FORTIFICATION OVERAGES OF THE FOOD SUPPLY

Vitamin A, Vitamin D and Calcium

Prepared as part of a New Zealand Food Safety Authority
contract for scientific services

by

Dr Barbara Thomson

June 2006

Client Report
FW0637

FORTIFICATION OVERAGES
OF THE FOOD SUPPLY

VITAMIN A, VITAMIN D AND CALCIUM

Dr Stephen On
Food Safety Programme Leader

Dr Barbara Thomson
Project Leader

Dr Jim Mitchell
Peer Reviewer

DISCLAIMER

This report or document ("the Report") is given by the Institute of Environmental Science and Research Limited ("ESR") solely for the benefit of the New Zealand Food Safety Authority ("NZFSA"), Public Health Services Providers and other Third Party Beneficiaries as defined in the Contract between ESR and the NZFSA, and is strictly subject to the conditions laid out in that Contract.

Neither ESR nor any of its employees makes any warranty, express or implied, or assumes any legal liability or responsibility for use of the Report or its contents by any other person or organisation.

ACKNOWLEDGEMENTS

The assistance of staff at the Christchurch Science Centre, ESR with the purchase and dispatch of samples is gratefully acknowledged.

The vitamin analyses were ably carried out by AgriQuality, Auckland and the calcium analyses by the Food Chemistry Laboratory, Christchurch Science Centre, ESR.

Appreciation to Peter Cressey for interrogation of the food consumption databases.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

CNS	National children's nutrition survey
CV	Coefficient of variation, equal to the standard deviation of results divided by the mean of results, expressed as a percentage
HPLC	High perfomance liquid chromatography
IANZ	International accreditation New Zealand
LOAEL	Lowest observed adverse effect level
MFD	Manufactured Foods Database
NOAEL	No observable adverse effect level
NNS	National nutrition survey
NZFSA	New Zealand Food Safety Authority
RDI	Recommended dietary intake
UL	Upper level of intake

SUMMARY

The aim of the current project was to assess the levels of vitamin A, vitamin D and calcium in fortified foods and to compare levels to those claimed on product labels to underpin the development of food standards relating to nutrient fortification.

Approximately 290 samples from seven different food groups were analysed for added vitamin A, vitamin D or calcium. Samples were purchased between November 2005 and May 2006 from Christchurch or Auckland retail outlets.

Vitamin A content was determined using a solvent extraction and analysis by reverse phase high performance liquid chromatography (HPLC) with fluorescence detection. The inter-sample variability for 5 batches of 22 foods, as measured in terms of CV, was 0-42%. Pre-vitamin D and vitamin D was extracted after saponification, purification by semi-preparative HPLC and analysis by isocratic, reversed-phase HPLC. The inter-sample variability for 5 batches of 18 foods, as measured in terms of CV, was 1-46%. Calcium was measured by atomic emission spectroscopy following ashing and dissolution in nitric acid. The inter-sample variability for 5 batches of 18 foods, as measured in terms of CV, was 2-47%.

In assessing the data, an overage or underage was defined as being where the label claim did not correspond to the measured value after making an allowance for the measurement uncertainty associated with this value.

<u>Vitamin A</u> concentration was 11-100% below the label claim in 41% of the products tested (9/22) and exceeded the label claim in 32% (7/22) of products with overages of 18-44%. High consumption of the product with the maximum vitamin A overage would result in an intake of up to 27% of the upper level of intake (UL).

<u>Vitamin D</u> concentration was 47-68% below the label claim in 28% of the products tested (5/18) and exceeded the label claim in 39% (7/18) of products with overages of 25-70%. High consumption of the product with the maximum vitamin D overage would result in an intake of up to 4% of the UL.

<u>Calcium</u> concentration was 7-18% below the label claim in 11% of the products tested (2/18) and exceeded the label claim 39% (7/18) of products with overages of 26-79%. High consumption of the product with the maximum calcium overage would result in an intake of up to 77% of the RDI or 8% of the UL

A total of 27% (16/58) of the foods sampled contained less fortificant than claimed, based on the criteria applied in this assessment. Consumers of these products are ingesting less of the added nutrients than they would believe, based on label claims.

A total of 36% (21/58) of the foods sampled contained more fortificant than claimed. None of the selected foods fortified with either vitamin A, vitamin D or calcium appear to present a realistic hazard of a consumer exceeding the UL of any of these nutrients.

All analytical measurements have associated uncertainty arising from sampling, the analytical method and the manufacturing technique. For standard setting, consideration may be given to defining a range around the label claim that takes measurement uncertainty into account.

1 INTRODUCTION

Work is currently being conducted on the development of food standards relating to nutrient fortification. The establishment of safe upper limits for nutrients added to foods relies on robust data on current intake, based on consumption data and concentration information for the foods of interest.

While there is sufficient data on the composition of unfortified foods, there is limited independent data on the actual levels of fortificants in fortified foods in New Zealand. The Manufactured Foods Database (MFD) is a compilation of food ingredient and composition data voluntarily provided by New Zealand food manufacturers and compiled by Nutrition Services, Auckland Hospital, under contract to the New Zealand Food Safety Authority (NZFSA). The MFD includes data on fortificants which are derived from either measured amounts or calculated from recipes by manufacturers (Nutrition Services, 2004). International evidence suggests that actual levels of fortificants can vary significantly, by up to 320% of the claimed label value (Whittaker *et al*., 2001), consistent with overages of up to 166% for iron and 296% for folate reported for New Zealand foods (Thomson, 2005).

There is also a potential public health and safety issue associated with over-consumption of some nutrients and interactions between nutrients if levels are too high. For this reason, Recommended Dietary Intakes (RDI)s and Upper Levels of Intake (UL)s have been estimated for New Zealand and Australia, for a range of nutrients including vitamin A, vitamin D and calcium (AG/MoH, 2006). Details for vitamin A, vitamin D and calcium RDIs and ULs are provided in Appendix 1.

Vitamin A is a fat soluble vitamin important for embryonic development and to help maintain normal reproductive, vision and immune function. Excess intake of vitamin A has resulted in disturbed fetal growth and development for women of childbearing age and liver abnormalities for other adults, leading to the derivation of ULs for these population groups (Appendix 1). For infants, the UL is derived from reports of dietary excess of vitamin A. A lack of data means that the UL for children and adolescents is extrapolated from adult data with allowance made for relative body weights. Those individuals with a high alcohol intake, pre-existing liver disease, high blood lipid levels or severe protein malnutrition are at risk to excess intake of vitamin A and may not be protected by the UL for the general population (AG/MoH, 2006).

Vitamin D naturally occurs in two forms. Vitamin D_3 is produced by the action of sunlight on skin and vitamin D_2 is found in a limited range of foods. The major function of vitamin D in humans is to maintain appropriate serum calcium concentrations by enhancing the ability of the small intestine to absorb calcium from the diet. The UL for vitamin D for adults is based on an absence of adverse effect at doses of 100 μg/day (Vieth *et al.*,2001) and an uncertainty factor of 1.2 because of inconsistencies between studies. For infants, the UL is derived from a no observable adverse effect (NOAEL) of 45 μg/day (Fomon *et al.,* 1966, Jeans and Stearns, 1938) together with an uncertainty factor of 1.8. In the absence of available data, ULs for children and adolescents are the same as for adults.

Calcium is essential for the normal development and maintenance of the skeleton and the proper functioning of neuromuscular and cardiac systems. Toxic effects of calcium have only been seen when high doses of calcium carbonate have been taken as an antacid, resulting in renal calcification and renal failure (Burnett *et al.*,1949). The UL for adults is derived from a lowest observed adverse effect level (LOAEL) of 5 g/day and an uncertainty factor of 2. The uncertainty takes into account the relatively common occurrence of kidney stones in Australia and New Zealand, the fact that hypercalciuria has been shown to occur at intakes as low as 1.7 g/day and concern that calcium will interfere with absorption of other minerals such as zinc and iron in vulnerable populations (AG/MoH, 2006).

There are an increasing number of fortified foods available on the New Zealand market. An analysis of actual levels of nutrients being added to these fortified foods is essential for undertaking a robust risk assessment of the consequences of nutrient additions to foods, both mandatory and voluntary, and will feed directly into the food standard setting process.

The aim of the current project was to measure the actual levels of the fortificants vitamin A, vitamin D and calcium added to fortified foods and to compare actual levels with levels claimed on product labels.

2 MATERIALS AND METHODS

2.1 Selection of foods for inclusion in the study

Foods that are fortified with vitamin A, vitamin D or calcium were identified from the MFD and grouped into food types. Foods from each food group were selected for analysis with consideration being given to both the relative popularity of the food while also ensuring the inclusion of as wide a range of fortified foods as possible. The following sample plan was agreed in consultation with representatives from the MFD (Auckland District Health Board), the NZFSA and ESR (Table 1). Further details of the foods listed in the MFD (Nutrition Services, 2004) as being fortified with vitamin A, vitamin D or calcium are shown in Appendix 2. The description of most foods is self explanatory with the exception of food drinks, a term used in the MFD for products including manufactured beverages (eg. Bournvita, drinking chocolate, Milo and sports drinks) and liquid meal replacements (eg. So Good, Up & Go, Alfalite, Naturally Slim, Vitaplan, Complan and liquid breakfasts).

Table 1: Selection and number of food products fortified with vitamin A, vitamin D or calcium for analysis and comparison with label claim

Food Type	Vitamin A	Vitamin D	Calcium
Baby foods	1 (x5)	1	1 (x5)
Breads	0	0	1 (x5)
Breakfast cereals	0	0	5 (x5)
Food drinks	6 (x5)	3 (x5)	7 (x5)
Fruit drink and cordial	1 (x5)	1 (x5)	1 (x5)
Margarine	8 (x5)	8 (x5)	0
Milk products	6 (x5)	5 (x5)	3 (x5)
Total	**110**	**90**	**90**

number of batches per food product in parenthesis

2.2 Sampling and sample preparation

Samples were only analysed for a selected fortificant if the fortificant was declared on the product label.

Foods were purchased between November 2005 and May 2006. Single packets from five batches of each selected food item were purchased from Christchurch retail outlets (except for the milk products that were purchased in Auckland or Christchurch until the required number of batches had been obtained).

For testing, the entire packet of each dry sample (breads and breakfast cereals) was ground in a domestic blender. For the analysis, approximately 50ml of the powdered material was frozen at -15°C until dispatch to the analytical laboratory by overnight courier.

Sub samples of homogeneous baby food and food drinks, were dispensed into foil covered containers, under low light and frozen at -15°C until dispatch to the analytical laboratory by overnight courier. Margarine samples were dispatched without sub sampling. Care was taken to ensure milk products remained sealed until analysis. Samples of baby food and fruit cordials were analysed without dilution.

2.3 Sample preparation and shelf life studies of vitamin A

The following study of vitamin A in milk products was undertaken when preliminary results showed consistently low levels of vitamin A in frozen sub samples compared with product claims. Triplicate samples of three batches of a flavoured milk were purchased and stored in a refrigerator. One unopened sample from each batch was analysed in duplicate, at three different time periods across the shelf life of the product (13 days). One opened sample was reanalysed on the "use by" date after seven days of refrigeration.

2.4 Laboratory analytical methods

2.4.1 Vitamin A analysis

The analysis of total pre-formed vitamin A, including *cis*- and –*trans* isomers, was based on the methodology of Brubacher *et al.*, (1986) with in-house modifications. Homogenised samples were saponified under reflux, extracted into organic solvent and concentrated by evaporation. Quantitation was achieved with isocratic, reversed phase high performance liquid chromatography (HPLC) using fluorescence detection and external calibration. The analyses were undertaken by AgriQuality Laboratory Services, Auckland who are accredited by International Accreditation New Zealand (IANZ) for both vitamin A and vitamin D analyses.

2.4.2 Vitamin D analysis

AgriQuality Laboratory Services, Auckland, measured the sum of vitamin D pre-cursors and vitamin D_3, in the selected food samples, using published methodology (Indyk and Woollard, 1985, Brubacher *et al*., 1986). In summary, samples were saponified in ethanolic potassium hydroxide, extracted, and purified of interfering substances by semi-preparative HPLC on a silica column with ergocalciferol (vitamin D_2) as an internal standard and measured by isocratic, reversed-phase HPLC.

2.4.3 Calcium analysis

A minimum of 250 g of each product was homogenized in a domestic blender. Duplicate 50 ml portions were frozen until analysis. An aliquot of sample was ashed in a muffle furnace at 500ºC, the residue dissolved in concentrated nitric acid, with caesium chloride as an ionization suppressant. Calcium was determined by atomic emission spectroscopy by the ESR Christchurch Science Centre Food Chemistry Laboratory. The laboratory is accredited by IANZ to the standard NZS/ISO/IEC/17025, under section 2.71/5 for this analysis.

2.4.4 Quality control procedures

The following quality assurance procedures were undertaken to ensure robust results:

- The analytical repeatability, in terms of coefficient of variation (CV) was determined for vitamin A, vitamin D and calcium by undertaking five analyses of each of three samples representing different food matrices. A coefficient of variation (CV = standard deviation of results divided by mean x 100%) of less than 10% is considered good but higher values may be more realistic for some matrices, analyte and concentration combinations (Vannoort, personal communication, 2005). The repeatability for vitamin A ranged from 2 to 12%, 5 to 12% for vitamin D and 1 to 4% for calcium (Appendix 3.1 to 3.3).

- Recovery compares the amount of the analyte (eg. vitamin A, vitamin D or calcium), measured in a sample to which a known amount has been added and corrected for the amount of analyte in the unspiked sample, with the amount of analyte added in the spike. Acceptable recoveries for nutrient analyses would generally be 70-125% (Vannoort, personal communication, 2005). The recoveries of vitamin A, vitamin D and calcium from spiked samples were acceptable, ranging from 78-120%, 76-124% and 88-121% respectively, confirming the accuracy of the analytical method (Appendix 3.4).
- Blind duplicates of different food types were submitted for analysis. The CVs for vitamin D and calcium were within 5% (Appendix 3.5.2 and 3.5.3). Greater variability (CV-17%) was repeatedly observed for vitamin A in one margarine sample reflecting the analytical challenge of this particular sample of this food type (Appendix 3.5.1).

2.5 Derivation of ranges for overage or underage assessment

No analytical result is exact, but the result will always have an associated degree of uncertainty indicating the "±" range from the measured result within which the true result will lie. It is important to quantify the measurement uncertainty so that a range can be defined, for which there is a known probability that a measured result will occur, as a basis for comparing the measured concentration of a fortificant with a label claim.

Uncertainty for the current samples is due to:

1. Intra-sample variability, or repeatability - a measure of the variation in results for multiple analyses of the same sample. This is a measure of variability resulting from the analytical method and sub-sampling procedures.
2. Inter-sample variability – a measure of the variability between different batches of the same product. This includes the variability of both the analytical method and the manufacturing technique. The homogeneity of a product depends on when and how the fortificant is added and may differ for different products. Lack of homogeneity is one source of both intra- and inter-sample variability.

A 95% uncertainty range of the mean was determined for each product sampled, using the standard deviation derived from the analysis of five different batches of each product and the formula (TELARC, 1987):

$$\text{Range (confidence limits)} = \text{mean} \pm \frac{t \times \text{standard deviation}}{\sqrt{n}}$$

where: "t" = a statistical factor found in statistical tables
n = number of sample replicates (5)

For a mean concentration falling within this range, there is a 95% probability that the true result lies within a range of the mean ± 1.2 (2.78/√5) x standard deviation of the measured concentration. It follows then that for a product where the label claim was outside this range, the level of confidence that the sample does not meet the label claim is approximately 95%.

Samples were assessed as complying with the label claim if the label claim was within the 95% uncertainty range and defined as non-complying if the label claim was outside this range.

3 RESULTS

3.1 Sample preparation and shelf life studies of vitamin A

A comparison of the measured levels of vitamin A in frozen sub samples compared with unopened fresh milk samples of a selected flavoured milk product, are shown in Table 2. Whilst there was good consistency within each sample type, the levels measured in the unopened fresh samples were clearly higher than those measured in frozen samples. Since there was no measurable difference in vitamin A concentration up to the shelf life limit of the fresh product, the apparent degradation was attributed to sub sampling and freezing and not to degradation within the unopened package. A 10% decrease in vitamin A was observed when an opened sample was reanalyzed after seven days refrigeration. Therefore, vitamin analyses of milk samples were performed on fresh product from unopened packages.

Table 2: Concentration of vitamin A in frozen and fresh flavoured milk, label claim 55µg/100ml

Frozen milk (µg/100ml)			Fresh milk (µg/100ml)						
				7 days to "use by"		4 days to "use by"		0 days to "use by"	
Batch number	Result 1	Result 2	Batch number	Result 1	Result 2	Result 1	Result 2	Result 1	Result 2
1	24	24	6	44	46	45	47	44	47
2	28	28	7	47	47	49	48	48	48
3	32	26	8	48	50	52	52	51	49
4	34	30							
5	30	33							

Quality assurance data for replicates, recoveries and blind duplicates for vitamin A, vitamin D and calcium are provided in Appendix 3.

For food products that were outside the 95% uncertainty range of the mean, the % overage or % underage was calculated as the difference between the mean concentration and the label claim as a percentage of the label claim. Products are identified by an asterisk (Tables 2-4) where the label claim was outside this range (see Section 2.4). For those results that do not have an asterisk, there is a possibility that these products are non-complying but there is less than 95% certainty.

3.2 Concentration of vitamin A in fortified foods

The mean concentration of vitamin A in the selected food products ranged from 3 to 1155 µg/100g (Table 3). A full set of results is included in Appendix 4.1. For margarine samples the labels stated that the products contained vitamin A but no amount was specified. The "label" claims cited in Table 2 are those stated in the MFD (Nutrition Services, 2004).

Table 3: Mean concentrations of vitamin A (µg/100g or µg /100ml) in fortified foods compared with label claim

Product	Label claim	Measured mean	Std dev	%CV	Mean 95% uncertainty range[a]	% Overage/ underage	
Baby food	282	330	34.4	10.4	288-371	17	*
Food drink 1	356	319	29.1	9.1	284-354	-10	*
Food drink 2	341	493	96.9	19.7	376-609	44	*
Food drink 3	395	432	67.2	15.6	351-512	9	
Food drink 4	40	35	2.4	6.8	32-38	-13	*
Food drink 5	51	46	3.1	6.8	42-49	-11	*
Food drink 6	63	26	10.8	42.1	13-39	-59	*
Fruit cordial 1	222	3	0.0	0.0	3-3	-99	*
Margarine 1	1000[b]	777	119.2	15.3	634-921	-22	*
Margarine 2	1000[b]	945	117.8	12.5	804-1086	-6	
Margarine 3	850[b]	1129	120.7	10.7	984-1274	33	*
Margarine 4	850[b]	1155	64.3	5.6	1078-1232	36	*
Margarine 5	850[b]	546	94.2	17.3	432-659	-36	*
Margarine 6	850[b]	938	243.8	26.0	646-1231	10	
Margarine 7	850[b]	1149	80.4	7.0	1053-1246	35	*
Margarine 8	850[b]	1127	111.4	9.9	993-1260	33	*
Milk products 1	55	48	2.2	4.6	45-50	-13	*
Milk products 2	55	44	4.3	9.8	39-49	-20	*
Milk products 3	74	88	10.8	12.3	75-100	18	*
Milk products 4	55	35	8.7	24.5	25-46	-36	*
Milk products 5	55	51	21.3	42.1	25-76	-8	
Milk products 6	30	30	2.0	6.7	28-32	0	

CV = coefficient of variation, a= mean ± 1.2 standard deviations of the measured concentration
* = measured concentration greater than, or less, than the label claim at 95% level of confidence
b = not claimed on label but stated in MFD (Nutrition Services, 2004)

A comparison of the results for different batches of the same product (Appendix 4.1, Table 1A) shows that inter-sample variability was higher than intra-sample variability with CVs ranging from 0- 42%. The highest variabilities were observed for a food drink and a milk product where one batch of each product was repeatedly lower (duplicate or triplicate analyses) than the other four batches of the same product. The consistency of repeat analyses of the same sample suggests the variability reflects a manufacturing issue between batches.

The mean concentration of vitamin A compared with label claim, is shown graphically in Figure 1. Error bars for ± 1.2 standard deviation represent the variability across five batches of the same product. Where there is no error bar, multiple samples gave indistinguishable results.

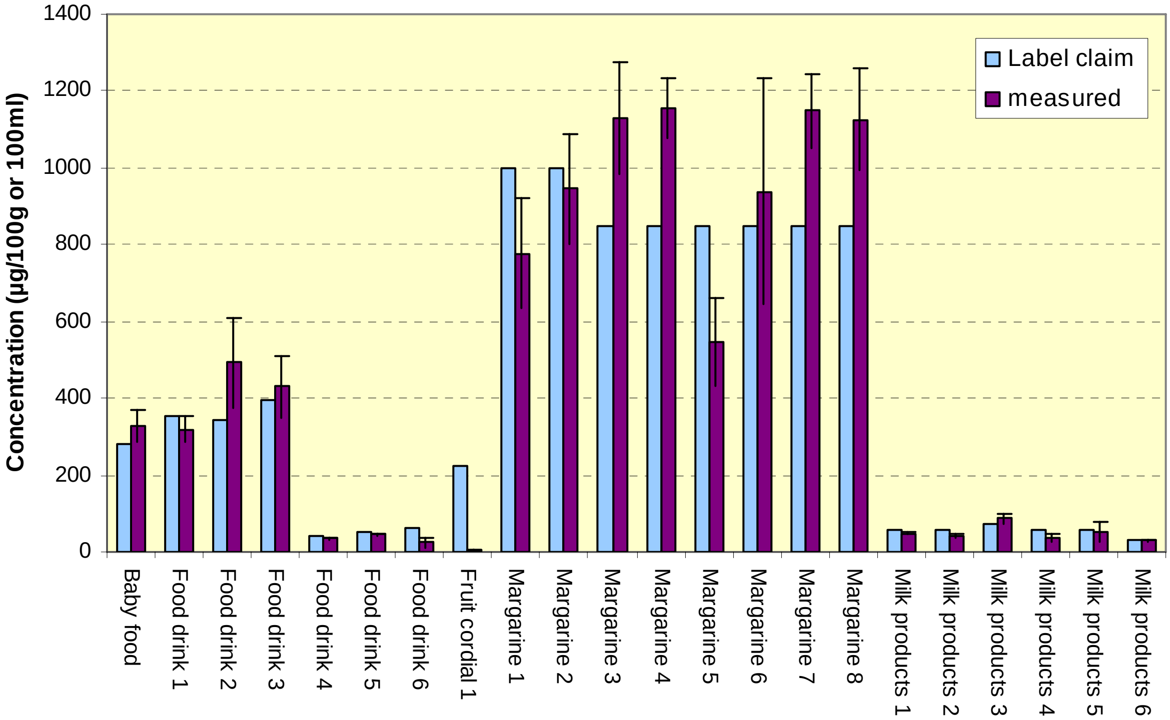

Figure 1: Measured concentrations of vitamin A compared with label claim
Errors bars are ± 1.2 x standard deviation.

Thirty two percent (7/22) of selected fortified foods contained more vitamin A than stated with the highest overage of 44% for one food drink product. Forty one percent (9/22) of selected foods contained less vitamin A than claimed.
The "fortified" cordial selected for analysis contained only 1% of the product claim of vitamin A.

3.3 Dietary modelling of exposure to vitamin A

The product with the highest % vitamin A overage was a food drink with a suggested serving size of 55 g. A single serving of this product, with an overage of 44% would result in an intake of 270µg of vitamin A contributing between 25 and 100% of the RDI for vitamin A, depending on the population group (AG/MoH, 2006).

Interrogation of the 1997 National Nutrition Survey (NNS; Russell *et al*., 1999) and 2002 National Children's Nutrition Survey (CNS; MoH, 2003) showed that a high adult consumer may consume 80g of this product and a child may consume up to 50 g/day. Consumption of 80g with an overage of 44% would result in a vitamin A intake of 13% of the UL for adults. A high child consumer might have an intake of 27% of the UL. To exceed the UL of vitamin A would require the consumption of two servings per day by an infant or young child (1-3 years), six servings per day by an adolescent and eleven servings per day of this product by an adult.

3.4 Concentration of vitamin D in fortified foods

A comparison of the results for different batches of the same product (Appendix 4, Table 4.2A) shows that inter-sample variability (as measured by CV) ranged from 1- 46% and was more variable than intra-sample variability. The highest variability was observed for a food drink product where the measured concentration of vitamin D varied by a factor of 3 across five batches. The consistency between replicates within a batch suggests the variability is a result of the manufacturing process rather than a sub sampling issue.

A summary of the mean concentration of vitamin D in the selected foods is shown in Table 4 with a full set of results included in Appendix 4. Only "Margarines 3 and 4" stated an amount of vitamin D on the label. "Label" claims for the other margarines have been taken from the MFD (Nutrition Services, 2004).

Table 4: Mean concentrations of vitamin D (µg/100g or µg/100ml) in fortified foods compared with label claim

Product	Label Claim	Measured mean	Std dev.	%CV	Mean 95% uncertainty range[a]	% overage /underage	
Baby food	5.2	6.0	1.0	16.1	4.8-7.1	14	
Food drink 1	11.5	11.3	1.4	12.7	9.6-13.0	-2	
Food drink 2	4.6	5.9	2.7	46.1	2.6-9.2	28	
Food drink 6	1.0	<0.5	0.1	1.0	0.4-0.6	-50	*
Fruit drink 2	1.3	1.4	0.2	14.2	1.2-1.7	15	
Margarine 1	18.0[b]	6.7	2.3	34.9	3.9-9.5	-63	*
Margarine 2	18.0[b]	9.6	3.3	34.1	5.7-13.5	-47	*
Margarine 3	10.0	13.3	0.9	6.4	12.3-14.3	33	*
Margarine 4	10.0	13.6	0.5	3.8	13.0-14.3	36	*
Margarine 5	10.0[b]	12.5	0.8	6.2	11.6-13.5	25	*
Margarine 6	10.0[b]	13.2	1.5	11.2	11.4-15.0	32	*
Margarine 7	10.0[b]	13.8	0.4	2.8	13.3-14.2	38	*
Margarine 8	10.0[b]	14.2	1.0	7.1	12.9-15.4	42	*
Milk products 1	0.5	0.5	0.0	8.6	0.5-0.6	1	
Milk products 2	0.5	0.5	0.1	13.2	0.4-0.6	4	
Milk products 3	0.7	1.1	0.2	15.0	0.9-1.3	70	*
Milk products 4	0.5	0.2	0.0	20.7	0.1-0.2	-62	*
Milk products 5	0.5	0.2	0.1	39.7	0.1-0.2	-68	*

a= ± 1.2 standard deviations of the mean of the measured concentration
* = measured concentration greater than, or less, than label claim at 95% level of confidence
b = not claimed on label but stated in MFD (Nutrition Services, 2004)

The mean concentration of vitamin D compared with label claim, is shown graphically in Figure 2. Error bars for ± 1.2 standard deviation represent the variability across five batches of the same product. Where there is no error bar, multiple batches gave indistinguishable results.

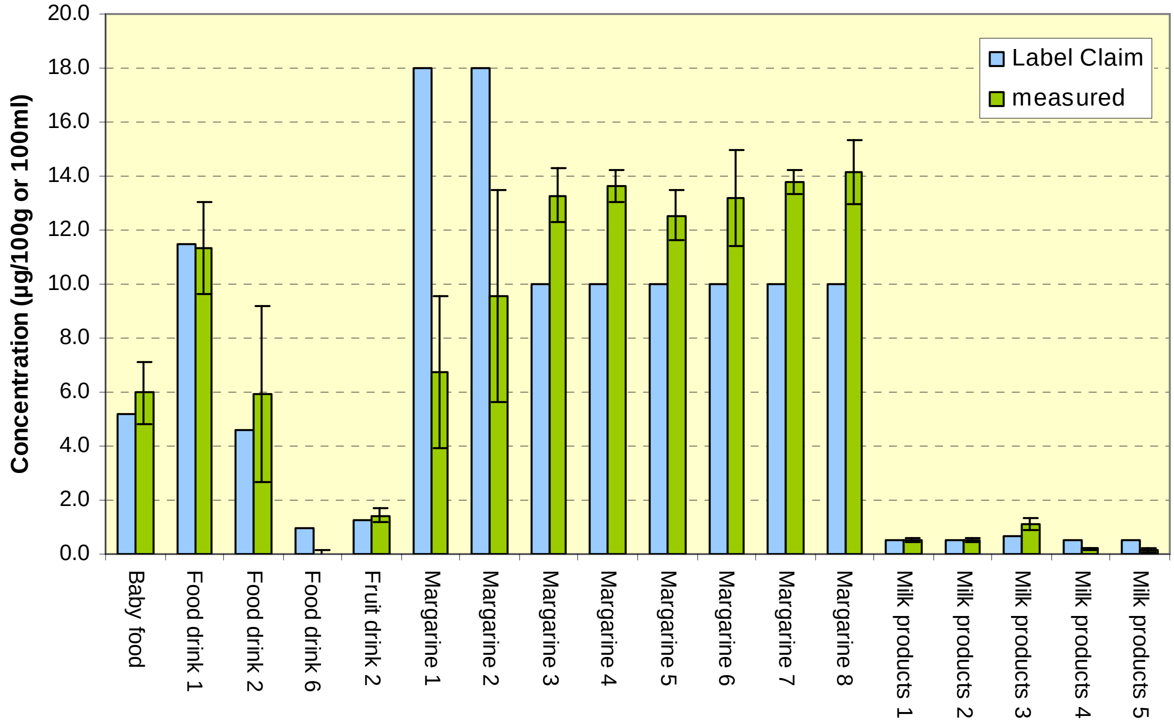

Figure 2: **Measured concentrations of vitamin D compared with label claim**
Errors bars are ± 1.2 x standard deviation.

Thirty nine percent (7/18) of selected fortified foods contained more vitamin D than stated with the highest overage of 70% for one milk product. Twenty eight percent (5/18) of the selected foods contained 47-68% less vitamin D than claimed. Of these, the two margarine samples, did not claim an amount on the label, although vitamin D was included in the list of ingredients

3.5 Dietary modelling of exposure to vitamin D

The maximum vitamin D overage was found in a milk product with an overage of 70%. Consumption of a single 125g serving of this product would result in an intake of 1.4 µg of vitamin D, equal to the maximum permitted contribution of 1.6 µg per 150g (FSANZ, 2002). An intake of 1.4 µg equates to 9-28% of the RDI depending on the age of the consumer. Interrogation of the NNS and CNS (Russell *et al*., 1999, MoH, 2003) shows that a high consumer may consume 300 g of this product in which case intake of vitamin D would be 3.3 µg per day, well within the UL of 80µg/day (AG/MoH, 2006).

3.6 Concentration of calcium in fortified foods

Inter-sample variability as measured by CV ranged from 2-47% for different batches of the same product (Appendix 4, Table 4.3A). The highest variability was observed for a food drink product. The consistency between replicates within a batch suggests the variability may be a result of the manufacturing process rather than a sub sampling issue.

The mean concentration of calcium in the selected foods ranged from 114 to 842 mg/100g (Table 5). A full set of results is included in Appendix 4.

Table 5: Mean concentrations of calcium (mg/100g or mg/100ml) in fortified foods compared with label claim

Product	Label Claim	Measured	Std dev.	%CV	Mean 95% uncertainty range[a]	% Overage/ underage	
Baby foods	681	634	38.0	6.0	589-680	-7	*
Bread	271	376	34.6	9.2	334-417	39	*
Breakfast cereal 1	267	381	43.7	11.5	328-433	43	*
Breakfast cereal 2	267	344	80.6	23.4	247-441	29	
Breakfast cereal 3	667	842	49.0	5.8	783-901	26	*
Breakfast cereal 4	333	597	84.0	14.1	496-698	79	*
Breakfast cereal 5	444	579	94.1	16.3	466-691	30	*
Food drink 1	639	763	29.4	3.9	727-798	19	*
Food drink 2	683	576	97.9	17.0	459-694	-16	
Food drink 3	450	443	46.0	10.4	388-498	-2	
Food drink 4	120	160	24.1	15.0	131-189	34	*
Food drink 5	160	217	27.4	12.6	184-250	35	
Food drink 7	120	114	53.1	46.7	50-177	-5	
Food drink 6	125	148	44.7	30.1	95-202	19	
Fruit drink	120	121	42.9	35.5	69-172	1	
Milk product 1	205	169	16.3	9.6	150-189	-18	*
Milk product 6	200	202	4.6	2.3	196-207	1	
Milk product 7	253	242	14.9	6.2	224-260	-4	

a= ± 1.2 standard deviations of the mean of the measured concentration
* = measured concentration greater than, or less, than label claim at 95% level of confidence

Thirty nine percent (7/18) of selected fortified foods contained more calcium than stated with the highest overage of 79% for one breakfast cereal product. Eleven percent (2/18) of the selected foods contained 7-18% less calcium than claimed.

The mean concentration of calcium compared with label claim, is shown graphically in Figure 3. Error bars for ± 1.2 standard deviation represent the variability between the five samples of each product tested.

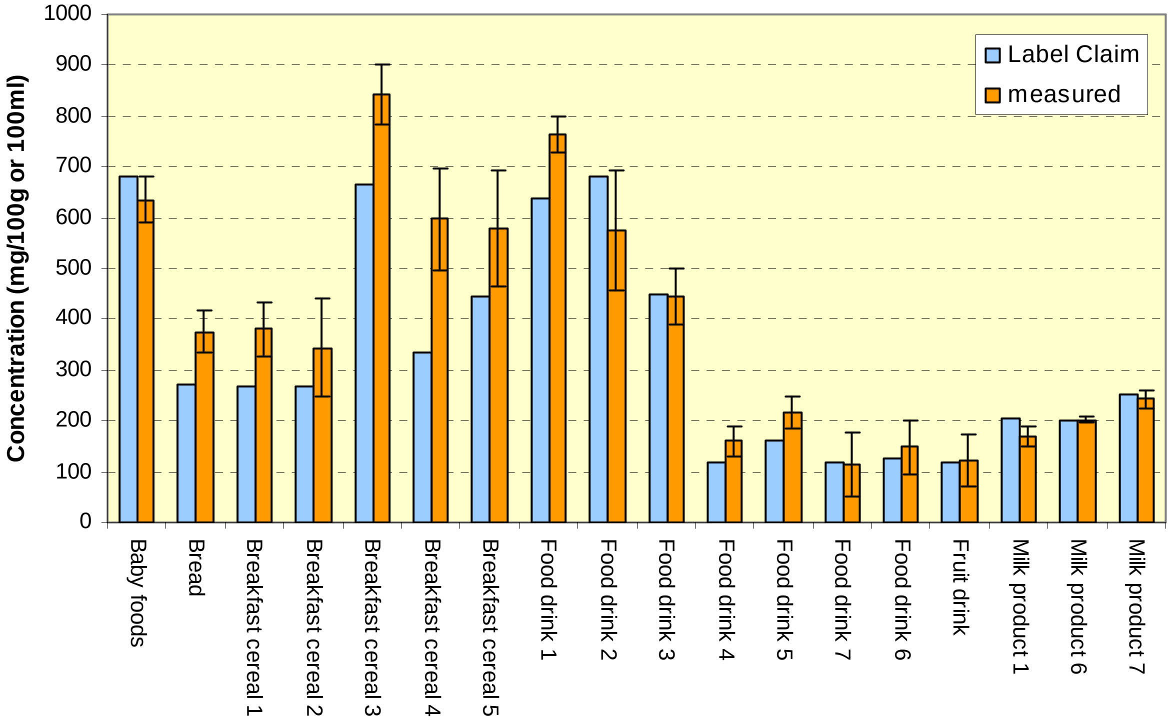

Figure 3: Measured concentrations of calcium compared with label claim
Errors bars are ± 1.2 x standard deviation.

3.7 Dietary modelling of exposure to calcium from fortified foods

The highest % calcium overage was found for a breakfast cereal with an overage of 79%. Consumption of a single 35g serving of this product would result in an intake of 209mg of calcium contributing between 16 and 42% of the RDI for calcium, or 8% of the UL, depending on the population group (AG/MoH, 2006).

Interrogation of the NNS and CNS (Russell *et al.*, 1999, MoH, 2003) shows that a high child consumer may consume 90g of this product in which case intake of calcium would be 537mg/day or 41-77% of the RDI for calcium. The highest consumption of this food by an adult was 40g, equivalent to 18-23% of the RDI and well within the UL for adults of 2500 mg/day. To exceed the UL of calcium, solely from this product, would require the consumption of twelve servings per day.

4 DISCUSSION AND CONCLUSIONS

No analytical measurement is absolute. All analytical measurements have associated uncertainty arising from sampling, the analytical method and the manufacturing technique. From this study, it is seen that realistic uncertainties for different batches of foods fortified with vitamin A, vitamin D and calcium are ± 25% CV but up to 20% of foods will have variability greater than this. Since measured concentrations in fortified foods are close to label values, the uncertainty in measured concentrations is important when assessing compliance with label claims.

Therefore, consideration may be given in standard setting to defining a tolerance around the label claim that incorporates these uncertainties. For example, compliance might be the label claim ± 1 standard deviation. Alternatively, a flat tolerance of ± 50% of the label claim might be considered as adopted by the Canadian Food Inspection Agency (CFIA, 2003).

Estimating a concentration range that includes the uncertainty for each product provides a transparent, science-based systematic approach to assessing whether the concentration measured in a sample meets its label claim.

The magnitude of the tolerance, and hence uncertainty range, will depend on the level of confidence that is required. The % level of confidence is a measure of how likely the stated outcome is true or correct. In other words, what is the likelihood that some samples that have been found to meet the label claim in fact do not and, what is the likelihood that some samples found to comply, in fact do not.

For a mean of five analyses, as in this study, the level of confidence that the true result lies within a range of the mean ± 1.2 times the CV is 95%. This means that if the concentration of a product is found to be just outside this range, there is a 5% chance that a product does in fact meet its label claim and a 95% chance that it does not.

If product compliance is based on the standard deviation, a highly variable product will have a wider tolerance range and therefore will more easily comply than a consistent product with a tighter tolerance range. Thus more variability favours the manufacturer and this may not be desirable nor equitable.

A total of 29% (17/58) of the foods sampled contained less fortificant than claimed, based on the criteria applied in this assessment. Consumers of these products are ingesting less of the added nutrients than they would believe, based on label claims.

A total of 36% (21/58) of the foods sampled contained more fortificant than claimed. None of the selected foods fortified with either vitamin A, vitamin D or calcium appear to present a realistic hazard of a consumer exceeding the UL of any of these nutrients.

5 REFERENCES

AG/MoH (Australian Government, Department of Health and Ageing, National Health and Medical Research Council/ New Zealand Ministry of Health). (2006) Nutrient reference values for Australia and New Zealand. Canberra: Commonwealth of Australia.

Brubacher G, Müller-Mulot W, Southgate DAT. (1986). Methods for the determination of vitamins in food – recommended by COST 91. London: Elsevier Science Publishers, p23-32.

Burnett CH, Commons RM, Albright F, Howard JE. (1949) Hypercalcaemia without hypercalcuria or hypophosphatemia, calcinosis and renal insufficiency. A syndrome following prolonged intake of milk and alkali. New England Journal of Medicine; 240:787-94.

CFIA (Canadian Food Inspection Agency). (2003). Nutrition labelling compliance test. Available at http://www.inspection.gc.ca/english/fssa/labeti/nutricon/nutricone.shtml

Fomon SJ, Younoszai MK, Thomas LN. (1966). Influence of vitamin D on linear growth of normal full-term infants. Journal of Nutrition; 88:345-50.

FSANZ (Food Standards Australia and New Zealand). (2002) Australia and New Zealand Food Standards Code 2002. Available at www.foodstandards.gov.au

Indyk H and Woollard DC. (1985) The determination of vitamin D in fortified milk powders and infant formulas by HPLC. Journal of Micronutrient Analysis;1:121-141.

Jeans PC, Stearns G. (1938) The effect of vitamin D on linear growth in infancy. II The effect of intakes above 1,800 USP units daily. Journal of Pediatrics; 13:730-40.

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

Nutrition Services. (2004). Fortified foods available in New Zealand. December 2004. Wellington: Ministry of Health.

Russell DG, Parnell WR, Wilson NC. (1999). NZ Food:NZ people. Key results of the 1997 National Nutrition Survey. Wellington: Ministry of Health.

TELARC (Testing Laboratory Registration Council of New Zealand) (1987). Precision and limits of detection for analytical methods. Auckland, New Zealand: Testing Laboratory Registration Council of New Zealand.

Thomson BM. (2005) Fortification overages of the food supply. Folate and iron. ESR Client Report FW 0536. Christchurch: ESR.

Vieth R, Chan PC, MacFarlane GD. (1938). Efficacy and safety of vitamin D3 intake exceeding the lowest observed adverse effect level. American Journal of Clinical Nutrition; 73: 288-94.

Whittaker P, Tufaro PR, Rader JI. (2001). Iron and folate on fortified cereals. American College of Nutrition; 20 (3):247-254.

Appendix 1: New Zealand and Australia RDIs and ULs for vitamin A, vitamin D and calcium (AG/MoH, 2006)

Age/gender group		Vitamin A(µg/day)[a]		Vitamin D (µg/day)		Calcium (mg/day)	
		RDI	UL	AI	UL	RDI	UL
Infants	0-6 mo.	AI = 250	600	5	25	AI = 210	BM
	7-12 mo.	AI = 430	600	5	25	AI=270	B/F
Children	1-3 yrs	300	600	5	80	500	2500
	4-8 yrs	400	900	5	80	700	2500
Boys	9-13 yrs	600	1700	5	80	1000-1300	2500
	14-18 yrs	900	2800	5	80	1300	2500
Girls	9-13 yrs	600	1700	5	80	1000-1300	2500
	14-18 yrs	700	2800	5	80	1300	2500
Men	19-30 yrs	900	3000	5	80	1000	2500
	31-50 yrs	900	3000	5	80	1000	2500
	51-70 yrs	900	3000	10	80	1000	2500
	>70 yrs	900	3000	15	80	1300	2500
Women	19-30 yrs	700	3000	5	80	1000	2500
	31-50 yrs	700	3000	5	80	1000	2500
	51-70 yrs	700	3000	10	80	1300	2500
	>70 yrs	700	3000	15	80	1300	2500
Pregnant	14-18 yrs	700	2800	5	80	1300	2500
	19-30 yrs	800	3000	5	80	1000	2500
	31-50 yrs	800	3000	5	80	1000	2500
Lactating	14-18 yrs	1100	2800	5	80	1300	2500
	19-30 yrs	1100	3000	5	80	1000	2500
	31-50 yrs	1100	3000	5	80	1000	2500

a = retinol equivalents, AI = Adequate intake, BM = amount normally received from breast milk of healthy women; B/F = amount in breast milk and food

APPENDIX 2: Foods fortified with vitamin A, vitamin D and calcium

2.1 Number of foods permitted to contain added vitamin A, D and/or calcium (MFD Nutrition Services, 2004)

Food manufacturers have identified the following numbers of foods as being fortified with vitamin A, vitamin D or calcium. This may not be a complete list but includes those companies who submitted data to the Manufactured Food Database and will reflect the situation as at December 2003 (Nutrition Services, 2004).

	Vitamin A	**Vitamin D**	**Calcium**
Baby Food	1	1	1
Biscuits	0	0	1
Breakfast cereals	0	0	7
Butter and margarine	17	17	0
Cheese and cheese products	0	0	2
Food drinks	31	18	37
Fruit juice, vege juice, fruit drink and cordial	2	4	2
Modified milks and skim milk	19	9	19
Protein beverages derived from legumes	0	0	8
Yoghurts	1	1	3
Miscellaneous	9	7	11
Total	**80**	**57**	**91**

Appendix 3: Quality assurance data

3.1 Repeatability for vitamin A

Food type	label claim	Analysis (µg/100g) 1	2	3	4	5	mean	Std dev	CV
Food drink	51	50	48	50	49	50	49.4	0.89	1.8
Margarine	1000	796	826	792	826	796	805	16	2
Milk product	55	24	30	31	31	28.5	28.9	3.6	12

3.2 Repeatability for vitamin D

Food type	label claim	Analysis (µg/100g) 1	2	3	4	5	mean	Std dev	CV
Food drink	4.6	4.9	5.1	5.4	4.4	5.5	5.0	0.6	12
Margarine	18	5.4	5.5	5.7	5.9	5.5	5.6	0.3	4.7
Milk product	0.50	0.48	0.53	0.50	0.40	0.48	0.48	0.05	10

3.3 Repeatability for calcium

Food type	label claim	Analysis (µg/100g) 1	2	3	4	5	mean	Std dev	CV
Breakfast cereal	444	524	557	536	565	568	550	19	3.5
Food drink	683	638	643	641	632	632	637	5.1	0.8
Milk product	205	176	175	174	178	172	175	2.2	1.3

std dev = standard deviation. CV= standard deviation relative to the mean ((std dev/mean)x100)

3.4 Spike recoveries for vitamin A, vitamin D and calcium

Vitamin A		Vitamin D		Calcium	
Food type	**% Recovery**	**Food type**	**% Recovery**	**Food type**	**% Recovery**
Baby food	91, 96	Baby food	86, 124	Bread	97
Margarine 1	86	Margarine 1	122, 115	Breakfast cereal 1	103, 88
Margarine 2	81 ,99	Margarine 2	92, 79	Breakfast cereal 4	90
Margarine 3	95	Margarine 3	96	Breakfast cereal 5	107
Margarine 4	78	Margarine 4	108	Food drink 3	107
Margarine 5	107	Margarine 5	95	Milk product 6	121, 95
Margarine 6	94, 93	Margarine 6	82, 76, 116		
Margarine 7	99	Margarine 7	94		
Margarine 8	99, 107	Margarine 8	90		
Food drink 1	-	Food drink 1	106		
Food drink 2	114	Food drink 2	105		
Food drink 3	90	Food drink 6	86		
Food drink 4	86, 89	Fruit cordial 2	97, 85		
Food drink 5	84	Milk product 1	113		
Food drink 6	109, 120	Milk product 2	90, 84		
Fruit cordial 1	101	Milk product 3	102		
Milk product 1	98, 97				
Milk product 2	92				
Milk product 3	115				
Milk product 4	85	-	-		
Milk product 5	91	-	-		

3.5.1 Blind duplicates for vitamin A.

Food sample	Result 1	Result 2	mean	Std dev	%CV
Baby food	305	315	310	3.8	1
Food drink 1	277	295	285	6.4	2
Food drink 4	39	33	36	1.9	5
Margarine 2	1053	980	1017	26.0	3
Margarine 5	991	611	801	134.2	17
Margarine 8	1231	1219	1225	4.4	0

3.5.2 Blind duplicates for vitamin D.

Food sample	Result 1	Result 2	mean	Std dev	CV
Baby food	6.1	6.3	6.2	0.1	1
Food drink 1	10.7	12.4	11.5	0.6	5
Food drink 6	<0.5	<0.5	<0.5	0	0
Fruit cordial 2	1.6	1.7	1.6	0	1
Margarine 2	8.5	7.9	8.2	0.2	3
Margarine 5	14.2	13.8	14.0	0.2	1
Margarine 8	13.1	14.7	13.9	0.6	4

3.5.3 Blind duplicates for calcium

Food sample	Result 1	Result 2	mean	Std dev	CV
Baby food	598	600	599	0.6	0
Breakfast cereal 1	388	442	415	19.3	5
Breakfast cereal 3	760	791	775	11.1	1
Breakfast cereal 4	718	731	725	4.6	1
Food drink 1	746	804	775	20.5	3
Food drink 3	408	406	407	0.5	0
Food drink 4	152	146	149	2.1	1
Milk product 6	199	203	201	1.4	1
Milk product 7	234	233	233	0.4	0

Appendix 4: Results for individual foods

Table 4.1A: Vitamin A concentration (µg/100g or 100ml)

Food	Label Claim	Measured	Std dev.	%CV	Mean 95% uncertainty range[a]	% overage
Baby food	282	336				
	282	315				
	282	379				
	282	334				
	282	285				
	mean	**330**	**34.4**	**10.4**	**288-371**	**17**
Food drink 1	356	289				
	356	322				
	356	330				
	356	361				
	356	295				
	mean	**319**	**29.1**	**9.1**	**284-354**	**-10**
Food drink 2	341	660				
	341	439				
	341	483				
	341	467				
	341	415				
	mean	**493**	**96.9**	**19.7**	**376-609**	**44**
Food drink 3	395	516				
	395	414				
	395	484				
	395	351				
	395	393				
	mean	**432**	**67.2**	**15.6**	**351-512**	**9**
Food drink 4	40	35				
	40	33				
	40	34				
	40	34				
	40	39				
	mean	**35**	**2.4**	**6.8**	**32-38**	**-13**
Food drink 5	51	47				
	51	43				
	51	45				
	51	50				
	51	43				
	mean	**46**	**3.1**	**6.8**	**42-49**	**-11**
Food drink 6	63	25				
	63	32				
	63	35				
	63	29				
	63	8				
	mean	**26**	**10.8**	**42.1**	**13**	**-59**
Fruit cordial 1	222	3				
	222	3				
	222	3				
	222	3				
	222	3				
	mean	**3**	**0.0**	**0.0**	**3-3**	**-99**
Margarine 1	1000	581				
	1000	771				
	1000	796				

Food	Label Claim	Measured	Std dev.	%CV	Mean 95% uncertainty range[a]	% overage
	1000	849				
	1000	891				
	mean	**777**	**119.2**	**15.3**	**634-921**	**-22**
Margarine 2	1000	1061				
	1000	992				
	1000	943				
	1000	980				
	1000	749				
	mean	**945**	**117.8**	**12.5**	**804-1086**	**-6**
Margarine 3	850	982				
	850	1078				
	850	1077				
	850	1251				
	850	1258				
	mean	**1130**	**120.7**	**10.7**	**984-1274**	**33**
Margarine 4	850	1133				
	850	1105				
	850	1175				
	850	1103				
	850	1258				
	mean	**1150**	**64.3**	**5.6**	**1078-1232**	**36**
Margarine 5	850	612				
	850	583				
	850	581				
	850	573				
	850	379				
	mean	**546**	**94.2**	**17.3**	**432-659**	**-36**
Margarine 6	850	1148				
	850	885				
	850	1056				
	850	1067				
	850	538				
	mean	**938**	**243.8**	**26.0**	**646-1231**	**10**
Margarine 7	850	1094				
	850	1137				
	850	1179				
	850	1066				
	850	1271				
	mean	**1150**	**80.4**	**7.0**	**1053-1246**	**35**
Margarine 8	850	1219				
	850	1166				
	850	963				
	850	1221				
	850	1065				
	mean	**1130**	**111.4**	**9.9**	**993-1260**	**33**
Milk products 1	55	45				
	55	47				
	55	49				
	55	50				
	mean	**48**	**2.22**	**5**	**45-50**	**-13**
Milk products 2	55	44				
	55	43				
	55	42				
	55	41				
	55	52				
	mean	**44**	**4.33**	**10**	**39-49**	**-20**

Food	Label Claim	Measured	Std dev.	%CV	Mean 95% uncertainty range[a]	% overage
Milk products 3	74	83				
	74	80				
	74	85				
	74	107				
	74	83				
	mean	**88**	**10.77**	**12**	**75-100**	**18**
Milk products 4	55	35				
	55	21				
	55	42				
	55	40				
	55	39				
	mean	**35**	**8.66**	**25**	**25-46**	**-36**
Milk products 5	55	61				
	55	63				
	55	13				
	55	58				
	55	58				
	mean	**51**	**21.27**	**42**	**25-76**	**-8**
Milk products 6	30	31				
	30	33				
	30	28				
	30	29				
	30	29				
	mean	**30**	**2.00**	**7**	**28-32**	**0**

a= mean ± 1.2 standard deviations of the measured concentration

Table 4.2A: Vitamin D concentration (µg/100g or 100ml)

Food	Label Claim	Measured	Std dev.	%CV	Mean 95% uncertainty range[a]	% overage
Baby food	5.2	4.5				
	5.2	6.3				
	5.2	5.9				
	5.2	6.3				
	5.2	7.1				
	mean	**6.0**	**1.0**	**16.1**	**4.8-7.1**	**14**
Food drink 1	11.5	11.9				
	11.5	10.9				
	11.5	9.0				
	11.5	12.4				
	11.5	12.4				
	mean	**11.3**	**1.4**	**12.7**	**9.6-13.0**	**-2**
Food drink 2	4.60	10.4	0.21	2.01		
	4.60	5.1	0.1			
	4.60	5.9				
	4.60	5.1	0.81			
	4.60	3.0	0			
	mean	**5.9**	**2.7**	**46.1**	**2.6-9.2**	**28**
Food drink 6	1.0	<0.5				
	1.0	<0.5				
	1.0	<0.5				
	1.0	<0.5				
	1.0	<0.5				
	mean	**<0.5**	**0.1**	**1.0**	**0.4-0.6**	**-50**
Fruit drink 2	1.3	1.5				
	1.3	1.7				
	1.3	1.5				
	1.3	1.5				
	1.3	1.1				
	mean	**1.4**	**0.2**	**14.2**	**1.2-1.7**	**15**
Margarine 1	18.0	10.6	0.3	2.43		
	18.0	5.4	0.1	1.85		
	18.0	6.0	0.1	1.19		
	18.0	4.7	0.1	1.52		
	18.0	6.9	0.4	5.68		
	mean	**6.7**	**2.3**	**34.9**	**3.9-9.5**	**-63**
Margarine 2	18.0	13.9				
	18.0	11.7				
	18.0	8.9				
	18.0	7.9				
	18.0	5.5				
	mean	**9.6**	**3.3**	**34.1**	**5.7-13.5**	**-47**
Margarine 3	10.0	12.6				
	10.0	12.7				
	10.0	12.7				
	10.0	14.2				
	10.0	14.3				
	mean	**13.3**	**0.9**	**6.4**	**12.3-14.3**	**33**
Margarine 4	10.0	13.9				
	10.0	13.1				
	10.0	14.4				
	10.0	13.7				
	10.0	13.2				
	mean	**13.6**	**0.5**	**3.8**	**13.0-14.3**	**36**

Food	Label Claim	Measured	Std dev.	%CV	Mean 95% uncertainty range[a]	% overage
Margarine 5	10.0	13.8				
	10.0	12.5				
	10.0	12.5				
	10.0	12.1				
	10.0	11.1				
	10.0	13.3				
	mean	**12.5**	**0.8**	**6.2**	**11.6-13.5**	**25**
Margarine 6	10.0	12.8				
	10.0	12.2				
	10.0	13.1				
	10.0	15.9				
	10.0	12.7				
	mean	**13.2**	**1.5**	**11.2**	**11.4-15.0**	**32**
Margarine 7	10.0	13.2				
	10.0	13.7				
	10.0	13.8				
	10.0	14.2				
	10.0	14.1				
	mean	**13.8**	**0.4**	**2.8**	**13.3-14.2**	**38**
Margarine 8	10.0	14.7				
	10.0	14.0				
	10.0	12.9				
	10.0	13.7				
	10.0	15.6				
	mean	**14.2**	**1.0**	**7.1**	**12.9-15.4**	**42**
Milk product 1	0.5	0.5				
	0.5	0.5				
	0.5	0.5				
	0.5	0.50				
	0.5	0.6				
	mean	**0.5**	**0.0**	**8.6**	**0.5-0.6**	**1**
Milk product 2	0.5	0.6				
	0.5	0.5				
	0.5	0.4				
	0.5	0.5				
	0.5	0.5				
	mean	**0.5**	**0.1**	**13.2**	**0.4-0.6**	**4**
Milk product 3	0.66	1.00				
	0.66	1.05				
	0.66	1.00				
	0.66	1.15				
	0.66	1.40				
	mean	**1.12**	**0.2**	**15.0**	**0.9-1.3**	**70**
Milk product 4	0.5	0.2				
	0.5	0.1				
	0.5	0.2				
	0.5	0.1				
	0.5	0.1				
	mean	**0.2**	**0.04**	**20.7**	**0.1-0.2**	**-62**
Milk product 5	0.5	0.2				
	0.5	0.2				
	0.5	0.0				
	0.5	0.2				
	0.5	0.2				
	mean	**0.2**	**0.06**	**39.7**	**0.1-0.2**	**-68**

a= mean ± 1.2 standard deviations of the measured concentration

Table 4.3A: Calcium concentration (mg/100g or 100ml)

Food	Label Claim	Measured	Std dev.	%CV	Mean 95% uncertainty range[a]	% overage
Baby foods	682	592				
	682	600				
	682	681				
	682	659				
	682	642				
	mean	**634**	**38.0**	**6.0**	**589-680**	**-7**
Bread	271	384				
	271	345				
	271	424				
	271	386				
	271	339				
	mean	**376**	**34.6**	**9.2**	**334-417**	**39**
Breakfast cereal 1	267	407				
	267	442				
	267	372				
	267	335				
	267	349				
	mean	**381**	**43.7**	**11.5**	**328-433**	**43**
Breakfast cereal 2	267	320				
	267	301				
	267	295				
	267	487				
	267	317				
	mean	**344**	**80.6**	**23.4**	**247-441**	**29**
Breakfast cereal 3	667	842				
	667	801				
	667	791				
	667	912				
	667	863				
	mean	**842**	**49.0**	**5.8**	**783-901**	**26**
Breakfast cereal 4	333	519				
	333	569				
	333	623				
	333	731				
	333	545				
	mean	**597**	**84.0**	**14.1**	**496-698**	**79**
Breakfast cereal 5	444	594				
	444	551				
	444	670				
	444	646				
	444	432				
	mean	**579**	**94.1**	**16.3**	**466-691**	**30**
Food drink 1	639	728				
	639	777				
	639	761				
	639	744				
	639	804				
	mean	**763**	**29.4**	**3.9**	**727-798**	**19**
Food drink 2	683	415				
	683	558				
	683	606				
	683	649				
	683	653				
	mean	**576**	**97.9**	**17.0**	**459-694**	**-16**

Food	Label Claim	Measured	Std dev.	%CV	Mean 95% uncertainty range[a]	% overage
Food drink 3	450	418				
	450	406				
	450	441				
	450	522				
	450	428				
	mean	**443**	**46.0**	**10.4**	**388-498**	**-2**
Food drink 4	120	150				
	120	146				
	120	203				
	120	154				
	120	148				
	mean	**160**	**24.1**	**15.0**	**131-189**	**34**
Food drink 5	160	255				
	160	186				
	160	233				
	160	211				
	160	199				
	mean	**217**	**27.4**	**12.6**	**184-250**	**35**
Food drink 7	120	135				
	120	196				
	120	99				
	120	67				
	120	72				
	mean	**114**	**53.1**	**46.7**	**50-177**	**-5**
Food drink 6	125	110				
	125	164				
	125	215				
	125	105				
	125	148				
	mean	**148**	**44.7**	**30.1**	**95-202**	**19**
Fruit cordial	120	164				
	120	168				
	120	109				
	120	86				
	120	77				
	mean	**121**	**42.9**	**35.5**	**69-172**	**1**
Milk product 1	205	184				
	205	186				
	205	171				
	205	152				
	205	153				
	mean	**169**	**16.3**	**9.6**	**150-189**	**-18**
Milk product 6	200	196				
	200	204				
	200	208				
	200	203				
	200	200				
	mean	**202**	**4.6**	**2.3**	**196-207**	**1**
Milk product 7	253	240				
	253	253				
	253	261				
	253	224				
	253	233				
	mean	**242**	**14.9**	**6.2**	**224-2601**	**-4**

a= mean ± 1.2 standard deviations of the measured concentration