

## **Microbiological survey of fresh-cut fruit salads (non-retorted) available in consumer-ready packs from retail in New Zealand**

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## Scientific Interpretative Summary

This Scientific Interpretative Summary is prepared by New Zealand Food Safety (NZFS) risk assessors to provide context to the following report for MPI risk managers and external readers.

### **FW14008 Microbiological survey of fresh-cut fruit salads (non-retorted) available in consumer-ready packs from retail in New Zealand.**

This microbiological survey was conducted by the Institute of Environmental Science and Research (ESR) between June 2013 and April 2014. A total of 75 fresh-cut, non-retorted, ready-to-eat, retail fruit salads, each had a composite of 5 individual (same batch) sub-samples representing 14 brands, were purchased from supermarkets or online retail stores. Composite samples were tested, using standard laboratory methods, within  $\pm 2$  days of expiry for:

- *Salmonella* (presence/absence)
- *Listeria* spp. (including *L. monocytogenes*) (presence/absence, enumeration)
- *Escherichia coli* (enumeration)
- Coagulase-positive *Staphylococcus* spp. (CPS) (enumeration)
- Mesophilic aerobic microflora (APC) counts
- pH

*Listeria monocytogenes* was detected in four (5.3%) samples at concentrations of <100 CFU/g. All were, or contained, melon. Each of the melon samples also tested positive for *L. innocua*. Seven additional samples tested positive only for *L. innocua*. Levels of *L. innocua* ranged from <100 to 1250 CFU/g. APCs were highly variable for the mixed fruit (between 3.2 and 8.9 log<sub>10</sub> CFU/g) and melon products (4.3 and 7.4 log<sub>10</sub> CFU/g). *Listeria* spp. were not isolated from fruit with a pH <4.

*Salmonella*, CPS and *E. coli* were not detected in any of the samples.

The detection of *Listeria* spp. (notably including *L. monocytogenes*, although at low concentrations) in several ready-to-eat fresh-cut retail fruit products available in New Zealand suggests these products could be potential vehicles for foodborne illness.

NZFS updated food safety guidance for people during pregnancy in 2020 and includes advice not to eat pre-packaged ready-to-eat fruit salads (<https://www.mpi.govt.nz/dmsdocument/7251-Food-safety-in-pregnancy-pullout-guide>). The New Zealand Food Safety Science & Research Centre has a programme focused on applying genomics to improve the understanding of food safety risks associated with *Listeria*.

Client report FW 14008



**MICROBIOLOGICAL SURVEY OF FRESH-CUT FRUIT SALADS  
(NON-RETORTED) AVAILABLE IN CONSUMER-READY  
PACKS FROM RETAIL IN NEW ZEALAND**

By

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**MICROBIOLOGICAL SURVEY OF FRESH-CUT FRUIT  
SALADS  
(NON-RETORTED) AVAILABLE IN CONSUMER-READY  
PACKS FROM RETAIL IN NEW ZEALAND**

Prepared for the Ministry for Primary Industries under project MFS/12/8 -  
Food Consultation, as part of overall contract for scientific services

Client report no. FW 14008

by

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September 2014



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## TABLE OF CONTENTS

<b>1</b>	<b>SUMMARY .....</b>	<b>8</b>
<b>1</b>	<b>INTRODUCTION.....</b>	<b>10</b>
<b>2</b>	<b>MATERIALS AND METHODS.....</b>	<b>12</b>
2.1	Sampling Programme.....	12
2.2	Sample preparation.....	13
2.3	Microbiological Methods.....	13
2.4	Statistics.....	16
<b>3</b>	<b>RESULTS.....</b>	<b>17</b>
3.1	Sample location and type.....	17
3.2	Microbial analyses.....	17
3.2.1	CPS, <i>E. coli</i> and <i>Salmonella</i> testing.....	32
3.2.2	<i>Listeria</i> testing.....	32
3.2.3	Aerobic Plate Counts.....	36
3.3	pH of fresh-cut fruit salads.....	37
3.3.1	Product packaging.....	38
<b>4</b>	<b>DISCUSSION.....</b>	<b>38</b>
<b>5</b>	<b>CONCLUSIONS.....</b>	<b>42</b>

## LIST OF FIGURES

Figure 1. Aerobic plate counts of composite samples of fresh-cut fruit products .....	36
Figure 2. pH of individual samples of fresh-cut fruit products by fruit type.....	37

## LIST OF TABLES

Table 1. Methods used for the microbiological analyses of fruit salad samples .....	16
Table 2. Sampling location and fruit product type .....	17
Table 3. Microbiological results for fresh-cut fruit salad samples (n=75) obtained nationwide at retail in New Zealand. ....	18
Table 4. Microbial analysis results for <i>L. monocytogenes</i> and/or <i>Listeria</i> spp. positive fresh-cut fruit samples .....	34

## LIST OF ABBREVIATIONS

ALOA	Agar <i>Listeria</i> Ottavani & Agosti
APC	aerobic plate count
CAMP test	Christie–Atkins–Munch-Peterson test - to differentiate <i>Listeria</i> spp.
CFU	colony forming unit
CPS	coagulase-positive staphylococci/ <i>Staphylococcus</i>
PALCAM	polymyxin-acriflavine-LiCl-ceftazidime-aesculin-mannitol agar
MKTTn	Muller Kauffmann tetrathionate-novobiocin broth
MPN	most probable number
RVS	Rappaport Vassiliadis soy broth
XLD	Xylose Lysine Deoxycholate agar

## SUMMARY

A microbiological survey of fresh-cut retail fruit salads (non-retorted, ready-to-eat) available in consumer-ready packs in New Zealand was conducted during 2013-2014. A total of 75 samples, each a composite of 5 individual sub-samples representing different packs from the same batch (when available), were purchased from supermarkets or online retail stores.

Analyses were performed at the end of the products' shelf-life to determine the presence of *Salmonella* and *Listeria* spp. (including *L. monocytogenes*), and to enumerate *Escherichia coli*, coagulase-positive *Staphylococcus* spp. (CPS) and mesophilic aerobic microflora in composite samples. Enumeration of sub-samples was undertaken when *Listeria* strains were detected in composite samples; or if *E. coli* or CPS were detected in composite samples above pre-determined concentrations.

*Listeria monocytogenes* was detected in four samples at concentrations of < 100 CFU/g; three samples of melon product and one sample of a mixed fruit product also containing melon. Each of the melon samples also tested positive for *L. innocua*. Seven additional samples tested positive only for *L. innocua*. Levels of *L. innocua* ranged from < 100 to 1250 CFU/g. Aerobic plate counts (APC) of mesophilic aerobic microflora were highly variable for the mixed fruit and melon products, with counts ranging between 3.2 and 8.9 log<sub>10</sub> CFU/g for mixed fruit products, and between 4.3 and 7.4 log<sub>10</sub> CFU/g for melon products. *Salmonella*, CPS and *E. coli* were not detected in any of the samples.

The detection of *Listeria* spp. (notably including *L. monocytogenes*) in several ready-to-eat fresh-cut retail fruit products available in New Zealand suggests these products could be potential vehicles for foodborne illness. This study is the first of its kind in New Zealand and



raising awareness of consumers and food producers to its contents (with the accompanying MPI Good Operating Practice) may help reduce the risk associated with this product category.

## 1 INTRODUCTION

The consumption of nutritionally sound meals that include whole or minimally-processed fresh fruit and vegetables is being increasingly emphasized for health promotion reasons (Cook, 2011). Moreover, consumer lifestyle changes have driven the need for convenience-type ready-to-eat foods in portion-packs. A combination of these factors has resulted in greater consumption of store-bought produce items that are minimally processed (Abadias *et al.*, 2008). However, consumption of minimally processed fresh produce also presents a risk of exposure to pathogenic microorganisms. Pathogens associated with fresh fruit such as tomatoes, strawberries, melons and papaya include pathogenic *Escherichia coli*, *Salmonella* spp., *Listeria* spp., Hepatitis A, human adenovirus, norovirus, *Cyclospora cayatanensis*, and *Cryptosporidium parvum* (Van Boxstael *et al.*, 2013; Calder *et al.*, 2003; Cosgrove *et al.*, 2011; CDC, 2014; FSANZ, 2013; Maunula *et al.*, 2013). Indeed, there has been an increase in the number of reported outbreaks of foodborne illness related to consumption of contaminated produce, from the 1970s to the mid-2000s, both country-specific and internationally (Lynch *et al.*, 2009). The pathogen-food category pair associated with the largest number of outbreak-related illnesses (446) in the U.S. in 2012 was *Salmonella* spp. in fruits (CDC, 2014). In that year there were 16 fruit-related outbreaks in the US (totalling 858 illnesses) (CDC, 2014). Other countries reporting fruit-related outbreaks are the United Kingdom (UK) (Little and Gillespie, 2008), Australia (Abelson *et al.* 2006), Canada (Landry *et al.* 2007) and Mexico (Mohle-Boetani *et al.* 1999). In New Zealand, an outbreak of salmonellosis has been epidemiologically and physically linked to the consumption of locally grown watermelon (McCallum *et al.*, 2010).

Fresh-cut fruit salads are visible convenience food options in New Zealand supermarkets and retail food outlets. Such foods are intended to be consumed within a relatively short time span. Nonetheless, certain pathogens are able to multiply or survive on fruit under refrigerated conditions and thus present a risk to consumers. For example, survival of five *Salmonella* serotypes was shown on three kinds of melon incubated at for 24 h at 5°C (Golden *et al.*, 1993). *Listeria monocytogenes* is able to grow on fresh-cut cantaloupe at temperatures ranging from 2°C to 43°C (Fang *et al.* 2013).

Furthermore, consumers may elect to store and consume product for periods outside of the recommended shelf-life ranges. Such conditions may increase the potential for growth of foodborne pathogens. Both *Shigella* and *Salmonella* exhibit growth on papaya cubes incubated at 25-27°C after a few hours (Escartin *et al.*, 1989). *Listeria monocytogenes* has been shown to grow on the melon components of these salads, with a predicted (model-based) increase of 4 log<sub>10</sub> CFU/g following 15 days of storage at 5°C, and a 1 log<sub>10</sub> CFU/g increase after 6 days of storage at 4°C (Danyluk *et al.* 2014, Ukuku *et al.* 2012). Both *L. monocytogenes* and *Salmonella enterica* serovar Enteritidis exhibit growth in the pulped fruit of melon, watermelon and papaya at temperatures as low as 10°C (Penteado and Leitão, 2004a, b).

In New Zealand, an earlier survey (McIntyre and Cornelius, 2009) profiled the microbiological quality of whole fruit (domestic, imported and export), but not of consumer-ready portion-packed fresh-cut fruit.

The objective of this survey was to provide a snapshot of the microbiological status of non-retorted, fresh-cut fruit salads available in consumer-ready packs at retail in New Zealand by characterizing their pathogenic and mesophilic bacterial profile. This information will inform the MPI *Salmonella* and *Listeria monocytogenes* risk management strategies. The microbiological results from this survey will provide an insight into the efficacy of food safety control measures for such products, particularly with respect to the control of *L. monocytogenes* and *Salmonella*, and in relation to the Food Act (2014) and recent (2014) changes to microbiological limits for *L. monocytogenes* effected by FSANZ. Ultimately, this study aims to provide data that may help assess these specified risks and thus potentially support the development of tools, including guidance for food control plans, with the goal to minimise the risk of foodborne illness for this category of retail food.

## 2 MATERIALS AND METHODS

### 2.1 Sampling Programme

In this study, 75 composite retail samples of pre-packaged fresh-cut fruit salad products representing 14 brands sold in New Zealand were collected for analysis. Each composite comprised five samples from the same batch (and thus identical best-before/use-by date) when available (some samples had less than five sub-samples due to insufficient product availability). The sample number of 75 was chosen as that which enabled the detection of a difference of 2.5% or greater in the prevalence, with a power of 0.8, and a statistically significant result would be obtained in the event of one positive result.

It was stipulated that all samples collected should be pre-packaged by the manufacturer for retail sale (via one of nine supermarkets or grocery stores), or for food service (via one of three high street cafés or restaurants) and readily available to consumers. Sampling was designed to cover processors across New Zealand to ensure a robust geographical sampling distribution. Samples were collected across a spectrum of retail outlets including the major supermarkets and specialty stores, in a number of locations in New Zealand. Retail outlets in Christchurch, Auckland and Wellington were sampled by in-store visits, and samples from other locations were obtained online or by phone. Staff from both ESR and MPI designed the sampling plan to examine as representative a set of commodities as feasible given the budget allocated.

Sampling and testing occurred from June 2013 until April 2014 and was carried out in 2 Rounds. Round 1 sampling occurred from June 2013 - December 2013, and Round 2 sampling was carried out between December 2013 and April 2014. Samples were purchased and stored under the processor's stated storage conditions until analysed within  $\pm 2$  days of the processor's stated best-before/use-by date. If purchased in another city, samples were shipped overnight in a chilly bin with ice-replacement packaging, to maintain the temperature at  $4 \pm 3^{\circ}\text{C}$ . Sample temperatures were checked upon receipt at ESR's Christchurch Science Centre. Each sample was assigned a unique 'Public Health Laboratory' identification number.



## 2.2 Sample preparation

The outer surface of each sub-sample (pottle/bag/cup) was disinfected with alcohol before cutting it open with a sterilized scissors or scalpel. Contents were blended for 1 minute at high speed using a sterilized blender (Waring®; East Windsor, NJ, United States of America) to ensure homogenous distribution of fruit in the sample. The contents of the blender were poured into a stomacher bag. The sub-sample was then treated to neutralise acid conditions if necessary, to achieve a final pH of 6.5-7.0. To do this, an aliquot of the homogenate was aseptically removed, the initial pH measured (Eutech Instruments Cyberscan Series pH510 pH meter), and drops of 10N NaOH added to the homogenate in the stomacher bag. This was stomached (Colworth Stomacher® Model 400, A. J. Seward Co. UK, or BagMixer® 400 W, Interscience, France) for 30 seconds, an aliquot was aseptically removed and the pH measured again. This process was repeated until the pH of the homogenate was in the desired range. Portions of homogenate were then weighed out to be pooled into a composite for the analyses (Table 1), and the remainder of each sample stored at 4°C for re-testing if required. Metadata on the sampling process and product (shelf-life, best-before date or use-by date, packed-on date, origin of products, type of packaging) was recorded. A photograph of each individual package was also taken.

## 2.3 Microbiological Methods

Product samples were tested for the following microbiological hazards, using the methods stated in Table 1:

- Presence/absence:
  - *L. monocytogenes*
  - *Listeria* spp.
  - *Salmonella*
- Enumeration:
  - coagulase-positive *Staphylococcus* (CPS) (and tested for staphylococcal enterotoxin if the cell number was greater than 100,000 CFU/g)

- *Listeria* spp. (including *L. monocytogenes*)
- Aerobic Plate Count (APC)
- *E. coli* by MPN

For the presence/absence tests, 125g of composite sample (made up of 25g from each of five sub-samples) was added to enrichment broth (demi-Fraser for *Listeria* and buffered peptone water for *Salmonella*), and incubated as per the test protocol (Table 1). After preliminary incubation, for *Listeria*, the enrichment broth was streaked onto ALOA and PALCAM agar, incubated at 37°C for 48h, and examined for the presence of presumptive *Listeria* colonies. Typical colonies were confirmed by Gram stain, motility, haemolysis, CAMP and biochemical tests including Microgen™ ListeriaID MID-67, (Microgen Bioproducts Ltd., UK). For *Salmonella*, preliminary incubation was followed by inoculation into MKTTn and RVS broths which were incubated at 37 or 41.5°C respectively, for 24 hours. Inoculum from these broths was streaked onto XLD or Hektoen agar, incubated at 37°C for 24 h and examined for the presence of presumptive *Salmonella* colonies. Typical colonies were confirmed by serological and biochemical tests including Microgen™ GN A+B - ID (Microgen Bioproducts Ltd.).

For the tests requiring enumeration, 50g of a composite sample was diluted 1:10 and the standard enumeration procedures (Table 1) carried out for CPS, APC, *Listeria* spp. and *E. coli*. Any presumptive positive samples from the *E. coli*, *Listeria* spp. and CPS testing were subjected to identification and confirmatory tests.

Further testing of individual sub-samples was undertaken when the presence/absence testing on composite samples yielded positive results for *Listeria* spp., or if enumeration (composite) test results exceeded the trigger levels listed below.

- *E. coli* > 20 CFU/g
- CPS > 20 CFU/g
- APC > 10<sup>7</sup> CFU/g\*

\* After 3 weeks of sample analyses, it was noticed that the APC counts of individual sub-samples (for those samples that triggered enumeration of individual sub-samples) were higher than those of the corresponding composite samples that had been enumerated about 4-6 days earlier. This occurred because of the growth of mesophilic aerobic organisms during interim sample refrigeration. Consequently, it was decided by MPI that APC counts would be done on composite samples only from this period onwards.

Culturally and biochemically-confirmed isolates of pathogens were further confirmed by serotyping (*Salmonella*, *L. monocytogenes*), and Pulsed Field Gel Electrophoresis (PFGE) for *L. monocytogenes* (Graves and Swaminathan, 2001).

Confirmed positive results for any of the pathogen tests were communicated immediately to MPI via telephone with an official laboratory report following later.

**Table 1. Methods used for the microbiological analyses of fruit salad samples**

Microorganism	Type of test	Method used	Method name/source
<i>L. monocytogenes</i> , <i>Listeria</i> spp.	Presence/ Absence	ISO 11290-1:1996/Amd.1:2004	Microbiology of food and animal feeding stuffs – Horizontal method for the detection and enumeration of <i>Listeria monocytogenes</i> – Part 1: Detection method
<i>L. monocytogenes</i> , <i>Listeria</i> spp.	Enumeration	ISO 11290-2:1998/Amd.1:2004	Microbiology of food and animal feeding stuffs – Horizontal method for the detection and enumeration of <i>Listeria monocytogenes</i> – Part 2: Enumeration method
<i>Salmonella</i>	Presence/ Absence	ISO 6579:2002	Microbiology of food and animal feeding stuffs – Horizontal method for the detection of <i>Salmonella</i> spp.
Aerobic plate count (APC), mesophilic	Enumeration	ISO 4833:2003	Microbiology of food and animal feeding stuff – Horizontal method for the enumeration of microorganisms – Colony-count technique at 30°C
Coagulase-positive <i>Staphylococcus</i>	Enumeration	ISO 6888-1:1999	Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coagulase-positive staphylococci ( <i>Staphylococcus aureus</i> and other species) – Part 1: Technique using Baird - Parker agar medium
<i>E. coli</i>	Enumeration	APHA	American Public Health Association (APHA 2001, 4th Edition) method, Chapter: 'Enterobacteriaceae, Coliforms, and <i>Escherichia coli</i> as Quality and Safety Indicators', sections 8.7/8.8/8.9

## 2.4 Statistics

The pH and APCs for different fruit salad types were plotted using the stripchart function of the R statistical package (R Core Team, 2014). The jitter option of the stripchart function was used to help distinguish between data points with similar pH or APC values.

### 3 RESULTS

#### 3.1 Sample location and type

A total of 75 fresh-cut fruit products were sampled as shown in Table 2. Products that had nationwide distribution were sampled from retail outlets in Christchurch. Of the 75 samples, 48 products were purchased in-store, 20 by phone and/or e-mail, and seven were ordered through the manufacturer's website.

**Table 2.** Sampling location and fruit product type

<b>Product composition</b>	<b>Christchurch</b>	<b>Auckland</b>	<b>Lower North Island</b>	<b>Total</b>
Mixed fruit types	16	24	1	41
Diced melons <sup>a</sup>	10	5	2	17
Diced pineapple	2	4	1	7
Apple slices	5	3	NS	8
Cut strawberries	NS	2	NS	2
<b>Total</b>	<b>33</b>	<b>38</b>	<b>4</b>	<b>75</b>

a: Includes watermelon, honeydew melon, rock melon and combinations of these.

NS: None sampled.

#### 3.2 Microbial analyses

Seventy-five packaged samples of fresh-cut fruit were obtained from supermarkets or independent sellers nationwide in New Zealand (See Section 2: Materials and Methods). Each of the samples were analysed as a composite of five individual sub-samples, for the presence of *Listeria* and *Salmonella*. Enumeration procedures were carried out for CPS, APC and *E. coli* (Table 1). Subsequently, sub-samples were individually analysed to enumerate microbial numbers if *Listeria* spp. were indicated, or if enumeration of composite samples yielded a result that exceeded pre-assigned trigger levels (described above) for CPS, APC or *E. coli*.

Detailed results for all microbiological analyses performed on all samples are shown in Table 3.

**Table 3. Microbiological results for fresh-cut fruit salad samples (n=75) obtained nationwide at retail in New Zealand.**

Sample number	Sub-sample	Product <sup>1</sup>	Initial pH	<i>Salmonella</i>		<i>L. monocytogenes</i>		<i>Listeria</i> spp.		<i>E. coli</i>		CPS		APC	
				(Presence/Absence) <sup>2</sup>	(Presence/Absence) <sup>2</sup>	Sub-sample count (CFU/g) <sup>3</sup>	(Presence/Absence) <sup>2</sup> and identification	Sub-sample count (CFU/g)	Count (MPN/g)	Sub-sample count (CFU/g)	Count (CFU/g)	Sub-sample count (CFU/g)	Count (CFU/g)	Sub-sample count (CFU/g)	
2	1	Fruit salad	4.8	-	-	ND	+ <i>L. innocua</i>	<100	<3	ND	<10	ND	1.45 x 10 <sup>6</sup>	ND	
	2		4.7			ND		<100		ND		ND			
	3		4.5			ND		<100		ND		ND			
	4		4.8			ND		<100		ND		ND			
	5		4.7			ND		<100		ND		ND			
4	1	Fruit salad	3.8	-	-	ND	-	ND	<3	ND	<10	ND	6.7 x 10 <sup>4</sup>	ND	
	2		4.2			ND		ND		ND					
	3		3.9			ND		ND		ND					
	4		3.8			ND		ND		ND					
	5		3.9			ND		ND		ND					
8	1	Fruit salad	4.1	-	-	ND	-	ND	<3	ND	<10	ND	5.9 x 10 <sup>6</sup>	ND	
	2		4.4			ND		ND		ND					
	3		4			ND		ND		ND					
	4		4.4			ND		ND		ND					
	5		4.4			ND		ND		ND					
13	1	Fruit salad	4.2	-	-	ND	-	ND	<3	ND	<10	ND	1.5 x 10 <sup>3</sup>	ND	
	2		4.2			ND		ND		ND					
	3		4.2			ND		ND		ND					
	ND														

12	1	Fruit salad	3.6	-	-	ND	-	ND	≤3	ND	<10	ND	4.5 x 10 <sup>3</sup>	ND
	2		3.6			ND		ND						
	3		3.6			ND		ND						
	4		3.5			ND		ND						
	5		3.7			ND		ND						
25	1	Fruit salad	4.2	-	-	ND	-	ND	≤3	ND	<10	ND	1.3 x 10 <sup>6</sup>	ND
	2		4			ND		ND						
	3		4			ND		ND						
	4		4			ND		ND						
	5		4.1			ND		ND						
22	1	Fruit salad	4.4	-	-	<100	+ <i>L. innocua</i>	<100	≤3	ND	<10	ND	7.8 x 10 <sup>4</sup>	ND
	2		4.2			<100		<100						
	3		4.1			<100		<100						
	4		4.5			<100		<100						
	5		4.4			<100		<100						
29	1	Fruit salad	4.2	-	-	ND	+ <i>L. innocua</i>	<100	≤3	ND	<10	ND	1.3 x 10 <sup>7</sup>	ND
	2		4.2			ND		<100						
	3		4.2			ND		<100						
	4		4.2			ND		<100						
	5		4.2			ND		<100						
31	1	Fruit salad	4.6	-	-	ND	-	ND	≤3	ND	<10	ND	8.9 x 10 <sup>6</sup>	ND
	2		4.4			ND		ND						
	3		4.3			ND		ND						
	4		4.7			ND		ND						
	5		4.4			ND		ND						
36	1	Fruit salad	4.6	-	-	ND	-	ND	≤3	ND	<10	ND	2.4 x 10 <sup>4</sup> (moulds present)	ND
	2		4.7			ND		ND						
	3		4.7			ND		ND						
	4		4.7			ND		ND						
	5		4.7			ND		ND						

43	1	Fruit salad	4.4	-	-	ND	-	ND		ND		ND	$5.0 \times 10^4$	ND
	2		4.4			ND		ND		ND		ND		ND
	3		4.4			ND		ND	<3	ND	<1	ND		ND
	4		4.5			ND		ND		ND		ND		ND
	5		4.4			ND		ND		ND		ND		ND
44	1	Fruit salad	3.6			ND		ND		ND		ND	$6.8 \times 10^3$	ND
	2		3.8			ND		ND		ND		ND		ND
	3		3.7			ND		ND		ND		ND		ND
	4		3.6	-	-	ND	-	ND		ND	<10	ND		ND
	5		3.7			ND		ND	<3	ND		ND		ND

63	1	Fruit salad	4.1	-	-	ND	-	ND		ND		ND	$6.85 \times 10^5$	ND
	2		4.1			ND		ND		ND		ND		ND
	3		4.2			ND		ND	<3	ND	<10	ND		ND
	4		4.2			ND		ND		ND		ND		ND
	5		4.3			ND		ND		ND		ND		ND
56	1	Fruit salad	4.5			ND		ND		ND		ND	$3.8 \times 10^3$	ND
	2		4.6			ND		ND		ND		ND		ND
	3		4.6	-	-	ND	-	ND		ND	<10	ND		ND
	ND ND								<3					
65	1	Fruit salad	4	-	-	ND	-	ND		ND		ND	$1.3 \times 10^7$	ND
	2		4.2			ND		ND		ND		ND		ND
	ND													
	ND ND													



68	1	Fruit salad	4	-	-	ND	-	ND	≤3	ND	<10	ND	1.93 x 10 <sup>5</sup>	ND
	2		3.9			ND		ND		ND		ND		
	3		3.9			ND		ND		ND		ND		
	4		4			ND		ND		ND		ND		
	5		3.9			ND		ND		ND		ND		
72	1	Fruit salad	4.1	-	-	ND	-	ND	≤3	ND	<10	ND	1.4 x 10 <sup>7</sup>	ND
	2		4.3			ND		ND		ND		ND		
	3		4.3			ND		ND		ND		ND		
	4		4.2			ND		ND		ND		ND		
	ND													

26	1	Fruit mix	4	-	-	ND	-	ND	≤3	ND	<10	ND	5.5 x 10 <sup>3</sup>	ND
	2		4			ND		ND		ND		ND		
	3		4.1			ND		ND		ND		ND		
	4		4			ND		ND		ND		ND		
	ND													
28	1	Fruit mix	4.1	-	-	ND	-	ND	≤3	ND	<10	ND	4.5 x 10 <sup>7</sup>	ND
	2		4.2			ND		ND		ND		ND		
	3		4.2			ND		ND		ND		ND		
	ND													
	ND													
60	1	Fruit mix	5.2	-	-	ND	-	ND	≤3	ND	<10	ND	9.85 x 10 <sup>6</sup>	ND
	2		5.3			ND		ND		ND		ND		
	3		4.9			ND		ND		ND		ND		
	4		5.1			ND		ND		ND		ND		
	ND													
71	1	Fruit mix	4.5	-	-	ND	-	ND	≤3	ND	<10	ND	6.7 x 10 <sup>7</sup>	ND
	2		4.7			ND		ND		ND		ND		
	3		4.6			ND		ND		ND		ND		
	4		4.6			ND		ND		ND		ND		
	5		4.6			ND		ND		ND		ND		

15	1	Fruit tray	4.2	-	-	ND	-	ND	≤3	ND	<10	ND	1.2 x 10 <sup>6</sup>	ND
	2		4.2			ND		ND						
	3		4.3			ND		ND						
	4		4.2			ND		ND						
	5		4.2			ND		ND						
51	1	Fruit tray	4.2	-	-	ND	-	ND	≤3	ND	<10	ND	3.5 x 10 <sup>5</sup>	ND
	2		4.1			ND		ND						
	3		4.1			ND		ND						
	4		4.1			ND		ND						
	5		4.1			ND		ND						
1	1	Melons, mixed	6.2	-	-	ND	+ <i>L. innocua</i>	<100	≤3	ND	<10	ND	1.0 x 10 <sup>7</sup>	ND
	2		6.3			ND		<100		ND				
	3		6.1			ND		<100		ND				
	4		6.1			ND		<100		ND				
	5		6.3			ND		<100		ND				
30	1	Melons, mixed	4.6	-	-	ND	-	ND	≤3	ND	<10	ND	1.3 x 10 <sup>7</sup>	ND
	2		4.7			ND		ND						
	ND													
	ND													
32	1	Melons, mixed	5.8	-	-	ND	-	ND	≤3	ND	<10	ND	1.8 x 10 <sup>6</sup>	ND
	2		6.2			ND		ND						
	3		6			ND		ND						
	4		6.2			ND		ND						
	5		6			ND		ND						
57	1	Melons, mixed	6.2	-	-	ND	-	ND	≤3	ND	<10	ND	1.2 x 10 <sup>7</sup>	ND
	2		6			ND		ND						
	3		6.3			ND		ND						
	4		6.1			ND		ND						
	ND													



62	1	Melons, mixed	6.3	-	-	ND	-	ND		ND	ND	2.02 x 10 <sup>6</sup>	ND
	2		6.4			ND		ND		ND	ND		
	3		6.4			ND		ND	<3	ND	ND		
	4		6.3			ND		ND		<10	ND		
	5		6.4			ND		ND			ND		
50	1	Melon and grapes	4.9			ND		ND		ND	ND	7.6 x 10 <sup>8</sup>	ND
	2		5.1			ND		ND		ND	ND		
	3		4.9			ND		ND	<3	ND	ND		
	4		4.7	-	-	ND	-	ND		<10	ND		
	5		4.7			ND		ND			ND		
27	1	Melon and grapes	4.9			ND		ND		ND	ND	1.5 x 10 <sup>4</sup>	ND
	2 3		4.9			ND		ND		ND	ND		
	4		4.6			ND		ND	<3	ND	ND		
	4		4.9	-	-	ND	-	ND		<10	ND		
	5		4.9			ND		ND			ND		

7	1	Honeydew melon	5.7			<100		<100		ND	ND	2.1 x 10 <sup>4</sup>	ND
	2		5.7			<100		<100		ND	ND		
	3		5.8			<100	+	<100	<3	ND	ND		
	4		5.9	-	+	<100	<i>L. innocua</i>	<100		<10	ND		
	5		5.8			<100		<100			ND		
21	1	Honeydew melon	5.3			<100		350		ND	ND	1.5 x 10 <sup>7</sup>	ND
	2		5.7			<100		650		ND	ND		
	3		5.4			<100	+	500	<3	ND	ND		
	4		5.4	-	+	50	<i>L. innocua</i>	650		<10	ND		
	5		5.3			<100		900			ND		



37	1	Honeydew melon	6.1	-	-	ND	-	ND	≤3	ND	<10	ND	1.8 x 10 <sup>5</sup>	ND
	2		6.2			ND		ND		ND		ND		
	3		6.1			ND		ND		ND		ND		
	4		6.1			ND		ND		ND		ND		
	5		6			ND		ND		ND		ND		
6	1	Rockmelon	6.7	-	-	ND	+ <i>L. innocua</i>	<100	≤3	ND	<10	ND	1.35 x 10 <sup>7</sup>	5.6 x 10 <sup>8</sup>
	2		6.3			ND		200		ND		5.5 x 10 <sup>8</sup>		
	3		6.5			ND		<100		ND		4.5 x 10 <sup>8</sup>		
	4		6.6			ND		<100		ND		2.8 x 10 <sup>8</sup>		
	5		6.6			ND		<100		ND		3.7 x 10 <sup>8</sup>		
23	1	Rockmelon	6.3	-	+	50	+ <i>L. innocua</i>	750	≤3	ND	<10	ND	2.4 x 10 <sup>7</sup>	ND
	2		6.2			<100		200		ND		ND		
	3		6.3			<100		950		ND		ND		
	4		6.3			<100		900		ND		ND		
	5		6.2			<100		1250		ND		ND		
35	1	Rockmelon	5.7	-	-	ND	-	ND	≤3	ND	<10	ND	1.6 x 10 <sup>6</sup>	ND
	2		5.4			ND		ND		ND		ND		
	3		5.6			ND		ND		ND		ND		
	4		5.7			ND		ND		ND		ND		
	5		5.5			ND		ND		ND		ND		
38	1	Rockmelon	6.4	-	-	ND	-	ND	≤3	ND	<10	ND	7.9 x 10 <sup>5</sup>	ND
	2		6.4			ND		ND		ND		ND		
	3		6.3			ND		ND		ND		ND		
	4		6.5			ND		ND		ND		ND		
	5		6.5			ND		ND		ND		ND		

64	1	Rockmelon	6.7	-	-	ND	-	ND	≤3	ND	<10	ND	2.2 x 10 <sup>6</sup>	ND
	2		6.7			ND		ND		ND		ND		
	3		6.7			ND		ND		ND		ND		
	4		6.7			ND		ND		ND		ND		



	5		6.6			ND		ND		ND		ND		ND
74	1 2 ND ND ND	Rockmelon	6.6 6.7	-	-	<100 <100	+ <i>L. innocua</i>	<100 <100	<3	ND ND	<10	ND ND	2.5 x 10 <sup>6</sup>	ND ND
5	1 2 3 4 5	Watermelon	6 5.8 6.1 5.9 5.8	-	-	ND ND ND ND ND	-	ND ND ND ND ND	<3	ND ND ND ND ND	<10	ND ND ND ND ND	3.75 x 10 <sup>4</sup>	ND ND ND ND ND
34	1 2 3 4 5	Watermelon	6.4 6.4 6.6 6.5 6.5	-	-	ND ND ND ND ND	-	ND ND ND ND ND	<3	ND ND ND ND ND	<10	ND ND ND ND ND	4.3 x 10 <sup>5</sup>	ND ND ND ND ND
75	1 2 ND ND ND	Watermelon	5.6 5.7	-	-	ND ND	-	ND ND	<3	ND ND	<10	ND ND	2.3 x 10 <sup>5</sup>	ND ND

9	1 2 3 4 5	Apple slices	3.9 4 4 4 3.9	-	-	ND ND ND ND ND	-	ND ND ND ND ND	<3	ND ND ND ND ND	<10	ND ND ND ND ND	6.15 x 10 <sup>6</sup>	ND ND ND ND ND
10	1 2 3 4 ND	Apple slices	3.7 3.7 3.7 3.6	-	-	ND ND ND ND	-	ND ND ND ND	<3	ND ND ND ND	<10	ND ND ND ND	3.6 x 10 <sup>7</sup>	2.4 x 10 <sup>8</sup> 2.0 x 10 <sup>8</sup> 1.6 x 10 <sup>8</sup> 1.6 x 10 <sup>8</sup>



11	1	Apple slices	3.8	-	-	ND	-	ND	<3	ND	<10	ND	1.5 x 10 <sup>6</sup>	ND
	2		3.8			ND		ND						
	3		3.8			ND		ND						
	4		3.8			ND		ND						
	5		3.8			ND		ND						
16	1	Apple slices	3.9	-	-	ND	-	ND	<3	ND	<10	ND	4.2 x 10 <sup>6</sup>	ND
	2		3.9			ND		ND						
	3		3.9			ND		ND						
	4		3.9			ND		ND						
	5		3.9			ND		ND						
46	1	Apple slices	3.8	-	-	ND	-	ND	<3	ND	<10	ND	5.4 x 10 <sup>5</sup>	ND
	2		3.8			ND		ND						
	3		3.8			ND		ND						
	4		3.8			ND		ND						
	5		3.7			ND		ND						
42	1	Apple slices	3.7	-	-	ND	-	ND	<3	ND	<10	ND	5.2 x 10 <sup>6</sup>	ND
	2		3.6			ND		ND						
	3		3.7			ND		ND						
	4		3.7			ND		ND						
	5		3.7			ND		ND						
53	1	Apple slices	3.7	-	-	ND	-	ND	<3	ND	<10	ND	1.6 x 10 <sup>7</sup>	ND
	2		3.7			ND		ND						
	3		3.7			ND		ND						
	ND													
	ND													

58	1	Apple slices	3.8	-	-	ND	-	ND	≤3	ND	<10	ND	1.6 x 10 <sup>7</sup>	ND
	2		3.7			ND		ND		ND		ND		
	3		3.8			ND		ND		ND		ND		
	4		3.7			ND		ND		ND		ND		
	5		3.8			ND		ND		ND		ND		
24	1	Pineapple	4	-	-	<100	+ <i>L. innocua</i>	<100	≤3	ND	<10	ND	5.2 x 10 <sup>4</sup>	ND
	2		4.1			<100		<100		ND		ND		
	3		4.1			<100		<100		ND		ND		
	4		4			<100		<100		ND		ND		
	5		4.1			<100		<100		ND		ND		
33	1	Pineapple	4	-	-	ND	-	ND	≤3	ND	<10	ND	3.9 x 10 <sup>4</sup>	ND
	2		4			ND		ND		ND		ND		
	3		4.3			ND		ND		ND		ND		
	4		4			ND		ND		ND		ND		
	5		4			ND		ND		ND		ND		
3	1	Pineapple	3.3	-	-	ND	-	ND	≤3	ND	<10	ND	5 x 10 <sup>3</sup>	ND
	2		3.3			ND		ND		ND		ND		
	3		3.4			ND		ND		ND		ND		
	4		3.4			ND		ND		ND		ND		
	5		3.4			ND		ND		ND		ND		
14	1	Pineapple	3.5	-	-	ND	-	ND	≤3	ND	<10	ND	4.25 x 10 <sup>3</sup>	ND
	2		3.3			ND		ND		ND		ND		
	3		3.4			ND		ND		ND		ND		
	4		3.4			ND		ND		ND		ND		
	5		3.4			ND		ND		ND		ND		
40	1	Pineapple	3.4	-	-	ND	-	ND	≤3	ND	<10	ND	6.1 x 10 <sup>4</sup>	ND
	2		3.3			ND		ND		ND		ND		
	3		3.3			ND		ND		ND		ND		
	4		3.3			ND		ND		ND		ND		
	5		3.4			ND		ND		ND		ND		

45	1	Pineapple	3.3	-	-	ND	-	ND	≤3	ND	<10	ND	8.7 x 10 <sup>3</sup>	ND
	2		3.3			ND		ND						
	3		3.2			ND		ND						
	4		3.3			ND		ND						
	5		3.3			ND		ND						
66	1	Pineapple	3.4	-	-	ND	-	ND	≤3	ND	<10	ND	1.65 x 10 <sup>4</sup>	ND
	2		3.3			ND		ND						
	3		3.3			ND		ND						
	4		3.3			ND		ND						
	5		3.3			ND		ND						
20	1	Pineapple mix	3.7	-	-	ND	-	ND	≤3	ND	<10	ND	6.9 x 10 <sup>4</sup>	ND
	2		3.7			ND		ND						
	3		3.6			ND		ND						
	4		3.6			ND		ND						
	5		3.6			ND		ND						
70	1	Pineapple mix	3.7	-	-	ND	-	ND	≤3	ND	<10	ND	1.2 x 10 <sup>4</sup>	ND
	2		3.7			ND		ND						
	3		3.7			ND		ND						
	4		3.7			ND		ND						
	5		3.7			ND		ND						
47	1	Pineapple and mango	3.4	-	-	ND	-	ND	≤3	ND	<10	ND	2.5 x 10 <sup>4</sup>	ND
	2		3.4			ND		ND						
	3		3.5			ND		ND						
	4		3.5			ND		ND						
	5		3.4			ND		ND						



17	1	Pineapple and Mango	3.7	-	-	ND	-	ND	≤3	ND	<10	ND	1.27 x 10 <sup>4</sup>	ND
	2		3.8			ND		ND		ND		ND		
	3		3.8			ND		ND		ND		ND		
	4		3.8			ND		ND		ND		ND		
	5		3.7			ND		ND		ND		ND		
52	1	Mango fruit mix	4.4	-	-	ND	-	ND	≤3	ND	<10	ND	3.9 x 10 <sup>7</sup>	ND
	2		4.5			ND		ND		ND		ND		
	3		4.4			ND		ND		ND		ND		
	4		4.3			ND		ND		ND		ND		
	5		4.5			ND		ND		ND		ND		
54	1	Mango mix	4.7	-	-	ND	-	ND	≤3	ND	<10	ND	1.4 x 10 <sup>4</sup>	ND
	2		4.9			ND		ND		ND		ND		
	3		4.6			ND		ND		ND		ND		
	4		4.8			ND		ND		ND		ND		
	5		4.9			ND		ND		ND		ND		
49	1	Mango fruit mix	4.2	-	+	<100	-	<100	≤3	ND	<10	ND	4.5 x 10 <sup>7</sup>	ND
	2		4.2			<100		ND		ND		ND		
	3		4.3			<100		ND		ND		ND		
	4		4.3			<100		ND		ND		ND		
	5		4.5			<100		ND		ND		ND		
73	1	Mango mix	4.6	-	-	ND	-	ND	≤3	ND	<10	ND	2.2 x 10 <sup>5</sup>	ND
	2		4.6			ND		ND		ND		ND		
	3		4.4			ND		ND		ND		ND		
	4		4.5			ND		ND		ND		ND		
	5		4.5			ND		ND		ND		ND		
41	1	Citrus mix	3.6	-	-	ND	-	ND	≤3	ND	<10	ND	5.3 x 10 <sup>4</sup>	ND
	2		3.7			ND		ND		ND		ND		
	3		3.6			ND		ND		ND		ND		
	4		3.7			ND		ND		ND		ND		
	5		3.5			ND		ND		ND		ND		

61	1	Citrus mix	3.5	-	-	ND	-	ND		ND	ND	ND	$3.6 \times 10^3$	ND
	2		3.6			ND		ND		ND	ND	ND		ND
	3		3.6			ND		ND	≤3	ND	<10	ND		ND
	4		3.6			ND		ND		ND	ND	ND		ND
	5		3.6			ND		ND		ND	ND	ND		ND
67	1	Strawberries	3.5			ND		ND		ND	ND	ND	$9.2 \times 10^3$	ND
	2		3.6			ND		ND		ND	ND	ND		ND
	3		3.6			ND		ND		ND	ND	ND		ND
	4		3.5	-	-	ND	-	ND	≤3	ND	<10	ND		ND
	5		3.5			ND		ND		ND	ND	ND		ND
39	1	Strawberries	3.5	-	-	ND	-	ND		ND	ND	ND	$9.4 \times 10^3$	ND
	2		3.6			ND		ND		ND	ND	ND		ND
	3		3.5			ND		ND	≤3	ND	<10	ND		ND
	4		3.5			ND		ND		ND	ND	ND		ND
	5		3.6			ND		ND		ND	ND	ND		ND
18	1	Kiwifruit mix	3.6			ND		ND		ND	ND	ND	$4.5 \times 10^3$	ND
	2		3.6			ND		ND		ND	ND	ND		ND
	3		3.7			ND		ND	≤3	ND	<10	ND		ND
	4		3.7	-	-	ND	-	ND		ND	ND	ND		ND
	5		3.7			ND		ND		ND	ND	ND		ND
55	1	Kiwifruit mix	3.8			ND		ND		ND	ND	ND	$6.7 \times 10^4$	ND
	2		3.9			ND		ND		ND	ND	ND		ND
	3		3.7			ND		ND	≤3	ND	<10	ND		ND
	4		3.8	-	-	ND	-	ND		ND	ND	ND		ND
	5		3.7			ND		ND		ND	ND	ND		ND

59	1	Kiwifruit mix	3.4	-	-	ND	-	ND		ND	ND	1.3 x 10 <sup>4</sup>	ND
	2		3.4			ND		ND		ND	ND		
	3		3.3			ND		ND	<3	ND	<10		
	4		3.4			ND		ND		ND	ND		
	ND												
48	1	Kiwifruit mix	3.6			ND		ND		ND	ND	7.9 x 10 <sup>3</sup>	ND
	2		3.7			ND		ND		ND	ND		
	3		3.6			ND		ND		ND	ND		
	4		3.6	-	-	ND	-	ND		ND	<10		
	5		3.5			ND		ND	<3	ND	ND		
19	1	Exotic fruit salad	3.7			ND		ND		ND	ND	2.6 x 10 <sup>4</sup>	ND
	2		3.7			ND		ND		ND	ND		
	3		3.8			ND		ND		ND	ND		
	4		3.7	-	-	ND	-	ND		ND	<10		
	5		3.8			ND		ND	<3	ND	ND		
69	1	Exotic fruit mix	4			ND		ND		ND	ND	3.9 x 10 <sup>5</sup>	ND
	2		4.1			ND		ND		ND	ND		
	3		3.8			ND		ND		ND	ND		
	4		4	-	-	ND	-	ND		ND	<10		
	5		4.1			ND		ND	<3	ND	ND		

P/A = Presence absence test, ND = Not determined

<sup>1</sup>Product type by ingredient list

<sup>2</sup> Presence (+), Absence (-)

<sup>3</sup> Concentrations are on a per gram basis

The limit of detection was: 10 CFU/g (CPS), 3 MPN/g (*E. coli*), 10 CFU/g (APC), 100 CFU/g (*Listeria*).

### 3.2.1 CPS, *E. coli* and *Salmonella* testing

Coagulase-positive staphylococci were not detected in any of the samples, with a limit of detection of 10 CFU/g (Table 3). Similarly, *E. coli* was not detected above the limit of detection of 3 MPN/g in any sample (Table 3). *Salmonella* spp. were not detected in presence/absence testing of samples (Table 3).

### 3.2.2 *Listeria* testing

*L. monocytogenes* was detected in four fruit product samples; these were three samples of melon product and one sample of mixed fruit product (Table 3) from two supermarket brands. These same three melon samples also tested positive for *L. innocua* (Table 3). Seven additional samples of fresh-cut fruit product tested positive for *L. innocua* only (Table 3) therefore *Listeria* spp. were detected in 10 fruit product samples from a total of three supermarket brands.

The data from the samples where *Listeria* spp. (*L. innocua* and *L. monocytogenes*) were detected were further analysed (Table 4). Brand A *Listeria* spp. positive samples were all procured in the same week (Table 4). Brand B positive samples (for *L. monocytogenes* and *Listeria* spp.) were procured in three different months during the sampling period (Table 4). The Brand C positive sample for *Listeria* spp. was obtained in late October 2013.

The *L. monocytogenes* isolates were subjected to further discriminatory testing to determine the serotype and pulsotype by macrorestriction profiling using PFGE. Typing results are summarised in Table 4 and three distinct strain types were identified. Two strains representing serotype O1/2 and PFGE pulsotype Asc0059:Apa0046 were isolated from different melon varieties sold by the same brand and isolated in the same sampling period. This type has been seen previously in the New Zealand database<sup>1</sup>, with isolates noted from 2006, 2007 and 2012. Human cases corresponding to this type during the aforementioned sampling period were not observed. The pulsotype Asc0076:Apa0007 (from Brand B honeydew melon) has also been recorded previously in New Zealand human case related isolates in the PulseNet Aotearoa New Zealand database<sup>1</sup>. This pattern has been identified in Canada, where

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<sup>1</sup> <http://www.esr.cri.nz/capabilities/Pages/PulseNetAotearoa.aspx> - accessed 30 May 2014



it was last seen in 2005 (Brent Gilpin, ESR, personal communication). The pulsotype Asc0053a: ApaNOCUT was not in the database. However, a closely related Asc0053: ApaNOCUT pulsotype from the fruit mix sample was previously recorded from a New Zealand human case in 2007. This pattern has been seen once in the U.S. CDC database, from a patient, in 2002 (Brent Gilpin, ESR, personal communication). The serotypes of *L. monocytogenes* isolates are listed in Table 4. Two of these, from the Brand A products, have the serotype O1/2, while the two isolates from Brand B and C products are of the O4 serotype. Due to the potential public health risk of these detections, these results were immediately communicated to MPI and appropriate action was taken.

**Table 4. Microbial analysis results for fresh-cut fruit samples where *L. monocytogenes* and/or *Listeria* spp. was detected**

Brand	Fruit type	Sampling date	Best before / Use-by date	<i>L. monocytogenes</i> isolated (Serotype)	Subsample counts CFU/g	PFGE profile	Other <i>Listeria</i> spp. isolated	Sub-sample count range CFU/g:
A	Diced honeydew melon	26/09/2013	2/10/2013	Yes (O1/2)	all <100 <sup>a</sup>	Asc0059:Apa0046	<i>L. innocua</i>	350 to 900
	Diced rock melon	26/09/2013	2/10/2013	Yes (O1/2)	all <100 <sup>a</sup>	Asc0059:Apa0046	<i>L. innocua</i>	200 to 1250
	Fruit salad <sup>b</sup>	26/09/2013	2/10/2013	No			<i>L. innocua</i>	all <100
	Diced pineapple	26/09/2013	2/10/2013	No			<i>L. innocua</i>	all <100
B	Diced honeydew melon	23/06/2013	26/06/2013	Yes (O4)	all <100	Asc0076: Apa0007	<i>L. innocua</i>	all <100
	Diced mixed melon	15/06/2013	20/06/2013	No			<i>L. innocua</i>	all <100
	Diced rock melon	23/06/2013	26/06/2013	No			<i>L. innocua</i>	4 samples: <100, 1 sample: 200
	Fruit Mix <sup>c</sup>	5/02/2014	10/02/2014	Yes (O4)	all <100	Asc0053a:ApaNOC UT	No	

D'Sa and Hudson, 2014

	Rock melon	11/04/2014	14/04/2014	No			<i>L. innocua</i>	all <100
	Fruit Salad <sup>d</sup>	15/06/2013	20/06/2013	No			<i>L. innocua</i>	all < 100
C	Fruit salad <sup>e</sup>	31/10/2013	6/11/2013	No			<i>L. innocua</i>	all <100

a: Four sub samples had no identifiable colonies on duplicate plates and one subsample had one colony on a single plate (equivalent to 50 CFU/g).

b: Ingredients: honeydew and rock melon, apple, orange, grapes, pineapple.

c: Ingredients: watermelon, pineapple, persimmon, grapes, mango.

d: Ingredients: honeydew, rock and water melon, grapes, pineapple.

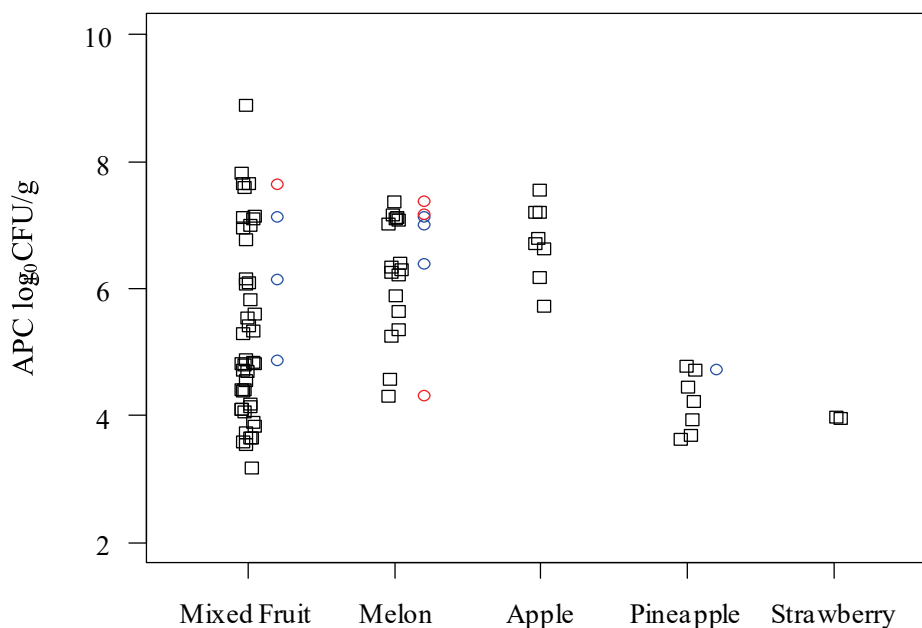
e: Ingredients: honeydew and rock melon, grapes, apple, pineapple, watermelon.

### 3.2.3 Aerobic Plate Counts

The APC for the composite samples are plotted by fruit type in Figure 1. The APC were highly variable for the mixed fruit and melon products with counts ranging between 3.2 and 8.9 log<sub>10</sub> CFU/g for mixed fruit products, and between 4.3 and 7.4 log<sub>10</sub> CFU/g for melon products. The pineapple and strawberry products had a lower APC than the apple samples taken. However due to the number of samples, this may not be a reflection of the APC profile of these products in general, and further testing would be required to establish any differences in APCs between these products. The highest APC (of composites) noted was for a Brand A 'Melon and grape' product with an APC of 8.9 log<sub>10</sub> CFU/g and the lowest APC was from a Brand C 'Citrus Mix' product (3.6 log<sub>10</sub> CFU/g).

The samples in which *Listeria* spp. were detected are also indicated in Figure 1. There was no clear association between the APC and the presence of *Listeria* spp.

**Figure 1. Aerobic plate counts (log<sub>10</sub> CFU/g) of composite samples of fresh-cut fruit products<sup>a</sup>.**



<sup>a</sup>Samples testing positive for *L. monocytogenes* are indicated with a red circle. Other samples only testing positive for *L. innocua* are indicated with a blue circle.

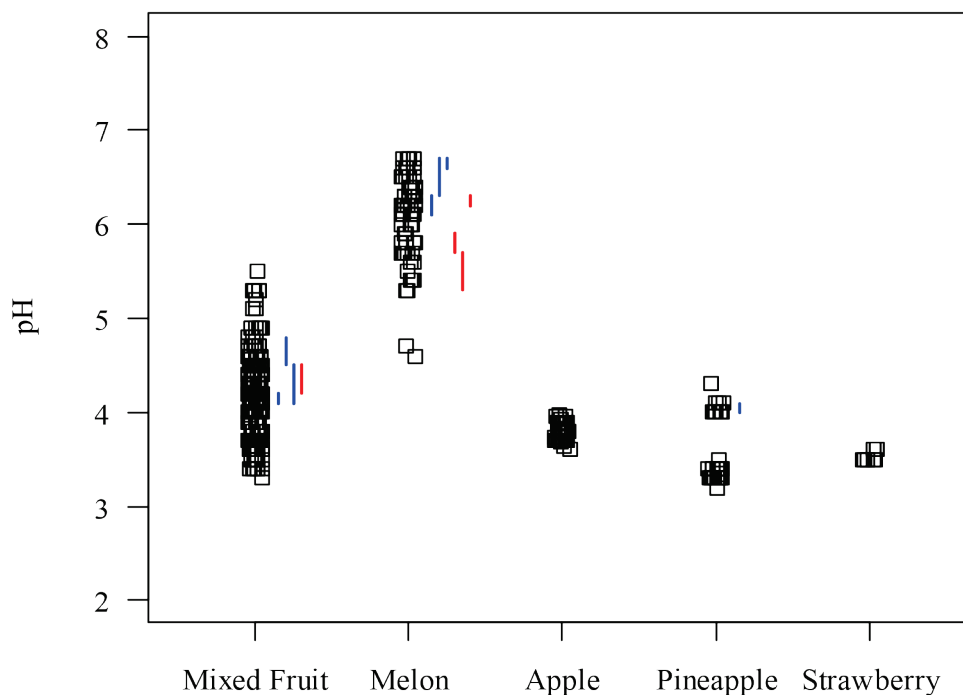


### 3.3 pH of fresh-cut fruit salads

The pH of samples (i.e. individual retail packs of fruit subsequently homogenised by blending for analyses) from each batch of the 75 products examined was taken before samples were acid neutralised (to between 6.5-7.0 if the initial pH was outside this range) (Table 3). The pH of individual samples of different fruit types are plotted in Figure 2. Melon samples were noticeably less acidic than apple, pineapple or strawberry samples. The pH of mixed fruit samples were reflected in the individual fruit types used as ingredients in the products.

*Listeria* spp. were detected in 10 of 45 fruit product samples with a pH between 4.0 and 6.7. However, as expected from established growth characteristics (Phan-Thanh 1998; FSANZ, 2014), *Listeria* spp. were not detected in samples with a pH below 4. Three of the four isolations of *L. monocytogenes* were from products containing melon varieties only; the fourth from a fruit salad that comprised mango, rockmelon, and pineapple (Table 3; S. On, unpublished data).

**Figure 2. pH of individual samples of fresh-cut fruit products by fruit type<sup>a</sup>**



<sup>a</sup>The range of pH for each sample testing positive for *L. monocytogenes* is indicated by a red line and the range for other samples which only tested positive for *L. innocua* are indicated by a blue line.

### 3.3.1 Product packaging

Of the 75 fresh-cut fruit samples analysed, 16 were packaged in flexible, sealed plastic pouches or larger-sized bags. Two samples comprising semi-prepared fruit were in a Styrofoam tray overwrapped with plastic film. The remaining 57 samples were packaged in semi-rigid plastic pottles or cups. The shelf-lives of product from a given brand were usually described consistently as either “use by” or “best before” but exceptions were seen during the survey period. We found one example of the shelf life described as a date of expiry and one product that had no labelling at all.

## 4 DISCUSSION

In our survey of 75 fresh-cut fruit salad samples, *L. monocytogenes* and *Listeria* spp. were isolated from four (5.3%) and 10 (13.3%) of the fresh-cut fruit samples, respectively. Three of the four fruit samples harbouring *L. monocytogenes* were melon varieties and the fourth a fruit salad mixture comprising watermelon, rockmelon, pineapple, grapes, and mango; in each sample, pH values were >4.0 and the counts of *L. monocytogenes* were all < 100 CFU/g. Our study did not recover *Listeria* spp. from fruit samples with pH values lower than 4.0, which correlates with known properties of the organism (Phan-Thanh, 1998; FSANZ, 2014), and indicating that fruit varieties or blends of the more acidic varieties harbour a lower risk of conferring listeriosis to humans.

Given that our analyses were performed on samples that were within two days of the latest shelf-life date stated by the producer, these samples would comply with the 2014 revised limits for *L. monocytogenes* limits in fresh-cut and packaged horticultural produce (FSANZ, 2014). One caveat to this finding is that *L. innocua* was co-isolated from three of the four *L. monocytogenes*-positive melon samples (Table 3). It is documented that *L. innocua* can interfere with the detection of *L. monocytogenes* even where ISO-standard methods (as employed in our study) are used, to the extent that detection of this important pathogen may be masked entirely during routine testing (Zitz *et al.*, 2011). However, our follow-up investigations that included macrorestriction profiling did not reveal any link between the *L.*

*monocytogenes* isolates from this study, or human cases of listeriosis at or around the time of isolation or product availability. Nevertheless, fruit salads contain components e.g. melon, that support the growth of the organism (Penteado and Leitão, 2004a; Danyluk *et al*, 2014), and the fact that outbreaks of listeriosis have been linked to the consumption of fruit salads/fresh-cut fruits (CDC, 2012) reflects the ability of these foods to support sufficient growth of *L. monocytogenes* such that disease can result.

In addition to the melon varieties described above, *L. innocua* was detected in pineapple samples and mixed fruit salads containing melon varieties, grapes, pineapple and for one brand, apple. The counts of *L. innocua* were < 100 CFU/g for seven samples, and were 350-900, 200-1250 and 200 (for one sub-sample) CFU/g in the remaining three samples. The close relationship between *L. innocua* and *L. monocytogenes* (Buchreiser, 2007) means that the former is used as an indicator for growth potential in the latter, hence foods in which *L. innocua* are found are generally regarded as having the potential to harbour the pathogen *L. monocytogenes*. However, *L. innocua* outcompetes *L. monocytogenes* in mixed culture (Zitz *et al.* 2011) which may reflect its wider distribution in this and other studies. In a UK survey of ready-to-eat cut fruit (Little and Mitchell, 2004) 86 of 997 samples (8.6%), contained *Listeria* spp. and 78 (7.8%) *L. monocytogenes*. Counts were 100 or more CFU/g *L. monocytogenes* in one of the samples tested. These results were thus approximately consistent with the results of our survey.

In other investigations, a Swiss survey of 64 fresh-cut fruit samples collected from a production plant found that none contained *L. monocytogenes* (Althaus *et al.* 2012), and a survey of 22 fruit samples in Spain also failed to detect *L. monocytogenes* (Sospedra *et al.*, 2013). In a survey conducted in Germany (Becker and Tauscher, 2011), *L. monocytogenes* was detected in 19.5% (24 of 123) fresh-cut fruit and fruit salad samples. In a larger study of 194 fruit samples in Western Australia (Western Australia Food Monitoring Program, 2005), *L. monocytogenes* was found in one sample of pineapple at < 3 MPN, which is in the 'marginal' category of the 2001 FSANZ guidelines (FSANZ, 2001). Kramarenko *et al.* (2013) detected *L. monocytogenes* in 2.5% and 3.5% of fruit and vegetable-based RTE products in Estonia, in 2009 and 2010, respectively. No *L. monocytogenes* was found in a Spanish study of 21 freshcut fruit samples (Abadias *et al.*, 2008).

A large Japanese survey of 504 pre-cut fruit samples collected over Winter and Summer detected presumptive *E. coli* in three (0.6%) samples, but enterohaemorrhagic *E. coli* and enterotoxigenic *E. coli* were not detected (Mori *et al.* 2010). In the Little and Mitchell (2004) study, three (0.3%) of the samples contained *E. coli*. No *E. coli* was found in the Swiss study (Althaus *et al.*, 2012). In the German survey, *E. coli* was detected in 17 (13.8%) of 123 samples at a maximum level of  $3.0 \times 10^4$  CFU/g (Becker and Tauscher, 2011). A Canadian survey of 151 samples of muskmelon detected *E. coli* in 1.3% of the fruit (Arthur *et al.*, 2007). These findings are different from our current survey, in which this organism was not detected. However, in a Spanish study (Abadias *et al.*, 2008), and a Norwegian study (Johannessen *et al.*, 2002), no *E. coli* were detected in 21 fresh-cut fruit samples, and 154 strawberry samples, respectively. Positive findings of *E. coli* noted could be attributed to contamination at different levels of the farm-to-fork food chain, whereas in the surveys where *E. coli* was not detected, consistent good manufacturing (GMPs) and hygiene practices are most likely in place.

In a German survey, *Staphylococcus* spp. were detected in 13% of samples at levels ranging from  $1 \times 10^2$  to  $2 \times 10^3$  CFU/g (Becker and Tauscher, 2011). In the Indian study of Viswanathan and Kaur (2001), *S. aureus* was detected in five mixed fruit samples, four pineapple samples, and seven watermelon samples. In an Argentinian survey of 71 fruit salad samples from retail shops (Estrada *et al.*, 2013), *S. aureus* (CPS) was isolated from 11 (7.81%) of the samples, with counts between 1.30-2.47  $\log_{10}$  CFU/g. These findings are different from our current survey, in which this organism was not detected. Here too, the differences in the findings of CPS can be attributed to GMPs being in place at the growing and manufacturing premises.

APC levels of pre-cut fruit samples ranged from  $7.3 \times 10^2$  to  $1.6 \times 10^{10}$  CFU/g in the German survey (Becker and Tauscher, 2011). In the study by Viswanathan and Kaur (2001), APC levels ranged from  $1.5 \times 10^8$  –  $7.3 \times 10^8$  for mixed fruit,  $7 \times 10^6$  –  $1.6 \times 10^8$  for pineapple, and  $7 \times 10^6$  –  $1.0 \times 10^8$  for watermelon. Seow *et al.* (2012) found that the APC of 42 fruit samples (apple, mango, orange) from major supermarkets and local markets in Singapore ranged from 1.6 to 5.1  $\log_{10}$ . In the Argentinian survey of 71 artisanal fruit salad samples, the APCs were between 1.6-4.7  $\log_{10}$  CFU/g (Estrada *et al.*, 2013). In a Spanish study (Abadias *et al.*, 2008), 21 freshcut fruit samples were analysed, with APCs in the range of 2.0-7.1  $\log_{10}$  CFU/g. The APC levels in our survey ranged from 3.6-8.9  $\log_{10}$  CFU/g. APC levels reflect the fruit type, the growing environment, and the processing and handling facilities, in addition to the mix of ingredients

in the product and time point in the shelf-life of the product when examined. Thus, variability seen in the levels is not unusual. Even though our testing was performed on product close to the retailers stipulated shelf-life date, we observed no clear association of APC count with the presence of the pathogen *L. monocytogenes*, suggesting the former should not be used to mark the microbial safety of fruit products, and represents a more general indicator of production hygiene.

Most of the surveys reviewed (Althaus *et al.*, 2012; Little and Mitchell 2004; Becker and Tauscher, 2011; Seow *et al.*, 2012; de Paula *et al.*, 2009; Arthur *et al.*, 2007; Estrada *et al.*, 2013; Abadias *et al.*, 2008; Johannessen *et al.*, 2002) reported no isolation of *Salmonella* from fruit salads or fresh cut fruit. Similarly, we detected no *Salmonella* spp. in any samples examined in our survey. However, fruit salads/pre-cut fruit have been the vehicle for outbreaks of salmonellosis in the past, including three multistate outbreaks of *Salmonella enterica* serovar Poona infection associated with eating cantaloupe from Mexico, in 2000-2002. (CDC, 2002). Furthermore, the study by Viswanathan and Kaur (2001) on fruit samples in Mumbai, India, detected the presence of *Salmonella* in three mixed fruit, four pineapple, and two watermelon samples. Similarly, a Malaysian study (Pui *et al.*, 2011) detected *Salmonella* in 23.3% of 210 sliced fruit samples from stalls and markets, with numbers ranging from 0-19 MPN/g. In a survey conducted in Ireland from 2005-2009 (Duggan *et al.*, 2012), *Salmonella* was detected in one of 3477 (0.03%) samples in 2007. The New Zealand *Salmonella* outbreak attributed to the consumption of contaminated watermelon indicates this food-hazard combination remains relevant here (McCallum *et al.*, 2010).

Current FSANZ standards for the microbial food safety of ready-to-eat fruit and horticultural products that do not receive bactericidal treatment before sale include the stipulation of a refrigerated shelf-life of no greater than 5 days (FSANZ, 2014). In our study, the shelf-life of ready-to-eat fruit salads in New Zealand (where stated on the labels of products examined in this study: E. D'Sa, personal communication) ranged from 2 to 6 days when stored at 4°C. At the highest value, the FSANZ standards are, strictly speaking, not complied with. We also observed variance in the terms used by retailers to denote their products shelf-life; “use by” and “best before” terms were seen extensively, “expiry” seen on one occasion and in one brand, a prepared fruit tray possessed no labelling at all (Stephen On, pers. comm.). Current guidelines for describing the shelf-life of foods stipulate that the term “use by” be employed for highly

perishable foods that may pose a health risk if consumed beyond the label date (NZFSA, 2005). Although this survey did not identify product that breached regulatory compliance or recover pathogens that were linked to any contemporaneous disease outbreak, available data from this study and overseas suggest that ready-to-eat fruit products can harbour certain microbial pathogens, and that their shelf-life may best be denoted by the “use by” descriptor rather than the “best before” label.

## 5 CONCLUSIONS

The present survey of fresh-cut fruit salads in New Zealand was the first of its kind in this country and identified the pathogen *L. monocytogenes* in four of 75 samples of this category of retail food, each containing melon varieties. The presence of related non-pathogenic *Listeria innocua* in 10 of the 75 samples indicates a wider potential for such products to harbour a risk of listeriosis infection. Conversely, *Salmonella*, *E. coli* and CPS were not detected in any of the samples. These results could be used to increase awareness among producers and retailers of fresh-cut fruit products of the potential for *Listeria* contamination in order to improve controls for this environmentally widespread organism. A focus on controls for fresh-cut fruit products containing melon may be prudent; the risk from fruit products with a  $\text{pH} \leq 4$  seems negligible, which correlates with the known growth properties of *L. monocytogenes*.

Microbiological surveys of similar fruit products reported in the international literature do not always test for all organisms of significance. For example, enteric viruses including Hepatitis E and Human Adenovirus have been found in berry fruit (Maunula et al. 2013). Many factors, including geographical location (and associated climatic factors) and processing methods significantly influence the presence of fruit-borne microbial pathogens. Each of the studies to date (including the one described here) thus represents a time-bound snapshot of some, but not all, microbial risks related to fruit. This report should be viewed in that context.

Variability in the terms used by producers to describe the shelf-life of consumer-ready fresh-cut fruit product was observed. The data suggest that the shelf-life of ready-to-eat fresh-cut fruit products should be described only by the “use by” term, with the standards that this implies.

## REFERENCES

- Abadias M, Usall J, Anguera M, Solsona C and Viñas I (2008) Microbiological quality of fresh, minimally-processed fruit and vegetables, and sprouts from retail establishments. *International Journal of Food Microbiology*; 123:121-129.
- Abelson P, Forbes M P and Hall G (2006) The annual cost of foodborne disease in Australia. Applied Economics Pty Ltd.
- Althaus D, Hofer E, Corti S, Julmi A and Stephan R (2012) Bacteriological survey of ready-to-eat lettuce, fresh-cut fruit, and sprouts collected from a Swiss market. *Journal of Food Protection*; 75:1338-1341.
- APHA (2001) *Compendium of Methods for the Microbiological Examination of Foods*, 4th ed. American Public Health Association, Washington, DC
- Arthur L, Jones S, Fabri M and Odumeru J (2007) Microbial survey of selected Ontario-grown fresh fruits and vegetables. *J. Food Prot.* 70:12:2864-2867.
- Becker B and Tauscher B (2011) An assessment of the microbial quality of fresh-cut fruit. *Journal of Food Safety and Quality* 62:33-72.
- Buchrieser C (2007) Biodiversity of the species *Listeria monocytogenes* and the genus *Listeria*. *Microbes and Infection* 9:1147-1155.
- Calder L, Simmons G, Thornley C, Taylor P, Pritchard K, Greening G and Bishop J (2003) An outbreak of hepatitis A associated with consumption of raw blueberries. *Epidemiol Infect.* Aug;131(1):745-51.
- CDC (2012) Multistate Outbreak of Listeriosis Linked to Whole Cantaloupes from Jensen Farms, Colorado. *At:* <http://www.cdc.gov/listeria/outbreaks/cantaloupes-jensenfarms/082712/index.html>. Accessed August 22, 2014.
- CDC (2014) Surveillance for Foodborne Disease Outbreaks, United States, 2012, Annual Report. Centers for Disease Control and Prevention, Atlanta, Georgia: US Department of Health and Human Services. *At:* <http://www.cdc.gov/foodsafety/pdfs/foodbornedisease-outbreaks-annual-report-2012-508c.pdf>. Accessed August 22, 2014.
- Cook R (2011) Tracking demographics and U.S. fruit and vegetable consumption patterns. Department of Agricultural and Resource Economics, University of California, Davis. *At:* [http://files.are.ucdavis.edu/uploads/filer\\_public/2014/05/19/blueprintseoconsumptioncookfinaljan2012figures.pdf](http://files.are.ucdavis.edu/uploads/filer_public/2014/05/19/blueprintseoconsumptioncookfinaljan2012figures.pdf). Accessed August 22, 2014.
- Cosgrove S, Cronquist A, Wright G, Ghosh T, Vogt R and Teitell P (2011) Multistate outbreak of Listeriosis associated with Jensen Farms cantaloupe - United States, August-September 2011. *MMWR*: 60:1357-1358.
- Danyluk M D, Friedrich L M and Schaffner D W (2014) Modeling the growth of *Listeria monocytogenes* on cut cantaloupe, honeydew and watermelon. *Food Microbiology*; 38:52-55.
- De Paula N, Boas E, Rodrigues L, Carvalho R, and Piccoli R (2009) Quality of fresh-cut produce commercialized on supermarket shelves in the cities of Lavras-MG, Brasília-DF, and São Paulo-SP. *Ciênc. Agrotec.*, Lavras, 32:1:219-227.
- Duggan S, Jordan E, Gutierrez M, Barrett G, O'Brien T, Hand D, Kenny K, Fanning J, Leonard N and Egan J (2012). *Salmonella* in meats, water, fruit and vegetables as disclosed from testing undertaken by Food Business Operators in Ireland from 2005 to 2009. *Irish Veterinary Journal*. 65: 17.

- Escartin E F, Ayala A C and Lozano J S (1989) Survival and growth of *Salmonella* and *Shigella* on sliced fresh fruit. *Journal of Food Protection*; 52:471-472.
- Estrada C, Alcaráz L, Satorres S, Manfredi E and Velázquez L (2013) Presence of enterotoxigenic *Staphylococcus aureus* in artisan fruit salads in the city of San Luis, Argentina. *Brazilian Journal of Microbiology*. 44:4:1155-1161.
- Fang T, Liu Y and Huang L (2013) Growth kinetics of *Listeria monocytogenes* and spoilage microorganisms in fresh-cut cantaloupe. *Food Microbiology*; 34:174-181.
- FSANZ (Food Standards Australia and New Zealand) (2001) Guidelines for the microbiological examination of ready-to-eat foods. At <http://www.foodstandards.gov.au/publications/pages/guidelinesformicrobi1306.aspx>. Accessed August 22, 2014.
- FSANZ (Food Standards Australia and New Zealand) (2013) Agents of foodborne illness, 2<sup>nd</sup> edition. Food Standards Australia New Zealand. At: [http://www.foodstandards.gov.au/publications/Documents/FSANZ\\_FoodborneIllness\\_2013\\_WEB.pdf](http://www.foodstandards.gov.au/publications/Documents/FSANZ_FoodborneIllness_2013_WEB.pdf). Accessed August 22, 2014.
- FSANZ (Food Standards Australia and New Zealand) (2014) Food standards (Proposal P1017 - criteria for *Listeria monocytogenes* - microbiological limits for foods) variation. At <http://www.foodstandards.gov.au/code/microbiollimits/Pages/Criteria-for-Listeriamonocytogenes-in-ready-to-eat-foods.aspx>. Accessed 15<sup>th</sup> January, 2015.
- Golden D A, Rhodehamel E J and Keutter D A (1993) Growth of *Salmonella* spp. in cantaloupe, watermelon, and honeydew melons. *Journal of Food Protection*; 56:194196.
- Graves L M, Swaminathan B (2001) PulseNet standardized protocol for subtyping *Listeria monocytogenes* by macrorestriction and pulsed-field gel electrophoresis. *Int J Food Microbiol*. Apr 11; 65(1-2):55-62.
- Johannessen G, Loncarevic S and Kruse H (2002) Bacteriological analysis of fresh produce in Norway. *Int. J. of Food Microbiol*. 77:199-204.
- Kramarenko T, Roasto M, Meremäe K, Kuningas M, Pölttsama P and Elias T (2013) *Listeria monocytogenes* prevalence and serotype diversity in various foods. *Food Control*. 30:24-29.
- Landry L, Phan Q, Kelly S, Phillips K, Onofrey S, Daly E R, Talbot E A, Fage M, Deasy M, Lynch M and Olson C K (2007) *Salmonella* Oranienburg infections associated with fruit salad served in health care facilities-Northeastern United States and Canada, 2006. *Journal of the American Medical Association*; 298:2362-2364.
- Little C L and Gillespie I A (2008) Prepared salads and public health. *Journal of Applied Microbiology*; 105:1729-1743.
- Little C L and Mitchell R T (2004) Microbiological quality of pre-cut fruit, sprouted seeds, and unpasteurised fruit and vegetable juices from retail and production premises in the UK, and the application of HACCP. *Communicable Disease and Public Health* 7: 184190.
- Lynch M F, Tauxe R V and Hedberg C W (2009) The growing outbreaks of foodborne outbreaks due to contaminated fresh produce: risks and opportunities. *Epidemiol. Infect.* 137:307-315.
- Maunula L, Kaupke A, Vasickova P, Söderberg K, Kozyra I, Lazic S, van der Poel W H, Bouwknecht M, Rutjes S, Willems KA, Moloney R, D'Agostino M, de Roda Husman A M, von Bonsdorff C H, Rzeżutka A, Pavlik I, Petrovic T and Cook N (2013) Tracing enteric viruses in the European berry fruit supply chain. *International Journal of Food Microbiology* 167:177-1785.



- McCallum L, Torok M, Dufour M, Hall A, and Cramp G (2010) An outbreak of *Salmonella* Typhimurium phage type 1 associated with watermelon in Gisborne, January 2009. The New Zealand Medical Journal, Vol. 123 No. 1322, 39-45.
- McIntyre L and Cornelius A (2009) FW 09064. Microbiological survey of retail fresh produce of imported, domestic conventional and domestic organic origin. ESR.
- Mohle-Boetani J C, Reporter R, Werner S B, Abbott S, Farrar J, Waterman S H and Vugia D J (1999) An outbreak of *Salmonella* serogroup Saphra due to cantaloupes from Mexico. Journal of Infectious Diseases; 180:1361-1364.
- Mori T, Tanaka H, Wada S, Ito T, Udagawa F and Hara-Kudo Y (2010) Survey of microbiological contamination in commercial pre-cut vegetables, pre-cut fruit and sprout. Japanese Journal of Food Microbiology; 27:163-170.
- New Zealand Food Safety Authority (2005). A guide to calculating the shelf life of foods. [http://www.foodsafety.govt.nz/elibrary/industry/Guide\\_Calculating\\_Contains\\_Background.pdf](http://www.foodsafety.govt.nz/elibrary/industry/Guide_Calculating_Contains_Background.pdf)
- Phan-Thanh L (1998) Physiological and biochemical aspects of the acid survival of *Listeria monocytogenes*. Journal of General and Applied Microbiology 44:183-191.
- Pui C F, Wong W C, Chai L C, Nillian E, Ghazali F, Cheah Y K, Nakaguchi Y, Nishibuchi M and Radu S (2011) Simultaneous detection of *Salmonella* spp., *Salmonella* Typhi and *Salmonella* Typhimurium in sliced fruits using multiplex PCR. Food Control. 22: 337-342.
- Penteado A L and Leitão M F (2004a) Growth of *Listeria monocytogenes* in melon, watermelon and papaya pulps. International Journal of Food Microbiology; 92:89-94.
- Penteado A L and Leitão M F F (2004b) Growth of *Salmonella* Enteritidis in melon, watermelon and papaya pulp stored at different times and temperatures. Food Control; 15:369-373.
- R Core Team (2014) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>.
- Seow J, Agoston R, Phua L and Yuk H (2012) Microbiological quality of fresh vegetables and fruits sold in Singapore. Food. Control. 25:39-44.
- Sospedra I, Rubert J, Soriano J M and Mañes J (2013) Survey of microbial quality of plant-based foods served in restaurants. Food Control. 30: 418-422.
- Ukuku D O, Olanya M, Geveke D J and Sommers C H (2012) Effect of native microflora, waiting period, and storage temperature on *Listeria monocytogenes* serovars transferred from cantaloupe rind to fresh-cut pieces during preparation. Journal of Food Protection; 75:1912-1919.
- Van Boxstael S, Habib I, Jacxsens L, de Vocht M, Baert L, van de Perre E, Rajkovic A, Lopez-Galvez F, Sampers I, Spanoghe P, de Meuleaner B and Uyttendaele M (2013) Food safety issues in fresh produce: Bacterial pathogens, viruses and pesticide residues indicated as major concerns by stakeholders in the fresh produce chain. Food Control. 32: 190-197.
- Viswanathan P, and Kaur R (2001) Prevalence and growth of pathogens on salad vegetables, fruits and sprouts. International Journal of Hygiene and Environmental Health 203:205213.
- Western Australia Food Monitoring Program (2005) Microbiological quality of fruit and vegetables in Western Australia retail outlets. At: [http://www.health.wa.gov.au/publications/documents/WAFMP%20Technical%20report%20Microbiological%20quality%20of%20Fruit%20&%20Veg\\_Final%20version%2060511.pdf](http://www.health.wa.gov.au/publications/documents/WAFMP%20Technical%20report%20Microbiological%20quality%20of%20Fruit%20&%20Veg_Final%20version%2060511.pdf). Accessed August 22, 2014.

Zitz U, Zunabovic M, Domig K J, Wilrich P-T and Kneifel W (2011) Reduced detectability of *Listeria monocytogenes* in the presence of *Listeria innocua*. *J Food Prot*; 74 (8): 1282–1287.