Risk of Listeria: Fresh Produce

A Guide for Food Manufacturers

A document produced jointly by iNet and University of Nottingham

Catherine Rees
Associate Professor of Food Microbiology

Christine Dodd
Professor of Food Microbiology

Ogueri Nwaiwu
UoN Research Fellow
Risk of Listeria: Fresh Produce

A Guide for Food Manufacturers

Introduction

Consumption of fresh produce continues to increase, and associated with this has been an increase in produce-linked food poisoning outbreaks. It has been reported that larger scale production and more efficient distribution of fresh produce over the past two decades have contributed to an increase in the number of illnesses associated with these products. Pathogen contamination of fresh produce may originate before or after harvest and once contaminated, produce is difficult to sanitize. This problem is compounded if the bacteria invade the vascular system of the plants as they are then protected from any conventional surface sanitation treatments applied. Such treatments reduce the overall microbial load and reduce the levels of surface contamination, but do not penetrate the plant tissue.

The organism *Listeria monocytogenes* is best known as a serious human pathogen that is transmitted to humans via the consumption of contaminated food products. However it is also a bacterium that occurs commonly in soils, associated with decaying plant matter. Hence it can be naturally associated with any plant product grown in contact with soil. Unusually for human pathogens, it can use plant sugars for growth and hence the organism is often a problem associated with minimally processed fruit or vegetables. Specifically, when vegetables or fruit are cut, sugars are released which the organism can

---

ERDF-iNet Partnership with Universities

The Food Standards Agency (FSA) aims to reduce the number of cases of listeriosis in the UK by the year 2015 through the Listeria Risk Management Programme. The program has three areas of focus: firstly *Listeria* awareness with reference to consumer behaviour, secondly procurement of food to the vulnerable and thirdly industrial compliance. To this end, the ERDF-iNet has entered a partnership with the University of Nottingham to help local food producers by establishing a Knowledge Network. Producers will be encouraged to report any information they have about products affected by *Listeria* contamination and the University will collate and analyse the information collected, and then share the information anonymously with the wider industry.

utilize for growth. However it is still unclear whether *Listeria* can become internalised in plant tissue.

**Internalization of bacteria in plant tissue**

It has been very well established that some bacterial pathogens can internalise into plant tissue. There is still a lack of knowledge about exactly how far bacteria are transmitted into the plant vascular system, and also little knowledge of whether these bacteria are simply surviving – protected from sanitizers by the plant tissue – or are actively growing within the plant. Because of their association with very large outbreaks of food borne infection transmitted via fresh vegetables, most studies have been carried out on Gram-negative bacterial pathogens, such as *E. coli* and *Salmonella*. Hence there is very limited research describing the interaction of *Listeria* with plants.

In 2010, the Texas Department of State Health Services ordered a San Antonio produce processing plant to halt operations and launched a widespread recall after laboratory tests found *Listeria monocytogenes* in packages of chopped celery sold to hospitals, restaurants and schools.

The investigation into the company was prompted by a spate of 10 cases of listeriosis (including five deaths) reported to the health department over a period of eight months.

Although the celery was not sold directly to the public, investigators linked contaminated celery to at least six of these cases of listeriosis.

*Source: Los Angeles Times, October, 2010*
Routes of entry for bacteria into plant tissue

This is a topic that is still being debated, but clearly there are two obvious explanations of why bacteria are found within plant tissue. Firstly they enter through natural openings in the plant surface (stomata, lenticels, sites of lateral root emergence, etc.) and/or through sites of biological or physical damage. Secondly they are pulled into the internal tissues along with water.

 Normally, water movement is driven by capillary action from the stem scar/calyx into the core of fruit. Other sources could be through wounds or bruises in the surface of a fruit or leaf, entry via the roots following exposure to pathogen-contaminated water and from stamen via the pollen tube into new fruit. There is evidence that some bacteria may be able to persist in the complete plant life cycle, from seed to sprout. Evidence for bacterial contamination via hydroponic systems has been demonstrated and this can lead to entry into plants via both roots or leaves.

Hence, during production, water is used to soak seeds, irrigate plants and wash produce crops following harvest, and all of these processes can be seen as potential sources of contamination.

Reproduced from Deering et al., 2012 Food Research International, 45 (2) 567–575

Major Product Recall 2013

An America sprout grower recalled all sprouted seeds sold by the firm and distributed throughout Washington, Oregon, Alaska and British Columbia in Canada due to discovery of Listeria contamination.

The initial recall included broccoli, clover and spicy sprouts and alfalfa sprouts where the contamination was discovered following testing of finished product by the Department of Agriculture. However this was voluntarily expanded to include all of the company’s products, including bean sprouts, sandwich sprouts, deli Sprouts, Wheatgrass and Pea Shoots after further tests were carried out at the firm’s production facility.

Listeria in plant tissue

The information currently available on the internalization of *Listeria* is from very limited studies and some of the results are contradictory. It has been shown that, like *E. coli*, *Listeria* can enter the stomata of leaves but whether this is an active process or a passive entrapment of bacteria within the structure (which is far larger than the bacterial cell) has not been determined. However bacteria able to enter natural openings in the plant can be protected from various sanitizers following closure of the guard cells.

Since the organism is commonly found in soil, the entry of *Listeria* into leaf tissue is more likely to occur post-harvest rather than during growth. Studies have shown that fruit and vegetable crops can be contaminated post-harvest when there is a big enough temperature differential between the crop and wash water to allow movement of water into the plant tissue. Following entry it is likely that the bacteria are transported via the mass flow of water entering the plant and moving within it. This process has been demonstrated by using bacteria-sized polystyrene beads which could be found within the body of a plant after being taken up from the soil.

The exception to this is when *Listeria*-contaminated manure has been used as a fertilizer, as occurred in the Maritime coleslaw outbreak in 1981. This was the first outbreak of *L. monocytogenes* that could be definitely linked to food and was caused by commercially prepared coleslaw in Canada and resulted in at least 41 cases and 7 confirmed deaths. In this case it was found that manure from *Listeria*-infected sheep had been used as an organic fertilizer when growing the cabbages used to prepare the salad, leading to heavy leaf contamination.

Bacteria can also reach the interior of the plants by the roots. However, again, there are very few studies that have been described investigating whether *Listeria* can...
enter plants by this system and the published reports suggest that they do not readily enter plant tissue via the roots. This would be consistent with the biology of the bacterium in that it is attracted towards the sugar cellobiose which is produced from the breakdown of cellulose. This breakdown is most frequently carried out by fungi and bacteria that live in the rhizosphere – the community of organisms associated with the plant roots. So the highest concentration of these Listeria-attractive plant sugars are likely to be found outside the root structures rather than within the plant tissue.

This ability to use these plant sugars may explain why produce outbreaks seemed to be frequently associated with processed produce and often involved storage under suboptimal conditions (for instance the Canteloupe melon outbreak in 2011) or environmental cross-contamination after processing.

**Growth of Listeria on fresh produce**

Recent reports show that commodities can differ in their ability to support growth. Some studies have been carried out to compare growth on intact and damaged or cut produce. Growth has been reported on intact tomatoes, but studies on carrots, cabbage, peppers and cantaloupe melon reported growth only on cut, shredded or damaged produce. In general Listeria grew well on shredded lettuce, with populations increasing during storage.

Survival and growth patterns on vegetables have been found to vary with strain, product type and packaging atmosphere. It has been suggested that packaging under modified atmosphere increases the ability of L. monocytogenes to grow by inhibiting competing microflora, but this remains to be proven, and the effect may differ by commodity, atmosphere composition, and storage conditions. However, packaging under modified atmosphere...
atmosphere evidently does not inhibit growth of \textit{L. monocytogenes}, and the prolonged shelf life may in itself increase the listeriosis risk.

Significant differences have been observed in terms of the ability of \textit{Listeria} to survive in heat and acidic conditions and on packaged vegetables. Cooked or pasteurized produce usually supports rapid growth and may represent a risk after post-processing contamination, especially if not refrigerated and consumed without heating. It is now accepted that most produce commodities support growth of \textit{L. monocytogenes}.

**Practical steps to control \textit{Listeria} in fresh produce**

Assuming the bacteria are not internalised in the plant tissue, surface sanitisation is normally an effective way to remove \textit{Listeria} from product. Many reports show that contaminated surfaces are most likely the source of product contamination, and that the risk of contamination is highest between the primary trimming and chopping and packaging stages.

Sources of contamination that should be considered are:
- Hands and gloves and personal protective equipment
- Slicers
- Conveyors
- Washing tanks and wash water
- Holding containers
- Racks for packaging and packaging equipment

In addition general plant or factory sanitation and employee hygiene must be taken into consideration for effective control of \textit{Listeria}. More advice can be found in a previous technical publication (“Dealing with Listeria” by UoN/Diversey).

**Concluding remarks**

\textit{Listeria} is unlike many other bacteria that cause food borne disease. As well as being able to infect the human body, it can readily adapt to survive and grow in the environment, and forms a natural part of the soil micro flora. Hence its association with fresh produce does not always indicate that there has been a major contamination event – rather the organism may have entered the production facility and its versatility has allowed it to take advantage of this
situation. For this reason, the more we understand the biology of this bacterium, the more likely we are to be able to develop methods to combat it.

Acknowledgements

This work was funded by the ERDF and iNet. Figure reproduced by permission of publisher John Wiley & Sons.

Disclaimer

Every effort has been made to ensure the information in this document is accurate. However University of Nottingham does not accept any responsibility or liability whatsoever for any error of fact, omission, interpretation or opinion that may be present, however it may have occurred.

References


