

Microbiological
quality of fruit and
vegetables in
Western Australian
retail outlets



2005

MICROBIOLOGICAL QUALITY OF FRUIT AND VEGETABLES IN WESTERN AUSTRALIAN RETAIL OUTLETS 2005

**Results of a pilot survey designed by the
Western Australian Food Monitoring Program (WAFMP)
to establish data on the microbiological quality of a range of
raw fruit and vegetables, domestic and imported.**



Department of Health
Government of Western Australia



TABLE OF CONTENTS

ACKNOWLEDGEMENTS	i
EXECUTIVE SUMMARY	ii
INTRODUCTION	1
CURRENT LEGISLATIVE POSITION	3
METHODOLOGY	4
<i>Inclusion and exclusion criteria</i>	4
<i>Microbiological tests</i>	4
<i>Results interpretation criteria</i>	5
RESULTS	7
DISCUSSION	12
CONCLUSION	14
RECOMMENDATIONS	15
REFERENCES	16
APPENDIX 1: Origin of samples tested	18
APPENDIX 2: Summary of microbiological quality tests results for commodities categorised in accordance with FSANZ guidelines	19

LIST OF TABLES

<i>Table 1</i>	<i>FSANZ guidelines for the microbiological examination of ready-to-eat foods</i>	5
<i>Table 2</i>	<i>Origin of commodities and the number sampled and tested</i>	7
<i>Table 3</i>	<i>Microbiological testing conducted</i>	8
<i>Table 4</i>	<i>Number of samples tested for each commodity</i>	8
<i>Table 5</i>	<i>Commodities tested and categorised in accordance with FSANZ guidelines</i>	9
<i>Table 6</i>	<i>Quantitative levels exceeding the FSANZ guidelines 'satisfactory' category for commodities by origin</i>	10

LIST OF FIGURES

<i>Figure 1</i>	<i>Percentage of commodities sampled by origin</i>	7
-----------------	--	---

ACKNOWLEDGEMENTS

The Department of Health (WA) gratefully acknowledges the assistance of the following:

The 42 local governments state-wide for collecting samples for analysis:

Albany	Kalamunda
Armadale	Katanning
Bayswater	Kwinana
Belmont	Mandurah
Broome	Melville
Bunbury	Mundaring
Busselton	Murray
Cambridge	Narrogin
Canning	Nedlands
Capel	Northam
Claremont	Perth
Cockburn	Rockingham
Cottesloe	South Perth
Dardanup	Serpentine/Jarrahdale
Donnybrook/Balingup	Stirling
Fremantle	Subiaco
Greenough	Swan
Gosnells	Victoria Park
Harvey	Vincent
Irwin	Wagin
Joondalup	Wanneroo

The PathWest Laboratory Medicine WA - Food Laboratory for analysis of the samples.

Curtin University of Technology, School of Public Health, for conducting the statistical analyses and interpretation of results.

EXECUTIVE SUMMARY

Fruit and vegetables are an important part of a balanced diet. The Australian annual consumption of fruit and vegetables increased significantly from 1988/89 to 1998/99 when up to 135 kg per person per year of fruit and 162 kg of vegetables were consumed. These figures are expected to increase further, especially with the initiation of the 'Gofor2&5'TM campaign. This national initiative encourages adults to consume at least two serves of fruit and five serves of vegetables daily to improve their intake of healthy foods.

However, the health of consumers can be adversely affected by consumption of microbiologically unsafe fruit and vegetables. Microbiological contamination of fruit and vegetables can occur directly or indirectly from animals or insects, soil, manures, water and equipment used to grow these horticultural commodities as well as human handling along the food chain. The microbiological contaminants may have an adverse health effect if the consumer omits to prepare the fruit and vegetables to ensure safety prior to consumption. Growers, processors and retailers can assist with the commodities' food safety by adequate washing and hygienic handling of these products prior to retail sale. However, consumer preparation in the home must involve good hygiene practices combined with further processing such as washing, peeling or cooking. These processes and practices will reduce any likelihood of food-borne illness due to contamination.

In Australia there is limited information available regarding the microbiological quality of fruit and vegetables. There is no baseline microbiological data for these commodities at the point of retail sale in Western Australia. Previous Western Australian Food Monitoring Program (WAFMP) surveys have focused on higher risk ready-to-eat salads and ready-to-eat sprouts but have not examined the microbiological quality of non ready-to-eat raw fruit and vegetables available for retail sale, or differentiated between imported and domestic fruit and vegetable commodities.

The aim of this survey is to establish data on the microbiological quality of a range of raw fruit and vegetables, domestic and imported.

A total of 491 raw fruit and vegetable samples were collected by local government Environmental Health Officers from localities across the state of Western Australia. The samples were selected from 39 (imported or locally grown) fruit and vegetable types (commodities) that were readily available for retail sale. The differentiation between imported and locally grown commodities was designed to enable some comparison between both sources of these raw commodities. The samples were submitted for analysis to the

PathWest Laboratory Medicine WA - Food Laboratory for the presence of six commonly associated food-borne pathogens (*Bacillus cereus*, *Campylobacter*, Coagulase - positive *Staphylococci*, *E. coli* O157:H7, *Listeria monocytogenes* and *Salmonella*) and the non pathogenic indicator organism *E. coli*.

It is important to note that there are no microbiological standards for raw fruits and vegetables. Currently the Australia New Zealand Food Standards Code includes 'guidelines for the microbiological examination of ready-to-eat foods'.

In the absence of microbiological standards for non ready-to-eat horticultural commodities, the results have been compared to the Food Standards Australia New Zealand (FSANZ) ready-to-eat guidelines to assess their compliance with these guidelines and to assess their acceptability for human consumption without further processing.

Three thousand four hundred and twenty five (3,425) microbiological tests were performed on the 491 fruit and vegetable samples. The significant majority (98.7% n=3380) of test results were considered to be of satisfactory microbiological quality when compared with FSANZ guidelines. No enterohaemorrhagic *E. coli* O157:H7, *Campylobacter* or *Salmonella* were detected in any of the samples and all samples tested for Coagulase-positive *Staphylococci* were within the 'satisfactory' FSANZ category.

The remaining 1.3% (n=45) of test results were found to be, 'marginal', 'unsatisfactory' or 'potentially hazardous' if consumed without prior treatment. Of these, the pathogen *Bacillus cereus* accounted for over half (0.7% (n=26) of all test results), including the only test result within the 'potentially hazardous' category. This was for spinach that was grown in Western Australia. *Listeria monocytogenes* was detected in two of these tests (0.1% of all test results) with both being at 'marginal' levels (< 3 MPN). The enteric indicator organism *E. coli* accounted for the remaining 'marginal' or 'unsatisfactory' results (0.5% (n=17) of all test results).

Statistical comparison between imported and local Australian grown commodities revealed no difference ($p > 0.05$) in their microbiological quality.

From a health perspective, even though the results of this survey indicate that almost 99% of commodities tested were of satisfactory microbiological quality, pathogens could be present in these commodities. It is important that consumers ensure that all raw fruit and vegetables are thoroughly washed, peeled or cooked prior to consumption.



From the results of this survey, it is recommended:

1. Department of Health WA continues to reinforce its message to consumers that *"fruit and vegetables need to be thoroughly washed prior to consumption"*.
2. The food industry notes the benefits of the above recommendation and develops ways to convey the message to consumers that *"fruit and vegetables need to be thoroughly washed prior to consumption"*.



INTRODUCTION

Fruit and vegetables are an important part of a balanced diet. Australians consumed approximately 112 kg fresh fruit and 150 kg of fresh vegetables per person in 1988/89. The consumption figures increased significantly over the 10 years to 1998/99 when up to 135 kg per person per annum (20% increase) of fruit and 162 kg per person per annum (8% increase) of vegetables were consumed (Australian Bureau of Statistics 2003). More recent data are not available, but consumption is expected to have increased, especially with the initiation of national programmes such as 'Gofor2&5'TM campaign which encourages adults to consume at least two serves of fruit and five serves of vegetables every day to improve their intake of healthy foods (Department of Health WA 2002).

Adequate fresh fruit and vegetable consumption is a necessary component of a healthy diet, however, health has been compromised by food-borne disease outbreaks associated with the consumption of these commodities. In the United States from 1973 through 1997, fruit and vegetable commodities were observed to account for an increasing proportion of all food-borne disease outbreaks associated with specific food, increasing from 0.7% in the 1970s to 6% in the 1990s (Sivapalasingam et al 2004). In 2000 the United Kingdom Food Standards Agency reported that six food-borne disease outbreaks were attributed to salads and vegetables. These commodities were ranked as the third highest food group attributing to outbreaks, only being surpassed by poultry and red meat with 15 and 10 outbreaks respectively (UK Food Standards Agency 2001). In Australia during 2004, salad and vegetables were implicated as the food groups responsible for two of 118 outbreaks, resulting in 34 affected people and three hospitalisations (OZFoodNet 2004).

Fruit and vegetables which are good sources of nutrients can become contaminated at any point during their growth, harvesting, processing, distribution, retail sale and final preparation (USFDA 2001). Vegetables are typically grown in soil and manure and irrigated with bore and dam water. All three of these horticultural necessities are potential sources of pathogenic micro-organisms such as *E. coli* O157:H7 and Salmonella (Wang, Zhao & Doyle 1996; Zhuang, Beuchat & Angulo 1995). Fruit harvested from trees, such as peaches and plums, can be contaminated with faecal pathogens by pickers and handlers in the fields including harvesting and packaging equipment (USFDA 2001).

Due to the potential for contamination of fruit and vegetables to occur prior to their purchase by the consumer, the Department of Health WA recommends that 'all raw fruit and vegetables be at least thoroughly washed by the consumer prior to consumption' (WAFMP 1992; WAFMP 2000).



Food retailers endeavour to present fruit and vegetable products, within their stores, in a manner that is appealing to consumers. This often requires growers to remove roots, exterior leaves and dirt and also includes an increasing trend of packaging the products so they appear cleaner and more hygienic. This may or may not involve a washing step which may or may not be carried out in a hygienic processing environment. Consumers can easily mistake these products as being ready to eat and therefore not wash them in the home prior to consumption. A number of food-borne disease outbreaks have been attributed to unsatisfactory further processing operations (Sivapalasingam et al, 2004).

Furthermore, the globalisation of fresh fruit and vegetables (including extended food storage) has resulted in a potential increased risk of illness outbreaks associated with the consumption of these raw commodities (Sivapalasingam et al 2004). The distribution of fruit and vegetables over larger geographical areas potentially increases human exposure to a wider variety of food-borne pathogens (USFDA 2001).

In Western Australia, no survey had previously been undertaken to obtain information regarding the microbiological quality of non ready-to-eat fruit and vegetables available for retail sale in Western Australia.

Due to the lack of baseline data, the WAFMP designed this pilot survey to examine a variety of fruit and vegetable commodities grown both domestically and overseas for their microbiological quality at the point of retail sale in Western Australia.



CURRENT LEGISLATIVE POSITION

It is important to note that there are no microbiological standards for raw fruits and vegetables as such.

A statutory microbiological standard does not exist in the Australia New Zealand Food Standards Code for non ready-to-eat fruit and vegetable commodities under Standard 1. 6. 1 – Microbiological limits for food (FSANZ 2006a). These commodities are considered by Australian food regulatory bodies to require further washing or processing such as peeling and cooking prior to consumption, unless stated otherwise on packaging or advertising material (WAFMP 1992; Department Human Services 2005).

Currently the Australian New Zealand Food Standards Code includes 'guidelines for the microbiological examination of ready-to-eat foods'. These guidelines are applicable to some ready-to-eat fruits and vegetables such as fruit salads, lettuce, alfalfa and bean sprouts.



METHODOLOGY

A total of 491 samples of fruit and vegetable products were collected (using aseptic technique) by Environmental Health Officers (EHO) from 42 local governments in the rural and metropolitan areas of Western Australia. The samples were submitted to the PathWest Laboratory Medicine WA - Food Hygiene Laboratory for analysis during November and December 2005. Additional information about the sample (including commodity origin) was collected and submitted by the local government EHO.

Inclusion and exclusion criteria

The sampling frame was developed in conjunction with the fruit and vegetable industry. Sample commodity types for collection were selected based on their expected availability from WA retail outlets and the likelihood that commodities of both locally grown and imported origin would be available for comparative purposes. Therefore products such as lettuce, which is not commonly imported, were not included in the sampling frame.

Due to EHOs experiencing difficulty in obtaining imported fruit and vegetable commodities (in particular imported fruit) from the established sampling frame of 30 commodities (comprising 15 fruit and 15 vegetables), the frame was widened. This resulted in 39 commodities being sampled including seven additional types of fruit.

Microbiological tests

All samples (in whole form as presented at point of sale) submitted under the WAFMP survey were subjected to the following tests:

- Escherichia coli* (enteric indicator organism)
- Escherichia coli* O157:H7 detection
- Coagulase - positive Staphylococci
- Listeria monocytogenes* detection
(and Most Probable Number 'MPN' if present)
- Bacillus cereus*
- Campylobacter detection (and speciation if present)
- Salmonella detection (and speciation if present)

Microbiological analysis was conducted in accordance with appropriate Australian Standard Methods for the Microbiological Examination of Food and PCR by BAX detection systems. Further information relating to the procedures for microbiological detection is available from the PathWest Laboratory Medicine WA - Food Hygiene Laboratory.

Results interpretation criteria

Currently no microbiological standard exists (i.e. microbiological limits for food – Standard 1.6.1) in the Australia New Zealand Food Standards Code for horticultural commodities. Furthermore, the microbiological limits recommended by Food Standards Australia New Zealand (FSANZ) in their 'guidelines for the microbiological examination of ready-to-eat foods' are not applicable to foods that are 'not ready to eat' (FSANZ 2006b). It should be noted that many fruit and vegetable types (commodities) tested are not ordinarily consumed in the same state as they are sold. For example some of the commodity types sampled (such as potatoes, asparagus, turnips, etc.) are typically cooked before consumption. Therefore to provide comparative reference, in the absence of microbiological standards or guidelines for non ready-to-eat horticultural commodities, the results have been compared to the ready-to-eat guidelines (refer Table 1).

Table 1 FSANZ guidelines for the microbiological examination of ready-to-eat foods

Micro-organism	Microbiological Quality (CFU/g)			
	Satisfactory	Marginal	Unsatisfactory	Potentially Hazardous
APC	N/A	N/A	N/A	-
<i>E. coli</i> /g (Indicator organisms)	< 3	3 – 100	≥ 100	**
Coagulase-positive Staphylococci /g	< 10 ²	10 ² – 10 ³	10 ³ – 10 ⁴	≥ 10 ⁴ SET +ve
<i>Bacillus cereus</i> /g	< 10 ²	10 ² – 10 ³	10 ³ – 10 ⁴	≥ 10 ⁴
Campylobacter spp / 25g	Not detected in 25g	-	-	Detected
Salmonella spp / 25g	Not detected in 25g	-	-	Detected
<i>Listeria monocytogenes</i> / 25g	Not detected in 25g	Detected but < 10 ² **	-	≥ 10 ² ##

CFU/g = Colony forming units per gram of material analysed.

** Pathogenic strains of *E. coli* should be absent.

** Foods with a long shelf life stored under refrigeration should have no *L. monocytogenes* detected in 25g.

The detection of *L. monocytogenes* in ready-to-eat foods specifically for 'at risk' population groups (the elderly, immunocompromised and infants) should also be considered potentially hazardous.

N/A – APC testing not applicable. This applies to foods such as fresh fruits and vegetables (including salad vegetables), fermented foods and foods incorporating these (such as sandwiches and filled rolls).

SET +ve - Staphylococci enterotoxin positive



RESULTS

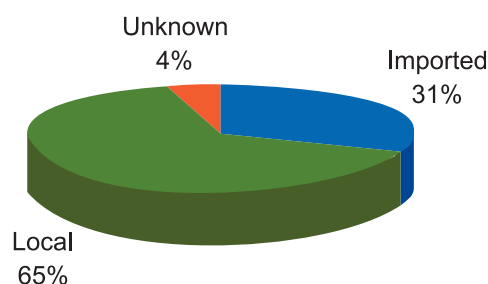
A total of 3,425 tests were conducted on 491 samples and compared to the FSANZ guidelines for ready-to-eat foods to determine their microbiological acceptability for human consumption without prior treatment in the home such as washing, peeling or cooking. The samples (n=491) comprised of 39 commodities that are available in Western Australia, which were grown both locally in Australia and overseas. Due to inadequate product labelling, it was not possible to determine the origin of some samples tested (4% n=22).

Commodities were assigned to the following origin classifications: 'local' (product of Australia), 'imported' (product from outside Australia) and 'unknown' (origin not available) (refer to Table 2, Figure 1 and Appendix 1).

Table 2 Origin of commodities and the number sampled and tested

Origin	Number sampled
Imported	151
Local	318
Unknown	22
Total	491

Figure 1 Percentage of commodities sampled by origin



1,473 tests were undertaken to determine the quantitative levels of microbiological quality for the enteric indicator organism *E. coli* (n=491) and the food pathogens *Bacillus cereus* (n=491) and Coagulase-positive Staphylococci (n=491). In addition 1952 tests were carried out to determine the presence or absence of the pathogens *E. coli* O157:H7 (n=479), *Campylobacter* (n=491), *Salmonella* (n=491) and *Listeria monocytogenes* (n=491) (refer to table 3). Additionally, quantitative tests were carried out for *Listeria monocytogenes* (n=2) when it was detected.

Table 3 Microbiological testing conducted

Micro-organisms tested	Imported	Local	Unknown	Total
<i>Bacillus cereus</i>	151	318	22	491
Campylobacter	151	318	22	491
Coagulase - positive Staphylococci	151	318	22	491
<i>E. coli</i>	151	318	22	491
<i>E. coli</i> O157:H7	147	310	22	479
<i>Listeria monocytogenes</i>	151	318	22	491
Salmonella	151	318	22	491
Total	1053	2218	154	3425

The number of samples tested for each commodity is presented in Table 4.

Table 4 Number of samples tested for each commodity (total= 491 samples)

Commodity	Total	Commodity	Total	Commodity	Total
Apples	12	Grapes	1	Plums	1
Apricots	1	Kiwi Fruit	14	Potatoes	6
Asparagus	26	Lemons	6	Shallots	8
Avocado	1	Limes	24	Snow Peas	28
Bananas	36	Mandarins	3	Spinach	7
Beans	19	Mangoes	14	Squash	1
Beetroot	17	Mushrooms	4	Strawberries	1
Capsicum	3	Onions	55	Sugar Snaps	20
Cherries	1	Oranges	34	Sweet Corn	12
Cucumber	4	Peaches	3	Sweet Potatoes	27
Durian	1	Pears	6	Tomatoes	4
Garlic	51	Peas	2	Turnips	1
Grapefruit	33	Pineapples	3	Zucchini	1

Table 5 shows that Campylobacter, enterohaemorrhagic *E. coli* O157:H7 and Salmonella were not detected in any of the 39 commodities tested. All samples tested for Coagulase-positive Staphylococci were within the 'satisfactory' category as prescribed in the FSANZ guidelines.

Table 5 Commodities tested and categorised in accordance with FSANZ guidelines

Description	Absent	Satisfactory	Marginal	Unsatisfactory	Potentially Hazardous	Total
<i>Bacillus cereus</i>		465 (94.7%)	19 (3.9%)	6 (1.2%)	1 (0.2%)	491
* <i>Campylobacter</i>	491 (100%)					491
Coagulase - positive Staphylococci		491 (100%)				491
<i>E.coli</i>		474 (96.5%)	10 (2.1%)	7 (1.4%)		491
* <i>E.coli</i> O157:H7	479 (100%)					479
** <i>Listeria monocytogenes</i>	489 (99.6%)		2 (0.4%)			491
* <i>Salmonella</i>	491 (100%)					491
Total	1950 (56.93%)	1430 (41.75%)	31 (0.91%)	13 (0.38%)	1 (0.03%)	3425 (100%)
All micro-organisms tested	98.7%		1.3% (0.7% <i>Bacillus cereus</i> ; 0.5% <i>E. coli</i> ; <i>Listeria monocytogenes</i> 0.1%)			100%

* Note: tested for presence or absence only;

** tested for presence / absence and MPN (when detected)

25 (n=230) of the 39 commodities tested were observed to be of satisfactory microbiological quality for all six pathogens tested and levels of *E. coli*.

Of the remaining 14 commodities some had samples that had levels of *E. coli* and *Bacillus cereus* which fell into categories of microbiological quality ranging from 'marginal' to 'potentially hazardous' and *Listeria monocytogenes* was detected in two commodities both of which were at 'marginal' levels (< 3 MPN). Refer to Table 6.

Table 6 Quantitative levels exceeding the FSANZ guidelines 'satisfactory' category for commodities by origin

Commodity	Origin	Description	FSANZ Guideline Categories			Number of Tests	Number of Samples
			Marginal	Unsatisfactory	Potentially Hazardous		
Asparagus	imported	<i>E. coli</i>	1			26	26
Beetroot	local	<i>Bacillus cereus</i>	1			17	17
	unknown	<i>Bacillus cereus</i>	1				
	unknown	<i>E. coli</i>	2				
Garlic	imported	<i>Bacillus cereus</i>	3			51	51
	local	<i>Bacillus cereus</i>	2	1			
Kiwi Fruit	imported	<i>Bacillus cereus</i>	3	2		14	14
Mushroom	unknown	<i>L. mono</i>	1			4	4
Onions	local	<i>E. coli</i>		1		55	55
Peaches	local	<i>Bacillus cereus</i>		1		3	3
Pineapple	local	<i>L. mono</i>	1			3	3
Potatoes	local	<i>Bacillus cereus</i>	1			6	6
Snow Peas	imported	<i>Bacillus cereus</i>	1			28	28
	imported	<i>E. coli</i>	1	1		28	
	local	<i>E. coli</i>	1				
Spinach	local	<i>Bacillus cereus</i>	2	2	1	7	7
	local	<i>E. coli</i>	1	2		7	
Sweet Corn	imported	<i>E. coli</i>	2	1		12	12
	local	<i>E. coli</i>	1				
Sweet Potatoes	local	<i>Bacillus cereus</i>	5			27	27
	local	<i>E. coli</i>	1	1		27	
Turnips	local	<i>E. coli</i>		1		1	1
Total			31	13	1	333	254

45 (3.0%) of the 1475 quantitative tests conducted exceeded the 'satisfactory' category of the FSANZ guidelines. Of these, 31 (68.9%), 13 (28.9%) and 1 (2.2%) of tested samples fell into the categories 'marginal', 'unsatisfactory' and 'potentially hazardous', respectively.

Of the 45 tests that exceeded the 'satisfactory' category, 26 (58%) were 'local' commodities and 15 (33%) were 'imported' commodities. The origin of the remaining four (9%) was unknown. It should be noted that 65% of commodities tested were local products compared to 31% and 4% for 'imported' and 'unknown', respectively.

One local commodity type had a *Listeria monocytogenes* result (n=1) in the 'marginal' category. Six local commodity types had nine *E. coli* results with 'marginal' (n=4) and 'unsatisfactory' (n=5) levels. In addition, six local commodities had 16 *B. cereus* results presenting in all three categories 'marginal' (n=11), 'unsatisfactory' (n=4) and 'potentially hazardous' (n=1). The sample (spinach) categorised with 'potentially hazardous' levels of *B. cereus* was a 'local' product from Western Australia.

E. coli levels in three 'imported' commodity types were assigned as 'marginal' (n=4) and 'unsatisfactory' (n=2). Three imported commodity types also had nine *B. cereus* results with 'marginal' (n=7) and 'unsatisfactory' (n=2) levels. Of the four 'marginal' results for the 'unknown' origin, three were for garlic (*E. coli*=1 and *B. cereus*=3) and the other was for mushroom (*L. monocytogenes*=1).

The percentage of tests exceeding the 'satisfactory' category for imported and local commodities were not found to be significantly different ($p > 0.05$) using the Chi-square test. 1.4% of imported commodities exceeded the 'satisfactory' category compared to 1.1% for the local commodities.

Fisher's Exact tests were conducted to assess the association between the origin of the commodities and the categories prescribed in the FSANZ guidelines, where data was available (see Appendices 1 & 2). Fisher's Exact test was used in place of Chi-square test due to the low frequencies in the tables. Based on the data available, for each commodity type and for each micro-organism tested, there were no significant associations ($p > 0.05$) between the origin of the commodities and the microbiological quality as categorised in accordance with the FSANZ guidelines. In conclusion, there is not sufficient evidence to suggest that there is a difference in microbiological quality between imported and local commodities tested.



DISCUSSION

Fruit and vegetables can become contaminated at any point during their growth, harvesting, processing, distribution, retail sale and final preparation (USFDA 2001). Vegetables are typically grown in soil and manure and irrigated with water from below-ground sources. All three of these horticultural necessities are potential sources of pathogenic micro-organisms such as *E. coli* O157:H7 and Salmonella (Wang, Zhao & Doyle 1996; Zhuang, Beuchat & Angulo 1995). Fruit harvested from trees, such as peaches and plums, can be contaminated with faecal pathogens by pickers and handlers in the fields including harvesting and packaging equipment (USFDA 2001).

Food retailers endeavour to present fruit and vegetable products, within their stores, in a manner that is appealing to consumers. This often requires growers to remove roots, exterior leaves and dirt and also includes an increasing trend of packaging the products so they appear cleaner and more hygienic. This may or may not involve a washing step which may or may not be carried out in a hygienic processing environment. Consumers can easily mistake these products as being ready to eat and therefore not wash them in the home prior to consumption. A number of food-borne disease outbreaks have been attributed to unsatisfactory further processing operations (Sivapalasingam et al, 2004).

The majority (98.7%) of microbiological tests on fruit and vegetables resulted in the commodities tested being declared of satisfactory microbiological quality when compared with the FSANZ guidelines for microbiological examination of ready-to-eat foods. It is important to note that there are no microbiological standards for raw fruits and vegetables as such.

Enterohaemorrhagic *E. coli* O157:H7, Campylobacter and Salmonella were not detected in any of the 39 commodities tested. All samples tested for Coagulase-positive Staphylococci were within the 'satisfactory' category as prescribed in the FSANZ guidelines.

The pathogen *Bacillus cereus* (0.7%; n=26) was detected at levels that fell within the 'marginal' (n=19), 'unsatisfactory' (n=6) and 'potentially hazardous' (n=1) categories, with spinach grown in Western Australia being the one commodity that reported a test result within the 'potentially hazardous' category.

B. cereus is found in a number of environments but is particularly found in soil and water that is run off soil. *B. cereus* causes diarrhoeal illness upon consumption of moderate to high numbers of organisms and production of enterotoxin within the digestive system. Foods implicated in cases of *B. cereus*-



induced illness usually contain at least 10^5 CFU/g, although about 10% of outbreaks have been associated with food containing less than this amount (Jenson & Moir 2003).

Listeria monocytogenes was the only other pathogen detected (0.1%) being observed in 2 out of the 39 commodities (a local pineapple and a mushroom of unknown origin). *Listeria monocytogenes* is widely distributed on plant vegetation through environmental sources such as air, soil and water, insects, animal and human activity. The organism can grow on fresh produce stored at refrigerated temperatures (Sutherland, Miles & Laboyrie 2003). *Listeria monocytogenes* is of particular health significance to pregnant women and people with immune systems weakened by long-term disease such as diabetes and cancer or drugs such as chemotherapy (Department of Health WA 2004). However, both of the results were at levels (< 3 MPN) well within potentially hazardous levels ($\geq 10^2$ CFU/g) and unlikely to pose any risk to pregnant women or immunocompromised people (FSANZ 2006b).

The enteric indicator organism *E. coli* accounted for the outstanding 0.5% (n=17) of test results that fell within the 'marginal' and 'unsatisfactory' categories. *E. coli* is an organism which forms part of the normal intestinal flora of the digestive system in humans and a wide variety of animals and is commonly found in animal manures (Desmarchelier & Fegan 2003).

Its presence in vegetables indicates the possibility of faecal contamination from manures and poor post-harvest washing by processors to remove soil and debris. Or it may be due to cross contamination by food handlers through poor hand washing, or contamination of utensils and preparation surfaces. *E. coli* is not normally pathogenic to humans; its presence indicates that faecal contamination is occurring at some point during the production process and other pathogenic micro-organisms associated with faecal contamination may be present, such as Salmonella and enterohaemorrhagic *E. coli* although none of these pathogens were detected in the samples submitted for this survey.

From a food safety perspective it is important to reduce contamination of these commodities before they reach the consumer through industry implementing food safety systems and policies, and also to increase consumer awareness that 'all raw fruit & vegetables require at least thorough washing prior to consumption'.



CONCLUSION

The majority 98.7% (n=3380) of microbiological tests on fruit and vegetables were considered to be of satisfactory microbiological quality when compared with the FSANZ guidelines for microbiological examination of ready-to-eat foods.

Enterohaemorrhagic *E. coli* O157:H7, *Campylobacter*, and *Salmonella* were not detected in any of the 39 commodities tested. All samples tested for Coagulase-positive *Staphylococci* were within the 'satisfactory' category as prescribed in the FSANZ Guidelines.

Bacillus cereus 0.7% (n=26) and *Listeria monocytogenes* 0.1% (n=2) were the only pathogens detected at levels that fell within the 'marginal', 'unsatisfactory' and 'potentially hazardous' (n=1) categories. Spinach grown in Western Australia was the only commodity with a test result (*B. cereus*) in the potentially hazardous category. The enteric indicator organism *E. coli* accounted for the outstanding 0.5% (n=17) of test results.

There is no observable statistically-significant ($p > 0.05$) difference in microbiological quality between imported (1.4%) and local Australian (1.1%) grown fruit and vegetables tested in this survey.

Whilst the survey results show the majority of fruit and vegetables were of satisfactory quality, the small proportion of results (1.3%) that fell within the FSANZ categories of microbiological quality ranging from 'marginal' to 'potentially hazardous', highlights the need for consumers to ensure that these commodities are thoroughly washed and/or peeled or cooked prior to consumption.



RECOMMENDATIONS

1. Department of Health WA continues to reinforce its message to consumers that *"fruit and vegetables need to be thoroughly washed prior to consumption"*.
2. The food industry notes the benefits of the above recommendation and develops ways to convey the message to consumers that *"fruit and vegetables need to be thoroughly washed prior to consumption"*.



REFERENCES

Australian Bureau of Statistics 2003, *Apparent Consumption of Foodstuffs, Australia*, ABS, Canberra. Viewed 2 August 2005, Available: <http://www.abs.gov.au/Ausstats/abs@.nsf/e8ae5488b598839cca25682000131612/123fcdbf086c4daaca2568a90013939a!OpenDocument>.

Department of Health WA 2002, *Healthy Food Fast - ways to get more fruit and vegies in your day*, Department of Health Western Australia, Perth WA.

Department of Health WA 2004, *Listeria Infection*, Environmental Health Guide, Department of Health Western Australia, Perth WA. Viewed 24 March 2004, Available: <http://www.population.health.wa.gov.au/environmental/resources/Listeria%20infection.pdf>

Department of Human Services 2005, *Hygienic food preparation and handling in food businesses*, Food Safety Unit, Department of Human Services, Melbourne, Victoria, viewed 24 March 2006, Available: http://www.health.vic.gov.au/foodsafety/downloads/hygienic_food_prep.pdf

Desmarchelier, P. M., Fegan, N. 2003, '*Enteropathogenic Escherichia coli*', in A. D. Hocking, (ed.) *Foodborne Micro-organisms of Public Health Significance*, Sixth edition edn, Australian Institute of Food Science and Technology Incorporated, Waterloo NSW.

Food Standards Agency 2001, *Setting the baseline for agencies food-borne disease target: Measures of food-borne disease in the UK*. FBDSCG/01/02, Foodborne Disease Strategy Consultative Group, Food Standards Agency United Kingdom. Viewed January 2006, Available <http://www.food.gov.uk/multimedia/pdfs/fdscg-baseline.pdf>

FSANZ 2006a, *Australia New Zealand Food Standards Code*, Food Safety Program, Food Standards Australia New Zealand, Canberra ACT.

FSANZ 2006b, *Guidelines for the microbiological examination of ready-to-eat foods*, Viewed 20 November 2005 Available: <http://www.foodstandards.gov.au/mediareleasespublications/publications/guidelinesformicrobi1306.cfm>.

Jenson, I., Moir, C. J., 2003, '*Bacillus cereus and other Bacillus species*', in A. D. Hocking, (ed.) *Foodborne Micro-organisms of Public Health Significance*, Sixth edn, Australian Institute of Food Science and Technology Incorporated, Waterloo NSW.

OzFoodNet 2004, Reported food-borne illness and gastroenteritis in Australia: Annual report of the OzFoodNet network 2004, The OzFoodNet working group, Australian Government Department of Health and Ageing, Canberra Australia. Available: [http://www.health.gov.au/internet/wcms/publishing.nsf/Content/cda-cdi2902-pdf-cnt.htm/\\$FILE/cdi2902f.pdf](http://www.health.gov.au/internet/wcms/publishing.nsf/Content/cda-cdi2902-pdf-cnt.htm/$FILE/cdi2902f.pdf)

Sivapalasingam, S., Friedman, C. R., Cohen, L., Tauxe, R. V., 2004, 'Fresh Produce: A Growing Cause of Outbreaks of Foodborne Illness in the United States, 1973 through 1997', *Journal of Food Protection*, vol. 67, no. 10, pp. 2342-2353.

Sutherland, P. S., Miles, D. W., Laboyrie, David. A. 2003, '*Listeria monocytogenes*', in A. D. Hocking, (ed.) *Foodborne Micro-organisms of Public Health Significance*, Sixth edn, Australian Institute of Food Science and Technology Incorporated, Waterloo NSW.

USFDA 2001, '*Outbreaks Associated with Fresh and Fresh-Cut Produce. Incidence, Growth, and survival of Pathogens in Fresh and Fresh-Cut Produce*', Chapter 1V, Analysis and Evaluation of Preventive Control Measures for the Control and Reduction of Microbiological Hazards on Fresh and Fresh-Cut Produce, Center for Food Safety and Applied nutrition, U.S. Food and Drug Administration. Available: <http://www.cfsan.fda.gov/~comm/ift3-4i.html>

WAFMP 1992, Western Australian Food Monitoring Program Survey of Microbiological Quality of Pre-packaged Salads, Department of Health Western Australia, Perth WA.

WAFMP 2000, Western Australian Food Monitoring Program Survey of the Microbiological Quality of Sprouts, *FoodWatch 10*, Department of Health Western Australia, Perth WA. Available: http://www.population.health.wa.gov.au/Environmental/resources_environ.cfm#food

Wang, G., Zhao, T., Doyle, M. P., 1996, Fate of enterohaemorrhagic *Escherichia coli* O157:H7 in bovine feces. *Applied and Environmental Microbiology*, vol. 62, pp. 2567-2570.

Zhuang, R. Y., Beuchat, L. R., Angulo, F. J., 1995, Fate of *Salmonella* Montevideo on and in raw tomatoes as affected by temperature and treatment with chlorine. *Applied and Environmental Microbiology*, vol. 61, pp. 2127-2131.



Appendix 1: Origin of samples tested

Commodity	Imported	Local	Unknown	Total
Apples		12		12
Apricots		1		1
Asparagus	1	23	2	26
Avocado		1		1
Bananas		36		36
Beans		18	1	19
Beetroot		15	2	17
Capsicum	2	1		3
Cherries		1		1
Cucumber		4		4
Durian	1			1
Garlic	39	11	1	51
Grapefruit	2	30	1	33
Grapes		1		1
Kiwi Fruit	14			14
Lemons	4	2		6
Limes	2	18	4	24
Mandarins		3		3
Mangoes	1	12	1	14
Mushrooms	1	3		4
Onions	28	23	4	55
Oranges	1	32	1	34
Peaches		3		3
Pears		5	1	6
Peas	1	1		2
Pineapples		3		3
Plums		1		1
Potatoes		6		6
Shallots	6	1	1	8
Snow Peas	20	7	1	28
Spinach		7		7
Squash		1		1
Strawberries		1		1
Sugar Snaps	18	2		20
Sweet Corn	10	2		12
Sweet Potatoes		26	1	27
Tomatoes		3	1	4
Turnips		1		1
Zucchini		1		1
Total	151	318	22	491

Appendix 2: Summary of microbiological quality tests results for commodities categorised in accordance with FSANZ guidelines

Commodity	Description	Absent	Satisfactory	Marginal	Unsatisfactory	Potentially Hazardous	Grand Total
Apples	Bacillus cereus		12				12
	Campylobacter	12					12
	Coagulase - positive						
	Staphylococci		12				12
	E.coli		12				12
	E.coli O157:H7	12					12
	Listeria monocytogenes (BAX PCR)	12					12
	Salmonella (BAX PCR)	12					12
Apricots	Bacillus cereus		1				1
	Campylobacter	1					1
	Coagulase - positive						
	Staphylococci		1				1
	E.coli		1				1
	E.coli O157:H7	1					1
	Listeria monocytogenes (BAX PCR)	1					1
	Salmonella (BAX PCR)	1					1
Asparagus	Bacillus cereus		26				26
	Campylobacter	26					26
	Coagulase - positive						
	Staphylococci		26				26
	E.coli		25	1			26
	E.coli O157:H7	25					25
	Listeria monocytogenes (BAX PCR)	26					26
	Salmonella (BAX PCR)	26					26
Avocado	Bacillus cereus		1				1
	Campylobacter	1					1
	Coagulase - positive						
	Staphylococci		1				1
	E.coli		1				1
	E.coli O157:H7	1					1
	Listeria monocytogenes (BAX PCR)	1					1
	Salmonella (BAX PCR)	1					1
Bananas	Bacillus cereus		36				36
	Campylobacter	36					36
	Coagulase - positive						
	Staphylococci		36				36
	E.coli		36				36
	E.coli O157:H7	35					35
	Listeria monocytogenes (BAX PCR)	36					36
	Salmonella (BAX PCR)	36					36
Beans	Bacillus cereus		19				19
	Campylobacter	19					19
	Coagulase - positive						
	Staphylococci		19				19
	E.coli		19				19
	E.coli O157:H7	19					19
	Listeria monocytogenes (BAX PCR)	19					19
	Salmonella (BAX PCR)	19					19
Beetroot	Bacillus cereus		15	2			17
	Campylobacter	17					17
	Coagulase - positive						
	Staphylococci		17				17
	E.coli		15	2			17
	E.coli O157:H7	17					17
	Listeria monocytogenes (BAX PCR)	17					17
	Salmonella (BAX PCR)	17					17



Western Australian Food Monitoring Program

Commodity	Description	Absent	Satisfactory	Marginal	Unsatisfactory	Potentially Hazardous	Grand Total
Capsicum	Bacillus cereus		3				3
	Campylobacter	3					3
	Coagulase - positive						
	Staphylococci		3				3
	E.coli		3				3
	E.coli O157:H7	3					3
	Listeria monocytogenes (BAX PCR)	3					3
Salmonella (BAX PCR)	3					3	
Cherries	Bacillus cereus		1				1
	Campylobacter	1					1
	Coagulase - positive						
	Staphylococci		1				1
	E.coli		1				1
	E.coli O157:H7	1					1
	Listeria monocytogenes (BAX PCR)	1					1
Salmonella (BAX PCR)	1					1	
Cucumber	Bacillus cereus		4				4
	Campylobacter	4					4
	Coagulase - positive						
	Staphylococci		4				4
	E.coli		4				4
	E.coli O157:H7	3					3
	Listeria monocytogenes (BAX PCR)	4					4
Salmonella (BAX PCR)	4					4	
Durian	Bacillus cereus		1				1
	Campylobacter	1					1
	Coagulase - positive						
	Staphylococci		1				1
	E.coli		1				1
	E.coli O157:H7	1					1
	Listeria monocytogenes (BAX PCR)	1					1
Salmonella (BAX PCR)	1					1	
Garlic	Bacillus cereus		45	5	1		51
	Campylobacter	51					51
	Coagulase - positive						
	Staphylococci		51				51
	E.coli		51				51
	E.coli O157:H7	48					48
	Listeria monocytogenes (BAX PCR)	51					51
Salmonella (BAX PCR)	51					51	
Grapefruit	Bacillus cereus		33				33
	Campylobacter	33					33
	Coagulase - positive						
	Staphylococci		33				33
	E.coli		33				33
	E.coli O157:H7	32					32
	Listeria monocytogenes (BAX PCR)	33					33
Salmonella (BAX PCR)	33					33	
Grapes	Bacillus cereus		1				1
	Campylobacter	1					1
	Coagulase - positive						
	Staphylococci		1				1
	E.coli		1				1
	E.coli O157:H7	1					1
	Listeria monocytogenes (BAX PCR)	1					1
Salmonella (BAX PCR)	1					1	



Western Australian Food Monitoring Program

Commodity	Description	Absent	Satisfactory	Marginal	Unsatisfactory	Potentially Hazardous	Grand Total
Kiwi Fruit	Bacillus cereus		9	3	2		14
	Campylobacter	14					14
	Coagulase - positive						
	Staphylococci		14				14
	E.coli		14				14
	E.coli O157:H7	14					14
	Listeria monocytogenes (BAX PCR)	14					14
Salmonella (BAX PCR)	14					14	
Lemons	Bacillus cereus		6				6
	Campylobacter	6					6
	Coagulase - positive						
	Staphylococci		6				6
	E.coli		6				6
	E.coli O157:H7	6					6
	Listeria monocytogenes (BAX PCR)	6					6
Salmonella (BAX PCR)	6					6	
Limes	Bacillus cereus		24				24
	Campylobacter	24					24
	Coagulase - positive						
	Staphylococci		24				24
	E.coli		24				24
	E.coli O157:H7	24					24
	Listeria monocytogenes (BAX PCR)	24					24
Salmonella (BAX PCR)	24					24	
Mandarins	Bacillus cereus		3				3
	Campylobacter	3					3
	Coagulase - positive						
	Staphylococci		3				3
	E.coli		3				3
	E.coli O157:H7	3					3
	Listeria monocytogenes (BAX PCR)	3					3
Salmonella (BAX PCR)	3					3	
Mangoes	Bacillus cereus		14				14
	Campylobacter	14					14
	Coagulase - positive						
	Staphylococci		14				14
	E.coli		14				14
	E.coli O157:H7	13					13
	Listeria monocytogenes (BAX PCR)	14					14
Salmonella (BAX PCR)	14					14	
Mushrooms	Bacillus cereus		4				4
	Campylobacter	4					4
	Coagulase - positive						
	Staphylococci		4				4
	E.coli		4				4
	E.coli O157:H7	4					4
	Listeria monocytogenes (BAX PCR)	3		1			4
Salmonella (BAX PCR)	4					4	
Onions	Bacillus cereus		55				55
	Campylobacter	55					55
	Coagulase - positive						
	Staphylococci		55				55
	E.coli		54			1	55
	E.coli O157:H7	54					54
	Listeria monocytogenes (BAX PCR)	55					55
Salmonella (BAX PCR)	55					55	



Western Australian Food Monitoring Program

Commodity	Description	Absent	Satisfactory	Marginal	Unsatisfactory	Potentially Hazardous	Grand Total
Oranges	Bacillus cereus		34				34
	Campylobacter Coagulase - positive	34					34
	Staphylococci		34				34
	E.coli		34				34
	E.coli O157:H7	33					33
	Listeria monocytogenes (BAX PCR)	34					34
	Salmonella (BAX PCR)	34					34
Peaches	Bacillus cereus		2				2
	Campylobacter Coagulase - positive	3			1		3
	Staphylococci		3				3
	E.coli		3				3
	E.coli O157:H7	3					3
	Listeria monocytogenes (BAX PCR)	3					3
	Salmonella (BAX PCR)	3					3
Pears	Bacillus cereus		6				6
	Campylobacter Coagulase - positive	6					6
	Staphylococci		6				6
	E.coli		6				6
	E.coli O157:H7	6					6
	Listeria monocytogenes (BAX PCR)	6					6
	Salmonella (BAX PCR)	6					6
Peas	Bacillus cereus		2				2
	Campylobacter Coagulase - positive	2					2
	Staphylococci		2				2
	E.coli		2				2
	E.coli O157:H7	2					2
	Listeria monocytogenes (BAX PCR)	2					2
	Salmonella (BAX PCR)	2					2
Pineapples	Bacillus cereus		3				3
	Campylobacter Coagulase - positive	3					3
	Staphylococci		3				3
	E.coli		3				3
	E.coli O157:H7	3					3
	Listeria monocytogenes (BAX PCR)	2		1			3
	Salmonella (BAX PCR)	3					3
Plums	Bacillus cereus		1				1
	Campylobacter Coagulase - positive	1					1
	Staphylococci		1				1
	E.coli		1				1
	E.coli O157:H7	1					1
	Listeria monocytogenes (BAX PCR)	1					1
	Salmonella (BAX PCR)	1					1
Potatoes	Bacillus cereus		5	1			6
	Campylobacter Coagulase - positive	6					6
	Staphylococci		6				6
	E.coli		6				6
	E.coli O157:H7	6					6
	Listeria monocytogenes (BAX PCR)	6					6
	Salmonella (BAX PCR)	6					6

Western Australian Food Monitoring Program

Commodity	Description	Absent	Satisfactory	Marginal	Unsatisfactory	Potentially Hazardous	Grand Total
Shallots	Bacillus cereus		8				8
	Campylobacter Coagulase - positive	8					8
	Staphylococci		8				8
	E.coli		8				8
	E.coli O157:H7	8					8
	Listeria monocytogenes (BAX PCR)	8					8
	Salmonella (BAX PCR)	8					8
Snow Peas	Bacillus cereus		27	1			28
	Campylobacter Coagulase - positive	28					28
	Staphylococci		28				28
	E.coli		25	2	1		28
	E.coli O157:H7	28					28
	Listeria monocytogenes (BAX PCR)	28					28
	Salmonella (BAX PCR)	28					28
Spinach	Bacillus cereus		2	2	2	1	7
	Campylobacter Coagulase - positive	7					7
	Staphylococci		7				7
	E.coli		4	1	2		7
	E.coli O157:H7	7					7
	Listeria monocytogenes (BAX PCR)	7					7
	Salmonella (BAX PCR)	7					7
Squash	Bacillus cereus		1				1
	Campylobacter Coagulase - positive	1					1
	Staphylococci		1				1
	E.coli		1				1
	E.coli O157:H7	1					1
	Listeria monocytogenes (BAX PCR)	1					1
	Salmonella (BAX PCR)	1					1
Strawberries	Bacillus cereus		1				1
	Campylobacter Coagulase - positive	1					1
	Staphylococci		1				1
	E.coli		1				1
	E.coli O157:H7	1					1
	Listeria monocytogenes (BAX PCR)	1					1
	Salmonella (BAX PCR)	1					1
Sugar Snaps	Bacillus cereus		20				20
	Campylobacter Coagulase - positive	20					20
	Staphylococci		20				20
	E.coli		20				20
	E.coli O157:H7	19					19
	Listeria monocytogenes (BAX PCR)	20					20
	Salmonella (BAX PCR)	20					20
Sweet Corn	Bacillus cereus		12				12
	Campylobacter Coagulase - positive	12					12
	Staphylococci		12				12
	E.coli		8	3	1		12
	E.coli O157:H7	12					12
	Listeria monocytogenes (BAX PCR)	12					12
	Salmonella (BAX PCR)	12					12



Western Australian Food Monitoring Program

Commodity	Description	Absent	Satisfactory	Marginal	Unsatisfactory	Potentially Hazardous	Grand Total
Sweet Potatoes	Bacillus cereus		22	5			27
	Campylobacter	27					27
	Coagulase - positive Staphylococci		27				27
	E.coli		25	1	1		27
	E.coli O157:H7	26					26
	Listeria monocytogenes (BAX PCR)	27					27
	Salmonella (BAX PCR)	27					27
Tomatoes	Bacillus cereus		4				4
	Campylobacter	4					4
	Coagulase - positive Staphylococci		4				4
	E.coli		4				4
	E.coli O157:H7	4					4
	Listeria monocytogenes (BAX PCR)	4					4
	Salmonella (BAX PCR)	4					4
Turnips	Bacillus cereus		1				1
	Campylobacter	1					1
	Coagulase - positive Staphylococci		1				1
	E.coli				1		1
	E.coli O157:H7	1					1
	Listeria monocytogenes (BAX PCR)	1					1
	Salmonella (BAX PCR)	1					1
Zucchini	Bacillus cereus		1				1
	Campylobacter	1					1
	Coagulase - positive Staphylococci		1				1
	E.coli		1				1
	E.coli O157:H7	1					1
	Listeria monocytogenes (BAX PCR)	1					1
	Salmonella (BAX PCR)	1					1
Total		1950	1430	31	13	1	3425





Department of Health
Government of Western Australia

Produced by Environmental Health Directorate
© Department of Health 2006