

Radiation Doses from the Average Australian Diet

Technical Report 181

October 2019

Sandra Sdraulig, Blake Orr, David Urban and Rick Tinker

|  |
| --- |
| © Commonwealth of Australia 2019  This publication is protected by copyright. Copyright (and any other intellectual property rights, if any) in this publication is owned by the Commonwealth of Australia as represented by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA).  ISSN 0157-1400    **Creative Commons**  With the exception of the Commonwealth Coat of Arms, any ARPANSA logos and any content that is marked as being third party material, this publication, *Radiation Doses from the Average Australian Diet*, by the Australian Radiation Protection and Nuclear Safety Agency is licensed under a Creative Commons Attribution 3.0 Australia licence (to view a copy of the licence, visit [*http://creativecommons.org/licenses/by/3.0/au*](http://creativecommons.org/licenses/by/3.0/au)). It is a further condition of the licence that any numerical data referred to in this publication may not be changed. To the extent that copyright subsists in a third party, permission will be required from the third party to reuse the material.  In essence, you are free to copy, communicate and adapt the material as long as you attribute the work to ARPANSA and abide by the other licence terms. The works are to be attributed to the Commonwealth as follows:-  ‘© Commonwealth of Australia 2019, as represented by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)’  The publication should be attributed as: *Radiation Doses from the Average Australian Diet*.  **Use of the Coat of Arms**  The terms under which the Coat of Arms can be used are detailed on the Department of the Prime Minister and Cabinet website ([www.dpmc.gov.au/government/commonwealth-coat-arms](http://www.dpmc.gov.au/government/commonwealth-coat-arms)).  Enquiries regarding the licence and any use of this report are welcome.  ARPANSA  619 Lower Plenty Road  YALLAMBIE VIC 3085  Tel: 1800 022 333 (Freecall) or +61 3 9433 2211   Email: [info@arpansa.gov.au](mailto:info@arpansa.gov.au)  Website: [www.arpansa.gov.au](http://www.arpansa.gov.au) |

Contents

[Acknowledgements iv](#_Toc20228244)

[Executive summary 1](#_Toc20228245)

[1. Introduction 2](#_Toc20228246)

[1.1 Radionuclides in Australian food 2](#_Toc20228247)

[1.2 A risk based approach 3](#_Toc20228248)

[1.3 Objective 4](#_Toc20228249)

[1.4 Scope of the study 4](#_Toc20228250)

[2. Calculation of dose and population dose 5](#_Toc20228251)

[2.1 Calculation of committed effective dose 5](#_Toc20228252)

[2.2 Population weighted dose 6](#_Toc20228253)

[3. Reference activity concentrations applied for method selection 7](#_Toc20228254)

[3.1 Consumption data 7](#_Toc20228255)

[3.2 Age Groups 8](#_Toc20228256)

[3.3 Calculation of reference activity concentrations 8](#_Toc20228257)

[3.4 Naturally occurring radionuclides 9](#_Toc20228258)

[3.5 Anthropogenic radionuclides 9](#_Toc20228259)

[4. Sample preparation and analysis 10](#_Toc20228260)

[4.1 Sample collection 10](#_Toc20228261)

[4.2 Selection of foods for determination of naturally occurring radionuclides 10](#_Toc20228262)

[4.3 Sample preparation 10](#_Toc20228263)

[4.4 Analysis for anthropogenic radionuclides 11](#_Toc20228264)

[4.5 Analysis for naturally occurring radionuclides 11](#_Toc20228265)

[5. Dose assessment inputs 13](#_Toc20228266)

[5.1 Food consumption data 13](#_Toc20228267)

[5.2 Dose coefficients 13](#_Toc20228268)

[6. Results 14](#_Toc20228269)

[6.1 Activity concentrations – anthropogenic radionuclides 14](#_Toc20228270)

[6.2 Committed effective dose – anthropogenic radionuclides 14](#_Toc20228271)

[6.3 Activity concentrations – naturally occurring radionuclides 15](#_Toc20228272)

[6.4 Committed effective dose - naturally occurring radionuclides 20](#_Toc20228273)

[6.5 Population weighted committed effective dose 23](#_Toc20228274)

[7. Discussion 24](#_Toc20228275)

[8. Conclusion 25](#_Toc20228276)

[9. References 27](#_Toc20228277)

[Appendix 1 Dose coefficients 30](#_Toc20228278)

[Appendix 2 Determination of reference activity concentration 31](#_Toc20228279)

[Appendix 3 Analysis details – naturally occurring radionuclides 32](#_Toc20228280)

[A3.1 Potassium-40 32](#_Toc20228281)

[A3.2 Polonium-210 32](#_Toc20228282)

[A3.3 Lead-210 32](#_Toc20228283)

[A3.4 Uranium/thorium 32](#_Toc20228284)

[A3.5 Radium 33](#_Toc20228285)

[A3.6 Alpha spectrometry/liquid scintillation counting 33](#_Toc20228286)

[Appendix 4 Food mapping and consumption rates 34](#_Toc20228287)

[Appendix 5 Anthropogenic radionuclides plus 40K 37](#_Toc20228288)

[Appendix 6 Naturally occurring radionuclides 66](#_Toc20228289)

[Appendix 7 Committed effective dose 71](#_Toc20228290)

# Acknowledgements

The authors wish to acknowledge the staff from the radiochemistry laboratory; Liesel Green, Ilonka Bokor and Jane Courtier for the analysis of anthropogenic radionuclides.

The authors would like to acknowledge staff from Foods Standards Australia New Zealand for the collection and provision of samples and for compiling the data on the food consumption and food mapping information for the Australian diet.

# Executive summary

All food products in the human diet contain radionuclides. Many factors influence the concentration of radionuclides in food products, including: their physical and chemical properties, abundance in the environment, biological uptake from the environment and how the food is cooked and prepared for consumption. Although most radionuclides consumed in our diet are of natural origin, some of these, known as anthropogenic radionuclides, are due to human activities.

Australia has previously introduced public health actions to manage radionuclides in some food products. In the 1950’s and 60’s radionuclides in milk were monitored and reported in response to concerns about wide spread contamination from atmospheric nuclear weapons testing in Australia and the South Pacific. Imported food monitoring programs and food restrictions were introduced in response to the 1986 Chernobyl and the 2011 Fukushima Dai-ichi nuclear power plant accidents. Although programmes like these provide an appropriate level of action to mitigate public exposure to radiation, little is known about the baseline level of radionuclides in food products in Australia and the risk to the population from consumption.

In collaboration with Food Standards Australia New Zealand (FSANZ), ARPANSA assessed the health risk to the Australian population from exposure to both anthropogenic and naturally occurring radionuclides in food products consumed in Australia. This assessment required the measurement of radionuclides in the food followed by a radiation dose assessment from their consumption.

The key findings were:

* anthropogenic radionuclides 60Co, 134Cs and 241Am were not detected in any food product, while low levels of 137Cs were detected in some foods
* naturally occurring radionuclides were detected in most foods, at varying concentrations
* radiation dose estimates were much less than the reference level of 1 mSv/year for existing radiation exposure situations
* consumption of these food products by the Australian population is not expected to have any long term health impacts.

The benefit of this baseline exposure study of radionuclides in food products consumed in Australia is in providing a better understanding of the dose to people from a typical diet. Further, more informed decisions can be made on the management of radionuclides in food.

This study was done as part of the 25th Australian Total Diet Study (ATDS) undertaken by FSANZ in surveying Australian food to determine exposure to contaminants. Water was not included in the measurements and assessment but may be considered in future studies.

# Introduction

Exposure to ionising radiation in our daily lives occurs via a number of different pathways. One pathway is the ingestion of food containing radionuclides. The exposure and subsequent radiation dose to people is dependent on the radionuclides consumed, the activity concentration of these radionuclides, the age of the person and the quantity of food ingested. Food consumption rates are influenced by a number of factors including climate, cultural preferences and agriculture (FSANZ, 2019; UNSCEAR, 2000, 2013). Radionuclides that are present in the food chain originate from human activity, known as anthropogenic radionuclides, or are naturally occurring.

Anthropogenic radionuclides are present in the environment predominantly as a result of fallout due to atmospheric nuclear weapons testing conducted between 1945 and 1980 and from nuclear power plant reactor accidents such as the Chernobyl accident in 1986 and, more recently, the Fukushima Dai-ichi accident in 2011 (UNSCEAR, 2000, 2013).

Naturally occurring radionuclides originate from cosmic or terrestrial sources. Cosmogenic radionuclides form in the upper atmosphere or in space. These radionuclides (including 7Be and 14C) may attach to particles and be deposited onto the earth’s surface. The terrestrial radionuclides include the long-lived uranium and thorium radionuclides and their decay products, and radioactive potassium (40K). The decay products of uranium and thorium include radioactive isotopes of uranium (U), thorium (Th), protactinium (Pa), radium (Ra), radon (Rn), polonium (Po), lead (Pb), bismuth (Bi) and actinium (Ac). These radionuclides have half-lives that range from microseconds to billions of years and have existed in the environment since the formation of the earth. Due to the shorter half-lives of the decay products, the radionuclides in the decay chain exist in a state of secular equilibrium (equal activities) unless natural or anthropogenic processes disrupt this equilibrium (L'Annunziata, 2012; Longworth and Geoff, 1998).

Radionuclides make their way into the food chain via a range of processes. Plants take up radionuclides via direct deposition or, through transfer mechanisms from the soil, water or the atmosphere. Animals take up radionuclides from their environment or from feed materials. Humans ingest radionuclides via the consumption of food and water.

The transport mechanisms of the radionuclides, once inside the body, are dependent on the properties of the element. Once ingested, the digestive system will partially break down food into a suitable form for the body to use. Soluble radionuclides contained within the food may transfer to the bloodstream and be carried throughout the body. The chemical properties of each radionuclide influences where it deposits in the body (Martin and Harbison, 1996). For example, radium (Ra) is chemically similar (analogous) to calcium and will deposit in bone while caesium (Cs) and its isotopes will deposit in all body tissues. Once the body incorporates the radionuclide, the radiation emitted will interact with the surrounding tissues and organs. The radiological effect will vary for each organ or tissue exposed depending on the radiation type, the radionuclide’s retention time and the sensitivity of the tissue or organ to the radiation exposure.

## Radionuclides in Australian food

Food Standards Australia New Zealand (FSANZ) regularly undertakes surveys of Australian food to determine exposure to contaminants such as pesticide residues and heavy metals. The focus of the 25th Australian Total Diet Study (ATDS) was to determine the levels of agricultural and veterinary chemical residues, metal contaminants and anthropogenic radionuclides in food consumed in Australia. The inclusion of anthropogenic radionuclides in the study provided important information about their current concentrations in Australian food as this information was not previously available.

The anthropogenic radionuclides in this study were chosen based on past and potential releases into the environment from nuclear weapon detonations, nuclear power plant accidents or other industrial processes. Cobalt-60 (60Co), caesium-137 (137Cs), caesium-134 (134Cs) and americium-241 (241Am) were used as indicators of the levels of anthropogenic radionuclides in the environment. Caesium-137, due to its relatively long half-life, was expected to be present in low levels in the food. A recent study of radioactivity in seafood sourced from northern Australia had shown the presence of 137Cs at low levels in Australian seafood (Urban et al., 2015). Strontium-90 (90Sr), also with a long half-life may be present at low levels due to fallout from past nuclear weapons detonations. However, the analysis for 90Sr is complex and lengthy and was therefore not included in this study. A conservative assumption commonly used is that the level of 90Sr in the environment is the same as that of 137Cs based on historical fallout monitoring results (AIRAC, 1975).

In addition to the anthropogenic radionuclides specified, the study was expanded to include the analysis of a selection of important naturally occurring radionuclides in the food. Studies of radionuclides in food consumed in other countries have shown the important contribution of naturally occurring radionuclides to the overall ingestion dose (Al-Masri et al., 2004; Choi et al., 2008; Patra et al., 2014; Pearson et al., 2016b; Pietrzak-Flis et al., 1997). In Australia, there have been studies of naturally occurring radionuclides in northern Australian bushfoods consumed by the indigenous people living in the Alligator Rivers Region of the Northern Territory (Martin et al., 1998; Ryan et al., 2008; Ryan et al., 2005). Prior to the current study there was little information on the activity concentrations of these naturally occurring radionuclides in the typical Australian diet.

## A risk based approach

A risk based approach provides a process of systematically assessing the potential impact of a hazard on a defined individual or population. Risk assessments are required where there is a plausible chance that there could be an increased risk of harm to people (enHealth, 2012). An important role of the risk assessment process is to clearly document key assumptions and uncertainties to establish the credibility of results and allow decision makers, including the public, to make informed decisions about any risks taken.

The United Nations Scientific Committee on the Effects of Atomic Radiation estimates a global ingestion dose range from 0.2 to 1.0 mSv/year and recognises that this dose range will depend on the radionuclide composition of foods (UNSCEAR, 2008). In Australia, an effective dose to a person from consuming food should not generally exceed a value of 1 mSv/year (ARPANSA 2017).

In this study a risk assessment was undertaken to evaluate the potential health effects resulting from exposure to radionuclides found in food products consumed in Australia. The hazard was quantified by estimating radionuclide activity concentrations in targeted food products. A range of factors including age groups and food consumption rates were taken into account to develop an exposure scenario based on ingestion of radionuclides in the Australian diet.

The information gained through this study provides vital information of the base line concentration of radionuclides in food consumed in a typical Australian diet. This information may be used in managing food safety in Australia and allows radiation risks to be compared to other risks encountered in everyday life. The base line data can assist in optimising radiation protection and communicate risk in the unlikely event of a radiological or nuclear emergency that causes contamination of food in Australia.

## Objective

In collaboration with Food Standards Australia New Zealand (FSANZ), the objective of the study was to characterise the potential health effects to the Australian population from exposure to radionuclides found in typical food products consumed in Australia.

## Scope of the study

The scope of this study was to:

* determine reference activity concentrations adequate to ensure that the dose could be calculated at or below the reference level
* ensure that analytical methods were selected to obtain measurements at or below the derived activity concentrations
* screen all the ATDS food samples collected for the 25th ATDS for the anthropogenic radionuclides 137Cs, 134Cs, 60Co and 241Am to determine current levels in Australian foods
* select a representative sample of foods from the ATDS and determine the levels of the naturally occurring radionuclides 234U, 238U, 230Th, 226Ra, 210Pb and 210Po from the 238U decay chain, and 232Th and 228Ra from the 232Th decay chain
* estimate the radiological dose and health impact to the Australian population from the radionuclide levels determined in this study.

The contribution from cosmogenic radionuclides was not considered within this study. Water and other beverages were analysed as part of the ATDS screening process for anthropogenic radionuclides but were not included in the assessment of naturally occurring radionuclides.

# Calculation of dose and population dose

After ingestion, radionuclides incorporated in the human body irradiate organs in the body over time. The dose received depends on the radionuclide’s physical half-life and its biological retention (biological half‑life) within the body. Therefore radionuclides may deliver radiation doses to organs for many months or years after the intake. To estimate the accumulation of radiation dose over extended periods of time requires the calculation of the committed effective dose. The commitment period is taken to be 50 years for adults, and to age 70 years for children (ICRP, 2012).

## Calculation of committed effective dose

The total committed effective dose due to the ingestion of radionuclides present in all types of food, for a particular age group, may be determined using equation 1:

(1)

Where: is the committed effective dose (mSv/year) due to the ingestion of all radionuclides for all food types for the age group (*j*)

is the ingestion dose coefficient (Sv/Bq) for radionuclide (*i*) for each age group (*j*)

is the consumption rate (kg/year) for the age group (*j*)for food type (*k*)

is the activity concentration of the radionuclide in the food (Bq/kg) for radionuclide (*i*) and food type (*k*)

### Dose coefficients

The International Commission on Radiological Protection (ICRP) has published dose coefficients for each radionuclide which take into account the sensitivity of organs and tissues in the body, the biological half-life of the radionuclide and the type of radiation emitted (ICRP, 2012).

The dose coefficients for the anthropogenic and naturally occurring radionuclides are shown in Appendix 1. Generally, the dose coefficient is higher in younger age groups. This relationship is especially evident for 241Am, which has the highest dose coefficient for the selected anthropogenic radionuclides (Table A1.1).

The four naturally occurring radionuclides with the highest dose coefficients are 210Po, 228Ra, 210Pb and 226Ra with 228Ra being the highest for an infant of 3 months according to the ICRP age groups. Further, the dose coefficients for these four radionuclides are higher than any of the dose coefficients for the anthropogenic radionuclides.

Potassium-40 is not included in the determination of committed effective dose. The human body maintains a relatively constant level of potassium, and hence a constant level of 40K. Therefore, an increase in the amount of 40K ingested does not result in accumulation and, consequently, the dose due its presence has been determined to be 0.165 and 0.185 mSv/year for adults and children, respectively (UNSCEAR, 2000).

## Population weighted dose

The population weighted dose, in mSv/year, is the sum of all the individual doses to members of the population divided by the total population. Although the population weighted dose does not represent any single age group, it represents the average dose across the entire population.

The population weighted dose is calculated using equation 2:

(2)

Where: is the total committed effective dose (mSv/year) due to the ingestion of all radionuclides for all food types for the age group (*j*)

is the population of age group (*j*)

is the total population

# Reference activity concentrations applied for method selection

For the naturally occurring radionuclides, a reference level for exposure was set as a total committed effective dose of 1 mSv/year. This value is consistent with the recommendation by the International Atomic Energy Agency (IAEA) in Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, General Safety Requirements Part 3 (IAEA, 2014) adopted within the Australian Guide for Radiation Protection in Existing Exposure Situations, Radiation Protection Series G-2 (ARPANSA, 2017).

For the anthropogenic radionuclides a less sensitive approach was applied. In Australia it is expected that anthropogenic radionuclides in food would be at trace levels, largely because there has been no significant radiological or nuclear accident in Australia that would contaminate the food chain. Therefore a reference level for exposure to each of the radionuclides was set as a committed effective dose of 1 mSv/year. This is consistent with the guidance developed jointly by the Food and Agriculture Organisation of the United Nations (FAO) and the World Health Organisation (WHO) and described within the international “Food Code”, *The Codex Alimentarius* (FAO/WHO, 1995).

It is important to select analytical methods for radionuclide measurements that are sufficiently sensitive to allow estimates of dose contribution below the described reference levels of 1 mSv/year.

To achieve sufficient measurement performance, reference activity concentrations were determined to assist with the selection of appropriate analytical methods. These analytical methods were needed to achieve a minimum detectable activity concentration for the radionuclides that would allow the calculation of doses below the reference level.

Therefore, the reference activity concentration for each radionuclide was determined by taking into account the reference level for the committed effective dose, the food consumption rate and ingestion dose coefficient.

Using this method of deriving the reference activity concentrations has some limitations. In particular, it was assumed that radionuclides had no preferential uptake in certain foods and that naturally occurring radionuclides were present in secular equilibrium.

## Consumption data

For the determination of reference activity concentrations, international studies were used as the source of information on food consumption rates. Table 1 shows these consumption rates. At the time of determining reference activity concentrations, detailed consumption data for Australia was not available. Consumption data for an infant (1 year), child and adult were sourced from the UNSCEAR 2000 report (UNSCEAR, 2000), while the consumption for an infant (3 months) was based on ‘mixed’ infant formula consumption at a rate of 800 mL/day, matched to the intake rate for breast milk (ICRP, 2005).

Table 1. Food consumption rate data (kg/year) derived from international publications

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Food type | Infant  (3 months) | Infant (1 year) | Child | Adult |
| Milk products | 290 | 120 | 110 | 120 |
| Meat products |  | 15 | 35 | 50 |
| Grain products |  | 45 | 90 | 140 |
| Leafy vegetables |  | 20 | 40 | 60 |
| Roots and fruits |  | 60 | 110 | 170 |
| Fish products |  | 5 | 10 | 15 |
| Total | 290 | 265 | 395 | 555 |

## Age groups

The ICRP have determined dose coefficients for a range of age groups. Age group consumption data, sourced from international studies, was matched as closely as possible to the ICRP age groups (Table 2) to calculate the reference activity concentrations.

Table 2. ICRP dose coefficients age group mapping to international studies

|  |  |
| --- | --- |
| ICRP age groups | Age groups from international studies |
| Infant (3 months) | Infant (3 months) |
| 1 year | Infant (1 year) |
| 5 years | Child |
| 10 years | N/A |
| 15 years | N/A |
| Adult | Adult |

## Calculation of reference activity concentrations

The reference activity concentrations for the radionuclides were determined by rearranging equation 1 to form equation 3:

(3)

Where: is the committed effective dose (mSv/year) (reference level for exposure) due to the ingestion of radionuclide (*i*) for all food types for the age group (*j*)

is the ingestion dose coefficient (Sv/Bq) for radionuclide (*i*) for each age group (*j*)

is the consumption rate (kg/year) for all food types the age group (*j*)

is the activity concentration of the radionuclide in the food (Bq/kg) for radionuclide (*i*) and age group (*j*)

Infant formula was treated separately to other foods due to its almost exclusive consumption by the infant (3 months) age group. Consequently, it was considered to contribute very little to the consumption in any other age group. Example calculations are illustrated in Appendix 2.

## Naturally occurring radionuclides

The calculation of reference activity concentrations assumed that the radionuclides in the uranium and thorium decay chains were in secular equilibrium. Taking into account all age groups, the concentration giving a dose equal to the reference level of 1 mSv/year was selected as the reference activity concentration for each radionuclide. The reference level for exposure of 1 mSv/year was for the contribution of all naturally occurring radionuclides in the average diet.

Table 3 shows that the reference activity concentration for infant formula was determined to be 0.041 Bq/kg, while the reference activity concentration for other foods was determined to be 0.18 Bq/kg.

Table 3. Calculated reference activity concentrations for naturally occurring radionuclides

| Radionuclide | Concentration (Bq/kg) for 1 mSv/year | | | | Reference activity concentrations (Bq/kg) | |
| --- | --- | --- | --- | --- | --- | --- |
| Naturally occurring | Infant (3 months) | Infant (1 year) | Child | Adult | **Infant formula** | **Other foods** |
| 0.041 | 0.18 | 0.21 | 0.52 | **0.041** | **0.18** |

## Anthropogenic radionuclides

The reference level for exposure was set to 1 mSv/year for each of the anthropogenic radionuclides in this study. The reference activity concentration was calculated in the same way as for the naturally occurring radionuclides. Table 4 shows that the reference activity concentration was lowest for 241Am in infant formula at 0.9 Bq/kg, other food at 5 Bq/kg. Reference activity concentrations for the other radionuclides were much higher than those for 241Am.

Table 4. Calculated reference activity concentrations for anthropogenic radionuclides

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Radionuclide | Concentration (Bq/kg) for 1 mSv/year | | | | Reference activity concentrations (Bq/kg) | |
| Infant (3 months) | Infant (1 year) | Child | Adult | **Infant formula** | **Other foods** |
| 60Co | 64 | 140 | 150 | 540 | **50** | **100** |
| 134Cs | 132 | 235 | 195 | 97 | **100** | **50** |
| 137Cs + 90Sr | 25 | 45 | 44 | 44 | **10** | **10** |
| 241Am | 0.93 | 10 | 9 | 9 | **0.9** | **5** |

# Sample preparation and analysis

## Sample collection

FSANZ provided the food samples for analysis based on the sampling regime and sample preparation protocols for the 25th ATDS (FSANZ, 2019). These detailed the processes for purchasing, transporting, preparing and storing foods for the study. Foods were categorised as being either ‘national’ or ‘regional’. National foods comprised largely processed foods where variations within the country were not expected. Regional foods were grown or produced in different regions of Australia and therefore variation in activity concentrations of radionuclides within the food could be expected.

The project covered two sampling periods: autumn 2013 and summer 2014. Eighty-eight different food sample types were collected, with individual food purchases composited into a total of 248 samples for the autumn period and 260 samples for the summer period. All foods were screened for anthropogenic radionuclides and a selection of foods were analysed for naturally occurring radionuclides.

## Selection of foods for determination of naturally occurring radionuclides

From the range of foods sampled for the ATDS, ARPANSA selected representative foods to determine the levels of naturally occurring radionuclides. A variety of foods were selected to represent the expected consumption rates by all ICRP age groups. Table 5 shows the food categories and selected foods in each category. These foods are also consistent with the food categories shown in the UNSCEAR report (UNSCEAR, 2000). Using this criteria, twenty-two foods across both sampling periods, were selected for analysis.

Table 5. Food and food categories for analysis of natural radionuclides

|  |  |
| --- | --- |
| Food category | Food type |
| Milk products | Milk, infant formula |
| Meat products | Beef mince, chicken, eggs |
| Grain products | Bread, breakfast cereal, pasta, rice |
| Leafy vegetables | Broccoli, lettuce |
| Roots and fruits | Carrot, onion, peanut butter, potatoes, apples, bananas, mango, nectarine, tomato, fruit juice |
| Fish products | Fish |

## Sample preparation

Foods collected were prepared and/or cooked with oversight by FSANZ, so that they were in a ‘ready to eat’ state prior to being received by ARPANSA.

The samples were frozen prior to shipping and stored frozen until sample preparation and analysis commenced. Any remaining sample was stored for further analysis. The samples received were either unprocessed portions or pre-ground and homogenised. Samples received in the unprocessed state were ground and homogenised using a laboratory grade or commercial blender depending on the food. Pre-ground samples were thoroughly mixed prior to subsampling for analysis. Approximately 500 g of the homogenised sample was subsampled for analysis of anthropogenic radionuclides by high-resolution gamma spectrometry.

For the analysis of the naturally occurring radionuclides, a larger mass was required. Composite samples were prepared by mixing equal amounts of all original samples of a given food type. For example, if four different regional samples were collected, equal amounts of the four regional samples were combined to produce one composite sample. The composite samples were dried at 90oC to a constant mass and ground, using a knife mill, to a fine powder. Some of the dried sample was reserved for analysis of specific radionuclides and another portion was further subsampled for pre-treatment (ashing) using a muffle furnace at 400oC or 500oC for additional radionuclide analysis.

## Analysis for anthropogenic radionuclides

The samples were analysed for anthropogenic radionuclide activity concentrations using high-resolution gamma spectrometry. High purity germanium detectors, calibrated for energy and efficiency using NIST (National Institute of Standards and Technology) traceable multi-radionuclide sources, were used for gamma counting.

Samples were dispensed into medium (450 mL) Marinelli beakers: a geometry suitable for the measurement of gamma emitting radionuclides. Samples were counted for a minimum of eight hours for this screening. The composite samples (twenty-two samples in total) were also analysed for anthropogenic radionuclides, following drying and grinding.

## Analysis for naturally occurring radionuclides

The methods used for the determination of activity concentrations of naturally occurring radionuclides from the 238U and 232Th decay chain are summarised in Table 6 and details of the procedures are provided in Appendix 3.

Table 6. Summary of procedures used in the analysis of natural radionuclides

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Radionuclides | 210Po | 210Pb | U/Th | Ra |
| **Sample preparation** | Dried | Ashed @ 400oC | Ashed @ 500oC | Ashed @ 500oC |
| **Dissolution** | HNO3, HNO3/H2O2 | HNO3 plus additional ashing | HNO3 plus additional ashing | HNO3 plus additional ashing |
| **Separation** | Manganese dioxide (MnO2) precipitation | Sr resin, MnO2 precipitation for separation of ingrown 210Po | Co-precipitated with Ca2PO4,  U: separation using UTEVA resin  Th: separation using TEVA resin | Co-precipitated with PbSO4, purification with BaCl2  228Ra: 228Th allowed to grow in, TEVA resin separation |
| **Source preparation** | Autodeposition (silver disc) | Autodeposition  (silver disc) | Electrodeposition (stainless steel discs) | 226Ra: dissolved in EDTA, scintillant added  228Ra: Electrodeposition of Th |
| **Counting technique** | Alpha spectrometry | Alpha spectrometry | Alpha spectrometry | 226Ra: LSC  228Ra: alpha spectrometry |

# Dose assessment inputs

## Food consumption data

FSANZ provided a report detailing the consumption data for the twenty-two food groups analysed for naturally occurring radionuclides. The data was based on the 2011-12 Australian National Nutrition and Physical Activity Survey (ABS, 2014). This survey was a 24-hour recall survey and for 64% of respondents, a second 24 hour recall survey was undertaken. Only the consumption information, where two days of data was available (n=7735), was used for this study and for the estimation of dose.

Where possible, the foods consumed in the nutrition survey were matched to the twenty-two food types selected for testing. Where no exact matches were possible, the foods were matched as closely as possible to the items for which data existed to provide a suitable approximation or ‘mapping’ for dietary consumption and radionuclide intake. For example, ‘broccoli’ captures broccoli, broccoflower, cauliflower, stalk and stem vegetables, based on the assumption that similar types of foods would have similar radionuclide concentrations. This broad mapping was done in order to capture as many foods from the diet as possible. Recipes were used to break down mixed foods or dishes that didn’t match directly to one food type into its major ingredients. These ingredients were then matched to the foods analysed e.g. hamburgers that are composed of meat, bread, tomato, cheese and lettuce could be better matched by this component breakdown. Some foods were not able to be included in this matching process and they were not classified (e.g. coffee, sugar, confectionary). Table A1.1 in Appendix 4 shows the twenty-two ‘ARPANSA’ food groups, the foods matched to the food group and the consumption data for the different age groups.

The data from FSANZ covered the following age groups: 2 years, 3–7 years, 8–12 years, 13–17 years and 18 years and above. For infants, the consumption rate used was the same as that used to determine the reference activity concentration given by the ICRP (ICRP, 2005) of 800 mL/day.

## Dose coefficients

The provided age group data for Australian food consumption was matched to the ICRP age groups, shown in Table 7, in order to undertake the detailed dose assessments.

Table 7. ICRP dose coefficients age group mapped to Australian consumption data

|  |  |
| --- | --- |
| ICRP age groups | Age groups used in this study |
| Infant (3 months) | <1 year |
| 1 year | 2 years |
| 5 years | 3–7 years |
| 10 years | 8–12 years |
| 15 years | 13–17 years |
| Adult | More than 18 years |

# Results

The activity concentration results are shown in Appendix 5 and Appendix 6. The results are reported in Bq/kg based on the sample “as received”. As detailed in section 4.3, foods collected had either been prepared and/or cooked so that they were in a ‘ready to eat’ state, so are not reported as wet weight or dry weight. The reported uncertainty is the combination of the standard uncertainties and is reported with a coverage factor of k=1, giving a confidence factor of approximately 68%. A result less than the minimum detectable activity concentration (MDC) has been reported as “ND” (not detected). This is consistent with current IAEA recommendations (IAEA, 2017). There is some variation in MDC, due to differences in factors such as the measurement technique used, mass of sample used for analysis, counting time and recovery of the radionuclide during the assay.

## Activity concentrations – anthropogenic radionuclides

Appendix 5 (Tables A5.1 and A5.2) lists the results of all the samples screened for anthropogenic radionuclides. For comparison, these tables also list the results for 40K obtained during the screening process.

Some radionuclides, 60Co, 134Cs and 241Am, were not detected in any of the food samples. The radionuclide 137Cs was detected in twelve samples at an activity concentration ranging from 0.061 to 0.389 Bq/kg. As previously discussed, 137Cs is present at low levels in the environment due to the deposition of global fallout and because of its longer half-life. Therefore, the presence of 137Cs in some food was expected.

There was insufficient data available to make any comparisons of the anthropogenic radionuclide content of the foods between the autumn and summer periods.

Where the radionuclide was not detected, the MDC was well below the most restrictive reference activity concentrations for 241Am of 0.9 Bq/kg for infant formula and 5 Bq/kg for other foods, refer to Table 4.

## Committed effective dose – anthropogenic radionuclides

The committed effective dose from the intake of anthropogenic radionuclides, 60Co, 134Cs and 241Am could not be calculated because the radionuclides were not detected in any of the samples analysed. 137Cs was detected in only a small number of samples.

All the radionuclide levels were below the reference activity concentrations for all foods. Therefore the committed effective dose was less than 1 mSv/year for each radionuclide across all the age groups. In the case of 60Co, 134Cs and 137Cs the MDCs were considerably less than the reference activity concentrations. For the composite samples, the dose for each radionuclide was estimated using the MDC if the radionuclide was not detected. This data is shown in Table 8.

Table 8. Estimated dose contribution for each radionuclide in all composite foods.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Age Group | Dose contribution from anthropogenic radionuclides (mSv/year) | | | |
| 241Am | 60Co | 134Cs | 137Cs + 90Sr |
| Infant | <0.03 | <0.01 | <0.01 | <0.01 |
| 2 years | <0.03 | <0.01 | <0.01 | <0.01 |
| 3–7 years | <0.03 | <0.01 | <0.01 | <0.01 |
| 8–12 years | <0.03 | <0.01 | <0.01 | <0.01 |
| 13–17 years | <0.03 | <0.01 | <0.01 | <0.01 |
| >18 years | <0.03 | <0.01 | <0.01 | <0.01 |

## Activity concentrations – naturally occurring radionuclides

The measured activity concentrations and the uncertainties (k=1) for the uranium and thorium decay chain radionuclides in the composite samples are shown in Appendix 6. The results, except for infant formula, are shown graphically in Figures 1-8. Where a radionuclide was not detected, the MDC is shown as a black bar. A black dashed line on the graph indicates the reference activity concentration. The activity concentrations for the selected radionuclides in infant formula are shown in Figure 9 where the dashed line shows the calculated reference activity concentration for an infant (< 3 months).

All the MDCs were well below the reference activity concentrations indicating that the methods of analysis provided suitable results to establish that the calculated committed effective dose was below the reference level of 1 mSv/year.

The activity concentrations for the naturally occurring radionuclides varied depending on the radionuclide and the food type. Thorium-232 was not detected in any of the composite samples and 230Th was detected in five samples only. Comparison of Figures 2-9 shows that the radionuclides were not in secular equilibrium. The radionuclides in the 238U decay chain showed varied activity concentrations in the same food type, indicating some disequilibrium. This can be explained by the decay product having become separated from its parent radionuclide by different processes within the environment (UNSCEAR, 2000).

All activity concentration values for the naturally occurring radionuclides were below 0.3 Bq/kg, with isotopes of radium generally being the dominant contributor. Radium-228 results showed the highest activity concentrations in cereal, eggs and peanut butter. Radium‑226 showed a similar relative activity concentration trend, although the values are lower within each comparable food.

The 40K activity concentrations are shown in Appendix 5. The 40K activity was not considered for dose calculations.



Figure 1. Activity concentrations for 210Po for the composite samples



Figure . Activity concentrations for 210Pb for the composite samples



Figure . Activity concentrations for 228Ra for the composite samples



Figure . Activity concentrations for 226Ra for the composite samples



Figure . Activity concentrations for 234U for the composite samples



Figure . Activity concentrations for 238U for the composite samples



Figure . Activity concentrations for 230Th for the composite samples



Figure . Activity concentrations for 232Th for the composite samples



Figure . Activity concentration for the selected radionuclides in infant formula.

## Committed effective dose - naturally occurring radionuclides

The committed effective dose was calculated for each age and food group. An example of the calculation (for the consumption of 226Ra by a two-year-old) is detailed in Table A7.1 in Appendix 7. The committed effective dose was determined using two methods:

1. if the radionuclide was not detected the activity concentration was deemed to be zero
2. if the radionuclide was not detected, the MDC for the radionuclide was used as an activity concentration for that sample.

Figures A7.1 to A7.6 in Appendix 7 show the committed effective dose for each food group and includes the dose contributed by each radionuclide (calculated using the MDC as an activity concentration where there was no detection).

The committed effective doses were calculated for the food and age groups and are shown in Table 9 with and without including the MDC in the calculation. The total committed effective doses for the different age groups are shown in Figure 10. The reference level for exposure of 1 mSv/year is indicated by a dotted line. For most of the age groups the committed effective dose did not show a significant difference when the two different calculation methods were applied. The exception was for infant formula where the activity concentration for 228Ra was below the detection limit. In this case the use of the MDC in the calculation resulted in a much higher dose than if the activity concentration was assumed to be zero.

The dose coefficients given in ICRP Publication 95 (ICRP, 2005) for chronic exposure were used to estimate the committed effective dose for an infant consuming breast milk. The dose coefficients model the exposure pathway based on the radionuclide intake by the mother (adult), radionuclide transfer into breast milk and subsequent consumption of breast milk by the infant.

Table 9. Committed effective dose (mSv/year), due to the naturally occurring radionuclides, for the age groups and food categories and the total committed effective dose

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Age groups | MDC included in calculation of dose | Food categories | | | | | | Total committed effective dose (mSv/y) |
| Milk products | Meat products | Grain products | Leafy vegetables | Root vegetables and fruit | Fish products |
| Infant (formula) | No­­ | 0.11 |  |  |  |  |  | 0.11 |
| Yes | 0.26 |  |  |  |  |  | 0.26 |
| Infant (breast milk) | No | 0.015 |  |  |  |  |  | 0.015 |
| Yes | 0.017 |  |  |  |  |  | 0.017 |
| 2 years | No | 0.091 | 0.016 | 0.086 | 0.0028 | 0.078 | 0.0039 | 0.28 |
| Yes | 0.094 | 0.022 | 0.088 | 0.0032 | 0.089 | 0.0039 | 0.30 |
| 3–7 years | No | 0.046 | 0.011 | 0.063 | 0.0014 | 0.045 | 0.0020 | 0.17 |
| Yes | 0.048 | 0.014 | 0.065 | 0.0017 | 0.053 | 0.0021 | 0.18 |
| 8–12 years | No | 0.042 | 0.013 | 0.069 | 0.0012 | 0.049 | 0.0024 | 0.18 |
| Yes | 0.044 | 0.017 | 0.071 | 0.0017 | 0.056 | 0.0025 | 0.19 |
| 13–17 years | No | 0.044 | 0.017 | 0.085 | 0.0017 | 0.051 | 0.0018 | 0.20 |
| Yes | 0.045 | 0.023 | 0.088 | 0.0025 | 0.057 | 0.0018 | 0.22 |
| >18 years | No | 0.012 | 0.0051 | 0.017 | 0.0009 | 0.014 | 0.0018 | 0.051 |
| Yes | 0.014 | 0.0071 | 0.018 | 0.0011 | 0.018 | 0.0018 | 0.059 |



Figure . Total committed effective dose ranges for the consumption of food containing radionuclides from the U and Th decay series.

## Population weighted committed effective dose

The population weighted committed effective dose was calculated using equation 2 and is shown in Table 10.

Table 10. Population weighted committed effective dose (mSv/year), due to the naturally occurring radionuclides.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Age groups | Total committed effective dose (mSv/year) | | Percentage of the Australian population\* | Contribution to population weighted dose  (mSv/year) | |
| No MDC | MDC | No MDC | MDC |
| Infant (formula) | 0.11 | 0.26 | 0.65^ | **0.00074** | **0.0017** |
| Infant (breast milk) | 0.015 | 0.017 | 0.65^ | **0.0001** | **0.0001** |
| 2 years | 0.28 | 0.30 | 2.7 | **0.0075** | **0.0081** |
| 3-7 years | 0.17 | 0.18 | 6.5 | **0.011** | **0.012** |
| 8-12 years | 0.18 | 0.19 | 6.3 | **0.011** | **0.012** |
| 13-17 years | 0.20 | 0.22 | 6.5 | **0.013** | **0.014** |
| >18 years | 0.051 | 0.059 | 76.8 | **0.039** | **0.045** |
| **Population weighted average dose (mSv/year)** | | | | **0.083** | **0.094** |

\*Sourced from 2011 census (ABS, 2011)

**^50/50 ratio of breast milk and formula milk infants (AIHW, 2011)**

# Discussion

In a worldwide context, the activity concentrations of naturally occurring radionuclides can vary by many orders of magnitude depending on region. Consequently, radionuclide concentrations in foods vary widely because of these regional differences. These differences arise from variations in radionuclide background levels in soil, the climate and the agricultural conditions that prevail. There are also differences in the types of local food included in categories such as vegetables, fruits and fish. Reference values have been documented by UNSCEAR, which are based on the most widely available data (UNSCEAR, 2000).

In this study the measured activity concentrations of the naturally occurring radionuclides varied by two orders of magnitude. However, the results were generally consistent with the reference values reported by UNSCEAR and other authors (Choi et al., 2008; Pearson et al., 2016b; UNSCEAR, 2000). For example, in this study the 228Ra and 226Ra activity concentrations in the composite carrot sample were four to five times higher than the average reported by UNSCEAR for root vegetable and fruits, but were within the range reported across a range of countries, noting that the data for 228Ra was very limited (UNSCEAR, 2000).

The UNSCEAR reference value for 210Po in fish products of 2 Bq/kg is much higher than the results obtained in this study of 0.125 Bq/kg. Polonium is known to accumulate in seafood and activity concentrations may be high when compared to concentrations in other food types. A study by Urban et al (2015) showed the levels in different types of fish were significantly higher than found in this study, ranging from less than 0.02 Bq/kg to 10.9 Bq/kg. The activity concentration may have also depended on the species of fish. Polonium-210 is generally higher in shellfish and large pelagic predators and may not be in secular equilibrium with the parent, 210Pb (Carvalho, 2011; Pearson et al., 2016a).

The consumption rates used in this study were different to UNSCEAR values. A comparison table can be found in Appendix 4, Table A.4.2. In particular, the consumption rates for the categories of ‘milk products’ and ‘roots and fruits’ were higher in this study, while ‘leafy vegetable’ and ‘fish products’ consumption rates were lower. The UNSCEAR consumption rate dataset was useful as a reference and as a way to compare studies. However, the differences demonstrate the importance of having country specific consumption rates to obtain a more accurate representation of dose for a given population.

The committed effective dose due to the consumption of food containing radionuclides was considerably less than the reference level of 1 mSv/year. Generally the ingestion dose for children was higher than for adults due to the higher dose coefficients for children. In this case, the differences were most notable for the ingestion of 228Ra, 210Po and 210Pb. The calculated doses were generally consistent with results obtained in other studies (Choi et al., 2008; Landstetter et al., 2013; UNSCEAR, 2000).

A comparison table of various studies reporting the activity concentrations of natural radionuclides in infant formula is presented in Appendix 6, Table A6.3. There was some consistency with international studies for 234U and 238U. The reported value in this study of 0.065 Bq/kg for 210Po was similar to the studies reported in Slovenia and India. The greatest difference was in the reported values for 226Ra. The reported values from this study of 0.033 Bq/kg were similar to those reported in the Slovenian study but were 1 to 2 orders of magnitude lower than the studies in Malaysia and Saudi Arabia. Further, the studies from Malaysia and Saudi Arabia included infant formula sourced from Australia. This may indicate that further investigation of radionuclide content of infant formula may be warranted to understand the differences in 226Ra activity concentrations. However, it is important to note that even if the 226Ra activity concentration from the Malaysian and Saudi Arabian data were applied, the dose to a formula fed infant would not be above 1 mSv/year.

When the doses were calculated with and without including the MDC comparison showed that there was generally no notable difference in the results (Table 9). A notable exception is the formula fed infant. The calculated dose to a formula fed infant which used the MDC values for 228Ra was more than double than the dose for when the activity concentration was assumed to be zero.

The dose contribution from anthropogenic radionuclides was found to be much lower than the 1 mSv/year reference level. In the majority of cases anthropogenic radionuclides were not detected. Where MDCs were used for dose estimates, the contributions were below 0.03 mSv/year for 241Am and below 0.01 mSv/year for the other radionuclides analysed.

Overall, the study showed that, based on the average Australian diet, the committed effective dose from the ingestion of food (excluding water) was very low at 0.059 mSv/year for adults. The total committed effective dose ranged from 0.017 for a breast fed infant to 0.30 mSv/year for a 2-year-old child. The differences in the dose with age group was dependent predominately on dose coefficients and rate of food consumption. The dose coefficients are generally higher in younger age groups, however, the food consumption increases with age resulting in some complexity with dose estimates.

There have been many large scale studies worldwide of cancer risk arising from ionising radiation exposure (UNSCEAR, 2006). The risk from exposure to high radiation doses is relatively well quantified, but for low radiation exposures the scientific evidence for increased health risk is more limited. While there is a possible increased risk of cancer at low radiation doses or for radiation delivered over a long period of time, scientific studies show that these effects are not always detectable within populations (UNSCEAR, 2017). However, the current Linear No Threshold (LNT) model for radiation protection indicates that the likelihood of effects increases as dose increases.

In order to differentiate between magnitudes of exposure of the whole body, it is useful to consider:

* very low doses (below 10 mSv), which corresponds to the range of exposure any member of the public may experience under normal circumstances on a yearly basis
* low doses (10 to 100 mSv), that may be incurred by a few individuals as a result of their profession, or from medical examinations
* moderate doses (100 mSv to 1 Sv), harmful tissue reactions may be detected if the dose is incurred under relatively short time periods, and where, at the higher dose end, acute effects of short-term exposures are to be expected
* high doses (more than 1 Sv), where acute effects from short-term exposures will occur.

Harmful tissue reactions, ranging from skin burns to vomiting, reduced blood cell counts and death, occur when doses are moderate to high (greater than about 500 mSv). Doses that may result in harmful tissue reactions are not a concern in food consumed in Australia, except in the event of a potential extreme accident situation.

# Conclusion

This study was conducted to evaluate the levels of anthropogenic and naturally occurring radionuclides in Australian foods that form the largest part of a typical Australian diet. The study was run in conjunction with the FSANZ as part of the 25th Australian Total Diet Survey. A total of 508 food samples were collected during autumn of 2013 and the summer of 2014. This sample set represented 88 different food types from different regions of the country. All of these foods were screened for anthropogenic radionuclides and 22 food types (as composites) were analysed for naturally occurring radionuclides. There were 248 samples collected during autumn and 260 samples were collected in summer to investigate seasonal impacts of food growing in Australia.

The study showed that the anthropogenic radionuclides, 60Co, 134Cs and 241Am were not detectable in any of the food samples analysed. Caesium-137 was detected at very low activity concentrations in only 2.4% of the samples. This meant that there was insufficient data to make comparisons between samples collected during the autumn and the summer sampling periods. Caesium-137 has a relatively long half-life and is present in the environment at trace levels in the southern hemisphere, primarily due to global fallout.

To ensure sufficient analytical sensitivity in measuring naturally occurring radionuclides, food samples of the same food type were combined to create composite samples. These composite samples were predominately from the summer sampling period. Naturally occurring radionuclides were detectable in all 22 composite food samples. The need for composites combined with the dominant representation from the autumn sampling period meant that seasonal comparisons in radionuclide content could not be made in this case.

The calculated committed effective dose due to the consumption of food containing radionuclides was estimated at less than 0.4 mSv/year for all age groups. Naturally occurring radionuclides contained within food contributed more to the overall dose than anthropogenic radionuclides. The highest contribution to the dose was from exposure to 228Ra, 210Po and 210Pb. The calculated population weighted average dose was less than 0.1 mSv/year. This dose represents a small fraction of the average background dose of 1.5 mSv/year to the Australian public (excluding medical exposures) (Webb et al., 1999). Therefore, the dose due to the consumption of food containing anthropogenic or naturally occurring radionuclides contributes only a very small portion of the overall dose to the population.

It was noted that there were some differences in the activity concentrations reported for infant formula when compared to international studies. Further investigation into infant formula may be warranted, although doses are not expected to be above 1 mSv/year for formula fed infants.

The focus of this study was food and excluded the contribution from the consumption of water. The average adult in Australia was estimated to consume approximately 2 litres of water in a day. Therefore this is an important consideration in the ingestion pathway and may contribute significantly to the overall dose. Further work is required to investigate the levels of radionuclides, especially the naturally occurring fraction, in water. These levels are expected to vary depending on the source of water. For example, there may be large differences if the water is obtained from a reservoir compared to an underground aquifer or between different geographical regions. Data on radionuclide levels in water and information on water consumption rates and water sources will be required to be able to determine the dose from the ingestion of drinking water.

# References

ABS, 2011, Australian Statistical Geography Standard: Statistical Area Level 1, Basic Community Profile.

ABS, 2014, National Nutrition and Physical Activity Survey.

AIHW, 2011, 2010 Australian National Infant Feeding Survey: indicator results, Canberra, Australia, Australian Institute of Health and Welfare.

AIRAC, 1975, AIRAC Report no. 2 Fallout over Australia from nuclear tests.

Al-Masri, M. S., H. Mukallati, H. Al-Hamwi, H. Khalili, M. Hassan, H. Assaf, Y. Amin, and Nashawati, 2004, Natural radionuclides in Syrian diet and their daily intake: Journal of Radioanalytical and Nuclear Chemistry, v. 260, p. 405-412.

ARPANSA, 2017, Guide for Radiation Protection in Existing Exposure Situations. Radiation Protection Series G-2.

Carvalho, F. P., 2011, Polonium (210Po) and lead (210Pb) in marine organisms and their transfer in marine food chains: Journal of Environmental Radioactivity, v. 102, p. 462-472.

Choi, M.-S., X.-J. Lin, S. A. Lee, W. Kim, H.-D. Kang, S.-H. Doh, D.-S. Kim, and D.-M. Lee, 2008, Daily intakes of naturally occurring radioisotopes in typical Korean foods: Journal of Environmental Radioactivity, v. 99, p. 1319-1323.

enHealth, 2012, Environmental Health Risk Assessment-Guidelines for assessing human health risks from environmental hazards, Commonwealth of Australia.

FAO/WHO, 1995, Codex Alimentarius International Food Standards, p. 59.

FSANZ, 2019, The 25th Australian Total Diet Study, Canberra, Australia.

IAEA, 2014, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. General Safety Requirements Part 3.

IAEA, 2017, Determination and Interpretation of Characteristic Limits for Radioactivity Measurements. IAEA/AQ/48, IAEA Analytical Quality in Nuclear Application Series, Vienna, IAEA.

ICRP, 2005, Doses to Infants from Ingestion of Radionuclides in Mother's Milk. ICRP Publication 95.

ICRP, 2012, Compendium of Dose Coefficients based on ICRP Publication 60. ICRP Publication 119. Anna. ICRP 41 (Suppl.).

Jemii, E., and T. Alharbi, 2018, Measurements of natural radioactivity in infant formula and radiological risk assessment: Journal of Radioanalytical and Nuclear Chemistry, v. 315, p. 157-161.

L'Annunziata, M. F., 2012, Handbook of Radioactivity Analysis.

Landstetter, C., M. Zapletal, M. Sinojmeri, and C. Katzlberger, 2013, Measurements of natural and artificial radionuclides in food samples and water for human consumption in Austria for the calculation of the ingestion dose: Journal of Radioanalytical and Nuclear Chemistry, v. 296, p. 905-908.

Longworth, and Geoff, 1998, The Radiochemical Manual.

Martin, A., and S. A. Harbison, 1996, An Introduction to Radiation Protection.

Martin, P., G. J. Hancock, A. Johnston, and A. S. Murray, 1998, Natural-series radionuclides in traditional North Australian aboriginal foods: Journal of Environmental Radioactivity, v. 40, p. 37-58.

Patra, A. C., S. Mohapatra, S. K. Sahoo, P. Lenka, J. S. Dubey, V. K. Thakur, A. V. Kumar, P. M. Ravi, and R. M. Tripathi, 2014, Assessment of ingestion dose due to radioactivity in selected food matrices near Vizag, India: Journal of Radioanalytical and Nuclear Chemistry, v. 300, p. 903-310.

Pearson, A. J., S. Gaw, N. Hermanspahn, and C. N. Glover, 2016a, Activity concentrations of 137Caesium and 210Polonium in seafood from fishing regions of New Zealand and the dose assessment for seafood consumers: Journal of Environmental Radioactivity, v. 151, Part 3, p. 542-550.

Pearson, A. J., S. Gaw, N. Hermanspan, and C. N. Glover, 2016b, Natural and anthropogenic radionuclide activity concentrations in the New Zealand diet: Journal of Environmental Radioactivity, v. 151, p. 601-608.

Pietrzak-Flis, Z., E. Chrzanowski, and S. Dembinska, 1997, Intake of 226Ra, 210Pb and 210Pb with food in Poland: The Science of the Total Environment, v. 203, p. 157-165.

Prabhath, R. K., S. R. Sreejith, M. G. Nair, D. D. Rao, and K. S. Pradeepkumar, 2015, Determination of Po-210 concentration in commercially available infant formulae and assessment of daily ingestion dose: Journal of Radiation Research and Applied Sciences, v. 8, p. 470-476.

Ryan, B., A. Bollhöfer, and P. Martin, 2008, Radionuclides and metals in freshwater mussels of the upper South Alligator River, Australia: Journal of Environmental Radioactivity, v. 99, p. 509-526.

Ryan, B., P. Martin, and M. Iles, 2005, Uranium-series radionuclides in native fruits and vegetables of northern Australia: Journal of Radioanalytical and Nuclear Chemistry, v. 264, p. 407-412.

Strok, M., and B. Smodis, 2009, Natural radionuclides in milk from the vicinity of a former uranium mine: International Conference Nuclear Energy for New Europe, p. 1011.1-1011.8.

Trdin, M., and L. Benedik, 2017, Uranium, polonium and thorium in infant formulas (power milk) and assessment of a cumulative ingestion dose: Journal of Food Composition and Analysis, v. 64, p. 198-202.

UNSCEAR, 2000, Sources and Effects of Ionizing Radiation, UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes.

UNSCEAR, 2006, UNSCEAR 2006 - Effects of ionising radiation Vol. 1 Report to the general assembly.

UNSCEAR, 2008, Sources and Effects of Ionizing Radiation, UNSCEAR 2008 Report, Volume 1: Sources Report to the General Assembly Scientific Annexes A and B.

UNSCEAR, 2013, Sources, Effects and Risks of Ionizing Radiation, UNSCEAR 2013 Report Volume 1 Report to the General Assembly.

UNSCEAR, 2017, UNSCEAR 2017 ANNEX B - Epidemiological studies of cancer risk due to low-dose-rate radiation from environmental sources.

Urban, D., J. Carpenter, S. Sdraulig, M. Grzechnik, and R. Tinker, 2015, Background Radioactivity in Northern Australian Seafood.

Uwatse, O. B., M. A. Olatunji, M. U. Khandaker, and Y. M. Amin, 2014, Radiation Dose to Malaysian Infants from Natural Radionuclides via Consumption of Powdered Milk: National Physics Conference, p. 120002-1-120002-5.

Webb, D. V., S. B. Solomon, and J. E. M. Thomson, 1999, Background radiation levels and medical exposure levels in Australia: Radiation Protection in Australasia, v. 16.

1. Dose coefficients

Table A1.1 Age related dose coefficients (selected anthropogenic radionuclides).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Radionuclide | Ingestion dose coefficient (Sv/Bq) | | | | | | |
| Infant – Breast milk (from adult intake) | Infant | 1-year-old | 5-year-old | 10-year-old | 15-year-old | Adult |
| 241Am | 8.5E-11 | 3.7E-6 | 3.7E-7 | 2.7E-7 | 2.2E-7 | 2.0E-7 | 2.0E-7 |
| 60Co | 2.0E-9 | 5.4E-8 | 2.7E-8 | 1.7E-8 | 1.1E-8 | 7.9E-9 | 3.4E-9 |
| 134Cs | 3.1E-9 | 2.6E-8 | 1.6E-8 | 1.3E-8 | 1.4E-8 | 1.9E-8 | 1.9E-8 |
| 137Cs | 2.6E-9 | 2.1E-8 | 1.2E-8 | 9.6E-9 | 1.0E-8 | 1.3E-8 | 1.3E-8 |
| 90Sr | 1.5E-8 | 2.3E-7 | 7.3E-8 | 4.7E-8 | 6.0E-8 | 8.0E-8 | 2.8E-8 |

Table A1.2 Age related dose coefficients (naturally occurring radionuclides)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Radionuclide | Ingestion dose coefficient (Sv/Bq) | | | | | | |
| Infant – Breast milk (from Adult intake) | Infant | 1-year-old | 5-year-old | 10-year-old | 15-year-old | Adult |
| 238U | 3.4E-11 | 3.4E-7 | 1.2E-7 | 8.0E-8 | 6.8E-8 | 6.7E-8 | 4.5E-8 |
| 234U | 3.6E-11 | 3.7E-7 | 1.3E-7 | 8.8E-8 | 7.4E-8 | 7.4E-8 | 4.9E-8 |
| 230Th | 3.9E-11 | 4.1E-6 | 4.1E-7 | 3.1E-7 | 2.4E-7 | 2.2E-7 | 2.1E-7 |
| 226Ra | 2.8E-8 | 4.7E-6 | 9.6E-7 | 6.2E-7 | 8.0E-7 | 1.5E-6 | 2.8E-7 |
| 210Pb | 2.2E-7 | 8.4E-6 | 3.6E-6 | 2.2E-6 | 1.9E-6 | 1.9E-6 | 6.9E-7 |
| 210Po | 7.1E-8 | 2.6E-5 | 8.8E-6 | 4.4E-6 | 2.6E-6 | 1.6E-6 | 1.2E-6 |
| 232Th | 6.0E-11 | 4.6E-6 | 4.5E-7 | 3.5E-7 | 2.9E-7 | 2.5E-7 | 2.3E-7 |
| 228Ra | 1.8E-7 | 3.0E-5 | 5.7E-6 | 3.4E-6 | 3.9E-6 | 5.3E-6 | 6.9E-7 |

1. Determination of reference activity concentration

Relevant equation -

Table A2.1 Age related dose coefficients (naturally occurring radionuclides)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Quantity | Dose criteria per nuclide (*i*) per age group (*j*) | Food consumption per age group (*j*) | Ingestion dose coefficient per nuclide (*i*) per age group (*j*) | Derived activity concentration per nuclide (*i*) per age group (*j*) |
| Variable | *Doseing,ij* | *Rj* | *DCing,ij* | *Ci,j* |
| Unit | mSv/year | kg/year | Sv/Bq | Bq/kg |
| Assumption | For the naturally occurring radionuclides (NORM), a reference level for exposure is set as the total committed effective dose of 1 mSv/year.  For the anthropogenic radionuclides, a reference level for exposure to each of the radionuclides was set as a committed effective dose of 1 mSv/year. | Total consumption per year is used.  No preferential nuclide uptake for food types.  Food consumption data based on international data from UNSCEAR. Infant formula treated separately due to it being a potential dominant pathway for infants, 800ml/day. | Age dependant ingestion dose coefficients from the ICRP.  In the case of NORM, the assumption is that the 238U & 232Th series are in equilibrium, this allows the dose coefficients to be summed. | The assumption of equilibrium for NORM materials means that the derived activity concentration can be applied to each NORM isotope within the 238U and 232Th series. |
| Examples | | | | |
| Anthropogenic: 241Am | | | | |
| Infant (formula) | 1 | 290 | 3.7E-6 | 0.9 |
| Infant | 1 | 265 | 3.7E-7 | 10 |
| Child | 1 | 395 | 2.7E-7 | 9 |
| Adult | 1 | 555 | 2.0E-7 | 9 |
| NORM: 238U & 232Th series | | | | |
| Infant (formula) | 1 | 290 | 8.5E-5 | 0.041 |
| Infant | 1 | 265 | 2.1E-5 | 0.18 |
| Child | 1 | 395 | 1.2E-5 | 0.21 |
| Adult | 1 | 555 | 3.5E-6 | 0.52 |

1. Analysis details – naturally occurring radionuclides

Information on sample preparation procedures and measurement, for the naturally occurring radionuclides, is provided below. Quality control samples, including check samples and method blanks were analysed with each batch of samples. Sample spikes and duplicate samples were also included randomly.

A3.1 Potassium-40

Potassium-40 is a naturally occurring gamma emitter. Information on the activity concentration of 40K was obtained for all samples as part of the screening for anthropogenic radionuclides using high-resolution gamma spectrometry.

A3.2 Polonium-210

The dried composite samples were used for the analysis of 210Po. A subsample (5–10 g) was weighed into a glass beaker, a known amount of tracer (209Po) was added and the sample digested using concentrated nitric acid and refluxed overnight. The following day the digestion was continued using a nitric acid/hydrogen peroxide mixture. The digested solution was evaporated to near dryness. Water was added and a manganese dioxide precipitation was used to separate the polonium from the matrix. The precipitate was dissolved using hydroxylamine hydrochloride (20% w/v) and hydrochloric acid. Ascorbic and citric acids were added, the pH adjusted to 1.5 - 2 and the polonium was then auto deposited onto a pre-cleaned silver disc. The discs were counted using alpha spectrometry.

A3.3 Lead-210

Ashed composite samples were used for the analysis of 210Pb. A known amount of stable lead was added to the samples. The samples were digested using nitric acid. If the dissolution was not complete additional ashing was undertaken. In this case, the solution was allowed to evaporate to dryness and the beaker was placed into a heated muffle furnace (300–400oC). This treatment was repeated until the remaining residue could be easily dissolved in dilute nitric acid.

The solution was passed through a column containing 3 g of Eichrom Sr resin rinsed with 70 mL of 2 M HCl. After the sample was loaded, the resin was rinsed with 60 mL of 2 M HCl to remove the radium fraction. The column was then rinsed using 50 mL of 6 M HNO3, separating the polonium from the column. The lead was eluted using 50 mL of 6 M HCl and collected in a small bottle. A small subsample of the eluate was taken for the analysis of lead, using flame atomic absorption spectrometry, to determine the recovery of the added lead. Polonium tracer (209Po) was added to the eluate and the sample allowed to sit for six months for in-growth of the decay product (210Po).

Following the in-growth period, the sample was transferred to a glass beaker. The sample bottle was rinsed with a small amount of concentrated nitric acid and this rinse was also added to the beaker. The polonium was separated using the manganese dioxide precipitation method previously described in section A3.2 and auto deposited onto a silver disc. The discs were counted using alpha spectrometry.

A3.4 Uranium/thorium

Separate subsamples were prepared for uranium and thorium radionuclides. Portions of the ashed composite samples were taken through an additional ashing step at 500oC. Tracer (232U or 229Th) and nitric acid were added to the ash. The acid was evaporated and, if necessary, samples re-ashed in a muffle furnace. This process was repeated until the sample easily dissolved in a solution of nitric acid.

The uranium/thorium was separated from the matrix by co-precipitation using calcium phosphate. This was then dissolved in 3 M HNO3-1 M Al(NO3)3 and loaded onto Eichrom resins, UTEVA resin for the separation of uranium and TEVA resin for the separation of thorium. The resins were rinsed to remove interfering radionuclides. The uranium was eluted using 0.5 M HCl and the thorium was eluted using 6 M HCl. The eluted radionuclides were evaporated and electrodeposited onto stainless steel discs from a sulphate solution. The discs were counted using alpha spectrometry.

A3.5 Radium

Separate subsamples were prepared for 226Ra and 228Ra. Ashed composite samples were re-ashed at 500oC. Tracer (133Ba) was added and the samples were dissolved, with additional ashing steps if required. The residue was dissolved in a dilute nitric acid solution. The radium and barium were separated using a lead sulphate precipitation. This precipitate was dissolved in DTPA and a barium sulphate precipitation was used to separate the radium/barium from other radionuclides. The radium/barium sulphate precipitate was counted using high resolution gamma spectrometry to determine the recovery of the added 133Ba tracer.

For 226Ra analysis, the precipitate was dissolved in EDTA and then a toluene based naphthalene scintillation cocktail was added to the solution. The samples were sealed and allowed to sit for a minimum of two weeks for the ingrowth of 222Rn decay products, before being measured using liquid scintillation counting with alpha/beta discrimination.

For the 228Ra, analysis the precipitate was left for a minimum of six months to allow for the ingrowth of 228Th. Tracer (229Th) was added and the precipitate was dissolved in EDTA. The thorium was then separated using an iron hydroxide precipitation. The precipitate was dissolved in a nitric acid solutions and TEVA Eichrom resin was used to purify the thorium. Electrodeposition onto stainless steel discs was used to prepare the source for counting by alpha spectrometry. The result for 228Ra was calculated based on the result of the 228Th.

A3.6 Alpha spectrometry/liquid scintillation counting

Canberra passivated implanted planar silicon (PIPS) detectors were used for alpha spectrometry measurements. The detectors have active area of 450 mm2 and a nominal resolution of 20 keV. Banks of twelve chambers are dedicated to different radionuclides (polonium, thorium and uranium) to reduce interferences. A layer of air and an applied bias voltage were applied to reduce contamination from recoil.

The detectors were calibrated using a mixed radionuclide electrodeposited source containing 238U, 234U, 239Pu and 241Am. The samples were placed on the highest shelf to maximise the efficiency. Apex-Alpha software was used for the treatment of data and calculation of results.

A Quantulus liquid scintillation counter was used for the determination of 226Ra. A set of calibrated standards (traceable to NIST), were prepared and used for the efficiency determination.

1. Food mapping and consumption rates

Table A4.1 Food consumption data provided by Foods Standards Australia and New Zealand

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ‘ARPANSA’ foods | Food represented in diet | Mean consumption (grams/person/day) | | | | |
| 2 years | 3–7 years | 8–12 years | 13–17 years | >18 years­ |
| Apples | Pome fruits (excludes juice; includes dried) | 64 | 70 | 90 | 55 | 49 |
| Bananas | Bananas, plantains, citrus fruits, kumquats, pineapple, jackfruit and melons. Excludes juice; includes dried | 71 | 71 | 75 | 46 | 54 |
| Beef mince | Meat, offal and fat from mammals (cattle, non-bird game, pork, deli meats (except poultry-based), lamb, mutton, goat, kangaroo and rabbit) | 36 | 43 | 65 | 80 | 86 |
| Bread | Breads (all types), buns, crumpets, English-style muffins | 65 | 81 | 100 | 110 | 91 |
| Cereal | Breakfast cereals, oats, flours and rice crackers | 43 | 58 | 66 | 60 | 53 |
| Broccoli | Broccoli, broccoflower, cauliflower, stalk and stem vegetables. Includes juices from these vegetables | 12 | 9.4 | 8.4 | 12 | 18 |
| Carrots | Root vegetables (non-starchy)-includes carrots, ginger, radishes, celeriac, horseradish, wasabi, sarsaparilla, chicory root, angelica root, gentian root, liquorice, ginseng and orris root. Includes juices from these vegetables | 19 | 17 | 19 | 19 | 25 |
| Chicken | Meat, offal and fat from poultry and game birds | 26 | 24 | 37 | 52 | 50 |
| Eggs | Eggs | 7.1 | 10 | 13 | 14 | 18 |
| Fish | All seafood including plain/crumbed/battered/smoked/canned fish, crustacea and molluscs | 7.9 | 8.1 | 14 | 12 | 26 |
| Infant formula | Infant formula | 2.7 | 0.2 | 0 | 0 | 0 |
| Fruit juice | Fruit juices, ciders and perry, wine | 76 | 79 | 95 | 100 | 140 |
| Lettuce | Cabbages, and Brussels sprouts; leafy vegetables and herbs | 6 | 7.6 | 12 | 15 | 25 |
| Milk | Milk, cream, butter, cheeses and yoghurt | 690 | 640 | 710 | 700 | 660 |
| Onions | Onions, shallots, spring onions, leeks and garlic; mushrooms | 6.2 | 5.5 | 6.5 | 12 | 14 |
| Pasta | Pasta, noodles (except rice) and couscous | 36 | 37 | 44 | 65 | 45 |
| Peanut butter | Seeds and tree nuts (including coconut); peanuts and peanut butter | 3 | 2.3 | 4.1 | 4.3 | 9.1 |
| Potatoes | Potatoes, Jerusalem artichokes, cassava, parsnips, swedes, sweet potatoes, taro, turnips | 35 | 56 | 80 | 110 | 94 |
| Rice | Rice and rice products (excluding rice crackers) and rice-based breakfast cereals | 20 | 34 | 32 | 51 | 51 |
| Tomatoes | Avocadoes and olives; capsicums, chillies and spices; cucumbers and chokos; fresh beans and bean sprouts; peas (fresh, dried and sprouts); pumpkins, squash, marrows and zucchini; sweetcorn; tomatoes/eggplant/okra (cooked or processed), tomatoes/eggplant/okra/pepino (raw or sun-dried) | 69 | 64 | 73 | 86 | 120 |
| Mango | Tropical fruits (smooth-skinned, except bananas, plantains, avocadoes & olives); tropical fruit (rough or furry skin, except pineapples and jackfruit) | 8.7 | 7.1 | 13 | 5.4 | 11 |
| Nectarine | Canned fruits (excluding pineapples); stone fruits and fresh figs; grapes; berries | 59 | 64 | 42 | 36 | 61 |
| Not classified | Coffee, teas (includes herbal), water (all sources) and intensely sweetened soft drinks, oils, chocolates and fudge; honey; sugars, confectionery and syrups | 690 | 940 | 1300 | 1600 | 2100 |

Table A4.2. Comparison of Australian consumption data with data in UNSCEAR (2000)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Food group | UNSCEAR (kg/y) | | | Australian data (kg/y) | | | | |
| Infant | Children | Adults | 2 years | 3–7 years | 8–12 years | 13–17 years | >18 years |
| Milk products | 120 | 110 | 120 | 253 | 234 | 259 | 256 | 241 |
| Meat products | 15 | 35 | 50 | 25 | 28 | 42 | 53 | 56 |
| Grain products | 45 | 90 | 140 | 60 | 77 | 88 | 104 | 88 |
| Leafy vegetables | 20 | 40 | 60 | 7 | 6 | 7 | 10 | 16 |
| Roots and fruits | 60 | 110 | 170 | 150 | 159 | 182 | 173 | 211 |
| Fish products | 5 | 10 | 15 | 3 | 3 | 5 | 4 | 9 |
| Water and beverages | 150 | 350 | 500 | Not classified | | | | |

1. Anthropogenic radionuclides plus 40K

Table A5.1 Autumn sampling program: activity concentration results. ND: not detected. The MDC for 60Co, 134Cs, 137Cs and 241Am was lower than 1 Bq/kg, for 40K lower than 5 Bq/kg and for infant formula, the MDC was 0.6 Bq/kg.

| ARPANSA sample no. | Sample | Activity concentration (Bq/kg) uncertainties k=1 | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| 40K | 60Co | 134Cs | 137Cs | 241Am |
| FA13-126-0266 | 234811-D-16 apples | 30.6 ± 2.0 | ND | ND | ND | ND |
| FA13-126-0267 | 237568-D-13 apples | 29.7 ± 2.0 | ND | ND | ND | ND |
| FA13-126-0268 | 234762-D-13 apples | 33.2 ± 2.1 | ND | ND | ND | ND |
| FA13-126-0269 | 234910-D-1 apples | 31.4 ± 2.0 | ND | ND | ND | ND |
| FA13-126-0270 | Composite apple | 33.3 ± 1.9 | ND | ND | ND | ND |
| FA13-126-0271 | 234811-D-17 bananas | 96.0 ± 5.6 | ND | ND | ND | ND |
| FA13-126-0272 | 234762-D-30 bananas | 145.6 ± 8.5 | ND | ND | ND | ND |
| FA13-126-0273 | 234910-D-2 bananas | 106.2 ± 6.2 | ND | ND | ND | ND |
| FA13-126-0274 | 237568-D-14 bananas | 100.2 ± 5.9 | ND | ND | ND | ND |
| FA13-126-0275 | Composite bananas | 111.1 ± 6.2 | ND | ND | ND | ND |
| FA13-126-0276 | 234746-D-13 beef mince | 115.9 ± 7.4 | ND | ND | ND | ND |
| FA13-126-0277 | 235141-D-23 beef mince | 153.5 ± 9.4 | ND | ND | 0.197 ± 0.057 | ND |
| FA13-126-0278 | 236936-D-15 beef mince | 132.8 ± 8.1 | ND | ND | ND | ND |
| FA13-126-0279 | 235756-D-21 beef mince | 122.6 ± 7.5 | ND | ND | ND | ND |
| FA13-126-0280 | Composite beef mince | 137.8 ± 7.7 | ND | ND | 0.0847 ± 0.0073 | ND |
| FA13-126-0281 | 234811-D-11 bread | 30.5 ± 3.0 | ND | ND | ND | ND |
| FA13-126-0282 | 234762-D-14 bread | 37.4 ± 2.9 | ND | ND | ND | ND |
| FA13-126-0283 | 234910-D-23 bread | 39.7 ± 3.3 | ND | ND | ND | ND |
| FA13-126-0284 | 237568-D-16 bread | 47.4 ± 3.2 | ND | ND | ND | ND |
| FA13-126-0285 | Composite bread | 38.4 ± 2.2 | ND | ND | ND | ND |
| FA13-126-0286 | 234811-D-2 cereal | 105.9 ± 6.1 | ND | ND | ND | ND |
| FA13-126-0287 | 234910-D-11 cereal | 93.1 ± 6.1 | ND | ND | ND | ND |
| FA13-126-0288 | Composite cereal | 107.2 ± 6.0 | ND | ND | ND | ND |
| FA13-126-0289 | 234746-D-15 broccoli | 95.3 ± 5.6 | ND | ND | ND | ND |
| FA13-126-0290 | 235141-D-13 broccoli | 97.3 ± 5.6 | ND | ND | ND | ND |
| FA13-126-0291 | 236936-D-17 broccoli | 125.7 ± 7.3 | ND | ND | ND | ND |
| FA13-126-0292 | 235756-D-4 broccoli | 95.6 ± 5.6 | ND | ND | ND | ND |
| FA13-126-0293 | Composite broccoli | 102.4 ± 5.9 | ND | ND | ND | ND |
| FA13-126-0294 | 234746-D-16 carrots | 38.0 ± 2.4 | ND | ND | ND | ND |
| FA13-126-0295 | 235141-D-14 carrots | 56.5 ± 3.3 | ND | ND | ND | ND |
| FA13-126-0296 | 236936-D-18 carrots | 42.3 ± 2.6 | ND | ND | ND | ND |
| FA13-126-0297 | 235756-D-5 carrots | 39.6 ± 2.4 | ND | ND | ND | ND |
| FA13-126-0298 | Composite carrots | 46.4 ± 2.6 | ND | ND | 0.0123 ± 0.0024 | ND |
| FA13-126-0299 | 234746-D-18 chicken | 151.2 ± 9.0 | ND | ND | ND | ND |
| FA13-126-0300 | 235141-D-24 chicken | 147.2 ± 9.0 | ND | ND | ND | ND |
| FA13-126-0301 | 236936-D-20 chicken | 118.0 ± 7.2 | ND | ND | ND | ND |
| FA13-126-0302 | 235756-D-22 chicken | 110.8 ± 6.9 | ND | ND | ND | ND |
| FA13-126-0303 | Composite chicken | 133.0 ± 7.4 | ND | ND | 0.0175 ± 0.0025 | ND |
| FA13-126-0304 | 234746-D-19 eggs | 34.8 ± 2.6 | ND | ND | ND | ND |
| FA13-126-0305 | 235141-D-16 eggs | 33.1 ± 2.5 | ND | ND | ND | ND |
| FA13-126-0306 | 236936-D-21 eggs | 38.1 ± 2.7 | ND | ND | ND | ND |
| FA13-126-0307 | 235756-D-7 eggs | 38.8 ± 2.8 | ND | ND | ND | ND |
| FA13-126-0308 | Composite eggs | 36.5 ± 2.0 | ND | ND | ND | ND |
| FA13-126-0309 | 234746-D-4 fish | 58.9 ± 3.9 | ND | ND | ND | ND |
| FA13-126-0310 | 235756-D-13 fish | 74.5 ± 4.7 | ND | ND | 0.133 ± 0.034 | ND |
| FA13-126-0311 | Composite fish | 71.5 ± 4.0 | ND | ND | 0.0523 ± 0.0042 | ND |
| FA13-126-0312 | 234762-D-6 infant formula | 23.0 ± 2.0 | ND | ND | ND | ND |
| FA13-126-0313 | 237568-D-6 infant formula | 15.8 ± 1.2 | ND | ND | ND | ND |
| FA13-126-0314 | Composite infant formula | 21.7 ± 1.2 | ND | ND | 0.0055 ± 0.0015 | ND |
| FA13-126-0315 | 234811-D-5 fruit juice | 31.9 ± 2.1 | ND | ND | ND | ND |
| FA13-126-0316 | 234910-D-15 fruit juice | 45.1 ± 2.7 | ND | ND | ND | ND |
| FA13-126-0317 | Composite fruit juice | 41.4 ± 2.3 | ND | ND | ND | ND |
| FA13-126-0318 | 234811-D-26 lettuce | 51.2 ± 3.2 | ND | ND | ND | ND |
| FA13-126-0319 | 234762-D-21 lettuce | 62.2 ± 3.8 | ND | ND | ND | ND |
| FA13-126-0320 | 234910-D-29 lettuce | 49.5 ± 3.0 | ND | ND | ND | ND |
| FA13-126-0321 | 237568-D-24 lettuce | 40.0 ± 2.6 | ND | ND | ND | ND |
| FA13-126-0322 | Composite lettuce | 51.1 ± 2.9 | ND | ND | ND | ND |
| FA13-126-0323 | 234746-D-23 milk | 40.9 ± 2.9 | ND | ND | ND | ND |
| FA13-126-0324 | 235141-D-27 milk | 39.6 ± 2.7 | ND | ND | 0.137 ± 0.039 | ND |
| FA13-126-0325 | 236936-D-25 milk | 38.7 ± 2.8 | ND | ND | ND | ND |
| FA13-126-0326 | 235756-D-9 milk | 40.0 ± 2.6 | ND | ND | ND | ND |
| FA13-126-0327 | Composite milk | 43.1 ± 2.4 | ND | ND | 0.0332 ± 0.0035 | ND |
| FA13-126-0328 | 234811-D-12 onions | 59.9 ± 4.1 | ND | ND | ND | ND |
| FA13-126-0329 | 234762-D-23 onions | 62.0 ± 4.1 | ND | ND | ND | ND |
| FA13-126-0330 | 234910-D-30 onions | 67.8 ± 4.3 | ND | ND | ND | ND |
| FA13-126-0331 | 237568-D-26 onions | 59.9 ± 3.9 | ND | ND | ND | ND |
| FA13-126-0332 | Composite onions | 63.6 ± 3.7 | ND | ND | ND | ND |
| FA13-126-0333 | 234762-D-8 pasta | 17.1 ± 1.5 | ND | ND | ND | ND |
| FA13-126-0334 | 237568-D-8 pasta | 18.3 ± 1.4 | ND | ND | ND | ND |
| FA13-126-0335 | Composite pasta | 17.9 ± 1.0 | ND | ND | ND | ND |
| FA13-126-0336 | 235141-D-7 peanut butter | 193 ± 11 | ND | ND | ND | ND |
| FA13-126-0337 | 236936-D9 peanut butter | 191 ± 11 | ND | ND | ND | ND |
| FA13-126-0338 | Composite peanut butter | 193 ± 11 | ND | ND | 0.0451 ± 0.0094 | ND |
| FA13-126-0339 | 234811-D-13 potatoes | 57.9 ± 3.6 | ND | ND | ND | ND |
| FA13-126-0340 | 234762-D-24 potatoes | 50.4 ± 3.2 | ND | ND | ND | ND |
| FA13-126-0341 | 234910-D-31 potatoes | 106.6 ± 6.2 | ND | ND | ND | ND |
| FA13-126-0342 | 237568-D-27 potatoes | 99.8 ± 5.8 | ND | ND | ND | ND |
| FA13-126-0343 | Composite potatoes | 82.6 ± 4.6 | ND | ND | ND | ND |
| FA13-126-0344 | 234762-D-10 rice | 4.82 ± 0.94 | ND | ND | ND | ND |
| FA13-126-0345 | 237568-D-10 rice | 6.66 ± 0.86 | ND | ND | ND | ND |
| FA13-126-0346 | Composite rice | 7.57 ± 0.44 | ND | ND | ND | ND |
| FA13-126-0347 | 234811-D-30 tomatoes | 72.0 ± 4.3 | ND | ND | ND | ND |
| FA13-126-0348 | 234762-D-27 tomatoes | 57.5 ± 3.4 | ND | ND | ND | ND |
| FA13-126-0349 | 237568-D-30 tomatoes | 68.4 ± 4.1 | ND | ND | ND | ND |
| FA13-126-0350 | 237568-D-30 tomatoes | 62.7 ± 3.7 | ND | ND | ND | ND |
| FA13-126-0351 | Composite tomatoes | 66.1 ± 3.7 | ND | ND | ND | ND |
| FA13-134-0364 | 234746-D-1 Bacon | 84.4 ± 5.0 | ND | ND | ND | ND |
| FA13-134-0365 | 235756-D-11 Bacon | 138.3 ± 8.4 | ND | ND | ND | ND |
| FA13-134-0366 | 234811-D-24 Beans, green | 67.5 ± 4.1 | ND | ND | ND | ND |
| FA13-134-0367 | 234762-D-20 Beans, green | 49.3 ± 3.0 | ND | ND | ND | ND |
| FA13-134-0368 | 234910-D-27 Beans, green | 71.4 ± 4.6 | ND | ND | ND | ND |
| FA13-134-0369 | 237568-D-22 Beans, green | 84.2 ± 5.2 | ND | ND | ND | ND |
| FA13-134-0370 | 234811-D-18 Bok choi | 76.3 ± 5.1 | ND | ND | ND | ND |
| FA13-134-0371 | 234762-D-31 Bok choi | 56.9 ± 3.6 | ND | ND | ND | ND |
| FA13-134-0372 | 234910-D-22 Bok choi | 95.8 ± 5.6 | ND | ND | ND | ND |
| FA13-134-0373 | 237568-D-15 Bok choi | 127.3 ± 7.4 | ND | ND | ND | ND |
| FA13-134-0374 | 234746-D-14 Bread, multigrain | 63.7 ± 4.1 | ND | ND | ND | ND |
| FA13-134-0375 | 235141-D-12 Bread, multigrain | 60.0 ± 3.8 | ND | ND | ND | ND |
| FA13-134-0376 | 236936-D-16 Bread, multigrain | 51.3 ± 3.2 | ND | ND | ND | ND |
| FA13-134-0377 | 235756-D-3 Bread, multigrain | 51.3 ± 3.8 | ND | ND | ND | ND |
| FA13-134-0378 | 235141-D-20 Butter | 3.94 ± 0.78 | ND | ND | ND | ND |
| FA13-134-0379 | 236936-D-3 Butter | 6.64 ± 0.93 | ND | ND | ND | ND |
| FA13-134-0380 | 234746-D-3 Cake, chocolate, iced | 72.2 ± 4.3 | ND | ND | ND | ND |
| FA13-134-0381 | 235756-D-1 Cake, chocolate, iced | 65.1 ± 4.0 | ND | ND | ND | ND |
| FA13-134-0382 | 234811-D-19 Capsicum | 53.3 ± 3.6 | ND | ND | ND | ND |
| FA13-134-0383 | 234762-D-15 Capsicum | 60.1 ± 4.0 | ND | ND | ND | ND |
| FA13-134-0384 | 234910-D-24 Capsicum | 54.0 ± 3.3 | ND | ND | ND | ND |
| FA13-134-0385 | 237568-D-17 Capsicum | 67.1 ± 4.0 | ND | ND | ND | ND |
| FA13-134-0386 | 234811-D-20 Cauliflower | 76.2 ± 4.6 | ND | ND | ND | ND |
| FA13-134-0387 | 234762-D-16 Cauliflower | 50.3 ± 3.1 | ND | ND | ND | ND |
| FA13-134-0388 | 234910-D-3 Cauliflower | 91.6 ±5.3 | ND | ND | ND | ND |
| FA13-134-0389 | 237568-D-18 Cauliflower | 78.6 ± 5.1 | ND | ND | ND | ND |
| FA13-134-0390 | 234746-D-17 Celery | 80.3 ± 4.7 | ND | ND | ND | ND |
| FA13-134-0391 | 235141-D-15 Celery | 84.9 ± 5.5 | ND | ND | ND | ND |
| FA13-134-0392 | 236936-D-19 Celery | 86.7 ± 5.5 | ND | ND | ND | ND |
| FA13-134-0393 | 235756-D-6 Celery | 104.2 ± 6.4 | ND | ND | ND | ND |
| FA13-134-0394 | 234811-D-21 Cheese, cheddar, full fat | 22.0 ± 1.8 | ND | ND | ND | ND |
| FA13-134-0395 | 234762-D-17 Cheese, cheddar, full fat | 17.7 ± 1.5 | ND | ND | ND | ND |
| FA13-134-0396 | 234910-D-25 Cheese, cheddar, full fat | 21.2 ± 1.6 | ND | ND | ND | ND |
| FA13-134-0397 | 237568-D-19 Cheese, cheddar, full fat | 22.7 ± 1.6 | ND | ND | ND | ND |
| FA13-134-0398 | 234762-D-3 Chocolate, milk | 119.8 ± 7.4 | ND | ND | ND | ND |
| FA13-134-0399 | 237568-D-3 Chocolate, milk | 138.8 ± 8.4 | ND | ND | ND | ND |
| FA13-134-0400 | 235141-D-3 Coffee, instant | 10.52 ± 0.94 | ND | ND | ND | ND |
| FA13-134-0401 | 236936-D-4 Coffee, instant | 24.1 ± 2.0 | ND | ND | ND | ND |
| FA13-134-0402 | 234811-D-22 Cucumber | 51.5 ± 3.5 | ND | ND | ND | ND |
| FA13-134-0403 | 234762-D-18 Cucumber | 56.6 ± 3.8 | ND | ND | ND | ND |
| FA13-134-0404 | 234910-D-26 Cucumber | 45.2 ± 3.1 | ND | ND | ND | ND |
| FA13-134-0405 | 237568-D-20 Cucumber | 45.0 ± 2.8 | ND | ND | ND | ND |
| FA13-134-0406 | 234811-D-23 Fish fillets, plain from takeaway | 104.2 ± 6.2 | ND | ND | ND | ND |
| FA13-134-0407 | 234762-D-19 Fish fillets, plain from takeaway | 83.6 ± 4.9 | ND | ND | ND | ND |
| FA13-134-0408 | 234910-D-7 Fish fillets, plain from takeaway | 114.5 ± 6.6 | ND | ND | ND | ND |
| FA13-134-0409 | 237568-D-21 Fish fillets, plain from takeaway | 105.8 ± 6.8 | ND | ND | ND | ND |
| FA13-134-0410 | 234762-D-4 Garlic | 180 ± 10 | ND | ND | ND | ND |
| FA13-134-0411 | 237568-D-4 Garlic | 181 ± 10 | ND | ND | ND | ND |
| FA13-134-0412 | 234746-D-20 Grapes | 70.7 ± 4.5 | ND | ND | ND | ND |
| FA13-134-0413 | 235141-D-17 Grapes | 67.4 ± 4.0 | ND | ND | ND | ND |
| FA13-134-0414 | 236936-D-22 Grapes | 80.7 ± 5.1 | ND | ND | ND | ND |
| FA13-134-0415 | 235756-D-8 Grapes | 81.3 ± 5.0 | ND | ND | ND | ND |
| FA13-134-0416 | 234811-D-14 Ham, sliced delicatessen style | 163.5 ± 9.5 | ND | ND | ND | ND |
| FA13-134-0417 | 234910-D-13 Ham, sliced delicatessen style | 169.6 ± 9.7 | ND | ND | ND | ND |
| FA13-134-0418 | 234746-D-21 Hamburger | 59.5 ± 4.0 | ND | ND | ND | ND |
| FA13-134-0419 | 235141-D-25 Hamburger | 63.9 ± 3.8 | ND | ND | ND | ND |
| FA13-134-0420 | 236936-D-23 Hamburger | 55.7 ± 3.3 | ND | ND | ND | ND |
| FA13-134-0421 | 235756-D-23 Hamburger | 53.9 ± 3.6 | ND | ND | ND | ND |
| FA13-134-0422 | 234746-D-5 Hot chocolate beverage | 17.2 ± 1.5 | ND | ND | ND | ND |
| FA13-134-0423 | 235756-D-14 Hot chocolate beverage | 54.6 ± 3.6 | ND | ND | ND | ND |
| FA13-134-0424 | 234910-D-33 Ice cream, full fat, vanilla | 49.7 ± 3.2 | ND | ND | ND | ND |
| FA13-134-0425 | 237568-D-5 Ice cream, full fat, vanilla | 40.0 ± 2.9 | ND | ND | ND | ND |
| FA13-134-0426 | 234811-D-4 Infant cereal, mixed | 11.72 ± 0.85 | ND | ND | ND | ND |
| FA13-134-0427 | 234910-D-14 Infant cereal, mixed | 8.23 ± 0.76 | ND | ND | ND | ND |
| FA13-134-0428 | 235141-D-5 Infant dessert, milk based | 28.7 ± 1.9 | ND | ND | ND | ND |
| FA13-134-0429 | 236936-D-6 Infant dessert, milk based | 22.8 ± 1.8 | ND | ND | ND | ND |
| FA13-134-0430 | 234746-D-6 Infant dinner | 67.0 ± 4.2 | ND | ND | ND | ND |
| FA13-134-0431 | 235756-D-15 Infant dinner | 50.2 ± 3.1 | ND | ND | ND | ND |
| FA13-134-0432 | 234811-D-25 Kiwifruit | 81.5 ± 4.9 | ND | ND | ND | ND |
| FA13-134-0433 | 234762-D-32 Kiwifruit | 87.1 ± 5.4 | ND | ND | ND | ND |
| FA13-134-0434 | 234910-D-28 Kiwifruit | 83.6 ± 5.0 | ND | ND | ND | ND |
| FA13-134-0435 | 237568-D-23 Kiwifruit | 88.5 ± 5.1 | ND | ND | ND | ND |
| FA13-134-0436 | 234746-D-22 Lamb chops, loin | 93.7 ± 5.5 | ND | ND | ND | ND |
| FA13-134-0437 | 235141-D-26 Lamb chops, loin | 105.9 ± 6.2 | ND | ND | 0.248 ± 0.040 | ND |
| FA13-134-0438 | 236936-D-24 Lamb chops, loin | 98.3 ± 5.6 | ND | ND | ND | ND |
| FA13-134-0439 | 235756-D-24 Lamb chops, loin | 85.9 ± 5.3 | ND | ND | ND | ND |
| FA13-134-0440 | 235141-D-21 Liver pate (chicken) | 48.3 ± 3.2 | ND | ND | ND | ND |
| FA13-134-0441 | 236936-D-7 Liver pate (chicken) | 85.0 ± 5.1 | ND | ND | ND | ND |
| FA13-134-0442 | 234762-D-7 Margarine, monounsaturated | 24.1 ± 1.9 | ND | ND | ND | ND |
| FA13-134-0443 | 237568-D-7 Margarine, monounsaturated | 21.6 ± 1.6 | ND | ND | ND | ND |
| FA13-134-0444 | 234811-D-27 Mushrooms | 101.5 ± 6.2 | ND | ND | ND | ND |
| FA13-134-0445 | 234762-D-22 Mushrooms | 97.7 ± 5.8 | ND | ND | ND | ND |
| FA13-134-0446 | 234910-D-8 Mushrooms | 107.8 ± 6.3 | ND | ND | ND | ND |
| FA13-134-0447 | 237568-D-25 Mushrooms | 108.6 ± 6.6 | ND | ND | ND | ND |
| FA13-134-0448 | 234811-D-15 Mussels | 25.0 ± 1.6 | ND | ND | ND | ND |
| FA13-134-0449 | 234910-D-16 Mussels | 21.0 ± 1.8 | ND | ND | ND | ND |
| FA13-134-0450 | 235141-D-6 Oats, rolled | 12.9 ± 1.1 | ND | ND | ND | ND |
| FA13-134-0451 | 236936-D-8 Oats, rolled | 15.7 ± 1.0 | ND | ND | ND | ND |
| FA13-134-0452 | 234746-D-24 Orange | 52.4 ± 3.2 | ND | ND | ND | ND |
| FA13-134-0453 | 235141-D-18 Orange | 52.7 ± 3.2 | ND | ND | ND | ND |
| FA13-134-0454 | 236936-D-26 Orange | 53.3 ± 3.2 | ND | ND | ND | ND |
| FA13-134-0455 | 235756-D-10 Orange | 50.0 ± 3.4 | ND | ND | ND | ND |
| FA13-134-0456 | 234746-D-8 Peas, frozen | 30.6 ± 2.2 | ND | ND | ND | ND |
| FA13-134-0457 | 235756-D-17 Peas, frozen | 43.8 ± 2.8 | ND | ND | ND | ND |
| FA13-158-0503 | 235141-D-1 Almonds | 225 ± 13 | ND | ND | ND | ND |
| FA13-158-0504 | 236936-D-1 Almonds | 235 ± 14 | ND | ND | ND | ND |
| FA13-158-0505 | 234762-D-1 Baked beans in tomato sauce | 77.4 ± 4.6 | ND | ND | ND | ND |
| FA13-158-0506 | 237568-D-1 Baked beans in tomato sauce | 86.0 ± 5.0 | ND | ND | ND | ND |
| FA13-158-0507 | 234811-D-1 Beer, full strength | 5.56 ± 0.90 | ND | ND | ND | ND |
| FA13-158-0508 | 234910-D-10 Beer, full strength | 7.5 ± 1.0 | ND | ND | ND | ND |
| FA13-158-0509 | 235141-D-2 Beetroot, canned | 56.2 ± 3.3 | ND | ND | ND | ND |
| FA13-158-0510 | 236936-D-2 Beetroot, canned | 61.2 ± 3.7 | ND | ND | ND | ND |
| FA13-158-0511 | 234746-D-2 Biscuits, savoury | 55.7 ± 4.0 | ND | ND | ND | ND |
| FA13-158-0512 | 235756-D-12 Biscuits, savoury | 50.2 ± 3.5 | ND | ND | ND | ND |
| FA13-158-0513 | 234762-D-2 Breakfast cereals, rice based | 32.7 ± 2.0 | ND | ND | ND | ND |
| FA13-158-0514 | 237568-D-2 Breakfast cereals, rice based | 27.1 ± 1.6 | ND | ND | ND | ND |
| FA13-158-0515 | 234811-D-3 Coconut, desiccated | 236 ± 14 | ND | ND | ND | ND |
| FA13-158-0516 | 234910-D-12 Coconut, desiccated | 230 ± 14 | ND | ND | ND | ND |
| FA13-158-0517 | 235141-D-4 Honey | 16.8 ± 1.0 | ND | ND | ND | ND |
| FA13-158-0518 | 236936-D-5 Honey | 19.9 ± 1.6 | ND | ND | ND | ND |
| FA13-158-0519 | 234746-D-7 Oil, canola and olive | ND | ND | ND | ND | ND |
| FA13-158-0520 | 235756-D-16 Oil, canola and olive | ND | ND | ND | ND | ND |
| FA13-158-0521 | 234811-D-6 Peach, natural juice | 43.3 ± 3.0 | ND | ND | ND | ND |
| FA13-158-0522 | 234910-D-17 Peach, natural juice | 37.3 ± 2.5 | ND | ND | ND | ND |
| FA13-158-0523 | 234762-D-9 Pie, meat, individual size | 72.9 ± 4.6 | ND | ND | ND | ND |
| FA13-158-0524 | 237568-D-9 Pie, meat, individual size | 41.7 ± 2.6 | ND | ND | ND | ND |
| FA13-158-0525 | 234811-D-7 Pineapple, canned in natural juice | 29.5 ± 1.8 | ND | ND | ND | ND |
| FA13-158-0526 | 234910-D-18 Pineapple, canned in natural juice | 26.7 ± 2.2 | ND | ND | ND | ND |
| FA13-158-0527 | 235141-D-22 Pizza, meat and vege topping | 63.7 ± 4.2 | ND | ND | ND | ND |
| FA13-158-0528 | 236936-D-10 Pizza, meat and vege topping | 59.8 ± 4.0 | ND | ND | ND | ND |
| FA13-158-0529 | 234746-D-9 Potato crisps | 369 ± 22 | ND | ND | ND | ND |
| FA13-158-0530 | 235756-D-18 Potato crisps | 398 ± 22 | ND | ND | ND | ND |
| FA13-158-0531 | 234746-D-25 Prawns, cooked | 38.0 ± 2.5 | ND | ND | ND | ND |
| FA13-158-0532 | 235141-D-28 Prawns, cooked | 50.6 ± 3.2 | ND | ND | ND | ND |
| FA13-158-0533 | 236936-D-27 Prawns, cooked | 45.1 ± 2.8 | ND | ND | ND | ND |
| FA13-158-0534 | 235756-D-25 Prawns, cooked | 11.92 ± 0.88 | ND | ND | ND | ND |
| FA13-158-0535 | 234762-D-25 Pumpkin | 68.7 ± 4.2 | ND | ND | ND | ND |
| FA13-158-0536 | 234910-D-4 Pumpkin | 103.5 ± 6.1 | ND | ND | ND | ND |
| FA13-158-0537 | 237568-D-28 Pumpkin | 82.8 ± 4.9 | ND | ND | ND | ND |
| FA13-158-0538 | 234811-D-28 Pumpkin | 77.6 ± 5.0 | ND | ND | ND | ND |
| FA13-158-0539 | 234811-D-8 Sauce, savoury,  non-tomato | 27.4 ± 2.0 | ND | ND | ND | ND |
| FA13-158-0540 | 234910-D-19 Sauce, savoury,  non-tomato | 70.8 ± 4.4 | ND | ND | ND | ND |
| FA13-158-0541 | 235141-D-8 Sauce, tomato | 83.2 ± 5.0 | ND | ND | ND | ND |
| FA13-158-0542 | 236936-D-11 Sauce, tomato | 49.0 ± 3.0 | ND | ND | ND | ND |
| FA13-158-0543 | 234746-D-26 Sausages, beef | 77.1 ± 4.8 | ND | ND | ND | ND |
| FA13-158-0544 | 235141-D-29 Sausages, beef | 84.4 ± 5.3 | ND | ND | ND | ND |
| FA13-158-0545 | 236936-D-28 Sausages, beef | 63.1 ± 3.8 | ND | ND | ND | ND |
| FA13-158-0546 | 235756-D-26 Sausages, beef | 69.3 ± 4.2 | ND | ND | ND | ND |
| FA13-158-0547 | 234746-D-10 Soft drink | ND | ND | ND | ND | ND |
| FA13-158-0548 | 235756-D-19 Soft drink | 1.37 ± 0.32 | ND | ND | ND | ND |
| FA13-158-0549 | 234762-D-11 Soy beverage, full fat | 36.4 ± 2.7 | ND | ND | ND | ND |
| FA13-158-0550 | 237568-D-11 Soy beverage, full fat | 44.0 ± 3.0 | ND | ND | ND | ND |
| FA13-158-0551 | 234811-D-29 Strawberries | 53.3 ± 3.3 | ND | ND | ND | ND |
| FA13-158-0552 | 234762-D-26 Strawberries | 53.1 ± 3.2 | ND | ND | ND | ND |
| FA13-158-0553 | 234910-D-9 Strawberries | 55.6 ± 3.8 | ND | ND | ND | ND |
| FA13-158-0554 | 237568-D-29 Strawberries | 56.9 ± 3.8 | ND | ND | ND | ND |
| FA13-158-0555 | 234811-D-9 Sugar, white | ND | ND | ND | ND | ND |
| FA13-158-0556 | 234910-D-20 Sugar, white | ND | ND | ND | ND | ND |
| FA13-158-0557 | 235141-D-9 Sultanas | 283 ± 16 | ND | ND | ND | ND |
| FA13-158-0558 | 236936-D-12 Sultanas | 256 ± 15 | ND | ND | ND | ND |
| FA13-158-0559 | 234746-D-27 Sushi roll, nori | 44.9 ± 3.1 | ND | ND | ND | ND |
| FA13-158-0560 | 235141-D-30 Sushi roll, nori | 36.7 ± 2.6 | ND | ND | ND | ND |
| FA13-158-0561 | 236936-D-29 Sushi roll, nori | 44.9 ± 2.8 | ND | ND | ND | ND |
| FA13-158-0562 | 235756-D-27 Sushi roll, nori | 25.2 ± 1.8 | ND | ND | ND | ND |
| FA13-158-0563 | 234746-D-11 Sweetcorn, kernels, frozen | 48.0 ± 3.2 | ND | ND | ND | ND |
| FA13-158-0564 | 235756-D-20 Sweetcorn, kernels, frozen | 71.5 ± 4.5 | ND | ND | ND | ND |
| FA13-158-0565 | 234762-D-12 Tea | 3.80 ± 0.60 | ND | ND | ND | ND |
| FA13-158-0566 | 237568-D-12 Tea | 3.36 ± 0.54 | ND | ND | ND | ND |
| FA13-158-0567 | 234811-D-10 Tomatoes, canned | 76.1 ± 4.8 | ND | ND | ND | ND |
| FA13-158-0568 | 234910-D-21 Tomatoes, canned | 95.6 ± 5.6 | ND | ND | ND | ND |
| FA13-158-0569 | 235141-D-10 Tuna, canned in brine | 51.8 ± 3.2 | ND | ND | ND | ND |
| FA13-158-0570 | 236936-D-13 Tuna, canned in brine | 64.7 ± 3.9 | ND | ND | ND | ND |
| FA13-158-0571 | 234746-D-28 Water, tap | ND | ND | ND | ND | ND |
| FA13-158-0572 | 235141-D-31 Water, tap | ND | ND | ND | ND | ND |
| FA13-158-0573 | 236936-D-30 Water, tap | ND | ND | ND | ND | ND |
| FA13-158-0574 | 235756-D-28 Water, tap | ND | ND | ND | ND | ND |
| FA13-158-0575 | 234811-D-31 Watermelon | 36.8 ± 2.4 | ND | ND | ND | ND |
| FA13-158-0576 | 234762-D-28 Watermelon | 38.3 ± 2.8 | ND | ND | ND | ND |
| FA13-158-0577 | 234910-D-6 Watermelon | 39.9 ± 2.5 | ND | ND | ND | ND |
| FA13-158-0578 | 237568-D-31 Watermelon | 32.0 ± 2.0 | ND | ND | ND | ND |
| FA13-158-0579 | 234746-D-29 Wine, red and white | 23.9 ± 1.8 | ND | ND | ND | ND |
| FA13-158-0580 | 235141-D-19 Wine, red and white | 21.7 ± 1.5 | ND | ND | ND | ND |
| FA13-158-0581 | 236936-D-31 Wine, red and white | 20.9 ± 1.5 | ND | ND | ND | ND |
| FA13-158-0582 | 235756-D-29 Wine, red and white | 25.7 ± 1.6 | ND | ND | ND | ND |
| FA13-158-0583 | 234811-D-32 Yoghurt, fruit, full fat | 51.9 ± 3.4 | ND | ND | ND | ND |
| FA13-158-0584 | 234762-D-29 Yoghurt, fruit, full fat | 57.7 ± 3.6 | ND | ND | ND | ND |
| FA13-158-0585 | 234910-D-32 Yoghurt, fruit, full fat | 52.3 ± 3.3 | ND | ND | ND | ND |
| FA13-158-0586 | 237568-D-32 Yoghurt, fruit, full fat | 51.8 ± 3.2 | ND | ND | ND | ND |
| FA13-163-0593 | 234746-D-12 Avocados | 175 ± 10 | ND | ND | ND | ND |
| FA13-163-0594 | 235141-D-11 Avocados | 126.5 ± 7.8 | ND | ND | ND | ND |
| FA13-163-0595 | 235756-D-2 Avocados | 116.5 ± 7.0 | ND | ND | ND | ND |
| FA13-163-0596 | 236936-D-14 Avocados | 151.7 ± 8.8 | ND | ND | ND | ND |

Table A5.2 Summer sampling program: activity concentration results. ND: not detected. The MDC, for 60Co, 134Cs, 137Cs and 241Am, was lower than 1 Bq/kg, for 40K lower than 5 Bq/kg and for infant formula, the MDC was 0.6 Bq/kg.

| ARPANSA Sample no. | Sample | Activity concentration (Bq/kg) uncertainties k=1 | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| 40K | 60Co | 134Cs | 137Cs | 241Am |
| FA14-066-0134 | FS275857-1 apples | 34.6 ± 2.2 | ND | ND | ND | ND |
| FA14-066-0135 | FS275886-1 apples | 42.0 ± 2.6 | ND | ND | ND | ND |
| FA14-066-0136 | FS275900-1 apples | 32.0 ± 2.1 | ND | ND | ND | ND |
| FA14-066-0137 | FS275925-1 apples | 28.1 ± 1.8 | ND | ND | ND | ND |
| FA14-066-0138 | FS275857-2 bananas | 109.2 ± 6.5 | ND | ND | ND | ND |
| FA14-066-0139 | FS275886-2 bananas | 105.4 ± 6.1 | ND | ND | ND | ND |
| FA14-066-0140 | FS275900-3 bananas | 92.3 ± 5.7 | ND | ND | ND | ND |
| FA14-066-0141 | FS275925-3 bananas | 91.3 ± 5.4 | ND | ND | ND | ND |
| FA14-066-0142 | FS275857-13 beans, green | 103.8 ± 6.1 | ND | ND | ND | ND |
| FA14-066-0143 | FS275886-13 beans, green | 73.5 ± 4.4 | ND | ND | ND | ND |
| FA14-066-0144 | FS275900-14 beans, green | 80.5 ± 4.6 | ND | ND | ND | ND |
| FA14-066-0145 | FS275925-14 beans, green | 109.5 ± 6.4 | ND | ND | ND | ND |
| FA14-066-0146 | FS275857-5 bread, white | 34.5 ± 2.6 | ND | ND | ND | ND |
| FA14-066-0147 | FS275886-5 bread, white | 39.1 ± 2.7 | ND | ND | ND | ND |
| FA14-066-0148 | FS275900-5 bread, white | 35.3 ± 2.4 | ND | ND | ND | ND |
| FA14-066-0149 | FS275925-5 bread, white | 37.9 ± 2.5 | ND | ND | ND | ND |
| FA14-066-0150 | FS275857-6 cereal | 93.1 ± 5.6 | ND | ND | ND | ND |
| FA14-066-0151 | FS275886-6 cereal | 87.6 ± 5.1 | ND | ND | ND | ND |
| FA14-066-0152 | FS275813-6 broccoli | 91.7 ± 5.7 | ND | ND | ND | ND |
| FA14-066-0153 | FS275876-6 broccoli | 90.0 ± 5.5 | ND | ND | ND | ND |
| FA14-066-0154 | FS275919-6 broccoli | 100.6 ± 5.8 | ND | ND | ND | ND |
| FA14-066-0155 | FS275932-6 broccoli | 86.2 ± 5.1 | ND | ND | ND | ND |
| FA14-066-0156 | FS275813-8 carrots | 54.1 ± 3.0 | ND | ND | ND | ND |
| FA14-066-0157 | FS275876-8 carrots | 51.8 ± 3.0 | ND | ND | ND | ND |
| FA14-066-0158 | FS275919-8 carrots | 36.6 ± 2.1 | ND | ND | ND | ND |
| FA14-066-0159 | FS275932-8 carrots | 43.7 ± 2.5 | ND | ND | ND | ND |
| FA14-066-0160 | FS275813-10 chicken | 106.9 ± 6.4 | ND | ND | ND | ND |
| FA14-066-0161 | FS275876-10 chicken | 98.7 ± 5.9 | ND | ND | ND | ND |
| FA14-066-0162 | FS275919-10 chicken | 109.0 ± 6.4 | ND | ND | ND | ND |
| FA14-066-0163 | FS275932-10 chicken | 106.5 ± 6.2 | ND | ND | ND | ND |
| FA14-066-0164 | FS275813-11 eggs | 33.7 ± 2.6 | ND | ND | ND | ND |
| FA14-066-0165 | FS275876-12 eggs | 38.8 ± 2.8 | ND | ND | ND | ND |
| FA14-066-0166 | FS275919-12 eggs | 35.7 ± 2.6 | ND | ND | ND | ND |
| FA14-066-0167 | FS275932-11 eggs | 38.7 ± 2.6 | ND | ND | ND | ND |
| FA14-066-0168 | FS275813-12 fish | 52.3 ± 3.2 | ND | ND | ND | ND |
| FA14-066-0169 | FS275932-12 fish | 59.0 ± 3.6 | ND | ND | ND | ND |
| FA14-066-0170 | FS275900-16 infant formula | 25.1 ± 1.7 | ND | ND | ND | ND |
| FA14-066-0171 | FS275925-16 infant formula | 24.7 ± 1.6 | ND | ND | ND | ND |
| FA14-066-0172 | FS275857-16 fruit juice | 41.9 ± 2.9 | ND | ND | ND | ND |
| FA14-066-0173 | FS275886-16 fruit juice | 36.2 ± 2.6 | ND | ND | ND | ND |
| FA14-066-0174 | FS275857-18 lettuce | 43.0 ± 3.1 | ND | ND | ND | ND |
| FA14-066-0175 | FS275886-18 lettuce | 60.5 ± 4.0 | ND | ND | ND | ND |
| FA14-066-0176 | FS275900-18 lettuce | 32.7 ± 2.4 | ND | ND | ND | ND |
| FA14-066-0177 | FS275925-18 lettuce | 49.8 ± 3.3 | ND | ND | ND | ND |
| FA14-066-0178 | FS275813-18 mango | 41.1 ± 2.8 | ND | ND | ND | ND |
| FA14-066-0179 | FS275857-19 mango | 45.8 ± 3.1 | ND | ND | ND | ND |
| FA14-066-0180 | FS275886-19 mango | 43.6 ± 2.8 | ND | ND | ND | ND |
| FA14-066-0181 | FS275932-18 mango | 45.1 ± 3.2 | ND | ND | ND | ND |
| FA14-066-0182 | Composite mango | 45.1 ± 2.5 | ND | ND | ND | ND |
| FA14-066-0183 | FS275813-19 milk | 42.2 ± 2.6 | ND | ND | 0.103 ± 0.028 | ND |
| FA14-066-0184 | FS275876-19 milk | 43.9 ± 2.7 | ND | ND | ND | ND |
| FA14-066-0185 | FS275919-19 milk | 57.1 ± 3.6 | ND | ND | ND | ND |
| FA14-066-0186 | FS275932-19 milk | 43.2 ± 2.7 | ND | ND | ND | ND |
| FA14-066-0187 | FS275876-20 nectarine | 70.7 ± 4.3 | ND | ND | ND | ND |
| FA14-066-0188 | FS275813-20 nectarine | 77.1 ± 4.6 | ND | ND | ND | ND |
| FA14-066-0189 | FS275919-20 nectarine | 76.0 ± 4.5 | ND | ND | ND | ND |
| FA14-066-0190 | FS275925-21 nectarine | 64.1 ± 3.8 | ND | ND | ND | ND |
| FA14-066-0191 | FS275932-20 nectarine | 82.2 ± 5.1 | ND | ND | ND | ND |
| FA14-066-0192 | FS275900-21 nectarine | 61.4 ± 3.9 | ND | ND | ND | ND |
| FA14-066-0193 | FS275857-22 nectarine | 73.7 ± 4.6 | ND | ND | ND | ND |
| FA14-066-0194 | FS275886-22 nectarine | 76.2 ± 4.4 | ND | ND | ND | ND |
| FA14-066-0195 | Composite nectarine | 71.9 ± 4.0 | ND | ND | ND | ND |
| FA14-066-0196 | FS275857-23 onions | 48.6 ± 3.4 | ND | ND | ND | ND |
| FA14-066-0197 | FS275886-23 onions | 45.0 ± 3.0 | ND | ND | ND | ND |
| FA14-066-0198 | FS275900-22 onions | 49.2 ± 3.2 | ND | ND | ND | ND |
| FA14-066-0199 | FS275925-22 onions | 51.6 ± 3.4 | ND | ND | ND | ND |
| FA14-066-0200 | FS275900-23 pasta | 8.78 ± 0.96 | ND | ND | ND | ND |
| FA14-066-0201 | FS275925-23 pasta | 14.8 ± 1.2 | ND | ND | ND | ND |
| FA14-066-0202 | FS275876-23 peanut butter | 157.8 ± 8.8 | ND | ND | ND | ND |
| FA14-066-0203 | FS275919-23 peanut butter | 179 ± 10 | ND | ND | ND | ND |
| FA14-066-0204 | FS275813-24 potato crisps | 419 ± 24 | ND | ND | ND | ND |
| FA14-066-0205 | FS275932-24 potato crisps | 355 ± 20 | ND | ND | ND | ND |
| FA14-066-0206 | FS275857-28 sauce savoury | 68.2 ± 4.2 | ND | ND | ND | ND |
| FA14-066-0207 | FS275886-28 sauce savoury | 61.8 ± 3.8 | ND | ND | ND | ND |
| FA14-066-0208 | FS275857-32 tomatoes | 47.5 ± 3.0 | ND | ND | ND | ND |
| FA14-066-0209 | FS275886-32 tomatoes | 55.6 ± 3.4 | ND | ND | ND | ND |
| FA14-066-0210 | FS275900-31 tomatoes | 68.5 ± 4.1 | ND | ND | ND | ND |
| FA14-066-0211 | FS275925-31 tomatoes | 54.8 ± 3.4 | ND | ND | ND | ND |
| FA14-080-0232 | FS275813-1 avocados | 133.1 ± 7.8 | ND | ND | ND | ND |
| FA14-080-0233 | FS275876-2 avocados | 148.1 ± 8.6 | ND | ND | ND | ND |
| FA14-080-0234 | FS275919-2 avocados | 134.4 ± 7.7 | ND | ND | ND | ND |
| FA14-080-0235 | FS275932-1 avocados | 172.7 ± 9.9 | ND | ND | ND | ND |
| FA14-080-0236 | FS275813-2 bacon | 85.9 ± 5.5 | ND | ND | ND | ND |
| FA14-080-0237 | FS275932-2 bacon | 81.2 ± 5.1 | ND | ND | ND | ND |
| FA14-080-0238 | FS275857-3 beer | 10.0 ± 1.0 | ND | ND | ND | ND |
| FA14-080-0239 | FS275886-3 beer | 9.7 ± 1.0 | ND | ND | ND | ND |
| FA14-080-0240 | FS275857-4 bok choi | 77.4 ± 5.0 | ND | ND | ND | ND |
| FA14-080-0241 | FS275886-4 bok choi | 89.4 ± 5.5 | ND | ND | ND | ND |
| FA14-080-0242 | FS275900-4 bok choi | 82.6 ± 5.1 | ND | ND | ND | ND |
| FA14-080-0243 | FS275925-4 bok choi | 44.3 ± 3.0 | ND | ND | ND | ND |
| FA14-080-0244 | FS275813-5 bread, multigrain | 59.0 ± 3.4 | ND | ND | ND | ND |
| FA14-080-0245 | FS275876-5 bread, multigrain | 62.7 ± 3.6 | ND | ND | ND | ND |
| FA14-080-0246 | FS275919-5 bread, multigrain | 59.9 ± 3.4 | ND | ND | ND | ND |
| FA14-080-0247 | FS275932-5 bread, multigrain | 52.5 ± 3.0 | ND | ND | ND | ND |
| FA14-080-0248 | FS275876-7 butter | 6.41 ± 0.72 | ND | ND | ND | ND |
| FA14-080-0249 | FS275919-7 butter | 6.88 ± 0.73 | ND | ND | ND | ND |
| FA14-080-0250 | FS275813-7 cake, chocolate | 51.9 ± 3.4 | ND | ND | ND | ND |
| FA14-080-0251 | FS275932-7 cake, chocolate | 73.9 ± 4.4 | ND | ND | ND | ND |
| FA14-080-0252 | FS275857-7 capsicum | 63.1 ± 4.6 | ND | ND | ND | ND |
| FA14-080-0253 | FS275886-7 capsicum | 55.0 ± 4.0 | ND | ND | ND | ND |
| FA14-080-0254 | FS275900-7 capsicum | 51.9 ± 3.9 | ND | ND | ND | ND |
| FA14-080-0255 | FS275925-7 capsicum | 61.9 ± 4.0 | ND | ND | ND | ND |
| FA14-080-0256 | FS275857-8 cauliflower | 93.6 ± 5.8 | ND | ND | ND | ND |
| FA14-080-0257 | FS275886-8 cauliflower | 82.1 ± 5.1 | ND | ND | ND | ND |
| FA14-080-0258 | FS275900-8 cauliflower | 74.3 ± 4.6 | ND | ND | ND | ND |
| FA14-080-0259 | FS275925-8 cauliflower | 66.4 ± 3.9 | ND | ND | 0.149 ± 0.025 | ND |
| FA14-080-0260 | FS275813-9 celery | 75.9 ± 4.9 | ND | ND | ND | ND |
| FA14-080-0261 | FS275876-9 celery | 90.5 ± 5.6 | ND | ND | ND | ND |
| FA14-080-0262 | FS275919-9 celery | 97.5 ± 5.9 | ND | ND | ND | ND |
| FA14-080-0263 | FS275932-9 celery | 78.8 ± 4.9 | ND | ND | ND | ND |
| FA14-080-0264 | FS275857-9 cheese, cheddar | 19.3 ± 1.4 | ND | ND | ND | ND |
| FA14-080-0265 | FS275886-9 cheese, cheddar | 18.1 ± 1.4 | ND | ND | ND | ND |
| FA14-080-0266 | FS275900-9 cheese, cheddar | 22.2 ± 1.5 | ND | ND | ND | ND |
| FA14-080-0267 | FS275925-9 cheese, cheddar | 17.0 ± 1.2 | ND | ND | ND | ND |
| FA14-080-0268 | FS275900-10 chocolate | 110.7 ± 6.6 | ND | ND | ND | ND |
| FA14-080-0269 | FS275925-10 chocolate | 106.4 ± 3.4 | ND | ND | ND | ND |
| FA14-080-0270 | FS275876-11 coffee, instant | 11.73 ± 0.92 | ND | ND | ND | ND |
| FA14-080-0271 | FS275919-11 coffee, instant | 6.81 ± 0.69 | ND | ND | ND | ND |
| FA14-080-0272 | FS275857-11 cucumber | 43.1 ± 3.2 | ND | ND | ND | ND |
| FA14-080-0273 | FS275886-11 cucumber | 48.7 ± 3.4 | ND | ND | ND | ND |
| FA14-080-0274 | FS275900-11 cucumber | 43.7 ± 3.0 | ND | ND | ND | ND |
| FA14-080-0275 | FS275925-11 cucumber | 48.6 ± 3.3 | ND | ND | ND | ND |
| FA14-080-0276 | FS275857-12 fish fillets | 106.4 ± 6.2 | ND | ND | 0.144 ± 0.028 | ND |
| FA14-080-0277 | FS275886-12 fish fillets | 85.9 ± 5.0 | ND | ND | ND | ND |
| FA14-080-0278 | FS275900-12 fish fillets | 52.5 ± 3.2 | ND | ND | ND | ND |
| FA14-080-0279 | FS275925-12 fish fillets | 95.8 ± 5.5 | ND | ND | ND | ND |
| FA14-080-0280 | FS275900-13 garlic | 182 ± 10 | ND | ND | ND | ND |
| FA14-080-0281 | FS275925-13 garlic | 188 ± 11 | ND | ND | ND | ND |
| FA14-080-0282 | FS275813-13 grapes | 64.0 ± 4.1 | ND | ND | ND | ND |
| FA14-080-0283 | FS275876-13 grapes | 67.0 ± 4.2 | ND | ND | ND | ND |
| FA14-080-0284 | FS275919-13 grapes | 62.5 ± 4.0 | ND | ND | ND | ND |
| FA14-080-0285 | FS275932-13 grapes | 65.5 ± 4.0 | ND | ND | ND | ND |
| FA14-080-0286 | FS275857-14 ham, sliced | 115 ± 7.0 | ND | ND | ND | ND |
| FA14-080-0287 | FS275886-14 ham, sliced | 156 ± 9.0 | ND | ND | ND | ND |
| FA14-080-0288 | FS275813-14 hamburger | 68.4 ± 4.1 | ND | ND | ND | ND |
| FA14-080-0289 | FS275876-14 hamburger | 61.1 ± 3.6 | ND | ND | ND | ND |
| FA14-080-0290 | FS275919-14 hamburger | 57.9 ± 3.5 | ND | ND | ND | ND |
| FA14-080-0291 | FS275932-14 hamburger | 57.3 ± 3.4 | ND | ND | ND | ND |
| FA14-080-0292 | FS275813-15 hot chocolate | 73.5 ± 4.7 | ND | ND | ND | ND |
| FA14-080-0293 | FS275932-15 hot chocolate | 58.2 ± 3.8 | ND | ND | ND | ND |
| FA14-080-0294 | FS275900-15 ice cream | 27.5 ± 2.0 | ND | ND | ND | ND |
| FA14-080-0295 | FS275925-15 ice cream | 24.6 ± 1.7 | ND | ND | ND | ND |
| FA14-080-0296 | FS275857-15 infant cereal | 48.4 ± 3.0 | ND | ND | ND | ND |
| FA14-080-0297 | FS275886-15 infant cereal | 9.20 ± 0.80 | ND | ND | ND | ND |
| FA14-080-0298 | FS275876-16 infant dessert | 37.8 ± 2.3 | ND | ND | ND | ND |
| FA14-080-0299 | FS275919-16 infant dessert | 35.1 ± 2.2 | ND | ND | ND | ND |
| FA14-080-0300 | FS275813-16 infant dinner | 56.2 ± 3.3 | ND | ND | ND | ND |
| FA14-080-0301 | FS275932-16 infant dinner | 50.3 ± 2.9 | ND | ND | ND | ND |
| FA14-080-0302 | FS275857-17 kiwifruit | 66.7 ± 4.4 | ND | ND | ND | ND |
| FA14-080-0303 | FS275886-17 kiwifruit | 74.7 ± 4.6 | ND | ND | ND | ND |
| FA14-080-0304 | FS275900-17 kiwifruit | 81.2 ± 5.1 | ND | ND | ND | ND |
| FA14-080-0305 | FS275925-17 kiwifruit | 83.1 ± 5.1 | ND | ND | ND | ND |
| FA14-080-0306 | FS275813-17 lamb chops, loin | 93.0 ± 5.5 | ND | ND | ND | ND |
| FA14-080-0307 | FS275876-17 lamb chops, loin | 90.8 ± 5.3 | ND | ND | ND | ND |
| FA14-080-0308 | FS275919-17 lamb chops, loin | 96.5 ± 5.6 | ND | ND | 0.406 ± 0.046 | ND |
| FA14-080-0309 | FS275932-17 lamb chops, loin | 89.0 ± 5.1 | ND | ND | 0.347 ± 0.035 | ND |
| FA14-080-0310 | FS275876-18 liver pate | 40.6 ± 2.6 | ND | ND | ND | ND |
| FA14-080-0311 | FS275919-18 liver pate | 52.0 ± 3.3 | ND | ND | ND | ND |
| FA14-080-0312 | FS275900-19 margarine | 8.0 ± 1.1 | ND | ND | ND | ND |
| FA14-080-0313 | FS275925-19 margarine | 5.74 ± 0.84 | ND | ND | ND | ND |
| FA14-080-0314 | FS275857-20 mushrooms | 89.8 ± 5.3 | ND | ND | ND | ND |
| FA14-080-0315 | FS275886-20 mushrooms | 91.7 ± 5.4 | ND | ND | ND | ND |
| FA14-080-0316 | FS275900-20 mushrooms | 82.5 ± 5.1 | ND | ND | ND | ND |
| FA14-080-0317 | FS275925-20 mushrooms | 75.5 ± 4.7 | ND | ND | ND | ND |
| FA14-080-0318 | FS275857-21 mussels | 23.0 ± 1.6 | ND | ND | ND | ND |
| FA14-080-0319 | FS275886-21 mussels | 23.6 ± 1.6 | ND | ND | ND | ND |
| FA14-080-0320 | FS275876-21 oats, rolled | 12.4 ± 1.0 | ND | ND | ND | ND |
| FA14-080-0321 | FS275919-21 oats, rolled | 19.5 ± 1.2 | ND | ND | ND | ND |
| FA14-080-0322 | FS275813-22 orange | 43.6 ± 2.9 | ND | ND | ND | ND |
| FA14-080-0323 | FS275876-22 orange | 47.8 ± 3.2 | ND | ND | ND | ND |
| FA14-080-0324 | FS275919-22 orange | 46.5 ± 2.8 | ND | ND | ND | ND |
| FA14-080-0325 | FS275932-22 orange | 47.9 ± 3.0 | ND | ND | ND | ND |
| FA14-080-0326 | FS275813-23 peas, frozen | 52.2 ± 3.2 | ND | ND | ND | ND |
| FA14-080-0327 | FS275932-23 peas, frozen | 35.3 ± 2.2 | ND | ND | ND | ND |
| FA14-098-0378 | FS275876-1 almonds | 204 ± 11 | ND | ND | ND | ND |
| FA14-098-0379 | FS275919-1 almonds | 208 ± 11 | ND | ND | ND | ND |
| FA14-098-0380 | FS275900-2 baked beans | 70.4 ± 4.2 | ND | ND | ND | ND |
| FA14-098-0381 | FS275925-2 baked beans | 68.6 ± 4.1 | ND | ND | ND | ND |
| FA14-098-0382 | FS275813-3 beef mince lean | 108.9 ± 6.4 | ND | ND | ND | ND |
| FA14-098-0383 | FS275876-3 beef mince lean | 117.6 ± 6.8 | ND | ND | ND | ND |
| FA14-098-0384 | FS275919-3 beef mince lean | 127.5 ± 7.4 | ND | ND | 0.389 ± 0.050 | ND |
| FA14-098-0385 | FS275932-3 beef mince lean | 106.2 ± 6.1 | ND | ND | 0.267 ± 0.035 | ND |
| FA14-098-0386 | FS275876-4 beetroot, canned | 50.8 ± 2.3 | ND | ND | ND | ND |
| FA14-098-0387 | FS275919-4 beetroot, canned | 60.4 ± 2.5 | ND | ND | ND | ND |
| FA14-098-0388 | FS275813-4 biscuits, savoury | 49.0 ± 3.5 | ND | ND | ND | ND |
| FA14-098-0389 | FS275932-4 biscuits, savoury | 48.5 ± 2.8 | ND | ND | ND | ND |
| FA14-098-0390 | FS275900-6 breakfast cereals-rice based | 32.9 ± 2.6 | ND | ND | ND | ND |
| FA14-098-0391 | FS275925-6 breakfast cereals-rice based | 29.9 ± 2.4 | ND | ND | ND | ND |
| FA14-098-0392 | FS275857-10 coconut | 224 ± 13 | ND | ND | ND | ND |
| FA14-098-0393 | FS275886-10 coconut | 220 ± 12 | ND | ND | ND | ND |
| FA14-098-0394 | FS275876-15 honey | 23.6 ± 1.7 | ND | ND | ND | ND |
| FA14-098-0395 | FS275919-15 honey | 19.1 ± 1.4 | ND | ND | ND | ND |
| FA14-098-0396 | FS275813-21 oil | ND | ND | ND | ND | ND |
| FA14-098-0397 | FS275932-21 oil | ND | ND | ND | ND | ND |
| FA14-098-0398 | FS275857-24 peach | 39.2 ± 1.5 | ND | ND | ND | ND |
| FA14-098-0399 | FS275886-24 peach | 37.8 ± 1.5 | ND | ND | ND | ND |
| FA14-098-0400 | FS275900-24 pie, meat | 50.7 ± 3.5 | ND | ND | ND | ND |
| FA14-098-0401 | FS275925-24 pie, meat | 44.8 ± 3.0 | ND | ND | ND | ND |
| FA14-098-0402 | FS275857-25 pineapple | 32.8 ± 2.4 | ND | ND | ND | ND |
| FA14-098-0403 | FS275886-25 pineapple | 26.5 ± 1.8 | ND | ND | ND | ND |
| FA14-098-0404 | FS275876-24 pizza | 66.9 ± 4.3 | ND | ND | ND | ND |
| FA14-098-0405 | FS275919-24 pizza | 63.0 ± 3.9 | ND | ND | ND | ND |
| FA14-098-0406 | FS275857-26 potato | 103.7 ±6.3 | ND | ND | ND | ND |
| FA14-098-0407 | FS275886-26 potato | 107.5 ± 6.3 | ND | ND | ND | ND |
| FA14-098-0408 | FS275900-25 potato | 95.7 ± 5.6 | ND | ND | ND | ND |
| FA14-098-0409 | FS275925-25 potato | 108.6 ± 6.2 | ND | ND | 0.087 ± 0.023 | ND |
| FA14-098-0410 | FS275813-25 prawns | 60.0 ± 4.2 | ND | ND | ND | ND |
| FA14-098-0411 | FS275876-25 prawns | 36.0 ± 2.8 | ND | ND | ND | ND |
| FA14-098-0412 | FS275919-25 prawns | 44.3 ± 3.0 | ND | ND | ND | ND |
| FA14-098-0413 | FS275932-25 prawns | 31.3 ± 2.1 | ND | ND | ND | ND |
| FA14-098-0414 | FS275857-27 pumpkin | 79.3 ± 4.8 | ND | ND | ND | ND |
| FA14-098-0415 | FS275886-27 pumpkin | 77.2 ± 4.6 | ND | ND | ND | ND |
| FA14-098-0416 | FS275900-26 pumpkin | 53.7 ± 3.5 | ND | ND | ND | ND |
| FA14-098-0417 | FS275925-26 pumpkin | 110.3 ± 6.5 | ND | ND | ND | ND |
| FA14-098-0418 | FS275900-27 rice | 8.5 ± 1.0 | ND | ND | ND | ND |
| FA14-098-0419 | FS275925-27 rice | 6.5 ± 1.0 | ND | ND | ND | ND |
| FA14-098-0420 | FS275876-26 sauce tomato | 83.0 ± 5.1 | ND | ND | ND | ND |
| FA14-098-0421 | FS275919-26 sauce tomato | 98.8 ± 5.8 | ND | ND | ND | ND |
| FA14-098-0422 | FS275813-26 sausages beef | 72.3 ± 4.4 | ND | ND | ND | ND |
| FA14-098-0423 | FS275876-27 sausages beef | 61.4 ± 3.7 | ND | ND | ND | ND |
| FA14-098-0424 | FS275919-27 sausages beef | 66.1 ± 4.0 | ND | ND | ND | ND |
| FA14-098-0425 | FS275932-26 sausages beef | 64.3 ± 3.8 | ND | ND | 0.061 ± 0.020 | ND |
| FA14-098-0426 | FS275813-27 soft drink | 2.35 ± 0.46 | ND | ND | ND | ND |
| FA14-098-0427 | FS275932-27 soft drink | ND | ND | ND | ND | ND |
| FA14-098-0428 | FS275900-28 soy beverage | 42.6 ± 2.9 | ND | ND | ND | ND |
| FA14-098-0429 | FS275925-28 soy beverage | 39.3 ± 2.6 | ND | ND | ND | ND |
| FA14-098-0430 | FS275857-29 strawberries | 46.5 ± 3.2 | ND | ND | ND | ND |
| FA14-098-0431 | FS275886-29 strawberries | 48.2 ± 3.2 | ND | ND | ND | ND |
| FA14-098-0432 | FS275900-29 strawberries | 53.3 ± 3.3 | ND | ND | ND | ND |
| FA14-098-0433 | FS275925-29 strawberries | 50.6 ± 3.4 | ND | ND | ND | ND |
| FA14-098-0434 | FS275857-30 sugar white | ND | ND | ND | ND | ND |
| FA14-098-0435 | FS275886-30 sugar white | ND | ND | ND | ND | ND |
| FA14-098-0436 | FS275876-28 sultanas | 265 ± 15 | ND | ND | ND | ND |
| FA14-098-0437 | FS275919-28 sultanas | 256 ± 15 | ND | ND | ND | ND |
| FA14-098-0438 | FS275813-28 sushi roll, nori | 33.0 ± 2.1 | ND | ND | ND | ND |
| FA14-098-0439 | FS275876-29 sushi roll, nori | 38.0 ± 2.3 | ND | ND | ND | ND |
| FA14-098-0440 | FS275919-29 sushi roll, nori | 40.2 ± 2.8 | ND | ND | ND | ND |
| FA14-098-0441 | FS275932-28 sushi roll, nori | 44.4 ± 3.0 | ND | ND | ND | ND |
| FA14-098-0442 | FS275813-29 sweetcorn, kernels | 85.3 ± 5.0 | ND | ND | ND | ND |
| FA14-098-0443 | FS275932-29 sweetcorn, kernels | 60.2 ± 3.5 | ND | ND | ND | ND |
| FA14-098-0444 | FS275900-30 tea | 2.37 ± 0.61 | ND | ND | ND | ND |
| FA14-098-0445 | FS275925-30 tea | 4.49 ± 0.61 | ND | ND | ND | ND |
| FA14-098-0446 | FS275857-31 tomatoes, canned | 86.8 ± 5.5 | ND | ND | ND | ND |
| FA14-098-0447 | FS275886-31 tomatoes, canned | 85.6 ± 5.5 | ND | ND | ND | ND |
| FA14-098-0448 | FS275876-30 tuna, canned | 66.5 ± 4.3 | ND | ND | ND | ND |
| FA14-098-0449 | FS275919-30 tuna, canned | 60.7 ± 3.9 | ND | ND | ND | ND |
| FA14-098-0450 | FS275813-30 water, tap | ND | ND | ND | ND | ND |
| FA14-098-0451 | FS275876-31 water, tap | ND | ND | ND | ND | ND |
| FA14-098-0452 | FS275919-31 water, tap | ND | ND | ND | ND | ND |
| FA14-098-0453 | FS275932-30 water, tap | ND | ND | ND | ND | ND |
| FA14-098-0454 | FS275857-33 watermelon | 40.0 ± 2.7 | ND | ND | ND | ND |
| FA14-098-0455 | FS275886-33 watermelon | 37.9 ± 2.6 | ND | ND | ND | ND |
| FA14-098-0456 | FS275900-32 watermelon | 39.3 ± 2.4 | ND | ND | ND | ND |
| FA14-098-0457 | FS275925-32 watermelon | 32.8 ± 2.1 | ND | ND | ND | ND |
| FA14-098-0458 | FS275813-31 wine | 18.6 ± 1.4 | ND | ND | ND | ND |
| FA14-098-0459 | FS275876-32 wine | 14.3 ± 1.2 | ND | ND | ND | ND |
| FA14-098-0460 | FS275919-32 wine | 23.0 ± 1.6 | ND | ND | ND | ND |
| FA14-098-0461 | FS275932-31 wine | 19.6 ± 1.3 | ND | ND | ND | ND |
| FA14-098-0462 | FS275857-34 yogurt | 47.1 ± 2.9 | ND | ND | ND | ND |
| FA14-098-0463 | FS275886-34 yogurt | 55.3 ± 3.8 | ND | ND | ND | ND |
| FA14-098-0464 | FS275900-33 yogurt | 63.0 ± 4.0 | ND | ND | ND | ND |
| FA14-098-0465 | FS275925-33 yogurt | 61.8 ± 3.5 | ND | ND | 0.084 ± 0.015 | ND |

1. Naturally occurring radionuclides

Naturally occurring radionuclides (210Po, 210Pb, 226Ra and 228Ra)

Table A6.1 Activity concentrations: naturally occurring radionuclides 210Po, 210Pb, 226Ra and 228Ra

| ARPANSA Sample no. | Sample | Activity concentration (Bq/kg) uncertainties k=1 | | | |
| --- | --- | --- | --- | --- | --- |
| 210Po | 210Pb | 226Ra | 228Ra |
| FA13-126-0270 | Composite apples | 0.0293 ± 0.0045 | 0.0306 ± 0.0054 | 0.0177 ± 0.0029 | 0.0223 ± 0.0086 |
| FA13-126-0275 | Composite bananas | 0.0205 ± 0.0062 | 0.0155 ± 0.0090 | 0.0522 ± 0.0043 | 0.123 ± 0.015 |
| FA13-126-0280 | Composite beef mince | 0.076 ± 0.015 | ND | 0.0051 ± 0.0023 | ND |
| FA13-126-0285 | Composite bread | 0.0730 ± 0.0094 | 0.087 ± 0.015 | 0.0697 ± 0.0051 | 0.069 ± 0.016 |
| FA13-126-0288 | Composite cereal | 0.083 ± 0.029 | 0.088 ± 0.016 | 0.1256 ± 0.0086 | 0.268 ± 0.032 |
| FA13-126-0293 | Composite broccoli | 0.0233 ± 0.0041 | 0.039 ± 0.011 | 0.0207 ± 0.0024 | 0.0267 ± 0.0089 |
| FA13-126-0298 | Composite carrots | 0.0068 ± 0.0014 | 0.0158 ± 0.0079 | 0.116 ± 0.017 | 0.102 ± 0.012 |
| FA13-126-0303 | Composite chicken | ND | ND | 0.0066 ± 0.0019 | 0.045 ± 0.015 |
| FA13-126-0308 | Composite eggs | 0.0244 ± 0.0068 | ND | 0.121 ± 0.015 | 0.259 ± 0.020 |
| FA13-126-0311 | Composite fish | 0.125 ± 0.020 | 0.020 ± 0.010 | 0.0219 ± 0.0027 | 0.0254 ± 0.0078 |
| FA13-126-0314 | Composite infant formula | 0.0081 ± 0.0036 | 0.0172 ± 0.0076 | 0.0041 ± 0.0008 | ND |
| FA13-126-0317 | Composite fruit juice | 0.0316 ± 0.0036 | 0.023 ± 0.010 | 0.0171 ± 0.0017 | 0.0306 ± 0.0096 |
| FA13-126-0322 | Composite lettuce | 0.0182 ± 0.0028 | 0.0219 ± 0.0068 | 0.0072 ± 0.0011 | ND |
| FA13-126-0327 | Composite milk | 0.0225 ± 0.0048 | 0.0145 ± 0.0067 | 0.0048 ± 0.0013 | 0.0188 ± 0.0059 |
| FA13-126-0332 | Composite onions | 0.0120 ± 0.0034 | ND | 0.0205 ± 0.0043 | 0.0359 ± 0.0093 |
| FA13-126-0335 | Composite pasta | 0.0082 ± 0.0030 | 0.0152 ± 0.0067 | 0.0453 ± 0.0037 | 0.062 ± 0.015 |
| FA13-126-0338 | Composite peanut butter | ND | 0.0255 ± 0.0084 | 0.112 ± 0.014 | 0.156 ± 0.021 |
| FA13-126-0343 | Composite potatoes | ND | ND | 0.0154 ± 0.0022 | 0.0246 ± 0.0063 |
| FA13-126-0346 | Composite rice | 0.0358 ± 0.0053 | 0.0089 ± 0.0057 | 0.0130 ± 0.0049 | ND |
| FA13-126-0351 | Composite tomatoes | 0.0113 ± 0.0019 | ND | 0.0208 ± 0.0026 | 0.0236 ± 0.0078 |
| FA14-066-0182 | Composite mango | 0.0418 ± 0.0052 | ND | 0.0590 ± 0.0065 | 0.078 ± 0.018 |
| FA14-066-0195 | Composite nectarine | 0.0243 ± 0.0025 | 0.0237 ± 0.0075 | 0.0073 ± 0.0031 | ND |
|  |  |  |  |  |  |
| *MDC (MDC infant formula)* | | *0.030* | *0.013* |  | *0.025 (0.016)* |

Naturally occurring radionuclides (uranium and thorium)

Table A6.2 Activity concentrations: naturally occurring radionuclides uranium and thorium

| ARPANSA sample no. | Sample | Activity concentration (Bq/kg) Uncertainties k=1 | | | |
| --- | --- | --- | --- | --- | --- |
| 234U | 238U | 230Th | 232Th |
| FA13-126-0270 | Composite apples | ND | ND | ND | ND |
| FA13-126-0275 | Composite bananas | ND | ND | ND | ND |
| FA13-126-0280 | Composite beef mince | 0.0049 ± 0.0023 | 0.0070 ± 0.0029 | ND | ND |
| FA13-126-0285 | Composite bread | 0.0456 ± 0.0069 | 0.0482 ± 0.0073 | 0.0409 ± 0.0093 | ND |
| FA13-126-0288 | Composite cereal | 0.0108 ± 0.0049 | 0.0173 ± 0.0059 | 0.0146 ± 0.0079 | ND |
| FA13-126-0293 | Composite broccoli | 0.0093 ± 0.0039 | 0.0092 ± 0.0039 | 0.0064 ± 0.0027 | ND |
| FA13-126-0298 | Composite carrots | ND | ND | ND | ND |
| FA13-126-0303 | Composite chicken | ND | ND | ND | ND |
| FA13-126-0308 | Composite eggs | ND | ND | ND | ND |
| FA13-126-0311 | Composite fish | 0.0057 ± 0.0024 | 0.0042 ± 0.0029 | ND | ND |
| FA13-126-0314 | Composite infant formula | 0.0036 ± 0.0013 | 0.0027 ± 0.0011 | ND | ND |
| FA13-126-0317 | Composite fruit juice | 0.0034 ± 0.0013 | ND | ND | ND |
| FA13-126-0322 | Composite lettuce | ND | ND | ND | ND |
| FA13-126-0327 | Composite milk | ND | ND | ND | ND |
| FA13-126-0332 | Composite onions | 0.0032 ± 0.0016 | 0.0032 ± 0.0013 | ND | ND |
| FA13-126-0335 | Composite pasta | ND | ND | 0.0070 ± 0.0055 | ND |
| FA13-126-0338 | Composite peanut butter | ND | ND | 0.0098 ± 0.0069 | ND |
| FA13-126-0343 | Composite potatoes | ND | ND | ND | ND |
| FA13-126-0346 | Composite rice | ND | ND | ND | ND |
| FA13-126-0351 | Composite tomatoes | ND | ND | ND | ND |
| FA14-066-0182 | Composite mango | 0.0033 ± 0.0020 | ND | ND | ND |
| FA14-066-0195 | Composite nectarine | 0.0024 ± 0.0013 | ND | ND | ND |
|  |  |  |  |  |  |
| *MDC (MDC infant formula)* | | *0.0092* | *0.0090* | *0.012 (0.0048)* | *0.010 (0.0028)* |

Table A6.3 Comparison of data from studies of radionuclides in infant formula.

1 Formula has been scaled to dry powder based on a ratio of 13% dry formula to 87% water to make up a liquid formula (Trdin & Benedik, 2017) with negligible contribution from water.

| Study | Activity concentration (Bq/kg) in Infant formula | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 210Po | 210Pb | 226Ra | 228Ra | 234U | 238U | 230Th | 232Th |
| **Australia (This study)** | 0.0081 | 0.0172 | 0.00410 | ND | 0.0036 | 0.0027 | ND | ND |
| **Australia (This study) Scaled to dry powder1** | 0.065 | 0.14 | 0.033 | ND | 0.029 | 0.0216 | ND | ND |
| **Slovenia  (Trdin and Benedik, 2017)** | 0.16 – 0.36 | NA | NA | NA | 0.007 – 0.037 | 0.0097 – 0.034 | 0.29 – 0.58 | NA |
| **Slovenia (Strok and Smodis, 2009)** | 0.055 – 0.082 | 0.29 – 0.65 | 0.057 – 0.063 | NA | 0.074 – 0.091 | 0.065 – 0.071 | NA | NA |
| **Malaysia  (Uwatse et al., 2014)** | NA | NA | 1.36 – 7.1 | NA | NA | NA | NA | 0.31 – 8.6 |
| **India  (Prabhath et al., 2015)** | 0.08 – 0.23 | NA | NA | NA | NA | NA | NA | NA |
| **Saudi Arabia (Jemii and Alharbi, 2018)** | NA | NA | 0.26 – 1.06 | NA | NA | NA | NA | 0.21 – 0.84 |

1. Committed effective dose

Table A7.1 Example of the calculation of committed effective dose for 226Ra for a 2–year–old.

| Food type/category | Consumption kg/year | 226Ra Bq/kg | Intake Bq/year | | Dose coefficient Sv/Bq | Dose mSv/year |
| --- | --- | --- | --- | --- | --- | --- |
| **Milk products** | | | | | | |
| Milk | 252 | 0.0048 | 1.21 | | 9.6E10-7 | 1.16E10-3 |
| Infant formula | 0.986 | 0.0041 | 0.00404 | | 9.6E10-7 | 3.88E10-6 |
| **Meat products** | | | | | | |
| Beef mince | 13.1 | 0.0051 | 0.0671 | | 9.6E10-7 | 6.44E10-5 |
| Chicken | 9.50 | 0.0066 | 0.0627 | | 9.6E10-7 | 6.02E10-5 |
| Eggs | 2.59 | 0.121 | 0.314 | | 9.6E10-7 | 3.01E10-4 |
| **Grain products** | | | | | | |
| Bread | 23.7 | 0.070 | 1.65 | | 9.6E10-7 | 1.59E10-3 |
| Breakfast cereal | 15.7 | 0.126 | 1.97 | | 9.6E10-7 | 1.89E10-3 |
| Pasta | 13.1 | 0.0453 | 0.596 | | 9.6E10-7 | 5.72E10-4 |
| Rice | 7.30 | 0.013 | 0.0950 | | 9.6E10-7 | 9.12E10-5 |
| **Leafy vegetables** | | | | | | |
| Broccoli | 4.38 | 0.0207 | 0.0907 | | 9.6E10-7 | 8.71E10-5 |
| Lettuce | 2.19 | 0.0072 | 0.0158 | | 9.6E10-7 | 1.51E10-5 |
| **Roots and fruits** | | | | | | |
| Carrot | 6.94 | 0.116 | 0.802 | | 9.6E10-7 | 7.69E10-4 |
| Onion | 2.26 | 0.0205 | 0.0464 | | 9.6E10-7 | 4.46E10-5 |
| Peanut butter | 1.10 | 0.112 | 0.123 | | 9.6E10-7 | 1.18E10-4 |
| Potatoes | 12.8 | 0.0154 | 0.197 | | 9.6E10-7 | 1.89E10-4 |
| Apples | 23.4 | 0.0177 | 0.414 | | 9.6E10-7 | 3.97E10-4 |
| Bananas | 25.9 | 0.0522 | 1.35 | | 9.6E10-7 | 1.30E10-3 |
| Mango | 3.18 | 0.0590 | 0.187 | | 9.6E10-7 | 1.80E10-4 |
| Nectarine | 21.5 | 0.0073 | 0.157 | | 9.6E10-7 | 1.51E10-4 |
| Tomato | 25.2 | 0.0208 | 0.524 | | 9.6E10-7 | 5.03E10-4 |
| Fruit juice | 27.8 | 0.0171 | 0.475 | | 9.6E10-7 | 4.56E10-4 |
| **Fish products** | | | | | | |
| Fish | 2.89 | 0.0219 | 0.0632 | | 9.6E10-7 | 6.07E10-5 |
| **Total** | | | | **1.00E10-2** | | |

Figure A7.1. Committed effective dose for infants (MDC included).

Figure A7.2. Committed effective dose for a child of 2 years old (MDC included)

Figure A7.3. Committed effective dose for a child, 3–7 years old (MDC included)

Figure A7.4. Committed effective dose for a child, 8–12 years old (MDC included)

Figure A7.5. Committed effective dose for a child, 13–17 years (MDC included)

Figure A7.6. Committed effective dose for an adult (MDC included)