
Oil	1	0.001	0.026	0.051	<0.009	<0.093
Onion	1	0.001	0.001	0.002	<0.002	0.003
Orange juice	0	0	0.001	0.001	<0.001	<0.001
Orange	0	0	0.001	0.002	<0.002	<0.002
Other cereals	8	0.070	0.070	0.070	0.011	0.142
Other cereals (iAs)	4 (4)[a]	0.032	0.032	0.032	0.011	0.050
Oyster	8	2.689	2.689	2.689	2.135	3.779
Oyster (iAs)	7 (8)[a]	0.056	0.059	0.063	<0.050	0.080
Pasta, dried	0	0	0.005	0.010	<0.010	<0.010
Peach, canned	0	0	0.001	0.002	<0.002	<0.002
Peanut butter	2	0.003	0.006	0.010	<0.009	0.013
Peanut	2	0.003	0.007	0.010	<0.010	0.013
Pear	6	0.003	0.003	0.003	<0.002	0.005
Peas, frozen	0	0	0.001	0.002	<0.002	<0.002
Pineapple, canned	2	0.001	0.001	0.002	<0.002	0.003
Pizza	8	0.006	0.006	0.006	0.003	0.010
Pork roast	4	0.002	0.002	0.003	<0.002	0.004
Potato crisps	0	0	0.005	0.010	<0.010	<0.010
Potato, hot chips	0	0	0.001	0.002	<0.002	<0.002
Potato, peeled	1	0.001	0.001	0.002	<0.002	0.002
Potato, with skin	1	0.001	0.001	0.002	<0.002	0.003
Prawn/shrimp	8	0.179	0.179	0.179	0.116	0.217
Prawn/shrimp (iAs)	1 (8)[a]	0.003	0.019	0.035	<0.020	0.050

Food	No of samples >LOR	Mean concentration (mg/kg)[b]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Prune	1	0.002	0.006	0.010	<0.010	0.012
Pumpkin	1	0.001	0.001	0.002	<0.002	0.003
Raisins/sultanas	7	0.013	0.014	0.014	<0.010	0.021
Raisins/sultanas (iAs)	0 (2)[a]	0.008	0.011	0.014	<0.010	<0.020
Rice dish	8	0.030	0.030	0.030	0.014	0.046
Rice dish (iAs)	0 (8)[a]	0	0.012	0.024	<0.020	<0.050
Rice, white	8	0.038	0.038	0.038	0.022	0.060
Rice, white (iAs)	8 (8)[a]	0.031	0.031	0.031	0.030	0.040
Salad dressing	1	0.001	0.005	0.010	<0.009	0.010
Sausage	7	0.008	0.008	0.008	<0.002	0.014
Silverbeet	0	0	0.001	0.002	<0.002	<0.002
Simmer sauce, bottled	1	0.001	0.001	0.002	<0.002	0.003
Snack bar	5	0.008	0.010	0.012	<0.010	0.016
Snacks, flavoured	4	0.007	0.010	0.012	<0.010	0.020
Snacks, flavoured (iAs)	0 (1)[a]	0.005	0.009	0.013	<0.010	<0.020
Soup, vegetable	2	0.001	0.001	0.002	<0.001	0.002
Soya milk	5	0.002	0.004	0.005	<0.001	0.010
Spaghetti in sauce, canned	1	0.002	0.002	0.003	<0.002	0.012
Strawberry	5	0.003	0.004	0.004	<0.002	0.013
Sugar	0	0	0.005	0.010	<0.010	<0.010
Sushi	8	0.295	0.295	0.295	0.218	0.417
Sushi (iAs)	0 (8)[a]	0	0.018	0.035	<0.020	<0.050
Table spread	0	0	0.005	0.010	<0.010	0.010
Taro	3	0.003	0.004	0.004	<0.002	0.019
Tea	0	0	0.001	0.001	<0.001	0.001
Tofu	0	0	0.003	0.007	<0.002	0.010
Tomato	1	0.001	0.001	0.002	<0.002	0.002
Tomato sauce	1	0.001	0.001	0.002	<0.002	0.003
Tomatoes in juice, canned	0	0	0.001	0.002	<0.002	0.002
Water, bottled	2	0.002	0.003	0.003	<0.001	0.009
Water, tap	2	0.001	0.001	0.001	<0.001	0.003
Wheat biscuit cereal	6	0.018	0.020	0.021	<0.010	0.028
Wheat biscuit cereal (iAs)	3 (6)[a]	0.009	0.014	0.019	<0.010	0.030
Wine, still red	8	0.002	0.002	0.002	0.001	0.005
Wine, still white	8	0.004	0.004	0.004	0.002	0.006
Yeast extract	6	0.052	0.053	0.055	<0.009	0.088
Yeast extract (iAs)	6 (6)[a]	0.045	0.046	0.047	<0.009	0.070
Yoghurt	1	0.001	0.001	0.002	<0.002	0.002

[a] The number of samples <LOR for iAs includes the number of samples in brackets analysed for this species.
[b] Lower-bound (LB; not detected result = zero), mid-bound (MB; not detected = 50% the LOR) and upper-bound (UB; not detected = 100% LOR) mean concentrations. Samples with detected total arsenic below 0.02 mg/kg which were not further analysed for iAs are treated as containing 100% iAs for the purposes of the LB, MB and UB mean calculations. All mean values rounded to three decimal places.

Appendix 11.3: Cadmium concentrations (mg/kg) in foods of the 2016 NZTDS

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Almond	8	0.0092	0.0092	0.0092	0.0061	0.0146
Apple	1	0.0001	0.0003	0.0005	<0.0004	0.0011
Apple-based juice	0	0	0.0001	0.0002	<0.0002	<0.0002
Avocado	8	0.0180	0.0180	0.0180	0.0082	0.0291
Bacon	8	0.0013	0.0013	0.0013	0.0008	0.0019
Baked beans	8	0.0051	0.0051	0.0051	0.0016	0.0086
Banana	5	0.0007	0.0007	0.0008	<0.0004	0.0024
Beef, mince	2	0.0002	0.0003	0.0005	<0.0004	0.0007
Beef, rump	0	0	0.0002	0.0004	<0.0004	<0.0004
Beer	0	0	0.0001	0.0002	<0.0002	<0.0002
Beetroot, canned	8	0.0108	0.0108	0.0108	0.0082	0.0137
Biscuit, chocolate	8	0.0245	0.0245	0.0245	0.0121	0.0400
Biscuit, cracker	8	0.0155	0.0155	0.0155	0.0050	0.0282
Biscuit, plain sweet	8	0.0145	0.0145	0.0145	0.0036	0.0192
Bran flake cereal, mixed	8	0.0183	0.0183	0.0183	0.0055	0.0356
Bread, mixed grain	8	0.0142	0.0142	0.0142	0.0072	0.0244
Bread, wheatmeal	8	0.0161	0.0161	0.0161	0.0043	0.0289
Bread, white	8	0.0118	0.0118	0.0118	0.0031	0.0191
Broccoli/cauliflower	8	0.0040	0.0040	0.0040	0.0021	0.0100
Butter	0	0	0.0010	0.0020	<0.0020	<0.0020
Cabbage	8	0.0031	0.0031	0.0031	0.0016	0.0048
Caffeinated beverage	0	0	0.0001	0.0002	<0.0002	<0.0002
Cakes and slices	8	0.0090	0.0090	0.0090	0.0049	0.0189
Capsicum	4	0.0009	0.0010	0.0011	<0.0004	0.0043
Carbonated drink	0	0	0.0001	0.0002	<0.0002	<0.0002
Carrot	8	0.0249	0.0249	0.0249	0.0163	0.0420
Celery	8	0.0191	0.0191	0.0191	0.0055	0.0441
Cheese	0	0	0.0010	0.0020	<0.0019	<0.0020
Chicken	1	0.0001	0.0003	0.0004	<0.0004	0.0007
Chicken takeaway	8	0.0020	0.0020	0.0020	0.0006	0.0042
Chocolate beverage	8	0.0100	0.0100	0.0100	0.0048	0.0178
Coconut cream, canned	3	0.0010	0.0016	0.0023	<0.0019	0.0031
Coffee beans, ground	0	0	0.0001	0.0002	<0.0002	<0.0002
Coffee, instant	0	0	0.0001	0.0002	<0.0002	<0.0002
Confectionery	0	0	0.0010	0.0020	<0.0020	<0.0020
Corn, frozen	7	0.0025	0.0025	0.0026	<0.0004	0.0060
Corned beef	6	0.0010	0.0011	0.0011	<0.0004	0.0023
Cornflakes	2	0.0013	0.0020	0.0028	<0.0020	0.0076
Courgette (zucchini)	8	0.0025	0.0025	0.0025	0.0006	0.0074
Cucumber	3	0.0002	0.0004	0.0005	<0.0004	0.0007
Dairy dessert	8	0.0054	0.0054	0.0054	0.0004	0.0112
Egg	4	0.0003	0.0004	0.0005	<0.0004	0.0011

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Fish cakes	8	0.0080	0.0080	0.0080	0.0035	0.0133
Fish fingers	8	0.0045	0.0045	0.0045	0.0007	0.0071
Fish, battered	7	0.0055	0.0056	0.0057	<0.0020	0.0110
Fish, canned	8	0.0103	0.0103	0.0103	0.0013	0.0221
Fish, fresh	8	0.0014	0.0014	0.0014	0.0008	0.0023
Fruit drink	2	0.0006	0.0006	0.0007	<0.0002	0.0025
Grape	3	0.0002	0.0004	0.0005	<0.0004	0.0010
Ham	8	0.0021	0.0021	0.0021	0.0010	0.0049
Hamburger, plain	8	0.0073	0.0073	0.0073	0.0031	0.0104
Honey	1	0.0003	0.0012	0.0021	<0.0020	0.0025
Hummus	8	0.0022	0.0022	0.0022	0.0014	0.0043
Ice cream	0	0	0.0002	0.0004	<0.0004	<0.0004
Infant/follow-on formula	0	0	0.0010	0.0020	<0.0020	<0.0020
Infant weaning food, cereal based	8	0.0017	0.0017	0.0017	0.0009	0.0041
Infant weaning food, custard/fruit dish	1	0.0002	0.0003	0.0005	<0.0004	0.0013
Infant weaning food, savoury dish	8	0.0048	0.0048	0.0048	0.0017	0.0098
Jam	3	0.0014	0.0020	0.0026	<0.0020	0.0053
Kiwifruit	5	0.0004	0.0005	0.0005	<0.0004	0.0008
Kumara	8	0.0069	0.0069	0.0069	0.0037	0.0124
Lamb/mutton	0	0	0.0002	0.0004	<0.0004	<0.0004
Lambs liver	8	0.0777	0.0777	0.0777	0.0158	0.2186
Lettuce	8	0.0152	0.0152	0.0152	0.0062	0.0216
Mandarin	0	0	0.0002	0.0004	<0.0004	<0.0004
Meat pie	8	0.0040	0.0040	0.0040	0.0016	0.0071
Melon	7	0.0015	0.0015	0.0015	<0.0004	0.0037
Milk chocolate	8	0.0206	0.0206	0.0206	0.0101	0.0357
Milk, 0.5% fat	0	0	0.0001	0.0002	<0.0002	<0.0002
Milk, 3.25% fat	0	0	0.0001	0.0002	<0.0002	<0.0002
Milk, flavoured	8	0.0027	0.0027	0.0027	0.0010	0.0050
Mixed berries, frozen	8	0.0057	0.0057	0.0057	0.0010	0.0192
Mixed vegetables, frozen	8	0.0097	0.0097	0.0097	0.0016	0.0197
Muesli	8	0.0175	0.0175	0.0175	0.0112	0.0298
Muffins and scones	8	0.0128	0.0128	0.0128	0.0077	0.0167
Mushroom	8	0.0072	0.0072	0.0072	0.0043	0.0118
Mussels	8	0.2433	0.2433	0.2433	0.0780	0.3869
Nectarine	8	0.0009	0.0009	0.0009	0.0006	0.0011
Noodle dish	8	0.0082	0.0082	0.0082	0.0041	0.0251
Noodles, instant	8	0.0057	0.0057	0.0057	0.0016	0.0090
Oats, rolled	6	0.0020	0.0023	0.0025	<0.0020	0.0038
Oil	0	0	0.0010	0.0020	<0.0019	<0.0020
Onion	8	0.0181	0.0181	0.0181	0.0077	0.0414
Orange juice	0	0	0.0001	0.0002	<0.0002	<0.0002
Orange	0	0	0.0002	0.0004	<0.0004	<0.0004

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Other cereals	8	0.0154	0.0154	0.0154	0.0033	0.0326
Oyster	8	1.2786	1.2786	1.2786	0.2425	3.1852
Pasta, dried	8	0.0081	0.0081	0.0081	0.0023	0.0132
Peach, canned	7	0.0008	0.0009	0.0009	<0.0004	0.0023
Peanut butter	8	0.0694	0.0694	0.0694	0.0167	0.1666
Peanut	8	0.0763	0.0763	0.0763	0.0352	0.1585
Pear	8	0.0027	0.0027	0.0027	0.0015	0.0034
Peas, frozen	8	0.0019	0.0019	0.0019	0.0005	0.0043
Pineapple, canned	7	0.0010	0.0010	0.0010	<0.0004	0.0037
Pizza	8	0.0110	0.0110	0.0110	0.0063	0.0134
Pork roast	2	0.0002	0.0003	0.0005	<0.0004	0.0006
Potato crisps	8	0.1369	0.1369	0.1369	0.0614	0.2349
Potato, hot chips	8	0.0390	0.0390	0.0390	0.0245	0.0538
Potato, peeled	8	0.0229	0.0229	0.0229	0.0128	0.0444
Potato, with skin	8	0.0365	0.0365	0.0365	0.0213	0.0605
Prawn/shrimp	8	0.0014	0.0014	0.0014	0.0005	0.0044
Prune	1	0.0003	0.0011	0.0020	<0.0020	0.0020
Pumpkin	8	0.0085	0.0085	0.0085	0.0062	0.0110
Raisins/sultanas	0	0	0.0010	0.0020	<0.0020	<0.0020
Rice dish	8	0.0065	0.0065	0.0065	0.0039	0.0094
Rice, white	7	0.0060	0.0062	0.0063	<0.0020	0.0110
Salad dressing	3	0.0014	0.0020	0.0026	<0.0019	0.0051
Sausage	8	0.0037	0.0037	0.0037	0.0019	0.0073
Silverbeet	8	0.0179	0.0179	0.0179	0.0066	0.0342
Simmer sauce, bottled	8	0.0139	0.0139	0.0139	0.0060	0.0185
Snack bar	8	0.0178	0.0178	0.0178	0.0081	0.0633
Snacks, flavoured	2	0.0016	0.0024	0.0031	<0.0020	0.0071
Soup, vegetable	8	0.0056	0.0056	0.0056	0.0003	0.0135
Soya milk	8	0.0015	0.0015	0.0015	0.0008	0.0020
Spaghetti in sauce, canned	8	0.0073	0.0073	0.0073	0.0018	0.0119
Strawberry	8	0.0068	0.0068	0.0068	0.0008	0.0241
Sugar	0	0	0.0010	0.0020	<0.0020	<0.0020
Sushi	8	0.0187	0.0187	0.0187	0.0128	0.0325
Table spread	0	0.0000	0.0010	0.0020	<0.0020	<0.0020
Taro	8	0.0188	0.0188	0.0188	0.0012	0.0565
Tea	0	0	0.0001	0.0002	<0.0002	<0.0002
Tofu	8	0.0136	0.0136	0.0136	0.0097	0.0230
Tomato	3	0.0008	0.0009	0.0011	0.0004	0.0051
Tomato sauce	8	0.0145	0.0145	0.0145	0.0045	0.0213
Tomatoes in juice, canned	8	0.0101	0.0101	0.0101	0.0074	0.0142
Water, bottled	0	0	0.0001	0.0001	<0.00005	<0.00005
Water, tap	0	0	0.0001	0.0001	<0.00005	<0.00005
Wheat biscuit cereal	8	0.0101	0.0101	0.0101	0.0077	0.0134

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Wine, still red	1	0.0001	0.0002	0.0004	<0.0002	0.0004
Wine, still white	5	0.0002	0.0003	0.0003	<0.0002	0.0004
Yeast extract	8	0.0060	0.0060	0.0060	0.0025	0.0116
Yoghurt	3	0.0003	0.0004	0.0005	<0.0004	0.0010

[a] Lower-bound (LB; not detected result = zero), mid-bound (MB; not detected = 50% the LOR) and upper-bound (UB; not detected = 100% LOR) mean concentrations. All mean values rounded to four decimal places.

Appendix 11.4: Lead concentrations (mg/kg) in foods of the 2016 NZTDS

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Almond	0	0	0.005	0.010	<0.010	<0.010
Apple	0	0	0.001	0.002	<0.002	<0.002
Apple-based juice	5	0.002	0.002	0.002	<0.001	0.003
Avocado	0	0	0.005	0.010	<0.010	<0.010
Bacon	6	0.003	0.003	0.003	<0.002	0.008
Baked beans	2	0.001	0.001	0.002	<0.002	0.003
Banana	0	0	0.001	0.002	<0.002	<0.002
Beef, mince	1	0.000	0.001	0.002	<0.002	0.002
Beef, rump	1	0.000	0.001	0.002	<0.002	0.002
Beer	0	0	0.001	0.001	<0.001	<0.001
Beetroot, canned	1	0.000	0.001	0.002	<0.002	0.003
Biscuit, chocolate	4	0.022	0.024	0.027	<0.010	0.133
Biscuit, cracker	0	0	0.005	0.010	<0.010	<0.010
Biscuit, plain sweet	0	0	0.005	0.010	<0.010	<0.010
Bran flake cereal, mixed	0	0	0.005	0.010	<0.010	<0.010
Bread, mixed grain	0	0	0.005	0.010	<0.010	<0.010
Bread, wheatmeal	1	0.002	0.006	0.011	<0.010	0.017
Bread, white	0	0	0.005	0.010	<0.010	<0.010
Broccoli/cauliflower	1	0.000	0.001	0.002	<0.002	0.003
Butter	0	0	0.005	0.010	<0.010	<0.010
Cabbage	0	0	0.001	0.002	<0.002	<0.002
Caffeinated beverage	0	0	0.001	0.001	<0.001	<0.001
Cakes and slices	1	0.002	0.006	0.011	<0.010	0.014
Capsicum	0	0	0.001	0.002	<0.002	<0.002
Carbonated drink	0	0	0.001	0.001	<0.001	<0.001
Carrot	5	0.008	0.009	0.009	<0.002	0.019
Celery	0	0	0.001	0.002	<0.002	<0.002
Cheese	0	0	0.005	0.010	<0.010	<0.010
Chicken	0	0	0.001	0.002	<0.002	<0.002
Chicken takeaway	3	0.001	0.002	0.002	<0.002	0.003
Chocolate beverage	8	0.006	0.006	0.006	0.002	0.013
Coconut cream, canned	0	0	0.005	0.010	<0.010	<0.010

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Coffee beans, ground	0	0	0.001	0.001	<0.001	<0.001
Coffee, instant	0	0.001	0.001	0.001	<0.001	<0.001
Confectionery	1	0.004	0.008	0.012	<0.010	0.028
Corn, frozen	1	0.001	0.001	0.002	<0.002	0.005
Corned beef	3	0.002	0.002	0.003	<0.002	0.006
Cornflakes	0	0	0.005	0.010	<0.010	<0.010
Courgette (zucchini)	1	0.001	0.001	0.002	<0.002	0.004
Cucumber	0	0	0.001	0.002	<0.002	0.002
Dairy dessert	4	0.002	0.002	0.003	<0.002	0.005
Egg	0	0	0.001	0.002	<0.002	<0.002
Fish cakes	6	0.004	0.004	0.004	<0.002	0.009
Fish fingers	3	0.002	0.003	0.003	<0.002	0.007
Fish, battered	2	0.001	0.003	0.006	<0.002	0.010
Fish, canned	2	0.001	0.002	0.002	<0.002	0.003
Fish, fresh	4	0.002	0.002	0.003	0.002	0.004
Fruit drink	2	0.001	0.001	0.001	<0.001	0.002
Grape	2	0.001	0.002	0.002	<0.002	0.005
Ham	8	0.005	0.005	0.005	0.003	0.007
Hamburger, plain	8	0.004	0.004	0.004	0.003	0.006
Honey	1	0.002	0.006	0.010	<0.010	0.012
Hummus	3	0.001	0.002	0.002	<0.002	0.003
Ice cream	0	0	0.001	0.002	<0.002	<0.002
Infant/follow-on formula	0	0	0.005	0.010	<0.010	<0.010
Infant weaning food, cereal based	3	0.001	0.002	0.002	<0.002	0.005
Infant weaning food, custard/fruit dish	4	0.011	0.011	0.012	<0.002	0.036
Infant weaning food, savoury dish	3	0.001	0.002	0.002	<0.002	0.005
Jam	2	0.003	0.007	0.011	<0.010	0.016
Kiwifruit	0	0	0.001	0.002	<0.002	<0.002
Kumara	8	0.004	0.004	0.004	0.003	0.007
Lamb/mutton	0	0	0.001	0.002	<0.002	<0.002
Lambs liver	8	0.027	0.027	0.027	0.010	0.054
Lettuce	1	0.001	0.001	0.002	<0.002	0.003
Mandarin	0	0	0.001	0.002	<0.002	<0.002
Meat pie	4	0.002	0.002	0.003	<0.002	0.008
Melon	0	0	0.001	0.002	<0.002	<0.002
Milk chocolate	2	0.003	0.007	0.010	<0.010	0.013
Milk, 0.5% fat	0	0	0.001	0.001	<0.001	<0.001
Milk, 3.25% fat	0	0	0.001	0.001	<0.001	<0.001
Milk, flavoured	6	0.001	0.001	0.001	<0.001	0.002
Mixed berries, frozen	5	0.002	0.003	0.003	<0.002	0.006
Mixed vegetables, frozen	7	0.003	0.003	0.003	<0.002	0.004
Muesli	1	0.001	0.006	0.010	<0.010	0.011
Muffins and scones	0	0	0.005	0.010	<0.010	<0.010

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Mushroom	7	0.006	0.006	0.006	<0.002	0.013
Mussels	8	0.133	0.133	0.133	0.082	0.228
Nectarine	2	0.001	0.001	0.002	<0.002	0.002
Noodle dish	6	0.003	0.003	0.003	<0.002	0.006
Noodles, instant	4	0.002	0.002	0.003	<0.002	0.004
Oats, rolled	0	0	0.003	0.006	<0.002	<0.010
Oil	0	0	0.005	0.010	<0.010	<0.010
Onion	4	0.002	0.002	0.003	<0.002	0.006
Orange juice	0	0	0.001	0.001	<0.001	<0.001
Orange	0	0	0.001	0.002	<0.002	<0.002
Other cereals	3	0.006	0.009	0.012	<0.010	0.018
Oyster	8	0.061	0.061	0.061	0.034	0.137
Pasta, dried	0	0	0.005	0.010	<0.010	<0.010
Peach, canned	8	0.033	0.033	0.033	0.006	0.124
Peanut butter	1	0.002	0.006	0.010	<0.010	0.013
Peanut	0	0	0.005	0.010	<0.010	<0.010
Pear	1	0.001	0.001	0.002	<0.002	0.002
Peas, frozen	4	0.002	0.002	0.003	<0.002	0.005
Pineapple, canned	8	0.014	0.014	0.014	0.005	0.028
Pizza	8	0.004	0.004	0.004	0.003	0.005
Pork roast	0	0	0.001	0.002	<0.002	<0.002
Potato crisps	0	0	0.005	0.010	<0.010	<0.010
Potato, hot chips	1	0.001	0.001	0.002	<0.002	0.002
Potato, peeled	0	0	0.001	0.002	<0.002	<0.002
Potato with skin	3	0.001	0.002	0.002	<0.002	0.003
Prawn/shrimp	8	0.010	0.010	0.010	0.004	0.031
Prune	2	0.004	0.007	0.011	<0.010	0.019
Pumpkin	3	0.001	0.002	0.002	<0.002	0.004
Raisins/sultanas	4	0.006	0.009	0.011	<0.010	0.015
Rice dish	5	0.003	0.003	0.003	<0.002	0.007
Rice, white	0	0	0.005	0.010	<0.010	<0.010
Salad dressing	0	0	0.005	0.010	<0.010	<0.010
Sausage	7	0.004	0.004	0.004	<0.002	0.007
Silverbeet	7	0.005	0.005	0.005	<0.002	0.010
Simmer sauce, bottled	8	0.004	0.004	0.004	0.003	0.007
Snack bar	1	0.002	0.006	0.010	<0.010	0.014
Snacks, flavoured	0	0	0.005	0.010	<0.010	0.010
Soup, vegetable	7	0.001	0.001	0.001	<0.001	0.002
Soya milk	6	0.001	0.001	0.001	<0.001	0.002
Spaghetti in sauce, canned	2	0.001	0.002	0.002	<0.002	0.004
Strawberry	0	0	0.001	0.002	<0.002	<0.002
Sugar	1	0.005	0.009	0.014	<0.010	0.039
Sushi	8	0.004	0.004	0.004	0.003	0.007

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Table spread	0	0	0.005	0.010	<0.010	<0.010
Taro	4	0.005	0.005	0.006	<0.002	0.018
Tea	0	0	0.001	0.001	<0.001	<0.001
Tofu	8	0.006	0.006	0.006	0.004	0.009
Tomato	0	0	0.001	0.002	<0.002	<0.002
Tomato sauce	5	0.002	0.002	0.003	<0.002	0.004
Tomatoes in juice, canned	8	0.011	0.011	0.011	0.004	0.022
Water, bottled	0	0	0.0001	0.0001	<0.0001	<0.0001
Water, tap	7	0.0002	0.0002	0.0002	<0.0001	0.0003
Wheat biscuit cereal	0	0	0.005	0.010	<0.010	<0.010
Wine, still red	6	0.003	0.003	0.003	<0.002	0.004
Wine, still white	8	0.012	0.012	0.012	0.009	0.015
Yeast extract	3	0.006	0.009	0.012	<0.010	0.017
Yoghurt	1	0.001	0.001	0.002	<0.002	0.002

[a] Lower-bound (LB; not detected result = zero), mid-bound (MB; not detected = 50% the LOR) and upper-bound (UB; not detected = 100% LOR) mean concentrations. All mean values rounded to three decimal places, except for water (bottled and tap) which is rounded to four decimal places.

Appendix 11.5: Mercury (total and methylmercury(MeHg)) concentrations (mg/kg) in foods of the 2016 NZTDS

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Almond	0	0	0.005	0.010	<0.010	<0.010
Apple	0	0	0.001	0.002	<0.002	<0.002
Apple-based juice	0	0	0.001	0.001	<0.001	<0.001
Avocado	0	0	0.005	0.010	<0.010	<0.010
Bacon	0	0	0.001	0.002	<0.002	<0.002
Baked beans	0	0	0.001	0.002	<0.002	<0.002
Banana	0	0	0.001	0.002	<0.002	<0.002
Beef, mince	0	0	0.001	0.002	<0.002	<0.002
Beef, rump	0	0	0.001	0.002	<0.002	<0.002
Beer	0	0	0.001	0.001	<0.001	<0.001
Beetroot, canned	0	0	0.001	0.002	<0.002	<0.002
Biscuit, chocolate	0	0	0.005	0.010	<0.010	<0.010
Biscuit, cracker	0	0	0.005	0.010	<0.010	<0.010
Biscuit, plain sweet	0	0	0.005	0.010	<0.010	<0.010
Bran flake cereal, mixed	0	0	0.005	0.010	<0.010	<0.010
Bread, mixed grain	0	0	0.005	0.010	<0.010	<0.010
Bread, wheatmeal	0	0	0.005	0.010	<0.010	<0.010
Bread, white	0	0	0.005	0.010	<0.010	<0.010
Broccoli/cauliflower	0	0	0.001	0.002	<0.002	<0.002
Butter	0	0	0.005	0.010	<0.010	<0.010
Cabbage	1	0.001	0.001	0.002	<0.002	0.005
Caffeinated beverage	0	0	0.001	0.001	<0.001	<0.001

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Cakes and slices	0	0	0.005	0.010	<0.010	<0.010
Capsicum	0	0	0.001	0.002	<0.002	<0.002
Carbonated drink	0	0	0.001	0.001	<0.001	<0.001
Carrot	0	0	0.001	0.002	<0.002	<0.002
Celery	0	0	0.001	0.002	<0.002	<0.002
Cheese	0	0	0.005	0.010	<0.010	<0.010
Chicken	0	0	0.001	0.002	<0.002	<0.002
Chicken takeaway	0	0	0.001	0.002	<0.002	<0.002
Chocolate beverage	0	0	0.001	0.001	<0.001	<0.001
Coconut cream, canned	0	0	0.005	0.010	<0.010	<0.010
Coffee beans, ground	0	0	0.001	0.001	<0.001	<0.001
Coffee, instant	0	0	0.001	0.001	<0.001	<0.001
Confectionery	0	0	0.005	0.010	<0.010	<0.010
Corn, frozen	0	0	0.001	0.002	<0.002	<0.002
Corned beef	0	0	0.001	0.002	<0.002	<0.002
Cornflakes	0	0	0.005	0.010	<0.010	<0.010
Courgette (zucchini)	0	0	0.001	0.002	<0.002	<0.002
Cucumber	0	0	0.001	0.002	<0.002	<0.002
Dairy dessert	0	0	0.001	0.002	<0.002	<0.002
Egg	0	0	0.001	0.002	<0.002	<0.002
Fish cakes	8	0.031	0.031	0.031	0.016	0.053
Fish cakes (MeHg)	8	0.030	0.030	0.030	0.019	0.055
Fish fingers	8	0.064	0.064	0.064	0.016	0.182
Fish fingers (MeHg)	8	0.059	0.059	0.059	0.018	0.159
Fish, battered	8	0.151	0.151	0.151	0.057	0.330
Fish, battered (MeHg)	8	0.134	0.134	0.134	0.045	0.402
Fish, canned	8	0.038	0.038	0.038	0.010	0.104
Fish, canned (MeHg)	8	0.036	0.036	0.036	0.009	0.100
Fish, fresh	8	0.157	0.157	0.157	0.076	0.285
Fish, fresh (MeHg)	8	0.151	0.151	0.151	0.079	0.266
Fruit drink	0	0	0.001	0.001	<0.001	<0.001
Grape	0	0	0.001	0.002	<0.002	0.002
Ham	0	0	0.001	0.002	<0.002	<0.002
Hamburger, plain	0	0	0.001	0.002	<0.002	<0.002
Honey	0	0	0.005	0.010	<0.010	<0.010
Hummus	0	0	0.001	0.002	<0.002	<0.002
Ice cream	0	0	0.001	0.002	<0.002	<0.002
Infant/follow-on formula	0	0	0.005	0.010	<0.010	<0.010
Infant weaning food, cereal based	0	0	0.001	0.002	<0.002	<0.002
Infant weaning food, custard/fruit dish	0	0	0.001	0.002	<0.002	<0.002
Infant weaning food, savoury dish	0	0	0.001	0.002	<0.002	<0.002
Jam	0	0	0.005	0.010	<0.010	<0.010
Kiwifruit	0	0	0.001	0.002	<0.002	<0.002

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Kumara	0	0	0.001	0.002	<0.002	<0.002
Lamb/mutton	0	0	0.001	0.002	<0.002	<0.002
Lambs liver	6	0.002	0.003	0.003	<0.002	0.006
Lettuce	0	0	0.001	0.002	<0.002	<0.002
Mandarin	0	0	0.001	0.002	<0.002	<0.002
Meat pie	0	0	0.001	0.002	<0.002	<0.002
Melon	0	0	0.001	0.002	<0.002	<0.002
Milk chocolate	0	0	0.005	0.010	<0.010	<0.010
Milk, 0.5% fat	0	0	0.001	0.001	<0.001	<0.001
Milk, 3.25% fat	0	0	0.001	0.001	<0.001	<0.001
Milk, flavoured	0	0	0.001	0.001	<0.001	<0.001
Mixed berries, frozen	0	0	0.001	0.002	<0.002	<0.002
Mixed vegetables, frozen	0	0	0.001	0.002	<0.002	<0.002
Muesli	0	0	0.005	0.010	<0.010	<0.010
Muffins and scones	0	0	0.005	0.010	<0.010	<0.010
Mushroom	4	0.002	0.002	0.003	<0.002	0.007
Mussels	7	0.015	0.016	0.016	<0.010	0.026
Mussels (MeHg)	3	0.002	0.004	0.005	<0.004	0.009
Nectarine	0	0	0.001	0.002	<0.002	<0.002
Noodle dish	0	0	0.001	0.002	<0.002	<0.002
Noodles, instant	0	0	0.001	0.002	<0.002	<0.002
Oats, rolled	0	0	0.003	0.006	<0.002	<0.010
Oil	0	0	0.005	0.010	<0.010	<0.010
Onion	0	0	0.001	0.002	<0.002	<0.002
Orange juice	0	0	0.001	0.001	<0.001	<0.001
Orange	0	0	0.001	0.002	<0.002	<0.002
Other cereals	0	0	0.005	0.010	<0.010	<0.010
Oyster	7	0.027	0.028	0.028	<0.010	0.056
Oyster (MeHg)	4	0.004	0.005	0.006	<0.004	0.011
Pasta, dried	0	0	0.005	0.010	<0.010	<0.010
Peach, canned	0	0	0.001	0.002	<0.002	<0.002
Peanut butter	0	0	0.005	0.010	<0.010	<0.010
Peanut	0	0	0.005	0.010	<0.010	<0.010
Pear	0	0	0.001	0.002	<0.002	<0.002
Peas, frozen	0	0	0.001	0.002	<0.002	<0.002
Pineapple, canned	0	0	0.001	0.002	<0.002	<0.002
Pizza	0	0	0.001	0.002	<0.002	<0.002
Pork roast	6	0.002	0.003	0.003	<0.002	0.005
Potato crisps	0	0	0.005	0.010	<0.010	<0.010
Potato, hot chips	0	0	0.001	0.002	<0.002	<0.002
Potato, peeled	0	0	0.001	0.002	<0.002	<0.002
Potato, with skin	0	0	0.001	0.002	<0.002	<0.002
Prawn/shrimp	8	0.006	0.006	0.006	0.004	0.012

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Prawn/shrimp (MeHg)	6	0.005	0.006	0.007	<0.004	0.014
Prune	0	0	0.005	0.010	<0.010	<0.010
Pumpkin	0	0	0.001	0.002	<0.002	<0.002
Raisins/sultanas	0	0	0.005	0.010	<0.010	<0.010
Rice dish	0	0	0.001	0.002	<0.002	<0.002
Rice, white	0	0	0.005	0.010	<0.010	<0.010
Salad dressing	0	0	0.005	0.010	<0.010	<0.010
Sausage	1	0.001	0.001	0.002	<0.002	0.003
Silverbeet	0	0	0.001	0.002	<0.002	<0.002
Simmer sauce, bottled	0	0	0.001	0.002	<0.002	<0.002
Snack bar	0	0	0.005	0.010	<0.010	<0.010
Snacks, flavoured	0	0	0.005	0.010	<0.010	<0.010
Soup, vegetable	0	0	0.001	0.001	<0.001	<0.001
Soya milk	0	0	0.001	0.001	<0.001	<0.001
Spaghetti in sauce, canned	0	0	0.001	0.002	<0.002	<0.002
Strawberry	0	0	0.001	0.002	<0.002	<0.002
Sugar	0	0	0.005	0.010	<0.010	<0.010
Sushi	8	0.006	0.006	0.006	0.002	0.015
Sushi (MeHg)	2	0.002	0.004	0.005	<0.004	0.010
Table spread	0	0	0.005	0.010	<0.010	<0.010
Taro	0	0	0.001	0.002	<0.002	<0.002
Tea	0	0	0.001	0.001	<0.001	<0.001
Tofu	0	0	0.001	0.002	<0.002	<0.002
Tomato	0	0	0.001	0.002	<0.002	<0.002
Tomato sauce	0	0	0.001	0.002	<0.002	<0.002
Tomatoes in juice, canned	0	0	0.001	0.002	<0.002	<0.002
Water, bottled	0	0	0.001	0.002	<0.002	<0.002
Water, tap	0	0	0.001	0.001	<0.0001	<0.002
Wheat biscuit cereal	0	0	0.005	0.010	<0.010	<0.010
Wine, still red	0	0	0.001	0.002	<0.001	<0.002
Wine, still white	0	0	0.001	0.001	<0.001	<0.001
Yeast extract	0	0	0.005	0.010	<0.010	<0.010
Yoghurt	0	0	0.001	0.002	<0.002	<0.002

[a] Lower-bound (LB; not detected result = zero), mid-bound (MB; not detected = 50% the LOR) and upper-bound (UB; not detected = 100% LOR) mean concentrations. All mean values rounded to three decimal places.

Appendix 11.6: Tin concentrations (mg/kg) in foods of the 2016 NZTDS

All values rounded to two significant figures; or the nearest 0.001mg/kg for water and nearest 0.01 mg/kg for all other foods.

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Almond	0	0	0.03	0.05	<0.05	<0.05
Apple	0	0	0.01	0.01	<0.01	<0.01
Apple-based juice	0	0	0.01	0.01	<0.01	<0.01
Avocado	0	0	0.02	0.05	<0.05	<0.05
Bacon	0	0.	0.01	0.01	<0.01	<0.01
Baked beans	8	25	25	25	0.29	55
Banana	1	0	0.01	0.01	<0.01	0.01
Beef, mince	1	0	0.01	0.01	<0.01	0.02
Beef, rump	0	0	0.01	0.01	<0.01	<0.01
Beer	0	0	0.01	0.01	<0.01	<0.01
Beetroot, canned	8	1.3	1.3	1.3	0.56	2.3
Biscuit, chocolate	0	0	0.03	0.05	<0.05	<0.05
Biscuit, cracker	0	0	0.03	0.05	<0.05	<0.05
Biscuit, plain sweet	0	0	0.03	0.05	<0.05	<0.05
Bran flake cereal, mixed	0	0	0.03	0.05	<0.05	<0.05
Bread, mixed grain	0	0	0.03	0.05	<0.05	<0.05
Bread, wheatmeal	0	0	0.03	0.05	<0.05	<0.05
Bread, white	0	0	0.03	0.05	<0.05	<0.05
Broccoli/cauliflower	0	0	0.01	0.01	<0.01	<0.01
Butter	0	0	0.03	0.05	<0.05	<0.05
Cabbage	0	0	0.01	0.01	<0.01	<0.01
Caffeinated beverage	0	0	0.01	0.01	<0.01	<0.01
Cakes and slices	0	0	0.03	0.05	<0.05	<0.05
Capsicum	0	0	0.01	0.01	<0.01	<0.01
Carbonated drink	0	0	0.01	0.01	<0.01	<0.01
Carrot	0	0	0.01	0.01	<0.01	<0.01
Celery	0	0	0.01	0.01	<0.01	<0.01
Cheese	0	0	0.02	0.05	<0.05	<0.05
Chicken	0	0	0.01	0.01	<0.01	<0.01
Chicken takeaway	0	0	0.01	0.01	<0.01	<0.01
Chocolate beverage	1	0.01	0.01	0.01	<0.01	0.01
Coconut cream, canned	0	0	0.02	0.05	<0.05	<0.05
Coffee beans, ground	0	0	0.01	0.01	<0.01	<0.01
Coffee, instant	0	0	0.01	0.01	<0.01	<0.01
Confectionery	0	0	0.03	0.05	<0.05	<0.05
Corn, frozen	1	0.01	0.01	0.02	<0.01	0.06
Corned beef	8	2.5	2.5	2.5	0.65	5.2
Cornflakes	0	0	0.03	0.05	<0.05	<0.05
Courgette (zucchini)	0	0	0.01	0.01	<0.01	<0.01
Cucumber	0	0	0.01	0.01	<0.01	<0.01
Dairy dessert	0	0	0.01	0.01	<0.01	<0.01

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Egg	0	0	0.01	0.01	<0.01	<0.01
Fish cakes	0	0	0.01	0.01	<0.01	<0.01
Fish fingers	4	0.01	0.01	0.01	<0.01	0.01
Fish, battered	1	0.01	0.02	0.03	<0.01	0.05
Fish, canned	5	0.02	0.02	0.02	<0.01	0.03
Fish, fresh	1	0.01	0.01	0.01	<0.01	0.02
Fruit drink	0	0	0.01	0.01	<0.01	<0.01
Grape	0	0	0.01	0.01	<0.01	<0.01
Ham	1	0.01	0.01	0.01	<0.01	0.01
Hamburger, plain	2	0.01	0.01	0.01	<0.01	0.01
Honey	0	0	0.03	0.05	<0.05	<0.05
Hummus	2	0.01	0.01	0.01	<0.01	0.01
Ice cream	0	0	0.01	0.01	<0.01	<0.01
Infant/follow-on formula	0	0	0.03	0.05	<0.05	<0.05
Infant weaning food, cereal based	3	18	18	18	<0.01	64
Infant weaning food, custard/fruit dish	5	20	20	20	<0.01	66
Infant weaning food, savoury dish	3	0.03	0.03	0.03	<0.01	0.10
Jam	0	0	0.03	0.05	<0.05	<0.05
Kiwifruit	0	0	0.01	0.01	<0.01	<0.01
Kumara	0	0	0.01	0.01	<0.01	<0.01
Lamb/mutton	0	0	0.01	0.01	<0.01	<0.01
Lambs liver	1	0.01	0.01	0.01	<0.01	0.02
Lettuce	0	0	0.01	0.01	<0.01	<0.01
Mandarins	0	0	0.01	0.01	<0.01	<0.01
Meat pie	6	0.03	0.03	0.03	<0.01	0.08
Melon	0	0	0.01	0.01	<0.01	<0.01
Milk chocolate	0	0	0.03	0.05	<0.05	<0.05
Milk, 0.5% fat	0	0	0.01	0.01	<0.01	<0.01
Milk, 3.25% fat	0	0	0.01	0.01	<0.01	<0.01
Milk, flavoured	1	0.01	0.01	0.01	<0.01	0.01
Mixed berries, frozen	0	0	0.01	0.01	<0.01	<0.01
Mixed vegetables, frozen	0	0	0.01	0.01	<0.01	<0.01
Muesli	0	0	0.03	0.05	<0.05	<0.05
Muffins and scones	1	0.08	0.10	0.12	<0.05	0.62
Mushroom	0	0	0.01	0.01	<0.01	<0.01
Mussels	0	0	0.02	0.04	<0.04	<0.05
Nectarine	0	0	0.01	0.01	<0.01	<0.01
Noodle dish	3	0.01	0.01	0.01	<0.01	0.01
Noodles, instant	0	0	0.01	0.01	<0.01	<0.01
Oats, rolled	1	0.01	0.02	0.03	<0.01	0.05
Oil	0	0	0.02	0.05	<0.05	<0.05
Onion	0	0	0.01	0.01	<0.01	<0.01
Orange juice	0	0	0.01	0.01	<0.01	<0.01

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Orange	0	0	0.01	0.01	<0.01	<0.01
Other cereals	0	0	0.03	0.05	<0.05	<0.05
Oyster	1	0.01	0.03	0.05	<0.05	0.06
Pasta, dried	0	0	0.03	0.05	<0.05	<0.05
Peach, canned	8	52	52	52	29	94
Peanut butter	0	0	0.02	0.05	<0.05	<0.05
Peanut	0	0	0.03	0.05	<0.05	<0.05
Pear	0	0	0.01	0.01	<0.01	<0.01
Peas, frozen	0	0	0.01	0.01	<0.01	<0.01
Pineapple, canned	8	96	96	96	52	162
Pizza	8	4	4	4	0.52	8
Pork roast	0	0	0.01	0.01	<0.01	<0.01
Potato crisps	0	0	0.03	0.05	<0.05	<0.05
Potato, hot chips	0	0	0.01	0.01	<0.01	<0.01
Potato, peeled	0	0	0.01	0.01	<0.01	<0.01
Potato with skin	0	0	0.01	0.01	<0.01	<0.01
Prawn/shrimp	0	0	0.01	0.01	<0.01	<0.01
Prune	0	0	0.03	0.05	<0.05	<0.05
Pumpkin	0	0	0.01	0.01	<0.01	<0.01
Raisins/sultanas	0	0	0.03	0.05	<0.05	<0.05
Rice dish	5	0.27	0.27	0.28	<0.01	2.1
Rice, white	0	0	0.03	0.05	<0.05	<0.05
Salad dressing	0	0	0.02	0.05	<0.05	<0.05
Sausage	3	0.02	0.03	0.03	<0.01	0.09
Silverbeet	0	0	0.01	0.01	<0.01	<0.01
Simmer sauce, bottled	8	0.26	0.26	0.26	0.02	0.72
Snack bar	0	0	0.03	0.05	<0.05	<0.05
Snacks, flavoured	0	0	0.03	0.05	<0.05	<0.05
Soup, vegetable	4	0.05	0.05	0.05	0.01	0.17
Soya milk	0	0	0.01	0.01	<0.01	<0.01
Spaghetti in sauce, canned	8	35	35	35	0.43	74
Strawberry	0	0	0.01	0.01	<0.01	<0.01
Sugar	0	0	0.03	0.05	<0.05	<0.05
Sushi	0	0	0.01	0.01	<0.01	<0.01
Table spread	0	0	0.03	0.05	<0.05	<0.05
Taro	1	0.01	0.01	0.01	<0.01	0.01
Tea	0	0	0.01	0.01	<0.01	<0.01
Tofu	0	0	0.01	0.01	<0.01	<0.01
Tomato	0	0	0.01	0.01	<0.01	<0.01
Tomato sauce	4	0.08	0.08	0.09	<0.01	0.33
Tomatoes in juice, canned	8	47	47	47	2.9	150
Water, bottled	0	0	0.001	0.001	<0.001	<0.001
Water, tap	0	0	0.001	0.001	<0.001	<0.001

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Wheat biscuit cereal	0	0	0.03	0.05	<0.05	<0.05
Wine, still red	2	0.01	0.01	0.01	<0.01	0.02
Wine, still white	2	0.01	0.01	0.01	<0.01	0.01
Yeast extract	2	0.04	0.06	0.07	<0.05	0.21
Yoghurt	0	0	0.01	0.01	<0.01	<0.01

[a] Lower-bound (LB; not detected result = zero), mid-bound (MB; not detected = 50% the LOR) and upper-bound (UB; not detected = 100% LOR) mean concentrations.

Appendix 12: Summary of estimated weekly or monthly dietary exposures to contaminant elements in the 2016 NZTDS

Appendix 12.1: Estimated weekly adult exposures to contaminants present in the µg/kg bw range

Element	HBGV	Weekly mean dietary exposures (µg/kg bw/week and % of HBGV; LB–MB–UB)				
		Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Arsenic (total)	None	11.47–11.73–11.98	12.49–12.71–12.92	12.17–12.44–12.71	13.00–13.26–13.51	12.72–13.03–13.34
Arsenic (inorganic)	None	0.48–0.80–1.13	0.48–0.76–1.04	0.54–0.88–1.22	0.58–0.90–1.22	0.65–1.04–1.43
Lead	None	0.27–0.52–0.76	0.22–0.42–0.62	0.29–0.55–0.81	0.26–0.50–0.74	0.32–0.61–0.91
Mercury (inorganic)[b]	4 µg/kg bw/wk	0.01–0.30–0.58	0.01–0.25–0.48	0.02–0.32–0.62	0.02–0.29–0.56	0.01–0.36–0.70
% PTWI		7%	6%	8%	7%	9%
Mercury (methylmercury)	1.6 µg/kg bw/wk	0.43[a]	0.47[a]	0.42[a]	0.45–0.46–0.46	0.45[a]
% PTWI		27%	30%	26%	28%	28%

[a] Lower-bound (LB), mid-bound (MB) and upper-bound (UB) means all derive the same rounded value.
[b] Excludes any dietary contribution from fish species and 74% of the mercury concentration in oysters and mussels.

Appendix 12.2: Estimated monthly adult mean dietary exposures to contaminants present in the µg/kg bw range

Element	HBGV	Monthly dietary exposure (µg/kg bw/month and % of HBGV; LB–MB–UB)				
		Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Cadmium	25 µg/kg bw/month	5.06–5.16–5.26	4.43–4.51–4.58	6.47–6.58–6.69	5.81–5.90–5.99	6.77–6.88–6.99
% PTMI		21%	18%	26%	24%	28%

Appendix 12.3: Estimated weekly adult mean dietary exposures to contaminants present in the mg/kg bw range

Element	HBGV	Weekly dietary exposures (mg/kg bw/week and % of HBGV; LB–MB–UB)				
		Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Aluminium	2 mg/kg bw/wk	1.44–1.46–1.47	1.12–1.13–1.14	1.50–1.52–1.53	1.32–1.34–1.36	1.71–1.73–1.75
% PTWI		73%	57%	76%	67%	87%
Tin	14 mg/kg bw/wk	0.18[a]	0.12[a]	0.18[a]	0.15[a]	0.18–0.18–0.19
% PTWI		1%	1%	1%	1%	1%

[a] Lower-bound (LB), mid-bound (MB) and upper-bound (UB) means all derive the same rounded value.

Appendix 12.4: Estimated weekly mean dietary infant, child and teenage exposures to contaminants present in the µg/kg bw range

Element	HBGV	Weekly dietary exposures (µg/kg bw/week and % of HBGV; LB–MB–UB)				
		Teenage boys	Teenage girls	Children	Toddlers	Infants
Arsenic (total)	None	10.20–10.58–10.96	5.55–5.86–6.17	9.62–10.25–10.88	10.66–11.45–12.24	9.78–11.98–12.49
Arsenic (inorganic)	None	0.57–1.01–1.44	0.43–0.78–1.14	0.91–1.63–2.35	1.08–1.96–2.84	0.99–3.26–5.54
Lead	None	0.31–0.66–1.02	0.28–0.57–0.86	0.53–1.13–1.73	0.68–1.44–2.19	0.76–2.91–5.05
Mercury (inorganic)[b]	4 µg/kg bw/wk	0.01–0.43–0.86	0.01–0.36–0.72	0.01–0.75–1.50	0.01–0.94–1.88	0.01–2.30–4.60
% PTWI		11%	9%	19%	24%	58%
Mercury (methylmercury)	1.6 µg/kg bw/wk	0.39–0.40–0.40	0.21[a]	0.45[a]	0.49[a]	0.47[a]
% PTWI		25%	13%	28%	31%	30%

[a] Lower-bound (LB), mid-bound (MB) and upper-bound (UB) means all derive the same rounded value.
[b] Excludes any dietary contribution from fish species and 74% of the mercury concentration in oysters and mussels.

Appendix 12.5: Estimated monthly infant, child and teenage exposures to contaminants present in the µg/kg bw range

Element	HBGV	Monthly exposures (µg/kg bw/month and % of HBGV; LB–MB–UB)				
		Teenage boys	Teenage girls	Children	Toddlers	Infants
Cadmium	25 µg/kg bw/month	7.69–7.79–7.89	6.89–6.98–7.07	12.01–12.19–12.38	12.38–12.50–12.82	9.45-11.03-12.61
% PTMI		32%	28%	49%	50%	44%

Appendix 12.6: Estimated weekly infant, child and teenage exposures to contaminants present in the mg/kg bw range

Element	HBGV	Weekly exposures (mg/kg bw/week and % of HBGV; LB–MB–UB)				
		Teenage boys	Teenage girls	Children	Toddlers	Infants
Aluminium	2 mg/kg bw/wk	1.62–1.64–1.66	2.25–2.27–2.28	2.94–2.98–3.01	2.93–2.98–3.03	2.26–2.46–2.65
% PTWI		82%	113%	149%	149%	123%
Tin	14 mg/kg bw/wk	0.18–0.18–0.19	0.15–0.16–0.16	0.42–0.43–0.43	0.65–0.66–0.66	1.29–1.30–1.31
% PTWI		1%	1%	3%	5%	9%

Appendix 13: Nutrient elements – fluoride, iodine, selenium, sodium and zinc in the 2016 NZTDS

Appendix 13.1: Fluoride concentrations (mg/kg) of 2016 NZTDS foods

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Almond	8	5.66	5.66	5.66	2.35	14.18
Apple	0	0	0.12	0.23	<0.21	<0.25
Apple-based juice	3	0.24	0.29	0.35	<0.17	1.03
Avocado	0	0	0.11	0.23	<0.22	<0.24
Banana	0	0	0.12	0.24	<0.20	<0.25
Baked beans	0	0	0.12	0.24	<0.22	<0.25
Beer	8	0.48	0.48	0.48	0.40	0.56
Beetroot, canned	0	0	0.12	0.24	<0.21	<0.25
Biscuit, cracker	0	0	0.57	1.14	<1.00	<1.22
Biscuit, plain sweet	0	0	0.59	1.19	<1.03	<1.25
Bran flake cereal, mixed	0	0	0.58	1.17	<1.09	<1.23
Bread, mixed grain	0	0	0.57	1.15	<1.00	<1.22
Bread, wheatmeal	0	0	0.60	1.20	<1.10	<1.25
Bread, white	0	0	0.58	1.17	<1.11	<1.23
Broccoli/cauliflower	0	0	0.12	0.23	<0.22	<0.25
Cabbage	0	0	0.11	0.23	<0.21	<0.25
Caffeinated beverage	3	0.22	0.28	0.33	<0.17	0.64
Capsicum	0	0	0.11	0.23	<0.21	<0.25
Carbonated drink	1	0.02	0.10	0.18	<0.17	0.18
Carrot	0	0	0.11	0.23	<0.22	<0.25
Celery	0	0	0.11	0.22	<0.20	<0.25
Coconut cream, canned	2	0.10	0.20	0.31	<0.24	0.48
Coffee beans, ground	0	0	0.09	0.17	<0.17	<0.18
Coffee, instant	0	0	0.09	0.17	<0.17	<0.17
Corn, frozen	0	0	0.15	0.30	<0.23	<0.45
Cornflakes	0	0	0.59	1.19	<1.16	<1.22
Courgette (Zucchini)	0	0	0.12	0.23	<0.23	<0.25
Cucumber	0	0	0.11	0.23	<0.20	<0.24
Fruit drink	0	0	0.09	0.17	<0.17	<0.17
Grape	0	0	0.12	0.23	<0.22	<0.24
Kiwifruit	0	0	0.11	0.22	<0.21	<0.23
Kumara	0	0	0.11	0.23	<0.21	<0.25
Lettuce	0	0	0.11	0.23	<0.22	<0.25
Mandarin	0	0	0.12	0.23	<0.22	<0.24
Melon	0	0	0.11	0.22	<0.20	<0.24
Mixed berries, frozen	0	0	0.12	0.24	<0.23	<0.25
Mixed vegetables, frozen	0	0	0.12	0.24	<0.22	<0.25
Muesli	0	0	0.58	1.16	<1.08	<1.21
Mushroom	0	0	0.11	0.23	<0.21	<0.24

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Nectarine	0	0	0.11	0.23	<0.22	<0.24
Noodles, instant	0	0	0.18	0.35	<0.24	<0.50
Oats, rolled	0	0	0.36	0.72	<0.23	<1.23
Onion	0	0	0.11	0.22	<0.20	<0.24
Orange juice	2	0.17	0.23	0.30	<0.17	0.68
Orange	0	0	0.11	0.22	<0.21	<0.23
Other cereals	0	0	0.60	1.21	<1.16	<1.23
Pasta, dried	0	0	0.55	1.09	<1.00	<1.22
Peach, canned	0	0	0.12	0.24	<0.24	<0.25
Pear	0	0	0.12	0.23	<0.22	<0.24
Peas, frozen	0	0	0.17	0.34	<0.23	<0.47
Pineapple, canned	0	0	0.12	0.23	<0.22	<0.24
Potato crisps	0	0	0.60	1.20	<1.15	<1.21
Potato, hot chips	1	0.03	0.31	0.59	<0.24	1.08
Potato, peeled	0	0	0.12	0.24	<0.22	<0.25
Potato with skin	0	0	0.12	0.23	<0.20	<0.24
Prune	0	0	0.56	1.12	<1.00	<1.21
Pumpkin	0	0	0.12	0.24	<0.22	<0.25
Raisins/sultanas	1	0.19	0.63	1.06	<1.00	1.52
Rice, white	0	0	0.54	1.09	<1.00	<1.20
Silverbeet	0	0	0.11	0.23	<0.22	<0.24
Soup, vegetable	1	0.06	0.16	0.26	<0.20	0.48
Soya milk	7	0.82	0.83	0.84	<0.17	1.46
Spaghetti in sauce, canned	0	0	0.12	0.24	<0.23	<0.25
Strawberry	0	0	0.11	0.23	<0.22	<0.24
Taro	0	0	0.15	0.30	<0.23	<0.50
Tea	8	3.97	3.97	3.97	1.12	6.48
Tofu	8	1.07	1.07	1.07	0.64	1.44
Tomato	0	0	0.12	0.24	<0.22	<0.30
Tomato sauce	2	0.07	0.16	0.25	<0.24	0.29
Tomatoes in juice, canned	0	0	0.12	0.24	<0.23	<0.25
Water, bottled	3	0.02	0.05	0.08	<0.05	0.10
Water, tap	8	0.44	0.44	0.44	0.08	0.77
Wheat biscuit cereal	0	0	0.61	1.22	<1.20	<1.23
Wine, still red	4	0.12	0.17	0.21	<0.17	0.34
Wine, still white	7	0.19	0.20	0.21	<0.17	0.31

[a] Lower-bound (LB; not detected result = zero), mid-bound (MB; not detected = 50% the LOR) and upper-bound (UB; not detected = 100% LOR) mean concentrations. All mean values rounded to two decimal places.

Appendix 13.2: Iodine concentrations (mg/kg) of 2016 NZTDS foods

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Almond	0	0	0.005	0.010	<0.010	<0.010
Apple	4	0.003	0.003	0.004	<0.002	0.006
Apple-based juice	7	0.005	0.005	0.005	<0.001	0.012
Avocado	0	0	0.005	0.010	<0.009	<0.010
Bacon	8	0.035	0.035	0.035	0.017	0.076
Baked beans	8	0.008	0.008	0.008	0.004	0.016
Banana	2	0.001	0.001	0.002	<0.002	0.004
Beef, mince	8	0.011	0.011	0.011	0.007	0.021
Beef, rump	8	0.005	0.005	0.005	0.004	0.007
Beer	8	0.004	0.004	0.004	0.003	0.005
Beetroot, canned	8	0.006	0.006	0.006	0.003	0.009
Biscuit, chocolate	7	0.078	0.079	0.079	<0.010	0.168
Biscuit, cracker	2	0.003	0.007	0.011	<0.010	0.014
Biscuit, plain sweet	3	0.008	0.011	0.014	<0.010	0.029
Bran flake cereal, mixed	0	0	0.005	0.010	<0.010	<0.010
Bread, mixed grain	8	0.372	0.372	0.372	0.237	0.543
Bread, wheatmeal	8	0.414	0.414	0.414	0.324	0.537
Bread, white	8	0.388	0.388	0.388	0.247	0.522
Broccoli/cauliflower	0	0	0.001	0.002	<0.002	<0.002
Butter	8	0.020	0.020	0.020	0.013	0.033
Cabbage	1	0.000	0.001	0.002	<0.002	0.002
Caffeinated beverage	2	0.001	0.001	0.002	<0.001	0.004
Cake and slices	8	0.103	0.103	0.103	0.051	0.144
Capsicum	0	0	0.001	0.002	<0.002	<0.002
Carbonated drink	0	0	0.001	0.001	<0.001	<0.001
Carrot	6	0.007	0.007	0.007	<0.002	0.017
Celery	5	0.007	0.007	0.008	<0.002	0.030
Cheese	8	0.044	0.044	0.044	0.032	0.068
Chicken	4	0.004	0.008	0.013	<0.004	0.020
Chicken takeaway	8	0.031	0.031	0.031	0.014	0.058
Chocolate beverage	6	0.019	0.019	0.019	<0.001	0.054
Coconut cream, canned	4	0.020	0.022	0.025	<0.009	0.046
Coffee beans, ground	0	0	0.001	0.001	<0.001	<0.001
Coffee, instant	1	0.001	0.001	0.002	<0.001	0.008
Confectionery	2	0.011	0.015	0.019	<0.010	0.066
Corn, frozen	0	0	0.001	0.002	<0.002	<0.002
Corned beef	8	0.198	0.198	0.198	0.014	0.959
Cornflakes	1	0.002	0.006	0.010	<0.010	0.014
Courgette (zucchini)	4	0.002	0.003	0.003	<0.002	0.009
Cucumber	7	0.006	0.007	0.007	<0.002	0.013
Dairy dessert	8	0.048	0.048	0.048	0.028	0.084
Egg	8	0.544	0.544	0.544	0.450	0.678

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Fish cakes	8	0.052	0.052	0.052	0.016	0.138
Fish fingers	7	0.122	0.122	0.123	<0.010	0.625
Fish, battered	8	0.116	0.116	0.116	0.032	0.265
Fish, canned	8	0.182	0.182	0.182	0.064	0.505
Fish, fresh	8	0.211	0.211	0.211	0.152	0.264
Fruit drink	2	0	0.001	0.001	<0.001	0.002
Grape	7	0.006	0.006	0.007	<0.002	0.015
Ham	8	0.033	0.033	0.033	0.017	0.051
Hamburger, plain	8	0.244	0.244	0.244	0.172	0.293
Honey	0	0	0.005	0.010	<0.010	<0.010
Hummus	4	0.002	0.008	0.014	<0.003	0.040
Ice cream	8	0.064	0.064	0.064	0.043	0.096
Infant/follow-on formula	8	0.132	0.132	0.132	0.122	0.152
Infant weaning food, cereal based	5	0.008	0.010	0.012	<0.002	0.036
Infant weaning food, custard/fruit dish	5	0.038	0.039	0.039	<0.002	0.088
Infant weaning food, savoury dish	5	0.008	0.010	0.011	<0.004	0.020
Jam	0	0	0.005	0.010	<0.010	<0.010
Kiwifruit	0	0	0.001	0.002	<0.002	<0.002
Kumara	4	0.003	0.003	0.004	<0.002	0.009
Lamb/mutton	5	0.294	0.295	0.297	<0.005	2.316
Lambs liver	8	0.052	0.052	0.052	0.041	0.064
Lettuce	1	0.001	0.001	0.002	<0.002	0.002
Mandarin	0	0	0.001	0.002	<0.002	<0.002
Meat pie	8	0.039	0.039	0.039	0.007	0.110
Melon	2	0.001	0.002	0.003	<0.002	0.006
Milk chocolate	8	0.198	0.198	0.198	0.091	0.334
Milk, 0.5% fat	8	0.078	0.078	0.078	0.037	0.128
Milk, 3.25% fat	8	0.078	0.078	0.078	0.040	0.119
Milk, flavoured	8	0.053	0.053	0.053	0.040	0.080
Mixed berries, frozen	0	0	0.001	0.002	<0.002	<0.002
Mixed vegetables, frozen	2	0.001	0.002	0.002	<0.002	0.005
Muesli	4	0.009	0.012	0.014	<0.010	0.030
Muffins and scones	8	0.068	0.068	0.068	0.054	0.096
Mushroom	8	0.003	0.003	0.003	0.002	0.004
Mussels	8	1.858	1.858	1.858	0.886	3.115
Nectarine	0	0	0.001	0.002	<0.002	<0.002
Noodle dish	8	0.056	0.056	0.056	0.004	0.108
Noodles, instant	8	0.254	0.254	0.254	0.207	0.331
Oats, rolled	0	0	0.003	0.006	<0.002	<0.010
Oil	0	0	0.025	0.051	<0.009	<0.093
Onion	8	0.007	0.007	0.007	0.003	0.014
Orange juice	4	0.002	0.002	0.002	<0.001	0.007
Oranges	1	0.001	0.001	0.002	<0.002	0.003

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Other cereals	4	0.030	0.033	0.035	<0.010	0.128
Oyster	8	1.171	1.171	1.171	0.807	1.770
Pasta, dried	2	0.036	0.040	0.043	<0.010	0.145
Peach, canned	5	0.006	0.006	0.007	<0.002	0.012
Peanut butter	3	0.007	0.010	0.013	<0.009	0.022
Peanut	0	0	0.005	0.010	<0.010	<0.010
Pear	1	0.001	0.001	0.002	<0.002	0.003
Peas, frozen	1	0.001	0.001	0.002	<0.002	0.003
Pineapple, canned	6	0.022	0.022	0.022	<0.002	0.060
Pizza	8	0.061	0.061	0.061	0.027	0.087
Pork roast	8	0.006	0.006	0.006	0.004	0.010
Potato crisps	4	0.007	0.009	0.012	<0.010	0.019
Potato, hot chips	3	0.029	0.029	0.030	<0.002	0.220
Potato, peeled	1	0.001	0.001	0.002	<0.002	0.004
Potato, with skin	5	0.004	0.005	0.005	<0.002	0.012
Prawn/shrimp	8	0.066	0.066	0.066	0.039	0.103
Prune	4	0.007	0.009	0.012	<0.010	0.014
Pumpkin	4	0.002	0.003	0.003	<0.002	0.005
Raisins/sultanas	5	0.011	0.013	0.015	<0.010	0.026
Rice dish	8	0.066	0.066	0.066	0.020	0.177
Rice, white	1	0.002	0.006	0.011	<0.010	0.014
Salad dressing	4	0.016	0.018	0.020	<0.009	0.045
Sausage	8	0.178	0.178	0.178	0.050	0.517
Silverbeet	8	0.009	0.009	0.009	0.003	0.026
Simmer sauce, bottled	8	0.016	0.016	0.016	0.011	0.027
Snack bar	8	0.031	0.031	0.031	0.014	0.042
Snacks, flavoured	7	0.234	0.235	0.235	<0.010	0.442
Soup, vegetable	8	0.008	0.008	0.008	0.002	0.014
Soya milk	6	0.042	0.043	0.044	<0.001	0.111
Spaghetti in sauce, canned	8	0.008	0.008	0.008	0.002	0.014
Strawberry	2	0.001	0.001	0.002	<0.002	0.003
Sugar	0	0	0.005	0.010	<0.010	<0.010
Sushi	8	0.294	0.294	0.294	0.178	0.762
Table spread	0	0	0.005	0.010	<0.010	<0.010
Taro	3	0.009	0.010	0.010	<0.002	0.038
Tea	0	0	0.001	0.001	<0.001	<0.001
Tofu	4	0.003	0.005	0.008	<0.002	0.011
Tomato	0	0	0.001	0.002	<0.002	<0.002
Tomato sauce	8	0.014	0.014	0.014	0.002	0.027
Tomatoes in juice, canned	8	0.005	0.005	0.005	0.002	0.006
Water, bottled	4	0.001	0.001	0.001	<0.001	0.002
Water, tap	4	0.003	0.004	0.004	<0.001	0.012
Wheat biscuit cereal	0	0	0.005	0.010	<0.010	<0.010

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Wine, still red	8	0.009	0.009	0.009	0.003	0.015
Wine, still white	7	0.005	0.005	0.005	<0.001	0.010
Yeast extract	8	0.036	0.036	0.036	0.013	0.083
Yoghurt	8	0.047	0.047	0.047	0.029	0.074

[a] Lower-bound (LB; not detected result = zero), mid-bound (MB; not detected = 50% the LOR) and upper-bound (UB; not detected = 100% LOR) mean concentrations. All mean values rounded to three decimal places.

Appendix 13.3: Selenium concentrations (mg/kg) of 2016 NZTDS foods

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Almond	0	0	0.010	0.020	<0.020	<0.020
Apple	0	0	0.002	0.004	<0.004	<0.004
Apple-based juice	0	0	0.001	0.002	<0.002	<0.002
Avocado	0	0	0.010	0.019	<0.019	<0.020
Bacon	8	0.138	0.138	0.138	0.107	0.203
Baked beans	8	0.015	0.015	0.015	0.011	0.021
Banana	5	0.009	0.010	0.011	<0.004	0.034
Beef, mince	8	0.077	0.077	0.077	0.058	0.101
Beef, rump	8	0.113	0.113	0.113	0.064	0.244
Beer	0	0	0.001	0.002	<0.002	<0.002
Beetroot, canned	1	0.001	0.002	0.004	<0.004	0.004
Biscuit, chocolate	2	0.009	0.017	0.024	<0.020	0.042
Biscuit, cracker	3	0.032	0.038	0.044	<0.020	0.109
Biscuit, plain sweet	3	0.014	0.020	0.027	<0.020	0.062
Bran flake cereal, mixed	8	0.090	0.090	0.090	0.066	0.130
Bread, mixed grain	7	0.049	0.050	0.052	<0.020	0.097
Bread, wheatmeal	8	0.065	0.065	0.065	0.022	0.111
Bread, white	6	0.050	0.052	0.055	<0.020	0.096
Broccoli/cauliflower	5	0.008	0.009	0.010	<0.004	0.024
Butter	2	0.005	0.013	0.020	<0.020	0.021
Cabbage	2	0.003	0.005	0.006	<0.004	0.014
Caffeinated beverage	0	0	0.001	0.002	<0.002	<0.002
Cakes and slices	8	0.053	0.053	0.053	0.033	0.079
Capsicum	0	0	0.002	0.004	<0.004	<0.004
Carbonated drink	0	0	0.001	0.002	<0.002	<0.002
Carrot	3	0.003	0.004	0.005	<0.004	0.010
Celery	0	0	0.002	0.004	<0.004	<0.004
Cheese	8	0.095	0.095	0.095	0.090	0.103
Chicken	8	0.254	0.254	0.254	0.241	0.277
Chicken takeaway	8	0.209	0.209	0.209	0.151	0.274
Chocolate beverage	6	0.004	0.004	0.004	<0.002	0.008
Coconut cream, canned	0	0	0.009	0.019	<0.018	<0.020
Coffee beans, ground	0	0	0.001	0.002	<0.002	<0.002

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Coffee, instant	0	0	0.001	0.002	<0.002	<0.002
Confectionery	0	0	0.010	0.020	<0.020	<0.020
Corn, frozen	3	0.005	0.006	0.007	<0.004	0.018
Corned beef	8	0.096	0.096	0.096	0.074	0.161
Cornflakes	5	0.021	0.025	0.029	<0.020	0.040
Courgette (zucchini)	1	0.001	0.003	0.004	<0.004	0.007
Cucumber	0	0	0.002	0.004	<0.004	<0.004
Dairy dessert	8	0.008	0.008	0.008	0.006	0.011
Egg	8	0.272	0.272	0.272	0.249	0.315
Fish cakes	8	0.139	0.139	0.139	0.092	0.208
Fish fingers	8	0.237	0.237	0.237	0.157	0.293
Fish, battered	8	0.299	0.299	0.299	0.192	0.475
Fish, canned	8	0.456	0.456	0.456	0.230	0.782
Fish, fresh	8	0.481	0.481	0.481	0.414	0.592
Fruit drink	0	0	0.001	0.002	<0.002	<0.002
Grape	0	0	0.002	0.004	<0.004	<0.004
Ham	8	0.179	0.179	0.179	0.095	0.296
Hamburger, plain	8	0.084	0.084	0.084	0.048	0.103
Honey	0	0	0.010	0.020	<0.020	<0.020
Hummus	3	0.019	0.032	0.044	<0.004	0.127
Ice cream	6	0.008	0.008	0.009	<0.004	0.017
Infant/follow-on formula	7	0.020	0.021	0.022	<0.020	0.027
Infant weaning food, cereal based	3	0.006	0.011	0.017	<0.004	0.025
Infant weaning food, custard/fruit dish	3	0.002	0.003	0.004	<0.004	0.005
Infant weaning food, savoury dish	2	0.003	0.008	0.013	<0.004	0.019
Jam	0	0	0.010	0.020	<0.020	<0.020
Kiwifruit	2	0.002	0.004	0.005	<0.004	0.016
Kumara	0	0	0.002	0.004	<0.004	<0.004
Lamb/mutton	8	0.057	0.057	0.057	0.031	0.074
Lambs liver	8	0.222	0.222	0.222	0.095	0.380
Lettuce	1	0.001	0.002	0.004	<0.004	0.005
Mandarin	0	0	0.002	0.004	<0.004	<0.004
Meat pie	8	0.058	0.058	0.058	0.046	0.073
Melon	0	0	0.002	0.004	<0.004	<0.004
Milk chocolate	8	0.029	0.029	0.029	0.022	0.040
Milk, 0.5% fat	8	0.010	0.010	0.010	0.007	0.013
Milk, 3.25% fat	8	0.008	0.008	0.008	0.006	0.010
Milk, flavoured	8	0.012	0.012	0.012	0.008	0.014
Mixed berries, frozen	0	0	0.002	0.004	<0.004	<0.004
Mixed vegetables, frozen	3	0.007	0.008	0.009	<0.004	0.037
Muesli	8	0.073	0.073	0.073	0.042	0.113
Muffins and scones	8	0.049	0.049	0.049	0.039	0.072
Mushroom	8	0.337	0.337	0.337	0.249	0.428

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Mussels	8	0.577	0.577	0.577	0.441	0.813
Nectarine	0	0	0.002	0.004	<0.004	<0.004
Noodle dish	8	0.039	0.039	0.039	0.021	0.067
Noodles, instant	8	0.046	0.046	0.046	0.008	0.078
Oats, rolled	4	0.007	0.011	0.015	<0.004	0.028
Oil	0	0	0.051	0.102	<0.019	<0.187
Onion	4	0.008	0.009	0.010	<0.004	0.029
Orange juice	0	0	0.001	0.002	<0.002	<0.002
Orange	0	0	0.002	0.004	<0.004	<0.004
Other cereals	7	0.074	0.075	0.077	<0.020	0.183
Oyster	8	0.487	0.487	0.487	0.334	0.721
Pasta, dried	8	0.103	0.103	0.103	0.027	0.182
Peach, canned	0	0	0.002	0.004	<0.004	<0.004
Peanut butter	7	0.060	0.061	0.063	<0.019	0.140
Peanut	8	0.097	0.097	0.097	0.034	0.135
Pear	0	0	0.002	0.004	<0.004	<0.004
Peas, frozen	3	0.002	0.004	0.005	<0.004	0.009
Pineapple, canned	0	0	0.002	0.004	<0.004	<0.004
Pizza	8	0.070	0.070	0.070	0.032	0.100
Pork roast	8	0.177	0.177	0.177	0.162	0.193
Potato crisps	0	0	0.010	0.020	<0.020	<0.020
Potato, hot chips	2	0.002	0.003	0.005	<0.004	0.008
Potato, peeled	4	0.003	0.004	0.005	<0.004	0.012
Potato with skin	3	0.005	0.006	0.007	<0.004	0.022
Prawn/shrimp	8	0.237	0.237	0.237	0.177	0.335
Prune	0	0	0.010	0.020	<0.020	<0.020
Pumpkin	2	0.001	0.003	0.004	<0.004	0.006
Raisins/sultanas	0	0	0.010	0.020	<0.020	<0.020
Rice dish	8	0.068	0.068	0.068	0.032	0.098
Rice, white	0	0	0.010	0.020	<0.020	<0.020
Salad dressing	3	0.019	0.025	0.031	<0.019	0.073
Sausage	8	0.091	0.091	0.091	0.051	0.112
Silverbeet	4	0.012	0.013	0.014	<0.004	0.048
Simmer sauce, bottled	7	0.017	0.018	0.018	<0.004	0.032
Snack bar	5	0.031	0.035	0.039	<0.020	0.100
Snacks, flavoured	7	0.028	0.030	0.031	<0.020	0.056
Soup, vegetable	4	0.003	0.004	0.005	<0.002	0.009
Soya milk	5	0.007	0.010	0.014	<0.005	0.020
Spaghetti in sauce, canned	8	0.008	0.008	0.008	0.005	0.015
Strawberry	0	0	0.002	0.004	<0.004	<0.004
Sugar	0	0	0.010	0.020	<0.020	<0.020
Sushi	8	0.068	0.068	0.068	0.056	0.078
Table spread	0	0	0.010	0.020	<0.020	<0.020

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Taro	1	0.001	0.002	0.004	<0.004	0.004
Tea	0	0.000	0.001	0.002	<0.002	<0.002
Tofu	8	0.062	0.062	0.062	0.029	0.153
Tomato	0	0	0.002	0.004	<0.004	<0.004
Tomato sauce	1	0.003	0.005	0.007	<0.004	0.025
Tomatoes in juice, canned	2	0.001	0.003	0.004	<0.004	0.007
Water, bottled	0	0	0.001	0.001	<0.001	<0.001
Water, tap	0	0	0.001	0.001	<0.001	<0.001
Wheat biscuit cereal	8	0.166	0.166	0.166	0.086	0.226
Wine, still red	0	0	0.001	0.002	<0.002	<0.002
Wine, still white	1	0.001	0.001	0.002	<0.002	0.002
Yeast extract	6	0.077	0.080	0.082	<0.019	0.189
Yoghurt	8	0.010	0.010	0.010	0.007	0.013

[a] Lower-bound (LB; not detected result = zero), mid-bound (MB; not detected = 50% the LOR) and upper-bound (UB; not detected = 100% LOR) mean concentrations. All mean values rounded to three decimal places.

Appendix 13.4: Sodium concentrations (mg/kg) in 2016 NZTDS foods

All values are rounded to two significant figures.

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Almond	0	0	25	50	<50	<50
Apple	5	9	11	13	<10	18
Apple-based juice	7	50	51	51	<5	150
Avocado	8	150	150	150	97	230
Bacon	8	16,000	16,000	16,000	15,000	18,000
Baked beans	8	4300	4300	4300	3000	4900
Banana	0	0	5	10	<10	<10
Beef, mince	8	820	820	820	740	880
Beef, rump	8	600	600	600	550	650
Beer	8	19	19	19	14	24
Beetroot, canned	8	2400	2400	2400	2000	3200
Biscuit, chocolate	8	2200	2200	2200	880	3800
Biscuit, cracker	8	6900	6900	6900	3500	9500
Biscuit, plain sweet	8	3900	3900	3900	3300	4500
Bran flake cereal, mixed	8	2800	2800	2800	1800	3700
Bread, mixed grain	8	4200	4200	4200	4000	4600
Bread, wheatmeal	8	4100	4100	4100	3900	4300
Bread, white	8	4400	4400	4400	4400	4600
Broccoli/cauliflower	8	35	35	35	17	53
Butter	8	5300	5300	5300	5000	5600
Cabbage	8	49	49	49	31	75
Caffeinated beverage	8	550	550	550	140	1300
Cakes and slices	8	2800	2800	2800	2300	3600

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Capsicum	0	0	5	10	<10	<10
Carbonated drink	8	47	47	47	9	97
Carrot	8	610	610	610	270	1100
Celery	8	360	360	360	160	870
Cheese	8	6700	6700	6700	6100	7200
Chicken	8	570	570	570	410	860
Chicken takeaway	8	5300	5300	5300	2900	7200
Chocolate beverage	6	140	140	140	<5	430
Coconut cream, canned	8	160	160	160	120	290
Coffee beans, ground	0	0	3	5	<5	<5
Coffee, instant	1	18	20	23	<5	145
Confectionery	7	230	230	230	50	450
Corn, frozen	1	1	6	10	<10	12
Corned beef	8	6900	6900	6900	5900	7700
Cornflakes	8	5200	5200	5200	4100	6300
Courgette (zucchini)	0	0	5	10	<10	<10
Cucumber	8	24	24	24	16	47
Dairy dessert	8	490	490	490	380	570
Egg	8	1400	1400	1400	1300	1500
Fish cakes	8	5000	5000	5000	2400	7800
Fish fingers	8	3900	3900	3900	2400	5800
Fish, battered	8	1800	1800	1800	1300	3000
Fish, canned	8	3600	3600	3600	2300	4800
Fish, fresh	8	810	810	810	710	1000
Fruit drink	8	98	98	98	7	170
Grape	6	24	25	27	<10	50
Ham	8	12,000	12,000	12,000	9200	15,000
Hamburger, plain	8	4400	4400	4400	3400	5000
Honey	5	45	54	64	<50	100
Hummus	8	4500	4500	4500	3700	5400
Ice cream	8	470	470	470	350	560
Infant/follow-on formula	8	250	250	250	210	310
Infant weaning food, cereal based	8	68	68	68	20	170
Infant weaning food, custard/fruit dish	7	81	82	83	<10	170
Infant weaning food, savoury dish	8	110	110	110	72	160
Jam	3	80	96	110	<50	270
Kiwifruit	4	9	12	14	<10	24
Kumara	8	430	430	430	120	860
Lamb/mutton	8	730	730	730	580	840
Lambs liver	8	870	870	870	750	1000
Lettuce	7	20	20	21	<10	51
Mandarin	5	10	12	14	<10	25
Meat pie	8	4700	4700	4700	3900	5300

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Melon	8	90	90	90	42	150
Milk chocolate	8	660	660	660	570	780
Milk, 0.5% fat	8	360	360	360	320	400
Milk, 3.25% fat	8	350	350	350	310	390
Milk, flavoured	8	360	360	360	310	420
Mixed berries, frozen	0	0	5	10	<10	<10
Mixed vegetables, frozen	8	120	120	120	73	220
Muesli	7	690	690	700	<50	1800
Muffins and scones	8	5200	5200	5200	4600	5800
Mushroom	8	62	62	62	39	83
Mussels	8	4500	4500	4500	2700	7700
Nectarine	0	0	5	10	<10	<10
Noodle dish	8	4200	4200	4200	2100	5600
Noodles, instant	8	4700	4700	4700	3700	5700
Oats, rolled	0	0	15	30	<10	<50
Oil	0	0	24	49	<48	<50
Onion	8	38	38	38	18	85
Orange juice	8	11	11	11	5	14
Orange	1	1	6	10	<10	11
Other cereals	8	3300	3300	3300	1100	5400
Oyster	8	4900	4900	4900	4300	5400
Pasta, dried	2	25	43	62	<50	99
Peach, canned	8	35	35	35	16	47
Peanut butter	8	4100	4100	4100	1900	5800
Peanut	6	2900	2900	2900	<50	5100
Pear	3	5	8	11	<10	14
Peas, frozen	2	4	7	11	<10	17
Pineapple, canned	4	22	24	27	<10	80
Pizza	8	4800	4800	4800	4400	5200
Pork roast	8	640	640	640	490	900
Potato crisps	8	6200	6200	6200	4500	8300
Potato, hot chips	8	2100	2100	2100	1400	3700
Potato, peeled	2	3	7	10	<10	11
Potato, with skin	5	10	12	14	<10	20
Prawn/shrimp	8	5600	5600	5600	3600	7000
Prune	0	0	25	50	<50	<50
Pumpkin	1	2	6	10	<10	12
Raisins/sultanas	7	93	96	99	<50	190
Rice dish	8	3600	3600	3600	2,000	4500
Rice, white	0	0	25	50	<50	<50
Salad dressing	8	7000	7000	7000	4200	8600
Sausage	8	9200	9200	9300	8200	9900
Silverbeet	8	440	440	440	220	600

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Simmer sauce, bottled	8	4400	4400	4400	3600	5800
Snack bar	8	1100	1100	1100	590	2100
Snacks, flavoured	8	6600	6600	6600	4700	11,000
Soup, vegetable	8	2300	2300	2300	1600	3000
Soya milk	8	380	380	380	280	600
Spaghetti in sauce, canned	8	3800	3800	3800	1600	4700
Strawberry	2	4	8	11	<10	19
Sugar	0	0	25	50	<50	<50
Sushi	8	4500	4500	4500	3400	6500
Table spread	8	3600	3600	3600	2900	5600
Taro	2	4	8	12	<10	22
Tea	0	0	3	5	<5	<5
Tofu	8	660	660	660	11	3300
Tomato	8	20	20	20	12	34
Tomato sauce	8	7300	7300	7300	4900	10,000
Tomatoes in juice, canned	8	520	520	520	26	2300
Water, bottled	8	10	10	10	0	23
Water, tap	8	9	9	9	4	16
Wheat biscuit cereal	8	2700	2700	2700	2400	2900
Wine, still red	8	30	30	30	22	44
Wine, still white	8	26	26	26	14	41
Yeast extract	8	40,000	40,000	40,000	34,000	49,000
Yoghurt	8	320	320	320	250	370

[a] Lower-bound (LB; not detected result = zero), mid-bound (MB; not detected = 50% the LOR) and upper-bound (UB; not detected = 100% LOR) mean concentrations.

Appendix 13.5: Zinc concentrations (mg/kg) in 2016 NZTDS foods

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Almond	8	33.6	33.6	33.6	29.0	38.7
Apple	8	0.3	0.3	0.3	0.3	0.4
Apple-based juice	6	0.1	0.1	0.1	0.1	0.2
Avocado	8	5.5	5.5	5.5	4.9	6.5
Bacon	8	21.1	21.1	21.1	18.9	22.1
Baked beans	8	5.3	5.3	5.3	4.4	6.5
Banana	8	1.8	1.8	1.8	1.5	2.1
Beef, mince	8	76.6	76.6	76.6	72.1	89.6
Beef, rump	8	61.4	61.4	61.4	55.3	68.0
Beer	0	0	0.1	0.1	<0.1	<0.1
Beetroot, canned	8	2.4	2.4	2.4	1.9	3.4
Biscuit, chocolate	8	6.3	6.3	6.3	5.3	7.7
Biscuit, cracker	8	9.9	9.9	9.9	3.9	19.2

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Biscuit, plain sweet	8	4.8	4.8	4.8	4.1	5.8
Bran flake cereal, mixed	8	36.9	36.9	36.9	21.4	64.3
Bread, mixed grain	8	9.6	9.6	9.6	8.2	11.0
Bread, wheatmeal	8	12.4	12.4	12.4	10.4	13.8
Bread, white	8	7.5	7.5	7.5	6.9	8.1
Broccoli/cauliflower	8	2.0	2.0	2.0	1.5	2.4
Butter	0	0	0.5	1.0	<1.0	<1.0
Cabbage	8	1.8	1.8	1.8	1.1	2.6
Caffeinated beverage	0	0	0.1	0.1	<0.1	<0.1
Cakes and slices	8	4.7	4.7	4.7	3.8	7.0
Capsicum	8	1.7	1.7	1.7	1.1	2.6
Carbonated drink	0	0	0.1	0.1	<0.1	<0.1
Carrot	8	1.9	1.9	1.9	1.4	2.3
Celery	8	0.8	0.8	0.8	0.5	1.4
Cheese	8	35.5	35.5	35.5	31.1	40.2
Chicken	8	10.6	10.6	10.6	8.4	12.3
Chicken takeaway	8	14.0	14.0	14.0	10.5	17.7
Chocolate beverage	8	2.6	2.6	2.6	1.4	4.5
Coconut cream, canned	7	1.4	1.4	1.5	<1.0	2.5
Coffee beans, ground	0	0	0.1	0.1	<0.1	<0.1
Coffee, instant	1	0.1	0.1	0.1	<0.1	0.2
Confectionery	0	0	0.5	1.0	<1.0	<1.0
Corn, frozen	8	4.7	4.7	4.7	4.1	5.4
Corned beef	8	43.2	43.2	43.2	33.5	48.2
Cornflakes	8	14.7	14.7	14.7	2.0	51.0
Courgette (zucchini)	8	3.9	3.9	3.9	3.0	5.0
Cucumber	8	1.0	1.0	1.0	0.6	1.3
Dairy dessert	8	4.1	4.1	4.1	3.4	5.0
Egg	8	13.8	13.8	13.8	12.0	17.2
Fish cakes	8	4.7	4.7	4.7	3.4	6.3
Fish fingers	8	4.0	4.0	4.0	3.0	5.2
Fish, battered	8	3.6	3.6	3.6	2.6	4.9
Fish, canned	8	7.6	7.6	7.6	6.0	8.9
Fish, fresh	8	4.0	4.0	4.0	3.5	5.1
Fruit drink	1	0.1	0.1	0.1	<0.1	0.1
Grape	8	0.6	0.6	0.6	0.4	0.8
Ham	8	15.3	15.3	15.3	13.2	17.0
Hamburger, plain	8	24.0	24.0	24.0	20.4	31.4
Honey	3	0.5	0.8	1.1	<1.0	1.4
Hummus	8	9.9	9.9	9.9	5.8	12.8
Ice cream	8	3.4	3.4	3.4	1.2	5.4
Infant/follow-on formula	8	5.7	5.7	5.7	4.6	6.7
Infant weaning food, cereal based	8	2.4	2.4	2.4	0.9	4.4

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Infant weaning food, custard/fruit dish	8	1.1	1.1	1.1	0.3	1.7
Infant weaning food, savoury dish	8	3.4	3.4	3.4	1.0	5.3
Jam	1	0.1	0.6	1.0	<1.0	1.0
Kiwifruit	8	1.2	1.2	1.2	0.9	1.7
Kumara	8	4.9	4.9	4.9	4.1	5.5
Lamb/mutton	8	56.1	56.1	56.1	48.4	66.8
Lambs liver	8	63.3	63.3	63.3	53.9	83.7
Lettuce	8	1.5	1.5	1.5	0.6	2.9
Mandarin	8	0.9	0.9	0.9	0.6	1.4
Meat pie	8	15.6	15.6	15.6	12.9	21.7
Melon	8	1.0	1.0	1.0	0.6	1.5
Milk chocolate	8	12.8	12.8	12.8	8.8	16.5
Milk, 0.5% fat	8	3.8	3.8	3.8	3.5	4.2
Milk, 3.25% fat	8	3.3	3.3	3.3	3.1	3.7
Milk, flavoured	8	4.6	4.6	4.6	4.2	5.0
Mixed berries, frozen	8	1.7	1.7	1.7	1.3	2.1
Mixed vegetables, frozen	8	3.9	3.9	3.9	2.1	5.5
Muesli	8	21.6	21.6	21.6	17.9	25.8
Muffins and scones	8	7.4	7.4	7.4	5.2	8.5
Mushroom	8	8.4	8.4	8.4	6.3	10.1
Mussels	8	15.0	15.0	15.0	10.2	21.5
Nectarine	8	1.4	1.4	1.4	1.2	1.6
Noodle dish	8	6.4	6.4	6.4	2.8	9.1
Noodles, instant	8	11.4	11.4	11.4	1.1	22.0
Oats, rolled	8	4.9	4.9	4.9	3.7	5.6
Oil	0	0	0.5	1.0	<1.0	<1.0
Onion	8	2.5	2.5	2.5	2.0	3.5
Orange juice	8	0.3	0.3	0.3	0.2	0.3
Orange	8	0.7	0.7	0.7	0.5	1.2
Other cereals	8	38.0	38.0	38.0	9.6	92.9
Oyster	8	147.4	147.4	147.4	56.2	299.7
Pasta, dried	8	6.0	6.0	6.0	3.1	9.6
Peach, canned	8	0.5	0.5	0.5	0.5	0.6
Peanut butter	8	27.4	27.4	27.4	21.8	30.1
Peanut	8	29.7	29.7	29.7	26.0	34.3
Pear	8	1.0	1.0	1.0	0.9	1.3
Peas, frozen	8	8.1	8.1	8.1	6.6	11.1
Pineapple, canned	8	0.8	0.8	0.8	0.4	1.3
Pizza	8	12.0	12.0	12.0	10.8	14.2
Pork roast	8	30.4	30.4	30.4	23.1	42.3
Potato crisps	8	11.8	11.8	11.8	9.6	14.2
Potato, hot chips	8	4.9	4.9	4.9	4.3	5.2
Potato, peeled	8	2.1	2.1	2.1	1.4	2.4

Food	No of samples >LOR	Mean concentration (mg/kg)[a]			Minimum (mg/kg)	Maximum (mg/kg)
		LB	MB	UB		
Potato, with skin	8	3.4	3.4	3.4	2.4	4.2
Prawn/shrimp	8	6.8	6.8	6.8	5.1	8.8
Prune	8	4.3	4.3	4.3	3.8	5.6
Pumpkin	8	4.2	4.2	4.2	1.8	5.9
Raisins/sultanas	7	1.4	1.4	1.5	<1.0	3.1
Rice dish	8	9.4	9.4	9.4	6.5	13.2
Rice, white	8	5.3	5.3	5.3	4.3	6.3
Salad dressing	2	0.4	0.7	1.1	<1.0	1.6
Sausages	8	18.2	18.2	18.2	13.3	23.2
Silverbeet	8	2.0	2.0	2.0	1.2	3.1
Simmer sauce, bottled	8	2.1	2.1	2.1	1.9	2.3
Snack bar	8	12.2	12.2	12.2	10.6	14.4
Snacks, flavoured	8	6.1	6.1	6.1	1.4	16.1
Soup, vegetable	8	1.8	1.8	1.8	0.2	3.4
Soya milk	8	1.5	1.5	1.5	0.9	2.8
Spaghetti in sauce, canned	8	2.3	2.3	2.3	1.3	5.3
Strawberry	8	1.6	1.6	1.6	1.2	2.1
Sugar	0	0	0.5	1.0	<1.0	<1.0
Sushi	8	6.2	6.2	6.2	5.3	7.0
Table spread	0	0.0	0.5	1.0	<1.0	<1.0
Taro	8	19.9	19.9	19.9	9.2	30.4
Tea	6	0.1	0.1	0.1	<0.1	0.2
Tofu	8	11.4	11.4	11.4	9.5	16.2
Tomato	8	1.3	1.3	1.3	1.0	1.7
Tomato sauce	8	1.4	1.4	1.4	0.7	1.7
Tomatoes in juice, canned	8	1.1	1.1	1.1	0.8	1.2
Water, bottled	7	0.01	0.01	0.01	<0.001	0.02
Water, tap	8	0.02	0.02	0.02	0.01	0.04
Wheat biscuit cereal	8	18.3	18.3	18.3	15.4	22.6
Wine, still red	8	0.8	0.8	0.8	0.6	1.3
Wine, still white	8	0.8	0.8	0.8	0.3	1.2
Yeast extract	8	52.6	52.6	52.6	29.5	81.3
Yoghurt	8	4.3	4.3	4.3	3.8	4.7

[a] Lower-bound (LB; not detected result = zero), mid-bound (MB; not detected = 50% the LOR) and upper-bound (UB; not detected = 100% LOR) mean concentrations. Mean values are rounded to one decimal place.

Appendix 14: Daily mean dietary intake of nutrient elements for each population cohort in the 2016 NZTDS

Appendix 14.1: Daily dietary intakes for nutrients in the range of µg/day for adult population cohorts

Element	Nutrient dietary intakes (µg/day; and % NRVs; LB–MB–UB)				
	Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Iodine (unadjusted)[a]	100–102–104	111–113–115	133–136–138	146–148–151	153–155–157
Iodine (adjusted)[b]	98–100–101	106–108–110	130–133–135	137–140–142	131–133–134
% of EAR (EAR in µg /day)[c]	100% (100)	108% (100)	133% (100)	140% (100)	133% (100)
% of UL (UL in µg /day)[c]	9% (1100)	10% (1100)	12% (1100)	13% (1100)	12% (1100)
Selenium	65–68–72	79–82–86	79–83–88	104–109–113	93–97–101
% of EAR (EAR in µg /day)	136% (50)	164% (50)	138% (60)	182% (60)	162% (60)
% of UL (UL in µg /day)	17% (400)	21% (400)	21% (400)	27% (400)	24% (400)

[a] Includes iodine result of 2.32mg/kg detected in a single sample of lamb/mutton.
[b] Excludes iodine result of 2.32 mg/kg detected in a single sample of lamb/mutton.
[c] Comparison to EAR and UL for Iodine is made with the mid-bound mean intake value that excludes the iodine result of 2.32 mg/kg detected in a single sample of lamb/mutton.

Appendix 14.2: Daily dietary intakes for nutrients in the range of mg/day for adult population cohorts

Element	Nutrient dietary intakes (mg/day and % NRVs; LB–MB–UB)				
	Adult females	Adult females of Pacific Island ethnicity	Adult males	Adult males of Pacific Island ethnicity	Young adult males
Fluoride	1.8–2.0–2.2	1.0–1.2–1.4	1.6–1.9–2.2	1.1–1.3–1.6	0.5–0.8–1.1
% of AI (AI in mg /day)	67% (3)	40% (3)	48% (4)	33% (4)	20% (4)
% of UL (UL in mg /day)	20% (10)	12% (10)	19% (10)	13% (10)	8% (10)
Sodium	2062–2068–2073	2381–2385–2390	2893–2899–2905	3033–3039–3045	3466–3470–3475
% of AI (AI in mg /day)	225–450% (460–920)	259–518% (460–920)	315–630% (460–920)	330–661% (460–920)	377–754% (460–920)
% of SDT (2017) (SDT in mg /day)	103% (2000)	119% (2000)	145% (2000)	152% (2000)	174% (2000)
% of UL (pre-2017) (UL in mg /day)	90% (2300)	104% (2300)	126% (2300)	132% (2300)	151% (2300)
Zinc	9.2–9.3–9.4	11.4–11.5–11.5	12.6–12.7–12.8	15.2–15.3–15.4	13.8–13.9–14.0
% of EAR (EAR in mg /day)	143% (6.5)	177% (6.5)	106% (12)	128% (12)	116% (12)
% of UL (UL in mg /day)	23% (40)	29% (40)	32% (40)	38% (40)	34% (40)

Appendix 14.3: Daily intakes for nutrients in the range of µg/day for infant, child and teenage population cohorts

Element	Nutrient dietary intakes (µg/day and % NRVs; LB–MB–UB)				
	Teenage boys	Teenage girls	Children	Toddlers	Infants
Iodine (unadjusted)[a]	133–135–136	108–110–111	95–96–97	70–71–71	83–84–84
Iodine (adjusted)[b]	131–133–134	107–108–109	94–95–96	69–70–71	83–83–84
% of EAR (EAR in µg /day)[c]	177% (75)	144% (75)	146% (65)	108% (65)	76% (110)[d]
% of UL (UL in µg /day)[c]	22% (600)	18% (600)	32% (300)	35% (200)	Not established
Selenium	69–72–75	51–54–56	40–42–44	26–28–29	23–24–26
% of EAR (EAR in µg /day)	180% (40)	135% (40)	168% (25)	140% (20)	160% (15)[d]
% of UL (UL in µg /day)	26% (280)	19% (280)	28% (150)	31% (90)	40% (60)

[a] Includes iodine result of 2.32mg/kg detected in a single sample of lamb/mutton.
[b] Excludes iodine result of 2.32mg/kg detected in a single sample of lamb/mutton.
[c] Comparison to EAR and UL for Iodine is made with the mid-bound mean intake value that excludes the iodine result of 2.32mg/kg detected in a single sample of lamb/mutton.
[d] EAR values have not been set for iodine and selenium in Infants <12 months, AI values are used for reference instead.

Appendix 14.4: Daily intakes for nutrients in the range of mg/day for infant, child and teenage population cohorts

Element	Nutrient dietary intakes (mg/day and % NRV ; LB-MB-UB)				
	Teenage boys	Teenage girls	Children	Toddlers	Infants
Fluoride	0.2–0.5–0.7	0.2–0.4–0.6	0.2–0.4–0.6	0.11–0.22–0.33	0.06–0.12–0.18
% of AI (AI in mg /day)	25% (2.0)	20% (2.0)	40% (1.0)	31% (0.7)	24% (0.5)
% of UL (UL in mg /day)	5% (10.0)	4% (10.0)	18% (2.2)	17% (1.3)	13% (0.9)
Sodium	2875–2877–2880	2417–2419–2421	1918–1920–1922	1360–1361–1362	841–842–842
% of AI (AI in mg /day)	360–719% (400–800)	302–603% (400–800)	320–640% (300–600)	340–681% (200–400)	495% (170)
% of UL (UL in mg /day)	144% (2000)	121% (2000)	137% (1400)	136% (1000)	Not established
Zinc	12.5–12.5–12.6	9.9–10.0–10.0	7.9–8.0–8.0	6.4[a]	5.7–5.8–5.8
% of EAR (EAR in mg /day)	250% (5)	200% (5)	267% (3)	256% (2.5)	232% (2.5)
% of UL (UL in mg /day)	50% (25)	40% (25)	67% (12)	91% (7)	116% (5)

[a] Lower-bound (LB), mid-bound (MB) and upper-bound (UB) means all derive the same rounded value.

Appendix 15: Glossary of terms, abbreviations and acronyms

AF Adult Female (25 years and above), general population

AF(P) Adult Female (15 years and above), Pacific Island ethnicity

AM Adult Male (25 years and above), general population

AM(P) Adult Male (15 years and above), Pacific Island ethnicity

ATDS 23rd Australian Total Diet Study (2008)

24th Australian Total Diet Study – Phase 1 (2011)

Benchmark Dose

The dose of a substance which corresponds with a particular level or rate of physiological response. It is derived by modelling the dose-response curve in a range of relevant observable data, and then using that model to estimate a dose that corresponds to a particular level of response. The Benchmark Dose Lower Confidence Level ($BMDL_{5}$) refers to the dose that corresponds with a 5% response rate for a particular physiological response.

BTDS Brazilian Total Diet Study

bw body weight

C Child (5–6 years), general population

FITDS French Infant Total Diet Study (2011–2014)

FTDS Second French Total Diet Study (2006–2010)

HBGV Health Based Guidance Value – A numerical value derived by dividing a point of departure (a NOAEL, BMD or BMDL) by a composite uncertainty factor to determine a level that can be ingested over a defined time period (e.g. lifetime or 24 h) without appreciable health risk. (FAO/WHO, 2009). May include:

- **ADI – Acceptable Daily Intake:** The estimate of the amount of a substance in food or drinking-water, expressed on a body weight basis, which can be ingested daily over a life time without appreciable health risk to the consumer. The ADI is expressed in milligrams of the chemical per kilogram of body weight.
- **$PDE_{(food)}$ – Potential Daily Exposure through Food:** The estimate of the amount of a hazardous substance in food, expressed on a body weight basis, which can be ingested daily over a life-time without appreciable health risk to the consumer. The $PDE_{(food)}$ is expressed in milligrams of the chemical per kilogram of body weight.
- **PTDI – Provisional Tolerable Daily Intake:** The permissible human daily exposures to food contaminants unavoidably associated with the consumption of otherwise wholesome and nutritious food. The tolerable intake is referred to as 'provisional' as there is often a lack of data on the consequences of human exposure at low levels and new data may result in changes to the tolerable intake.
- **PTMI – Provisional Tolerable Monthly Intake:** The permissible human monthly exposures to food contaminants unavoidably associated with the consumption of otherwise wholesome and nutritious food. The tolerable intake is referred to as 'provisional' as there is often a lack of data on the consequences of human exposure at low levels and new data may result in changes to the tolerable intake.
- **PTWI – Provisional Tolerable Weekly Intake:** The permissible human weekly exposures to food contaminants unavoidably associated with the consumption of otherwise wholesome and nutritious food. The tolerable intake is referred to as 'provisional' as there is often a lack of data on the consequences of human exposure at low levels and new data may result in changes to the tolerable intake.
- **TDI – Tolerable Daily Intake:** The estimate of the amount of contaminant in food or drinking-water, expressed on a body weight basis, which can be ingested daily over a life-time without appreciable health risk to the consumer. The TDI is expressed in milligrams of the chemical per kilogram of body weight.

HKTDS First Hong Kong Total Diet Study (2010/2011)

I Infant (6–12 months), general population.

ITDS Irish Total Diet Study (2012/14)

kg kilogram

LB Lower-bound: Substitution method used to manage not detected results when assessing mean food concentrations. The lower-bound is obtained by assigning zero to all samples with non-detect results.

LOAEL Lowest Observed Adverse Effect Level: The lowest dose level of a substance that produces adverse effects in the most sensitive test species.

LOR Limit of Reporting: The lowest concentration level that the laboratory reports analytical results.

MB Mid-bound: Substitution method used to manage non detected results when assessing mean food concentrations. The mid-bound is obtained by assigning half the LOR to all samples with non-detect results.

mg milligram

MOE Margin of Exposure: The ratio of the no observed adverse effect level (NOAEL) or benchmark dose lower confidence limit (BMDL) for the critical effect to the theoretical, predicted or estimated exposure. The calculation usually involves a reference point value (also called a point of departure) derived from the hazard assessment that is then divided by an estimate of human dietary exposure to give a dimensionless ratio that is the MOE.

NOAEL No observed adverse effect level: The highest dose level of a substance that produces no adverse effects in the most sensitive test species.

- **NRV – Nutrient Reference Value:** A set of nutritional recommendations, based on current scientific knowledge, used to assess the health status of populations and individuals (DOH/MOH, 2017). May include:
  - **AI – Adequate Intake:** The average daily nutrient intake level based on observed or experimentally-determined approximations or estimates of nutrient intake by group (or groups) of apparently healthy people that are assumed to be adequate (used when an EAR cannot be determined).
  - **EAR – Estimated Average Requirement:** A daily nutrient level estimated to meet the requirements of half the healthy individuals in a particular life stage and gender group.
  - **SDT – Suggested Dietary Target:** A daily average intake from food and beverages for certain nutrients that may help in the prevention of chronic disease.
  - **UL – Upper Level of Intake:** The highest average daily nutrient intake level likely to pose no adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects increases.

NZTDS New Zealand Total Diet Study/Survey

T Toddler (1–3 years), general population

TB Teenage Boy (11–14 years), general population

TG Teenage Girl (11–14 years), general population

UB Upper-bound: Substitution method used to manage not detected results when assessing mean food concentrations. An upper-bound is estimated by assigning the LOR to all samples with non-detect results

YM Young Adult Male (19–24 years), general population

µg microgram