

# ***LISTERIA MONOCYTOGENES – RECENT OUTBREAK BROADEN PERSPECTIVE ON CONTROL***

Martin Bucknavage

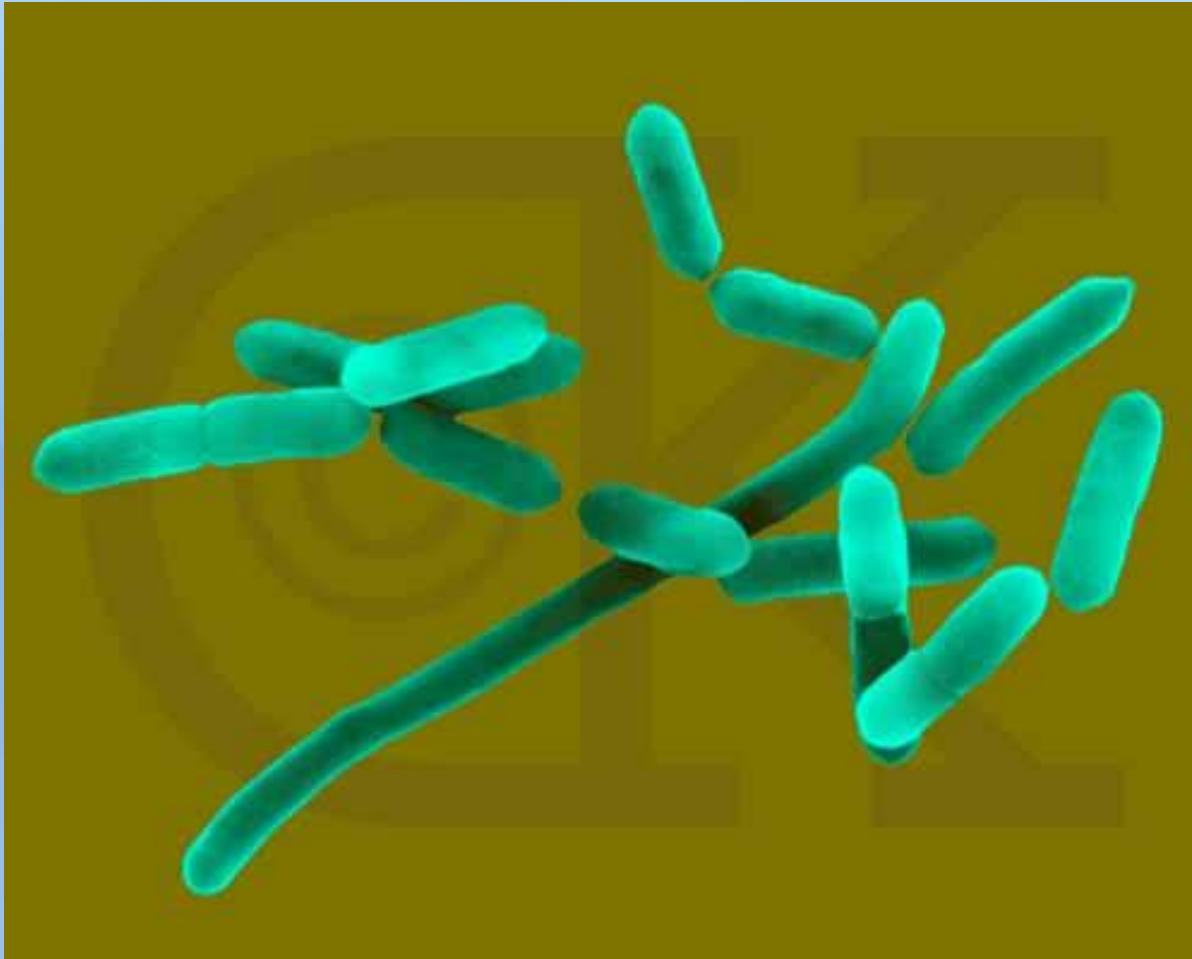
Senior Food Safety Extension Associate

Penn State Department of Food Science



Penn State **Extension**

# Listeria monocytogenes



## Disease from *Listeria monocytogenes*

- *Listeria monocytogenes* is a bacterial pathogen that causes disease when the organism is ingested
- Can result in septicemia, meningitis, encephalitis
- Primarily a risk in high risk populations Most at risk – elderly, pregnant women and infants, and adults with weakened immune systems. (Rarely, persons without these risk factors can also be affected.)
- High mortality rate – 20 to 30%
- The higher the level of contamination, the greater the risk, however, a minimum infectious dose (MID) not determined. (Consumption of < 1000 organisms/gm in milk may cause disease)

# Foods Involved in Outbreaks

## Types of foods

Generally, foods that allow the organism to grow are considered more of a risk

- Dairy products including unpasteurized milk, soft cheeses
- Cooked or processed foods including ready-to-eat meats and seafood
- Prepared foods held at refrigeration

# *Listeria monocytogenes* Outbreaks

## **Outbreaks from traditional sources**

- Raw milk (2016) – 2 infected, 1 death in 2014
- Soft cheese (2015) – 30 infected, 3 deaths
- Ice Cream (2015) – 10 infected, 3 deaths
- Soft cheese (2014) – 8 infected, 1 death
- Soft cheese (2013) – 6 infected, 1 death
- *Listeria* and deli meat – Canada (2008)

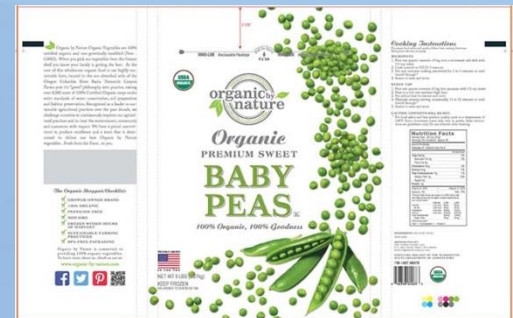
# Outbreaks Associated with LM in Produce

- Cantaloupe (2011) – 147 cases, 33 deaths
- Stone fruit (2104) – 2 cases, 1 death
- Sprouts (2014) – 5 cases, 2 deaths
- Caramel Apples (2014) – 35 cases, 7 deaths
- Packaged salads (2015/2016) – 19 cases, 1 death
  
- Cole slaw (1981)- 41 cases, 17 deaths
- Celery (2010) – 10 cases, 5 deaths



## Recent Recalls due to Presence of LM in Produce

- Frozen corn and peas – April 23, 2016
- Frozen onions used as an ingredient in frozen vegetable mixes and used in salads – April 10, 2016
- Cut fruit packages containing apples – April 5, 2016
- Fresh frozen broccoli cuts – April 1, 2016



# Listeria monocytogenes and Control

- Characteristics of Listeria monocytogenes
- Sources of LM
- LM and Produce
- Control of LM in different applications





# Characteristics of *Listeria monocytogenes*

## General

- Gram positive, motile rod
- LM is a facultative organism - can grow under aerobic, reduce oxygenated (semi-anaerobic), and anaerobic conditions
- Capable of growing at refrigeration temperatures

## Characteristics of *Listeria monocytogenes*

### Growth Temperature

- Range: 30°F to 106°F (at optimal pH)
- Optimal: 86°F to 98.6°F
- While it grows at refrigeration temperatures, it grows slowly
- Generation times –
  - at ~32°F between 62 and 131 hrs
  - At 40°F – between 28.5 and 46 hrs
  - At 70°F – 1.8 hrs
  - At 95°F – 42 minutes
- Freezing does not kill the organism

# Characteristics of *Listeria monocytogenes*

## Heat Destruction

- Killed by normal cooking temperatures including pasteurization and blanching
- Studies in milk have demonstrated that LM is inactivated at pasteurization temperatures (162F)
- D-values – time to achieve a 90% reduction (tested in ice cream mix)
  - 155°F – 3.9 minutes
  - 165°F – 0.53 minutes (32 seconds)
  - 175°F - .043 minutes (2.5 seconds)

## Characteristics of *Listeria monocytogenes*

### Acidity

- Optimum pH for growth is between 6.0 and 8.0
- Organism is acid tolerant , although growth has not been demonstrated below a pH of 4.0.
- If conditions are not optimal for survival, decrease in cell numbers can be seen at a pH <5.5 and that decrease accelerates as the pH drops (and temperature increases)
- While refrigeration inhibits growth, it favors survival in acidic foods.

## Characteristics of *Listeria monocytogenes*

### Moisture (Water Activity or $A_w$ )

- Water activity is considered the moisture that is available for microbial growth and ranges from 0 to 1 (no moisture to pure water)
- *Listeria* generally requires a  $A_w$  of  $> 0.97$  (but has been shown grow to down to a  $A_w$  of 0.90 in scientifically optimized conditions)
- It can survive in dry conditions (at or below 0.90) for long periods of time
- It can also tolerate high concentrations of salt ( $>12\%NaCl$ )

## Characteristics of *Listeria monocytogenes*

### Preservatives

- Organic acids and their salts are often used to inactivate LM on food surfaces. These include sodium lactate and sodium diacetate
- Lauric arginate has been used in edible films
- Lactic acid and citric acid have been used as washes
- Lactic acid bacteria are generally antagonistic against *Listeria*
- Bacteriocins (nisin, pediocin) are used to control *Listeria* growth.

# Characteristics of *Listeria monocytogenes*

## Biofilm formation

- LM can form biofilms under the right conditions
- A biofilm is an accumulation of bacterial cells immobilized at a surface and frequently embedded in a matrix of bacterial origin
- Biofilms allow for the attachment, colonization, and survival of the organism in food processing environments

# Sources of *Listeria monocytogenes*

## Sources

- Found in nature, but a higher prevalence on ruminant farms
  - High correlation between specific farm and farm activities to areas where food is stored/handled/processed
- More prevalent in soil and vegetation when moist



## Sources of *Listeria monocytogenes*

### Sources - Fruits

- Lack of studies on incidence in fruits, especially tree fruits.
- Growth can occur specifically on sliced low acid fruits (melons, watermelon) and to a lesser extent on acidic fruits when held at elevated temperatures.

## Sources of *Listeria monocytogenes*

### Sources - Vegetable

- Numerous studies in 1980's and 1990's have shown a very low incidence of LM in raw produce - more often associated with root crops (radishes, potatoes, but not carrots), also with cabbage, cucumbers, and lettuce
- Studies demonstrated that when large dosages of LM were applied, cabbage, lettuce and asparagus did support growth during storage.

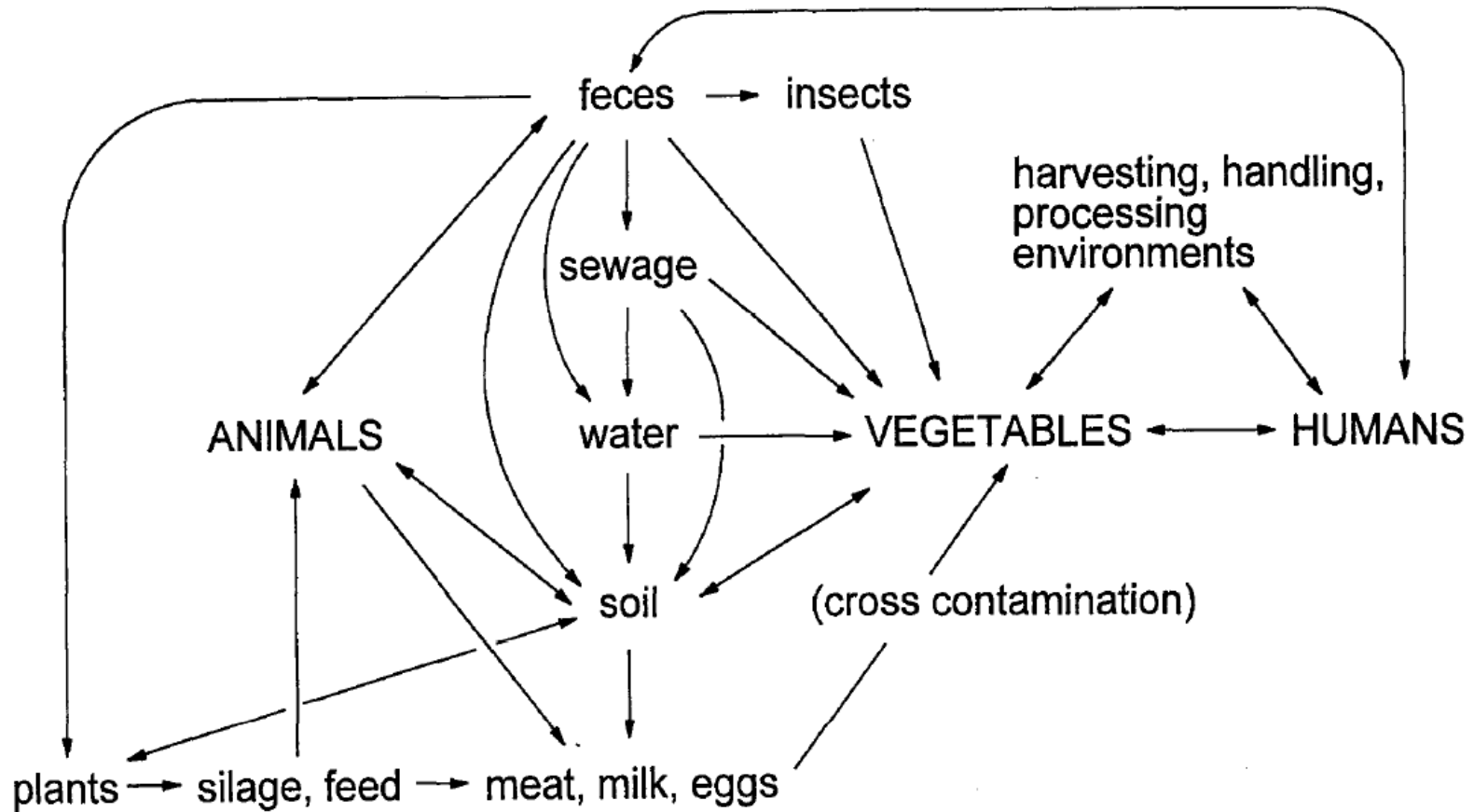
## Sources of *Listeria monocytogenes*

### Sources - Vegetable

- *L. monocytogenes* population levels remained constant on all fresh-cut vegetables stored at 4°C for 9 days, except for carrots and butternut squash: counts of cell numbers declined on carrots and increased on the butternut squash. Fresh-cut vegetables stored at 10°C, however, supported good growth of *L. monocytogenes* on all vegetables tested, except for chopped carrots, where the population decreased approximately 2 log units over a 9-day storage period.

# Penn State Extension

*Listeria monocytogenes*: incidence on vegetables: L.R. Beuchat

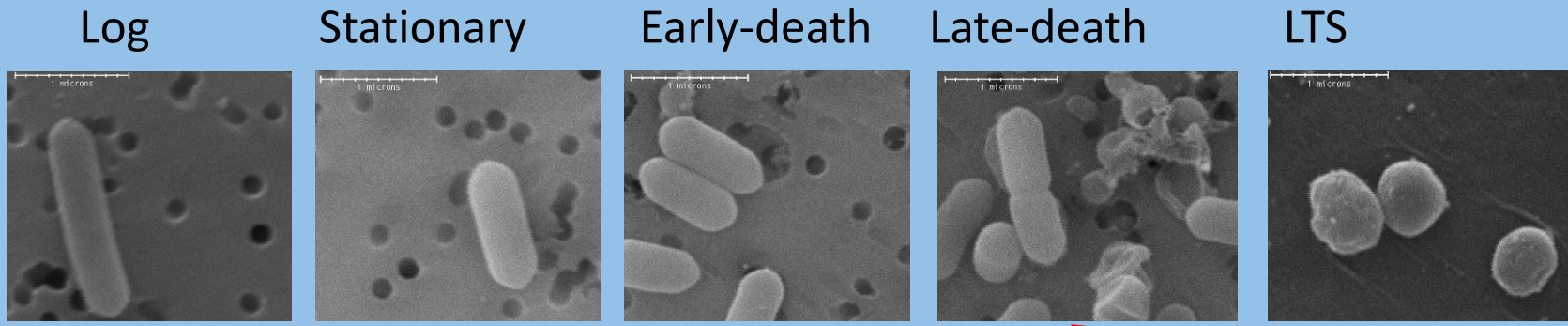


**Figure 1** Potential pathways for transmission of *L. monocytogenes* to humans via vegetables.

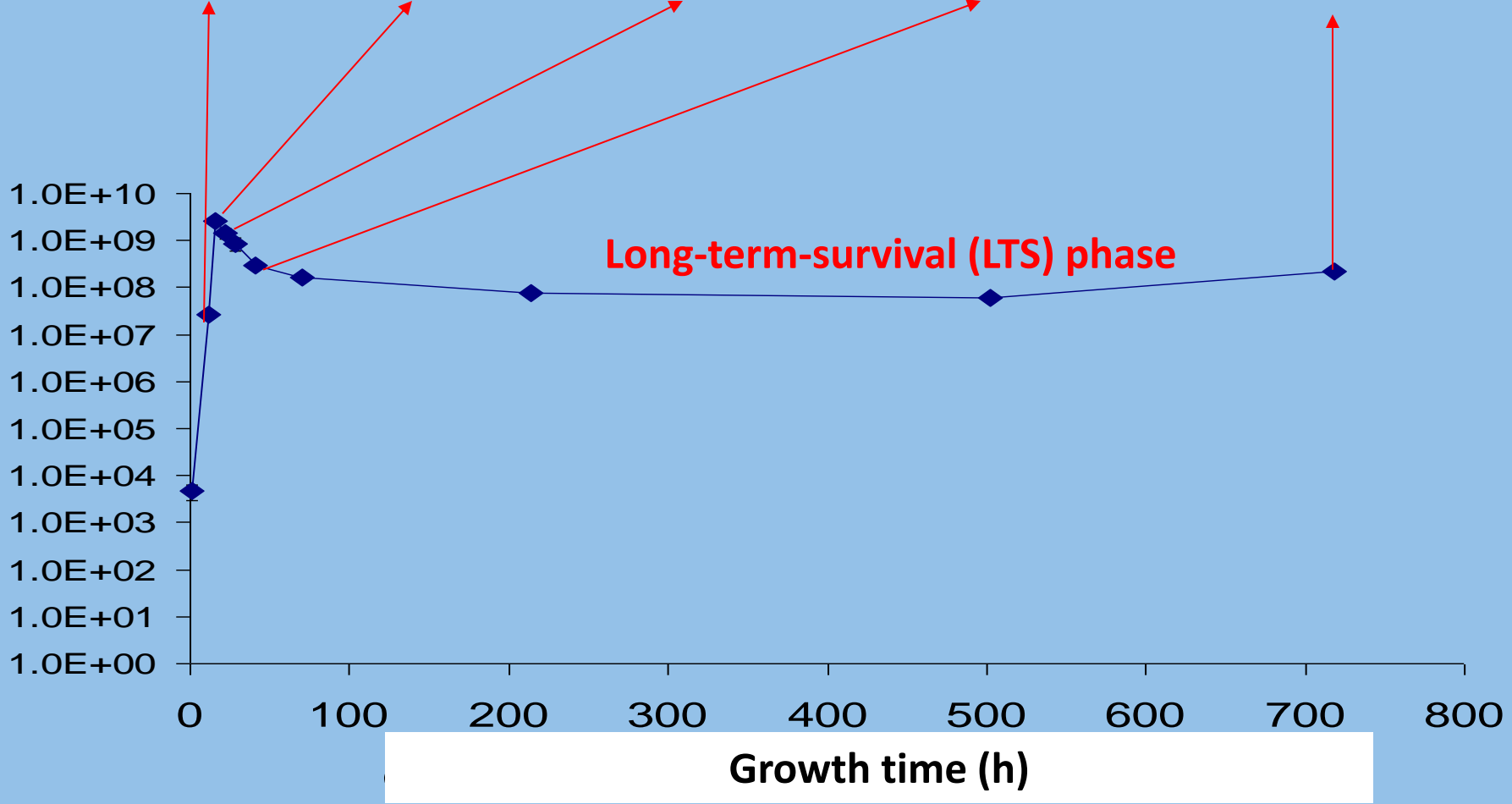
## Sources of *Listeria monocytogenes*

### Sources – Processing Facility

- Can be transported from location to location through a number of different vectors – people, equipment, etc
- Can be found in food processing plants where conditions conducive to growth exist (food source, moisture, etc)
- Can become a persistent environmental contaminate – has been reported in various types of food processing plants



**CFU/ml TSBYE**



Growth curve of *L. monocytogenes* in TSBYE at 35° C. (Wen et al. 2009)

## Sources of *Listeria monocytogenes*

### Sources – Processing Facility

- The plant environment must be considered an important source for *Listeria*.
- So while it is important to establish controls for preventing the introduction of *Listeria*, in many outbreaks, it has been organisms that have had become established over time.

## ***Listeria monocytogenes* and Produce**

### **Central Issues:**

- Wash / flume tanks subject to LM biofilm formation
- Long term refrigerated storage may allow for growth (Small amounts of growth can be an issue)
- While blanching or sanitizing processes will eliminate/reduce the pathogen, there is can be an issue with post-process contamination
- Produce items are used as ingredients in other foods that changes the nature of that item or puts that item in a matrix that will support growth



## ***Listeria monocytogenes* and Produce**

### **Operational Issues:**

- Packing houses and processing facilities were not built with microbiological control in mind
  - Seasonal operations
  - Poor flow patterns
  - Floors and drain systems difficult to clean
- Many of the facilities are older
  - Cracks in floors and walls
  - Pitted / worn equipment
  - Excessive moisture / standing water
- *Listeria* monitoring systems are still underdeveloped

## ***Listeria monocytogenes* and Fresh Produce**

### **Issues:**

- Listeria in cantaloupe
- Listeria in bagged salad
- Caramel apples

Listeria contaminates the food items during handling / washing

During storage and distribution, there is the potential for growth

Further processing can change the product or place it in an environment that supports growth

# ***Listeria monocytogenes* and Fresh Produce**

## **Controls**

- Washing systems are properly maintained – equipment is regularly cleaned and sanitizer concentration is maintained
- Processing environment is cleaned and maintained in a sanitary manner
- Reduction of excess moisture
- Eliminate poor flow patterns in operation
- Maintain proper storage conditions
- Conduct risk assessment

# ***Listeria monocytogenes* and Frozen Produce**

## **Frozen Vegetables – LM Issue**

- Product is blanched before freezing
- Blanching systems should be adequate to destroy *Listeria*
- Post-process Contamination

Freezing prevents growth, and if cooked by consumer, that would eliminate the organism. But increased usage by customers / consumers in RTE applications

- Added to salads
- Used in vegetable / fruit juice blends

## Control of *Listeria monocytogenes*

### Controls - Blanching of Vegetables

- Mazzotta (2001) JFP Vol 64
- 5 log reduction in pouches of vegetables
  - 167°F – 10 seconds
  - 180°F – <1 second (instantaneous)

## Control of *Listeria monocytogenes*

### Post-process environmental control

- Cleaning and sanitizing of food contact surfaces
- Sanitary design of equipment and facilities
- Cleaning of non-contact areas
- Establishment the post-process area as 'high hygiene' - control movement of personnel, raw ingredients, and equipment into post-process environment
- Monitor area for Listeria – pre-operational and during operations for zones 1 to 4

## **Control of *Listeria monocytogenes***

### **Controls for Customer / Consumer**

- Validated cooking instructions
- Limit the application of downstream processing applications by processing customers
- Conducting risk assessment of those products likely to be used in RTE applications

## Control of *Listeria monocytogenes*

### Controls for Suppliers

- FSMA Preventive Controls regulations requires Supplier Control for those incoming materials where there is a potential risk
- Just a COA will not be enough!!
- Suppliers need to have an active Listeria control program that includes real monitoring



# **FSMA – Preventive Controls for Human Foods**

## **Hazard Analysis and Preventive Controls**

- As part of 21 CFR 117 Part C, facilities must conduct a hazard analysis and put preventive controls in place
- This includes process, sanitation and supplier controls
- Environmental monitoring and product testing can be used as a verification of that control

# LM and Produce

## – Issues for Control at Retail

### Caramel Apples

- Growth of *Listeria* can occur at the stick / apple interface
- Refrigeration of caramel apple product would prevent growth during shelf-life of 30 days.

**Growth of *Listeria monocytogenes* within a Caramel-Coated Apple Microenvironment** Kathleen A. Glass, etal (2015)

## **LM and Produce** **– Issues for Control at Retail**

Use of raw vegetables in juice operations

- Addressed in Food Code 3-302.15 A. “.....raw fruits and vegetables shall be thoroughly washed in water to remove soil and other contaminate before being cut, combined with other ingredients, cooked, served, or offered for human consumption in READ-TO-EAT form.”
- Is this sufficient especially considering items that are more difficult to wash?
- Consumers?



## LM and Produce

### – Issues for Control at Retail

Use of frozen vegetables in RTE applications – salads, juice blends, etc

- By regulation, these items are restricted to 7 days of storage at refrigerated temperatures
- Many of the frozen food items are sold with cooking instructions thus are not made for RTE application
- What about consumer made products?



Sweet Pea and Dill Salad  
From allrecipes.com using  
Blanched sweet peas

## **LM and Produce**

### **– Issues for Control at Retail**

- Many of these applications are viewed as healthful – what implications does this have for high risk populations who are more apt to consume these products?
- What controls can be implemented upstream to reduce the prevalence?
- What is the impact of intermittent temperature abuse?
- What applications or situation are occurring that have not been considered?

## **LM and Produce** **– Issues for Control at Retail**

Can this occur?

- A 'Juicer' gets a load of kale. Realizing they can't sell it within a few weeks, the person liquefies it and freezes it in gallon jugs. Throughout the year, they remove jugs from the freezer, thaw, and then add it to other fruit-and -vegetable blends.
- Shortcuts occur such as thawing at room temperature, allowing the item sit at room temperature, and keeping the juice for too many days, moving it in and out of the refrigerator.
- The product is sold by the glass for consumption on-site.

# Questions

