Dietary iodine intake of New Zealand children following fortification of bread with iodine

Ministry of Agriculture and Forestry
Te Manatū Ahuwhenua, Ngāherehere

BIOSECURITY
NEW ZEALAND

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Executive Summary

Iodine is an essential component of the thyroid hormones which play a key role in the normal growth and development of the human body. Poor intakes of iodine can lead to detrimental health outcomes throughout all life stages and include impaired mental development, congenital abnormalities, hypothyroidism, cretinism and goitre (1,2).

Studies indicating the prevalence of mild to moderate iodine deficiency in the New Zealand population led to the introduction of mandatory fortification of bread with iodine, through the replacement of salt with iodised salt, in New Zealand in September 2009. Organic and unleavened breads are exempt from mandatory fortification requirements (3).

Results of the post-fortification survey of 530 breads for sale in New Zealand during April 2010 found median iodine concentrations, of various bread types required to contain iodine, to be between 32 and 53µg/100g. As expected, organic breads and crumpets did not contain any iodine as these were excluded from mandatory fortification requirements.

Through the use of dietary modelling techniques estimated iodine intakes of children 5-14 years of age increased by 52µg between baseline and post-fortification. The percentage of children with estimated iodine intakes less than the estimated average requirement (EAR) reduced from 38% at baseline to 4% post-fortification when 1g iodised salt was added to the daily estimated iodine intake of children identified as consumers of discretionary iodised salt from the 2002 Children's Nutrition Survey. When discretionary iodised salt was not included in the analysis, the percentage of children with iodine intakes less than the EAR reduced from 95% at baseline to 18% post-fortification. Regardless of whether discretionary iodised salt was included in the analysis, less than 1% of children had intakes above the upper level of intake (UL) at post-fortification.

Performance of the mandatory iodine fortification programme was measured against the following Ministry of Agriculture and Forestry (MAF) Domestic Food Review project (DFR5) performance monitoring indicator: *"improvement in the iodine status of the New Zealand population, so that 70% of school-aged children achieve the ideal range for dietary intake over a five-year monitoring period"*. Results of this study indicate that in MAF's first year of monitoring, mandatory fortification of bread with iodine has been successful in achieving ideal iodine intakes in over 70% of school-aged children.

Following mandatory fortification of bread with iodine, bread is now the major contributor to dietary iodine intakes (up to 50%), followed by milk and dairy products (20%).

Background

Iodine is a trace element and essential component of the thyroid hormones which play a key role in the normal growth and development of the human body. Poor intakes of iodine may lead to a number of detrimental health outcomes throughout all life stages and include impaired mental development, congenital abnormalities, hypothyroidism, cretinism and goitre (1,2).

Studies of New Zealand children and adults over the past decade have indicated the presence of mild-moderate iodine deficiency in the New Zealand population (4-12). In 2005, the Australia New Zealand Food Regulation Ministerial Council noted that mandatory fortification with iodine was an effective public health strategy and requested that FSANZ, as a matter of priority, progress consideration of fortification of the Australia and New Zealand food supply with iodine.

Following several years of draft standard development and consultation, mandatory fortification of bread with iodine was introduced into New Zealand and Australia in September and October 2009, respectively. Standard 2.1.1 - Cereals and Cereal Products in the Australia New Zealand Food Standards Code was amended requiring the mandatory replacement of non-iodised salt with iodised salt in most bread for sale in New Zealand. Organic and unleavened breads are exempt from mandatory requirements (3).

The Ministry of Agriculture and Forestry (MAF) measures the performance of its regulatory food program on an on-going basis. Following introduction of mandatory fortification of bread with iodine, MAF has undertaken to monitor iodine concentrations of the bread supply and the dietary iodine intakes in children 5-14 years of age.

The Domestic Food Review project 5 (DFR 5) provides a series of performance indicators by which to measure potential hazards in the food supply against. The success of mandatory fortification of bread with iodine will, in part, be determined by whether the following DFR5 performance indicator is achieved:

> *"Improvement in the iodine status of the New Zealand population, so that 70% of school-aged children achieve the ideal range for dietary intake of iodine over a five-year monitoring period."*

The results of this monitoring work will be used to inform Ministers and government agencies of any potential risks or benefits to the New Zealand population with current iodine fortification levels and provide appropriate recommendations for managing risks. It is important to note that this work has been undertaken for dietary intake monitoring purposes only, and will not be used for compliance and enforcement purposes.

Aim

The aim of this study was to estimate the impact of the mandatory replacement of non-iodised salt with iodised salt in bread in New Zealand on the dietary iodine intakes of children 5-14 years of age and report this against the DFR 5 Performance Monitoring Indicator:

> *"Improvement in the iodine status of the New Zealand population, so that 70% of school-age children achieve the ideal range for dietary intake of iodine over a five-year monitoring period."*

Objectives

1. To analyse a representative sample of breads available for sale in New Zealand for their mean and median iodine and sodium contents.

2. To estimate the proportion of New Zealand children aged 5-14 years with inadequate intakes of iodine pre- and post-fortification.

3. To estimate the proportion of New Zealand children aged 5-14 years with excessive intakes of iodine pre- and post-fortification.

4. To identify the key food contributors to iodine intakes of New Zealand children aged 5-14 years pre- and post-fortification.

5. Compare results against the DFR 5 Performance Monitoring Indicator.

Methodology

BREAD SELECTION

The aim was to obtain a representative sample of breads consumed in New Zealand. This sample would reflect current market share of brands and bread types (including crumpets and organic breads); different batches of the same bread; and regional differences in breadmaking.

A bread sampling frame was created collating brand, bread type and annual production data. (Synovate Aztec New Zealand). Breads were sorted by annual production and categorised as "high", "medium", or "low" market share, as shown in Table 1.

Table 1. Bread sampling frame

Market Share	Number of breads	Market Share (%)	Number of bread samples
High	10	38	120
Medium	46	43	180
Low	152	29	180

All 10 of the high market share breads were to be sampled over a number of weeks and regions, with a total of 120 samples. The medium and low market share breads were listed separately and randomised. Fifteen medium and low market share breads from the lists were to be sampled over a number of weeks and regions with a total of 180 samples for each.

THE SAMPLING SCHEDULE

Breads were collected in April 2010 over three weeks from four New Zealand regions (Auckland, Central North Island (Napier, Palmerston North and Wanganui), Christchurch and Dunedin). Table 2 below outlines the sampling schedule.

Table 2. Bread sampling schedule

Region	Auckland			Central North Island			Christchurch			Dunedin			Total breads
Weeks	High	Med	Low	High	Med	Low	High	Med	Low	High	Med	Low	
1	10	15	15	10	15	15	10	15	15	10	15	15	160
2	10	15	15	10	15	15	10	15	15	10	15	15	160
3	10	15	15	10	15	15	10	15	15	10	15	15	160
Total	30	45	45	30	45	45	30	45	45	30	45	45	480

Four samplers completed three sampling rounds, one week apart in each of the four regions. The sampling weeks were from 6 - 11 April (Week 1), 12 - 18 April (Week 2) and 19 - 25 April 2010 (Week 3). A total of 480 breads were expected to be collected (120 from each region).

Samplers were able to visit any of the supermarkets within their designated region in order to collect all of the breads listed. Samplers were required to package and send breads to a laboratory for analysis at the end of the week following collection.

All four samplers were provided with a sampling protocol which included the list of high, medium and low breads to be collected. If a medium or low market share bread from the list could not be located, the next available bread on the randomised list was collected until the target number of breads were obtained.

LABORATORY METHODOLOGY

RJ Hill Laboratories Ltd (Hill Laboratories) were contracted to analyse breads for iodine and sodium. All analyses were performed at Hill Laboratories - Food & Bioanalytical Division, Waikato Innovation Park, Ruakura Lane, Hamilton.

Hill Laboratories are an accredited laboratory under International Accreditation New Zealand (IANZ). Hill Laboratories used tests for iodine and sodium which were not accredited.

Breads were delivered by courier to Hill Laboratories. Bread loaves were analysed as received. Three slices of bread were randomly selected from the bread package, homogenised and stored in the freezer at -18 ºC until required. Remaining bread was discarded. Nominally dry or dried samples were ground or crushed to form ground sample fraction before analysing for iodine and sodium.

Iodine analysis included tetramethylammonium hydroxide (TMAH) micro digestion, at 90ºC for 1 hour, with filtration, followed by analysis using inductively coupled plasma – mass spectrometry (ICP-MS)(13). The limit of detection (LOD) was reported as 0.010 milligrams per kilogram (mg/kg). Only one iodine analysis per bread was completed.

Sodium analysis involved nitric and hydrochloric acid micro digestions, at 85ºC for 1 hour, followed by analysis using inductively coupled plasma – optical emission spectroscopy (ICP-OES). The LOD was reported as 0.005 grams per 100 grams (g/100g). Only one sodium analysis per bread was completed.

BREAD CATEGORISATION

Following data collection, breads were categorised into eight different categories based on their descriptors: white, fibre white, wholemeal, mixed grain, rye, fruited, organic and crumpets. These categories were based on those used in the Food Standards Australia New Zealand (FSANZ) Dietary Modelling of Nutritional Data (DIAMOND) computer program which is used to conduct dietary exposure assessments.

DIETARY MODELLING OF NUTRITIONAL DATA

The DIAMOND computer program may be used to estimate dietary exposure to a range of chemicals including nutrients. Food composition data, which includes the nutrient of interest, and food consumption data are both required to conduct a dietary exposure assessment.

For this project, the 2002 New Zealand Children's Nutrition Survey (CNS02) data and two food composition data sources, namely the New Zealand Food Composition Database (NZFCD) and 2003/04 New Zealand Total Diet Survey (NZTDS), were used to underpin dietary exposure assessments for iodine in the DIAMOND computer program.

The CNS02 is a cross sectional population survey which collected information on the food and nutrient intakes, eating patterns, and anthropometric and clinical measures of New Zealand children during 2002. This survey collected data on 3275 children aged 5- 14 years of age with over-sampling of Maori and Pacific Island children. The 24-hour recall method was used to collect information on all food and drink consumed over a 24-hour period. This method was repeated on a second day in a sub-sample of the surveyed population in order to estimate usual nutrient intakes (10).

The NZFCD contains iodine concentrations which are a combination of analytical values, borrowed values and product label data; the data collected in the 2003/04 NZTDS are solely analytical values. Iodine concentrations from both data sources were used to provide the most accurate and up-to-date iodine concentrations to estimate iodine intakes.

In order to estimate iodine intakes pre-fortification of bread with iodine, all foods (including bread) consumed in the CNS02 were attributed an iodine concentration based on the NZFCD and NZTDS data. To estimate iodine intakes post-fortification, all breads consumed in the CNS02 were attributed a median iodine concentration based on the data collected in the bread survey. Iodine concentrations for other foods were taken from the NZFCD and NZTDS data. All data was entered into the DIAMOND computer program to estimate iodine intakes pre- and post-fortification.

Bread matching

The breads collected in the analytical survey were categorised into eight bread groups (white, fibre white, wholemeal, mixed grain, rye, fruited, organic and crumpets) and were attributed a unique bread code (e.g. white bread = B1, fibre white = B2, mixed grain = B4 etc). Descriptions of breads consumed in the CNS02 were then matched with breads collected in the analytical survey.

Where there was an exact bread descriptor match, a unique bread code was applied to that bread. To provide a made up example, if Johnny's Rye bread was consumed in the CNS02 and also collected in the bread survey, Johnny's Rye bread would be attributed a unique bread code. If the bread was identified as having an exact match, it was still included in the broader bread category. For example, Johnny's Rye bread was also included in the broad rye category (B5). In total there were 48 unique bread codes, eight of which were broader bread categories (B1-B8). All breads consumed in the CNS02 were attributed a unique bread code.

Other bread type products

There are a range of bread type products in the CNS02 data set that were not captured as part of the analytical survey. Products include pita breads, Turkish bread, hamburger buns and bread rolls. The Australia New Zealand Food Standards Code outlines which breads are covered by mandatory fortification. By definition[1], pita breads, Turkish bread, hamburger buns and bread rolls are included in the mandatory fortification requirements (3). For the purposes of dietary modelling, it was assumed these particular products were white breads and therefore included in the white bread category (B1). A list of assumptions is provided in Appendix 1. Assumptions for matching bread codes in analytical survey with Children's Nutrition Survey (CNS02) breads.

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[1] Bread means the product made by yeast-leavened dough prepared from one or more cereal flours or meals and water. The definition of bread for the purposes of the mandatory fortification addition of iodised salt to bread does not include pizza bases, breadcrumbs, pastries, cakes, including but not limited to brioche, panettone and stolen; biscuits or crackers. Reference Standard 2.1.1, Australia New Zealand Food Standards Code, 2002.

Calculating median iodine concentrations for bread

Once the bread codes were defined, a median iodine concentration was derived and attributed to each bread code. Iodine concentrations of individual breads within a bread category were used to calculate the median concentration. Analytical values identified as outliers were included if the value was considered to be accurate after cross checking with the laboratory. Therefore for all 48 unique bread codes, eight of which were broader bread categories (B1-B8), each had a median iodine concentration attributed to it.

Bread codes were then matched to all breads consumed in the CNS02. Each bread type that was consumed in the CNS02 was assigned a median iodine concentration based on the analysed values.

Foods that contain bread as an ingredient

There are a number of foods in the CNS02 data set that contain bread or bread products as an ingredient. These are referred to as recipes. For example, a spaghetti and meatball dish may contain 2% bread (as an ingredient in the meatballs) or a ham sandwich purchased from a café may contain 50% bread (e.g. two slices).

In order to obtain accurate estimates of iodine intake, these recipes need to be taken into consideration in the dietary modelling phase. Some of the recipes are built in the DIAMOND computer program so that nutrient concentrations are sourced from a range of individual foods that make up the recipe. For example, a ham sandwich may include separate ingredients: white bread, ham and margarine.

Bread codes were mapped to each recipe where necessary. For example, if white bread made up 50% of a ham sandwich, then the bread code B1 (and relevant iodine concentration) was attributed to the ham sandwich at a rate of 50%.

Moisture retention factor

A toasted bread factor of 1.1 was applied to the median iodine concentrations of all breads consumed in the CNS02 that were reported as 'toasted'. Multiplying toasted breads by a factor of 1.1 takes account of the moisture loss through toasting, increasing the mean iodine concentration of toasted bread by 10%.

Discretionary salt use and dietary models

Depending on dietary habits, discretionary iodised salt can make a significant contribution to total dietary iodine intake. When assessing dietary intake of iodine, it is important to consider the impact discretionary iodised salt can make where there is data available. Three different models were run in the DIAMOND computer program which aimed to estimate this impact. These were a consumer behaviour model (iodised salt), a consumer behaviour model (non-iodised salt) and a CNS02 salt behaviour model. These models are summarised in Table 3 below.

Table 3. Summary of discretionary salt models

Model	Description
Consumer behaviour model (iodised salt)	In this model it was assumed that all of the respondents in the CNS02 consumed iodised discretionary salt. Therefore for all respondents, 1g of iodised salt with an iodine concentration of 48 micrograms (µg) was added to the total iodine intake consumed from food.
Consumer behaviour model (non-iodised salt)	In this model it was assumed that none of the respondents in the CNS02 consumed iodised discretionary salt. Therefore no iodised discretionary salt was added to the total intake of iodine consumed from food.
*CNS02 Salt behaviour model	In this model only those respondents, who were identified as iodised salt consumers by their responses in the CNS02 questionnaire were assigned an estimated intake of discretionary salt. Therefore for identified respondents, 1g of iodised salt with an iodine concentration of 48µg was added to the total iodine intake consumed from food.

* 2002 New Zealand Children's Nutrition Survey

Where discretionary iodised salt use was modelled, an iodine concentration of 48µg at an amount of 1g salt per day was used. The concentration was based on a report produced for the New Zealand Food Safety Authority that found that the midpoint of the mean concentrations of iodine in retail salts was 48mg of iodine per kg of salt (14). The Australia New Zealand Food Standards Code requires that iodised salt is fortified between 25 and 65mg of iodine per kg of salt, with an aim of achieving the midpoint 45mg of iodine per kg of salt (3).

One gram of discretionary salt per day was chosen to be consistent with dietary modelling fortification scenarios, conducted by the Life In New Zealand (LINZ) Research Group at the University of Otago to inform mandatory fortification decision making, and because new data on discretionary salt use was not available (15). Refer to Appendix 2 for an outline of the discretionary salt decision making process.

Summary of DIAMOND computer program models

Table 4 summarises the discretionary salt models and the bread scenarios entered into the DIAMOND computer program.

Table 4. Summary of the DIAMOND computer program models

Discretionary salt models		Bread scenarios	
		^Baseline	$Post fortification
All respondents	Consumer behaviour model (iodised salt)	X	X
	Consumer behaviour model (non-iodised salt)	X	X
Selected respondents	*CNS02 Salt behaviour model	X	X

* 2002 New Zealand Children's Nutrition Survey
^ The baseline model reflects pre-fortification iodine concentrations of breads
$ Median iodine concentration of breads used

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Results

IODINE CONCENTRATIONS OF BREAD

A total of 530 breads were collected and analysed for iodine and sodium content. Due to oversampling, an extra 50 breads were collected than initially planned in the sampling frame (n=480). Two breads were excluded from further investigation as they were not on the lists provided to samplers. Two breads of the same brand contained minimal iodine and on further investigation of the label, did not contain iodised salt. These breads were excluded from further investigation as iodine concentrations could skew the data. A total of 526 breads were included in further analysis; 118, 184 and 224 breads were categorised as high, medium and low market share respectively. Refer to Figure 1 below.

Figure 1. Summary of breads in relation to market share
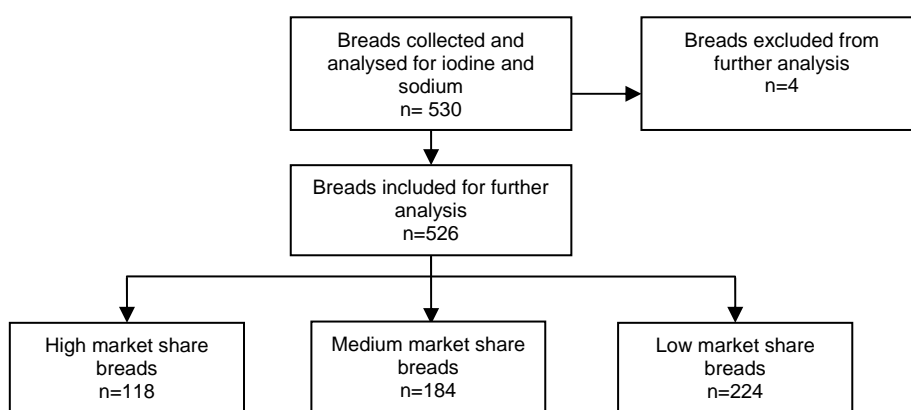
All breads, regardless of market share, were grouped into eight categories: fibre white, fruited, mixed grain, rye, white, wholemeal, organic and crumpets. The mean and median iodine concentrations are provided in Table 5.

Table 5. Summary of iodine concentrations (µg/100g bread and per slice) by bread category

Bread category	n	Mean iodine (µg/ 100g bread (95% CIs))	Median iodine (µg/100g bread)	Range iodine (µg/ 100g bread)	Mean iodine (µg/ slice bread (30-45g))$
Fibre white	14	52.6 (42.0, 63.2)	48.5	31 - 109	15.8 – 23.7
Fruited	41	31.8 (28.2, 35.3)	29.0	18.9 - 81	9.5 - 14.3
Mixed grain	312	44.4 (41.6, 47.3)	41.0	2.9 - 380	13.3 - 20.0
Rye	26	41.6 (37.3, 45.9)	42.0	24 - 72	12.5 - 18.7
White	73	50.3 (46.9, 53.6)	49.0	30 - 115	15.1 – 22.6
Wholemeal	47	47.2 (43.3, 51.1)	44.0	29 - 95	14.2 - 21.3
Organic^	11	<0.5*	<0.5	…	…
Crumpets^	2	<0.5*	<0.5	…	…

* Where an iodine concentration was found to be below the limit of detection, i.e. <0.01mg/kg, one half the limit of detection value was used (0.005mg/kg or 0.5µg/100g).
^ Organic breads and crumpets are exempt from mandatory fortification requirements.
$ Estimated weights of bread slices were sourced from the Concise New Zealand Food Composition Tables 7th ed. 2006 (16)(17)

The number of breads collected in each of the bread categories ranged between two and 312. The range in iodine concentrations of all breads collected, excluding organic and crumpets, was between 2.9 and 380µg/100g bread. Iodine concentrations for all organic breads and crumpets were below the limit of detection (LOD) (<0.01mg/kg). Fibre white bread had the highest mean concentration (52.6µg) followed by white bread (50.3µg); although both had similar median iodine concentrations with 48.5 and 49.0µg respectively. Fruited bread had the lowest mean and median iodine concentrations of all the breads above the LOD (31.8µg and 29.0µg respectively). Mean iodine concentrations per slice of bread (30-45g) are estimated to be between 9.5 and 23.7µg.

The iodine concentration of one mixed grain bread, which appeared to be an outlier at 380µg/100g bread, was queried with Hill Laboratories for its accuracy. A re-check of the analytical reports indicated that the value was reported correctly and was therefore not excluded from mean and median calculations.

A box and whiskers plot of iodine concentrations by bread category (excluding organic breads and crumpets) is provided in Figure 2. The plot illustrates the wide range of iodine concentrations for each bread category, in particular mixed grain breads. There is cross over in iodine concentrations between all bread categories when the 10th to 90th percentile ranges are compared.

Figure 2. Box and whisker plots of iodine concentrations by bread category*^
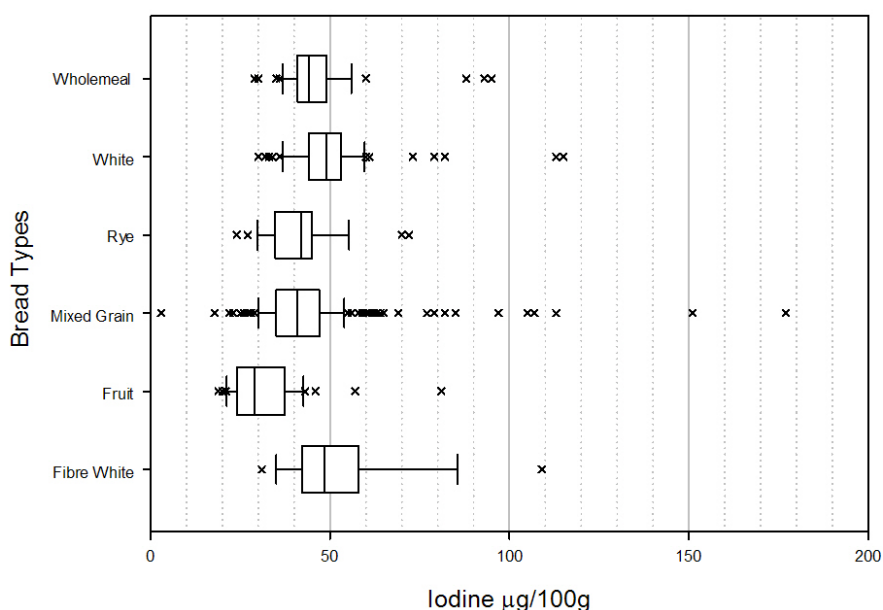
* The extreme value of 380µg /100g for mixed grain has been removed from the graph for scaling purposes.
^ The boundary of the box closest to zero indicates the 25th percentile, the line within the box marks the median, and the boundary of the box farthest from zero indicates the 75th percentile. Extremes of the whiskers to the left and right of the box indicate the 10th and 90th percentiles. Identified outliers are to the left and right of the 10th and 90th percentiles.

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A non-parametric analysis of the iodine concentration with bread type as the factor yielded a highly significant result (Kruskal-Wallis test, p < 0.001). A follow-up non-parametric all pair-wise comparison showed that despite the wide range of iodine concentrations found in breads, there were highly significant differences between fruited bread and all other breads; white and mixed grain bread; and white and rye bread, as shown in Table 6 below.

Table 6. Results of a non-parametric all pair-wise comparison^ of iodine concentrations in breads

Breads	Fibre white	Fruited	Mixed grain	Rye	Wholemeal	White
Fibre white		***	ns	ns	ns	ns
Fruited	***		***	**	***	***
Mixed grain	ns	***		ns	*	***
Rye	ns	**	ns		ns	**
Wholemeal	ns	***	*	ns		ns
White	ns	***	***	**	ns	

^ Used R and Statistica packages to calculate non-parametric all-pairwise comparison
ns = not significant (p >0.05)
***p< 0.001, ** p<0.01, *p<0.05

Figure 3 illustrates the mean iodine concentrations with 95% confidence intervals for all bread and individual bread categories (except organic and crumpets). Fibre white breads (n=14) have a noticeably wider confidence interval for iodine concentrations compared to the wholemeal, white, rye, mixed grain and fruit breads. Fruit breads (n =41) have a lower mean iodine concentration than other breads, but have a similar confidence interval to wholemeal, white, rye and mixed grain breads. When all breads (n=513) were combined, the confidence interval was narrowed.

Figure 3. Mean iodine concentrations with 95% confidence intervals of all bread categories (except organic and crumpets)
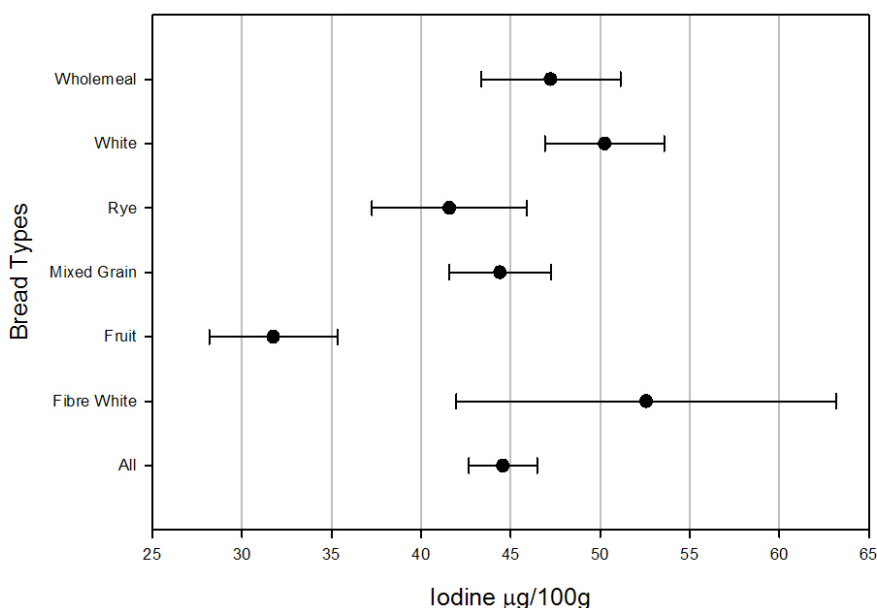
Figure 4 shows that there is a weak positive correlation between iodine and sodium in bread (Pearson correlation =0.289, p<0.001). The scatter-plot shows that there are a number of values far from the regression line, in particular for iodine.

Figure 4. Scatter-plot and regression line for iodine (µg/100g) versus sodium (g/100g) concentrations in bread*
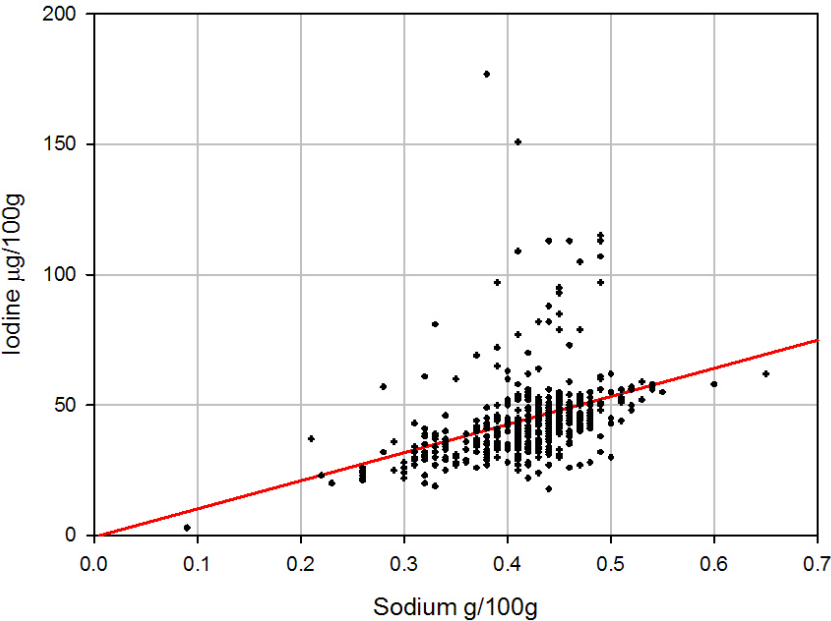
* The extreme value of 380µg /100g for mixed grain has been removed from the graph for scaling purposes.

Figure 5. Graph of the percentage of co-efficient of variation for sodium and iodine concentrations in bread

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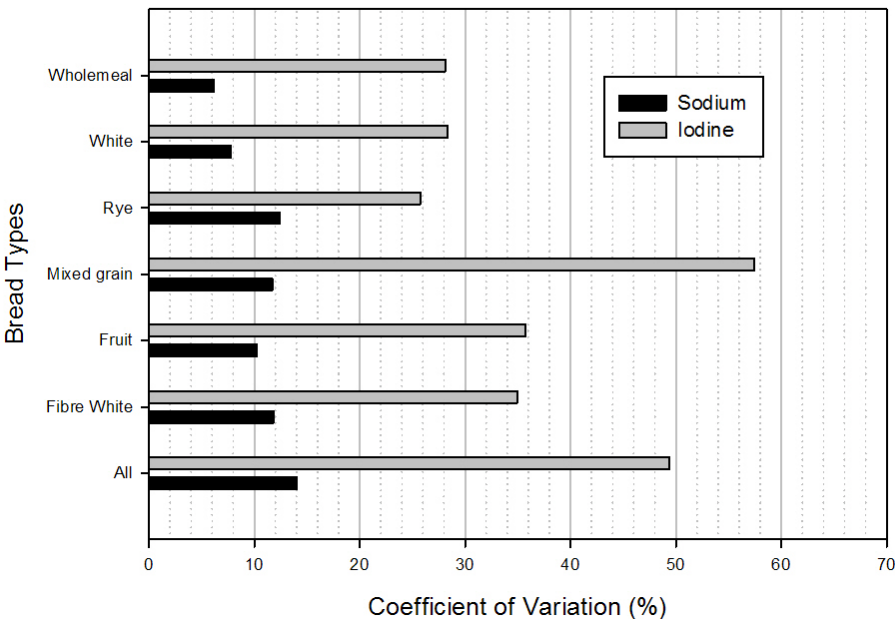
Figure 5 above shows the difference of co-efficient of variation between iodine and sodium. The co-efficient of variation describes the standard deviation as a percentage of the sample mean (18). This graph shows there was less variation in sodium concentrations compared to iodine concentrations for all bread types; 14.1% and 49.4% respectively. The spread in sodium and iodine variation is consistent between bread types.

ESTIMATED DIETARY IODINE INTAKE OF CHILDREN 5-14 YEARS OF AGE

The median iodine concentrations of breads, as reported in Table 5, were entered into the DIAMOND computer program and used to estimate dietary iodine intakes of children 5- 14 years of age. Three different models based on discretionary iodised salt use were used to estimate dietary iodine intakes; refer to Tables 7, 8 and 9 below.

Table 7 below provides the mean, 5th and 95th percentile estimated iodine intakes at baseline and post-fortification of bread with iodine for different age and gender groups using the consumer behaviour model, which does not include discretionary iodised salt. This model best reflects the change in iodine intakes from replacement of non-iodised salt with iodised salt in bread.

Table 7. Mean iodine intakes (µg/day) at baseline and post-fortification for specific age and gender groups using the consumer behaviour model (non-iodised salt)

| Age group (yrs)	Gender	n	Mean iodine intakes (5th, 95th percentile) µg/day	
			Baseline	*Post-fortification
5-8 yrs	Males	664	47 (25,73)	93 (72,111)
	Females	622	39 (28,50)	86 (44,133)
	All	1286	43 (26,65)	90 (53,122)
9-13 yrs	Males	857	52 (24,85)	111 (60,181)
	Females	818	41 (23,63)	88 (53,124)
	All	1675	47 (23,76)	100 (54,159)
14 yrs	Males	162	59 (25,96)	130 (51,201)
	Females	152	43 (23,69)	89 (58,117)
	All	314	51 (24,95)	110 (58,182)
5-14 yrs	Males	683	50 (24, 83)	105 (65,169)
	Females	1592	40 (24,60)	88 (50,126)
	All	3275	45 (24,75)	97 (54,152)

* Median bread concentration used

Table 8 provides the mean, 5th and 95th percentile estimated iodine intakes at baseline and post-fortification for different age and gender groups using the consumer behaviour model, which includes the addition of 1g of discretionary iodised salt (containing 48µg of iodine) for all survey respondents.

Table 8. Mean iodine intakes (µg/day) at baseline and post-fortification for specific age and gender groups using the consumer behaviour model (iodised salt)

Age group (yrs)	Gender	n	Mean iodine intakes (5th, 95th percentile) µg/day	
			Baseline	*Post-fortification
5-8 yrs	Males	664	97 (78,122)	146 (122,171)
	Females	622	90 (80,103)	137 (96,186)
	All	1286	94 (79,115)	141 (105,178)
9-13 yrs	Males	857	103 (74,143)	163 (112,237)
	Females	818	93 (76,116)	141 (106,179)
	All	1675	98 (75,132)	152 (108,214)
14 yrs	Males	162	113 (74,159)	183 (104,260)
	Females	152	94 (76,123)	142 (112,173)
	All	314	104 (76,157)	163 (111,238)
5-14 yrs	Males	683	102 (75,138)	158 (116,225)
	Females	1592	92 (77,113)	139 (103,180)
	All	3275	97 (76,129)	149 (107,206)

* Median bread concentration used

Table 9 provides the mean, 5th and 95th percentile estimated iodine intakes at baseline and post-fortification of bread with iodine for different age and gender groups using the CNS02 salt behaviour model which includes discretionary iodised salt for select respondents.

Table 9. Mean iodine intakes (µg/day) at baseline and post-fortification for specific age and gender groups using the CNS02 salt behaviour model

Age group (yrs)	Gender	n	Mean iodine intakes (5th, 95th percentile) µg/day	
			Baseline	*Post-fortification
5-8 yrs	Males	664	82 (28,137)	129 (75,187)
	Females	622	75 (26,120)	123 (53,192)
	All	1286	79 (27,126)	126 (62,189)
9-13 yrs	Males	857	89 (30,147)	148 (80,243)
	Females	818	80 (33,124)	127 (83,176)
	All	1675	85 (32,133)	138 (81,213)
14 yrs	Males	162	104 (51,168)	173 (94,262)
	Females	152	80 (29,117)	128 (90,166)
	All	314	93 (37,156)	151 (94,240)
5-14 yrs	Males	1683	88 (30,146)	143 (80,233)
	Females	1592	78 (29,123)	125 (69,181)
	All	3275	83 (29,133)	135 (75,209)

* Median bread concentration used

In the consumer behaviour (non-iodised salt) model, consumer behaviour (iodised salt) and the CNS02 salt behaviour model, mean iodine intakes increased from 45 to 97µg/day, 97 to 149µg/day and 83 to 135µg/day, respectively. Fortification levels were the same amongst the

Dietary iodine intake of New Zealand children following fortification of bread with iodine

three models, reflecting a consistent change in iodine intakes between baseline and post-fortification for each model. I.e. mean estimated iodine intakes of all 5-14 year old children increased by 52μg/day in all models between baseline and post-fortification. The amount and pattern of discretionary iodised salt use was the main difference between each of the three models.

In all three discretionary salt models, mean iodine intakes of females in each age category were lower than males at both baseline and post-fortification. In the consumer behaviour (non-iodised salt) model, consumer behaviour (iodised salt) and the CNS02 salt behaviour model at post-fortification, iodine intakes at the 95th percentile were highest for males 14 years of age (201μg/day, 260μg/day and 262μg/day) and females 5-8 years of age (133μg/day, 186μg/day and 192μg/day).

Figure 6. Comparison of mean iodine intakes (μg/day) of children 5 – 14 years of age using three discretionary salt models*
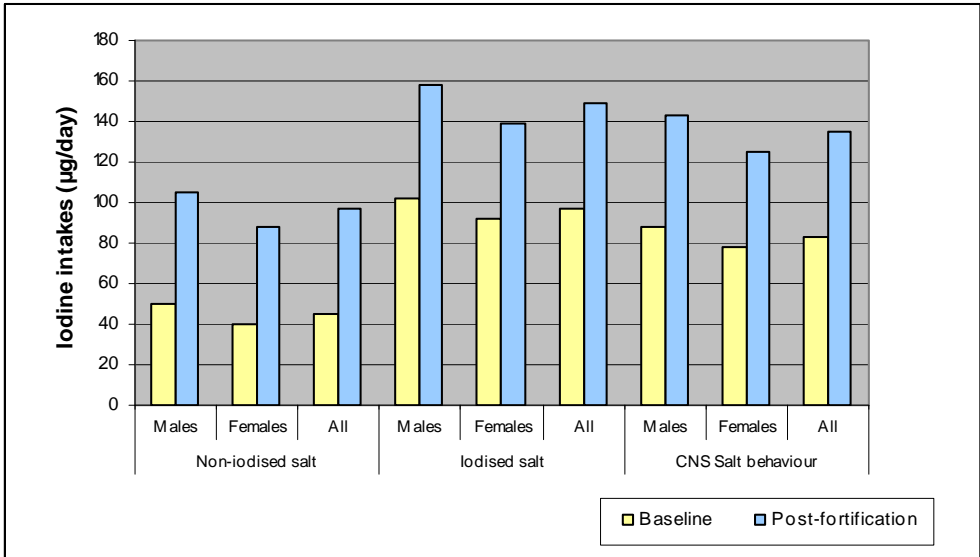
Figure 6 illustrates the variation in mean iodine intakes for all children 5-14 years of age at baseline and post-fortification for the three discretionary salt models. Mean iodine intakes (at baseline and post-fortification) are greatest using the consumer behaviour (iodised salt) model, followed by the CNS02 salt behaviour model and the consumer behaviour (non-iodised salt) model.

ASSESSMENT OF DIETARY INTAKES AGAINST NUTRIENT REFERENCE VALUES

The percentage of children with mean iodine intakes that are below the EAR is presented in Table 10. The EAR is defined as *"a daily nutrient level estimated to meet the requirements of half the healthy individuals in a particular life stage and gender group"* (19). The percentage of the population with usual intakes below the EAR reflects the prevalence of inadequate dietary intakes.

Table 10. Percentage of New Zealand children with mean iodine intakes less than the Estimated Average Requirement (EAR) for each age and gender group using three discretionary salt models

Age group (years)	Gender	n	EAR (µg/day)	Consumer Behaviour Model				±CNS02 Salt Behaviour Model	
				^Iodised salt		$Non-iodised salt			
				†Baseline (%)	‡Post (%)	†Baseline (%)	‡Post (%)	†Baseline (%)	‡Post (%)
	Males	664		0	0	90	3	31	3
5 - 8	Females	622	65	0	0	100	22	33	9
	All	1286		0	0	95	12	32	6
	Males	857		6	0	90	11	35	3
9 - 13	Females	818	75	4	0	99	25	43	3
	All	1675		5	0	94	18	39	3
	Males	162		29	0	92	18	52	5
14	Females	152	95	67	0	98	71	77	6
	All	314		48	0	95	43	64	5
	Males	1683		6	0	90	9	35	3
5 - 14	Females	1592	*	8	0	99	28	42	6
	All	3275		7	0	95	18	38	4

^Includes 48µg discretionary iodised salt for each respondent
$Includes 0µg discretionary iodised salt for each respondent
± Includes 48 µg discretionary iodised salt for selected respondents
*EARs as per age group above
† Baseline = % < EAR at baseline
‡ Post = % < EAR post-fortification

In the consumer behaviour model, where all subjects were assumed to use iodised discretionary salt (48µg/day), none of the children in all age and gender groups had mean iodine intakes less than the EAR post-fortification.

In contrast, for the consumer behaviour model which did not include any discretionary iodised salt, the percentage of children with mean iodine intakes less than the EAR was between 3 and 71% across all age and gender groups post-fortification. For all children 5-14 years of age, the percentage below the EAR reduced from 95% at baseline to 18% post-fortification.

In the CNS02 salt behaviour model, the percentage of children in all age and gender groups with mean iodine intakes less than the EAR was between 3 and 9% post-fortification. For all children 5-14 years of age, the percentage of children below than the EAR reduced from 38% at baseline to 4% post-fortification.

The Upper Level of Intake (UL) is used to estimate the percentage of the population at risk of adverse effects from excessive nutrient intakes (19). Although not presented here, in both the consumer behaviour model (iodised salt) and CNS02 salt behaviour model, <1% of children had iodine intakes above the UL post-fortification. No children in the consumer behaviour model (non-iodised salt) had intakes above the UL at baseline or post-fortification.

MAJOR FOOD CONTRIBUTORS TO MEAN IODINE INTAKES

Figure 7 illustrates which foods are key contributors to mean iodine intakes at baseline and post-fortification.

Figure 7. Percentage contribution of main food groups to mean iodine intakes of 5-14 year old children at baseline and post-fortification
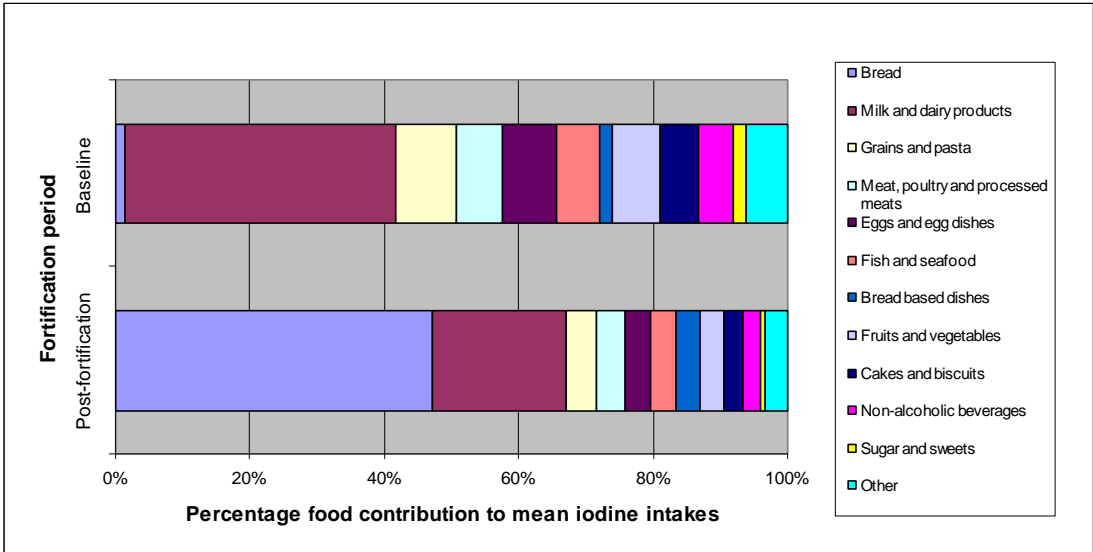
At baseline, the top five main food contributors to mean iodine intakes were milk and dairy products (40%), grains and pasta (9%), egg and egg dishes (8%), meat, poultry and processed meats (7%) and fish and seafood (6%).

After including the fortified breads values, at post-fortification the top five main food contributors were bread (47%), milk and dairy products (20%), grains and pasta (5%), meat, poultry and processed meats (4%) and egg and egg dishes (4%).

From baseline to post-fortification, bread has shifted from eleventh highest iodine contributor (1%) to the first (47%). The contribution from bread-based dishes increased from 2 to 4%, to be the seventh highest contributor to iodine intakes.

The first 11 categories in Figure 7 (bread; milk and dairy products; grains and pasta, meat, poultry and processed meats; egg and egg dishes; fish and seafood; bread-based dishes; fruits and vegetables, cakes and biscuits; non-alcoholic beverages; and sugar and sweets) represent approximately 94% and 97% of all foods at baseline and post-fortification respectively.

The category "other", which represents the least contribution to iodine intakes includes puddings/ desserts; pies and pasties; nuts and seeds; soups and stocks; savoury sauces and condiments; breakfast cereals; snack bars and snack foods; dietary supplements; butter, margarines, fats and oils; and alcoholic beverages.

Discussion

There were three main aspects of this study. Firstly, to measure the iodine concentration of breads for sale in New Zealand following mandatory fortification of bread with iodine; secondly, to estimate iodine intakes of children 5-14 years of age post-fortification; and thirdly, to determine whether MAF is meeting the target of 70% of school-aged children achieving ideal dietary iodine intakes in its first of a five-year monitoring programme.

Iodine concentrations of bread

The mandatory replacement of non-iodised salt with iodised salt in bread in New Zealand was introduced in September 2009. At this time, bread manufacturers were required to replace salt in bread with iodised salt. Iodised salt is required to contain no less than 25 and no more than 65mg of iodine/kg of salt; with the target level being 45 mg of iodine/kg salt for its addition to bread. The permitted forms of iodine include potassium iodide or iodate, or sodium iodide or iodate equivalent (20).

In a 2008 baseline analytical survey of sodium and iodine levels in bread, iodine concentrations ranged from <0.010 - 0.046µg/100g bread (21). The mean iodine concentrations of breads in this study post-fortification were between 32 - 53µg/100g bread. In comparing these results, it is evident that bread did not contain iodised salt prior to the mandatory replacement of non-iodised salt with iodised salt in bread in 2009.

The sample size for fibre white bread (n=14) was smaller than all bread categories (except organic and crumpets), resulting in a wide 95% confidence interval for the mean iodine concentration (42.0, 63.2 µg/100g). In contrast, the 95% confidence interval for mixed grain breads was much narrower (41.6, 47.3 µg/100g) as a result of the larger sample size (n=312). The imbalance of sample sizes between bread categories (n=2 to n=312) resulted from a combination of using the market share method to select breads, which favoured mixed grain and white breads, as well as more low market share breads being collected in proportion to other categories (explained further under sampling issues). Although there were only two crumpet products collected, these are excluded from the regulatory definition of bread and were not found to contain iodine at levels expected from mandatory replacement of non-iodised salt with iodised salt.

Iodine concentrations of breads (excluding organic and crumpets) varied widely (2.9-380µg/100g) in this study. There was a highly significant difference (p<0.001) in median iodine concentrations between fruited breads and all other bread categories; between white and rye breads, and between white and mixed grain breads. The range of iodine concentrations across all bread types is confirmed by the large co-efficient of variation of 49.4%. The range of sodium concentrations across all bread types was much narrower, with a co-efficient of variation of 14.1%.

Varying concentrations of iodine are reported to relate to the amount of salt being added by manufacturers; uneven distribution of iodine in bags of salt due to insufficient mixing or iodine particle size; and environmental and storage conditions (22). In this study, it is likely that variation in the iodine concentration of bread is due to an uneven distribution of iodine in bags of salt caused by the iodine particle size; the range in which iodine is required to be added to salt (25 - 65mg iodine/ kg salt); and the amount of iodised salt added to different bread types. For example, fruited breads, which were found to be significantly different to

iodine concentrations to other breads, generally contain less sodium per 100 grams compared to other regular breads (23). This is possibly due to taste and the addition of fruit reducing the proportion of sodium per 100 grams of bread.

Given that iodised salt is added to bread, one would expect iodine and sodium concentrations of bread to be strongly correlated. In this study, a weak but positive relationship was found between iodine and sodium concentrations in bread (Pearson correlation = 0.289, p<0.01). This may have been attributed to factors such as an uneven distribution of iodine in bags of salt before addition to the breadmaking process or the range of iodine concentrations permitted in the manufacture of iodised salt. It is unlikely that the lack of strong correlation is due to the addition of sodium from other sources permitted to be added to bread for sale in New Zealand, such as food additives or processing aids (3). According to New Zealand bread manufacturer Coupland's Bakery (24), the vast majority of sodium in bread comes from salt with a minimal amount from permitted additives. In one example provided by Coupland's Bakery, 98% (282mg of 287mg) of sodium present in bread came from added salt.

Based on modelling of sodium concentrations in bread, Rose et al (9) estimated that bread would contain approximately 15-31µg iodine/100g (or 14-28µg iodine/100g after baking) post-fortification; half of what was found in our analytical study (31.75-52.97µg/100g). The lower iodine estimates identified by Rose et al (9) can be attributed to using a lower iodine concentration in iodised salt (45mg iodine/ kg salt) and the assumption that 90% of sodium in bread comes from salt.

Iodine intakes

Both the baseline and post-fortification mean iodine intakes were calculated using the second day adjustment method in the DIAMOND computer program. The second-day adjustment method provides a better estimate of usual intakes compared to using single day iodine intake data only.

The estimated mean iodine intakes at baseline, using the consumer behaviour model excluding discretionary iodised salt with second-day adjusted data, were 43µg, 47µg and 51µg for children 5-8, 9-13 and 14 years of age respectively. These estimates are slightly less than reported in the FSANZ Final Assessment Report for Mandatory Fortification in New Zealand, which was based on single-day unadjusted data provided by the Life in New Zealand (LINZ) Applied Research Institute at Otago University. These were 50µg, 54µg and 64µg for children 5-8, 9-13 and 14 years of age respectively (15,25). The difference in mean iodine intakes between this report and the LINZ data is likely due to second-day adjusted data reducing within-person variation and differences in dietary modelling techniques used.

The discretionary salt model, whereby 48µg iodine was added to dietary iodine intakes for select respondents at baseline and post-fortification, provides the most likely estimate of iodine intakes for 5-14 year old children. Daily mean iodine intakes in this model increased from 79 to 126µg/day, 85 to 138µg/day and 93 to 151µg/day in children aged 5-8, 9-13 and 14 years respectively. Overall, iodine intakes increased from 83 to 135µg/day in all children aged 5-14 years.

In a study of Dunedin school children by Rose et al (9), iodine intakes were estimated to be 75-104µg/day post-fortification. Our results are not inconsistent with this study and closer to the higher end of this range. Aspects of the methodology used in this study are comparable to ours, although iodine concentrations of bread were only estimated in this study. Using single

day unadjusted data, FSANZ reported that estimated iodine intakes would be 106µg for 5-8 year olds, 119µg for 9-13 year olds and 137µg for 14 year olds at post-fortification (15,25). These estimates are slightly higher than what was found in our study, and did not take into account second-day adjusted intakes.

Iodine intakes in relation to the EAR and UL

The percentage of a population with estimated iodine intakes below the EAR provides information on the prevalence of inadequate iodine intakes (2,19). For children 5-8, 9-13 and 14 years of age, the EARs are 65, 75 and 95µg/day respectively (19). In contrast, the percentage of a population with estimated iodine intakes above the UL estimates the percentage of the population at potential risk of adverse effects from excess iodine intakes (19). For children 5-8, 9-13 and 14 years of age, the ULs are 300, 600 and 900µg/day respectively.

In our study, the percentage of children with iodine intakes less than the EAR decreased considerably across all age groups and in all three discretionary salt models at post-fortification. Results of the two consumer behaviour models that include and exclude discretionary iodised salt illustrate the potential impact of discretionary iodised salt use and the fortification of bread, respectively, on iodine intakes of all children 5-14 years of age. The consumer behaviour model that excluded discretionary iodised salt reduced the percentage of all children below the EAR by 77% (from 95% at baseline to 18% at post-fortification) demonstrating the positive effect of fortification of bread with iodine alone. For the consumer behaviour model that included 48µg iodine (from 1g of iodised salt) for all children, the percentage of children below the EAR reduced from 7% at baseline to 0% post-fortification. The 18% reduction in the percentage of children below the EAR, between the two consumer behaviour models at post-fortification, can be attributed to the addition of 1g of discretionary iodised salt (at 48µg) per person, per day. The CNS02 salt behaviour model reported a more likely reduction in the prevalence of inadequate intakes from 38% at baseline to 4% at post-fortification.

In terms of monitoring the effectiveness of the mandatory fortification of bread with iodine, our results found that regardless of which discretionary iodised salt model was used, the DFR 5 performance monitoring target of 70% of school-aged children achieving adequate iodine intakes post-fortification was achieved.

Overall, the results demonstrate the positive impact mandatory fortification of bread with iodine and the contribution iodised salt may make on the iodine intakes of children 5-14 years of age. The current New Zealand Ministry of Health recommendations for young children and adolescents around the use of salt include *"if using salt, choose iodised salt"* (26). This message remains an important one if children are to achieve adequate iodine intakes from food alone at current fortification levels.

In all three discretionary salt models, less than one percent of children in all age and gender categories had iodine intakes higher than the UL at post-fortification. These results show that not only has fortification of the bread supply with iodine been effective in reducing the prevalence of children below the EAR, it has also been effective in preventing children from consuming excessive iodine intakes even when discretionary iodised salt is included in the diet.

Food contributors to iodine intakes

Of the 122 foods analysed in the 2009 New Zealand Total Diet Study (NZTDS), mussels (1.88 mg/kg), oysters (1.74 mg/kg) and eggs (0.47 mg/kg) provided the highest concentrations of iodine. Despite these concentrations, dairy foods, other animal sources (eggs, mussels, fresh fish and oysters) and takeaways (a meat pie, hamburger, Chinese dish, and pizza) provided the majority of iodine in the diet for an 11-13 year old male (27). Although recent, this study did not include bread fortified with iodine.

In our study, the amount of iodine provided per slice of bread (30-45g) was estimated to be between 10 – 24µg, depending on the type of bread. Post-fortification, bread was the major food contributor to iodine intakes (47.2%) providing almost half of the dietary iodine intakes of 5-14 year olds. Bread was defined to include rolls, pita breads, fruit buns and flat breads. Iodine from sandwiches, filled rolls, pita breads and bagels were not included in the bread category, but were captured under bread-based dishes. Iodine intake from bread-based dishes increased from 1.5% to 3.6% at post-fortification. The overall iodine intake from bread is therefore likely to be closer to 50%.

At post-fortification, milk and dairy products became the second highest contributor to iodine intakes; declining from 40.4% at baseline to 19.9% post-fortification. This decline is primarily due to the increase in iodine intake from bread, as dietary intakes remained constant. The baseline results are relatively consistent with those found in the 2009 NZTDS, where dairy foods were the primary contributor to iodine intakes in 11-13 year olds (27).

Our study did not estimate iodine intakes from discretionary iodised salt due to the lack of data available. It is, however, likely that iodised salt provides some iodine to the diet of children 5-14 years of age. Results from the recent 2008/09 National Adults Nutrition Survey found that 16.3% of males and 14.7% females always add salt to food after cooking or preparation (11). Of those who used salt in the home, 85.7% used iodised salt (11). New Zealand manufacturer of iodised salt, Dominion Salt Ltd, report that approximately 70% of iodised salt for retail sale in New Zealand is iodised (28).

Sampling issues

The sampling methodology included the collection of 480 breads in total, however sodium and iodine concentrations were obtained for 530 breads. The higher sample size was due to too many low and too few high market share breads accidentally being collected in one region. To ensure an adequate sample size of high market share breads, additional high market share breads were collected in the region and analysed. The extra data on low market share breads, which included extra white, mixed grain, wholemeal, rye and fruit breads was not discarded as it was considered that additional samples would improve the accuracy and precision of mean iodine concentrations of bread categories.

One of the problems encountered was the unavailability of some bread products in retail locations during bread collection. We discovered that this was due to use of older market share data in determining the bread list. It appeared that manufacturers had not only undertaken to update the labelling of the bread product by changing "salt" to "iodised salt" in the ingredients list, during the transition phase of the introduction of mandatory fortification, but also the packaging design and bread product names. Samplers were advised to find the closest match the bread descriptor provided.

Although this survey was not intended to be a compliance and investigation survey, it was apparent that two of the 530 breads collected did not contain iodised salt. It is recommended that the manufacturer be contacted to advise them of the finding as it is possible that they are not aware of the mandatory fortification requirements.

Limitations

Dietary intake assessments rely on robust food composition data. Due to the poor reliability of iodine concentrations in the New Zealand Food Composition Database (NZFCDB), iodine intakes were not measured in the most recent New Zealand Adult Nutrition Survey (29). To overcome the limitations associated with using the NZFCDB data alone, the iodine concentrations used in our dietary modelling work were a combination of data from the NZFCDB and the 2003/04 NZTDS. The iodine concentrations provided from the 2003/04 NZTDS are analytical values, unlike the NZFCDB which contains both analytical and estimated values. In our study, best efforts have been made to use representative iodine concentrations from the information available.

This bread survey was limited to measuring iodine concentrations of key bread categories such as white, wholemeal and mixed grain breads. Bread products such as hamburger buns, paninis or pita bread were not included despite mandatory fortification requirements applying to these bread products. In order to ensure the best estimate of iodine intakes post-fortification, assumptions regarding the iodine content of these products had to be made. For example, the assumption was made that white hamburger buns and white pita breads have same iodine concentration as white bread.

The CNS02 survey data was collected in 2002 and is the most recent national consumption data available for children 5-14 years of age. Our iodine intake estimates assume that food consumption patterns of children, in particular iodine-containing foods, have not changed significantly between 2002 and 2011.

Conclusion

Two years following the introduction of mandatory fortification of bread with iodine, results of our dietary modelling illustrate the success of mandatory fortification on the iodine intakes of children aged 5-14 years of age.

Iodine intakes have increased considerably resulting in a reduction in the prevalence of children with inadequate iodine intakes from approximately 38% to 4%. Less than one percent of children in all age and gender groups were found to be at risk of consuming excessive iodine intakes. The first of a five-year mandatory iodine fortification performance monitoring target of 70% of school-aged children achieving the ideal range for dietary iodine intakes has also been met.

Of the key food groups (which exclude discretionary iodised salt) bread is now the most significant contributor to iodine intakes of children 5-14 years age, followed by milk and dairy products.

In future monitoring surveys of bread fortification, it would be useful to investigate the iodine concentration of other bread type products which are required to meet the mandatory fortification permissions, such as pita breads, burger buns and paninis. This will enable a

more accurate estimate of the contribution bread makes to iodine intakes, and therefore overall iodine intake.

It is proposed that a further post-fortification survey commence in 2012 to continue monitoring changes in the iodine concentration of bread and estimated iodine intakes of children 5-14 years of age.

Appendices

APPENDIX 1. ASSUMPTIONS FOR MATCHING BREAD CODES IN ANALYTICAL SURVEY WITH CHILDREN'S NUTRITION SURVEY (CNS02) BREADS

The following assumptions were made in order to match breads collected in our survey with those breads reported in the 2002 CNS02.

Bread categories

- Bread/ rolls/ hamburger buns = White bread, where not specified
- Bagels = white bread, where type of bagel is not specified
- French bread, plain panini = White bread
- Where wheatmeal featured in a descriptor = Wholemeal
- Where oatbran featured in a descriptor = Wholemeal
- Grain = Mixed grain
- Soy and linseed = Mixed grain
- Seed toppings were ignored in determining bread categories
- Hamburger buns with sesame seeds = White bread
- Wholemeal buns/ rolls with and without seeds = Wholemeal bread
- Where organic features in the descriptor = Organic bread
- Where wholemeal with grain features in the descriptor = Mixed grain

Other products

- Gluten free bread with no other descriptor = White bread
- Coconut buns - assume contain iodised salt – Samoan style meets the bread definition. (Coconut buns reported in the CNS02 may also have been interpreted to be sticky boston/ raspberry-styled buns with coconut on top, which are required to contain iodised salt) = White bread
- English muffins/ muffin splits = White bread
- Fruit muffin splits = Fruited bread
- Hot cross buns = Fruited bread
- Cheese/ cheese and bacon muffin splits = White bread (the basic English muffin recipe would be used in DIAMOND computer program to ensure that any sodium provided by cheese and bacon will not be included)
- Assume "pita bread white" and "pita bread not specified"= White bread
- Lebanese flat bread – assume contains yeast (according to recipe search) = White bread.
- Naan/roti = White bread
- Homemade breads - assume that iodised salt is used
- Breadcrumbs to be fortified and products containing breadcrumbs assumed to be impacted by fortification

Retention factors

- Retention factor of 1.1 applied to toasted breads (the concentration of iodine in toasted bread is higher compared to un-toasted bread which contains more moisture).
- 'Toasted muffin" recipes take moisture loss into account already, therefore a retention factor need not be applied.

- All breads with descriptor "NS Fresh/Toasted" are assumed to be fresh. However muffins and crumpets with this descriptor are assumed to be toasted, as they are more likely to be eaten toasted than not.

Exclusions

- Those bread products not containing yeast were excluded from bread matching as only bread contain yeast is required to be fortified with iodine. I.e. tortillas, chappattis and damper (according to recipe searches), paraoa bread, fry bread and rewena bread.
- Brioche is not impacted by fortification
- Breadmixes are not impacted by fortification (i.e. do not contain iodised salt - as per online product scan)

APPENDIX 2. DISCRETIONARY SALT DECISIONS FOR THE CNS02 SALT BEHAVIOUR MODEL

Using the 2002 CNS02 report, we identified several questions in the "Food Habits" questionnaire which could provide us with data to estimate users of iodised discretionary salt.

The four relevant questions asked were:

> 6a. Does the person who prepares your meals add salt when they are cooking?
> i) Yes, usually
> ii) Yes, sometimes
> iii) No
> iv) Don't know
>
> 6b. Is it iodised?
> i)Yes
> ii) No
> iii) Don't know
>
> 7a. Do you add salt to your meals at the table?
> i) Yes, usually
> ii) Yes, sometimes
> iii) No
> iv) Don't know
>
> 7b. Is it iodised?
> i) Yes
> ii) No
>   iii) Don't know

Using these questions, we identified likely users of discretionary iodised salt. The decision making process used is as follows:

Discretionary iodised salt users

Questions 6a and 7a – Discretionary salt use

1. If the answer to 6a AND 7a is Yes usually or Yes sometimes, then we assume they are **a consumer of discretionary salt.**

2. If the answer to either 6a OR 7a is Yes usually or Yes sometimes (and vice versa), then we assume they are **a consumer of discretionary salt.**

3. If the answer to both 6a AND 7a are No or Don't Know (and vice versa), then we assume they are not a consumer of discretionary salt.

Questions 6b and 7b – Discretionary iodised salt use

For those identified consumers of discretionary salt **from points 1 and 2 above**:

4. If the answer to both 6b AND 7b are Yes, then we assume they are **a consumer of iodised discretionary salt at 48mg/kg salt**

5. If the answer to either 6b OR 7b is Yes, then we assume they are **a consumer of iodised discretionary salt at 48mg/kg salt**

6. If the answer to both 6b AND 7b is No, then we assume they are **not a consumer of iodised discretionary salt (0mg iodine/kg salt).**

7. If the answer to 6b AND 7b is 'Don't know' and 'No' OR 'No' and 'Don't know' then we assume they are **not a consumer of iodised discretionary salt (0mg iodine/kg salt)**

8. If the answer to both 6b AND 7b is Don't Know, then we assume they are **not a consumer of iodised discretionary salt (0mg iodine/kg salt)**

Level of iodisation of discretionary salt

48mg iodine per kg salt will be applied to those consumers identified in 4 and 5 above (consumers of iodised discretionary salt). 48mg iodine/ kg salt was based on results of a 2009 study by Thomson[2] on levels of retail salt.

0mg iodine /kg salt will be applied to those consumers identified in 6,7, and 8 above (NOT consumers of iodised discretionary salt).

Amount of discretionary salt

Use 1 gram discretionary salt as per the bread fortification scenarios developed by the LINZ Applied Research Unit in 2007. [3]

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[2] Thomson, B. Levels of Iodine in New Zealand Retail Salt – Prepared as part of a New Zealand Food Safety Authority contract for scientific services, CFS/08/06. 2009
[3] Blakey CW, Parnell WR, Wilson NC. Iodine Fortification II. Report No. 2007.145. LINZ Applied Research Unit, Dunedin, New Zealand: University of Otago. 2007.

References

(1) National Academy of Sciences - Panel on Micronutrients, Subcommittees on Upper Reference Levels of Nutrients and of Interpretation and Use of Dietary Reference Intakes, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes,. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium and Zinc. 2000.

(2) Gibson RS. Principles of Nutritional Assessment. 2nd ed.: Oxford University Press; 2005.

(3) FSANZ (Food Standards Australia New Zealand). Australia New Zealand Food Standards Code. 2002;115:Chapter 1 General Food Standards-Chatper 4 Primary Production Standards (Australia Only).

(4) Skeaff S, Thomson C, Gibson R. Mild iodine deficiency in a sample of New Zealand schoolchildren. Eur J Clin Nutr 2002;56(12):1169-1175.

(5) Thomson CD, Woodruffe S, Colls AJ, Joseph J, Doyle TC. Urinary iodine and thyroid status of New Zealand residents. Eur J Clin Nutr 2001 May;55(5):387-392.

(6) Thomson CD, Smith TE, Butler KA, Packer MA. An evaluation of urinary measures of iodine and selenium status. Journal of Trace Element in Medicine and Biology 1996;10.

(7) Thomson CD, Colls AJ, Conaglen JV, Macormack M, Stile M, Mann J. Iodine status of New Zealand residents as assessed by urinary iodide excretion and thyroid hormones. British Journal of Nutrition 1997;78:901.

(8) Skeaff SA, Ferguson EL, McKenzie JE, Valeix P, Gibson RS, Thomson CD. Are breast-fed infants and toddlers in New Zealand at risk of iodine deficiency? Nutrition 2005;21:325.

(9) Rose M, Gordon R, Skeaff S. Using bread as a vehicle to improve the iodine status of New Zealand children. 2009;122(1290):14.

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

(11) Otago University. A focus on nutrition: Key findings of the 2008/09 New Zealand Adult Nutrition Survey. 2011.;Report No.: HP 5412.:i-333 p.

(12) Thomson CD, Skeaff SA. Iodine status and deficiency disorders in New Zealand. In Preedy V.R., Burrow G.N. and Watson R.R. Comprehensive Handbook of Iodine - Nutritional, Biochemical Pathological and Therapeutic aspects. 2009:1252.

(13) Fecher PA, Goldmann I, Nagengast A. Determination of iodine in food samples by inductively coupled plasma mass spectrometry after alkaline extraction. J Anal At Spectrom 1998;13(9):977-982.

(14) Thomson B. Levels of iodine in New Zealand retail salt. Prepared as part of a New Zealand Food Safety Authority contract for scientific services. 2009;CFS/08/06.

(15) FSANZ (Food Standards Australia New Zealand). Proposal P230: Consideration of mandatory fortification with iodine for New Zealand: Final Assessment Report. 2008.

(16) Crop and Food Research. FOODFiles 2006. 2010; Available at: http://www.crop.cri.nz/home/products-services/nutrition/foodcompdata/fcd-products/fcd-foodfiles/Components-in-FOODfiles-2004.pdf. Accessed July/21, 2010.

(17) Crop and Food Research. The 8th Edition of the Concise NZ Food Composition Tables. 2010; Available at: http://www.crop.cri.nz/home/products-services/nutrition/foodcompdata/Concise_8_Edition.pdf. Accessed July/21, 2010.

(18) Kirkwood BR, Sterne JAC. Essential Medical Statistics. 2nd ed. Oxford: Blackwell Science Ltd; 2003.

(19) National Health and Medical Research Council. Nutrient Reference Values for Australia and New Zealand Including Recommended Dietary Intakes. 2006.

(20) FSANZ (Food Standards Australia New Zealand). Nutrient Reference Values in the Australia New Zealand Food Standards Code - Potential Revision Consultation Paper. 2010;[11 - 10].

(21) Thomson BM, Jones S. Sodium and Iodine Levels in Bread. Prepared as part of a New Zealand Food Safety Authority contract for scientific services. 2009;FW0917.

(22) World Health Organization, Unicef, International Council for the Control of Iodine Deficiency Disorders. Assessment of iodine deficiency disorders and monitoring their elimination: a guide for program managers. 2007;3rd edition.

(23) Plant and Food Research. New Zealand Food Composition Database: Nutrition Information Panel. Available at: http://www.foodcomposition.co.nz/nip-database/search?keyword=bread+raisin&food_id=&search=Search. Accessed December, 2011.

(24) Campbell A. Bread manufacturer: Coupland's Bakery. 25 October 2011.

(25) Blakey CW, Parnell WR, Wilson NC. Iodine Fortification II. 2007;2007.145.

(26) McIntyre L. Personal Communication. Ministry of Health. October 2011.

(27) Vannoort RW, Thomson BM. 2009 New Zealand Total Diet Study: Agricultural compound residues, selected contaminant and nutrient elements. 2011.

(28) Hobson B. Personal Communication. Dominion Salt Ltd. July 2011.

(29) Otago University. Methodology Report for the 2008/2009 New Zealand Adult Nutrition Survey. 2011;Report No.: 5404.:i-91 p.