Acrylamide in New Zealand food and updated exposure assessment

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ACRYLAMIDE IN NEW ZEALAND FOOD AND UPDATED EXPOSURE ASSESSMENT

Report Number FW11061

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ACRYLAMIDE IN NEW ZEALAND FOOD AND UPDATED EXPOSURE ASSESSMENT

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Client report no. FW11061

by

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January 2012

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EXECUTIVE SUMMARY

Acrylamide concentrations were measured in selected New Zealand foods. Foods were selected on the basis of their likely contribution to dietary acrylamide exposure. Foods analysed included potato products (crisps, hot chips, oven fries), cereal products (bread, biscuits, breakfast cereals, muffins, fried rice/noodles and cereal-based snack foods) and nut products (peanut butter, roasted peanuts and cashews).

Mean acrylamide concentrations for potato crisps have decreased significantly since an earlier New Zealand survey (2006), from 1,570 µg/kg to 581 µg/kg. Mean acrylamide concentrations in potato hot chips and wheat biscuit cereals were very similar to concentrations determined in the 2006 survey, while concentrations in corn crisps were more than double the concentration determined in 2006 (596 µg/kg, compared to 270 µg/kg). However, it should be noted that the current survey sampled only a single brand of corn crisps (5 samples), while the 2006 survey analysed single samples only from two brands. The brand analysed in the current survey was different to the brands analysed in 2006.

The acrylamide concentrations of some potato crisp brands were significantly more variable than other brands. There was greater consistency, but not necessarily lower acrylamide concentrations, in hot chips purchased from the main national fast food chain outlets compared with local outlets. Wheatmeal bread was more variable than white bread.

Concentrations of acrylamide determined in the current survey were mostly within the range of concentrations from other studies reported in the literature, with the exception of potatoes roasted from frozen and corn crisps (both higher) and toasted bread (lower).

Mean estimates of dietary acrylamide exposure (0.72 - 1.04 µg/kg bw/day for adults) were very similar to estimates made in 2006 (0.74 - 0.99 µg/kg bw/day for adults), whether the estimate was derived from a deterministic total diet approach or from a dietary modelling approach. Estimates of dietary acrylamide exposure were towards the upper end of the range of estimates derived internationally. It is not possible to say whether this is due to true differences in exposure or differences in the methodology and assumptions used in dietary exposure assessment. Usual exposure estimates at the 95th percentile were within the range of equivalent estimates determined in studies in other countries.

The major foods contributing to dietary acrylamide exposure in New Zealand were potato products, bread, breakfast cereals and beverages. This is largely consistent with international findings. The contribution of potato crisps to acrylamide exposure appears to have decreased between 2006 and 2011 and the contribution from potato, hot chips and oven baked/roasted potatoes appears to have increased.

1 INTRODUCTION

Acrylamide is a potential human carcinogen which was found by Swedish researchers in 2002 to occur in carbohydrate-rich foods that are cooked at high temperature (Tareke *et al.*, 2002). Based on international studies, the amounts found, and therefore exposure, are likely to be variable and related to cooking conditions (Croft *et al.*, 2004; European Food Safety Authority, 2010; 2011; United States Food and Drug Administration, 2011; Vinci *et al.*, 2011). Regulatory and manufacturing risk reduction strategies depend on knowledge of the level of exposure from food produced in New Zealand as well as international data on the risk posed by these exposures.

The concentration of acrylamide in the carbohydrate-rich foods can be influenced by measures at various points in the production chain,[1] including:

- Agronomical. Plant breeding and fertilisation practices to reduce levels of chemicals involved in acrylamide formation (asparagine, sugars).
- Recipe. Addition of ingredients that inhibit acrylamide production, minimisation of sugar addition, piece size.
- Processing. Pre-treatment (asparaginase, washing, blanching), fermentation, thermal input and moisture control.
- Final preparation. Colour endpoint (degree of cooking), texture/flavour, product storage.

It is possible that levels of acrylamide in New Zealand foods may have decreased due to application of some of these measures by potato chip, crisp, snacks and bakery industries. New data would confirm this and provide a revised estimate of exposure.

1.1 Project Aim

To provide updated New Zealand data on the levels of acrylamide in risk foods and estimates of exposure so that New Zealand authorities can make reasoned and informed choices on the need for further action for New Zealand.

[1] http://ec.europa.eu/food/food/chemicalsafety/contaminants/ciaa_acrylamide_toolbox09.pdf

2 MATERIALS AND METHODS

2.1 Sample Selection

A sampling plan (Table 1) was developed and agreed after consideration of:

- the requirement to assess concentration data relative to previous New Zealand results (Love and Grounds, 2006),
- the requirement for information on variability of acrylamide concentrations across brands and within brands,
- market share, to target foods or brands most highly consumed,
- weighting towards foods that make the greatest contribution to exposure,
- sampling location and season (regional or national foods).

An emphasis was placed on potato-based products (crisps and hot chips, roasted potatoes) being the major contributors to acrylamide exposure, followed by cereal-based (bread - fresh and toasted, breakfast cereals, biscuits, muffins, fried rice/noodles, cereal-based snack foods), and other foods (peanut butter, roasted nuts) (Love and Grounds, 2006).

Five samples of most foods[2] were obtained to measure variation across the product range. This was achieved by purchasing different batches of pre-packaged foods (crisps, bread, biscuits, cereals, peanut butter, nuts and snacks) or by purchasing on different days those foods not sold pre-packaged (hot chips, muffins and fried rice/noodles). All foods were sampled during January and February 2011.

[2] In this context, a food is considered to be a unique combination of a product type and a brand or sampling location

Table 1: Sampling plan for acrylamide analyses

Food Type	Food Product	Description/Brand	Sample numbers
Potato products	Crisps	Major brands (3)[1] Other (4)	33 (7 brands x 5 batches)[2]
	Hot Chips[3]	National retail chains (3) Local Fish and chip shop (3)	30 (6 brands/locations x 5 sampling days)
	Oven baked/roasted	From raw potatoes Supermarket wedges	11 (2 sources x 5 or 6 types/batches)
Cereal products	Bread-fresh	White (2 brands) Wheatmeal (2 brands)	20 (4 product/brands x 5 batches)
	Bread-toasted[4]	White (2 brands) Wheatmeal (2 brands)	20 (4 product/brands x 5 batches)
	Biscuits/crackers	Plain (wine) Crispbread Extruded puffed Water cracker Plain sweet (non chocolate)	25 (5 product/brands x 5 batches)
	Breakfast cereals	Wheat biscuits (1 brand) Toasted muesli (2 brands)	15 (3 product/brands x 5 batches)
	Muffins	Supermarket (1) Retail outlet (1)	10 (2 locations/types x 5 sampling days)
	Fried rice	Retail outlet (1)	5 (1 location x 5 sampling days)
	Fried noodles	Retail outlet (2)	10 (2 locations x 5 sampling days)
	Cereal-based snacks	Corn chips (1 brand) Grain-based crisps (1 brand) Popcorn (1 brand)	15 (3 product/brands x 5 batches)
Nut products	Peanut Butter	Major brand (1) Other (1)	10 (2 brands x 5 batches)
	Roasted nuts	Dry roasted peanuts (1) Salted cashews (1)	10 (2 product/brands x 5 batches)
Total			**214**

[1] Well known brands surveyed previously (Love and Grounds, 2006)
[2] For one brand only three different batches could be obtained
[3] For this survey, „hot chips' refers to food purchased ready to consume and not frozen pre-cooked products purchased for further cooking by the consumer
[4] Breads were toasted in the laboratory to a „medium' level of toasting

2.2 Sampling and Sample Processing Procedures

All samples were purchased from retail outlets in Christchurch during January and February 2011.

Samples were received at the laboratory and given a unique alpha numeric identifier which remained with the sample throughout the analysis and reporting procedure. Shelf-stable samples were either processed immediately or stored at ambient temperature until processing.

Non-shelf stable foods (hot chips, fried rice, fried noodles) were processed on receipt at the laboratory.

All samples were homogenised using a food processor, stored frozen and thawed just prior to analysis.

2.3 Acrylamide Analysis Methodology

Acrylamide was analysed according to an Agilent Technologies Food Application procedure (Al-Taher, 2011). This procedure includes sample extraction and clean-up using the Agilent quick, easy, cheap, effective, rugged and safe (QuEChERS) system (Mastovska and Lehotay, 2006).

Approximately 1 g of homogenate was accurately weighed out. A deuterated acrylamide solution was then added as an internal standard to allow calculation of method recovery efficiency. Samples were left sealed overnight to allow equilibration of the internal standard with the sample matrix.

Acrylamide was extracted from samples using a solvent extraction followed by a clean-up procedure using a primary secondary amine according to the following procedure:

- The sample was treated with n-hexane (5 mL) to remove fat and grease from the sample matrix and enable a greater extraction efficiency to be achieved.
- Water (10 mL) and acetonitrile (10 mL) were added to the matrix followed by anhydrous magnesium sulphate (4 g) and sodium chloride (0.5 g) and the mixture shaken vigorously for approximately 1 minute. Water enables efficient extraction of acrylamide from the sample, and the salts force the acetonitrile and water to separate, with the majority of acrylamide remaining in the acetonitrile phase.
- Further clean-up was achieved by shaking an aliquot of the acetonitrile phase with primary secondary amine (50 mg) and anhydrous magnesium sulphate (150 mg) (Mastovska and Lehotay, 2006)

Samples were analysed using LC-MS/MS with a Kinetex C18 column, 2.5% Methanol mobile phase with 1% formic acid under isocratic flow conditions. The mass spectrometer (MS) was operated in positive ion mode and using multiple reaction monitoring (MRM) acquisition mode. Calibration was provided using an acrylamide dilution series in acetonitrile with deuterated acrylamide as an internal tracer. Sample acrylamide concentrations were automatically corrected using recovery efficiency derived from the internal standard; subsequent data manipulation was applied to correct for the dilution factors incurred during sample preparation.

2.3.1 Analytical quality control

The inclusion of a deuterated internal standard allows matrix effects on the analytical method to be accounted for.

External method validation was provided by simultaneous preparation and analysis of two FAPAS[3] acrylamide quality control materials; biscuit (T3028) and crispbread (T3026) in

[3] Food Analysis Performance Assessment Scheme. http://www.fapas.com/proficiency-testing-schemes/fapas/

each batch of samples run. A summary of the analytical results achieved and the expected acrylamide content of these materials is given in Table 2.

Table 2: Analysis of acrylamide quality control materials

Quality control material	Acrylamide concentration (µg/kg)		
	Assigned value	**Satisfactory range**	**ESR analytical result, mean (range)**
Biscuit (T3028)	1,030	702-1,358	1,075 (909-1,193) (n = 8)
Crispbread (T3026)	157	91-223	183 (139-245) (n = 8)

In general, analysis of FAPAS quality control materials demonstrated very good method performance, with only 1 of 16 analyses being just outside the satisfactory range. It should be noted that the other quality control material run on the same date returned a satisfactory result.

Duplicate samples were run for each distinct product/brand analysed and the variance assessed for compliance against acceptance criteria (samples rejected if the coefficient of variation (CV) was greater than 20%). Based on duplicate analyses, the overall method CV was 9.1%.

Additional reagent blanks were included in each analysis batch.

2.4 Acrylamide Dietary Exposure Assessment

For dietary exposure to chemicals, exposure can be defined as:

$$E_i = \frac{\Sigma Q_{i,k} \text{ x } C_{i,k}}{bw_i}$$

Where E_i is the exposure of individual *i* to some chemical at some specified point in time, $Q_{i,k}$ is the amount of food *k* consumed by individual *i*, $C_{i,k}$ is the concentration of the chemical of interest in food *k* consumed by individual *i* and bw_i is the body weight of individual *i*. For deterministic (point) estimates of exposure, these parameters (concentration, food consumption and body weight) are represented by population averages or selected percentiles. For dietary modelling, food consumption and body weight will be represented by actual reported values for an individual on one particular day or on several days, depending on the structure of the dietary survey.

In the current study, dietary acrylamide exposure was determined by two methods:

- A deterministic method using simulated, typical diets developed for the New Zealand Total Diet Survey (Vannoort and Thomson, 2005) (TD approach).
- A dietary modelling method using 24-hour dietary recall records from the 1997 National Nutrition Survey (Russell *et al.*, 1999) for adults 15 and over and records from the 2002

National Children's Nutrition Survey (Ministry of Health, 2003) for children 5-15 years (DM approach).

The TD approach was used to allow direct comparison with earlier New Zealand estimates of dietary acrylamide exposure (Love and Grounds, 2006), while the DM approach allows for an assessment of the distribution of acrylamide exposures in the population.

2.4.1 Acrylamide concentration data

Exposure to acrylamide is of concern due to its potential carcinogenicity (Scientific Committee on Food, 2002; Dybing *et al.*, 2005). In this context, the parameter of interest is the chronic, habitual/usual level of exposure. In the absence of more detailed information, it must be assumed that individuals within the population will be exposed to the complete distribution of acrylamide concentrations in a particular food over time. Therefore, the most appropriate parameter of the distribution of acrylamide concentrations for calculation of chronic exposure is the mean or expected value.

The data set for acrylamide in New Zealand foods contains a reasonably low proportion of left censored data, due to the selection of foods expected to contain appreciable concentrations of acrylamide. Left censorship refers to the situation where the distribution of observed results is truncated at the left hand end due to the limitations of measurement technologies (not detected). For foods where a proportion of analytical results were below the limit of detection, the approach recommended by Dybing *et al*. (2005) was employed and analytical results for these samples were represented by a value equal to half the limit of detection (LOD/2). This approach is based on an earlier World Health Organization (WHO) expert consultation (WHO GEMS/Food-Euro, 1995). After substitution for results below the LOD, arithmetic mean acrylamide concentrations were calculated for each food type. This was carried out as a two step process, with the mean of acrylamide concentrations for a particular brand or sampling location calculated and then the mean of these brand/location means calculated for a particular food type. This approach was necessary to give brands/locations with different numbers of analytical samples equal weighting.

It has been suggested that acrylamide concentrations in foods conform to a lognormal distribution (Dybing *et al.*, 2005; European Food Safety Authority, 2009; Mojska *et al.*, 2010). This suggests that calculation of a geometric, rather than an arithmetic mean, for acrylamide concentration data may be appropriate. This approach was taken by EFSA in determining acrylamide exposure for Sweden and the Netherlands in 2009 (European Food Safety Authority, 2009). However, more recent EFSA exposure assessments have employed arithmetic mean concentration values (European Food Safety Authority, 2011) and arithmetic means are used in the current study to maintain consistently with other studies performed internationally.

An assumption of lognormality is useful as it allows the data to be analysed by normal statistical methods following a log transformation. This approach was used in the current study to statistically test trends in acrylamide concentration of particular foods and to compare variability in different brands of the same food.

For foods other than those analysed in the current project, the consensus values adopted by Love and Grounds (2006) were used so that exposure trends to key foods might be assessed.

2.4.2 Food Consumption Information

Two food consumption data resources were used for the current project.

2.4.2.1 New Zealand Total Diet Survey (NZTDS) simulated typical diets

In the 2003-2004 NZTDS, simulated „typical' diets were developed for eight selected sub-sets of the New Zealand population: - young male 19-24 years, adult male 25 years and over, adult female 25 years and over, adolescent male 11-14 years, adolescent female 11-14 years, child 5-6 years, child 1-3 years, and infant 6-12 months (Brinsdon, 2004).

Fourteen day simulated „typical' diets were created for each of the population subgroups listed above. These were based on the NZTDS Food List which identified the foods most commonly consumed by the New Zealand population. Other foods were added to the list for specific population groups such as children and infants, as well as a number of foods identified as high risk for contaminants and pesticides, such as oysters, mussels and lambs liver. Fourteen day consumed food quantities were converted to daily consumed food quantities. It should be noted that this does not imply that all foods are eaten every day. Some foods would only be eaten once in the fourteen day period, while others may be consumed every day.

Construction of the simulated diets was based on the most recently available research on food consumption patterns. The main data sources were the National Nutrition surveys conducted for adults 15 and over years of age (Russell *et al.*, 1999) and children 5-14 years of age (Ministry of Health, 2003) and recent surveys of dietary habits of young children (Soh *et al.*, 2002). This enabled an estimate of the amount of each specific food from the NZTDS food list to be included in each „typical' diet. Diets were then created that would resemble an average consumer in each of the selected groups. In some situations industry sectors were contacted to confirm consumption patterns that may have changed since the adult nutrition survey was conducted in 1997. In constructing the simulated „typical' diets, the following guidelines were used: serving sizes at any meal would be realistic, the diets would be representative of the given population, and each diet would contain all appropriate foods from the NZTDS Food List in it (i.e. children's diets do not contain alcohol).

Simulated typical diets support estimation of deterministic (point) estimates of dietary exposure.

Use of simulated typical diets for acrylamide exposure assessment

The TD approach of Love and Grounds (2006) was used as the „base case' for the use of simulated typical diets to determine dietary acrylamide exposure in the current study. Mean concentrations of analytical results determined in the current study were substituted for values used in the earlier study. In some instances, the description of foods did not provide a perfect match and a mapping process was necessary to match food which had been analysed for acrylamide to foods in the simulated typical diets. A summary of these mapping decisions is included in Table 3.

Table 3: Matching of NZTDS simulated typical diet foods to acrylamide survey food descriptors

NZTDS food	Acrylamide survey food	
	Descriptor(s)	**Foods included in description**[1]
Biscuit, chocolate Biscuit, plain sweet	Biscuit, sweet	Plain wine and sweet (non-chocolate) biscuits
Biscuit, cracker	Biscuit, cracker	Crispbread, extruded puffed cracker, water cracker
Bran flake cereal, mixed	Cereal, other	Cereal, wheat biscuit and muesli, toasted
Bread, mixed grain	Bread, other	Bread, white and wheatmeal
Bread, wheatmeal	Bread, wheatmeal	Bread, wheatmeal
Bread, white	Bread, white	Bread, white
Cake	Muffin	Muffin
Cornflakes	Cereal, other	Cereal, wheat biscuit and muesli, toasted
Muesli	Cereal, muesli, toasted	Cereal, muesli, toasted
Muffin	Muffin	Muffin
Noodles, instant	Noodles, fried	Fried noodles
Peanut butter	Peanut butter	Peanut butter
Peanuts, whole	Peanuts, roasted	Dry roasted peanuts, salted cashews
Potato crisps	Potato crisps	Potato crisps
Potato, hot chips	Potato, hot chips	Potato, hot chips
Potatoes, with skin	Potato, oven roasted/baked	Potato, oven roasted/baked, from raw and from frozen
Rice, white	Rice, fried	Fried rice
Snacks flavoured	Snacks	Corn chips, grain crisps, popcorn
Wheatbiscuit cereals	Cereal, wheat biscuit	Cereal, wheat biscuit

[1] Where more than one survey food was included in a description the assigned acrylamide concentration was the mean of the acrylamide concentrations of the identified survey foods. For example, cornflakes were not analysed in the current survey. The NZTDS food „Cornflakes' was mapped to a survey descriptor „Cereal, other' which was assigned an acrylamide concentration equal to the mean of the two cereals that were analysed; „Cereal, wheat biscuit' and „Muesli, toasted'.

The full list of TD foods, the source of the acrylamide concentration data and the mean concentration value used are summarised in Appendix 1.

2.4.2.2 National Nutrition Survey (NNS) records

Periodic national nutrition surveys are carried out in New Zealand. The most recent are the 1997 National Nutrition Survey (97NNS) covering adult New Zealanders, aged 15 years and over (Russell *et al.*, 1999) and the 2002 National Children's Nutrition Survey (02CNS) covering New Zealand children aged 5-15 years (Ministry of Health, 2003).

These two surveys included 24-hour dietary recall records (24HDR). These include a complete listing of all foods consumed by an individual during one 24-hour period and the amount of the food consumed. Days of the week and time of year are randomised across the survey to avoid bias due to these factors. The 97NNS contains 24HDR records for 4,636 respondents and the 02CNS contains 24HDR records for 3,275 respondents.

24HDR records were used to provide individual estimates of dietary acrylamide exposure for the surveyed day.

Mapping of NNS foods to acrylamide-containing foods

The NNSs contain over 4000 unique food descriptors. In order to estimate the acrylamide concentration of each of these foods it is necessary to map the foods for which acrylamide concentrations are available to the list of unique NNS food descriptors. Three situations arise:

- The food description in Table 1 is sufficiently similar to the NNS food descriptor to allow direct application of the determined acrylamide concentration;
- The NNS food is unrelated to any food in Table 1 and is unlikely to contain acrylamide; or
- The NNS food is similar to or contains (as part of a recipe) one of the foods in Table 1.

Appendix 2 identifies the foods for which acrylamide concentration values were available, the wider group of foods that they were chosen to represent and the mean acrylamide concentration used. Where foods were not expected to contain acrylamide (for example, foods from animal sources, fresh fruit, dairy products) no mapping was carried out. These foods were assigned to an „Other' category, with a zero acrylamide concentration.

2.4.3 Estimation of the distribution of usual (long term) acrylamide exposure

While the 24HDR records provide a good record of the food intake by an individual on a particular day, this is not the same as the individual's usual long-term food intake and may include consumption of foods rarely eaten by the individual or exclude foods commonly eaten by the individual. This will usually mean that any exposure estimate based on 24HDR records may not be a true representation of habitual exposure for an individual. While the mean of exposures derived in this manner are likely to be good estimates of the true mean, it is expected that the variability in dietary exposure derived from 24HDR records will be greater than the true population habitual exposure variability, as it will include both between person variability (inter-person) and within person variability (intra-person) (Nusser *et al.*, 1996; Hoffmann *et al.*, 2002; Dodd *et al.*, 2006). Inter-person variability is the parameter of interest for risk assessment associated with chronic exposure, as is the case for acrylamide.

For the 97NNS and 02CNS, 24HDR dietary information was collected on a second day for approximately 15% of respondents. These duplicate days can be used to estimate intra-person variability and correct the overall estimate of exposure variability to only represent inter-person variability (Nusser *et al.*, 1996; Hoffmann *et al.*, 2002; Dodd *et al.*, 2006).

The distribution of usual (long term) acrylamide exposure for selected population sub-groups was determined from estimates using primary and repeat 24HDR records using PC-SIDE software (Iowa State University)[4].

[4] http://cssm.iastate.edu/software/side.html

2.5 Body Weights

For deterministic exposure estimates, based on the NZTDS simulated diets, mean body weights as used in the NZTDS were employed. Values used are summarised in Appendix 3.

The dietary modelling approach generates an estimate of acrylamide exposure for each respondent in the 97NNS or 02CNS and the corresponding actual body weights are used in this approach.

2.6 Statistical Analyses

All statistical analyses were carried out using R software.[5] Tests were considered to be statistically significant if $p<0.05$ (greater than 95% confidence).

[5] http://www.r-project.org/

3 RESULTS

3.1 Concentrations of Acrylamide in Selected New Zealand Foods

Acrylamide concentrations measured in selected New Zealand foods are summarised in Table 4. Results for individual products are given in Appendix 4.

Table 4: Concentration of acrylamide in selected New Zealand foods

Food Product	Number of brands or sampling locations[1]	Mean acrylamide concentration (range)[2] (µg/kg)	
		Current survey	Previous New Zealand results[3]
Potato crisps	7	581 (112-1,460)	1,570 (370-2,320)
Potato, hot chips	5	353 (70-1,016)	387 (230-510)
Potato, oven baked/roasted	From raw potatoes (1) Supermarket wedges (1)	116 (53-190) 1,278 (435-2,252)	NA NA
Bread-fresh	White (2) Wheatmeal (2)	31 (ND-52) 45 (ND-108)	NA NA
Bread-toasted[4]	White (2) Wheatmeal (2)	58 (22-154) 72 (16-136)	NA NA
Biscuits/crackers	Plain (wine) (1) Crispbread (1) Extruded puffed (1) Water cracker (1) Sweet-non chocolate (1)	137 (119-189) 598 (422-908) 104 (79-129) 278 (197-328) 101 (79-134)	NA NA NA NA NA
Breakfast cereals	Wheat biscuits (1) Toasted muesli (2)	293 (208-388) 42 (22-85)	260 NA
Muffins	Supermarket (1) Café (1)	40 (17-55) 23 (12-37)	NA NA
Fried rice	1	ND	NA
Fried noodles	2	72 (ND-145)	NA
Cereal-based snacks	Corn chips (1) Grain crisps (1) Popcorn (1)	596 (410-734) 197 (132-276) 154 (81-228)	270 (200-340) NA NA
Peanut butter	2	67 (40-102)	NA
Roasted nuts	2	42 (9-84)	NA

NA = not analysed ND = not detected at limits of detection in the range 8-19 µg/kg

[1] Each brand or sampling location was sampled 3-6 times

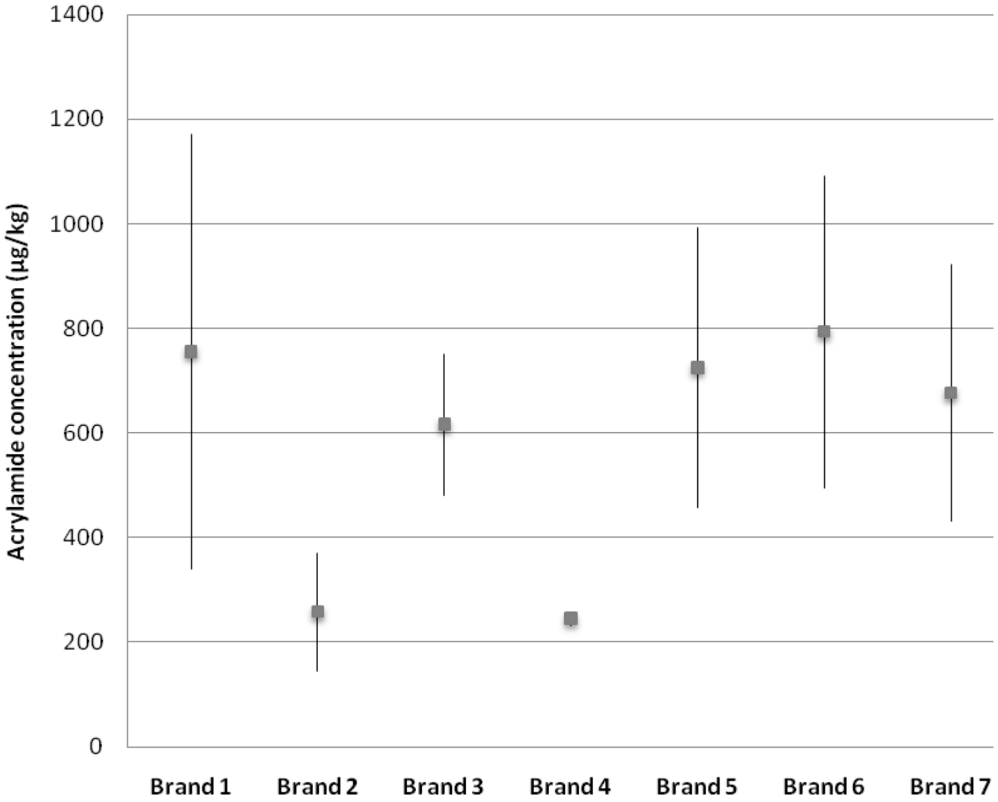
[2] Mean values shown here are the mean of the mean values for the different brands or sampling locations. The range shown here is the range of all individual analytical results

[3] (Love and Grounds, 2006)

[4] Bread was toasted to a level adjudged to be „medium'

Acrylamide concentrations varied from brand to brand (or sampling location to sampling location), but also varied significantly within some brands. The variability within a brand or retail outlet, expressed as co-efficient of variation (CV), ranged from a low of 5.1% for one brand of potato crisps to a high of 99.6% for hot chips from a regional fish and chip outlet (Appendix 4). Figure 1 shows the mean and standard deviation of the acrylamide concentration for the 7 brands of potato crisps analysed in the current study.

Figure 1: Acrylamide concentrations for potato crisp brands available in New Zealand[1]



[1]The markers represent the mean acrylamide concentration for 3-5 batches of the brand, while the vertical lines represent 1 standard deviation of acrylamide concentration. Brand 4 had a consistent concentration of acrylamide and a small standard deviation

In the case of potato crisps analysed in the current survey, it can be seen that the acrylamide concentration of Brand 4 was extremely consistent across batches (range 227-256 µg/kg), while concentrations for Brand 1 varied considerably across batches (range 371-1,460 µg/kg). The hypothesis that the variance in acrylamide concentrations is not equal for the different potato crisp brands can be tested using Levene's test using either the mean or median as the measure of central tendency.[6] Use of the median in Levene's test is preferred when the distribution of the data is skewed, while use of the mean is preferred when the distribution is symmetric. With small sample numbers (n=5), assigning a distribution to the concentration data is subjective. In the current situation, using the median results in the test statistic being not significant (variances for different brands are not significantly different), while using the mean results in a test statistic that is significant ($p = 0.03$). If it is assumed that the data are from a lognormal distribution, data can be log transformed and the more sensitive Bartlett's test can be applied.[7] For potato crisps, Bartlett's test gives a significant test statistic ($p < 0.05$) and the variance in acrylamide concentration between potato crisp brands can be said to be statistically significantly different. While small variance was observed for Brand 4, without

[6] http://www.itl.nist.gov/div898/handbook/eda/section3/eda35a.htm
[7] http://www.itl.nist.gov/div898/handbook/eda/section3/eda357.htm

further data, this is not sufficient to confirm that it is possible for crisp manufacturers to produce to this level of consistency with respect to acrylamide concentration.

Similar phenomena were observed for other product types, with some brands (biscuits, toasted muesli) or sampling locations (hot chips, fried noodles) maintaining acrylamide concentrations within a narrow range (%CV <25), while other brands or sampling location of the same foods had acrylamide concentrations that varied across a wide range (%CV >25). When differences in variance were tested using the Levene's test, only bread showed a significant difference between brands. This reflects the difference between white and wheatmeal bread with the latter being more variable. For hot chips, the variance was almost significant at $p<0.05$ using the Levene's test ($p=0.059$). Assuming lognormality in the distribution of these data, the variance of log transformed data was highly significantly different between sampling locations ($p=0.0009$) using the Bartlett's test. There was greater consistency, but not necessarily lower acrylamide concentrations, in hot chips purchased from the main national fast food chain outlets compared with local outlets.

3.1.1 Trends in acrylamide concentrations compared with previous New Zealand data

While the relatively low sample numbers means comparisons between surveys should be viewed with some caution, the results in Table 4 suggest a substantial reduction in the mean acrylamide concentration in potato crisps available in New Zealand. The mean concentration in the current survey was approximately one-third of the mean concentration determined by Love and Grounds (2006) across all brands and for the three dominant brands that were common across the two studies. In contrast, the acrylamide concentrations in hot chips appear remarkably similar between the two surveys with the exception of one brand that showed an acrylamide concentration half that reported in the previous New Zealand study. The concentration of acrylamide in corn crisps is approximately twice that reported in the previous New Zealand study.

In order to test the statistical significance of this trend information, it was assumed that the data were from an underlying lognormal distribution. Data were log transformed and tested using the Welch t-test (non-paired data, possibly unequal variances). The decrease in the acrylamide concentration of potato crisps was highly statistically significant ($p = 0.005$), while changes in the acrylamide concentration of hot chips were not statistically significant at the $p = 0.05$ level. It should be noted that the difference in the acrylamide concentration of potato crisps between the 2006 and the current surveys was also statistically significant when the non-parametric Mann-Whitney U test was applied. There were insufficient data to test the significance of changes in the acrylamide concentration of corn crisps.

3.1.2 Comparisons with international acrylamide data

Results of international studies on the acrylamide concentrations of foods are summarised in Appendix 5. Data have only been summarised for foods included in the current New Zealand survey.

Results from the current survey are, in most cases, consistent with typical results from international studies, although four results are worth noting:

- The mean acrylamide concentration in supermarket potato wedges, cooked from frozen (1,278 µg/kg) is approximately 4-5 times higher than similar products reported internationally, and summarised in Appendix 5. Although, it should be noted that it is not always possible to determine whether products in different studies are exactly equivalent.

- The mean acrylamide concentrations in toasted bread (58 and 72 µg/kg for white and wheatmeal bread, respectively) are markedly lower than the mean concentrations of any of the studies listed in Appendix 5.
- The mean acrylamide concentration in corn crisps (596 µg/kg) is high compared to the previous New Zealand survey (mean = 270 µg/kg) and is also high in comparison to concentrations reported internationally (mean values in range 150-425 µg/kg) (Appendix 5).
- The mean acrylamide concentration in roasted nuts (42 µg/kg) is within the range of concentrations reported internationally (Appendix 5), but is well towards the lower end of the reported range (mean values in the range 15-357 µg/kg).

3.2 Dietary Acrylamide Exposure Assessment using a Total Diet (TD) Approach

Deterministic (TD approach) dietary exposure estimates for acrylamide are summarised in Table 5, along with the equivalent results from the previous New Zealand study (Love and Grounds, 2006).

Table 5: Deterministic estimates of dietary acrylamide exposure for New Zealand population sub-groups, total diet (TD) approach

Population sub-group	Mean estimated dietary acrylamide exposure (µg/kg body weight/day)	
	Current Study	2006 Study[1]
Infant (6 months)	1.77	1.72
Toddler (1-3 years)	2.21	2.25
Child (5-6 years)	2.22	2.34
Female (11-14 years)	1.25	1.41
Male (11-14 years)	1.51	1.56
Male (19-24 years)	1.04	0.99
Female (25+ years)	0.72	0.74
Male (25+ years)	0.83	0.85

[1] (Love and Grounds, 2006)

3.2.1 Comparison with previous New Zealand exposure estimates

There is no substantial difference between the TD approach exposure estimates determined in the current study and those determined for New Zealand in 2006. While acrylamide concentration data are substantially lower than those used in 2006 for some foods (muffins, potato crisps), other concentrations are higher than in 2006 (cracker biscuits, oven roasted potatoes, flavoured snacks). The overall effect of these individual concentration fluctuations is that the estimated dietary acrylamide exposures are virtually unchanged.

3.2.2 Major food contributors to dietary acrylamide exposure

According to the TD approach model, the foods contributing most to dietary acrylamide exposure were the potato products; hot chips and roasted potatoes. The contribution of these two foods to the total estimated dietary acrylamide exposure ranged from 27% (infant) to 49% (11-14 year male). Other foods that contributed consistently to dietary acrylamide exposure were wheat biscuit breakfast cereal (2.5-15.3%), potato crisps (2.1-9.4%), white bread (2.9-5.2%), and cracker biscuits (1.1-7.3%). For adult New Zealanders, tea contributed 6-9% of the total dietary acrylamide exposure (Appendix 6).

While estimated dietary acrylamide exposures are virtually unchanged from 2006 to 2011, the contributions of various foods to estimated dietary exposure have changed. Trend information for the relative contribution of key foods is shown in Figures 2 and 3. The adult male (25+ years) and teenage female (11-14 years) population sub-groups were selected because of differences in tea, beer, coffee, potato crisp and snack consumption between these two groups. The contribution of potato crisps to acrylamide exposure has decreased between 2006 and 2011 and the contribution from potato, hot chips and oven baked/roasted potatoes appears to have increased.

Figure 2: Trend in major food contributors for 2006 and 2011 for an adult male (25+ years)

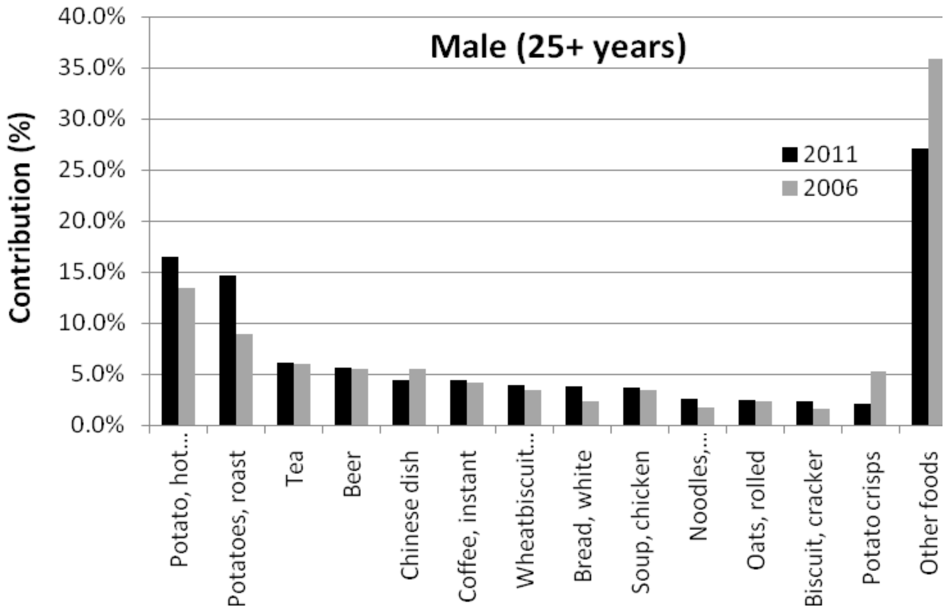
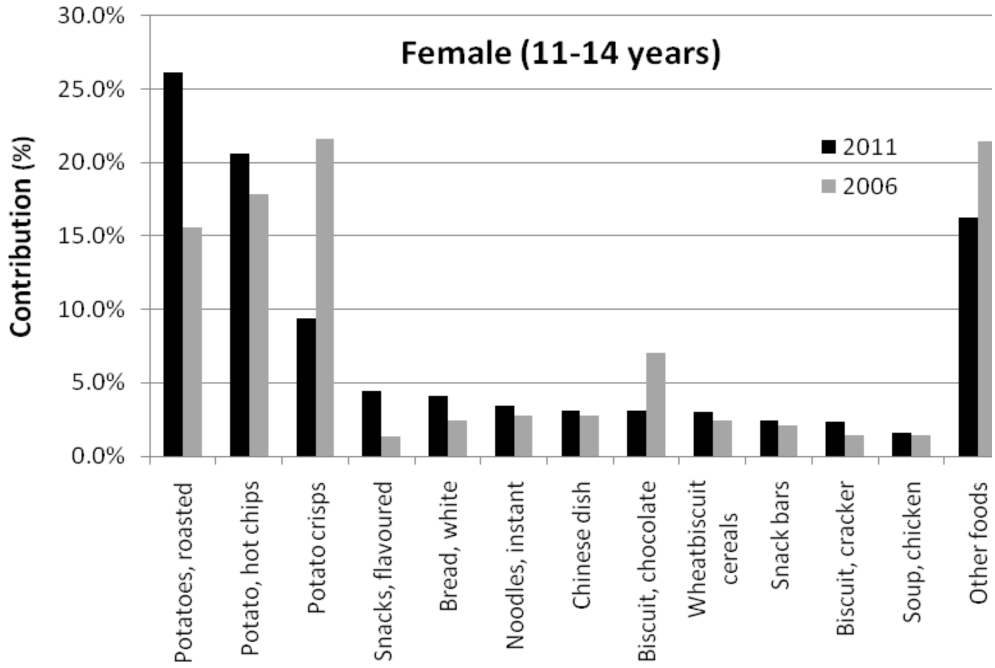


Figure 3: Trend in major food contributors for 2006 and 2011 for a teenage female (11-14 years)



The contributions from „Chinese dish" are based on a value of 300µg/kg for deep fried noodles. More recent data suggests the true value is lower than this and that the contribution from foods mapped to "Chinese dish" might range from <0.1 to 1.9% of total acrylamide, rather than <0.1 to 7.5% µg/kg bw/day as shown.

The pattern of contributing foods is similar to other international studies (see Appendix 7); although the proportional contribution of bread to total dietary acrylamide exposure appears lower in New Zealand than for a number of other countries.

3.3 Dietary Acrylamide Exposure Assessment using Dietary Modelling

Estimates of dietary acrylamide exposure derived from dietary modelling (DM approach) are summarised in Table 6. The estimates derived from the TD approach are included for comparison.

Table 6: Estimates of dietary acrylamide exposure for New Zealand population sub-groups, dietary modelling (DM) approach

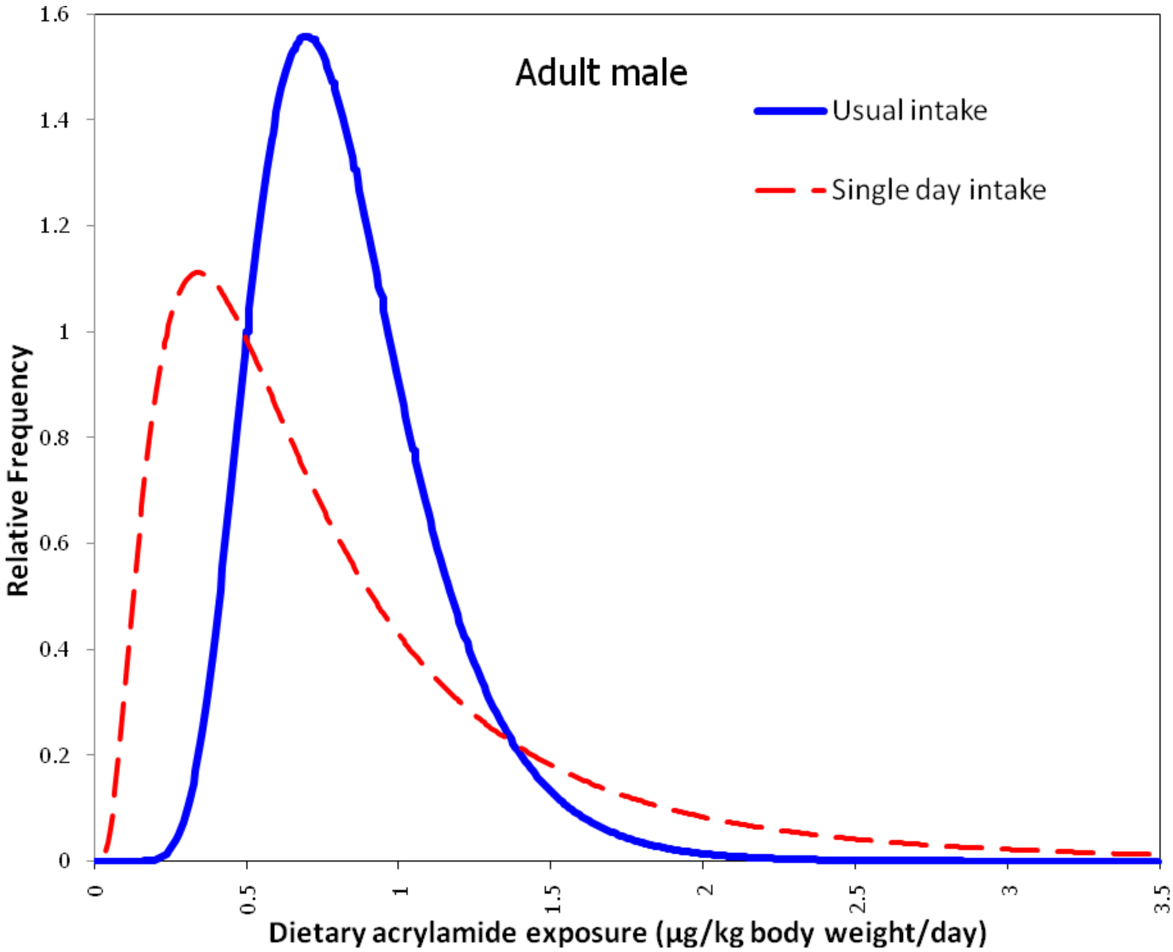
Population sub-group	**Mean estimated dietary acrylamide exposure and (95th percentile) (µg/kg body weight/day)**	
	DM Approach[1,2]	**TD Approach**
Infant (6 months)	NA	1.77
Toddler (1-3 years)	NA	2.21
Child (5-6 years)	1.89 (3.31)	2.22
Female (11-14 years)	0.98 (1.81)	1.25
Male (11-14 years)	1.36 (2.02)	1.51
Male (19-24 years)	1.01 (1.58)	1.04
Female (25+ years)	0.66 (1.15)	0.72
Male (25+ years)	0.84 (1.39)	0.83

[1] Means were weighted using nutrition survey weightings to align the respondent profile to the New Zealand population profile
[2] Means and 95 percentiles refer to the distribution of usual exposures, determined using PC-SIDE software (Iowa State University)
NA = not applicable, the nutrition surveys did not survey New Zealanders younger than 5 years
DM = dietary modelling
TD = Total diet

The two approaches to dietary exposure assessment used in the current study (TD and DM) show good agreement with respect to estimates of the mean dietary exposure to acrylamide. This is perhaps not surprising, as both approaches used the same acrylamide concentration information and the simulated typical diets used in the TD approach used nutrition survey data as a major input (Vannoort and Thomson, 2005).

As noted in the footnote to Table 6, the 95th percentiles refer to the distribution of usual (long-term) exposures for a highly exposed consumer. This distribution tends to be narrower than that derived from a single 24-hour dietary recall record. This is demonstrated in Figure 4 for acrylamide exposure for an adult male. For convenience, the exposure distributions have been represented in Figure 4 by lognormal distributions. The lognormal distribution is a good approximation to both the usual and single day exposure distributions.

Figure 4: Comparison of single day and usual dietary acrylamide exposure distributions for an adult New Zealand male



3.3.1 Major food contributors to dietary acrylamide exposure

The DM approach to dietary exposure assessment resulted in more diverse contributions of foods to total dietary exposure than the TD approach. For adult New Zealanders, 27% of exposure came from potato products (hot chips, roast potatoes, potato crisps), 15% from bread (fresh or toasted), 12% from breakfast cereals and 17% from beverages (beer, tea and coffee). For New Zealand children the major contributors were potato products (37%), breakfast cereals (16%), bread (10%), and biscuits (7%) (Appendix 6).

3.3.2 Comparison with international exposure estimates

International dietary exposure estimates for acrylamide are summarised in Appendix 7. It should be noted that these estimates are principally from European Union countries. Exposure estimates for New Zealand population sub-groups are within the range of international estimates, but tend to be towards the upper end of the international range. For example, dietary acrylamide exposure for adult New Zealanders is approximately 0.8 µg/kg bw/day, while of the many estimates for adult populations in Appendix 7, only the Czech Republic (0.73-0.77 µg/kg bw/day), Denmark (0.76-0.80 µg/kg bw/day), and Hungary (0.75-0.79 µg/kg bw/day) estimated dietary exposure to acrylamide at levels similar to New Zealand.

It is not possible to say whether this reflects an actual higher exposure to acrylamide in New Zealand or differences in the exposure assessment methods used and, particularly, in the assumptions made. It appears possible that this is due, at least in part, to New Zealand efforts to assign acrylamide concentration values to the widest possible range of foods. For example, beer that contributed 4.5% and 5.7% of TD exposure for adult males, 19-24 years and 25+ years respectively, was not included in the European food lists. Exposure estimates based only on the narrower range of foods, for which acrylamide concentrations were actually measured in 2011, would be in the range 0.40-0.46 µg/kg bw/day and would be similar to the European mean.

The 95th percentiles of the usual exposure distribution for New Zealanders are generally well within the range of international estimates (Appendix 7).

4 CONCLUSIONS

Acrylamide concentrations were measured in selected New Zealand foods. Foods were selected on the basis of their likely contribution to dietary acrylamide exposure. Foods analysed included potato products (crisp, hot chips, oven fries), cereal products (bread, biscuits, breakfast cereals, muffins, fried rice/noodles and cereal-based snack foods) and nut products (peanut butter, roasted peanuts and cashews).

Mean acrylamide concentrations for potato crisps have decreased significantly since an earlier New Zealand survey (2006), from 1,570 µg/kg to 581 µg/kg. Mean acrylamide concentrations in potato hot chips and wheat biscuit cereals were very similar to concentrations determined in the 2006 survey, while concentrations in corn crisps were more than double the concentration determined in 2006 (596 µg/kg, compared to 270 µg/kg). However, it should be noted that the current survey only sampled a single brand of corn crisps (5 samples), while the 2006 survey only analysed single samples from two brands. The brand analysed in the current survey was different to the brands analysed in 2006.

The acrylamide concentrations of some potato crisp brands were significantly more variable than other brands. The small variance observed for one brand of crisps supports that it is possible for a crisp manufacturer to produce a consistent product with respect to acrylamide concentration. There was greater consistency, but not necessarily lower acrylamide concentrations, in hot chips purchased from the main national fast food chain outlets compared with local outlets. Wheatmeal bread was more variable than white bread.

Concentrations of acrylamide determined in the current survey were mostly within the range of concentrations from other studies reported in the literature, with the exception of potatoes roasted from frozen and corn crisps (higher) and toasted bread (lower).

Mean estimates of dietary acrylamide exposure (0.72 - 1.04 µg/kg bw/day for adults) were very similar to estimates made in 2006 (0.74 - 0.99 µg/kg bw/day for adults), whether the estimate was derived from a deterministic TD approach or from a DM approach. Estimates of dietary acrylamide exposure were towards the upper end of the range of estimates derived internationally. It is not possible to say whether this is due to true difference in exposure or differences in the methodology and assumptions used in dietary exposure assessment. Usual exposure estimates at the 95th percentile were within the range of equivalent estimates determined in studies in other countries.

The major foods contributing to dietary acrylamide exposure in New Zealand were potato products, bread, breakfast cereals and beverages. This is largely consistent with international findings. The contribution of potato crisps to acrylamide exposure appears to have decreased between 2006 and 2011 and the contribution from potato, hot chips and oven baked/roasted potatoes appears to have increased.

5 REFERENCES

Al-Taher F. (2011) Analysis of acrylamide in French fries using Agilent SampliQ QuEChERS AOAC kit and LC/MS/MS. Agilent Technologies Food Application. Accessed at: http://www.chem.agilent.com/Library/applications/5990-5940EN.pdf. Accessed: 12 October 2011.

Arisseto AP, Toledo MCdF, Govaert Y, van Loco J, Fraselle S, Degroodt J-M, Caroba DCR. (2009) Contribution of selected foods to acrylamide intake by a population of Brazilian adolescents. LWT - Food Science and Technology; 42(1): 207-211.

Arribas-Lorenzo G, Morales FJ. (2009) Dietary exposure to acrylamide from potato crisps to the Spanish population. Food Additives and Contaminants: Part A; 26(3): 289-297.

Becalski A, Lau BPY, Lewis D, Seaman SW. (2003) Acrylamide in foods: Occurrence, sources, and modeling. Journal of Agricultural and Food Chemistry; 51(3): 802-808.

Becalski A, Stadler R, Hayward S, Kotello S, Krakalovich T, Lau BPY, Roscoe V, Schroeder S, Trelka R. (2010) Antioxidant capacity of potato chips and snapshot trends in acrylamide content in potato chips and cereals on the Canadian market. Food Additives and Contaminants: Part A; 27(9): 1193-1198.

Bermudo E, Moyano E, Puignou L, Galceran MT. (2008) Liquid chromatography coupled to tandem mass spectrometry for the analysis of acrylamide in typical Spanish products. Talanta; 76(2): 389-394.

Biedermann M, Grundböck F, Fiselier K, Biedermann S, Bürgi C, Grob K. (2010) Acrylamide monitoring in Switzerland, 2007-2009: Results and conclusions. Food Additives and Contaminants: Part A; 27(10): 1352-1362.

Brantsæter AL, Haugen M, Mul Ad, Bjellaas T, Becher G, Klaveren JV, Alexander J, Meltzer HM. (2008) Exploration of different methods to assess dietary acrylamide exposure in pregnant women participating in the Norwegian Mother and Child Cohort Study (MoBa). Food and Chemical Toxicology; 46(8): 2808-2814.

Brinsdon S. (2004) Simulated typical diets for the 2003/2004 New Zealand Total Diet Survey. A report for the New Zealand Food Safety Authority. Wellington: New Zealand Food Safety Authority.

Chen F, Yuan Y, Liu J, Zhao G, Hu X. (2008) Survey of acrylamide levels in Chinese foods. Food Additives and Contaminants: Part B; 1(2): 85-92.

Claeys W, Baert K, Mestdagh F, Vercammen J, Daenens P, de Meulenaer B, Maghuin-Rogister G, Huyghebaert A. (2010) Assessment of the acrylamide intake of the Belgian population and the effect of mitigation strategies. Food Additives and Contaminants: Part A; 27(9): 1199-1207.

Croft M, Tong P, Fuentes D, Hambridge T. (2004) Australian survey of acrylamide in carbohydrate-based foods. Food Additives and Contaminants; 21(8): 721-736.

DiNovi M. (2006) The 2006 exposure assessment for acrylamide. Accessed at: http://www.fda.gov/downloads/Food/FoodSafety/FoodContaminantsAdulteration/ChemicalContaminants/Acrylamide/UCM197239.pdf. Accessed: 1 September 2011.

Dodd KW, Guenther PM, Freedman LS, Subar AF, Kipnis V, Midthune D, Tooze JA, Krebs-Smith SM. (2006) Statistical methods for estimating usual intake of nutrients and foods: A review of the theory. Journal of the American Dietetic Association; 106(10): 1640-1650.

Dybing E, Farmer PB, Andersen M, Fennell TR, Lalljie SPD, Müller DJG, Olin S, Petersen BJ, Schlatter J, Scholz G, Scimeca JA, Slimani N, Törnqvist M, Tuijtelaars S, Verger P. (2005) Human exposure and internal dose assessments of acrylamide in food. Food and Chemical Toxicology; 43(3): 365-410.

Dybing E, Sanner T. (2003) Risk assessment of acrylamide in foods. Toxicological Sciences; 75(1): 7-15.

European Food Safety Authority. (2003) Acrylamide - EU summary of activities. Study area 1 - Levels of acrylamide in food. . Accessed at: http://ec.europa.eu.int/comm/food/food/chemicalsafety/contaminants/study_area1.pdf. Accessed: 11 October 2004 (no longer accessible).

European Food Safety Authority. (2009) Results on the monitoring of acrylamide levels in food.
European Food Safety Authority. (2010) Scientific report of EFSA, Results on acrylamide levels in food from monitoring year 2008. EFSA Journal; 8(5): 1-31.

European Food Safety Authority. (2011) Results on acrylamide levels in food from monitoring years 2007-2009 and exposure assessment. EFSA Journal; 9(4): 48.

Fernandes JO, Soares C. (2007) Application of matrix solid-phase dispersion in the determination of acrylamide in potato chips. Journal of Chromatography A; 1175(1): 1-6.

Geng Z, Jiang R, Chen M. (2008) Determination of acrylamide in starch-based foods by ion-exclusion liquid chromatography. Journal of Food Composition and Analysis; 21(2): 178-182.

Hirvonen T, Kontto J, Jestoi M, Valsta L, Peltonen K, Pietinen P, Virtanen SM, Sinkko H, Kronberg-Kippilä C, Albanes D, Virtamo J. (2010) Dietary acrylamide intake and the risk of cancer among Finnish male smokers. Cancer Causes and Control; 21(12): 2223-2229.

Hoffmann K, Boeing H, Dufour A, Volatier JL, Telman J, Virtanen M, Becker W, De Henauw S. (2002) Estimating the distribution of usual dietary intake by short-term measurements. European Journal of Clinical Nutrition; 56(SUPPL. 2): S53-S62.

Konings EJM, Baars AJ, Van Klaveren JD, Spanjer MC, Rensen PM, Hiemstra M, Van Kooij JA, Peters PWJ. (2003) Acrylamide exposure from foods of the Dutch population and an assessment of the consequent risks. Food and Chemical Toxicology; 41(11): 1569-1579.

Larsson SC, Åkesson A, Wolk A. (2009) Dietary acrylamide intake and prostate cancer risk in a prospective cohort of Swedish men. Cancer Epidemiology Biomarkers & Prevention; 18(6): 1939-1941.

Love J, Grounds P. (2004) Chemical food safety-Validation of the acrylamide method and sampling plan-2003/04 Year. ESR Client report FW0443 to the NZFSA. Wellington: MAF.

Love J, Grounds P. (2006) Chemical food safety. Acrylamide in New Zealand food. ESR Client Report FW0545. Christchurch: ESR.

Mastovska K, Lehotay SJ. (2006) Rapid sample preparation method for LC-MS/MS or GC-MS analysis of acrylamide in various food matrices. Journal of Agricultural and Food Chemistry; 54: 7001-7008.

Matthys C, Bilau M, Govaert Y, Moons E, De Henauw S, Willems JL. (2005) Risk assessment of dietary acrylamide intake in Flemish adolescents. Food and Chemical Toxicology; 43(2): 271-278.

Mills C, Tlustos C, Evans R, Matthews W. (2008) Dietary acrylamide exposure estimates for the United Kingdom and Ireland: Comparison between semiprobabilistic and probabilistic exposure models. Journal of Agricultural and Food Chemistry; 56(15): 6039-6045.

Ministry of Health. (2003) NZ Food NZ Children. Key results of the 2002 National Children's Nutrition Survey. Wellington: Ministry of Health.

Mojska H, Gielecińska I, Szponar L, Ołtarzewski M. (2010) Estimation of the dietary acrylamide exposure of the Polish population. Food and Chemical Toxicology; 48(8-9): 2090-2096.

Nusser SM, Carriquiry AL, Dodd KW, Fuller WA. (1996) A semiparametric transformation approach to estimating usual daily intake distributions. Journal of the American Statistical Association; 91(436): 1440-1449.

Ölmez H, Tuncay F, Özcan N, Demirel S. (2008) A survey of acrylamide levels in foods from the Turkish market. Journal of Food Composition and Analysis; 21(7): 564-568.

Ono H, Chuda Y, Ohnishi-Kameyama M, Yada H, Ishizaka M, Kobayashi H, Yoshida M. (2003) Analysis of acrylamide by LC-MS/MS and GC-MS in processed Japanese foods. Food Additives and Contaminants; 20(3): 215-220.

Russell DG, Parnell WR, Wilson NC, Faed J, Ferguson E, Herbison P, Horwath C, Nye T, Reid P, Walker R, Wilson B, Tukuitonga C. (1999) NZ Food: NZ People. Wellington: Ministry of Health.

Scientific Committee on Food. (2002) Opinion of the Scientific Committee on Food on new findings regarding the presence of acrylamide in food. Accessed at: http://ec.europa.eu/food/fs/sc/scf/out131_en.pdf. Accessed: 12 October 2011.

Soh P, Ferguson EL, McKenzie JE, Skeaff S, Parnell W, Gibson RS. (2002) Dietary intakes of 6-24-month-old urban South Island New Zealand children in relation to biochemical iron status. Public Health Nutrition; 5(2): 339-346.

Svensson K, Abramsson L, Becker W, Glynn A, Hellenäs KE, Lind Y, Rosén J. (2003) Dietary intake of acrylamide in Sweden. Food and Chemical Toxicology; 41(11): 1581-1586.

Takatsuki S, Nemoto S, Sasaki K, Maitani T. (2003) Determination of acrylamide in processed foods by LC/MS using column switching. Shokuhin Eiseigaku Zasshi; 44(2): 89-95.

Tareke E, Rydberg P, Karlsson P, Eriksson S, Törnqvist M. (2002) Analysis of acrylamide, a carcinogen formed in heated foodstuffs. Journal of Agricultural and Food Chemistry; 50(17): 4998-5006.

Tateo F, Bononi M, Gallone F. (2010) Acrylamide content in potato chips on the Italian market determined by liquid chromatography tandem mass spectrometry. International Journal of Food Science and Technology; 45(3): 629-634.

Tawfik MS, El-Ziney MG. (2008) Acrylamide levels in selected foods in Saudi Arabia with reference to health-risk assessment of dietary acrylamide intake. American Journal of Food Technology; 3(6): 347-353.

United States Food and Drug Administration. (2006) Survey Data on Acrylamide in Food: Individual Food Products. Accessed at: http://www.fda.gov/food/foodsafety/foodcontaminantsadulteration/chemicalcontaminants/acrylamide/ucm053549.htm. Accessed: 17 January.

United States Food and Drug Administration. (2009) Survey data on acrylamide in food: Total Diet Study results. Accessed at: http://www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/ChemicalContaminants/Acrylamide/ucm053566.htm. Accessed: 7 September 2011.

United States Food and Drug Administration. (2011) Survey Data on Acrylamide in Food: Individual Food Products. Accessed at: http://www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/ChemicalContaminants/Acrylamide/default.htm. Accessed: 1 September 2011.

Vannoort RW, Thomson BM. (2005) 2003/04 New Zealand Total Diet Survey. Agricultural compound residues, selected contaminants and nutrients. Wellington: New Zealand Food Safety Authority.

Vinci R, Mestdagh F, De Meulenaer B. (2011) Acrylamide formation in fried potato products-present and future, a critical review on mitigation strategies. Food Chemistry: In press.

WHO GEMS/Food-Euro. (1995) Second workshop on Reliable Evaluation of Low-level Contamination of Food, Kulmbach, Federal Republic of Germany, 26-27 March, 1995. EUR/ICP/EHAZ.94.12/WS04. Geneva: World Health Organization.

Wilson KM, Mucci LA, Rosner BA, Willett WC. (2010) A prospective study on dietary acrylamide intake and the risk for breast, endometrial, and ovarian cancers. Cancer Epidemiology Biomarkers & Prevention; 19(10): 2503-2515.

APPENDIX 1 DATA USED FOR DIETARY ACRYLAMIDE EXPOSURE ASSESSMENT – TD APPROACH

Food	Source of acrylamide data	Mean acrylamide concentration (µg/kg)	Concentration used in the previous study (2006) where this has changed in current study
Apple	(Love and Grounds, 2006)	0	
Apple-based juice	(Love and Grounds, 2006)	0	
Apricot, canned	(United States Food and Drug Administration, 2011)	10 (pineapple)	
Avocado	(Love and Grounds, 2006)	0	
Bacon	(European Food Safety Authority, 2003)[8]	50	
Banana	(Love and Grounds, 2006)	0	
Beans	(United States Food and Drug Administration, 2011)	11	
Beans, baked, canned	(United States Food and Drug Administration, 2011)	76	
Beef, corned	(Love and Grounds, 2006)	0	
Beef, mince	(Love and Grounds, 2006)	0	
Beef, rump	(Love and Grounds, 2006)	0	
Beer	(Love and Grounds, 2004)	10	
Beetroot, canned	(United States Food and Drug Administration, 2009)	10	
Biscuit, chocolate	Current study	119	300 (United States Food and Drug Administration, 2006)
Biscuit, cracker	Current study	327	220 (Love and Grounds, 2004)
Biscuit, plain sweet	Current study	119	80 (European Food Safety Authority, 2003)[9]
Bran flake cereal, mixed	Current study	167	189 (United States Food and Drug Administration, 2011)
Bread, mixed grain	Current study	38	30 (Love and Grounds, 2004)
Bread, wheatmeal	Current study	45	30 (Love and

[8] This reference is no longer accessible. An alternative reference for this concentration value was not found.

Food	Source of acrylamide data	Mean acrylamide concentration (µg/kg)	Concentration used in the previous study (2006) where this has changed in current study
			Grounds, 2004)
Bread, white	Current study	31	20 (Love and Grounds, 2004)
Broccoli/Cauliflower	(United States Food and Drug Administration, 2011)	10 (typical vegetable)	
Butter	(Love and Grounds, 2006)	0	
Cabbage	(United States Food and Drug Administration, 2011)	10 (typical vegetable)	
Caffeinated beverage	(Love and Grounds, 2006)	0	
Cake	Current study	31	100 (United States Food and Drug Administration, 2011)
Capsicum	(Love and Grounds, 2006)	0	
Carbonated drink	(Love and Grounds, 2006)	0	
Carrot	(United States Food and Drug Administration, 2011)	10 (typical vegetable)	
Celery	(United States Food and Drug Administration, 2011)	10 (typical vegetable)	
Cheese	(Love and Grounds, 2006)	0	
Chicken	(Love and Grounds, 2006)	0	
Chicken takeaway	Love and Grounds	10	
Chinese dish	(Ono *et al.*, 2003)	300[10]	
Chocolate beverage	(United States Food and Drug Administration, 2011)	10	
Chocolate, plain milk	(United States Food and Drug Administration, 2011)	0	
Coffee, beans, ground	(United States Food and Drug Administration, 2011)	10	
Coffee, instant	(United States Food and Drug Administration, 2011)	10	
Confectionery	(Love and Grounds, 2006)	0	
Corn, canned	(United States Food and Drug Administration,	10 (typical	

[10] An approximate average of two values for deep fried noodles (51 and 581),

Food	Source of acrylamide data	Mean acrylamide concentration (µg/kg)	Concentration used in the previous study (2006) where this has changed in current study
	2011)	vegetable)	
Cornflakes	Current study	167	110 (Love and Grounds, 2006)
Courgette	(United States Food and Drug Administration, 2011)	10 (typical vegetable)	
Cream	(Love and Grounds, 2006)	0	
Cucumber	(Love and Grounds, 2006)	0	
Dairy dessert	(Love and Grounds, 2006)	0	
Egg	(Love and Grounds, 2006)	0	
Fish fingers	(United States Food and Drug Administration, 2011)	12	
Fish, battered	(United States Food and Drug Administration, 2011)	30	
Fish, canned	(Love and Grounds, 2006)	0	
Fish, fresh	(United States Food and Drug Administration, 2011)	30	
Fruit drink	(Love and Grounds, 2006)	0	
Grapes	(Love and Grounds, 2006)	0	
Ham	(Love and Grounds, 2006)	0	
Hamburger, plain	(United States Food and Drug Administration, 2011)	0	
Honey	(Love and Grounds, 2006)	0	
Ice cream	(Love and Grounds, 2006)	0	
Infant and Follow-on formula	(United States Food and Drug Administration, 2011)	0	
Infant weaning food, cereal based	(United States Food and Drug Administration, 2011)	10	
Infant weaning food, custard/fruit dish	(United States Food and Drug Administration, 2011)	0	
Infant weaning food, savoury	(United States Food and Drug Administration, 2011)	50	
Jam	(United States Food and Drug Administration, 2011)	0	
Kiwifruit	(Love and Grounds, 2006)	0	
Kumara		15	

Food	Source of acrylamide data	Mean acrylamide concentration (µg/kg)	Concentration used in the previous study (2006) where this has changed in current study
Lamb/mutton	(Love and Grounds, 2006)	0	
Lambs liver	(Love and Grounds, 2006)	0	
Lettuce	(Love and Grounds, 2006)	0	
Margarine	(Love and Grounds, 2006)	0	
Meat pie	(United States Food and Drug Administration, 2011)	30	
Melon	(Love and Grounds, 2006)	0	
Milk, 0.5% fat	(United States Food and Drug Administration, 2011)	0	
Milk, 3.25% fat	(United States Food and Drug Administration, 2011)	0	
Milk, flavoured	(United States Food and Drug Administration, 2011)	0	
Muesli	Current study	42	40 (Love and Grounds, 2004)
Muffin	Current study	31	300 (United States Food and Drug Administration, 2011) (10 and 620 µg/kg)
Mushrooms	(United States Food and Drug Administration, 2011)	10 (typical vegetable)	
Mussels	(Love and Grounds, 2006)	0	
Nectarine	(Love and Grounds, 2006)	0	
Noodles, instant	Current study	72	50 (United States Food and Drug Administration, 2011)
Oats, rolled	(United States Food and Drug Administration, 2011)	70 (typical cereal)	
Oil	(Love and Grounds, 2006)	0	
Onion	(United States Food and Drug Administration, 2011)	13	
Orange	(Love and Grounds, 2006)	0	
Orange juice	(Love and Grounds, 2006)	0	
Oysters	(Love and Grounds, 2006)	0	
Pasta, dried	(United States Food and	50	

Food	Source of acrylamide data	Mean acrylamide concentration (µg/kg)	Concentration used in the previous study (2006) where this has changed in current study
	Drug Administration, 2011) (17-136 µg/kg)		
Peaches, canned	(United States Food and Drug Administration, 2011)	10 (pineapple)	
Peanut butter	Current study	67	100 (United States Food and Drug Administration, 2011)
Peanuts, whole	Current study	42	0 (United States Food and Drug Administration, 2011)
Pear	(Love and Grounds, 2006)	0	
Peas	(United States Food and Drug Administration, 2011)	10 (typical vegetable)	
Pineapple, canned	(Love and Grounds, 2006)	0	
Pizza	(United States Food and Drug Administration, 2011)	30	
Pork chop	(Love and Grounds, 2006)	0	
Potato crisps	Current study	581	1500 (Love and Grounds, 2006)
Potato, hot chips	Current study	353	300 (Love and Grounds, 2006)
Potatoes, peeled	(Love and Grounds, 2004)	10 (boiled)	
Potatoes, with skin	Current study	697	10 (Love and Grounds, 2004) (boiled)
Prunes	(United States Food and Drug Administration, 2011)	10	
Pumpkin	(United States Food and Drug Administration, 2011)	10	
Raisins/sultanas	(United States Food and Drug Administration, 2011)	10 (typical fruit)	
Rice, white	Current study	5	70 (United States Food and Drug Administration, 2011)
Salad dressing	(Love and Grounds, 2006)	0	
Sausages	(United States Food and	0	

Food	Source of acrylamide data	Mean acrylamide concentration (µg/kg)	Concentration used in the previous study (2006) where this has changed in current study
	Drug Administration, 2011)		
Silverbeet	(United States Food and Drug Administration, 2011)	10 (typical vegetable)	
Snack bars	(United States Food and Drug Administration, 2011)	200 (not potato)	
Snacks, flavoured	Current study	316	100 (United States Food and Drug Administration, 2011)
Soup, chicken	(United States Food and Drug Administration, 2011)	100	
Soy milk	(United States Food and Drug Administration, 2011)	0 (soy infant formula)	
Spaghetti in sauce, canned	(Love and Grounds, 2006)	76	
Strawberries	(Love and Grounds, 2006)	0	
Sugar	(Love and Grounds, 2006)	0	
Taro	(United States Food and Drug Administration, 2011)	10 (typical vegetable)	
Tea	(Takatsuki *et al.*, 2003)	10	
Tomato	(Love and Grounds, 2006)	0	
Tomato sauce	(United States Food and Drug Administration, 2011)	10 (typical vegetable)	
Tomatoes in juice	(United States Food and Drug Administration, 2011)	10 (typical vegetable)	
Water	(Love and Grounds, 2006)	0	
Wheatbiscuit cereals	Current study	293	260 (Love and Grounds, 2006)
Wine, still red	(Love and Grounds, 2006)	0	
Wine, still white	(Love and Grounds, 2006)	0	
Yeast extract	(Love and Grounds, 2006)	190	
Yoghurt	(Love and Grounds, 2006)	0	

APPENDIX 2 MAPPING OF FOODS FOR WHICH ACRYLAMIDE INFORMATION WAS AVAILABLE TO NATIONAL NUTRITION SURVEY FOODS – DM APPROACH

Food group description	Includes	Mean acrylamide concentration (µg/kg)
Information from current study		
Biscuit, cracker	All cracker style biscuits, except crispbreads	327
Biscuit, sweet	All plain, sweet, filled and chocolate-coated biscuits. The biscuit component of recipes with a biscuit base, such as cheesecakes and slices	119
Bread, other	All bread types, other than white and wheatmeal, including buns and the bread component of filled rolls and sandwiches	38
Bread, other, toast	All toasted bread types, other than white and wheatmeal	65
Bread, wheatmeal	All wheatmeal or wholemeal bread, including buns/rolls, pita, bagels and the bread component of wheatmeal bread filled rolls and sandwiches	45
Bread, wheatmeal, toast	All toasted or fried wheatmeal or wholemeal bread, including pita, and the bread component of wheatmeal bread toasted sandwiches	72
Bread, white	All white bread, including buns/rolls, pita, bagels, croissants and the bread component of white bread filled rolls, sandwiches, hamburgers and savouries with bread casings	31
Bread, white, toast	All toasted or fried white bread, including pita, panini and the bread component of white bread toasted sandwiches	58
Cereal, muesli, toasted	All toasted and non-toasted muesli, muesli bars, and muesli slices	42
Cereal, other	Miscellaneous cereals, including cooked, shaped and puffed cereals	167
Cereal, wheat biscuits	All wheat biscuit cereals	293
Corn chips, snacks	All corn or nacho crisps, taco shells and the corn crisp component of nacho recipes	596
Crisp, grain	All grain-based crisps, other than corn crisps	197
Crispbread	All crispbread-style crackers, crispbreads and rice wafers	598
Muffin	All cakes, crumpets, doughnuts, eclairs, lamingtons, loaves, muffins, cake-like puddings, scones and waffles	31

Food group description	Includes	Mean acrylamide concentration (µg/kg)
Noodle, fried	Fried or deep-fried noodles of all noodle types	72
Nuts, cashew, roasted	Roasted cashew nuts	23
Nuts, roasted	All roasted nuts, other than cashews and peanuts	42
Peanut butter	All peanut butters and peanut sauces (satay), including the sauce component of recipes containing peanut sauce	67
Peanuts, roasted	All roasted peanuts, including the peanut component of peanut snack bars	61
Popcorn	All popcorn, commercial or homemade	154
Potato crisps	All potato, sweet potato and other vegetable crisps	581
Potato, hot chips	All potato and sweet potato hot chips, hash browns, fried croquettes and fried potatoes, excluding those from specific sources	353
Potato, hot chips, specific sources	Potato hot chips from specific fast food retailers (separate mapping for each of three major retailers and for generic „fish and chip' retailers)	276-394
Potato, oven roasted/baked, from commercial	Potato wedges, cooked from frozen	1278
Potato, oven roasted/baked, from raw	All baked or roasted potatoes, baked potato croquettes or cakes, and potato wedges, cooked from fresh	116
Rice, fried	All fried rice, including rice risotto	5
Snacks	All extruded snack foods	316
Information from Love and Grounds (2006)		
Bacon	All bacon and bacon bits	50
Beans	All beans, except canned baked beans	11
Bean, baked canned	All canned baked beans, with or without other inclusions	76
Beer	All beer	10
Beetroot, corn, canned	All canned vegetables	10
Bran flake cereal, mixed	All bran flake cereals	189
Broccoli/cauliflower, cabbage	All brassica vegetables	10
Celery	All stalk and stem vegetables	10
Courgette, cucumber, pumpkin	All cucurbit vegetables	10
Chinese dish	All Chinese-style recipes	300
Chocolate beverage	Hot chocolate and drinking chocolate	10
Coffee, beans, ground	All brewed coffees	10

Food group description	Includes	Mean acrylamide concentration (µg/kg)
Coffee, instant	All coffee or coffee substitutes in dry form or prepared from dry. A proportion factor is used to account for the difference between dry and from dry forms	10
Cornflakes	All corn flake cereals and corn flake snack bars	110
Fish fingers	All manufactured finfish, crustacean and mollusc products (fingers, cakes, etc.)	12
Fish, battered	All battered and fried or deep fried finfish, crustacea and mollusca and other battered animal foods (e.g. battered sausages)	30
Fish, fresh[1]	All crumbed finfish, crustacea and mollusca	30
Fruit, canned (apricots, peaches, pineapple)	All canned fruit	10
Fruit, dried (prunes, raisins/sultanas)	All dried fruit, fruit bars and leathers and the dried fruit component of coated dried fruits	10
Kumara, potato (boiled), taro root	All root and tuber vegetables, other than crisps, hot chips or baked/roasted	10
Lettuce, silverbeet	All leafy vegetables	10
Meat pie	All pastries encased recipes, including pasties, pastries, pies (savoury and sweet), quiche with a pastry base, samosa, savouries with a pastry base, vol au vents and wontons	30
Mushrooms	All mushroom and edible fungi	10
Onions	All bulb vegetables	13
Pasta, dried	All plain, filled and noodle-like pasta and the pasta component of pasta-containing recipes	50
Peas	All legume vegetables	10
Pizza	All pizzas, commercial and homemade	30
Snack bars	All snack bars, other than muesli bars, cornflake parts and fruit bars	200
Soup, chicken	All soups, commercial or homemade	100
Spaghetti in sauce, canned	All canned spaghetti	76
Tea	All teas, based on *Camellia sinensis* or other	10
Tomato sauce	All tomato-based sauces, purées and pastes	10
Yeast extract	All yeast extract products	190

[1] The concentration value assigned to „Fish, fresh' by Love and Grounds (2006) was derived from a commercial crumbed product. In the current study, fresh fish cooked without any coating has been assumed to not contain acrylamide. This appears valid, due to a lack of carbohydrate in fresh fish.

APPENDIX 3 MEAN BODY WEIGHTS FOR DETERMINISTIC EXPOSURE ASSESSMENT

Age-gender group	Mean body weight (kg)
6-12 month infant	9
1-3 years toddler	13
5-6 years child	23
11-14 years girl	55
11-14 years boy	54
19-24 years young male	78
25+ years female	70
25+ years male	82

APPENDIX 4 INDIVIDUAL ACRYLAMIDE ANALYTICAL RESULTS FROM THE CURRENT STUDY

Food type	Brand or retail outlet number	Batch or sampling day number	Acrylamide concentration (µg/kg)	%CV[1]
Potato crisps	Brand 1	Batch 1	592.5	
		Batch 2	370.8	
		Batch 3	614.7	
		Batch 4	1459.7	
		Batch 5	738.9	
		Mean	**755.3**	**55.0**
Potato crisps	Brand 2	Batch 1	111.9	
		Batch 2	246.3	
		Batch 3	208.4	
		Batch 4	308.0	
		Batch 5	413.8	
		Mean	**257.7**	**43.7**
Potato crisps	Brand 3	Batch 1	653.9	
		Batch 2	466.3	
		Batch 3	728.0	
		Mean	**616.1**	**21.9**
Potato crisps	Brand 4	Batch 1	227.2	
		Batch 2	246.7	
		Batch 3	238.4	
		Batch 4	256.4	
		Batch 5	256.0	
		Mean	**245.0**	**5.1**
Potato crisps	Brand 5	Batch 1	971.4	
		Batch 2	518.1	
		Batch 3	1056.4	
		Batch 4	499.1	
		Batch 5	575.6	
		Mean	**724.1**	**37.0**
Potato crisps	Brand 6	Batch 1	565.4	
		Batch 2	521.1	
		Batch 3	971.3	
		Batch 4	1224.4	
		Batch 5	685.0	
		Mean	**793.4**	**37.6**
Potato crisps	Brand 7	Batch 1	507.8	
		Batch 2	501.9	
		Batch 3	1078.0	
		Batch 4	746.8	

Food type	Brand or retail outlet number	Batch or sampling day number	Acrylamide concentration (µg/kg)	%CV[1]
		Batch 5	546.2	
		Mean	**676.2**	**36.4**
Potato, hot chips	Retail outlet 1	Sampling day 1	376.1	
		Sampling day 2	469.2	
		Sampling day 3	400.4	
		Sampling day 4	258.6	
		Sampling day 5	464.1	
		Mean	**393.7**	**21.7**
Potato, hot chips	Retail outlet 2	Sampling day 1	246.2	
		Sampling day 2	289.0	
		Sampling day 3	275.6	
		Sampling day 4	255.6	
		Sampling day 5	312.3	
		Mean	**275.7**	**9.6**
Potato, hot chips	Retail outlet 3	Sampling day 1	254.7	
		Sampling day 2	454.9	
		Sampling day 3	430.9	
		Sampling day 4	459.1	
		Sampling day 5	389.7	
		Mean	**397.9**	**21.3**
Potato, hot chips	Retail outlet 4	Sampling day 1	220.2	
		Sampling day 2	493.8	
		Sampling day 3	936.4	
		Sampling day 4	1016.3	
		Sampling day 5	463.7	
		Mean	**626.1**	**54.0**
Potato, hot chips	Retail outlet 5	Sampling day 1	378.5	
		Sampling day 2	69.5	
		Sampling day 3	82.5	
		Sampling day 4	872.0	
		Sampling day 5	247.8	
		Mean	**330.1**	**99.6**
Potato, hot chips	Retail outlet 6	Sampling day 1	70.1	
		Sampling day 2	148.9	
		Sampling day 3	98.1	
		Sampling day 4	241.3	
		Sampling day 5	125.1	
		Mean	**136.7**	**47.9**
Oven Baked/Roasted Potatoes	Cooked from raw	Variety 1	169.8	
		Variety 2	155.1	
		Variety 3	53.3	

Food type	Brand or retail outlet number	Batch or sampling day number	Acrylamide concentration (µg/kg)	%CV[1]
		Variety 4	189.7	
		Variety 5	64.2	
		Variety 6	64.8	
		Mean	**116.2**	**53.8**
Oven Baked/Roasted Potatoes	Cooked from frozen	Batch 1	1482.5	
		Batch 2	435.1	
		Batch 3	1300.6	
		Batch 4	2252.4	
		Batch 5	918.6	
		Mean	**1277.8**	**53.0**
Bread, white	Brand 1	Batch 1	32.8	
		Batch 2	17.0	
		Batch 3	44.7	
		Batch 4	52.0	
		Batch 5	40.6	
		Mean	**37.4**	**35.6**
Bread, white	Brand 2	Batch 1	29.6	
		Batch 2	38.4	
		Batch 3	17.0	
		Batch 4	30.5	
		Batch 5	< 19	
		Mean	**25.0**	**35.3**
Bread, wheatmeal	Brand 1	Batch 1	54.8	
		Batch 2	16.3	
		Batch 3	7.1	
		Batch 4	57.0	
		Batch 5	37.5	
		Mean	**34.6**	**64.9**
Bread, wheatmeal	Brand 2	Batch 1	13.9	
		Batch 2	< 18	
		Batch 3	107.8	
		Batch 4	98.1	
		Batch 5	50.8	
		Mean	**55.9**	**78.4**
Bread, white, toast	Brand 1	Batch 1	22.1	
		Batch 2	71.9	
		Batch 3	41.2	
		Batch 4	59.8	
		Batch 5	26.4	
		Mean	**44.3**	**48.3**
Bread, white, toast	Brand 2	Batch 1	77.9	

Food type	Brand or retail outlet number	Batch or sampling day number	Acrylamide concentration (µg/kg)	%CV[1]
		Batch 2	153.8	
		Batch 3	60.9	
		Batch 4	37.8	
		Batch 5	26.7	
		Mean	**71.4**	**70.3**
Bread, wheatmeal, toast	Brand 1	Batch 1	41.5	
		Batch 2	110.1	
		Batch 3	135.6	
		Batch 4	96.8	
		Batch 5	113.3	
		Mean	**99.5**	**35.5**
Bread, wheatmeal, toast	Brand 2	Batch 1	16.1	
		Batch 2	36.8	
		Batch 3	46.2	
		Batch 4	43.9	
		Batch 5	80.5	
		Mean	**44.7**	**52.0**
Biscuits	Plain (wine)	Batch 1	119.8	
		Batch 2	125.9	
		Batch 3	133.7	
		Batch 4	189.1	
		Batch 5	118.6	
		Mean	**137.4**	**21.5**
Biscuits	Crispbread	Batch 1	489.2	
		Batch 2	615.8	
		Batch 3	907.9	
		Batch 4	557.0	
		Batch 5	422.1	
		Mean	**598.4**	**31.4**
Biscuits	Extruded puffed	Batch 1	99.0	
		Batch 2	79.0	
		Batch 3	128.8	
		Batch 4	103.3	
		Batch 5	110.9	
		Mean	**104.2**	**17.4**
Biscuits	Water cracker	Batch 1	288.4	
		Batch 2	274.1	
		Batch 3	328.2	
		Batch 4	197.4	
		Batch 5	304.0	
		Mean	**278.4**	**17.8**

Food type	Brand or retail outlet number	Batch or sampling day number	Acrylamide concentration (µg/kg)	%CV[1]
Biscuits	Plain sweet (non chocolate)	Batch 1	134.3	
		Batch 2	79.0	
		Batch 3	97.3	
		Batch 4	92.8	
		Batch 5	101.4	
		Mean	**101.0**	**20.3**
Breakfast cereal, wheat biscuit	Brand 1	Batch 1	262.0	
		Batch 2	208.3	
		Batch 3	305.7	
		Batch 4	301.0	
		Batch 5	387.7	
		Mean	**292.9**	**22.5**
Breakfast cereal, toasted muesli	Brand 1	Batch 1	31.3	
		Batch 2	32.9	
		Batch 3	28.0	
		Batch 4	42.4	
		Batch 5	35.6	
		Mean	**34.0**	**15.9**
Breakfast cereal, toasted muesli	Brand 2	Batch 1	85.1	
		Batch 2	48.7	
		Batch 3	37.4	
		Batch 4	22.3	
		Batch 5	53.7	
		Mean	**49.4**	**47.1**
Muffins	Retail outlet 1	Sampling day 1	13.5	
		Sampling day 2	15.7	
		Sampling day 3	35.0	
		Sampling day 4	36.8	
		Sampling day 5	11.5	
		Mean	**22.5**	**54.9**
Muffins	Retail outlet 2	Sampling day 1	35.6	
		Sampling day 2	45.2	
		Sampling day 3	17.3	
		Sampling day 4	55.3	
		Sampling day 5	46.5	
		Mean	**40.0**	**36.2**
Peanut Butter	Brand 1	Batch 1	72.7	
		Batch 2	70.8	
		Batch 3	61.4	
		Batch 4	101.9	
		Batch 5	83.0	

Food type	Brand or retail outlet number	Batch or sampling day number	Acrylamide concentration (µg/kg)	%CV[1]
		Mean	**78.0**	**19.8**
Peanut Butter	Brand 2	Batch 1	67.9	
		Batch 2	45.2	
		Batch 3	39.8	
		Batch 4	64.1	
		Batch 5	59.7	
		Mean	**55.3**	**22.2**
Roasted Nuts	Peanuts	Batch 1	45.2	
		Batch 2	60.8	
		Batch 3	57.7	
		Batch 4	54.6	
		Batch 5	84.0	
		Mean	**60.5**	**23.8**
Roasted Nuts	Cashews	Batch 1	29.7	
		Batch 2	15.9	
		Batch 3	14.1	
		Batch 4	8.9	
		Batch 5	48.6	
		Mean	**23.4**	**68.4**
Fried rice	Retail outlet 1	Sampling day 1	< 8	
		Sampling day 2	< 9	
		Sampling day 3	< 8	
		Sampling day 4	< 10	
		Sampling day 5	< 10	
		Mean	**4.5**	**22.2**
Fried noodles	Retail outlet 1	Sampling day 1	24.2	
		Sampling day 2	24.0	
		Sampling day 3	< 8	
		Sampling day 4	50.7	
		Sampling day 5	55.0	
		Mean	**31.6**	**62.9**
Fried noodles	Retail outlet 2	Sampling day 1	116.6	
		Sampling day 2	91.2	
		Sampling day 3	145.4	
		Sampling day 4	117.1	
		Sampling day 5	95.0	
		Mean	**113.1**	**19.2**
Snacks	Corn crisps	Batch 1	646.4	
		Batch 2	560.9	
		Batch 3	734.4	
		Batch 4	410.5	

Food type	Brand or retail outlet number	Batch or sampling day number	Acrylamide concentration (µg/kg)	%CV[1]
		Batch 5	626.7	
		Mean	**595.8**	**20.3**
Snacks	Grain-based crisps	Batch 1	202.5	
		Batch 2	132.5	
		Batch 3	149.0	
		Batch 4	222.4	
		Batch 5	276.4	
		Mean	**196.6**	**29.5**
Snacks	Popcorn	Batch 1	207.0	
		Batch 2	80.9	
		Batch 3	88.0	
		Batch 4	227.6	
		Batch 5	167.6	
		Mean	**154.2**	**43.6**

%CV = standard deviation/mean x 100
1 Values below the limit of quantification were assigned concentrations equal to the limit of quantification for CV calculation

APPENDIX 5 COMPARATIVE ACRYLAMIDE CONCENTRATION DATA FROM OVERSEAS

Food Product	Country	Mean acrylamide concentration (range) (µg/kg)	Reference
Potato crisps	Australia	560 (350 – 882)	(Croft *et al.*, 2004)
	Belgium	676[1] (38-1,612)	(Matthys *et al.*, 2005)
	Brazil	591[1] (max = 1,999)	(Arisseto *et al.*, 2009)
	Canada	701 (106-3,180)	(Becalski *et al.*, 2010)
	China	1,560 (1,305-1,815)	(Geng *et al.*, 2008)
	China	3,016 (2,129-3,763)	(Chen *et al.*, 2008)
	EU 2007	574-576[2] (P95 = 1,596)	(European Food Safety Authority, 2011)
	EU 2008	626-630[2] (P95 = 1,900)	(European Food Safety Authority, 2011)
	EU 2009	689-693[2] (P95 = 2,329)	(European Food Safety Authority, 2011)
	Italy	363 (27-1,400)	(Tateo *et al.*, 2010)
	Japan	1,210 (439-1,870)	(Ono *et al.*, 2003)
	Netherlands	1,249 (310-2,800)	(Konings *et al.*, 2003)
	New Zealand	1,570 (370-2,320)	(Love and Grounds, 2006)
	New Zealand	**581 (112-1,460)**	**Current study**
	Norway	780 (P95 = 2,000)	(Brantsæter *et al.*, 2008)
	Poland	904 (113-3,647)	(Mojska *et al.*, 2010)
	Portugal	664 (186-1,828)	(Fernandes and Soares, 2007)
	Saudi Arabia	620	(Tawfik and El-Ziney, 2008)
	Spain	1,039 (264-2,055)[3]	(Bermudo *et al.*, 2008)
	Spain	740 (81-2,622)	(Arribas-Lorenzo and Morales, 2009)
	Sweden	1,360 (330-2,300)	(Svensson *et al.*, 2003)
	Switzerland	455[4] (max = 1,400)	(Biedermann *et al.*, 2010)
	Turkey	834 (59-2,336)	(Ölmez *et al.*, 2008)
	USA	605 (117-2,762)	(United States Food and Drug Administration, 2011)
Potato, hot chips	Australia	262 (94-501)	(Croft *et al.*, 2004)
	Belgium	254[1] (56-729)	(Matthys *et al.*, 2005)
	Brazil	264[1] (max = 2,528)	(Arisseto *et al.*, 2009)
	Canada	825 (200-1,900)	(Becalski *et al.*, 2003)
	China	583 (339-997)	(Chen *et al.*, 2008)
	EU 2007	354-357 (P95 = 1,072)	(European Food Safety Authority, 2011)
	EU 2008	281-285[2] (P95 = 784)	(European Food Safety Authority, 2011)
	EU 2009	326-328[2] (P95 = 810)	(European Food Safety Authority, 2011)
	Netherlands	351 (<60-1,220)	(Konings *et al.*, 2003)
	New Zealand	387 (230-510)	(Love and Grounds, 2006)
	New Zealand	**353 (70-1,016)**	**Current study**
	Norway	279 (P95 = 510)	(Brantsæter *et al.*, 2008)
	Poland	313 (63-799)	(Mojska *et al.*, 2010)
	Sweden	540 (300-1,100)	(Svensson *et al.*, 2003)
	Switzerland	109 (Traditional) 345 (Western style)	(Biedermann *et al.*, 2010)
	Turkey	403 (355-436)	(Ölmez *et al.*, 2008)
	USA	367 (20-1,325)	(United States Food and Drug Administration, 2011)

Food Product	Country	Mean acrylamide concentration (range) (µg/kg)	Reference
Potato, oven baked/roasted	Australia	189 (56 – 368)	(Croft *et al.*, 2004)
	EU 2007	380-385[2] (P95 = 941)	(European Food Safety Authority, 2011)
	EU 2008	275-276[2] (P95 = 866)	(European Food Safety Authority, 2011)
	EU 2009	317 (P95 = 1,152)	(European Food Safety Authority, 2011)
	Netherlands	130 (<60-410)	(Konings *et al.*, 2003)
	New Zealand		**Current study**
	- From raw	**116 (53-190)**	
	- Supermarket wedges	**1,278 (435-2,252)**	
	Sweden	310 (34-688)	(Svensson *et al.*, 2003)
	USA	46 (17-102)	(United States Food and Drug Administration, 2009)
Bread, fresh	Australia	(<25 – 50)	(Croft *et al.*, 2004)
	Belgium	30[1] (27-36)	(Matthys *et al.*, 2005)
	Canada	23 (14-43)	(Becalski *et al.*, 2003)
	China	38 (10-133)	(Chen *et al.*, 2008)
	EU 2007	54-68[2] (P95 = 230)	(European Food Safety Authority, 2011)
	EU2008	31-46[2] (P95 = 127)	(European Food Safety Authority, 2011)
	EU 2009	27-37[2] (P95 = 90)	(European Food Safety Authority, 2011)
	Netherlands	15-44 (<30-60)[5]	(Konings *et al.*, 2003)
	New Zealand		**Current study**
	- White	**31 (max = 52)**	
	- Wheatmeal	**45 (max = 108)**	
	Norway	17 (P95 = 39)	(Brantsæter *et al.*, 2008)
	Poland	69 (35-110)	(Mojska *et al.*, 2010)
	Sweden	50 (<30-160)	(Svensson *et al.*, 2003)
	Switzerland	38 (max = 135)	(Biedermann *et al.*, 2010)
	Turkey	38 (<10-85)	(Ölmez *et al.*, 2008)
	USA	28 (<10-130)	(United States Food and Drug Administration, 2011)
Bread, toasted	Australia	92 (75-108)	(Croft *et al.*, 2004)
	Canada	159 (28-290)	(Becalski *et al.*, 2003)
	Netherlands	183 (<30-1,430)	(Konings *et al.*, 2003)
	New Zealand		**Current study**
	- White	**58 (22-154)**	
	- Wheatmeal	**72 (16-136)**	
	Turkey	164 (41-474)	(Ölmez *et al.*, 2008)
	USA	260 (57-364)	(United States Food and Drug Administration, 2011)
Biscuits, sweet	Australia	189 (25 – 598)	(Croft *et al.*, 2004)
	Belgium	143[1] (20-1,514)	(Matthys *et al.*, 2005)
	China	87 (25-350)	(Chen *et al.*, 2008)
	China	152 (120-183)	(Geng *et al.*, 2008)
	Netherlands	15-283 (<30-510)[5]	(Konings *et al.*, 2003)
	New Zealand		**Current study**
	- Plain (wine)	**137 (119-189)**	
	- Sweet	**101 (79-134)**	
	Sweden	<30	(Svensson *et al.*, 2003)
	Turkey	198 (<10-648)	(Ölmez *et al.*, 2008)
	USA	132 (<10-955)	(United States Food and Drug Administration, 2011)

Food Product	**Country**	**Mean acrylamide concentration (range) (µg/kg)**	**Reference**
Biscuits, crackers	Australia	449 (153-1,270)	(Croft *et al.*, 2004)
	Brazil	157 (max = 361)	(Arisseto *et al.*, 2009)
	EU 2007	291-292[2] (P95 = 1,024)	(European Food Safety Authority, 2011)
	EU 2008	203-206[2] (P95 = 597)	(European Food Safety Authority, 2011)
	EU 2009	195-208[2] (P95 = 865)	(European Food Safety Authority, 2011)
	Netherlands	218 (80-420)	(Konings *et al.*, 2003)
	New Zealand		**Current study**
	- Crispbread	**598 (422-908)**	
	- Extruded puffed	**104 (79-129)**	
	- Water cracker	**278 (197-328)**	
	Poland	859 (566-2,017)	(Mojska *et al.*, 2010)
	Sweden	300 (<30-640)	(Svensson *et al.*, 2003)
	Turkey	247 (26-587)	(Ölmez *et al.*, 2008)
	USA	233 (26-1,540)	(United States Food and Drug Administration, 2011)
Breakfast cereals, unspecified	Belgium	135[1] (37-623)	(Matthys *et al.*, 2005)
	EU 2007	130-150[2] (P95 = 420)	(European Food Safety Authority, 2011)
	EU 2008	140-156[2] (P95 = 540)	(European Food Safety Authority, 2011)
	EU 2009	132-142[2] (P95 = 403)	(European Food Safety Authority, 2011)
	Netherlands	15 (<30-<30)	(Konings *et al.*, 2003)
	Norway	120 (P95 = 260)	(Brantsæter *et al.*, 2008)
	Saudi Arabia	215	(Tawfik and El-Ziney, 2008)
	Sweden	220 (<30-1,400)	(Svensson *et al.*, 2003)
	USA	151 (<10-1,057)	(United States Food and Drug Administration, 2011)
Breakfast cereal, muesli	Australia	(25-50) (toasted) <25 (untoasted)	(Croft *et al.*, 2004)
	Netherlands	31 (<30-80)	(Konings *et al.*, 2003)
	New Zealand	**42 (22-85) (toasted)**	**Current study**
	Switzerland	146 (max = 1,080)	(Biedermann *et al.*, 2010)
	USA	42 (11-89)	(United States Food and Drug Administration, 2011)
Breakfast cereal, wheat biscuit	Australia	179	(Croft *et al.*, 2004)
	New Zealand	260	(Love and Grounds, 2006)
	New Zealand	**293 (208-388)**	**Current study**
Breakfast cereal, cornflakes	Brazil	30[1] (max = 49)	(Arisseto *et al.*, 2009)
	Netherlands	121 (<30-300)	(Konings *et al.*, 2003)
	Poland	223 (70-1,186)	(Mojska *et al.*, 2010)
	Turkey	122 (35-478)	(Ölmez *et al.*, 2008)
	USA	205 (51-534)	(United States Food and Drug Administration, 2011)
Muffins	Australia	(<25 – 62)	(Croft *et al.*, 2004)
	New Zealand		**Current study**
	- Supermarket	**40 (17-55)**	
	- Café	**23 (12-37)**	
	Sweden	<100	(Svensson *et al.*, 2003)
	USA	11 (<10-28)	(United States Food and Drug Administration, 2009)
Peanut Butter	**New Zealand**	**67 (40-102)**	**Current study**
	Turkey	54 (45-63)	(Ölmez *et al.*, 2008)
	USA	72 (52-93)	(United States Food and Drug Administration, 2009)

Food Product	Country	Mean acrylamide concentration (range) (µg/kg)	Reference
Roasted nuts	Canada - Almonds China - Peanuts - Chestnuts - Walnuts - Hazelnuts Japan – Chestnuts Netherlands – Peanuts **New Zealand** Turkey - Peanuts - Hazelnuts - Almonds USA - Peanuts	260 149 (100-214) 196 (118-271) 208 (39-447) 357 (333-402) 62 (51-72) 15 (<30) **42 (9-84)** 66 (<10-120) 128 (<10-421) 260 (207-313) 33 (15-62)	(Becalski *et al.*, 2003) (Chen *et al.*, 2008) (Ono *et al.*, 2003) (Konings *et al.*, 2003) **Current study** (Ölmez *et al.*, 2008) (United States Food and Drug Administration, 2009)
Fried rice/ noodles	Australia -Noodles Japan - Rice - Noodles **New Zealand** **- Rice** **- Noodles** Saudi Arabia - Rice Sweden - Rice USA - Rice	106 5 (2-7) 316 (51-581) **ND** **72 (max 145)** 430 <30 32 (<10-195)	(Croft *et al.*, 2004) (Ono *et al.*, 2003) **Current study** (Tawfik and El-Ziney, 2008) (Svensson *et al.*, 2003) (United States Food and Drug Administration, 2009)
Popcorn	Australia Belgium Japan **New Zealand** Sweden Turkey USA	332 (327-337) 160[1] (129-216) 318 (276-359) **154 (81-228)** 500 (365-715) 171 175 (97-352)	(Croft *et al.*, 2004) (Matthys *et al.*, 2005) (Ono *et al.*, 2003) **Current study** (Svensson *et al.*, 2003) (Ölmez *et al.*, 2008) (United States Food and Drug Administration, 2009)
Corn crisps	Australia Poland New Zealand **New Zealand** Sweden Turkey USA	188 188 (124-300) 270 (200-340) **596 (410-734)** 150 (120-180) 425 (109-835) 191 (74-355)	(Croft *et al.*, 2004) (Mojska *et al.*, 2010) (Love and Grounds, 2006) **Current study** (Svensson *et al.*, 2003) (Ölmez *et al.*, 2008) (United States Food and Drug Administration, 2009)

[1]The value is the median, rather than the mean

[2] The range represents the lower and upper bound estimates of the mean, that is, estimates of the mean assuming that results below the limit of detection are true zeroes and estimates of the mean assuming that results below the limit of detection represent results at the limit of detection

[3] Products were described as „artisan' potato crisps

[4] This mean value excluded a brand of „dark' potato crisps, which were found to contain acrylamide at concentrations up to 7,000 µg/kg

[5] A number of bread/biscuit types were reported on in this study. Figures presented here are the range of mean concentrations for different bread/biscuit types and the overall range of acrylamide concentrations

EU = European Union USA = United States of America

P95 = 95th percentile Max = maximum ND = Not detected

APPENDIX 6 MAJOR FOOD CONTRIBUTORS TO DIETARY ACRYLAMIDE EXPOSURE[1]

Foods	Contribution to estimated dietary acrylamide exposure (%)											
	Male (25+ years)		Female (25+ years)		Male (19-24 years)		Male (11-14 years)		Female (11-14 years)		Child (5-6 years)	
	TD	DM	TD	DM	TD	DM	TD	DM	TD	DM	TD	DM
Potato, hot chips[2]	16.5	16.6	10.9	12.5	25.7	26.5	21.7	26.0	20.6	26.4	15.8	20.9
Potatoes, with skin[3]	14.6	6.9	19.7	7.5	21.4	7.6	27.5	5.4	26.2	2.7	27.3	5.4
Tea	6.2	7.3	9.3	10.5	1.0	1.3	0.2	0.7	0.3	0.9	0.3	0.4
Beer	5.7	5.4	0.6	0.8	4.5	4.2	0.0	0.0	0.0	0.0	0.0	0.0
Chinese dish	4.4	1.0	7.6	2.1	5.3	5.7	3.2	5.5	3.1	5.6	0.1	3.0
Coffee, instant	4.4	5.3	6.7	6.6	1.5	3.7	0.0	0.4	0.0	0.5	0.0	0.3
Wheatbiscuit cereals	4.0	0.1	2.5	0.1	2.6	0.0	5.1	0.4	3.1	0.3	6.1	0.9
Bread, white	3.8	3.8	3.1	3.7	2.9	2.7	4.8	2.6	4.1	3.2	5.2	2.0
Soup, chicken	3.7	6.0	3.7	9.0	2.8	4.4	1.3	2.4	1.6	3.1	1.4	3.5
Noodles, instant[4]	2.7	0.1	2.1	0.1	1.9	0.7	1.9	0.1	3.5	0.1	3.0	0.1
Oats, rolled[5]	2.5	14.1	1.5	11.3	0.4	6.4	0.5	15.1	0.6	10.6	0.7	16.7
Biscuit, cracker	2.4	1.6	3.2	2.7	1.1	0.5	2.0	2.1	2.4	2.5	3.2	1.8
Potato crisps	2.1	2.2	2.9	3.0	5.9	8.1	7.1	8.4	9.4	10.9	7.3	9.0
All other foods	27.1	29.7	26.2	30.2	23.0	28.2	24.6	31.0	25.3	33.1	29.6	36.2

[1] Foods ranked for a Male (25+ years)
[2] Includes all hot chip outlets
[3] Includes oven baked/roasted cooked from raw and from frozen products
[4] All TDS noodles mapped to noodles, instant. DM foods mapped to noodles, fried
[5] DM foods mapped to cereal, other
TD = total diet
DM = dietary modelling

APPENDIX 7 OVERSEAS ESTIMATES OF ACRYLAMIDE EXPOSURE

Country	Year[1]	Population Group (years)	Mean acrylamide exposure (95th percentile) (µg/kg bw/day)	Major contributing foods	Reference
Australia	2002	2-6 2+	1.0-1.3 (3.2-3.5) 0.4-0.5 (1.4-1.5)	Hot potato chip, potato crisp, bread, toast	(Croft *et al.*, 2004)
Belgium	2003	13-18	0.51[6] (1.09)	French fries, bread, biscuit	(Matthys *et al.*, 2005)
Belgium	2002-2003	12-35 mths 3-10	2.25-2.37 (4.35-4.48) 1.95-2.05 (3.60-3.71)	Fried potato, bread, biscuit	(European Food Safety Authority, 2011)
Belgium	2004-2005	11-17	0.47-0.50 (1.24-1.30)	Fried potato, bread, biscuit, potato crisp	(European Food Safety Authority, 2011)
Belgium	2004-2005	18-64 65-74 75+	0.36-0.39 (0.95-0.99) 0.28-0.31 (0.76-0.82) 0.32-0.35 (0.84-0.87)	Fried potato, bread, roasted coffee	(European Food Safety Authority, 2011)
Belgium	2010	15+	0.19[6] (1.12)	Hot chips, crisps, sweet biscuits, coffee[2]	(Claeys *et al.*, 2010)
Brazil	2001	11-14 15-17	0.14 (0.57) 0.09 (0.46)	French fries	(Arisseto *et al.*, 2009)
Bulgaria	2007	1-12 mths	1.10-1.29 (3.69-3.97)	Fried potato, jarred baby food, biscuit	(European Food Safety Authority, 2011)
Bulgaria	2007	12-35 mths 3-10	2.01-2.13 (4.46-4.58) 1.64-1.74 (4.05-4.22)	Fried potato, bread, biscuit	(European Food Safety Authority, 2011)
China	2005-2006	General population	0.38 (1.27)	Flour and flour products, tubers, spices	(Chen *et al.*, 2008)
Cyprus	2003	11-17	0.71-0.74 (1.51-1.56)	Fried potato, bread, oven potato, potato crisp	(European Food Safety Authority, 2011)
Czech Republic	2003-2004	3-10	1.75-1.84 (3.68-3.84)	Fried potato, biscuit, bread	(European Food Safety Authority, 2011)
Czech Republic	2003-2004	11-17 18-64	1.29-1.36 (2.92-3.06) 0.73-0.77 (1.59-1.65)	Fried potato, bread	(European Food Safety Authority, 2011)
Denmark	2000-2002	3-10 11-17	1.36-1.47 (2.59-2.71) 0.94-1.00 (1.97-2.05)	Fried potato, bread, potato crisp	(European Food Safety Authority, 2011)
Denmark	2000-2002	18-64 65-74 75+	0.76-0.80 (1.50-1.56) 0.91-0.95 (1.74-1.84) 1.02-1.07 (2.19-2.26)	Fried potato, bread, roasted coffee	(European Food Safety Authority, 2011)
Finland	2000	3-10	0.82-0.90 (1.84-1.96)	Fried potato, muesli, bread, biscuit	(European Food Safety Authority, 2011)
Finland	2003-2006	12-35 mths 3-10	1.26-1.37 (3.06-3.25) 1.39-1.45 (2.72-2.83)	Bread, fried potato	(European Food Safety Authority, 2011)
Finland	2007	18-64 65-74	0.49-0.52 (1.04-1.09) 0.49-0.52 (1.06-1.14)	Bread, fried potato, roasted coffee, breakfast cereal	(European Food Safety Authority, 2011)
Finland	2010	Male smokers, 50-69	0.6[3]	Coffee (40.4%), fried potatoes (14.6%), rye bread (14.0%)	(Hirvonen *et al.*, 2010)
France	2005-2007	3-10	0.68-0.73 (1.39-1.50)	Biscuit, bread, fried potato, breakfast cereal	(European Food Safety Authority, 2011)
France	2005-2007	11-17	0.39-0.43 (0.89-0.94)	Bread, fried potato, biscuit, breakfast cereal	(European Food Safety Authority, 2011)

Country	Year[1]	Population Group (years)	Mean acrylamide exposure (95th percentile) (µg/kg bw/day)	Major contributing foods	Reference
France	2005-2007	18-64 65-74 75+	0.39-0.42 (0.87-0.92) 0.28-0.31 (0.57-0.62) 0.26-0.29 (0.55-0.58)	Roasted coffee, bread, fried potato	(European Food Safety Authority, 2011)
Germany	2006-2008	12-35 mths	1.50-1.82 (3.04-3.94)	Fried potato, jarred baby food, bread, biscuit	(European Food Safety Authority, 2011)
Germany	2006-2008	3-10	1.09-1.21 (2.04-2.32)	Fried potato, bread, potato crisp, biscuit	(European Food Safety Authority, 2011)
Germany	2005-2007	11-17	0.32-0.35 (0.88-0.93)	Bread, fried potato, potato crisp	(European Food Safety Authority, 2011)
Germany	2005-2007	18-64 65-74 75+	0.31-0.34 (0.79-0.83) 0.29-0.32 (0.72-0.76) 0.31-0.34 (0.81-0.84)	Fried potato, bread, roasted coffee	(European Food Safety Authority, 2011)
Greece	2004-2005	3-10	1.34-1.38 (3.07-3.15)	Fried potato, bread, biscuit, potato crisp	(European Food Safety Authority, 2011)
Hungary	2003	18-64 65-74 75+	0.75-0.79 (1.52-1.58) 0.69-0.73 (1.26-1.31) 0.79-0.83 (1.53-1.58)	Fried potato, bread	(European Food Safety Authority, 2011)
Ireland	1997-1999	18-64	0.54-0.58 (1.22-1.26)	Fried potato, bread, potato crisp	(European Food Safety Authority, 2011)
Ireland	NS	Adult	0.59 (1.75)[5]		(Mills *et al.*, 2008)
Italy	2005-2006	1-12 mths	0.54-0.73 (1.22-2.20)	Jarred baby food, fried potato, bread	(European Food Safety Authority, 2011)
Italy	2005-2006	12-35 mths	1.24-1.35 (3.15-3.21)	Fried potato, bread, biscuit, infant biscuit	(European Food Safety Authority, 2011)
Italy	2005-2006	3-10 11-17	1.21-1.29 (2.91-3.00) 0.81-0.86 (1.80-1.87)	Fried potato, bread, biscuit, crispbread	(European Food Safety Authority, 2011)
Italy	2005-2006	18-64 65-74 75+	0.54-0.57 (1.16-1.20) 0.50-0.53 (1.12-1.17) 0.50-0.54 (1.10-1.15)	Fried potato, bread, roasted coffee	(European Food Safety Authority, 2011)
Latvia	2008	3-10	0.96-1.02 (2.29-2.39)	Fried potato, bread, biscuit, breakfast cereal, potato crisp	(European Food Safety Authority, 2011)
Latvia	2008	11-17	0.74-0.78 (1.91-1.99)	Fried potato, bread, potato crisp, biscuit	(European Food Safety Authority, 2011)
Latvia	2008	18-64	0.42-0.45 (1.09-1.15)	Fried potato, bread, roasted coffee	(European Food Safety Authority, 2011)
Netherlands	2003	12-35 mths 3-10	1.07-1.16 (2.35-2.44) 0.99-1.06 (1.98-2.06)	Bread, biscuit, fried potato, potato crisp	(European Food Safety Authority, 2011)
Netherlands	2003	1-6 7-18 1-97	1.0 (1.1) 0.7 (0.9) 0.5 (0.6)	Crisps, hot chips, cake	(Konings *et al.*, 2003)
Netherlands	2005-2006	18-64	0.50-0.53 (1.25-1.30)	Fried potato, bread, potato crisp, biscuit, roasted coffee	(European Food Safety Authority, 2011)

Country	Year[1]	Population Group (years)	Mean acrylamide exposure (95th percentile) (µg/kg bw/day)	Major contributing foods	Reference
Norway	2002	Adult male Adult female 13 male 13 female 9 male 9 female	0.49 (1.62)[5] 0.46 (1.45)[5] 0.52 (2.85)[5] 0.49 (2.07)[5] 0.36 (1.50)[5] 0.32 (1.10)[5]	Coffee, potato crisp, bread Potato crisp, biscuit	(Dybing and Sanner, 2003)
Norway	2003-2004	23-44 female	0.41-0.48[6] (0.70-0.92)	Crispbread, potato crisp, bread	(Brantsæter *et al.*, 2008)
Poland	2010	1-6 7-18 9-96 1-96	0.75 (2.88) 0.62 (2.45) 0.33 (0.69) 0.43 (1.24)	Bread (45%), hot chips and potato crisps (23%), roasted coffee (19%)	(Mojska *et al.*, 2010)
Saudi Arabia	NS	18-25 female	0.57	Coffee, biscuit, fried rice, potato chips	(Tawfik and El-Ziney, 2008)
Spain	1998-2000	12-35 mths 3-10 11-17	1.59-1.69 (6.11-6.48) 0.86-1.37 (1.88-3.43) 0.77-0.82 (1.98-2.10)	Fried potato, bread, potato crisp	(European Food Safety Authority, 2011)
Spain	1999-	18-64	0.42-0.45 (1.09-1.13)	Fried potato, bread, biscuit	(European Food Safety Authority, 2011)
Spain	2004-2005	11-17	0.55-0.59 (1.31-1.33)	Fried potato, bread, biscuit, potato crisp	(European Food Safety Authority, 2011)
Spain	2009	11-17 18-64	0.69-0.72 (1.76-1.79) 0.55-0.57 (1.18-1.23)	Fried potato, bread, biscuit, potato crisp	(European Food Safety Authority, 2011)
Sweden	1997	45-79 males	0.45[4]	Coffee, bread, crispbread	(Larsson *et al.*, 2009)
Sweden	1997-1998	18-64	0.47-0.51 (0.93-0.98)	Fried potato, roasted coffee, bread, crispbread	(European Food Safety Authority, 2011)
Sweden	2003	3-10	1.02-1.13 (2.78-3.13)	Muesli, fried potato, bread, potato crisp	(European Food Safety Authority, 2011)
Sweden	2003	11-17	0.66-0.71 (1.61-1.71)	Fried potato, bread, potato crisp, muesli	(European Food Safety Authority, 2011)
Sweden	2003	18-74	0.44 (P95 = 0.89)[3]	Coffee (39%), hot chips (16%), bread (11%)	(Svensson *et al.*, 2003)
United Kingdom	2000-2001	18-64	0.61-0.65 (1.19-1.24)	Fried potato, oven potato, bread	(European Food Safety Authority, 2011)
United Kingdom	NS	Adult	0.61 (1.29)[5]		(Mills *et al.*, 2008)
USA	2006	2+	0.4	Hot chips (28%), crisps (10%), breakfast cereal (9%)	(DiNovi, 2006)
USA	2006	35-84 female	0.13-0.42	Coffee, breakfast cereal, french fries, potato chips	(Wilson *et al.*, 2010)

[1] Year of study. For EU studies, this relates to the year(s) of the dietary survey
[2] For a highly exposed individual. For an average consumer, the main contributing foods were bread and coffee
[3] Based on a standard body weight of 70 kg
[4] Based on an average body weight of 81 kg, calculated from body mass index and height data
[5] 97.5th percentile
[6] Median values
mths = months
NS = not stated