



**SODIUM AND IODINE LEVELS
IN BREAD**

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IN BREAD**

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ABBREVIATIONS AND DEFINITIONS

CI	Confidence interval. A statistical range with a specified probability (in this report 95% or 90%) that the true value (usually the mean) lies within the interval
CL	Confidence limits. The boundaries of the confidence interval
CV	Coefficient of variation, equal to the standard deviation of results divided by the mean of results, expressed as a percentage.
Label claim	Nutrient value stated in the nutrition information panel on the product label. For the purposes of this report label claim refers to sodium.
Na	The chemical abbreviation for sodium
NIP	Nutrition information panel
NZFSA	New Zealand Food Safety Authority
NZTDS	New Zealand Total Diet Survey
Overage	The measured amount that exceeds the amount of sodium claimed on the nutrition information panel of the food item.
Underage	The measured amount that is below the amount of sodium claimed on the nutrition information panel of the food item.

SUMMARY

The aim of this work was to provide information on the sodium and iodine concentration in a range of commercially produced bread currently being sold in New Zealand to:

- allow a comparison of analysed sodium concentration with label claim,
- compare values from this project with values from previous projects to determine whether sodium levels in bread have changed, and
- identify baseline values for iodine levels in bread which will be used as an integral part of monitoring the food supply post implementation of mandatory iodine fortification of bread in 2009.

Five batches of 25 breads were purchased from retail outlets in Auckland, Napier, Christchurch and Dunedin during October and November 2008. Information on purchase price and level of sodium claimed in the NIP on the product label were recorded. The latter was used as the basis for comparison with the measured level.

Samples were ashed in a muffle furnace and analysed for sodium concentrations by atomic emission spectroscopy. Samples for iodine analysis were digested with tetramethylammonium hydroxide (TMAH), filtered and analysed by inductively coupled plasma-mass spectrometry (ICP-MS). Breads were also analysed for moisture content.

The concentration of sodium claimed on labels ranged from a low of 205mg/100g in a rice bread to a high of 830mg/100g for crumpets, with a mean of 465mg/100g across 99 breads.

The mean measured concentration of sodium in the 100 selected breads, as purchased, ranged from 165mg/100g in a rice bread from Auckland to 856mg/100g in crumpets purchased in Napier. Most breads (83%) contained between 350 - 550mg Na/100g bread. A few breads (2%) contained less than 350mg Na/100g bread and 15% of breads, from five different brands, contained more than 550mg Na/100g bread.

A comparison of the results for different batches of the same product showed variability, including both measurement (analytical) uncertainty and batch variability measured as CV, ranging from 1-18% for sodium in bread. The inter batch variability for sodium in bread was less than half that found for various food fortificants previously analysed (calcium, folate, selenium in infant formula, vitamin A, vitamin C, vitamin D and zinc).

Some differences were observed in the mean measured sodium concentrations in six of the 10 breads, that were common to all four regions, with a trend for breads from Auckland to have lower sodium concentrations than the same breads purchased in Napier, Christchurch or Dunedin.

Measured levels were compared with label claims using two criteria. Based on criterion A, whereby the label claim falls within the 95% CI of the measured value, 61% of breads met the label claim, 21% of breads contained more sodium than claimed with overages ranging from 3 - 67%, and 18% of breads contained between 7% - 21% less sodium than claimed on the label.

Applying criterion B that included a 90% CI of the measured value and a tolerance of ± 150 mg or $\pm 30\%$ of the label claim, depending on the level of sodium in the bread, 90% of breads met the label claim and 10% contained more sodium than claimed. (Note: The 90% CI in

this test is akin to using 95% confidence intervals to establish a difference). None of the breads contained less sodium than claimed, based on criterion B.

Cheaper breads did not have a higher concentration of sodium than more expensive breads on a national basis. But when evaluated by region, there was a trend for cheaper breads in Christchurch, Dunedin and Napier to contain more sodium than more expensive breads in these regions. This trend was strongest for Christchurch followed by Dunedin then Napier, with no association between purchase price and sodium concentration for breads from Auckland. When evaluated by bread type, there was a trend for sodium concentration to be higher in cheaper “other” breads category that included brown rice, ciabatta, crumpets, foccacia, rice, seed and sourdough breads, compared with more expensive breads in this category.

Average sodium concentrations in New Zealand white and wheat breads have declined by about 100mg/100g since 1990.

The concentration of iodine in 100 breads ranged from less than the limit of detection, generally <0.010 mg/kg, to a maximum of 0.046mg/kg, consistent with levels found in the 2003/04 New Zealand Total Diet Survey. The measured concentrations of iodine reflected that none of the breads were manufactured with iodised salt.

1 INTRODUCTION

The effective management of risks in the food supply is an essential New Zealand Food Safety Authority (NZFSA) function. It has been estimated that many New Zealanders consume too much sodium (Thomson et al., 2008). Most of this sodium comes from processed foods, with bread making the single greatest contribution to sodium intake from processed food, accounting for 35-43% (Thomson, 2009). There is a causative link between sodium intake and blood pressure (SACN, 2003, WHO, 2007). Approximately one in five New Zealand adults has high blood pressure and there is convincing evidence that modest reductions in sodium intake can reduce blood pressure in adults with and without high blood pressure (Russell et al., 1999, He and MacGregor 2007).

There is already significant work going on to implement voluntary and mandatory controls on sodium. For example, The National Heart Foundation of New Zealand and the New Zealand bread industry are working together on a voluntary initiative to reduce the sodium content of low cost and high volume packaged breads. This initiative is estimated to remove 100-150 tonnes of salt per annum from the food supply (Namalie Jayasinha, National Heart Foundation, personal communication, May 2009). Additionally, in compliance with labelling requirements in the Australia New Zealand Food Standards Code salt and sodium-containing additives must be identified in the Ingredients List on food labels. The total sodium concentration of packaged foods (including naturally occurring sodium, sodium from additives and added salt) must also be declared on the Nutrition Information Panel (NIP) on the food label (Standard 1.2.8, FSANZ 2009).

Up-to-date compositional information on the sodium content of bread will be useful in monitoring changes to the food supply and determining the relative success of voluntary controls in reducing consumer's intake of dietary sodium.

Conversely, the average iodine exposure in New Zealand is only about half the recommended level for all population groups (Thomson et al., 2008). To redress low iodine exposure, the fortification of bread with iodised salt will become mandatory in September 2009 (Standard 2.1.1, FSANZ 2009). NZFSA and the Ministry of Health will be jointly responsible for monitoring the food supply for iodine content post September 2009.

The initiatives to reduce the salt concentration of bread will have a flow-on effect to the expected increase in iodine levels in the general population because the salt concentration of bread will be less than that used in the dietary modeling for iodine fortification. It is essential that on-going monitoring is conducted to ensure the safety and efficacy of foods that are mandatorily fortified. Such information will be necessary for making comparisons post fortification.

At present there are no tolerances defined around nutrient label claims in New Zealand and there are limited international precedents. The Danish regulators allow a tolerance of $\pm 15\%$ for sodium (EC, 2006). Local Authorities Coordinators of Regulatory Services (LACORS), a local government central body responsible for overseeing local authority regulatory and related services in the UK, has prepared draft guidance on tolerances to be applied to Nutrition Labelling Declarations. LACORS has proposed a guideline tolerance of $\pm 30\%$ where the label claim for sodium is greater than 0.5% of the food product, and $\pm 0.15g$ where the sodium claim is less than or equal to 0.5% of the food product (Terry Ryan, NZFSA personal communication, March 2009).

The aim of this work was to provide information on the sodium and iodine concentration in a range of commercially produced bread currently being sold in New Zealand for three purposes, namely:

- 1) to compare analysed sodium concentration with label claim; and
- 2) to compare values from this project with values from previous projects to determine whether sodium levels in bread have changed; and
- 3) to identify baseline values for iodine levels in bread which will be used as an integral part of monitoring the food supply post implementation of mandatory fortification of bread with iodised salt in 2009.

These results will be used to provide a body of evidence to enable robust decisions to be made as to whether the iodine level in salt might need reviewing.

2 MATERIALS AND METHODS

2.1 Selection of Foods for Inclusion in the Study

Breads were selected from a list of sales volumes based on supermarket barcode data supplied by Synovate Aztec, for the quarter June-September 2007 (Jason McLaughlin, Plant & Food, personal communication, November 2007). Data were available for 208 different packaged breads from both Progressive and Foodstuffs outlets, but excluded private label volume sales (e.g. Signature Range, Budget and Homebrand breads). Bread type was defined by the Synovate Aztec subcategory.

Eight breads, accounting for 33% of sales volumes, were sampled in each of four regions (Auckland, Napier, Christchurch and Dunedin). A further nine breads, which varied from region to region depending on availability, were randomly selected for analysis. These nine breads together with the top eight breads accounted for 80% of production. A further six samples of bread were randomly selected from the breads with low sales volume. Two private label white breads, one each from a Progressive and a Foodstuff outlet, were purchased in each of the four regions making a total of 25 different breads purchased in each of the four regions.

Five different batches of each of the 25 breads were purchased from retail outlets in the four regions in October and November 2008.

The level of sodium claimed in the NIP on the product label was recorded, and used as the basis for comparison with the measured level. The purchase price of the bread was also recorded.

2.2 Laboratory Methodology

2.2.1 Sample preparation

The entire packet of every bread purchased was ground in a domestic blender. The moisture content and iodine concentration was determined for a sub-sample of one batch of each bread product (i.e. 100 samples analyzed for moisture and 100 samples for iodine). All samples for iodine analysis were dispatched frozen to Hill Laboratories. Samples were sent in four consignments, on 14 and 30 October 2008 and 10 and 24 November 2008.

2.2.2 Sodium analysis

An aliquot of each bread was ashed in a muffle furnace at 450°C, the residue dissolved in concentrated nitric acid with caesium chloride as an ionization suppressant. Sodium was determined by atomic emission spectroscopy by the ESR Christchurch Science Centre Food Chemistry Laboratory. The laboratory is accredited by IANZ (International Accreditation New Zealand) to the standard NZS/ISO/IEC/17025, 2.72/5 for this analysis.

2.2.3 Iodine analysis

Samples for iodine analysis were digested with tetramethylammonium hydroxide (TMAH), filtered and analysed by inductively coupled plasma-mass spectrometry (ICP-MS) by Hill laboratories, Hamilton, based on methodology of Fecher et al., (1998), in accordance with IANZ accreditation requirements.

2.2.4 Moisture

The moisture content of samples was determined by oven drying at $102 \pm 3^\circ\text{C}$ at ambient pressure to a constant weight (Kirk and Sawyer, 1991).

2.2.5 Quality control procedures

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

- The analytical repeatability was determined for sodium and iodine by undertaking five analyses of each of three samples representing different types of bread, namely white bread, wheatmeal and heavy grain bread.
- Analytical precision was assessed from spike recoveries, blind duplicates (n=20) and the analysis of certified reference materials. A whole milk powder, PSRM 1069-M-1, was obtained fromASUREQuality, NZ, was used for sodium and NIST 1549, a non-fat milk powder was used for iodine measurements.

2.3 **Data analysis**

The mean and standard deviation of the reported sample results were calculated. From these the coefficient of variation (CV), and the 95% and 90% confidence intervals (CI) and confidence limits (CL) of the mean, were also calculated according to standard statistical methods (TELARC, 1987).

Analytical repeatability was assessed on the basis of the CV.

The relationship between the label claim for sodium and the measured concentration was assessed in two ways:

Criterion A

Was the label claim within the 95% confidence limits of the measured sample mean?

For those samples where the label claim was outside of the confidence limits, the percent overage or underage was calculated using the following formula.

$$\% \text{ overage/underage} = \frac{\text{mean concentration} - \text{label claim}}{\text{label claim}} \times 100$$

Criterion B

Was the measured sample mean $\pm 90\%$ CL within the tolerances for sodium recommended by LACORS, namely,

- within the label claim $\pm 30\%$ of label claim, where the declared concentration of sodium was $> 500\text{mg}/100\text{g}$ OR
- within the label claim $\pm 150\text{mg}$, where the declared concentration of sodium was $\leq 500\text{mg}/100\text{g}$?

3 RESULTS

3.1 Assessment of data quality

Sodium

The intra-sample variability or repeatability, for the analyses of sodium in bread, expressed as CV, were 1, 6 and 7% for, a wheatmeal bread, a heavy health bread and a white bread respectively (Appendix 1.1). The intra-sample CVs for the batch and blind duplicates ranged from 0.2-11.9 (Appendices 1.2 and 1.3) and were predictably higher than the repeatability results since they are based on duplicate analyses rather than five analyses, resulting in less precise estimates of the mean and thence higher CVs.

The measured concentration of sodium in the certified reference material varied from 279.4 - 412.8mg/100g (n=27). The mean measured concentration (350.6mg/100g) of the certified reference material was just outside the 95% but within the 90% confidence interval, of the certified value (346.3mg/100g) (Appendix 1.4).

The recovery of sodium from spiked samples ranged from 85 - 127%.

Iodine

The repeatability of iodine in bread, expressed as intra-sample CV of five analyses were 56% for white bread and 16% for heavy health bread (Appendix 1.6). The high value for the white bread is because the measured amounts of iodine were very low and close to the limit of detection of the assay, i.e. 56% of a small number is a small number. The intra-sample CVs for the five batch and blind duplicates above the limit of detection ranged from 6.4 - 25% (Appendix 1.7).

The mean measured concentration of iodine in the certified reference material (3.28 ± 0.1 , n=7) was within the 95% confidence interval of the certified value (3.28 ± 0.2 mg/kg).

The recovery of iodine from samples spiked at 0.2 and 1.0 mg/kg ranged from 100-125% and 96-110% respectively.

Together these quality assurance data give confidence in the analytical results for both sodium and iodine.

3.2 Concentration of sodium and iodine in breads

The mean measured concentration of sodium for five batches of each of the 100 selected breads, as purchased, ranged from 165mg/100g in a rice bread from Auckland to 856mg/100g in crumpets purchased in Napier. The average sodium concentration across the 100 breads was 478mg/100g. Most breads (83%) contained between 350 - 550mg Na/100g bread. A few breads (2%) contained less than 350mg Na/100g bread and 15% of breads, from five different brands, contained more than 550mg Na/100g bread. Results, averaged across five batches of each product are shown, per region, in Tables 1 - 4. A full set of results is included in Appendix 2. The label claims cited in Tables 1 - 4 are those stated in the NIP on the bread label.

The quantity of sodium claimed on labels ranged from a low of 205mg/100g in a rice bread to a high of 830mg/100g for crumpets, with a mean of 465mg/100g across 99 breads. The label claim of one Christchurch bread (Ch14) changed during the duration of the study so the label claim for this bread was not included in the calculation of the mean claimed quantity of sodium.

The measured concentration of iodine ranged from less than the limit of detection, generally < 0.010mg/kg but < 0.030 for a few breads, to a maximum of 0.046mg/kg, consistent with levels found in the 2003/04 New Zealand Total Diet Survey (Vannoort and Thomson, 2005). Bread manufactured with iodised salt would contain in the region of 0.700mg/kg iodine (Thomson, 2007a). Clearly none of the 100 breads were manufactured with iodised salt.

Table 1: Mean concentration of sodium (Na, mg/100g) using two criteria (A and B) compared with label claim, and iodine (mg/kg) in bread purchased in Auckland

Region	Bread	Label Claim Na	Measured Na mg/100g	95% CI for Na	Meets criterion A?	% under/over	90% CI for Na	Meets criterion B?	Iodine conc mg/kg
Auckland	1	450	455	399-512	Y	nil	412-499	Y	<0.010
	2	450	414	371-457	Y	nil	381-447	Y	<0.010
	3	430	407	370-445	Y	nil	378-436	Y	<0.010
	4	425	368	327-409	N	-13	336-400	Y	<0.010
	5	450	436	387-485	Y	nil	399-473	Y	<0.010
	6	500	442	415-468	N	-12	421-462	Y	<0.010
	7	445	432	387-478	Y	nil	397-467	Y	<0.010
	8	450	431	392-470	Y	nil	401-461	Y	<0.030
	9	450	406	380-432	N	-10	386-426	Y	<0.030
	10	510	432	423-440	N	-15	425-438	Y	<0.030
	11	450	415	380-450	N	-8	388-442	Y	<0.030
	12	500	396	356-436	N	-21	365-427	Y	<0.030
	13	400	423	327-519	Y	nil	349-497	Y	<0.030
	14	450	404	396-412	N	-10	398-411	Y	<0.030
	15	430	447	406-487	Y	nil	416-477	Y	<0.030
	16	450	362	321-404	N	-19	331-394	Y	<0.030
	17	450	450	412-489	Y	nil	421-480	Y	<0.030
	18	830	808	754-863	Y	nil	767-850	Y	<0.030
	19	500	505	401-610	Y	nil	425-586	Y	<0.030
	20	205	165	150-180	N	-19	153-177	Y	<0.030
	21	430	377	336-418	N	-12	345-408	Y	<0.030
	22	500	833	673-993	N	67	711-956	N	<0.030
	23	430	428	387-470	Y	nil	397-460	Y	<0.030
	24	505	497	428-566	Y	nil	444-550	Y	<0.030
	25	450	442	401-484	Y	nil	410-474	Y	<0.030

CI=confidence interval, Y = yes, N = no

Criterion A = The label claim was within the 95% CI of the sample mean

Criterion B = The 90% CI of the mean measured level of sodium was either within the label claim \pm 30% of label claim, where the declared concentration of sodium was > 500mg/100g OR within the label claim \pm 150mg, where the declared concentration of sodium was \leq 500mg/100g

Table 2: Mean concentration of sodium (mg/100g) using two criteria (A and B) compared with label claim, and iodine (mg/kg) in bread purchased in Napier

Region	Bread	Label Claim Na	Measured Na mg/100g	95% CI for Na	Meets criterion A?	% under/over	90% CI for Na	Meets criterion B?	Iodine conc mg/kg
Napier	1	450	470	446-494	Y	nil	451-488	Y	<0.010
	2	450	476	440-512	Y	nil	448-504	Y	<0.010
	3	430	402	367-437	Y	nil	375-429	Y	<0.010
	4	425	424	395-452	Y	nil	402-446	Y	0.019
	5	450	478	444-511	Y	nil	452-504	Y	<0.010
	6	500	543	522-563	N	9	527-558	Y	<0.010
	7	445	515	447-582	N	16	463-567	Y	<0.010
	8	450	450	393-508	Y	nil	406-494	Y	<0.010
	9	500	512	428-597	Y	nil	448-577	Y	<0.010
	10	510	452	422-481	N	-11	429-474	Y	<0.011
	11	450	457	445-469	Y	nil	447-466	Y	<0.010
	12	500	464	443-485	N	-7	448-480	Y	<0.010
	13	400	470	391-549	Y	nil	410-531	Y	<0.010
	14	450	465	428-502	Y	nil	436-493	Y	<0.010
	15	430	435	378-492	Y	nil	392-479	Y	<0.010
	16	450	394	383-406	N	-12	385-403	Y	<0.010
	17	450	434	398-470	Y	nil	406-462	Y	<0.010
	18	440	446	422-470	Y	nil	428-464	Y	<0.010
	19	420	408	369-447	Y	nil	378-438	Y	<0.010
	20	360	368	326-410	Y	nil	336-401	Y	<0.010
	21	430	449	382-516	Y	nil	398-501	Y	<0.010
	22	830	856	791-920	Y	nil	806-905	Y	0.030
	23	430	415	386-444	Y	nil	393-437	Y	<0.010
	24	505	502	453-552	Y	nil	464-541	Y	<0.010
	25	450	564	516-613	N	25	527-601	N	<0.010

CI=confidence interval, Y = yes, N = no

Criterion A = The label claim was within the 95% CI of the sample mean

Criterion B = The 90% CI of the mean measured level of sodium was either within the label claim \pm 30% of label claim, where the declared concentration of sodium was $>$ 500mg/100g OR within the label claim \pm 150mg, where the declared concentration of sodium was \leq 500mg/100g

Table 3: Mean concentration of sodium (mg/100g) using two criteria (A and B) compared with label claim, and iodine (mg/kg) in bread purchased in Christchurch (ChCh)

Region	Bread	Label Claim Na	Measured Na mg/100g	95% CI for Na	Meets criterion A?	% under/over	90% CI for Na	Meets criterion B?	Iodine conc mg/kg
ChCh	1	450	438	395-481	Y	nil	405-471	Y	<0.020
	2	450	606	570-642	N	35	579-634	N	0.043
	3	430	410	354-467	Y	nil	367-453	Y	0.042
	4	425	381	315-448	Y	nil	330-432	Y	0.046
	5	450	404	373-434	N	-10	380-427	Y	0.040
	6	500	485	446-523	Y	nil	455-514	Y	<0.010
	7	445	414	345-482	Y	-7	361-466	Y	<0.011
	8	450	439	388-490	Y	-2	400-478	Y	0.019
	9	450	571	533-609	N	27	542-600	N	<0.010
	10	510	507	450-564	Y	nil	463-551	Y	0.035
	11	450	563	491-636	N	25	507-619	N	<0.010
	12	500	451	407-494	N	-10	417-484	Y	0.031
	13	400	466	395-536	Y	nil	411-520	Y	0.028
	14	530/ 450	537	429-645	NA	NA	454-620	NA	<0.010
	15	430	414	362-467	Y	nil	374-455	Y	<0.020
	16	450	497	449-545	Y	nil	460-534	Y	0.023
	17	450	505	431-580	Y	nil	448-562	Y	<0.010
	18	440	392	364-419	N	-11	370-413	Y	<0.010
	19	420	390	358-422	Y	nil	366-415	Y	0.010
	20	360	346	305-388	Y	nil	315-378	Y	0.010
	21	505	505	438-572	Y	nil	453-556	Y	<0.020
	22	830	818	704-932	Y	nil	731-906	Y	0.036
	23	420	450	354-545	Y	nil	376-523	Y	0.015
	24	505	509	415-604	Y	nil	437-582	Y	<0.010
	25	450	572	505-640	N	27	520-624	N	0.023

NA = not applicable as the label changed over the duration of sampling

CI=confidence interval, Y = yes, N = no

Criterion A = The label claim was within the 95% CI of the sample mean

Criterion B = The 90% CI of the mean measured level of sodium was either within the label claim \pm 30% of label claim, where the declared concentration of sodium was $>$ 500mg/100g OR within the label claim \pm 150mg, where the declared concentration of sodium was \leq 500mg/100g

Table 4: Mean concentration of sodium (mg/100g) using two criteria (A and B), compared with label claim, and iodine (mg/kg) in bread purchased in Dunedin

Region	Bread	Label Claim Na	Measured Na mg/100g	95% CI for Na	Meets criterion A?	% under/over	90% CI for Na	Meets criterion B?	Iodine conc mg/kg
Dunedin	1	450	487	521-453	N	8	513-461	Y	<0.010
	2	450	583	601-566	N	30	597-570	Y	<0.010
	3	430	447	467-427	Y	nil	462-432	Y	<0.010
	4	425	402	435-368	Y	nil	428-376	Y	0.011
	5	450	471	484-457	Y	nil	481-460	Y	<0.010
	6	500	524	549-500	Y	5	543-505	Y	<0.010
	7	445	437	457-417	Y	nil	452-421	Y	<0.010
	8	450	464	478-450	Y	3	475-453	Y	<0.010
	9	450	570	624-517	N	27	611-530	N	<0.010
	10	510	529	564-495	Y	nil	556-503	Y	<0.010
	11	450	582	612-553	N	29	605-560	N	<0.010
	12	500	529	558-500	Y	6	551-507	Y	<0.010
	13	400	433	450-416	N	8	446-420	Y	<0.010
	14	450	597	606-587	N	33	604-589	N	<0.010
	15	430	465	475-455	N	8	473-457	Y	<0.010
	16	450	485	529-440	Y	nil	519-451	Y	<0.010
	17	450	488	525-452	N	9	516-461	Y	<0.010
	18	440	440	479-400	Y	nil	470-409	Y	<0.010
	19	420	421	439-402	Y	nil	435-406	Y	0.010
	20	360	379	399-359	Y	nil	394-364	Y	<0.010
	21	505	505	525-485	Y	nil	521-490	Y	<0.010
	22	830	817	907-727	Y	nil	886-748	Y	0.035
	23	405	491	550-431	N	18	537-445	Y	0.039
	24	505	515	589-442	Y	nil	572-459	Y	<0.010
	25	450	612	656-569	N	36	646-579	N	<0.010

CI=confidence interval, Y = yes, N = no

Criterion A = The label claim was within the 95% CI of the sample mean

Criterion B = The 90% CI of the mean measured level of sodium was either within the label claim \pm 30% of label claim, where the declared concentration of sodium was $>$ 500mg/100g OR within the label claim \pm 150mg, where the declared concentration of sodium was \leq 500mg/100g

3.3 Batch Variability

A comparison of the results for different batches of the same product (Appendices 2.1 - 2.4) showed variability, including both measurement (analytical) uncertainty and batch variability measured as CV, ranged from 1 - 18% for sodium in bread. The repeatability results where one sample was measured a number of times, showed measurement uncertainty contributed in the order of 1, 6 and 7% CV for a wheatmeal, a heavy health bread and a white bread respectively (Appendix 1.1).

3.4 Comparison with Label Claim

The mean concentrations of measured sodium, compared with label claims, are shown in Tables 1 - 4 along with the assessment of measured versus label claim using two different approaches. The label claim of one Christchurch bread (Ch14) changed during the duration of the study so that a comparison of the mean measured concentration against label claim was not achievable for this product, resulting in 99 rather than 100 breads for which label comparisons were possible.

Based on Criterion A, whereby the label claim falls within the 95% CI of the mean measured value, 61% (60/99) of breads met the label claim, 21% (21/99) of breads contained more sodium than claimed with overages ranging from 3 - 67%. and 18% (18/99) of breads contained between 7% - 21% less sodium than claimed on the label.

Applying Criterion B, that includes a 90% CI of the measured mean concentration and a tolerance of ± 150 mg or $\pm 30\%$ of the label claim depending on the level of sodium in the bread, 90% (89/99) of breads met the label claim and 10% (10/99) contained more sodium than claimed. None of the breads contained less sodium than claimed, based on Criterion B. These results are presented graphically in Figures 1 - 4 where breads meeting Criterion B are those where the black bar (measured concentration) fits within the dotted red bar (allowable tolerance of the label claim).

The results for Criterion A would be represented by a slightly wider black CI bar (95%) rather than 90% and no red tolerance bar around the label claim. To meet Criterion A the red label claim value would fall within the black bar.

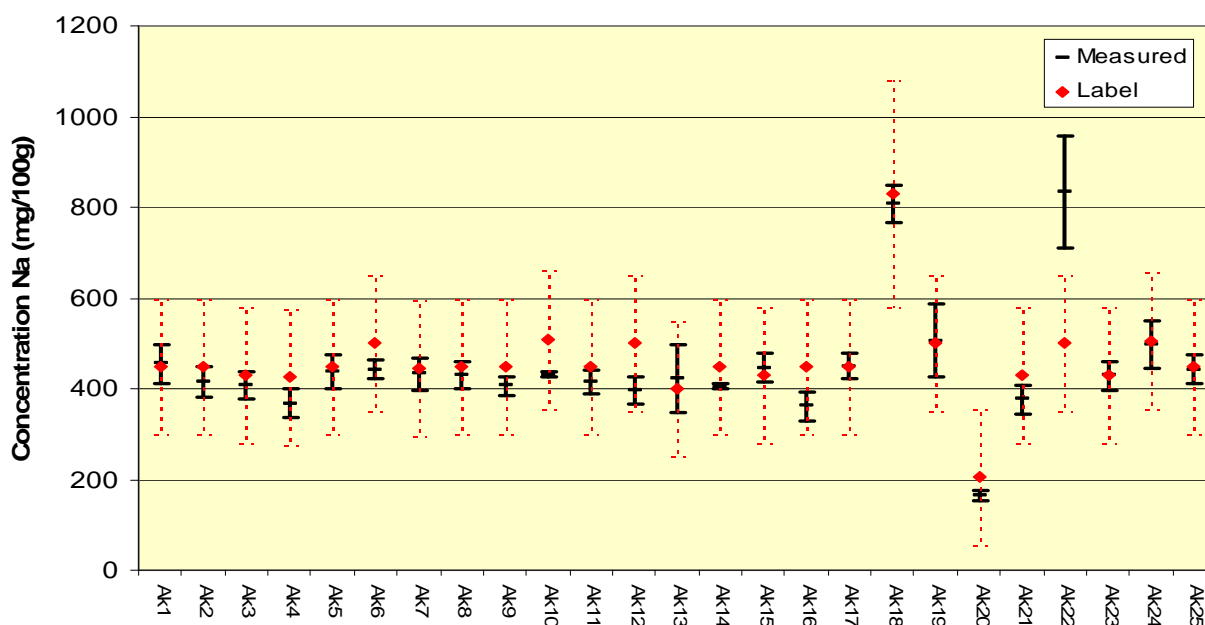


Figure 1: Measured sodium levels of bread purchased in Auckland, compared with label claim using Criterion B. CI (90%, in black) and tolerances (in red).

Using Criterion A, 14 breads in Auckland met the label claim and 24 breads met the label claim using Criterion B.

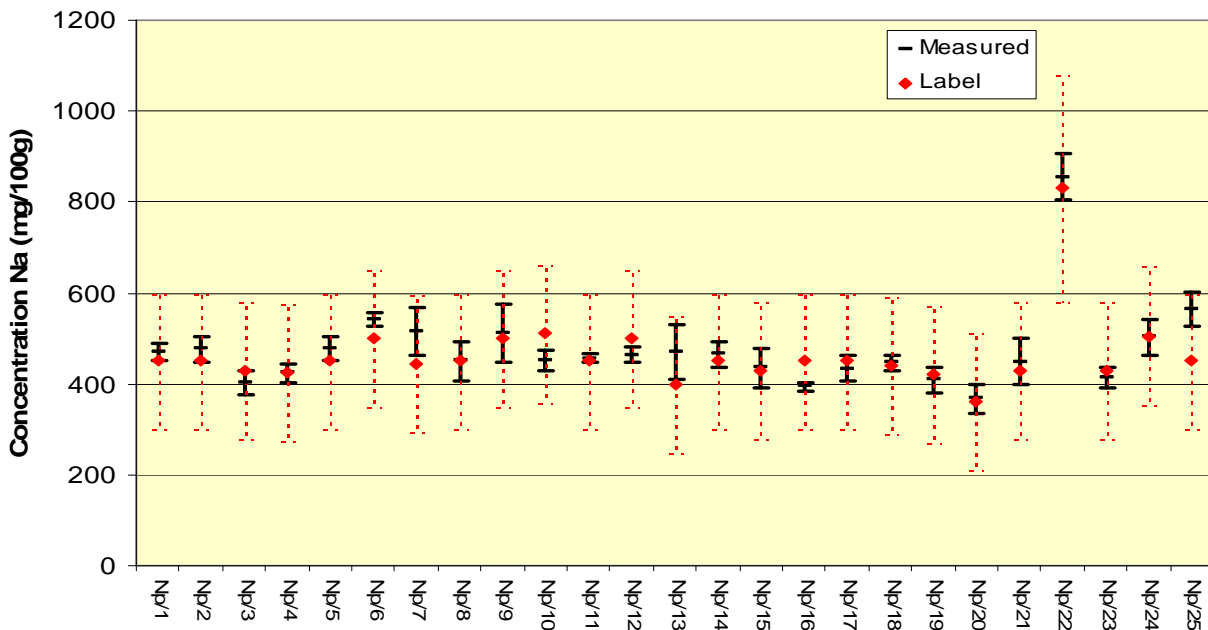


Figure 2: Measured sodium levels of bread purchased in Napier compared with label claim using Criterion B. CI (90%, in black) and tolerances (in red).

Using Criterion A, 19 breads in Napier met the label claim and 24 breads met the label claim using Criterion B.

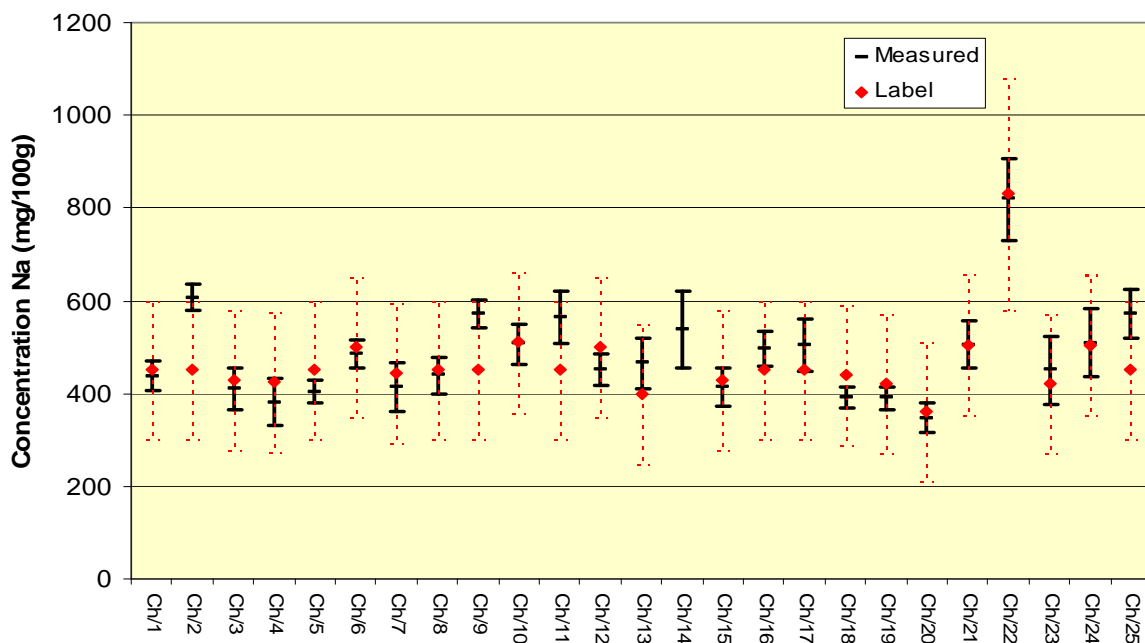


Figure 3: Measured sodium levels of bread purchased in Christchurch compared with label claim using Criterion B. CI (90%, in black) and tolerances (in red).

Using Criterion A, 17 breads in Christchurch met the label claim and 20 breads met the label claim using Criterion B.

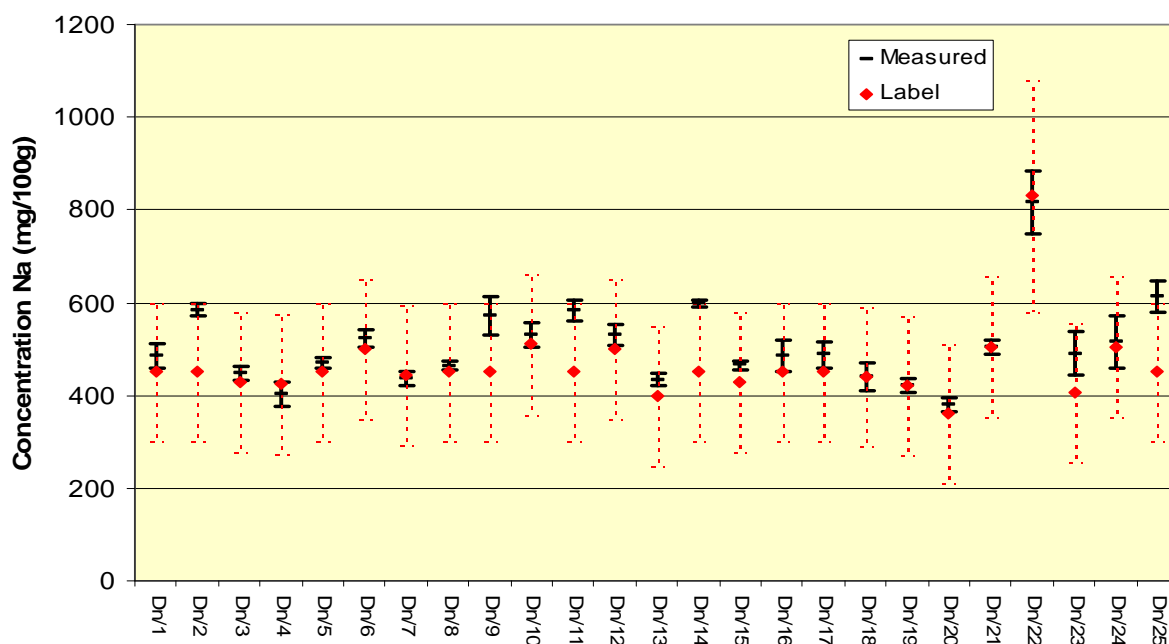


Figure 4: Measured sodium levels of bread purchased in Dunedin compared with label claim using Criterion B. CI (90%, in black) and tolerances (in red).

Using Criterion A 15 breads in Dunedin met the label claim and 21 breads met the label claim using Criterion B.

3.5 Regional differences

Of the 100 breads selected, 10, were purchased in each of the four regions. Generally, the sodium concentration was comparable across regions with a few exceptions (Figure 5).

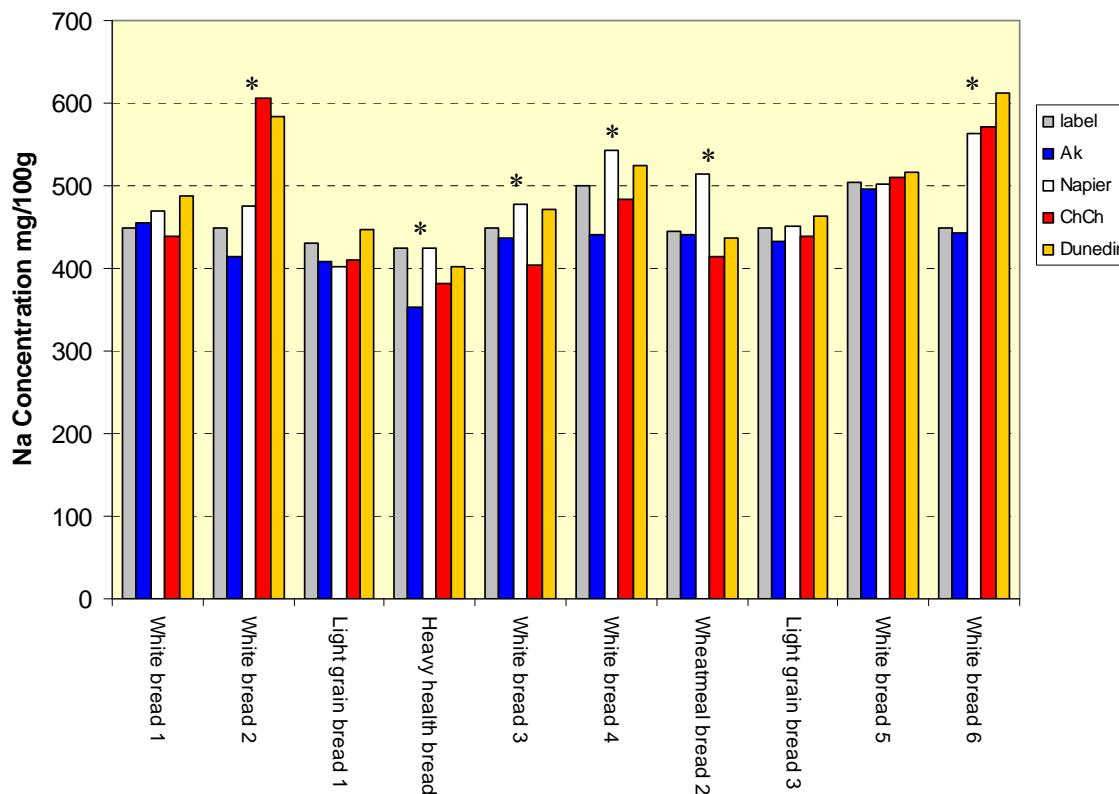


Figure 5: Label claims and mean measured sodium concentration (mg/100g) for five batches of the same 10 breads purchased in four regions. * indicates a statistically significant regional difference between breads.

There was no regional difference between the mean sodium concentrations of four of the breads namely, the White bread 1, Light grain bread 1, Light grain bread 3 and White bread 6 based on a single factor analysis of variance at a 5% level of significance. Some differences were observed in the mean sodium concentrations of the other six breads that were purchased from each region, marked * in Figure 5. The following regions showed statistically significant differences in sodium concentrations on the basis of a Tukey Test (Zar, 1999):

- White bread 2: Auckland and Napier breads contained significantly less sodium than those from Christchurch and Dunedin.
- Heavy health bread: The Auckland bread contained significantly less sodium (71 mg Na/100g bread) than the same bread from Napier.
- White bread 3: The breads from Christchurch contained significantly less sodium than those purchased in Napier and Dunedin.

- White bread 4: The bread from Auckland contained significantly less sodium than that from each of the other regions, and bread from Napier contained more sodium than bread from Christchurch.
- Wheatmeal bread 2: Bread from Napier contained more sodium than bread from Christchurch, Auckland and Dunedin.
- White bread 6: Auckland bread contained significantly less sodium than bread from the other regions.

3.6 Purchase price versus sodium concentration

There was only a weak inverse association between the price paid for the bread and sodium concentration across all breads as shown in Figure 6. In other words, cheaper breads did not necessarily have a higher sodium concentration than more expensive breads.

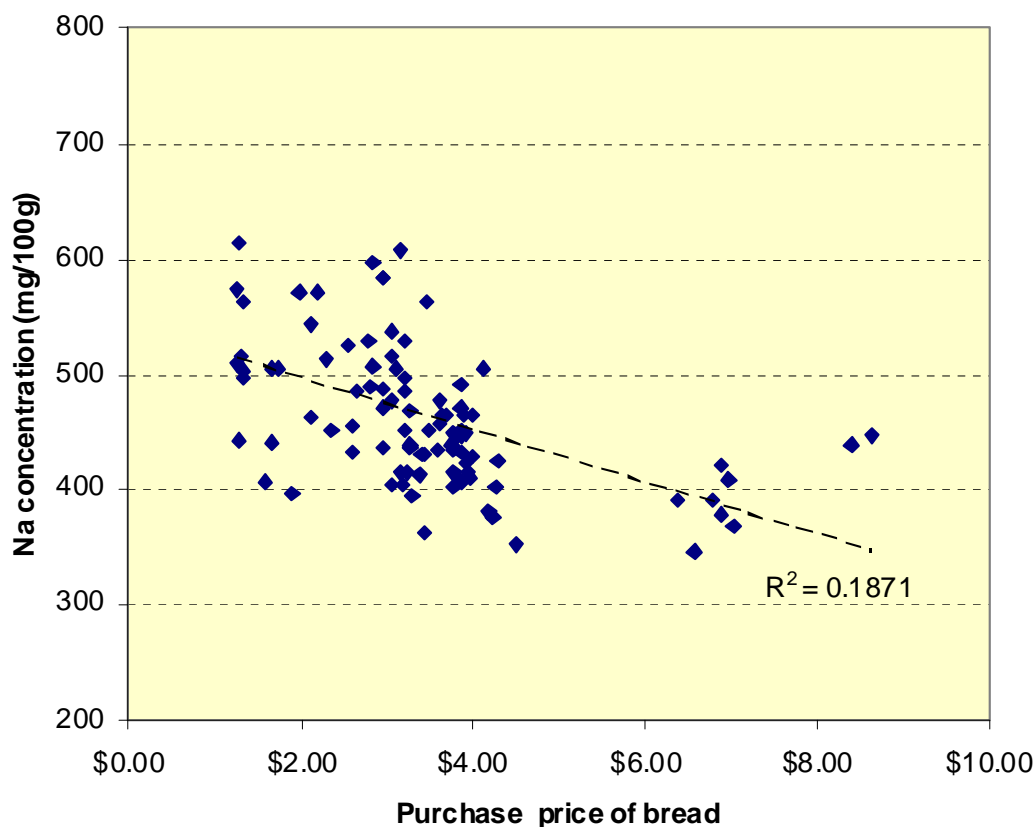


Figure 6: Purchase price of bread versus sodium concentration for 98 breads, excluding crumpets because of their very high sodium concentration.

When evaluated on a regional basis across bread types, the association was strongest for Christchurch ($R^2 = 0.4692$), followed by Dunedin ($R^2 = 0.4389$) then Napier ($R^2 = 0.4058$). There was no association between purchase price and sodium concentration for breads from Auckland ($R^2 = 0.0412$).

When evaluated by bread type, there was strongest association between purchase price and sodium concentration for the “other” bread category that included brown rice, ciabatta, crumpets, foccacia, rice, seed and sourdough breads ($R^2 = 0.593$), compared with white bread ($R^2 = 0.1358$) and wheat /grain breads ($R^2 = 0.1235$).

3.7 Comparison with other studies

A comparison of mean sodium concentration data based on measured results is shown in Table 5 where results for “light grain”, “wheatmeal” and “heavy health” breads from the current study have been combined into one category (wheat). There is an apparent decline in sodium concentrations of about 100mg/100g for both white and wheat breads since 1990.

Table 3: Comparison of mean sodium concentration (mg/100g) of breads from this study compared with successive New Zealand Total Diet Surveys

Bread	1987-8¹	1990-1¹	2003-4¹	2009²
Bread, white	582	596	506	490 (n=46)
Bread, wheat	539	547	501	442 (n=38)

1 New Zealand Total Diet Surveys (Thomson, 2009).

2 This study

4 DISCUSSION AND CONCLUSIONS

No analytical measurement is absolute. All analytical measurements have associated uncertainty arising from sampling, the analytical method and the manufacturing process.

From this study, it is seen that inter-batch variability, measured as CV, ranged from 1 - 18% for sodium across five batches of bread. The inter-batch variability for sodium in bread was less than half that found for various fortificants that have been similarly analysed: calcium (2-47%), folate (6-62%), selenium in infant formula (0-63%), vitamin A (0-42%), vitamin C (2-60%), vitamin D (1-46%) and zinc (3-42%) (Thomson, 2006, 2007b, Thomson and Jones, 2009). There are a number of possible explanations for this reduced variability compared with other analytes, namely, the single sample matrix (bread) of the current study compared with a multiplicity of food matrices assessed in previous studies, that sodium is more stable than the vitamins previously analysed, that the analytical methodology is simpler with less opportunity for extraction losses, that it is easier to add and mix a consistent amount of sodium to foods (as salt) compared with other analytes and that the sodium is added and therefore less intrinsically bound to the food matrix (and therefore more easily extracted) than some analytes such as folate.

Both Criteria A and B, for assessing measured concentration against label claim, acknowledge the variability around an analytical result but in slightly different ways in that Criterion A defines a 95% CI and Criterion B defines a narrower CI of 90% of the measured mean. Criterion A and B differ in that Criterion B specifies a magnitude of tolerable variability around the label claim.

Based on Criterion A, 61% of breads met the label claim for sodium concentration, 21% of breads contained more sodium than claimed and 18% of breads contained less sodium than claimed on the label. Criterion A is based on the 95% CI that is determined by both the number of batches analysed and the magnitude of the variability. For five batches, the 95% CI is the mean ± 1.2 standard deviations. A highly variable product (with a high standard deviation) will have a wider CI and therefore will more easily meet this criterion than a consistent product with a small standard deviation and tighter CI. Failure to meet this criterion provides no indication of the magnitude of the outlying result. Using Criterion A to assess measured concentration against label claim favours the manufacturer who produces a more variable product.

Applying Criterion B, that includes a tolerance of $\pm 150\text{mg}$ or $\pm 30\%$ of the label claim, depending on the level of sodium in the bread, and a CI of 90%, most breads (90%) met the label claim with 10% containing more sodium than claimed. None of the breads contained less sodium than claimed, based on Criterion B.

The results show a trend for breads from Auckland to have lower sodium concentrations than the same breads purchased in Napier, Christchurch and Dunedin. This suggests initiatives to reduce the salt concentration of bread are having more impact on the sodium concentration of bread in the Auckland area than in the other regions tested.

The inverse association between purchase price and sodium concentration reported by Monro et al (2004) was not observed in the 100 breads tested in the current study when assessed across all regions combined. However cheaper breads purchased in Christchurch, Dunedin and Napier are likely to have higher concentrations of sodium than more expensive breads

purchased in these regions. In terms of bread type, cheaper specialty breads are more likely to have higher levels of sodium than more expensive specialty breads. The current study, did however include only two private label breads and the low cost category may have been underrepresented. The two private brand white breads sampled in each of the four regions (n=8), in the current study were in the lowest quartile price category, and highest average quartile for measured sodium concentration, across the 46 white breads sampled, consistent with the results of Monro et al., (2004).

The measured concentration of sodium in both white and wheat breads appears to have declined by almost 20% between 1990 and 2009. Some caution is warranted given that the sampling protocols for the results of the current study were different to the comparative study.

Levels of iodine in 100 breads analysed in this study ranged from less than the limit of detection to a maximum of 0.046mg/kg. These concentrations are consistent with levels found in the 2003/04 New Zealand Total Diet Survey (Vannoort and Thomson, 2005). Bread manufactured with iodised salt would contain in the region of 0.700mg/kg iodine (Thomson, 2007a). There was no evidence that any of the 100 breads were manufactured with iodised salt.

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APPENDIX 1: QUALITY ASSURANCE DATA

1.1 Repeatability for sodium (mg/100g)

Food type	Label claim	Analysis					Mean	Std dev.	CV
		1	2	3	4	5			
White bread	450	656	659	559	588	618	616	43	7
Wheatmeal	445	372	374	370	382	374	374	5	1
Heavy health bread	425	391	446	446	432	453	434	25	6

CV = standard deviation/mean x 100

1.2 Batch duplicates for sodium (mg/100g)

Food sample	Result 1	Result 2	Mean	Std dev.	CV
Na/Ch/10/1	465	447	456	12.6	2.8
Na/Ch/13/3	388	401	395	9.1	2.3
Na/Ch/16/4	515	538	527	16.7	3.2
Na/Ch/19/2	346	330	338	11.5	3.4
Na/Ch/6/5	458	439	449	13.7	3.1
Na/Ch/18/1	388	405	397	11.9	3.0
Na/Ch/19/5	342	383	363	29.1	8.0
Na/Ak/1/4	410	418	414	5.3	1.3
Na/Ak/20/4	148	142	145	4.6	3.1
Na/Ak/10/1	372	391	382	13.9	3.6
Na/Ak/24/4	401	396	399	3.1	0.8
Na/Ak/17/3	358	356	357	1.3	0.4
Na/Ak/25/5	502	475	489	19.4	4.0
Na/Ak/19/3	526	493	510	23.7	4.6
Na/Np/2/4	449	445	447	2.6	0.6
Na/Np/11/1	477	446	462	22.0	4.8
Na/Np/6/5	575	545	560	21.5	3.8
Na/Np/16/4	371	399	385	19.4	5.0
Na/Np/4/5	473	544	508	50.5	9.9
Na/Np/5/2	446	458	452	8.4	1.8
Na/Dn/25/2	602	633	617	21.9	3.6
Na/Dn/6/3	515	514	514	1.0	0.2
Na/Ak/19/3	526	493	510	23.7	4.6
Na/Dn/10/5	517	499	508	13.2	2.6
Na/Dn/24/5	489	483	486	4.4	0.9
Na/Dn/23/3	634	643	639	6.2	1.0
Na/Ak/20/5	169	180	174	7.7	4.4

1.3 Blind duplicates for sodium (mg/100g)

Food sample	Result 1	Result 2	Mean	Std dev.	CV
Na/Ch/11/1	536	541	538	3.4	0.6
Na/Ch/24/1	454	537	496	58.8	11.9
Na/Ch/7/1	414	405	409	6.5	1.6
Na/Ch/17/1	494	474	484	14.4	3.0
Na/Ch/20/1	355	386	370	21.7	5.8
Na/Ak/5/1	438	416	427	15.6	3.6
Na/Ak/12/1	445	449	447	2.8	0.6
Na/Ak/3/1	390	386	388	2.8	0.7
Na/Ak/16/1	327	326	327	0.7	0.2
Na/Ak/19/1	453	458	456	3.5	0.8
Na/Np/14/1	569	499	534	49.3	9.2
Na/Np/21/1	414	416	415	1.7	0.4
Na/Np/8/1	455	495	475	28.1	5.9
Na/Np/23/1	433	431	432	1.6	0.4
Na/Np/18/1	450	473	461	16.1	3.5
Na/Dn/1/1	478	502	490	16.9	3.5
Na/Dn/25/1	602	650	626	33.7	5.4
Na/Dn/13/1	445	443	444	1.7	0.4
Na/Dn/22/1	773	783	778	7.0	0.9
Na/Dn/15/1	514	478	496	25.4	5.1

1.4 Concentration of sodium in certified reference material PSRM 1069-M-1(mg/100g)

361.8	403.8	279.4	361.2	364.8	347.0
339.4	347.1	280.2	353.1	370.0	359.3
365.2	297.1	361.1	349.4	363.9	
374.6	302.3	386.4	412.8	362.1	
364.4	283.6	356.6	355.7	364.5	

Mean measured value = 350.6, 95% CI 337.1-364.1 mg/100g.

Certified value = 346.3, 95% CI 342.6-350.2 mg/100g

1.5 Spike recoveries

The recoveries of one sample spiked in triplicate, at the equivalent of 20154 ppm NaCl:

	Sample ID	Spike 1	Spike 2	Spike 3	Mean
Batch 1	Na/Ch/10/1	0.94	0.93	0.98	95%
Batch 2	Na/Ch/13/3	1.02	1.05	1.13	107%
Batch 3	Na/Ch/16/4	1.02	1.12	1.21	112%
Batch 4	Na/Ch/19/2	1.17	1.04	1.17	113%
Batch 5	Na/Ch/6/5	1.06	1.27	1.19	117%
Batch 6	Na/Ch/18/1	1.16	0.95	1.20	110%
Batch 7	Na/Ch/19/5	1.04	0.92	0.80	92%

	Sample ID	Spike 1	Spike 2	Spike 3	Mean
Batch 8	Na/Ak/1/4	1.00	1.03	1.02	102%
Batch 9	Na/Ak/20/4	0.86	0.87	0.88	87%
Batch 10	Na/Ak/10/1	0.88	0.91	0.90	90%
Batch 11	Na/Ak/24/4	0.90	0.92	0.91	91%
Batch 12	Na/Ak/17/3	0.85	0.85	0.86	85%
Batch 13	Na/Ak/25/5	1.18	1.15	1.22	119%
Batch 14	Na/Ak/19/3	1.12	1.13	1.17	114%
Batch 15	Na/Np/2/4*	1.17	1.22	1.16	118%
Batch 16	Na/Np/11/1*	1.09	1.09	1.08	109%
Batch 17	Na/Np/6/5	1.09	1.23	1.17	116%
Batch 18	Na/Np/16/4	1.10	1.14	1.11	112%
Batch 19	Na/Np/4/5	1.19	1.09	1.08	112%
Batch 20	Na/Np/5/2	1.06	1.08	1.07	107%
Batch 21	Na/Dn/25/2	1.27	1.12	1.19	119%
Batch 22	Na/Dn/6/3	1.29	1.22	1.30	127%
Batch 23	Na/Dn/10/5	1.28	1.22	1.24	125%
Batch 24	Na/Dn/10/5	1.28	1.22	1.24	125%

1.6 Repeatability for iodine (mg/kg)

Food type	Analysis					Mean	Std dev.	CV
	1	2	3	4	5			
White bread	0.078	0.057	0.033	0.029	0.018	0.043	0.024	56.3
Wheatmeal	<0.010	<0.010	<0.010	<0.029	<0.030	<0.010	NA	NA
Heavy health bread	0.016	0.021	0.023	0.017	0.017	0.019	0.003	16.1

NA = not available since less than the limit of detection

1.7 Batch and blind duplicates for iodine (mg/kg)

Food sample	Result 1	Result 2	Mean	Std dev.	CV
Na/Ch/11/1	<0.010	<0.010	<0.010	NA	NA
Na/Ch/24/1	<0.010	<0.010	<0.010	NA	NA
Na/Ch/7/1	<0.011	<0.010	<0.010	NA	NA
Na/Ch/17/1	<0.010	<0.010	<0.010	NA	NA
Na/Ch/20/1	0.010	0.012	0.011	0.001	12.9
Na/Ak/5/1	<0.010	<0.030	<0.030	NA	NA
Na/Ak/12/1	<0.030	<0.030	<0.030	NA	NA
Na/Ak/3/1	<0.010	<0.030	<0.030	NA	NA
Na/Ak/16/1	<0.030	<0.010	<0.030	NA	NA
Na/Ak/19/1	<0.030	0.027	<0.030	NA	NA
Na/Np/4/1 C	0.023	0.021	0.022	0.001	6.4
Na/Np/14/1	<0.010	<0.010	<0.010	NA	NA
Na/Np/21/1	<0.010	<0.010	<0.010	NA	NA
Na/Np/8/1	<0.010	<0.010	<0.010	NA	NA

Food sample	Result 1	Result 2	Mean	Std dev.	CV
Na/Np/23/1	<0.010	<0.010	<0.010	NA	NA
Na/Np/18/1	<0.010	<0.010	<0.010	NA	NA
Na/Np/22/1	0.030	0.043	0.0365	0.009	25.2
Na/Dn/1/1	<0.010	<0.010	<0.010	NA	NA
Na/Dn/25/1	<0.010	<0.010	<0.010	NA	NA
Na/Dn/13/1	<0.010	<0.010	<0.010	NA	NA
Na/Dn/22/1	0.035	0.039	0.037	0.003	7.6
Na/Dn/15/1	<0.010	<0.010	<0.010	NA	NA
Na/Dn/4/1	0.012	0.010	0.011	0.001	12.9

NA = not available since less than the limit of detection

1.8 Spike recoveries

The recoveries of samples spiked at 0.2 and 1.0 mg/kg iodine were:

	Sample ID	Low spike	% Recovery	High spike	% Recovery
Batch 1	Na/Ch/2/1/E	0.20	100	1.0	100
Batch 2	Na/Ak/7/1/D	0.21	105	1.0	100
	BD/Ak/1	0.25	125	0.96	96
Batch 3	Na/Np/4/1 C	0.22	110	0.98	98
	Na/Np/22/1	0.24	120	1.1	110
Batch 4	Na/Dn/14/1	0.22	110	0.98	98

APPENDIX 2: MOISTURE CONTENT, LABEL CLAIM AND MEASURED SODIUM CONCENTRATION (MG/100G) OF INDIVIDUAL BREAD SAMPLES

2.1 Breads from Auckland

Bread ID	Bread Type	Price	Moisture	Label claim Na (mg/100g)	Measured Na (mg/100g)	Std Dev.	CV
Ak/1	White Bread 1	\$2.25	37.4	450	429		
		\$2.25		450	526		
		\$2.29		450	473		
		\$2.25		450	414		
		\$3.94		450	435		
	mean	\$2.60			455	45	10
Ak/2	White Bread 2	\$3.79	38.3	450	381		
		\$3.79		450	436		
		\$3.23		450	388		
		\$3.23		450	401		
		\$2.19		450	463		
	mean	\$3.25			414	35	8
Ak/3	Light Grain Bread 1	\$4.19	39.4	430	390		
		\$3.95		430	436		
		\$4.19		430	439		
		\$3.49		430	368		
		\$3.49		430	403		
	mean	\$3.86			407	30	7
Ak/4	Heavy Health Bread 1	\$4.59	46.1	425	353		
		\$4.09		425	357		
		\$4.59		425	348		
		\$4.63		425	427		
		\$4.64		425	353		
	mean	\$4.51			368	33	9
Ak/5	White Bread 3	\$2.25	38.7	450	438		
		\$2.25		450	420		
		\$3.93		450	403		
		\$3.94		450	417		
		\$3.94		450	502		
	mean	\$3.26			436	39	9
Ak/6	White Bread 4	\$1.69	37.5	500	463		
		\$1.31		500	457		
		\$1.99		500	413		
		\$1.69		500	425		
		\$1.69		500	449		
	mean	\$1.67			442	21	5
Ak/7	White Bread 5	\$2.25	40.3	445	374		
		\$2.29		445	418		
		\$3.94		445	461		
		\$2.29		445	458		
		\$2.29		445	449		
	mean	\$2.61			432	37	8
Ak/8	White Bread 6	\$3.29	34.2	450	443		
		\$3.09		450	423		
		\$3.09		450	399		
		\$3.29		450	411		
		\$4.29		450	478		
	mean	\$3.41			431	31	7

Bread ID	Bread Type	Price	Moisture	Label claim Na (mg/100g)	Measured Na (mg/100g)	Std Dev.	CV
Ak/9	Light Grain Bread 2	\$1.59	38.3	450	414		
		\$1.59		450	405		
		\$1.59		450	420		
		\$1.59		450	420		
		\$1.59		450	371		
	mean	\$1.59			406	21	5
Ak/10	Heavy Health Bread 2	\$2.99	34.0	510	426		
		\$3.57		510	426		
		\$3.57		510	441		
		\$2.99		510	428		
		\$3.99		510	437		
	mean	\$3.42			432	7	2
Ak/11	White Bread 7	\$3.79	37.9	450	397		
		\$3.79		450	417		
		\$3.23		450	460		
		\$3.23		450	416		
		1.81		450	386		
	mean	\$3.17			415	28	7
Ak/12	White Bread 8	\$1.99	41.1	500	445		
		\$2.50		500	376		
		\$1.69		500	402		
		\$1.69		500	359		
		\$1.69		500	397		
	mean	\$1.91			396	32	8
Ak/13	Light Grain Bread 3	\$4.19	39.5	400	438		
		\$3.95		400	391		
		\$3.95		400	550		
		\$3.95		400	355		
		\$3.49		400	379		
	mean	\$3.91			423	77	18
Ak/14	White Bread 9	\$2.00	37.7	450	406		
		\$3.23		450	398		
		\$3.79		450	410		
		\$3.99		450	411		
		\$2.99		450	397		
	mean	\$3.20			404	6	2
Ak/15	Light Grain Bread 4	\$3.49	38.4	430	456		
		\$3.95		430	436		
		\$4.19		430	437		
		\$3.49		430	408		
		\$3.95		430	496		
	mean	\$3.81			447	32	7
Ak/16	Light Grain Bread 5	\$2.99	39.5	450	327		
		\$2.99		450	381		
		\$3.57		450	338		
		\$3.57		450	356		
		\$3.99		450	409		
	mean	\$3.42			362	33	9
Ak/17	Meal Bread 3	\$3.79	39.4	450	474		
		\$3.23		450	415		
		\$3.79		450	419		
		\$2.00		450	465		
		\$3.23		450	479		
	mean	\$3.21			450	31	7

Bread ID	Bread Type	Price	Moisture	Label claim Na (mg/100g)	Measured Na (mg/100g)	Std Dev.	CV
Ak/18	Other Bread 1	\$3.09	46.0	830	868		
		\$2.69		830	780		
		\$2.69		830	839		
		\$3.09		830	792		
		\$2.69		830	763		
mean	\$2.85			808	44	5	
Ak/19	Other Bread 2	\$4.29	38.4	500	453		
		\$4.29		500	431		
		\$4.29		500	447		
		\$4.29		500	597		
		\$3.49		500	597		
mean	\$4.13			505	84	17	
Ak/20	Other Bread 3	\$4.82	49.5	205	147		
		\$4.82		205	163		
		\$6.25		205	168		
		\$4.82		205	167		
		\$4.82		205	181		
mean	\$5.11			165	12	7	
Ak/21	White Bread 10	\$4.29	37.4	430	344		
		\$4.30		430	348		
		\$3.96		430	423		
		\$4.29		430	374		
		\$4.29		430	395		
mean	\$4.23			377	33	9	
Ak/22	Other Bread 4	\$4.29	36.5	500	848		
		\$4.29		500	936		
		\$3.49		500	906		
		\$3.49		500	865		
		\$2.99		500	611		
mean	\$3.71			833	129	15	
Ak/23	Light Grain Bread 6	\$3.95	38.5	430	389		
		\$3.49		430	443		
		\$4.19		430	462		
		\$4.19		430	452		
		\$4.19		430	396		
mean	\$4.00			428	33	8	
Ak/24	White bread 11	\$1.34	38.2	505	482		
		\$1.34		505	455		
		\$1.34		505	535		
		\$1.34		505	439		
		\$1.34		505	572		
mean	\$1.34			497	56	11	
Ak/25	White bread 12	\$1.19	37.1	450	410		
		\$1.34		450	422		
		\$1.19		450	465		
		\$1.39		450	424		
		\$1.29		450	489		
mean	\$1.28			442	33	8	

Na = sodium, Std Dev. = Standard deviation, CV= standard deviation/mean x 100

Bread type as defined by Synovate Aztec (market information) subcategory

Pink = 8/8 most popular breads, based on production, plus 2 low cost breads, purchased in each region

Brown = 9/48 breads, mid range in popularity/production, may vary between regions

Green = 6/31 least popular/lowest production, may vary between regions.

2.2 Breads from Napier

Bread ID	Bread Type	Price	Moisture	Label claim Na (mg/100g)	Measured Na (mg/100g)	Std dev	CV
Np/1	White Bread 1	\$3.26	37.9	450	472		
		\$3.26		450	459		
		\$3.26		450	484		
		\$3.26		450	491		
		\$3.26		450	443		
	mean	\$3.26			470	20	4
Np/2	White Bread 2	\$3.59	38.3	450	502		
		\$3.59		450	511		
		\$3.59		450	467		
		\$3.69		450	447		
		\$3.69		450	453		
	mean	\$3.63			476	29	6
Np/3	Light Grain Bread 1	\$3.78	40.3	430	434		
		\$3.78		430	363		
		\$3.78		430	394		
		\$3.78		430	397		
		\$3.78		430	424		
	mean	\$3.78			402	28	7
Np/4	Heavy Health Bread 1	\$4.28	45.3	425	434		
		\$4.28		425	417		
		\$4.28		425	391		
		\$4.28		425	423		
		\$4.28		425	454		
	mean	\$4.28			424	23	5
Np/5	White Bread 3	\$2.24	37.8	450	493		
		\$3.26		450	452		
		\$3.26		450	467		
		\$3.26		450	517		
		\$3.26		450	459		
	mean	\$3.06			478	27	6
Np/6	White Bread 4	\$2.15	37.8	500	560		
		\$1.99		500	534		
		\$2.15		500	536		
		\$2.15		500	524		
		\$2.15		500	560		
	mean	\$2.12			543	16	3
Np/7	Meal Bread 2	\$2.24	39.0	445	532		
		\$3.26		445	553		
		\$3.26		445	419		
		\$3.26		445	545		
		\$3.26		445	524		
	mean	\$3.06			515	54	11
Np/8	Light Grain Bread 2	\$3.87	38.1	450	406		
		\$3.87		450	407		
		\$3.87		450	507		
		\$3.87		450	443		
		\$3.87		450	488		
	mean	\$3.87			450	46	10
Np/9	White Bread 5	\$2.15	37.9	500	526		
		\$2.15		500	552		
		\$2.99		500	393		

Bread ID	Bread Type	Price	Moisture	Label claim Na (mg/100g)	Measured Na (mg/100g)	Std dev	CV
		\$2.15		500	557		
		\$2.15		500	534		
		mean \$2.32			512	68	13
Np/10	Light Grain Bread 3	\$3.49	35.0	510	491		
		\$3.49		510	434		
		\$3.49		510	448		
		\$3.49		510	453		
		\$3.49		510	431		
		mean \$3.49			452	24	5
Np/11	White Bread 6	\$3.59	38.8	450	462		
		\$3.59		450	448		
		\$3.59		450	447		
		\$3.69		450	458		
		\$3.69		450	469		
		mean \$3.63			457	10	2
Np/12	White Bread 7	\$2.15	38.7	500	478		
		\$1.99		500	447		
		\$2.15		500	444		
		\$2.15		500	478		
		\$2.15		500	472		
		mean \$2.12			464	17	4
Np/13	Light Grain Bread 4	\$3.78	39.0	400	461		
		\$3.78		400	474		
		\$3.78		400	370		
		\$3.78		400	540		
		\$4.15		400	505		
		mean \$3.85			470	64	14
Np/14	White Bread 8	\$3.59	38.3	450	508		
		\$3.59		450	423		
		\$3.69		450	462		
		\$3.69		450	465		
		\$3.69		450	466		
		mean \$3.65			465	30	6
Np/15	Light Grain Bread 5	\$3.78	39.5	430	480		
		\$3.78		430	393		
		\$3.78		430	488		
		\$3.78		430	399		
		\$3.78		430	416		
		mean \$3.78			435	46	10
Np/16	Light Grain Bread 6	\$3.59	39.4	450	407		
		\$3.49		450	394		
		\$3.49		450	386		
		\$2.99		450	385		
		\$2.99		450	400		
		mean \$3.31			394	9	2
Np/17	Meal Bread 3	\$3.59	39.5	450	479		
		\$3.59		450	440		
		\$3.59		450	424		
		\$3.59		450	398		
		\$3.59		450	428		
		mean \$3.59			434	29	7
Np/18	Other Bread 1	\$8.80	39.5	440	450		
		\$8.58		440	454		
		\$8.58		440	457		

Bread ID	Bread Type	Price	Moisture	Label claim Na (mg/100g)	Measured Na (mg/100g)	Std dev	CV
		\$8.58		440	456		
		\$8.58		440	413		
		mean \$8.62			446	19	4
Np/19	Other Bread 2	\$6.98	42.2	420	458		
		\$6.98		420	420		
		\$6.98		420	378		
		\$6.98		420	395		
		\$6.98		420	390		
		mean \$6.98			408	31	8
Np/20	Other Bread 3	\$7.20	42.6	360	347		
		\$6.98		360	328		
		\$6.98		360	413		
		\$6.98		360	360		
		\$6.98		360	391		
		mean \$7.02			368	34	9
Np/21	White Bread 9	\$3.87	39.0	430	414		
		\$3.87		430	371		
		\$4.15		430	488		
		\$3.87		430	493		
		\$3.87		430	479		
		mean \$3.93			449	54	12
Np/22	Other Bread 4	\$3.04	44.9	830	926		
		\$3.04		830	847		
		\$3.04		830	842		
		\$3.04		830	785		
		\$3.04		830	878		
		mean \$3.04			856	52	6
Np/23	Light Grain Bread 7	\$3.78	37.0	430	433		
		\$3.78		430	429		
		\$3.78		430	377		
		\$3.78		430	426		
		\$3.78		430	409		
		mean \$3.78			415	23	6
Np/24	White bread 10	\$1.34	35.9	505	513		
		\$1.34		505	476		
		\$1.34		505	541		
		\$1.34		505	535		
		\$1.34		505	447		
		mean \$1.34			502	40	8
Np/25	White bread 11	\$1.33	37.9	450	602		
		\$1.33		450	526		
		\$1.33		450	570		
		\$1.33		450	601		
		\$1.33		450	522		
		mean \$1.33			564	39	7

Na = sodium, Std Dev. = Standard deviation, CV= standard deviation/mean x 100
 Bread type as defined by Synovate Aztec (market information) subcategory
 Pink = 8/8 most popular breads, based on production, plus 2 low cost breads, purchased in each region
 Brown = 9/48 breads, mid range in popularity/production, may vary between regions
 Green = 6/31 least popular/lowest production, may vary between regions.

2.3 Breads from Christchurch

Bread ID	Bread Type	Price	Moisture	Label claim Na (mg/100g)	Measured Na (mg/100g)	Std dev	CV
Ch/1	White Bread 1	\$3.55	38.5	450	426	34	8
		\$3.55		450	451		
		\$3.49		450	398		
		\$3.55		450	490		
		\$2.25		450	425		
		mean		\$3.28	438		
Ch/2	White Bread 2	\$3.59	37.9	450	616	29	5
		\$3.35		450	593		
		\$3.35		450	577		
		\$2.00		450	594		
		\$3.49		450	652		
		mean		\$3.16	606		
Ch/3	Light Grain Bread 1	\$4.08	39.3	430	345	46	11
		\$3.99		430	451		
		\$3.79		430	415		
		\$3.99		430	453		
		\$3.99		430	386		
		mean		\$3.97	410		
Ch/4	Heavy Health Bread 1	\$4.49	44.1	425	434	54	14
		\$4.45		425	327		
		\$3.99		425	329		
		\$3.49		425	437		
		\$4.45		425	379		
		mean		\$4.17	381		
Ch/5	White Bread 3	\$3.55	40.3	450	362	25	6
		\$3.49		450	425		
		\$2.25		450	410		
		\$2.25		450	404		
		\$3.78		450	418		
		mean		\$3.06	404		
Ch/6	White Bread 4	\$2.34	38.5	500	508	31	6
		\$2.99		500	526		
		\$2.99		500	469		
		\$2.45		500	472		
		\$2.49		500	449		
		mean		\$2.65	485		
Ch/7	Meal Bread 2	\$3.55	40.8	445	414	55	13
		\$3.78		445	501		
		\$3.55		445	358		
		\$3.78		445	374		
		\$2.25		445	420		
		mean		\$3.38	414		
Ch/8	Light Grain Bread 2	\$3.59	37.8	450	397	41	9
		\$3.89		450	485		
		\$3.09		450	420		
		\$4.29		450	412		
		\$3.89		450	481		
		mean		\$3.75	439		
Ch/9	White Bread 5	\$1.29	37.5	450	561		
		\$2.39		450	570		
		\$2.39		450	554		

Bread ID	Bread Type	Price	Moisture	Label claim Na (mg/100g)	Measured Na (mg/100g)	Std dev	CV
		\$2.39		450	547		
		\$2.59		450	623		
		\$2.21			571	30	5
Ch/10	Light Grain Bread 3	\$3.69	34.7	510	481		
		\$3.69		510	445		
		\$2.29		510	521		
		\$2.29		510	525		
		\$2.25		510	564		
		\$2.84			507	46	9
Ch/11	White Bread 6	\$3.49	38.0	450	536		
		\$3.49		450	657		
		\$3.35		450	548		
		\$3.35		450	502		
		\$3.59		450	574		
		\$3.45			563	58	10
Ch/12	White Bread 7	\$2.29	40.3	500	410		
		\$2.29		500	478		
		\$2.45		500	476		
		\$2.29		500	474		
		\$2.49		500	415		
		\$2.36			451	35	8
Ch/13	Light Grain Bread 4	\$3.99	41.1	400	523		
		\$4.25		400	464		
		\$3.79		400	395		
		\$3.99		400	520		
		\$3.99		400	426		
	mean	\$4.00			466	57	12
Ch/14	White Bread 8	\$1.99	38.5	535	463		
		\$4.09		535	494		
		\$1.99		535	526		
		\$3.59		450	687		
		\$3.59		450	515		
		\$3.05			537	87	16
Ch/15	Light Grain Bread 5	\$3.99	38.4	430	385		
		\$3.99		430	486		
		\$3.99		430	412		
		\$3.79		430	381		
		\$3.99		430	407		
		\$3.95			414	42	10
Ch/16	Light Grain Bread 6	\$3.69	38.7	450	482		
		\$3.89		450	545		
		\$2.29		450	485		
		\$2.29		450	527		
		\$3.89		450	447		
		\$3.21			497	39	8
Ch/17	Meal Bread 3	\$3.35	40.3	450	494		
		\$3.35		450	493		
		\$3.35		450	423		
		\$3.49		450	586		
		\$1.95		450	530		
		\$3.10			505	60	12
Ch/18	Other Bread 1	\$5.99	39.8	440	360		
		\$6.99		440	409		
		\$5.99		440	387		

Bread ID	Bread Type	Price	Moisture	Label claim Na (mg/100g)	Measured Na (mg/100g)	Std dev	CV
		\$6.99		440	384		
		\$5.99		440	417		
		mean \$6.39			392	22	6
Ch/19	Other Bread 2	\$5.79	41.9	420	430		
		\$7.29		420	378		
		\$7.99		420	390		
		\$6.99		420	360		
		\$5.79		420	393		
		mean \$6.77			390	26	7
Ch/20	Other Bread 3	\$5.79	42.3	360	355		
		\$7.29		360	401		
		\$6.99		360	334		
		\$5.79		360	320		
		\$6.99		360	323		
		mean \$6.57			346	33	10
Ch/21	White Bread 9	\$2.40	40.2	505	586		
		\$1.70		505	478		
		\$1.45		505	440		
		\$1.45		505	511		
		\$1.70		505	507		
		mean \$1.74			505	54	11
Ch/22	Other Bread 4	\$2.99	45.7	830	826		
		\$2.59		830	876		
		\$2.59		830	666		
		\$3.09		830	903		
		\$2.99		830	821		
		mean \$2.85			818	92	11
Ch/23	Light Grain Bread 7	\$3.75	43.3	420	564		
		\$3.75		420	485		
		\$3.75		420	373		
		\$3.75		420	432		
		\$3.85		420	393		
		mean \$3.77			450	77	17
Ch/24	White bread 10	\$1.27	38.8	505	454		
		\$1.27		505	581		
		\$1.27		505	489		
		\$1.27		505	426		
		\$1.27		505	597		
		mean \$1.27			509	76	15
Ch/25	White bread 11	\$1.27	38.1	450	624		
		\$1.25		450	505		
		\$1.27		450	542		
		\$1.27		450	632		
		\$1.27		450	558		
		mean \$1.27			572	55	10

Na = sodium, Std Dev. = Standard deviation, CV= standard deviation/mean x 100
Bread type as defined by Synovate Aztec (market information) subcategory
Pink = 8/8 most popular breads, based on production, plus 2 low cost breads, purchased in each region
Brown = 9/48 breads, mid range in popularity/production, may vary between regions
Green = 6/31 least popular/lowest production, may vary between regions.

2.4 Breads from Dunedin

Bread ID	Bread Type	Price	Moisture	Label claim Na (mg/100g)	Measured Na (mg/100g)	Std dev	CV
Dn/1	White Bread 1	\$2.19	40.2	450	502	28	6
		\$2.19		450	470		
		\$2.19		450	456		
		\$4.09		450	481		
		\$4.09		450	526		
		mean		\$2.95	487		
Dn/2	White Bread 2	\$3.59	38.1	450	597	14	2
		\$3.59		450	562		
		\$3.59		450	591		
		\$2.00		450	576		
		\$2.00		450	590		
		mean		\$2.95	583		
Dn/3	Light Grain Bread 1	\$4.09	39.3	430	436	16	4
		\$4.09		430	428		
		\$4.09		430	445		
		\$3.49		430	455		
		\$3.49		430	470		
		mean		\$3.85	447		
Dn/4	Heavy Health Bread 1	\$3.99	43.3	425	439	27	7
		\$3.99		425	399		
		\$3.99		425	410		
		\$4.65		425	364		
		\$4.65		425	396		
		mean		\$4.25	402		
Dn/5	White Bread 3	\$2.19	40.3	450	482	11	2
		\$2.19		450	470		
		\$2.19		450	466		
		\$4.09		450	480		
		\$4.09		450	455		
		mean		\$2.95	471		
Dn/6	White Bread 4	\$2.39	39.6	500	538	20	4
		\$2.39		500	550		
		\$2.39		500	514		
		\$2.79		500	519		
		\$2.79		500	500		
		mean		\$2.55	524		
Dn/7	Meal Bread 2	\$2.19	40.9	445	454	16	4
		\$2.19		445	425		
		\$2.19		445	454		
		\$4.09		445	430		
		\$4.09		445	420		
		mean		\$2.95	437		
Dn/8	Light Grain Bread 2	\$4.19	38.5	450	479	11	2
		\$4.19		450	449		
		\$4.19		450	460		
		\$2.99		450	469		
		\$2.99		450	464		
		mean		\$3.71	464		
Dn/9	White Bread	\$1.99	38.3	450	590		
		\$1.99		450	622		
		\$1.99		450	587		

Bread ID	Bread Type	Price	Moisture	Label claim Na (mg/100g)	Measured Na (mg/100g)	Std dev	CV
		\$1.99		450	517		
		\$1.99		450	536		
		mean \$1.99			570	43	8
Dn/10	Light Grain Bread	\$2.89	35.9	510	512		
		\$2.89		510	513		
		\$2.89		510	573		
		\$3.69		510	541		
		\$3.69		510	508		
		mean \$3.21			529	28	5
Dn/11	White Bread	\$3.59	38.9	450	614		
		\$3.59		450	564		
		\$3.59		450	593		
		\$2.00		450	555		
		\$2.00		450	587		
		mean \$2.95			582	23	4
Dn/12	White Bread	\$2.79	41.5	500	511		
		\$2.79		500	525		
		\$2.79		500	568		
		\$2.79		500	513		
		\$2.79		500	530		
		mean \$2.79			529	23	4
Dn/13	Light Grain Bread	\$4.09	41.5	400	443		
		\$4.09		400	452		
		\$4.09		400	420		
		\$3.49		400	428		
		\$3.49		400	423		
		mean \$3.85			433	14	3
Dn/14	White Bread	\$3.59	37.0	450	596		
		\$3.35		450	590		
		\$3.35		450	607		
		\$1.99		450	601		
		\$1.99		450	588		
		mean \$2.85			597	8	1
Dn/15	Light Grain Bread	\$4.09	40.3	430	478		
		\$4.09		430	461		
		\$4.30		430	457		
		\$3.49		430	468		
		\$3.49		430	461		
		mean \$3.89			465	8	2
Dn/16	Light Grain Bread	\$2.89	37.9	450	543		
		\$2.89		450	468		
		\$2.89		450	496		
		\$3.69		450	462		
		\$3.69		450	456		
		mean \$3.21			485	36	7
Dn/17	Meal Bread	\$3.59	40.8	450	522		
		\$2.89		450	479		
		\$3.59		450	506		
		\$1.99		450	491		
		\$1.99		450	445		
		mean \$2.81			488	29	6
Dn/18	Other Bread	\$8.40	38.4	440	424		
		\$8.40		440	397		
		\$8.40		440	446		

Bread ID	Bread Type	Price	Moisture	Label claim Na (mg/100g)	Measured Na (mg/100g)	Std dev	CV
		\$8.40		440	450		
		\$8.40		440	482		
		mean \$8.40			440	32	7
Dn/19	Other Bread	\$6.90	42.4	420	414		
		\$6.90		420	448		
		\$6.90		420	411		
		\$6.90		420	414		
		\$6.90		420	416		
		mean \$6.90			421	15	4
Dn/20	Other Bread	\$6.90	42.1	360	380		
		\$6.90		360	381		
		\$6.90		360	381		
		\$6.90		360	354		
		\$6.90		360	398		
		mean \$6.90			379	16	4
Dn/21	White Bread	\$1.70	39.4	505	499		
		\$1.70		505	516		
		\$1.70		505	526		
		\$1.70		505	484		
		\$1.50		505	503		
		mean \$1.66			505	16	3
Dn/22	Other Bread	\$2.99	45.6	830	783		
		\$2.99		830	941		
		\$2.99		830	775		
		\$2.99		830	767		
		\$2.99		830	818		
		mean \$2.99			817	72	9
Dn/23	Light Grain Bread	\$3.85	42.4	415	531		
		\$3.85		415	512		
		\$3.85		415	507		
		\$3.85		415	496		
		\$3.85		415	408		
		mean \$3.85			491	48	10
Dn/24	White bread	\$1.30	39.2	505	619		
		\$1.25		505	504		
		\$1.25		505	494		
		\$1.40		505	473		
		\$1.40		505	486		
		mean \$1.32			515	59	12
Dn/25	White bread	\$1.27	38.5	450	650		
		\$1.27		450	617		
		\$1.27		450	590		
		\$1.27		450	566		
		\$1.40		450	639		
		mean \$1.30			612	35	6

Na = sodium, Std Dev. = Standard deviation, CV= standard deviation/mean x 100
Bread type as defined by Synovate Aztec (market information) subcategory
Pink = 8/8 most popular breads, based on production, plus 2 low cost breads, purchased in each region
Brown = 9/48 breads, mid range in popularity/production, may vary between regions
Green = 6/31 least popular/lowest production, may vary between regions.