



The Organic Center

[www.organic-center.org](http://www.organic-center.org)

Critical Issue Report *E. Coli* O157: Preventing Outbreaks



# Unfinished Business: Preventing *E. Coli* O157 Outbreaks in Leafy Greens

by Charles Benbrook, Ph.D.

Chief Scientist

The Organic Center

June 2007

# Table of Contents

<b>Executive Summary</b> .....	<b>1</b>
Essential Ingredients in Widening Margins of Safety.....	3
Moving Forward .....	6
<b>The 2006 <i>E. coli</i> O157 Outbreak: Possible Causes and Lessons Learned (and Relearned)</b> .....	<b>7</b>
Location and Possible Causes of the 2006 Spinach Outbreak.....	8
Lessons Learned and Relearned .....	10
<b>The “GAP Metrics”</b> .....	<b>12</b>
A Work in Progress.....	12
<b>A Strategy to Prevent Foodborne Illness Outbreaks</b> .....	<b>15</b>
Monitor, Study, and Probe for Answers.....	15
Strengthen GAP Metrics and Grower–Processor Plans .....	16
Farm to Fork .....	16
Identify and Deal with High–Risk Areas and Circumstances .....	17
<b>References</b> .....	<b>19</b>

# Executive Summary

Much more than the fate of the multi-billion dollar fresh leafy greens industry is at stake in the wake of last fall's *E. coli* O157:H7 outbreak. Why? Because increasing daily consumption of fresh fruits and vegetables is an essential first step in improving the health of the average American.

The health promoting potential of fresh produce is why the government has recently recommended a big increase in daily fruit and vegetable consumption, from five servings a day to eight to 13, depending on an individual's size and activity level.

Any factor that erodes confidence in the safety of fresh produce will undermine ongoing efforts to increase consumption. The next high-visibility outbreak, whether triggered by spinach from California, melons from Mexico, green onions from a large conventional farm, or organic radicchio bought at a farmers market, will further erode consumer confidence in the safety of fresh produce.

## New Food Safety Initiatives

Since last fall's outbreak, everyone involved in the growing, processing, and marketing of fresh leafy greens has been focused on how to prevent another outbreak. The good news is that growers and processors, especially in California, have adopted significant, new prevention-based food safety practices. A set of "Good Agricultural Practice (GAP) Metrics" for leafy green growers and processors has been developed by a coalition of industry and farm organizations.

Fresh Express, a major lettuce and spinach processor, has recently provided \$2 million to fund nine studies focusing on the prevention of *E. coli* O157 in leafy greens. Projects are focusing on the ability of *E. coli* O157 to become internalized in lettuce and spinach; the possible role of insects in transmitting pathogens; and, environmental factors increasing the risk of extended survival or regrowth of foodborne pathogens.

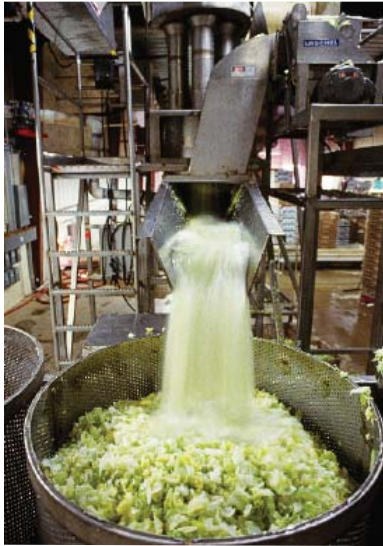


Natural Selection Foods (NSF), which is best known for its Earthbound Farm produce, processed the Dole brand baby spinach on August 15th that triggered the 2006 outbreak. The company's cooling, washing, and bagging procedures came under intense scrutiny as state and federal investigators searched for the cause of the outbreak. The effort to find where and how the *E. coli* O157 got into the raw spinach in the field was equally intensive and went on for over six months.

Within weeks of the outbreak and its own investigation of the outbreak, NSF decided to significantly augment its already strict food safety procedures, both in the plant and out in the field.

Testing of production inputs for pathogens was greatly expanded, and now encompasses seeds, irrigation water, composts and other soil amendments. All water used in the production process is tested weekly to monthly for enterohaemorrhagic *E. coli* and Salmonella. The environmental conditions in and around fields are assessed to identify - and avoid - possible sources of contamination. More, and more in depth field audits are routinely performed.

There were even more significant changes in NSF processing plant procedures. In the fall of 2006, two “firewalls” were added to their food safety system – the first “test and hold” firewall applies to raw product as it enters the plant, the second after product is washed, bagged and ready to ship. NSF now tests all incoming loads of raw product for enterohaemorrhagic *E. coli* (including



Leafy greens are washed three times in most processing plants.

O157:H7) and *Salmonella*, and holds the greens until the results confirm the absence of pathogens. Thus far, pathogens have been found in about three-dozen lots of raw produce, representing about one-tenth of one percent of the total pounds of raw product tested. These lots have been destroyed.

A second firewall is in place, focused on fully processed and packaged product that is ready to ship. Samples from all lots are tested and held, and shipped only after results confirm the

absence of pathogens. Thus far, no lots of finished product have tested positive, evidence that the dual-firewall approach is working.

The scope of foodborne pathogen problems, however, remains sobering, as does what it will take across the industry to prevent future outbreaks. Over 25,000 illnesses were triggered by *E. coli* O157:H7 in food in 2006, based on the most recent government data (see the box “The Challenge”). The spinach outbreak accounted for less than one-half of one percent of these cases, and about four percent of the illnesses likely triggered by *E. coli* in fresh produce.

Moreover, *E. coli* O157:H7 is not the only serious foodborne pathogen causing illness from consumption of fruits and vegetables. Three other strains of enterohaemorrhagic *E. coli* cause tens of thousands of cases each year. *Salmonella* causes many more cases than all strains of *E. coli* combined, but fewer cases leading to serious, life-threatening complications. Because of the significant health risks posed by *E. coli* and *Salmonella* infections and the upward trend in illnesses linked to fresh produce, these bacteria must become, at least in the near term, the dominant focus of monitoring and prevention efforts throughout the fresh cut industry.



Photo credit: Earthbound Farm

A worker takes a sample from a harvest machine to test for the presence of human pathogens. Everything that comes in contact with raw leafy greens must be carefully cleaned and continuously monitored.

The Organic Center	Critical Issue Report	Page
June 2007	<i>E. coli</i> 0157	3

## The Challenge

The fall 2006 spinach outbreak led, according to the FDA, to 204 illnesses. The California Department of Health Services recently reported, however, that only 162 of the individuals that suffered illnesses reported eating spinach, and 151 reported eating bagged spinach. While most of the spinach that was found to contain the outbreak strain of *E. coli* O157 was Dole spinach, other brands were implicated in the outbreak. For many cases, the brand was not known.

Given the national press attention devoted to the fall outbreak, one would think it accounted for a significant share of last year's *E. coli* O157 illnesses. Not true.

Based on the most recent FoodNet data, about 52,000 cases of *E. coli* O157 illnesses were expected in 2006 (down 29% from 73,000 cases in 1999). CDC attributes this encouraging reduction in cases since 1999 to progress in reducing illnesses caused by undercooked hamburger. (Some articles report an estimated 100,000 cases of *E. coli* human illnesses annually, also citing data from the CDC. This larger number reflects the cases caused by four enterohaemorrhagic strains of *E. coli*, including O157:H7).

The 2006 spinach outbreak therefore accounts for less than one-half of one percent of the 52,000 illnesses expected in 2006 from all sources of exposure to *E. coli* O157.

Foodborne sources of *E. coli* O157 likely accounted for about 50 percent of the total number of outbreaks in 2006 and one-half the cases, or about 26,000, based on a CDC epidemiological study (Rangel et al., 2005). Produce (mostly lettuce and salads) accounted for an estimated 21% of outbreaks linked to foodborne transmission, or 5,460 cases.

The 204 cases triggered by the 2006 spinach outbreak thus represent fewer than 4 percent of the total number of produce-triggered cases.

This problem is far larger than most people realize and fresh cut produce from the Salinas Valley accounts for just a small share of it. Reducing *E. coli* O157 illnesses linked to produce is a national challenge that must be attacked systematically, every day, wherever fruits and vegetables are grown and processed.

## Essential Ingredients in Widening Margins of Safety

The fastest way to substantially broaden fresh produce and leafy green margins of food safety will depend on a systematic, farm to fork approach. Success will depend on progress in three areas:

### Reduce Pathogen Loads

A promising way to reduce the millions of human illnesses triggered annually by foodborne pathogens is to track the pathogens to their source, understand the conditions in which they thrive, and change those conditions. This approach is logical and proven, yet in the case of *E. coli* and leafy greens, is barely on the radar screen of industry leaders or government regulators.

A mountain of data and experience with foodborne illness outbreaks linked to fresh produce points to proximity of production fields to dairy and beef cattle operations – and manure – as a significant risk factor for *E. coli* O157 contamination.

Cattle and crop farming have co-existed on the same farms, and in the same regions for hundreds of years with few *E. coli* O157 illnesses linked to consumption of crops. But leafy greens marketed as ready-to-eat, fresh cut product are uniquely vulnerable to foodborne pathogens because:

- The harvested portion of the plants grow very close to the soil,
- The produce is not cooked, and
- The bags or clamshells containing fresh cut greens provide an excellent environment for bacterial proliferation,

if bacteria survive the washing and sanitation procedures, especially if the cold chain is broken or when consumers do not respect the product expiration date.

The unique vulnerability of fresh cut leafy greens to *E. coli* and Salmonella calls for added measures to keep cattle, and their manure well away from production fields.

### Monitor, Study and Probe for Answers

More testing, and more accurate test methods are needed. *E. coli* O157 and Salmonella should be routinely tracked, rather than generic *E. coli* as now the case in the water testing provisions within the GAP Metrics.

The GAP Metrics total reliance on generic *E. coli* water testing is a serious flaw and should be rejected by growers, buyers, and the government. Innovative companies are already testing - and benefiting from - water and product testing protocols focusing on *E. coli* O157, other pathogenic forms of *E. coli*, and Salmonella. The industry has promised consumers that it will do everything possible to assure product safety. "Everything possible" surely must encompass routine testing of water and product for *E. coli* O157, other enterohaemorrhagic *E. coli*, and Salmonella.



Spinach samples are routinely collected in the field for testing.

The results of testing across farms, processors, and regions, whether done by individual farmers and processors, regulators, or researchers, need to be shared and analyzed by teams of experts so that new insights of value to everyone will emerge as quickly as possible.

The government can and should play a supportive role by offering financial support for testing, as long as accurate and verified methods are used and results pooled in a way that will allow researchers access to the broadest possible pool of test results.

### Identify and Deal with High-Risk Circumstances

Moderate and high-risk fields need to be identified, based on past records of the sources of contaminated product and ongoing raw product testing programs.

In particular, fields within one-half mile of cattle operations or open range should ideally be planted to other crops for the next few years as science sharpens understanding of the causes of O157 outbreaks. If such fields are used for fresh cut leafy greens, the raw product harvested from the fields should be processed only in conjunction with a raw product and finished-product testing program encompassing all pathogenic strains of *E. coli* and Salmonella.



The combination of cattle and flood conditions can create a "perfect storm" for nearby vegetable growers.

Levels of risk associated with different sources of irrigation water will vary by orders of magnitude. It makes no sense to force growers to continue testing very clean water sources as frequently as those sources known to periodically bear possibly risky pathogen loads.

Relative risks associated with agronomic and pest control practices, and production inputs need to be assessed and communicated to growers. Those practices and inputs known to open the door to pathogens, or to encourage their growth, need to be flagged and matched with more intensive sampling and testing.

## Tilting the Odds Against *E. coli* O157

Sprinkler irrigation systems are more efficient than furrow, or surface irrigation in transferring *E. coli* from water to growing plants. Over 90 percent of the spinach plants were contaminated with *E. coli* O157 after being irrigated with a sprinkler system, and water spiked with *E. coli*, compared to less than 20 percent of the plants under surface irrigation (Solomon et al., 2002a). Sprinkler systems result in more splashing onto leaf surfaces of a mixture of soil and water.

Management practices that support the establishment of diverse microbial communities on the leaf surface can slow or block the proliferation of *E. coli* O157 (Aruscavage et al., 2006). The lack of fungicide use in organic production systems and reliance on composts and other soil amendments that support microbial biodiversity can help place *E. coli* O157 bacteria at a competitive disadvantage. The generally higher levels of phytochemicals expressed by plants grown in organic systems can also lead to direct suppression of *E. coli* O157 (Dingman, 2000).

Plant defense mechanisms can also reduce the odds of *E. coli* O157 proliferation (Suslow et al., 2003). Healthy plants have been shown to ward themselves of *E. coli* infections within days to a few weeks after infections. The possible mechanisms leading to this outcome include the production of phytochemicals with anti-bacterial activity and stimulation of a plant's defenses through a process known as systemic acquired resistance (Aruscavage et al., 2006; Suslow et al., 2003).

Pathogenic bacteria that find their way to crop fields need a source of energy to proliferate. Excessive levels of nitrogen fertilizer in a field are known to increase the plant's release of nitrogen compounds both through the root system and the leaf surface, possibly stimulating bacterial growth (Aruscavage et al., 2006). Nitrogen is typically released more slowly in organic production systems, a factor that may emerge as a food safety advantage.

Practices and inputs known to be helpful in preventing initial pathogen colonization in a field, or capable of suppressing pathogen growth, also need to be identified and incorporated in production systems to the extent possible.

Some options are described in the box "Tilting the Odds Against *E. coli* O157," and include promoting microbial biodiversity, healthy plant defense mechanisms, and avoiding excessive levels of nitrogen in soils, which can stimulate plants to produce exudates that can stimulate *E. coli* O157 and Salmonella proliferation.

Throughout the 2007 production season, growers and processors must err on the side of excessive caution. They need to test for pathogens at more places, more frequently. The data generated will hopefully soon point to high-risk fields and practices, as well as fields and systems that pose little if any risks.

Only the highest quality production inputs should be used, especially composts and other soil amendments made from manure or other animal byproducts. Adherence to manufacturing and process standards should not be relied on

exclusively to assure that soil amendments are safe for use in fresh cut leafy green production. These important production inputs should be tested routinely through the 2007 season to assure that, for example, finished compost is really finished and stable, and pathogen free, and remains so until incorporated into the soil in a production field. Compost manufacturers should not be expected to shoulder the full cost of the intensified testing that is necessary for the next few years.



Internal inconsistencies and gaps in the soil amendment provisions in the GAP Metrics should be addressed in time to guide compost manufacturers this fall, as they produce the compost that will be used early in the 2008 production season. If stricter, more science-based

compost standards are not incorporated in the GAP Metrics by the fall of 2007, organic growers and certifiers should work together to develop additional compost quality standards that can be put in place quickly, so that organic farmers will be able to purchase compost in 2008 that is fully finished and meets the strict pathogen standards now in the GAP Metrics.

## Moving Forward

From farm to fork, multiple and redundant prevention-based practices should be implemented. And at each step along the way, testing should be relied on to check whether prevention-based interventions are working and to identify high-risk circumstances in need of special attention.

More sensitive and specific test methods should be adopted. This step will help assure an outbreak-free 2007 season, and should also generate critical new knowledge needed to chip away at the 52,000 cases of human illness traced to *E. coli* O157 in recent years.



Photo credit: Earthbound Farm

Leafy greens in the first wash cycle at the National Selection Foods, San Juan Bautiste plant.

Valuable new food safety measures pioneered and proven by one company should be quickly adopted industry-wide. In particular, the testing-based firewalls implemented by NSF appear to be working as intended, and are clearly affordable for any major processing plant.

Pursuing these and other new strategies can expand fresh leafy green margins of safety significantly and quickly, and without driving up production costs to the point where no farmer or processor can stay in business.

This is fortunate, since farms in California now account for a significant share of the daily consumption of fresh fruits and vegetables for many Americans during several months each year. If fresh leafy greens were no longer grown in California, imports would surge, no doubt bringing along with them another set of food safety challenges and outbreaks. Before long, trust in produce safety will decline enough to depress the average number of daily servings and in turn, our collective public health.

This is why the stakes are so high this summer. Progress has clearly been made through coordinated efforts within the industry, and individual companies have raised the food safety bar.

Thus far, the government has been a passive observer of events and has done little to support innovation, punish those who cut corners, and spread the costs required to widen margins of safety. This is unfortunate since more can and should be done to develop and fully implement strategies that will reliably drive down *E. coli* O157 and other foodborne pathogen risks to as close to zero as possible, as quickly as possible.