NITRATES AND NITRITES DIETARY EXPOSURE AND RISK ASSESSMENT

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by

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AND RISK ASSESSMENT

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SUMMARY

The purpose of the project was to estimate intakes of nitrates and nitrites from food (exogenous intakes), estimate the effect of the human body converting some of the nitrate into nitrite (endogenous), compare the results with Australian, international and previous New Zealand data, and comment on results relating to the growing methods of vegetables (eg nitrates in organic versus non-organic vegetables).

Processed foods such as meats and cheeses are permitted to contain added nitrates or nitrite. Nitrates occur naturally in vegetables and plants. One hundred processed foods and meats and 100 vegetable samples purchased in Christchurch and Auckland from 24 November to 16 December 2003 were prepared as for consumption and analysed for nitrite and nitrate concentration using standard, validated methodology of high pressure liquid chromatography with UV detection. The limits of detection were 5 mg/kg for both nitrate and nitrite (as sodium nitrate) except for some cheese samples where a higher limit of detection was necessary.

Foods that were analysed raw, or without further cooking, included ham, luncheon, salami, corned silverside (precooked), hamburger, cottage cheese, dip, cheddar cheese, cabbage, lettuce, watercress, celery, and carrots. Bacon, sausages and beef mince were fried without added fat, raw corned silverside, saveloys, potatoes, broccoli, spinach, silverbeet and pumpkin were boiled before analysis.

Nitrate was detected in at least one sample of each food except for cheddar cheese and cream cheese based dips in which none was detected. Nitrite was detected in half the processed foods and meats analysed but was not detected in any of the vegetable samples above the limit of detection with the exception of one sample of broccoli at 27 mg/kg nitrite. Ninety seven percent of the processed foods and meats analysed complied with the Australia New Zealand Food Standards, with two meat samples containing low levels of nitrate and one with excessive nitrite. Levels of nitrate and nitrite in the New Zealand samples were low or comparable with the results obtained in the 21st Australian Total Diet Study with the exception of one sample of New Zealand ham. The results from vegetables from the present survey were lower than or comparable with nitrate results from overseas.

An elevated concentration of nitrate was found in hydroponically compared with organic or conventionally grown lettuces. There was no apparent difference in nitrate concentration between organically and conventionally grown lettuces.

Concentration data was combined with 24 hour dietary recall information from the 1997 National Nutrition Survey to generate 4398 individual exposure scenarios for exogenous nitrite, for nitrate, and for total nitrite including a proportion from the endogenous conversion of nitrate. Dietary exposure was determined for New Zealand adults only.

The mean dietary exposure to nitrate (0.719 mg/kg bw/day as sodium nitrate) is approximately 14% of the ADI. For exogenous nitrite (excluding any contribution from the endogenous conversion of nitrate) the mean dietary exposure is approximately 13% of the ADI. When a contribution from the conversion of dietary nitrate to nitrite is included, the mean dietary exposure to nitrite is 49% of the ADI for an individual with an average conversion rate (5%) and 156% of the ADI for those individuals with a high conversion rate (20%). The ADI is exceeded for approximately 10 % of average converters and 50% of those with a high rate of conversion.

Over 97 % of exposure to nitrate from the foods selected for this study was from the consumption of vegetables. The two most significant contributors to both nitrate and nitrite exposure were potatoes (32%) and lettuce (29%).

New Zealand lettuce and potato samples are not unusually high by comparison with European and Asian data and New Zealand lettuce samples met the specified maximum limits for nitrate established in the EU.

1 INTRODUCTION

1.1 Dietary sources of nitrite and nitrate

Processed foods such as meats and cheeses are permitted to contain added nitrates or nitrite. Nitrates occur naturally in vegetables and plants. These are described as exogenous nitrites or nitrates. The human body is able to convert some of the nitrate in food into nitrite that is known as endogenous nitrite.

1.1.1 Use as an additive

Nitrate and nitrite are permitted additives in selected foods only. Maximum permitted levels are specified in Standard 1.3.1 of the Australia New Zealand Food Standards Code (FSANZ 2004). For example cured meat such as bacon, ham, saveloys, salami, and cheese and cheese products are permitted to contain nitrate and/or nitrite.

Nitrite may be used as a food additive in meat products, where it fulfils the functions of preservative, antimicrobial agent and colour fixative. Nitrate is also used in meat products, because it is a reservoir for in situ production of nitrite. Nitrate is also a permitted additive for cheese. Nitrates and nitrites can be added only as their sodium or potassium salts (additive numbers 249-252 inclusive).

A study of nitrite and nitrate in processed foods has recently been undertaken as part of the 21st Australian Total Diet (ATDS). The foods included for analysis were: Strassburg (a type of sausage), bacon, beef sausages, cheese (cheddar, cottage, processed cheddar), dip (cream cheese based), frankfurters, ham, luncheon sausage, pizza and salami. When concentration data from this study (Rob Keane, personal communication) was combined with New Zealand consumption information, the greatest contributors to dietary intake of nitrite were ham, bacon and pizza with smaller contributions from frankfurters and luncheon. This was used as a guide for sample selection for the current survey.

1.1.2 Naturally occurring

Nitrite and nitrate occur naturally in food and water as a consequence of the nitrogen cycle whereby nitrogen is fixed by bacteria. Nitrite is able to be produced endogenously. In humans, saliva is the major site for the formation of nitrite with about 5% of dietary nitrate converted to nitrite in the mouth (Gangolli et al., 1994).

Beetroot, broccoli, cabbage, celery, lettuce, radish and spinach have been reported to contain high concentrations (greater than 1000 mg/kg) of nitrate. By contrast, nitrite concentration in fresh vegetables is generally low (less than 1 mg/kg and not above 20 mg/kg) (Meah, 1994, Petersen and Stoltze 1999, Chung et al, 2003).

1.1.3 Method of cultivation

Vegetables may contain variable amounts of nitrate, depending on the rate and timing of fertilizer application, light intensity, daytime temperature and soil characteristics (Meah et al,1994, Petersen and Stoltze 1999). Vegetables grown in heated glasshouses have higher

nitrate contents than those grown outdoors because of lower light intensity and high nitrogen mineralization (Gangolli et al, 1994).

The EU has established different limits for nitrate concentration in spinach and lettuce depending on the season of cultivation. Higher levels of nitrate are permitted for produce grown in the winter months than the summer (European Commission, 1997). On the other hand, in a recent study of vegetables grown in Korea, no significant variance was found for most vegetables cultivated during the summer and winter (Chung et al, 2003).

As yet there are limited data on any difference in nitrate concentration between organic and conventionally grown vegetables. In a study of Italian lettuce, organically grown green salad (a mixture of endive and prickly lettuce) and rocket showed a significantly higher concentration of nitrate than conventionally grown samples (De Martin and Restani, 2003). By contrast, Malmaret et al,(2002) reported higher median and maximum concentrations of nitrate in organic compared with conventionally grown lettuces.

1.2 Toxicity of nitrite and nitrate

Nitrite has been implicated in a variety of long term health effects and the toxicity of nitrite has been evaluated several times as new information has been published. The most recent evaluation by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) (JECFA,2002) is based on effects on the heart and lung in a 2-year rat study. This study is the basis of the current Acceptable Daily Intake (ADI) of 0-0.07 mg/kg bw/day, (as nitrite ion).

Nitrite may also combine with secondary or tertiary amines to form N-nitroso derivatives. Certain N-nitroso compounds have been shown to produce cancers in a wide range of laboratory animals (Codex, 1998).

Nitrite interacts with haemaglobin, causing blood to be less efficient in transporting oxygen and resulting in a condition known as methaemoglobinaemia. This may occur after a single dose and therefore an acute reference dose (ARD) would be appropriate. An ARD for nitrite has not yet been established.

The toxic effects of nitrate are due to its endogenous conversion to nitrite. At its 44th meeting, JECFA concluded that the range of nitrate conversion is 5-7% for normal individuals and 20% for individuals with a high rate of conversion (JECFA, 2002). The ADI for nitrate is 0-3.7 mg/kg bw/day (expressed as nitrate ion).

1.3 Dietary Intake

JECFA (2002) recommends that assessments of the intake of nitrite should include sources other than food additives, such as vegetables and drinking water and that foods should be analysed as ‘ready to consume’ to account for losses of chemicals over time and during food storage, preparation and cooking. Yet surprisingly few dietary intake estimates for nitrite have been published that include both additive and naturally occurring sources in addition to an estimated contribution from the endogenous conversion of nitrate.

Intakes of 0.005-0.023 mg/kg bw/day of nitrite and 0.665-1.11 mg/kg bw/day of nitrate have been reported from Total Diet Study results for the Czech Republic 1994-2001 (http://sight.who.int). No details are provided. Daily intakes of 120 mg/day and 1.2 mg/day (equating to 1.61 and 0.016 mg/kg bw/day for a 75 kg body weight) of nitrate and nitrite respectively have been estimated for New Zealand adults using UK and New Zealand analytical data (Thomson, 1996).

In a comprehensive estimate of dietary exposure to nitrate from the 1997 UK Total Diet Study Ysart et al, (1999) estimated a total intake for the adult population of 93 mg/day comprising the following proportions: potatoes (33%), green vegetables (21%), other vegetables (15%), beverages (8.5%), meat products (4.2%), fresh fruit (3.5%), dairy (3.1%), milk (2.9%), miscellaneous cereals (2.1%), bread (1.6%) and other (5.1%). Approximately 70% of total dietary intake of nitrate was from the consumption of vegetables. Further data on nitrate and nitrite content and intake estimates for vegetables have been reported for Denmark (Petersen and Stoltze,1999), China (Zhong et al, 2002) and Korea (Chung et al,2003).

1.4 Project Aim

The purpose of the project was to estimate intakes of nitrates and nitrites from food (exogenous intakes), estimate the effect of the human body converting some of the nitrate into nitrite (endogenous), compare the results with Australian, international and previous New Zealand data, and comment on results relating to the growing methods of vegetables (eg nitrates in organic versus non-organic vegetables).

The following approach was taken:

- 100 processed foods would be analysed to provide surveillance information against the food code as well as dietary data.
- 100 foods would be analysed for nitrite and nitrate to reflect total dietary intake (including vegetables)
- results for our 3 major dietary contributors would be compared with results from other studies overseas to ascertain if NZ results are high or low. This might provide some information with respect to normal levels or levels reflecting environmental contamination or fertilizer use.

2 MATERIALS AND METHODS

2.1 Selection of foods for inclusion in the study

Processed foods were selected on the basis of estimated contributions of nitrates and nitrites to dietary intake from the Australian Total Diet Survey results in conjunction with consideration of NZ consumption preferences. Frankfurters were substituted by saveloys since saveloys are consumed by more people in larger amounts in New Zealand (Russell et al., 1999). The Australian study did not include corned meat (permitted to contain nitrite), hamburger mince or minced beef but these foods were included on the basis of UK data (Gangiolli et al, 1994) and historical ESR data (Love 1993)

Total diet foods were selected after consideration of exposure to nitrate from the 1997 UK Total Diet Study (Ysart et al, 1999) where it was shown that approximately 70% of total dietary intake of nitrate is from the consumption of vegetables. The major contributors to total dietary intake in the UK study were : potatoes (33%), green vegetables (21%), other vegetables (15%), beverages (8.5%) and meat products (4.2%). The nitrate from beverages presumably comes from nitrate in water (see below). Because vegetables vary greatly in concentration, it is not possible to assign a mean value to the concentration for the food group as a whole but rather it is necessary to calculate intake from individual vegetables. Within the relatively small scope of the current project, it was agreed that total diet samples be targeted to vegetables as the major contributors to nitrate intake.

Based on published results, and knowledge of New Zealand consumption preferences, the following vegetables were identified as the most likely contributors to dietary intake of nitrate: cabbage, lettuce, silverbeet (equivalent to spinach overseas), celery, broccoli and perhaps watercress and courgette. Other vegetables of significance are beetroot, potatoes, carrot and pumpkin.

Water and beverages were not included within the scope of this study because New Zealand water supplies are low in nitrate with 85% of 1908 water samples (collected 1983-1989) containing no nitrate compared with a guideline value of 44mg/L (New Zealand drinking water surveillance programme, Data Review 1983-89, 1991).

Factors affecting sampling:

Meat processing methods may vary between small and major suppliers and therefore both outlet types were sampled.

Vegetable nitrate concentrations vary with season. This needs to be considered in international comparisons. EU regulatory limits (lettuce and spinach) are different for different seasons..

Nitrate concentrations may be different for organically grown and conventionally grown lettuces (and probably other vegetables). Information on the method of cultivation was sought.

Concentrations change with cooking. Food was prepared as for consumption e.g. bacon was cooked, lettuce was analysed raw.

The following food list and sample numbers were targeted for analysis:

Table 1: **Food list for nitrite and nitrate surveillance**

100 processed foods	*Cooked or raw*	*# samples*	*Green vegetables*	*Cooked or raw*	*# samples*
bacon	C	10	cabbage	R	8
ham	R	10	lettuce	R	18
saveloys	C	10	silverbeet	C	8
luncheon sausage	R	10	watercress	R	8
salami	R	10	celery	R	8
beef sausages	C	10	broccoli	C	8
pizza	C	10	spinach	C	8
corned silverside	C	10	*Other vege*		
hamburger	C	4	Beetroot,canned	As is	8
beef, mince	C	4	potato	C	10
cheese, cottage	R	4	carrot	R	8
dip, cream cheese based	R	4	pumpkin	C	8
cheese, cheddar, full fat	R	4			
Total		**100**			**100**

C = cooked, R = raw

2.2 Sampling

Samples were purchased in Christchurch and Auckland from 24 November to 16 December 2003. Details of purchasing instructions are given (Appendix 1).

2.3 Sample Handling and Analysis

Samples purchased in Christchurch were dispatched to Auckland for preparation and analysis. Regional samples were kept separate. Samples were prepared as soon as possible on receipt at the laboratory with a maximum storage period of 4 days. Prepared foods were frozen until analysis.

Food preparation was based on the 2003 New Zealand Total Diet Survey (Vannoort, 2003). Details are given (Appendix 1).

Foods that may be consumed raw or as purchased from the retailer included: ham, luncheon, salami, corned silverside (precooked), hamburger, cottage cheese, dip, cheddar cheese, cabbage, lettuce, watercress, celery, and carrots.

Foods that are normally cooked before consumption were cooked as follows:

Dry fry - bacon, sausages, beef mince

Boil – raw corned silverside, saveloys, potatoes, broccoli, spinach, silverbeet and pumpkin.

2.4 Analytical Methods

Nitrate and nitrite were determined using standard, validated methodology (ESR Auckland Food Group Methods Manual, method:HPLC 6) based on the method of Eggers and Cattle (1986). In summary the technique involves solubilization of nitrite and nitrate ions in a buffered solution, cleanup with Carrez precipitating agents and analysis by high pressure liquid chromatography.

Results are expressed as mg/kg of sodium nitrite and sodium nitrate.

2.4.1 Limits of detection:

nitrite (as sodium nitrite) 5 mg/kg
nitrate (as sodium nitrate) 5 mg/kg

for all foods except some cheese samples that have a higher limit of detection for nitrite due to interference from sorbate.

2.4.2 Quality assurance

Analytical precision of results was obtained by analysing a percentage of samples in duplicate and applying the TELARC Guidelines (TELARC Technical Guide Number 5, February 1987 "Precision and Limits of Detection for Analytical Methods") to obtain standard deviation and coefficients of variation. Because of the wide variation in the magnitude of analytical results, the calculations were carried out on normalised data.

Table 2: Precision of nitrite and nitrate analyses

Food type	Analyte	Coefficient of variation
Meat	Nitrite (as sodium nitrite)	9.7%
	Nitrate (as sodium nitrite)	7.5%
Vegetables	Nitrite (as sodium nitrite)	*
	Nitrate (as sodium nitrite)	9.0%
Cheese/Pizza	Nitrite (as sodium nitrite)	14.4%
	Nitrate (as sodium nitrite)	**

* Only one positive nitrite result found in the vegetables.
** Insufficient positive duplicates for precision calculations.

Known amounts of nitrate and nitrite were spiked into survey foods and the amount recovered in the assay methods used was determined. Results are summarised in Table 3.

Table 3: Mean recoveries of nitrite and nitrate from spiked food samples

	Mean spike recovery (%)	
Food	**Nitrite**	**Nitrate**
Meat	100	96
Vegetable	93	77
Cheese/Pizza	107	97

All nitrite/nitrate results have been reported uncorrected for recovery.

2.5 Estimation of dietary exposure to nitrite and nitrate

Aggregated food descriptors from the 1997 National Nutrition Survey (NNS) (Russell *et al.*,1999) were assigned nitrite and nitrate concentrations based on the mean concentration results determined in this survey. A total of 1046 food descriptors were used. These foods and concentrations were combined with 24 hour dietary recall information for 4398 individual consumers for whom body weight information was available. Daily exposure scenarios were determined for exogenous nitrite, for nitrate and for total nitrite including a proportion from the endogenous conversion of nitrate. Conversion factors of 5% and 20% representing average and high levels of conversion from nitrate to nitrite (FAO/WHO, 1995) were applied separately.

Where a processed food did not contain measureable amounts of nitrate or nitrite, 'less than' values were assigned to be zero on the assumption that it had not been used as a food additive. Nitrate and nitrite occur naturally in foods as a consequence of the nitrogen cycle whereby nitrogen is fixed by bacteria. Small amounts of nitrite have been reported in vegetables (Chung *et al*, 2003, Meah, 1994, Petersen and Stolze,1999, Zhong *et al*, 2002). Therefore, a value of half the limit of detection was assigned where nitrite values for vegetables were below the limit of detection, in line with international recommendations (WHO, 1995).

For foods that had not been analysed in this survey, such as cauliflower, concentration values were approximated from similar foods (cauliflower = broccoli; parsnip = carrot; puha = silverbeet; swede and turnip = pumpkin, yams = potatoes.). Peas were not included in the assessment since no comparable concentration data was available. Where a food might be included in a recipe, such as carrot in a stir fry, a proportion of the ingredient in the recipe was approximated.

The process described above produced 4398 individual estimates of dietary exposure (expressed in mg/day) – one for each respondent to the 24 hour diet recall component of the NNS. Estimates of dietary exposure were then divided by the body weight of the NNS respondent to give a dietary exposure in mg/kg body weight/day.

3 RESULTS AND DISCUSSION

3.1 Concentration of nitrite and nitrate in foods

3.1.1 Concentrations in New Zealand foods

Table 4 gives the mean and range of nitrate and nitrite levels found in the current survey. Nitrate was detected in at least one sample of each food except for cheddar cheese and cream cheese based dips in which none was detected. Nitrite was detected in half the processed foods and meats analysed but was not detected in any of the vegetable samples above the limit of detection with the exception of broccoli at 27 mg/kg nitrite.

Table 4: Levels of nitrate and nitrite in foods analysed in the current survey (mg/kg as sodium salt).

Food	Nitrate			Nitrite		
	Mean mg/kg as $NaNO_3$	range	No. samples > LOD	Mean mg/kg as $NaNO_2$	range	No. samples > LOD
Processed foods						
Bacon	36.5	<5-81	9/10	15.9	<5-63	7/10
Ham	16.6	<5-32	9/10	19.9	<5-119	9/10
Saveloys	28.5	8-63	10/10	35.6	9-53	10/10
Luncheon	30.9	22-53	10/10	24.6	<5-71	9/10
Salami	24.8	<5-56	8/10	7.4	<5-36	4/10
Beef sausages	1.8	<5-18	1/10	0	all <5	0/10
Pizza	5.9	<5-10	8/10	0.6	<5-6	1/10
Corned silverside	18.1	7-36	10/10	9	<5-15	8/10
Hamburger	79	6-211	4/4	0	all <5	0/4
Beef mince	3.7	<5-15	1/4	0	all <5	0/4
Cottage cheese	2.3	<5-9	1/4	0	all<15	0/4
Dip, creamed cheese based	0	all <5	0/4	0	all<10	0/4
Cheddar cheese	0	all<5	0/4	0	all <5	0/4
Green vegetables						
Cabbage	331	120-690	8/8	2.5	all <5	0/8
Lettuce	1590	83-3420	18/18	2.5	all <5	0/18
Silverbeet	740	190-1690	8/8	2.5	all <5	0/8
Watercress	1640	870-2790	6/6	2.5	all <5	0/6
Celery	1610	880-2320	8/8	2.5	all <5	0/8
Broccoli	133	51-280	8/8	6	<5-27	1/8
Spinach	990	100-1560	8/8	2.5	all <5	0/8
Beetroot, canned	763	260-2220	8/8	2.5	all <5	0/8
Other vegetables						
Potato	129	48-240	8/8	2.5	all <5	0/8
Carrot	58.3	<5-290	6/8	2.5	all <5	0/8
Pumpkin	65.8	<5-350	4/8	2.5	all <5	0/8

< = less than

3.1.2 Non compliance

Nitrate and nitrite are permitted additives in selected foods only. Maximum permitted levels as specified in Standard 1.3.1 of the Australia New Zealand Food Standards Code (FSANZ 2004) are as follows:.

Bacon, ham, saveloys, luncheon, salami, pizza, corned silverside, hamburger:
125 mg/kg total of nitrates and nitrites, calculated as sodium nitrite
Sausage and sausage meat containing raw, unprocessed meat: nil
Mince: nil
Cheese and cheese products: 50 mg/kg calculated as nitrate ion (equivalent to 68.5 mg/kg as the sodium salt).

Ninety seven percent of the processed foods analysed complied with the Food Standards. One sample of beef sausages purchased from a butcher and one supermarket sample of mince contained low (less than 20 mg/kg as sodium nitrate) levels of nitrate. The sausage may perhaps have contained a small proportion of cured meat that accounted for the presence of nitrate . One hamburger sample contained 171 mg/kg of nitrate (as sodium nitrite), somewhat over the standard of 125 mg/kg. It is not possible to distinguish whether the nitrate in this sample was from use of nitrate as an additive or whether the hamburger contained a vegetable ingredient that was contributing to an elevated level.

3.1.3 Comparison of nitrite and nitrate levels with overseas data

There is some uncertainty with the form of many of the results in the literature. In New Zealand and Australia where nitrate and nitrite have been measured as a food additive, results are expressed as the sodium salt since this is the form that is added to food. In the international literature results are expressed simply as nitrate or nitrite. It is assumed that the international data has been reported as nitrate ion since it is not specified that concentrations have been measured as the sodium salt.

A comparison of the range of concentrations for nitrate and nitrite in processed foods for the 21st ATDS and New Zealand data from this survey is shown in Table 5.

Table 5: Comparison of nitrate and nitrite levels found in the ATDS and current survey (as mg/kg sodium nitrate and sodium nitrite).

	Nitrate (mg/kg)		Nitrite (mg/kg)	
	Australia 2003	NZ 2004	Australia 2003	NZ 2004
Food		**range**		**range**
Bacon	22-90	<5-81	12-45	<5-63
Ham	20-90	<5-32	8-50	<5-119
Saveloys	25-78	8-63	<5-70	9-53
Luncheon	35-60	22-53	18-70	<5-71
Salami	16-335	<5-56	<5-18	<5-36
Beef sausages	<2-10	<5-18	<2	all <5
Pizza	10-40	<5-10	<5-8	<5-6
Corned silverside	NA	7-36	NA	<5-15
Hamburger	NA	6-211	NA	all <5
Beef mince	NA	<5-15	NA	all <5
Cottage cheese	<2-10	<5-9	<2	all<15
Dip, creamed cheese based	<2	all <5	<2	all<10
Cheddar cheese	<2-18	all<5	<2-<10	all <5

NA=not available

Levels of nitrate and nitrite in the New Zealand samples are low or comparable with the results obtained for Australian samples, with the exception of one sample of New Zealand ham that had a nitrite level of 119 mg/kg. The elevated levels of nitrate (>150 mg/kg as sodium nitrate) found in 5/15 samples of salami in the Australian study were not observed in the 10 New Zealand samples.

A compilation of data for the concentration of nitrate in vegetables is shown in Table 6. The New Zealand data from the current survey has been reported in this table as nitrate ion for comparison with the other studies.

Table 6: Comparison of international data for nitrate in vegetables (mg/kg fresh weight basis)

Food	NZ[1] 2004	NZ[2] 1980	Review[3] 1990	UK[4] 1994	UK[5] 1999	Denmark[6] 1999	China[7] 2002	Italy[8] 2003	Korea[9] 2003
beetroot	635	3810	3288		1211	1390			
broccoli	111		1014						
butternut		469							
cabbage	275	542	712	860	338		1530		725
carrot	48		274	210	97				316
celery	1339	2100	3151	1200			3600		
chinese cabbage				1900		1170	2120		1740
courgette				810					
cucumber		25		23			170		212

Food	NZ[1] 2004	NZ[2] 1980	Review[3] 1990	UK[4] 1994	UK[5] 1999	Denmark[6] 1999	China[7] 2002	Italy[8] 2003	Korea[9] 2003
endive			1780						
garlic									124
green beans			466						
green onion									436
green pepper									76
leek						330			
lettuce	1323	450	2330	3000	1051	2440		1473	2430
onion				80	48				23
potato	107	102		110	155	229	164		452
pumpkin	55	3		410					639
radish			2600	1100					1878
Roth									5150
silverbeet	616	1770							
soy sprouts									56
spinach	824		2470	2100	1631	1783		1757	4259
tomatoes		19	80	1.3	17		78		
watercress	1364			1300					
melon			4932						
rhubarb			2900						

1= samples were prepared as consumed (cooked: silverbeet, broccoli, spinach, potato, pumpkin, beetroot, raw :cabbage, lettuce, watercress, celery, carrot).
2= Pickston et al, 1980, 3=Walker, 1990 (an international review), 4=Meah et al, 1994, 5= Ysart et al, 1999, 6= Petersen et al, 1999, 7=Zhong et al, 2002, 8=De Martin and Restani 2003, 9=Chung et al, 2003.

The vegetable results from the present survey were lower than or comparable with nitrate results from overseas. None of the foods from the present survey were noticeably higher in nitrate concentration. Lower results in the current survey for beetroot, broccoli, silverbeet and spinach relative to the comparative data can be explained by the difference in preparation. In the current survey these foods were cooked whereas comparative data is for nitrate levels in fresh foods.

3.1.4 Cultivation

In response to consumer concern about potentially high concentrations of nitrate in vegetables through fertilizer use, and with the knowledge that foods grown indoors have higher concentrations of nitrate, information on method of cultivation was obtained where possible. Table 7 shows apparently higher concentration of nitrate in hydroponically compared with organic or conventionally grown lettuces. There may be two reasons for this. Firstly, lettuce with open heads, such as the "fancy" red and green lettuces now available, contain more nitrate than iceberg lettuce (Petersen and Stoltze, 1999). Secondly, because it is a different cultivation system, hydoponically grown lettuce is likely to be grown indoors with a different fertilizer use than conventionally or organically grown lettuces. This result is consistent with the findings of Zhong et al, (2002) where celery that was cultivated by a hydroponic method contained about ten times more nitrate than celery that was grown by conventional methods. From the limited results presented there is no apparent difference in nitrate concentration for the organically and conventionally grown lettuces. International results are conflicting. Malmaret et al., (2002) reported higher median and maximum

concentrations of nitrate in conventional compared with organic lettuces whilst De Martin and Restani reported the reverse (2003).

Table 7: Concentration of nitrate in New Zealand grown lettuces (mg/kg as sodium nitrate) for different cultivation methods.

Hydroponic	Organic	Conventional	Unspecified
3053	1550	550	3240
1090	260	2140	970
3420	83	1090	800
3010			750
2420			1250
1740			
1190			

3.2 Dietary Exposure

3.2.1 Dietary exposure to nitrate and nitrite for new Zealanders

Table 8 summarises the mean and percentile dietary exposure estimates derived by combining mean preservative levels from the current survey with 24 hour dietary recall information from the 1997 NNS (Russell et al, 1999). This approach generates over 4000 daily exposure scenarios for nitrate and nitrite. The exposure scenarios generated are examples of exposure for one individual on one day rather than mean exposure of an individual. The combined scenarios represent a distribution of likely exposures across a population. Also included in the table are nitrite intakes including 5% and 20% contributions from the conversion of nitrate for the average individual and those with a high level of conversion. The values in bold reflect scenarios above the ADI.

Table 8: Mean and percentile dietary exposure estimates for New Zealand adults to nitrite, nitrate and total nitrite including conversion from nitrate (as sodium nitrate and sodium nitrite). (percentage of ADI)

	Estimated Dietary Exposure (mg/kg body weight/day)			
	Nitrate	**Nitrite**	**Nitrite +5% nitrate**	**Nitrite + 20% nitrate**
Mean	0.719 (14%)	0.013 (13%)	0.049 (49%)	0.156 (156%)
50th percentile (Median)	0.424	0.009	0.032	**0.097**
minimum	0	0	0	0
maximum	**33.9**	**0.330**	**1.87**	**6.96**
90th percentile	1.62	0.028	**0.108**	0.347
99th percentile	**5.02**	0.076	0.284	1.025
ADI (mg/kg body weight/day)	**0-5**	**0-0.10**	**0-0.10**	**0-0.10**

ADI = Acceptable Daily Intake, mean body weight of 4398 respondents = 74.8kg.

The mean dietary exposure to nitrate is approximately 14% of the ADI, while the median dietary exposure level is lower at 8% of the ADI. Approximately 1% of exposure scenarios resulted in daily dietary exposures above the ADI for nitrate.

For exogenous nitrite (excluding any contribution from the endogenous conversion of nitrate) the mean dietary exposure was approximately 13% of the ADI. Less than 1% of exposure scenarios resulted in daily dietary exposures above the ADI. When a contribution from the conversion of dietary nitrate to nitrite is included, the ADI for nitrite is exceeded 10% of the time for an average conversion rate (5%) and 50% of the time for those individuals with a high conversion rate (20%).

These estimates for nitrate and nitrite will be slightly low because they do not include contributions from water, bread, cereals or fruit. Any contribution from water is expected to be low because of the generally low concentration of nitrate in New Zealand waters (New Zealand drinking water surveillance programme, Data Review 1983-89, 1991).

3.2.2 Comparison with overseas estimates of dietary exposure to nitrate and nitrite.

Limited comparative information for dietary exposure to nitrate and nitrite is summarized in Table 9. The exposure for New Zealand adults to nitrate is comparatively low but the mean exposure to nitrite is the highest of those reported because this assessment gives a total nitrite exposure by including a contribution from the endogenous conversion of nitrate.

Table 9: Comparative estimates of dietary exposure to nitrate and nitrite.

Country	Nitrate (mg/kg bw/day)	Nitrite (mg/kg bw/day)
New Zealand 2004	0.52	0.033[1]
Czech Republic 1994-2001[2]	0.665-1.11	0.005-0.023
New Zealand 1996[3]	1.61	0.016
The Netherlands 1994	1.10	<0.003[4]

1=includes 5% endogenous conversion of nitrate, 2= http:sight.who.int, 3=Thomson,1996, 4=Median as no mean available (Vaessen and Schothorst).

More information is available for nitrate and nitrite intake from vegetable consumption and this has been collated in Table 10. From these results, exposure to nitrate from vegetables for a New Zealand adult is comparable with estimates for Denmark and England and lower than for China because of lower concentrations in the food and less consumption. Exposure to exogenous nitrite in vegetables is low and therefore not of health significance compared with the contribution from the endogenous conversion of nitrate to nitrite.

Table 10: Comparison of New Zealand mean intake of nitrate and nitrite from vegetable consumption with overseas studies (mg/kg bw/day).

Country	Vegetable consumption	Mean adult	Nitrate intake	Nitrate intake	Nitrite intake[1]	Nitrite intake

	(g/day)	body weight (kg)	(mg/day)	(mg/kg bw/day)	(mg/day)	(mg/kg bw/day)
NZ	231	75	52.5	0.70	0.59	0.008
China[2]	510	60	486	8.1	0.78	0.013
Denmark[3]	142	70	38.9	0.55	0.091	0.0013
England[4]	266	60	93	1.5	NR	NR
ADI	na	na	na	**0-3.7**	na	**0-0.07**

1=exogenous nitrite only, 2=Zhong et al, 2002, 3=Petersen and Stoltze,1999, 4=Ysart et al, 1999, na=not applicable, NR =no result.

3.2.3 Foods Contributing to Dietary Exposure

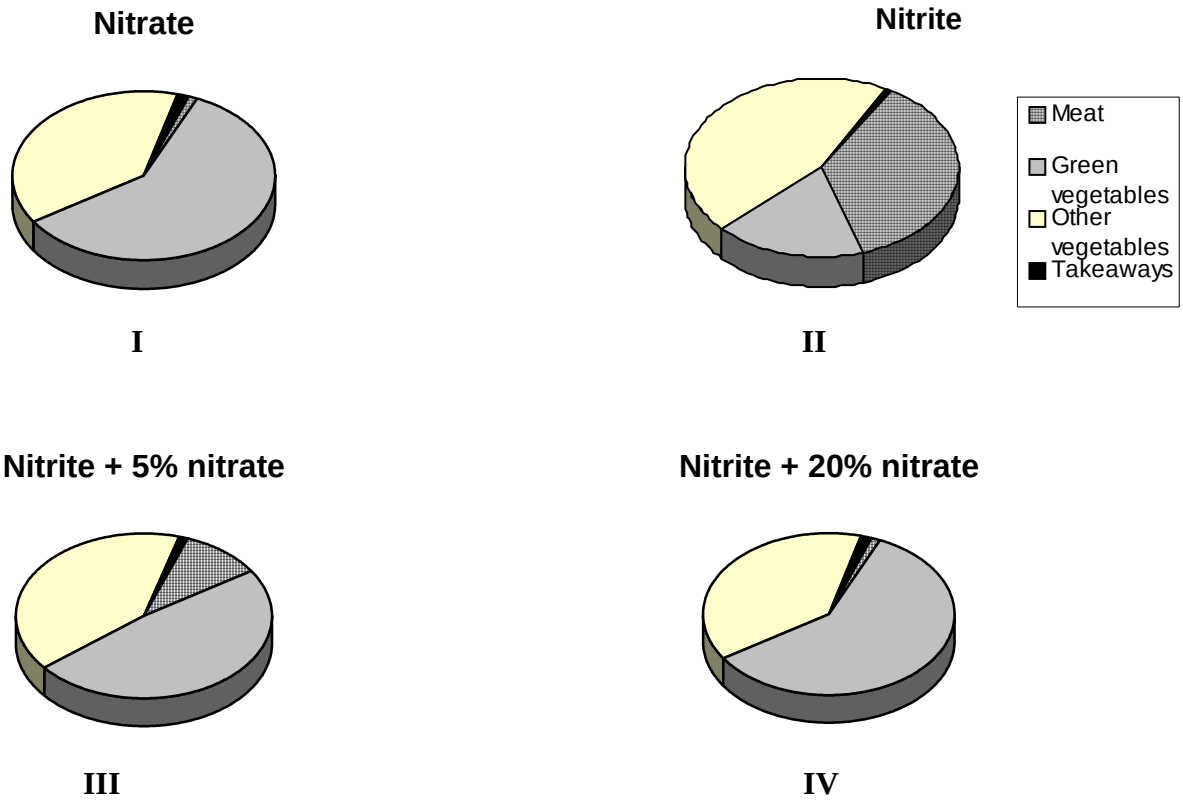
The relative contribution of those foods contributing more than 5% to to dietary exposure to nitrate and exogenous nitrite (for the foods analysed in this study) is shown in Table 11 and Figure 1.

Table 11: Foods contributing more than 5% of exogenous dietary exposure

Food	% nitrate	% nitrite	Ave. consumption (g/day)	Mean nitrate conc. (mg/kg)[1]	Mean nitrite conc. (mg/kg)[1]
Bacon		6.2	5.9		15.9
Broccoli		9.4	17.4		6.0
Cabbage	8.9		18.2	331	
Corned silverside		5.4	5.6		9.0
Ham		10.5	4.9		19.9
Lettuce	29.2		10.6	1590	
Luncheon		5.2	1.9		24.6
Potato	32.2	35.6	131.7	129	2.5
Saveloys		8.9	2.4		35.6
Silverbeet	5.4		3.8	740	
watercress	5.6		1.8	1640	

1= from Table 4

Figure 1: Contribution of different food types to exposure to nitrate and exogenous nitrite (showing the effect of endogenous (human body) conversion of nitrate at 5% and 20%)



Over 97 % of exposure to nitrate from the foods selected for this study is from the consumption of vegetables (Chart I). The two most significant contributors being potatoes (32%) and lettuce (29%).

Approximately one third of exogenous exposure to nitrite is from meat products (mostly ham) where nitrite may be used as an additive (Chart II). The food making the highest contribution to nitrite exposure is potato (36%). However, this is only theoretical as it is based on assuming a level of half the limit of detection (2.5 mg/kg) since nitrite was not detected in any of the samples above the limit of detection. (refer Table 4). This is a reasonable assumption when compared with an average nitrite concentration of 1.59mg/kg for potatoes reported by Zhong et al., (2002). When the endogenous conversion of nitrate is taken into account, the percentage contribution of meat products decreases from 37% to 10% for the average individual (Chart III) and to 4% for a high converter (Chart IV).

3.2.3 Lettuce and potatoes

Lettuce and potato consumption clearly make the greatest contribution to dietary intake of both nitrate and nitrite. One of the objectives of the current study was to compare New Zealand results with studies overseas to ascertain if New Zealand results are high or low as indicators of environmental contamination or fertilizer use. The comparative data for lettuces and potatoes in Table 6 indicates that the mean New Zealand concentrations are very consistent with those from other countries for both these vegetables.

The nitrate content of vegetables varies with available light and temperature. The EU (European Commission, 1997) has established the following different maximum levels of nitrate in lettuce grown at different times of the year and for different processing conditions.

Lettuce winter (1 Sept to 31 March), glasshouse	4500 mg/kg fresh weight
Lettuce summer (1 April to 31 August), glasshouse	3500 mg/kg fresh weight
Grown in open air (1 May to 31 August)	2500 mg/kg fresh weight

Eighteen samples of lettuce were analysed in the current survey. All of these samples were purchased in November, equating to a summer growing season. The concentration of nitrate in the New Zealand lettuce samples ranged from 60 to 2495 mg/kg fresh weight (as nitrate ion), all within the EU regulatory limits for summer lettuces (3500 mg/kg fresh weight) and for lettuces grown in the open air (2500 mg/kg fresh weight).

The implication is that the New Zealand lettuce and potato samples are not unusually high by comparison with European and Asian data. There is no evidence to substantiate a concern from too much nitrogen fertilizer.

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5 APPENDIX 1: FOOD PURCHASING AND PREPARATION INSTRUCTIONS

Equal numbers of samples will be purchased by ESR staff in Auckland and Christchurch to give the sample numbers listed in Table 1 i.e. 5 samples of bacon to be purchased in Auckland and 5 samples purchased in Christchurch.

Packaging

Whenever appropriate, foods should be maintained in their point-of-sale packaging. Where this is likely to be insufficiently secure, the sample in its point-of-sale packaging should be placed into a clip top or whirlpak bag. Sample identification labels, with all appropriate information filled in, should be attached to the final external packaging for each sample.

Samples requiring refrigeration (meats, dairy products) should be packed in a separate chilly bin to other foods (vegetables) and kept as cool as possible until preparation for analysis.

Documentation

Labels for each region will be supplied by CSC, including a sheet of spares. They will follow the format:

Sample ID:	(FoodNo./Region/Food No. e.g. Nitrates/Ak/01 for bacon sampled in Auckland.	
Food description:	(eg.Bacon)	
Place of purchase:	(eg. Foodshopname, Town)	purchaser fill in
Brand name/variety:	(eg. Brandname)	purchaser fill in
Date of purchase:	(eg. 10/11/03)	purchaser fill in
Country of origin:	(eg. NZ, China)	purchaser fill in
Method of cultivation:	(eg. Organic)	purchaser fill in for vegetables only
Sample number:	(eg. Lab number)	lab to fill in

The fields for ID and food description will be filled out before use by CSC. In this way the labels should help to make sample purchasing easier to ensure the correct samples are purchased, along with a ticklist to be provided by CSC.

The following purchases are required.

Unit purchases

The amount to be purchased follows the protocol for the New Zealand Total Diet Survey that is based on international protocols for exposure assessment. In some cases there will be more food than required for analysis but a larger sample is more representative than a smaller sample. It is important to homogenise the entire unit of each sample.

1 **Bacon**

Purchase: Package size 250 g, middle bacon. Purchase three packets of three different brands from supermarkets and 250g from each of two butchers.

Comment: 3 different brands, if available.

2 **Ham**

Purchase: Purchase size 250 g, cold sliced ready to eat ham. Make a total of five purchases of different brands from across supermarkets (3) and delicatessens or butchers (2).

3 **Saveloys**

Purchase: Purchase three lots of 250 g saveloys from supermarkets and two lots of 250 g from butcher shops. Total five units.

4 **Luncheon Sausage**

Purchase: Purchase size 250g luncheon sausage. Make a total of three purchases of different brands from supermarkets (3) and delicatessens or butchers (2).

5 **Salami**

Purchase: Purchase size 250g salami. Make a total of five purchases of different brands from across supermarkets/delis. If different brands are not possible, purchase duplicate brands from different batches.

6 **Beef sausages**

Purchase: Purchase three lots of 250 g uncooked beef (or beef flavoured) sausages from supermarket and two lots of 250 g uncooked beef sausages from butcher shop. Total five units.

7 **Pizza**

Purchase: Purchase five x 300 g of pizza of different brands, **with meat toppings** from different food outlets. Total five units.

Comment: Select frozen or refrigerated branded pizzas from supermarket, and fresh takeaway pizza (uncooked if possible, otherwise cooked).

8 **Corned silverside**

Purchase: Purchase size 250g corned silverside. Purchase 3 samples of cooked, sliced corned silverside from different supermarkets/delis, 1 samples of uncooked silverside from a supermarket and 1 sample uncooked silverside from a butcher.

9 **Hamburger, plain**

Purchase: Purchase four plain hamburgers, ready to eat, two from each of two different food outlets.

Comment: Major burger chain and one other food outlet

10 **Beef mince**

Purchase: Purchase a minimum of 250g raw minced beef. Make one purchase from a supermarket and one from a butcher.

11 **Cottage cheese**

Purchase: Purchase 1unit of two different brands from supermarket (minimum unit weight=250g).

12 **Dip, cream cheese based**

Purchase: Purchase 2 units of two different brands from supermarket.

13 **Cheddar cheese, full fat**

Purchase: Purchase 1 unit of 250g of two different brands from supermarket.

14 **Cabbage**

Purchase: Purchase four half cabbages (or 4 x 500g of cabbage), two from a supermarket and two from a green grocer. Total four units.

15 **Lettuce**

Purchase: Purchase a minimum of nine units of different types of lettuce, either head or leaf lettuce, or both if possible. If possible purchase three units of conventionally grown, three units of organically grown and three units of hydroponically grown lettuces. Make purchases from supermarkets and green grocers.

Comment: Record type of cultivation (organic, conventional, hydroponic, unknown).

16 **Silverbeet**

Purchase: Purchase two x 250g of silverbeet from each of supermarket and green grocer. Total four units.

Comment: Green silverbeet, not coloured varieties.

17 **Watercress**

Purchase: Purchase two x 250g of watercress from each of supermarket and green grocer. Total four units.

Comment: Record method of cultivation if available (wild, hydroponic, conventional, organic).

18 **Celery**

Purchase: Purchase approx 500g of celery (as presented) from each of 2 supermarkets and green grocers. Total four units.

19 **Broccoli**

Purchase: Purchase two x 500 g of the edible portion (head, excluding leaves) of broccoli from each of 2 supermarkets and green grocers. Total of 4 purchases .

20 **Spinach**

Purchase: Purchase two x 250g of spinach from each of supermarket and green grocer.

Total four units.

21 **Beetroot, canned**

Purchase: Purchase four x 400g cans of beetroot. Purchase different brands from a supermarket.

22 **Potatoes**

Purchase: Purchase three x 750g of different varieties from a supermarket and two x 750g from a green grocer. Choose equal weights of each variety available. Total of five units.

Comment: Please note the varieties of potato purchased.

23 **Carrots**

Purchase: Purchase two x 500g of carrots from each of supermarket and green grocer. Total four units.

24 **Pumpkin**

Purchase: Purchase two x 500g of pumpkin from each of supermarket and green grocer. Total four units, total weight 2 kg

Comment: Grey or orange type (not squash), crown or triamble type.

FOOD PREPARATION

Food preparation is based on the 2003 New Zealand Total Diet procedures.

Utensils and Equipment

- stainless steel knives
- wooden (good quality, smooth, crack free), plastic or glass chopping boards
- stainless steel or teflon-coated utensils. Glass equipment can also be used provided it is Pyrex.
- hotplates (electric), a domestic stove works well but the only oven cooked foods in this survey are possibly pizzas.
- food processors, high density plastic with stainless steel blades
- fry-pans (Teflon-coated)
- large stainless steel pots

Contamination control

Usual lab practice with clean working conditions, equipment and cleaning between samples is expected to avoid contamination.

Food Preparation

Keep regional samples separate. Samples should be prepared as soon as possible on receipt at the laboratory with a mmaximum storage period of 4 days. Perishable foods should be refrigerated until preparation. Once prepared foods can be frozen until analysis.

Cooking

Some working definitions:
Boiling Add sufficient water to just cover the vegetable. Boil as quickly as possible until just tender, with the lid on the pot. Drain by holding the lid against the pot. Discard the cooking water.

Frying: dry fry bacon, sausages and mince in a frying pan until edible. Stir or turn the samples for even cooking. Drain and discard any residual fat.

Quality assurance samples.

Include blanks, spikes and duplicate samples with each analytical run to ensure accuracy and reproducibility of the results. Provide a minimum of 20 QA results over the entire project.

Bacon

- Remove rind and dry fry the complete unit/packet for three minutes on each side.
- Homogenise each sample (10).
- Transfer each sample into a storage container, affix label and date.

- Freeze samples.

Ham, luncheon sausage, salami, corned silverside

- Homogenise each purchase (10).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples

Saveloys

- Boil each purchase in distilled water for 5 minutes
- Homogenise each purchase (10).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples

Beef sausages

- Boil in distilled water, then dry fry for 5 minutes on each side**.**
- Homogenise each sample (10).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples

Pizza

- Cook, if needed, as per instructions.
- Chop each purchase and homogenise (10).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Beef, mince

- Fry without fat until cooked, about 15 minutes**.**
- Homogenise each sample (4).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Hamburger

- Homogenise together 2 meat patties from each purchase (4)
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Cottage cheese

- Homogenise each purchase (4)
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Dip, cream cheese based

- Homogenise each purchase (4)
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Cheddar cheese

- Homogenise each purchase (4)
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Cabbage

- Take cabbage halves from within each region, remove outer leaves, rinse, then chop and homogenise raw (8 samples).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Lettuce

- Prepare by removing the outer leaves and cut off root. Rinse under distilled water and shake to remove excess water.
- Homogenze each purchase separately (18).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Silverbeet and spinach

- Cut off any roots. Wash in distilled water, slice and boil in distilled water for about 5 minutes until cooked.
- Drain and homogenize each purchase (8).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Watercress

- Prepare as for salad and analyse raw.
- Rinse, then chop and homogenise raw for each purchase (8).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Celery

- Prepare as for salad and analyse raw. Cut off roots and leafy heads and discard.
- Rinse, then chop and homogenise raw for each purchase (8).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Broccoli

- Cut into florets. Rinse. Boil equal weights of each food purchase in distilled water for five minutes.
- Drain and homogenise each sample (8).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Beetroot, canned

- Homogenise the contents of each purchase separately (8).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

Potatoes

- Peel (older) or scrub (new) potatoes, rinse and boil each potato purchase in distilled water until cooked for about 20 minutes
- Drain and homogenize each purchase (10).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples immediately.

Carrots

- Peel, rinse, chop and homogenise raw carrots from each purchase (8).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples immediately.

Pumpkin

- Cut off skin, cut into pieces, rinse and boil in distilled water until cooked, about 15 minutes.
- Drain and homogenize each purchase (8).
- Transfer each sample into a storage container, affix label and date.
- Freeze samples.

For any clarification, please contact Project Leader,

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APPENDIX 2: ANALYTICAL RESULTS

No.	Food	Region	Sample ID	Outlet Type	Concentration (mg/kg as sodium salt) Nitrate	nitrite
1	Bacon	Auckland	1/AK/01	supermarket	<5	<5
		Auckland	1/AK/02	butcher	20	22
		Auckland	1/AK/03	supermarket	54	63
		Auckland	1/AK/04	butcher	46	7
		Auckland	1/AK/05	supermarket	41	2
		Christchurch	1/CH/01	Supermarket	37	44
		Christchurch	1/CH/02	Supermarket	43	6
		Christchurch	1/CH/03	butcher	29	8
		Christchurch	1/CH/04	butcher	14	<5
		Christchurch	1/CH/05	Supermarket	81	7
				mean	**36.5**	**15.9**
2	Ham	Auckland	2/AK/01		28	5
		Auckland	2/AK/02	supermarket	<5	5
		Auckland	2/AK/03		20	12
		Auckland	2/AK/04	butcher	14	5
		Auckland	2/AK/05	butcher	14	119
		Christchurch	2/CH/01	supermarket	16	10
		Christchurch	2/CH/02	supermarket	13	8
		Christchurch	2/CH/03	butcher	9	18
		Christchurch	2/CH/04	delicatessen	32	17
		Christchurch	2/CH/05	supermarket	20	<5
				mean	**16.6**	**19.9**
3	Saveloys	Auckland	3/AK/01	butcher	41	47
		Auckland	3/AK/02	supermarket	17	42
		Auckland	3/AK/03	supermarket	14	34
		Auckland	3/AK/04	supermarket delicatessan	14	30
		Auckland	3/AK/05	supermarket	8	9
		Christchurch	3/CH/01	supermarket	34	26
		Christchurch	3/CH/02	butcher	63	33
		Christchurch	3/CH/03	supermarket	31	30
		Christchurch	3/CH/04	butcher	34	52
		Christchurch	3/CH/05	supermarket	29	53
				mean	**28.5**	**35.6**
4	Luncheon	Auckland	4/AK/01	supermarket	37	40
		Auckland	4/AK/02	supermarket	23	22
		Auckland	4/AK/03	supermarket	37	71
		Auckland	4/AK/04	supermarket	33	27
		Auckland	4/AK/05	butcher	29	28
		Christchurch	4/CH/01	delicatessen	26	15
		Christchurch	4/CH/02	supermarket	25	<5
		Christchurch	4/CH/03	delicatessen	22	13
		Christchurch	4/CH/04	supermarket	24	21
		Christchurch	4/CH/05	delicatessen	53	9
				mean	**30.9**	**24.6**
5	Salami	Auckland	5/AK/01	supermarket	19	<5
		Auckland	5/AK/02	butcher	26	9

No.	Food	Region	Sample ID	Outlet Type	Concentration (mg/kg as sodium salt) Nitrate	nitrite
		Auckland	5/AK/03	supermarket	56	36
		Auckland	5/AK/04		27	<5
		Auckland	5/AK/05	supermarket	<5	<5
		Christchurch	5/CH/01	supermarket	23	<5
		Christchurch	5/CH/02	delicatessen	19	<5
		Christchurch	5/CH/03	delicatessen	44	13
		Christchurch	5/CH/04	delicatessen	<5	<5
		Christchurch	5/CH/05	supermarket	34	16
				mean	**24.8**	**7.4**
6	Beef	Auckland	6/AK/01	supermarket	<5	<5
	sausages	Auckland	6/AK/02	supermarket	<5	<5
		Auckland	6/AK/03	butcher	<5	<5
		Auckland	6/AK/04	supermarket	<5	<5
		Auckland	6/AK/05	butcher	<5	<5
		Christchurch	6/CH/01	supermarket	<5	<5
		Christchurch	6/CH/02	supermarket	<5	<5
		Christchurch	6/CH/03	supermarket	<5	<5
		Christchurch	6/CH/04	butcher	<5	<5
		Christchurch	6/CH/05	butcher	18	<5
				mean	**1.8**	**0**
7	Pizza	Auckland	7/AK/01	supermarket	5	<5
		Auckland	7/AK/02	supermarket	<5	6
		Auckland	7/AK/03	supermarket	<5	<5
		Auckland	7/AK/04	takeaway	6	<5
		Auckland	7/AK/05	takeaway	7	<5
		Christchurch	7/CH/01	supermarket	5	<5
		Christchurch	7/CH/02	specialty	10	<5
		Christchurch	7/CH/03	supermarket	6	<5
		Christchurch	7/CH/04	specialty	13	<5
		Christchurch	7/CH/05	supermarket	7	<5
				mean	**5.9**	**0.6**
8	Corned	Auckland	8/AK/01		9	6
	silverside	Auckland	8/AK/02	supermarket	28	11
		Auckland	8/AK/03	?	22	13
		Auckland	8/AK/04	butcher	36	13
		Auckland	8/AK/05		29	15
		Christchurch	8/CH/01	butcher	9	10
		Christchurch	8/CH/02	delicatessen	20	<5
		Christchurch	8/CH/03	butcher	8	<5
		Christchurch	8/CH/04	supermarket	13	10
		Christchurch	8/CH/05	supermarket	7	12
				mean	**18.1**	**9**
9	Hamburger	Auckland	9/AK/01	takeaway	6	<5
		Auckland	9/AK/02	takeaway	93	<5
		Christchurch	9/CH/01a	takeaway	6	<5
		Christchurch	9/CH/02a	takeaway	211	<5
				mean	**79**	**0**

No.	Food	Region	Sample ID	Outlet Type	Concentration (mg/kg as sodium salt) Nitrate	nitrite
10	Beef mince	Auckland	10/AK/01	supermarket	15	<5
		Auckland	10/AK/02	butcher	<5	<5
		Christchurch	10/CH/01	supermarket	<5	<5
		Christchurch	10/CH/02	butcher	<5	<5
				mean	**3.75**	**0**
11	Cheese	Auckland	11/AK/01	supermarket	<5	<10
	cottage	Auckland	11/AK/02	supermarket	<5	<10
		Christchurch	11/CH/01	supermarket	<5	<15
		Christchurch	11/CH/02	supermarket	9	<15
				mean	**2.25**	**0**
12	Dip, cream	Auckland	12/AK/01	supermarket	<5	<10
	cheese	Auckland	12/AK/02	supermarket	<5	<10
	based					
		Christchurch	12/CH/01	supermarket	<5	<10
		Christchurch	12/CH/02	supermarket	<5	<10
				mean	**0**	**0**
13	Cheese	Auckland	13/AK/01		<5	<5
	cheddar	Auckland	13/AK/02		<5	<5
	full fat					
		Christchurch	13/CH/01	supermarket	<5	<5
		Christchurch	13/CH/02	supermarket	<5	<5
				mean	**0**	**111**
14	Cabbage	Auckland	14/AK/01	supermarket	130	<5
		Auckland	14/AK/02	supermarket	400	<5
		Auckland	14/AK/03	green grocer	150	<5
		Auckland	14/AK/04	green grocer	320	<5
		Christchurch	14/CH/01	supermarket	340	<5
		Christchurch	14/CH/02	green grocer	690	<5
		Christchurch	14/CH/03	green grocer	120	<5
		Christchurch	14/CH/04	supermarket	500	<5
				mean	**331.25**	**2.5**
15	Lettuce	Auckland	15/AK/01	supermarket	3053	<5
		Auckland	15/AK/02	green grocer	1090	<5
		Auckland	15/AK/03	supermarket	1250	<5
		Auckland	15/AK/04	green grocer	3420	<5
		Auckland	15/AK/05	green grocer	750	<5
		Auckland	15/AK/06	supermarket	800	<5
		Auckland	15/AK/07	supermarket	970	<5
		Auckland	15/AK/08	supermarket	3010	<5
		Auckland	15/AK/09	supermarket	3240	<5
		Christchurch	15/CH/01	?	550	<5
		Christchurch	15/CH/02	supermarket	2140	<5
		Christchurch	15/CH/03	supermarket	1550	<5
		Christchurch	15/CH/04	supermarket	260	<5
		Christchurch	15/CH/05	supermarket	83	<5
		Christchurch	15/CH/06	supermarket	2420	<5
		Christchurch	15/CH/07	supermarket	1740	<5
		Christchurch	15/CH/08	green grocer	1090	<5

No.	Food	Region	Sample ID	Outlet Type	Concentration (mg/kg as sodium salt) Nitrate	nitrite
		Christchurch	15/CH/09	supermarket	1190	<5
				mean	**1589.2**	**2.5**
16	Silverbeet	Auckland	16/AK/01	supermarket	490	<5
		Auckland	16/AK/02	green grocer (?)	190	<5
		Auckland	16/AK/03	supermarket	580	<5
		Auckland	16/AK/04	supermarket	270	<5
		Christchurch	16/CH/01	supermarket	980	<5
		Christchurch	16/CH/02	green grocer	1690	<5
		Christchurch	16/CH/03	supermarket	1030	<5
		Christchurch	16/CH/04	green grocer	690	<5
				mean	**740**	**2.5**
17	Watercress	Auckland	17/AK/01	grocer	1810	<5
		Auckland	17/AK/02	green grocer	1370	<5
		Auckland	17/AK/03	supermarket	2790	<5
		Christchurch	17/CH/01	green grocer	910	<5
		Christchurch	17/CH/02	supermarket	2110	<5
		Christchurch	17/CH/03	green grocer	870	<5
				mean	**1643**	**2.5**
18	Celery	Auckland	18/AK/01	supermarket	880	<5
		Auckland	18/AK/02	green grocer	1350	<5
		Auckland	18/AK/03	supermarket	1500	<5
		Auckland	18/AK/04	green grocer	1610	<5
		Christchurch	18/CH/01	green grocer	1650	<5
		Christchurch	18/CH/02	supermarket	1550	<5
		Christchurch	18/CH/03	supermarket	2320	<5
		Christchurch	18/CH/04	green grocer	2020	<5
				mean	**1610**	**2.5**
19	Broccoli	Auckland	19/AK/01	green grocer	280	<5
		Auckland	19/AK/02	green grocer	120	<5
		Auckland	19/AK/03	supermarket	51	<5
		Auckland	19/AK/04	supermarket	180	<5
		Christchurch	19/CH/01	green grocer	70	<5
		Christchurch	19/CH/02	green grocer	110	27
		Christchurch	19/CH/03	supermarket	72	<5
		Christchurch	19/CH/04	supermarket	180	<5
				mean	**133**	**6**
20	Spinach	Auckland	20/AK/01	supermarket	830	<5
		Auckland	20/AK/02	green grocer	1010	<5
		Auckland	20/AK/03	supermarket	840	<5
		Auckland	20/AK/04	supermarket	100	<5
		Christchurch	20/CH/01	supermarket	1060	<5
		Christchurch	20/CH/02	green grocer	1360	<5
		Christchurch	20/CH/03	supermarket	1160	<5
		Christchurch	20/CH/04	green grocer	1560	<5
				mean	**990**	**2.5**

No.	Food	Region	Sample ID	Outlet Type	Concentration (mg/kg as sodium salt) Nitrate	nitrite
21	Beetroot,	Auckland	21/AK/01	supermarket	1300	<5
	canned	Auckland	21/AK/02	supermarket	560	<5
		Auckland	21/AK/03	supermarket	470	<5
		Auckland	21/AK/04	supermarket	450	<5
		Christchurch	21/CH/01	supermarket	260	<5
		Christchurch	21/CH/02	supermarket	2220	<5
		Christchurch	21/CH/03	supermarket	400	<5
		Christchurch	21/CH/04	supermarket	440	<5
				mean	**763**	**2.5**
22	Potato	Auckland	22/AK/01	green grocer	160	<5
		Auckland	22/AK/02	supermarket	240	<5
		Auckland	22/AK/03	supermarket	110	<5
		Auckland	22/AK/04	?	48	<5
		Auckland	22/AK/05	green grocer	190	<5
		Christchurch	22/CH/01	supermarket	120	<5
		Christchurch	22/CH/02	green grocer	96	<5
		Christchurch	22/CH/03	supermarket	95	<5
		Christchurch	22/CH/04	green grocer	68	<5
		Christchurch	22/CH/05	supermarket	160	<5
				mean	**129**	**2.5**
23	Carrot	Auckland	23/AK/01	supermarket	49	<5
		Auckland	23/AK/02	supermarket	45	<5
		Auckland	23/AK/03	supermarket	<5	<5
		Auckland	23/AK/04	green grocer	7	<5
		Christchurch	23/CH/01	supermarket	290	<5
		Christchurch	23/CH/02	supermarket	26	<5
		Christchurch	23/CH/03	green grocer	49	<5
		Christchurch	23/CH/04	green grocer	<5	<5
				mean	**58.3**	**2.5**
24	Pumpkin	Auckland	24/AK/01	green grocer	<5	<5
		Auckland	24/AK/02	supermarket	83	<5
		Auckland	24/AK/03	green grocer	<5	<5
		Auckland	24/AK/04	supermarket	<5	<5
		Christchurch	24/CH/01	supermarket	<5	<5
		Christchurch	24/CH/02	supermarket	350	<5
		Christchurch	24/CH/03	green grocer	14	<5
		Christchurch	24/CH/04	green grocer	79	<5
				mean	**65.8**	**2.5**