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Microbiological quality of fresh cut vegetables

A survey to determine the safety of fresh cut leafy salad vegetables sold in NSW

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Contents

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Executive summary

Fresh cut vegetables are minimally processed by washing, slicing, dicing, peeling and/or shredding prior to sale. In Australia, leafy salad vegetables such as lettuce, rocket and baby spinach are the most common products in the fresh cut vegetable category, contributing towards an estimated national production value of $44 million for the year 1997/98 (Szabo & Coventry, 2001).

According to data from the Centers for Disease Control and Prevention in the US (CDC), foodborne illness due to contaminated vegetables is on the rise, with products implicated including baby spinach, lettuce, seed sprouts and green onion. Investigations into outbreaks have identified issues such as agricultural water quality, the use of manure as fertilisers, the presence of animals in fields or packing areas, and the health and hygiene of workers handling the fresh produce during production, packing, processing, transportation, distribution, or preparation. Many of these products are often consumed raw which can contribute to their potential as a source of foodborne illness.

Locally produced versions of similar products to those implicated in overseas foodborne illness outbreaks are on sale in NSW. As there is little information concerning their microbiological quality, in October 2006 the NSW Food Authority conducted a survey of fresh cut leafy salad vegetable product sold in NSW.

Overall, the results from the survey were excellent. When compared with the FSANZ guidelines for the microbiological examination of ready-to-eat foods 118/119 samples (99%) were categorised as satisfactory. A single sample of mixed loose leaf salad vegetables was categorised as marginal due to the presence of low numbers of *E. coli* (4 cfu/g), just above the guideline limits of 3 cfu/g. Two other samples were found to contain very low levels of faecal coliforms (4 cfu/g).

Salmonella, *L. monocytogenes* or verotoxigenic *E. coli* were not detected in any of the samples tested. While *L. monocytogenes* was not detected in any of the samples, the non pathogenic *Listeria innocua* was detected in one sample of watercress.

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Introduction

Fresh cut vegetables are minimally processed by washing, slicing, dicing, peeling and/or shredding prior to sale. In Australia, leafy salad vegetables such as lettuce, rocket and baby spinach are the most common products in the fresh cut vegetable category, contributing towards an estimated national production value of $44 million for the year 1997/98 (Szabo & Coventry, 2001).

Raw vegetables can harbour many microorganisms, which may be dispersed over the plant or appear as microcolonies embedded in the plant tissue (Szabo & Coventry, 2001). The majority of microorganisms associated with raw vegetables are non-pathogenic and gram negative organisms tend to dominate the bacterial population including *Enterobacter* spp. and other coliforms. During harvest and transport raw vegetables may be bruised resulting in the release of plant nutrients, providing nutrients for microorganisms present on the surface of the vegetable to grow.

The processing of fresh cut vegetables by slicing, dicing and shredding has little effects on the vegetables' tissue, however these processes may alter or increase the number and type of microorganisms present on the surface of the product. Washing in sanitised water is sometimes used to assist in reducing the number of microorganisms present. In addition, some fresh cut vegetables are packaged under modified atmosphere packaging (MAP) and refrigerated to extend the shelf life. With additional timeframe this creates, there is an increased risk from pathogens that are able to survive and grow in these foods.

According to data from the Centers for Disease Control and Prevention in the US (CDC), foodborne illness due to contaminated vegetables is on the rise, with products implicated including baby spinach, lettuce, seed sprouts and green onion (FDA, 2004). Investigations into outbreaks have identified issues such as agricultural water quality, the use of manure as fertilisers, the presence of animals in fields or packing areas, and the health and hygiene of workers handling the fresh produce during production, packing, processing, transportation, distribution, or preparation. Many of these products are often consumed raw which can contribute to their potential as a source of foodborne illness.

Sivapalasingam *et al* (2004) analysed data from 1973 through to 1997 from the Foodborne Disease Outbreak Surveillance System in the US and found that there were 25 lettuce-associated outbreaks causing 2078 reported illnesses, 181 hospitalisation and six deaths. The median size of lettuce-associated outbreaks was 61 cases (range from 3 to 347). In seventeen outbreaks where a cause was identified, those implicated included *E. coli* O157:H7, *Salmonella*, *Shigella*, *Cyclospora*, Norovirus, Hepatitis A virus, and *Giardia*.

In 1986, an outbreak of *Shigella sonnei* in Texas in three separate restaurants resulted in 347 patrons becoming ill. Follow up studies implicated shredded lettuce supplied from a single processing plant and it was thought the contamination originated from a food handler and was further exacerbated by processing methods, including a failure to wash food contact surfaces and holding the finished product at or near 14°C for up to 6 hours (Davis *et al*, 1988).

In 1995, 21 people associated with a hospital in Canada became infected with *E. coli* O157:H7. Although no food samples were available for testing, epidemiological studies concluded that the vehicle of infection was imported iceberg lettuce. On receipt of the lettuce, kitchen staff had filed an incident report citing heavy spoilage (Preston *et al*, 1997).

In late 2006, an outbreak across 26 states of the US affected 199 persons with a strain of *E. coli* O157:H7 (CDC, 2006). Among those persons affected, 102 (51%) were hospitalised, 31 (16%) developed Haemolytic uraemic syndrome (HUS) and three died. It was determined that that the spinach implicated in the outbreak was grown in three California counties: Monterey, San Benito, and Santa Clara. The affected products were also distributed to

Canada, Mexico, Taiwan, Hong Kong and Iceland. However, no illnesses were reported from these countries.

Locally produced versions of similar products to those implicated in these outbreaks are on sale in NSW. Given the wide availability of these products in supermarkets as a convenience food, and there is little information concerning their microbiological quality, in October 2006 the NSW Food Authority conducted a survey of fresh cut leafy salad vegetable product sold in NSW.

Methods

The NSW Food Authority purchased 119 packaged and loose fresh cut leafy vegetables from greengrocers and supermarkets around the Sydney metropolitan area during October 2006 (see Table 1).

Table 1: List of fresh cut leafy salad vegetable products tested

Product type	Number tested
Baby spinach	28
Lettuce	10
Mixed green leaf	42
Mixed lettuce	13
Rocket	25
Watercress	1
Total	**119**

Samples were submitted to the Division of Analytical Laboratories at Lidcombe, Sydney for testing of indicator organisms and pathogens. All samples were analysed within 24 hours of receipt at the laboratory using the appropriate Australian Standard method as detailed in Table 2.

Table 2: Methods used in the analysis of samples

Test	Method
Faecal coliforms	AS 1766.2.3
E. coli - enumeration	AS 1766.2.3
Salmonella - detection	AS 1766.2.5
Listeria monocytogenes - detection	AS/NZS 1766.16.1
Verotoxigenic *E. coli* (VTEC) - detection	ELISA Method

Results of the microbiological analysis were assessed against the criteria contained in the Food Standards Australia New Zealand (FSANZ) publication *Guidelines for the microbiological examination of ready-to-eat foods* (FSANZ, 2001), as shown in Table 3.

Table 3: Guidelines for the microbiological examination of ready-to-eat foods (FSANZ, 2001)

Test	Microbiological quality (cfu/g)			
	Satisfactory	**Marginal**	**Unsatisfactory**	**Potentially Hazardous**
Indicators				
Escherichia coli	< 3	3 - 100	≥ 100	[1]
Pathogens				
Salmonella	not detected in 25g			detected
Listeria monocytogenes	not detected in 25g	detected but < 10^2		≥ 10^2

Results

Overall, the results from the survey were excellent. When compared with the FSANZ guidelines 118/119 samples (99%) were categorised as satisfactory. A single sample of mixed loose leaf salad vegetables was categorised as marginal due to the presence of low numbers of *E. coli* (4 cfu/g), just above the guideline limits of 3 cfu/g. Two other samples were found to contain very low levels of faecal coliforms (4 cfu/g).

Salmonella, *L. monocytogenes* or verotoxigenic *E. coli* were not detected in any of the samples tested. While *L. monocytogenes* was not detected in any of the samples, the non pathogenic *Listeria innocua* was detected in one sample of watercress.

Discussion

Fresh cut leafy salad vegetables are raw agricultural products that have been processed by means of washing, trimming, cutting or slicing to make them ready for consumption. As such, there are many possible sources for the vegetables to become contaminated with bacteria, during growing, harvesting and processing. Many vegetable products do not undergo a kill step that will completely eliminate pathogens, however measures such as sanitising washes may be used to reduce microbial contamination of pathogens.

The presence of low level faecal coliforms and *E. coli* found in this survey are not unexpected. The faecal coliform group includes genera such as *Enterobacter* and *Klebsiella* which are commonly associated with raw vegetables (Szabo & Coventry, 2001). There are many possible sources for raw vegetables to become contaminated with coliforms, including soil, water and the environment.

Verotoxigenic strains of *E. coli* were not found in this survey and the results of other surveys conducted internationally suggest that the prevalence of pathogenic *E. coli* in fresh cut vegetables and salads is very low. Nevertheless, the potential exists for pathogenic *E. coli* to be present on vegetables, as has been observed in a number outbreaks overseas attributed to fresh cut vegetable products. Epidemiological investigations into these outbreaks have identified sources of contamination such as faeces from grazing animals in close proximity to

[1] Pathogenic strains of *E. coli* (eg VTEC) should be absent

growing areas or food handlers carrying the organism in their gut. The consequences of these outbreaks have been severe, including fatalities, high rates of hospitalisation and long terms effects such as HUS and kidney disease. However, not all *E. coli* are pathogenic and non-pathogenic *E. coli* are commonly found in the gut of healthy humans and other warm blooded animals (Craven, Eyles & Davey, 1997). The presence of *E. coli* and can be a useful indicator of potential hygiene and sanitation issues (FSANZ, 2001).

This survey did not detect Salmonellae or *L. monocytogenes* in any samples. Jay *et al* (2003) noted that the prevalence of *Salmonella* in raw vegetables is <10% and numbers are usually <1 cfu/g. Many fresh cut vegetables are packaged under modified atmosphere packaging (MAP) and refrigerated to extend the shelf life. This form of processing may lead to an increased risk with pathogens such as *L. monocytogenes* by allowing additional time for growth. Despite this, the FDA/USDA (2003) conducted a quantitative risk assessment on *L. monocytogenes* in ready-to-eat foods. The report concluded that vegetables and deli-type salads were low risk (ranked 18th and 19th respectively of the 23 foods examined). The report acknowledged the diversity of the product group and supported further study. To date, there has been no epidemiological evidence to link cases of *L. monocytogenes* infection in Australia with fresh cut vegetables. While it appears the probability of listeriosis infection from fresh-cut leafy vegetables is low, even for persons considered vulnerable to listeriosis, the consequences of the illness remains severe.

Conclusion

Plant products such as fresh cut vegetables generally have an image as healthy foods and form an important part of a healthy nutritious diet. However, the occurrence of several large scale outbreaks of foodborne illness in the US affecting thousands of consumers has highlighted the potential risks associated with these products.

Due to the increasing demand for convenience foods from consumers, the market share of pre-packaged fresh cut leafy salad vegetables on supermarket shelves has increased dramatically in the last several years. Despite the relatively small sample size of this survey, the results obtained have demonstrated that the microbiological quality of fresh cut leafy salad vegetables sold in NSW is excellent. However, to ensure the continued safety of these products into the future, it is critical that food safety control measures are effectively implemented.

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Appendix

Date of Sampling	Type	Product	Faecal coliforms (cfu/g)	*E. coli* (cfu/g)	VTEC	*Salmonella* (/25g)	*Listeria* (/25g)	*Listeria monocytogenes* (/25g)
4/10/2006	Packaged	Mixed lettuce	< 3	< 3	ND	ND[2]	ND	ND
4/10/2006	Packaged	Mixed lettuce	< 3	< 3	ND	ND	ND	ND
4/10/2006	Packaged	Rocket	< 3	< 3	ND	ND	ND	ND
4/10/2006	Packaged	Baby spinach	< 3	< 3	ND	ND	ND	ND
4/10/2006	Packaged	Baby spinach	< 3	< 3	ND	ND	ND	ND
4/10/2006	Packaged	Mixed lettuce	< 3	< 3	ND	ND	ND	ND
4/10/2006	Packaged	Rocket	< 3	< 3	ND	ND	ND	ND
4/10/2006	Packaged	Mixed commodities	**4**	< 3	ND	ND	ND	ND
4/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
4/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
4/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
4/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
4/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
4/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
4/10/2006	Packaged	Lettuce	< 3	< 3	ND	ND	ND	ND
5/10/2006	Loose leaf	Mixed lettuce	< 3	< 3	ND	ND	ND	ND
5/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
5/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
5/10/2006	Packaged	Baby spinach	< 3	< 3	ND	ND	ND	ND
5/10/2006	Packaged	Rocket	< 3	< 3	ND	ND	ND	ND
5/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
5/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
5/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
5/10/2006	Loose leaf	Mixed commodities	< 3	< 3	ND	ND	ND	ND
5/10/2006	Packaged	Lettuce	< 3	< 3	ND	ND	ND	ND
5/10/2006	Packaged	Lettuce	< 3	< 3	ND	ND	ND	ND
5/10/2006	Loose leaf	Mixed commodities	< 3	< 3	ND	ND	ND	ND
5/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
5/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
5/10/2006	Loose leaf	Lettuce	< 3	< 3	ND	ND	ND	ND
10/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
10/10/2006	Loose leaf	Mixed lettuce	< 3	< 3	ND	ND	ND	ND
10/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
10/10/2006	Packaged	Mixed lettuce	< 3	< 3	ND	ND	ND	ND
10/10/2006	Packaged	Rocket	< 3	< 3	ND	ND	ND	ND
10/10/2006	Loose leaf	Mixed commodities	**4**	**4**	ND	ND	ND	ND
10/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
10/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
10/10/2006	Loose leaf	Mixed commodities	< 3	< 3	ND	ND	ND	ND
10/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
10/10/2006	Packaged	Baby spinach	< 3	< 3	ND	ND	ND	ND
10/10/2006	Packaged	Rocket	< 3	< 3	ND	ND	ND	ND

[2] ND – Not detected

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Date of Sampling	Type	Product	Faecal coliforms (cfu/g)	*E. coli* (cfu/g)	VTEC	*Salmonella* (/25g)	*Listeria* (/25g)	*Listeria monocytogenes* (/25g)
10/10/2006	Loose leaf	Mixed commodities	< 3	< 3	ND	ND	ND	ND
10/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
10/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
11/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
11/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
11/10/2006	Loose leaf	Mixed commodities	< 3	< 3	ND	ND	ND	ND
11/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
11/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
11/10/2006	Packaged	Baby spinach	< 3	< 3	ND	ND	ND	ND
11/10/2006	Packaged	Rocket	< 3	< 3	ND	ND	ND	ND
11/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
11/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
11/10/2006	Packaged	Baby spinach	< 3	< 3	ND	ND	ND	ND
11/10/2006	Packaged	Rocket	< 3	< 3	ND	ND	ND	ND
11/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
11/10/2006	Loose leaf	Mixed commodities	< 3	< 3	ND	ND	ND	ND
11/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
11/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
17/10/2006	Packaged	Baby spinach	< 3	< 3	ND	ND	ND	ND
17/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
17/10/2006	Loose leaf	Mixed lettuce	< 3	< 3	ND	ND	ND	ND
17/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
17/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
17/10/2006	Loose leaf	Mixed lettuce	< 3	< 3	ND	ND	ND	ND
17/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
17/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
17/10/2006	Packaged	Watercress	< 3	< 3	ND	ND	**Detected**	ND
17/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
17/10/2006	Loose leaf	Mixed commodities	< 3	< 3	ND	ND	ND	ND
17/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
17/10/2006	Loose leaf	Mixed commodities	< 3	< 3	ND	ND	ND	ND
17/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
17/10/2006	Packaged	Mixed lettuce	< 3	< 3	ND	ND	ND	ND
18/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
18/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
18/10/2006	Packaged	Mixed lettuce	< 3	< 3	ND	ND	ND	ND
18/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
18/10/2006	Packaged	Lettuce	< 3	< 3	ND	ND	ND	ND
18/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
18/10/2006	Loose leaf	Mixed commodities	< 3	< 3	ND	ND	ND	ND
18/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
18/10/2006	Packaged	Rocket	< 3	< 3	ND	ND	ND	ND
18/10/2006	Packaged	Baby spinach	< 3	< 3	ND	ND	ND	ND
18/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
18/10/2006	Packaged	Baby spinach	< 3	< 3	ND	ND	ND	ND
18/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
18/10/2006	Packaged	Rocket	**4**	< 3	ND	ND	ND	ND

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Date of Sampling	Type	Product	Faecal coliforms (cfu/g)	*E. coli* (cfu/g)	VTEC	*Salmonella* (/25g)	*Listeria* (/25g)	*Listeria monocytogenes* (/25g)
18/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
24/10/2006	Packaged	Lettuce	< 3	< 3	ND	ND	ND	ND
24/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
24/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
24/10/2006	Loose leaf	Mixed lettuce	< 3	< 3	ND	ND	ND	ND
24/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
24/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
24/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
24/10/2006	Packaged	Mixed lettuce	< 3	< 3	ND	ND	ND	ND
24/10/2006	Packaged	Lettuce	< 3	< 3	ND	ND	ND	ND
24/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
24/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
24/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
24/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
24/10/2006	Loose leaf	Mixed commodities	< 3	< 3	ND	ND	ND	ND
24/10/2006	Packaged	Mixed lettuce	< 3	< 3	ND	ND	ND	ND
25/10/2006	Packaged	Baby spinach	< 3	< 3	ND	ND	ND	ND
25/10/2006	Packaged	Rocket	< 3	< 3	ND	ND	ND	ND
25/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
25/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
25/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
25/10/2006	Packaged	Baby spinach	< 3	< 3	ND	ND	ND	ND
25/10/2006	Packaged	Lettuce	< 3	< 3	ND	ND	ND	ND
25/10/2006	Packaged	Mixed commodities	< 3	< 3	ND	ND	ND	ND
25/10/2006	Loose leaf	Mixed commodities	< 3	< 3	ND	ND	ND	ND
25/10/2006	Loose leaf	Rocket	< 3	< 3	ND	ND	ND	ND
25/10/2006	Loose leaf	Baby spinach	< 3	< 3	ND	ND	ND	ND
25/10/2006	Loose leaf	Lettuce	< 3	< 3	ND	ND	ND	ND
25/10/2006	Packaged	Baby spinach	< 3	< 3	ND	ND	ND	ND
25/10/2006	Packaged	Lettuce	< 3	< 3	ND	ND	ND	ND

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