Food Safety Trends

Michael Doyle

Unprecedented Challenges in Producing and Serving Safe Foods

- Whole genome sequencing and foodborne disease surveillance
- Produce safety
- Imported foods
- Chemophobia/natural foods
- Food Safety Modernization Act

U.S. Foodborne Disease Surveillance System

- CDC and State Public Health Departments identify today many outbreaks that would have been undetected 5-10 years ago
- CDC monitoring ca. 30 - 60 outbreak clusters daily
- 1200 to 1500 foodborne disease outbreaks are reported annually
PulseNet USA

• National network of federal (CDC, FDA, USDA), state and local public health laboratories
• Standardized molecular typing of foodborne disease-causing bacteria by pulsed-field gel electrophoresis (PFGE)
  ▲ Transitioning to whole genome sequencing (WGS)
• Electronic sharing of DNA “fingerprints” with central database of DNA “fingerprints” at CDC


Whole Genome Sequencing

• Robotic sequencing now in a few hours to 2 days can provide the full-length genetic code or whole genome sequence of a bacterial pathogen
• Can identify key stable genetic markers that can differentiate foodborne outbreak strains from less related pathogens

High-Throughput Genomic Sequencing of Foodborne Pathogen Isolates

• Potential ramifications
  ▲ Gene sequences of foodborne pathogen isolates obtained from processing facilities and ingredients/food products will be put into a central database like PulseNet
  ▲ Gene sequences of foodborne pathogen isolates from patients associated with outbreaks or sporadic cases will be matched with isolates in database
  ▲ Because of high degree of specialty of gene sequences, DNA match may be used as a “fingerprint” to implicate food processor
Subtyping Foodborne Pathogens by Whole Genome Sequencing (WGS)

- Foodborne Disease Outbreak Detection
  - CDC – PulseNet (Clinical and some food isolates)
  - FDA – GenomeTrakr (Food and food processing plant isolates)
  - USDA-FSIS meat and poultry isolates are being WGS and put in PulseNet database

GenomeTrakr Database

- WGS database of foodborne bacterial pathogens based at the National Center for Biotechnology Information
- Sequenced more than 61,000 bacterial isolates (>40,000 Salmonella, 10,000 Listeria, 10,000 E. coli/Shigella, 1,000 Campylobacter) as of 2nd qtr 2016
  - Sequencing > 1,000 isolates monthly
US *Listeria* Whole Genome Sequence Project

- Listeria WGS Project in 2013
  - Collaboration among CDC, FDA, USDA, and state health
  - Complete DNA sequence in real-time of health departments every clinical, food and environmental isolate of *Listeria monocytogenes* collected in the United States
  - In addition, CDC sequenced all retained human isolates of *L. monocytogenes* obtained prior to 2013

**Listeriosis from Caramel Apples**

- 35 cases
- 12 states
- 34 hospitalizations
- 7 deaths
Examples of Recent *Listeriosis* Outbreaks Unraveled by Whole Genome Sequencing

- **Caramel Apples** (Jan 2015; 35 cases, 7 deaths)
- **Karovn Cheese**, (Jun 2010-Sept 2015; 30 cases, 3 deaths)
  - 5 PFGE patterns → 1 WGS profile

Examples of Recent *Listeriosis* Outbreaks Unraveled by Whole Genome Sequencing

- **Blue Bell Ice Cream** (2 Clusters; Cluster 1, Jan 2014-Jan 2015, 5 cases, 3 deaths; Cluster 2, 2010-2014, 5 cases)
  - Several PFGE patterns → 2 WGS profiles
  - SC Dept. of Health & Environmental Control isolated from BB Scoops ice cream sampled at distribution center

Learnings from Blue Bell Ice Cream Listeriosis Outbreak

- FDA Lm analysis of Blue Bell (>2500) ice cream samples revealed > 99% were Lm-positive, with most having Lm populations of <20/gm
Learnings from Recent Listeriosis Outbreaks

- WGS of Lm from retail food samples matched WGS of Lm from PulseNet and GenomeTrakr databases
- FDA has WGS profiles of Lm, Salmonella and EHEC isolates from food processing plants obtained at least 5 years ago
- CDC has WGS profiles of Lm isolates from patients obtained at least 5 years ago

Listeria Cluster Metrics, Before and After WGS

<table>
<thead>
<tr>
<th></th>
<th>Pre-WGS (09/12-08/13)</th>
<th>WGS Year 1 (09/13-08/14)</th>
<th>WGS Year 2 (09/14-08/15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of clusters detected</td>
<td>14</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td>No. of clusters detected only by WGS</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>No. of outbreaks linked to food source identified</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Median no. of cases per cluster detected sooner or only by WGS</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>No. of outbreaks linked to food source</td>
<td>10</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>No. of cases linked to food source</td>
<td>93</td>
<td>192</td>
<td>193</td>
</tr>
</tbody>
</table>

Courtesy: Brendan Jackson, Enteric Diseases Epidemiology Branch
Example of Recent Shiga toxin-producing *E. coli* Outbreak Unraveled by Whole Genome Sequencing

- General Mills Flour (Dec. 2015-Jul 2016; 62 cases of [O121 and 1 case of O26], 1 case HUS)
- **Raw** flour used for cookie dough or cake batter, and play dough for children
  - STEC O26 isolated from flour and patient
  - >40 million pounds of flour recalled (Production dates of Nov. 4, 2015-Feb. 10, 2016)

2014 PulseNet-Triggered or Enhanced Outbreak Investigations

- *Salmonella* Outbreak Linked to Cheese Sickness 15
  - 3 dead, 7 others sickened by *Salmonella* traced to cheese

- Tyson Recalls 33,000 Pounds Of Chicken After *Salmonella* Outbreak
  - Tyson Foods has recalled 33,000 pounds of ground chicken due to *Salmonella* contamination.

- **Premium Entrees**
  - **Kiev**
  - 6 individually wrapped entrees
  - **Raw Stuffed Chicken Breasts**
  - **16 oz (12.0 oz. Cooked)**
  - **6 servings per container**
  - **6 Individually wrapped entrees**
  - **Raw, Frozen**
  - **Nutritional Facts**
  - **Serving Size: 2/3 container**
  - **Calories: 90**
  - **Fat: 3g**
  - **Carbohydrates: 0g**
  - **Protein: 12g**
  - **Sodium: 320mg**
  - **Cholesterol: 90mg**
  - **Ingredients:** Chicken breast with chicken evolution, onion, bell pepper, red pepper, black pepper, garlic, salt, food grade propylene glycol, water, celery powder, beef broth, onion powder, black pepper, salt, spices, natural seasonings.
Recalls of *Salmonella* Outbreak-Associated Raw Chicken Products

- **Tyson Foods**
  - 9 ill from S. Heidelberg-contaminated mechanically separated chicken in January 2014
  - 39,840 pounds of product recalled
- **Barber Foods (Omaha Steaks)**
  - 9 ill from S. Enteritidis-contaminated chicken kiev in July 2014
  - 1.7 million pounds of product recalled
- **Aspen Foods**
  - 3 ill from S. Enteritidis-contaminated chicken cordon bleu in July 2015
  - 1.9 million pounds of product recalled

U.S. Food and Drug Administration’s Food Facilities’ Foodborne Pathogen Testing Program

- FDA inspectors during food facility inspections obtain 50 environmental samples (including drains) and assay for foodborne pathogens (including *L. monocytogenes* and *Salmonella*).
- Swab-A-Thon
- All pathogen isolates are whole genome sequenced and submitted to the GenomeTrakr database
- A foodborne pathogen “profile” is established for pathogen-positive food industry facilities
  - Aids in outbreak investigations
US Centers for Disease Control and Prevention and US Food and Drug Administration Using WGS to:

1. Determine source of foodborne illness outbreak with increased speed and precision
2. Determine which illnesses are part of an outbreak and which are not
3. Determine which ingredient in a multi-ingredient food is the source of the outbreak
4. Differentiate sources of contamination, even within the same outbreak
5. Link small numbers of illnesses, including geographically diverse illnesses occurring across multiple states, that might have been identified as a common outbreak

Examples of Produce/Pathogen Combinations Not Previously Associated with Foodborne Outbreaks Until 2006 - 2015

- Bagged spinach (E. coli O157:H7)
- Pasteurized carrot juice (Botulism)
- Peanut butter (Salmonella)
- Puff rice and corn snack food/dried imported vegetable seasoning (Salmonella)
- Peanut paste (Salmonella)
- White and black ground pepper (Salmonella)
- Jalapeno peppers (Salmonella)
- Turkish pine nuts (Salmonella)
- Pistachios (Salmonella)
- Hazelnuts (E. coli O157:H7)
- Bagged organic spinach and Spring mix (E. coli O157:H7)
- Pomegranate seeds (Hepatitis A)
- Bagged salad mix (lettuce, cabbage, carrots) (Cyclospora)
- Caramel apples (Listeria monocytogenes)

Foodborne Disease Outbreaks Attributed to a Single Commodity by Leading Food Vehicles, 2006-2007

<table>
<thead>
<tr>
<th>Year</th>
<th>Rank</th>
<th>Food Vehicle</th>
<th>% of Outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>1</td>
<td>Produce</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Meat</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Fish and Shellfish</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Poultry</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Meat</td>
<td>23</td>
</tr>
<tr>
<td>2007</td>
<td>2</td>
<td>Produce</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Poultry</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Fish and Shellfish</td>
<td>17</td>
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</table>

CDC. MMWR 58: 609-615 (2009)
### Foodborne Disease Outbreaks Attributed to a Single Commodity by Leading Food Vehicles, 2008-2010

<table>
<thead>
<tr>
<th>Year</th>
<th>Rank</th>
<th>Food Vehicle</th>
<th>% of Outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>1</td>
<td>Produce</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Meat</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Poultry</td>
<td>15</td>
</tr>
<tr>
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<td>4</td>
<td>Fish and Shellfish</td>
<td>14</td>
</tr>
<tr>
<td>2009-2010</td>
<td>1</td>
<td>Produce</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Meat</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Fish and Shellfish</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Dairy</td>
<td>12</td>
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CDC, MMWR 60: 1197-1202 (2011)

### Foodborne Disease Outbreaks by Food Category, 2011 and 2012

<table>
<thead>
<tr>
<th>Year</th>
<th>Rank</th>
<th>Food Vehicle</th>
<th>% of Outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>1</td>
<td>Produce</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Fish</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Dairy</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Pork</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Chicken</td>
<td>8</td>
</tr>
<tr>
<td>2012</td>
<td>1</td>
<td>Produce</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Fish</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Dairy</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Chicken</td>
<td>9</td>
</tr>
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</table>

CDC Surveillance of Foodborne Disease Outbreaks, US, 2011 Annual Report
CDC Surveillance of Foodborne Disease Outbreaks, US, 2012 Annual Report

### Foodborne Disease Outbreaks by Food Category, 2013

<table>
<thead>
<tr>
<th>Year</th>
<th>Rank</th>
<th>Food Vehicle</th>
<th>% of Outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>1</td>
<td>Fish</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Produce</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Mollusks</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Dairy</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Chicken</td>
<td>10</td>
</tr>
</tbody>
</table>

CDC SURVEILLANCE OF FOODBORNE DISEASE OUTBREAKS, US 2013 ANNUAL REPORT
**E. coli O157:H7 Outbreak Associated with Pre-packaged Lettuce (Sept - Oct 2005)**

- 25 cases of *E. coli* O157:H7 infection (23 MN, 1 WI, 1 OR)
- Implicated vehicle – Bagged, triple-washed romaine lettuce
  - *E. coli* O157 isolated from two intact bags of lettuce from the implicated lot
**E. coli O157:H7 Outbreak Associated with Bagged Fresh Spinach**  
(Aug – Sept 2006)

- 205 cases of *E. coli* O157 infection in 26 states and Canada  
  - 31 cases of HUS, 103 hospitalizations, 3 deaths
- Implicated vehicle – Bagged fresh spinach (Baby Spinach)  
  - Outbreak *E. coli* O157 strain isolated from 13 bags of baby spinach in 11 states  
  - Grown in Salinas Valley, California

U.S. Food and Drug Administration (Sept 28, 06)  
www.fda.gov/bbs/topics/NEWS/2006/NEW01466.html

**Dole Bagged Salad Listeriosis Outbreak**

- 33 cases of listeriosis in US and 14 cases in Canada between May 2015 – February 2016  
- Linked to Dole processing facility in Springfield, OH  
- OH Dept. of Agriculture isolated *Listeria monocytogenes* from retail package and it matched genetically (WGS & PFGE, CDC PulseNet) the Lm isolates from the patients

CDC January 28, 2016
Examples of Salmonellosis Outbreaks Associated with Cantaloupes

<table>
<thead>
<tr>
<th>Year</th>
<th>Pathogen</th>
<th>Location</th>
<th>No. of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989-90</td>
<td>S. Chester</td>
<td>Multistate</td>
<td>295</td>
</tr>
<tr>
<td>1991</td>
<td>S. Poona</td>
<td>Multistate</td>
<td>&gt; 400</td>
</tr>
<tr>
<td>1997</td>
<td>S. Saphra</td>
<td>California</td>
<td>24</td>
</tr>
<tr>
<td>1998</td>
<td>S. Oranienburg</td>
<td>Canada</td>
<td>22</td>
</tr>
<tr>
<td>2000</td>
<td>S. Poona</td>
<td>Multistate</td>
<td>46</td>
</tr>
<tr>
<td>2001</td>
<td>S. Poona</td>
<td>Multistate</td>
<td>50</td>
</tr>
<tr>
<td>2002</td>
<td>S. Poona</td>
<td>Multistate, Canada</td>
<td>58</td>
</tr>
<tr>
<td>2006</td>
<td>S. Oranienburg</td>
<td>10 States, Canada</td>
<td>41</td>
</tr>
<tr>
<td>2007</td>
<td>S. Litchfield</td>
<td>16 States, Canada</td>
<td>60</td>
</tr>
<tr>
<td>2008</td>
<td>S. Javiana</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>2011</td>
<td>S. Panama</td>
<td>10 States</td>
<td>20</td>
</tr>
<tr>
<td>2011</td>
<td>S. Uganda</td>
<td></td>
<td>25</td>
</tr>
</tbody>
</table>

Cantaloupe-associated Listeriosis Outbreak

- September-November 2011 a total of 146 cases of listeriosis, including 31 deaths and 1 miscarriage, in 28 states; mostly elderly
- Vehicle was Rocky-Ford brand cantaloupes grown by Jensen Farms, Granada, CO
What do these foods have in common?

United States Food Imports

- Approximately 15% of food consumed in USA in 2006 was imported; approx. 17% imported in 2009; ca. 18% imported in 2013
Food Safety News

Majority of FDA-registered food facilities now outside the U.S.

Food Safety News, a breaking news service for everyone’s consumption, reports that in a response it received from FDA under a Freedom of Information Act (FOIA) request, the number of food facilities registered as of January 1, 2016, was 207,655. More than half – 120,822 – are outside of the United States.

All food facilities that manufacture, process, pack or hold food, beverage or dietary supplement for consumption in the U.S. are required to register with FDA. The raw data show 83,875 of them, just less than 40 percent, are in the U.S.

Food Safety News

More than a fourth of FDA import refusals are for fruits, vegetables

Food Safety News, a breaking news service for everyone’s consumption, reports that more than a quarter of all food products currently subject to import refusals by the FDA are fruits and vegetables.

Approximately 1% of all fruits and vegetables entering the country are subject to import refusal, according to the report released Wednesday.

The FDA’s import refusals involve a variety of food products, including fresh salads, juices, and dried fruits and nuts, officials reported. With such a high percentage of items being rejected, FDA doesn’t have enough data to extrapolate these numbers.
### Import Shares (Percentage) of Major Foods Consumer in United States, by selected food categories (2009, 2010)

<table>
<thead>
<tr>
<th>Category</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>9.8</td>
<td></td>
</tr>
<tr>
<td>Lamb</td>
<td>52.4</td>
<td></td>
</tr>
<tr>
<td>Fish (fresh or frozen)</td>
<td>96.4</td>
<td></td>
</tr>
<tr>
<td>Fruits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresh</td>
<td>26.0</td>
<td></td>
</tr>
<tr>
<td>Canned</td>
<td>38.9</td>
<td></td>
</tr>
<tr>
<td>Dried</td>
<td>21.3</td>
<td></td>
</tr>
<tr>
<td>Juices</td>
<td>62.4</td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>28.3</td>
<td></td>
</tr>
<tr>
<td>Apple</td>
<td>85.2</td>
<td></td>
</tr>
</tbody>
</table>

### Import Shares (Percentage) of Major Foods Consumer in United States, by selected food categories (2009, 2010)

<table>
<thead>
<tr>
<th>Category</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree nuts</td>
<td>41.1</td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresh</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>Canned</td>
<td>14.6</td>
<td></td>
</tr>
<tr>
<td>Honey</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Spices</td>
<td>89.9</td>
<td></td>
</tr>
</tbody>
</table>

### USA Total Fruit Imports, 2012

<table>
<thead>
<tr>
<th>Country</th>
<th>Million $</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>3,513</td>
<td>28</td>
</tr>
<tr>
<td>Chile</td>
<td>1,518</td>
<td>12</td>
</tr>
<tr>
<td><strong>China</strong></td>
<td><strong>1,258</strong></td>
<td><strong>10</strong></td>
</tr>
<tr>
<td>Costa Rica</td>
<td>974</td>
<td></td>
</tr>
<tr>
<td>Guatemala</td>
<td>866</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>641</td>
<td></td>
</tr>
<tr>
<td>Ecuador</td>
<td>526</td>
<td></td>
</tr>
<tr>
<td><strong>Thailand</strong></td>
<td><strong>389</strong></td>
<td></td>
</tr>
<tr>
<td><strong>World Total</strong></td>
<td><strong>12,559</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

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[www.fas.usda.gov/gats](http://www.fas.usda.gov/gats)

# USA Total Vegetables (Fresh, Frozen, Dried, and Prepared) Imports, 2012

<table>
<thead>
<tr>
<th>Country</th>
<th>Million $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>4,761</td>
</tr>
<tr>
<td>Canada</td>
<td>2,119</td>
</tr>
<tr>
<td>China</td>
<td>538</td>
</tr>
<tr>
<td>Peru</td>
<td>515</td>
</tr>
<tr>
<td>Spain</td>
<td>267</td>
</tr>
<tr>
<td>India</td>
<td>258</td>
</tr>
<tr>
<td>World Total</td>
<td>9,797</td>
</tr>
</tbody>
</table>

www.ers.usda.gov/data-products/us-food-imports.aspx#UVw9KLwvw1
### Share of U.S. Consumption of Selected Fresh Vegetables and Melons from Imports

<table>
<thead>
<tr>
<th>Produce</th>
<th>1980 (Percent imported)</th>
<th>1990 (Percent imported)</th>
<th>2000 (Percent imported)</th>
<th>2007 (Percent imported)</th>
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</thead>
<tbody>
<tr>
<td>Asparagus</td>
<td>10.8</td>
<td>29.8</td>
<td>58.3</td>
<td>77.9</td>
</tr>
<tr>
<td>Bell Peppers</td>
<td>26.5</td>
<td>19.7</td>
<td>22.2</td>
<td>35.6</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>22.3</td>
<td>20.5</td>
<td>31.6</td>
<td>38.5</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>38.0</td>
<td>33.7</td>
<td>42.6</td>
<td>53.1</td>
</tr>
<tr>
<td>Artichokes</td>
<td>20.6</td>
<td>25.7</td>
<td>47.9</td>
<td>75.3</td>
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<tr>
<td>Eggplant</td>
<td>33.9</td>
<td>36.0</td>
<td>37.7</td>
<td>42.0</td>
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<tr>
<td>Garlic</td>
<td>12.5</td>
<td>17.4</td>
<td>29.0</td>
<td>55.5</td>
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<tr>
<td>Squash</td>
<td>16.5</td>
<td>21.9</td>
<td>30.7</td>
<td>42.0</td>
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<tr>
<td>Cantaloupe</td>
<td>12.8</td>
<td>23.0</td>
<td>35.6</td>
<td>34.0</td>
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<tr>
<td>Honeydews</td>
<td>8.2</td>
<td>22.3</td>
<td>27.3</td>
<td>39.3</td>
</tr>
<tr>
<td>All Fresh</td>
<td>8.3</td>
<td>10.1</td>
<td>14.1</td>
<td>18.6</td>
</tr>
</tbody>
</table>

USDA-ERS, Vegetables and Melons Yearbook 2008

### Microbiological Safety Issues Associated with Imported Foods

- **Sanitation practices** for food production and preparation are not universally equivalent throughout the world
- Importing foods can **move pathogens** from areas where pathogen is indigenous to locations where it seldom or does not exist
  - Example, *Cyclospora* in raspberries from Guatemala to U.S. and Canada

### Examples of Food Safety Concerns Associated with Imported Produce

- Centuries old tradition of using **human excreta on farmland** is widespread in east Asia, especially in China and Vietnam
- **Irrigation water** contaminated with **untreated human and animal fecal waste**
- **Insanitary harvesting practices** of importing countries
  - Children infected with norovirus or hepatitis A accompany parents in produce field during harvest
Food Safety Issues Associated with Aquaculture

Aquaculture Production

- Aquaculture is the fastest growing form of food animal protein in the world.
- Asia accounts for 89% of global aquaculture production.
  - China alone is 62%.
- USA imports greater than 90% of its seafood, about half is from aquaculture.
- Most aquaculture imports are shrimp, then salmon, tilapia (mostly China), and shellfish (Scallops (mostly China), mussels, clams, and oysters (mostly China)).


USA Total Fish and Shellfish Imports, 2012

<table>
<thead>
<tr>
<th>Country</th>
<th>Million $</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>2,633</td>
</tr>
<tr>
<td>Canada</td>
<td>2,484</td>
</tr>
<tr>
<td>Thailand</td>
<td>2,024</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1,287</td>
</tr>
<tr>
<td>Vietnam</td>
<td>1,018</td>
</tr>
<tr>
<td>World Total</td>
<td>13,912</td>
</tr>
</tbody>
</table>

Primary Types & Sources of U.S. Imported Fish and Seafood in 2014

- **Shrimp**: ca. 1.25 billion pounds
  - Thailand, Ecuador, Indonesia, China, Vietnam, India
- **Salmon**: 658 million pounds
  - Canada and Chile account for ca. 90% of all Atlantic salmon imports
- **Tilapia**: 509 million pounds
  - China, Taiwan, Ecuador

USDA, ERS, 2015

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U.S. Fish and Shellfish Import Trends

- Gains in seafood production will primarily come from farmed fish
  - **Aquaculture** accounted for 12% in 1984 and 50% in 2009; predicted 62% in 2030
- **Tilapia** consumption approaching salmon consumption in USA
  - ca. 75% of tilapia was imported from China in 2014

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Fecal Waste Used in Aquaculture Production

- Raw domestic sewage and/or livestock manure are frequently used in fish farming in many Asian countries
  - Estimates at least two-thirds of the world production of farmed fish is grown in ponds fertilized with animal manure or human sewage
  - ca. 50% of fish and seafood is raised in ponds
Chicken/Shrimp Farming in Thailand

- Chicken/shrimp farming is only means of income for many small stakeholders
- Chicken coops (e.g., 20,000 birds/farm) sit in rows suspended over ponds that hold shrimp
- Fecal waste from chickens is primary nutrients for pond flora on which shrimp feed

BBC News, January 27, 2004
Examples of Prevalence of Salmonella in Seafood and Fish

<table>
<thead>
<tr>
<th>Species</th>
<th>Country of Origin</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seafood</td>
<td>Raw Imported (FDA surveillance; 1990-98)</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Raw Domestic (USA) (FDA surveillance; 1990-98)</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>RTE Imported (e.g., cooked shrimp; 1990-98)</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>Vietnam (1990-98)</td>
<td>30</td>
</tr>
<tr>
<td>Shrimp</td>
<td>Vietnam (2005)</td>
<td>24.5</td>
</tr>
<tr>
<td></td>
<td>India (2003-2007)</td>
<td>5 - 9</td>
</tr>
<tr>
<td>Fish</td>
<td>Raw Imported (FDA surveillance; 1990-98)</td>
<td>12.2</td>
</tr>
</tbody>
</table>


Antibiotic Contaminants from Vietnamese Shrimp Farming

- Ciprofloxacin (500 mg) and oxytetracycline are used extensively (almost 100%) in Vietnamese shrimp farming to kill or inhibit the growth of shrimp disease-causing bacteria (e.g., Vibrio, Pseudomonas, Aeromonas) during shrimp larval rearing
  - Extensive use of antibiotics has led to high levels of residues in shrimp ponds and the surrounding environment, with the resulting proliferation of drug-resistant bacteria

Multidrug-resistant *Salmonella* in China

- “Multidrug-resistant *Salmonella* of animal origin constitute an even more serious problem in China than in developed countries of the world.”
- “Findings . . . indicate that multidrug-resistant *Salmonella* now contaminate 67% of domestic animals in China, with some strains resistant to 17 different antimicrobial agents.”
  - Lu et al. Foodborne Pathogens and Disease 8:45-53 (2011)

Antibiotic-resistant Microbes in China

- “The situation with respect to overuse of antibiotics and antibiotic resistance in China is severe.”
- “China has the world’s most rapid growth rate of resistance” (22% average growth in a study spanning 1994 to 2000)
Antibiotic Livestock Use Growing Substantially Outside the U.S.

Antibiotic Resistance Issue

- Many critical antibiotics for human therapy are becoming less effective/useful
- Need to restrict use, but prudently
- Complex problem with no simple solution(s); solutions are complex
  - Ban of their use in agriculture has led to some unintended adverse consequences
- Global problem that cannot be solved by USA and/or EU alone; need global commitment and involvement
  - Global travel
  - Food imports
The New York Times  By GARDNER HARRIS DEC. 3, 2014

© Kuni Takahashi for The New York Times  A mother nursing her newborn at a hospital in Haryana, where almost every baby born in hospitals in recent years has been injected with antibiotics.

Food Safety Chemical Issues Associated with Foods Produced in China

- Farmers rely on heavy use of chemicals to deal with pest pressures, and antibiotics are widely used to control disease in livestock, poultry and aquaculture
  - Use many highly toxic pesticides, including some that are banned in the USA
  - Farm chemicals are sometimes mislabeled and inappropriately used
  - Some farmers have little understanding of correct chemical use, resulting in excessive residues in harvested product

USDA-ERS  www.ers.usda.gov/AmberWaves/November08/Features/FoodSafety.htm

Food Safety Chemical/Microbiological Issues Associated with Foods Produced in China

- Industrialization and lax environment controls contribute to heavy metal contamination of foods
- Untreated human and animal wastes are applied to fields directly and through contaminated irrigation water

USDA-ERS  www.ers.usda.gov/AmberWaves/November08/Features/FoodSafety.htm
China’s Farmland Puts Consumers At Risk

- 19.4% of China’s farmland is contaminated with heavy metals, including mercury, lead, cadmium, arsenic and nickel
- Mining and industrial wastes are primary sources
- 16.1% of all of China’s soils are contaminated
- In April 2013 discovered unusually large amounts of cadmium in rice grown in Hunan

Chemophobia/"Natural Foods" and the Blogosphere

- Consumer movement, initially in Europe, to remove food additives/"chemicals" from foods
  - Using "blogosphere" to communicate, which includes misinformation that is not grounded in science-based data
- "Processed foods" are a target
  - Marion Nestle's (New York University) definition of "processed foods" is based on number of food additives, especially those with esoteric names
Chemophobia/"Natural Foods"

- Can have adverse public health consequences
  - Remove benzoate from foods
    - Pressure from retailers on food manufacturers to remove benzoate from processed foods
    - Benzoic acid is a naturally-occurring antimicrobial in cranberries, blackberries, apricots, cherries, plums, cinnamon, cloves, coffee beans, honey

Chemophobia/"Natural Foods"

- Significance of removing benzoate
  - Frequently used in foods (e.g., beverages, dairy-based fillings in baked goods) to control molds and yeasts
  - Can also inhibit growth of foodborne bacterial pathogens such as *Staphylococcus aureus* and *Listeria monocytogenes*

Chemophobia/"Natural Foods"

- Next to be removed from foods is sorbate (naturally occurring in certain berries such as European mountain ash berries)
- Significance of removing sorbate
  - Frequently used in foods to control molds and yeasts
  - Can also inhibit growth of foodborne bacterial pathogens such as * Clostridium botulinum* (e.g., process cheese) and is bactericidal to *Salmonella*
Chemophobia/Preservative-free Foods

- Recent recalls or consumer complaints of **preservative-free** foods
  - Organic baby food (microbial spoilage)
  - String cheese (microbial spoilage)
  - Yogurt (microbial spoilage)
  - UHT-packaged juice-like beverage (microbial spoilage)
“Natural” Bacon

Kraft Heinz Recalls Oscar Mayer Turkey Bacon for Possible Salmonella Concerns

FOX NEWS

Gerber recalls food pouches which may be spoiled

The company is voluntarily recalling three lots of Gerber Baby Cereals due to possible salmonella contamination. The affected products were distributed nationwide in stores.

Gerber has not received any reports of illness associated with these products. If you have purchased these products, please do not consume them and return them to the store for a refund.

The affected lots are:
- Lot 1: Best by date of June 12, 2016
- Lot 2: Best by date of July 12, 2016
- Lot 3: Best by date of July 14, 2016

The recall is being conducted in cooperation with the Food and Drug Administration. If you have any questions, please contact Gerber at 1-800-985-0050.
Chemophobia/"Natural Foods"

- **Learnings**
  - Removing certain food preservatives can have **unintended consequences** with regard to the **microbiological safety** of a product
  - Can substantially **reduce shelf life** of many foods
  - Will undoubtedly lead to increased **food waste**
  - Base use of microbial inhibitors on **public health implications and sound science**
Some Industry Challenges in Implementing Food Safety Modernization Act Rules

- Developing and applying relevant, useful food safety plans
- Adopting advanced food safety interventions
- Validating food safety interventions/control points

Industry Challenges in Providing Safe Foods

- Whole genome sequencing of foodborne pathogens is revolutionizing outbreak detection and traceback globally
  ▲ Will likely be more outbreaks detected with small numbers of cases (3-10)
  ▲ Average number of cases in listeriosis outbreaks is now 3
  ▲ More companies and specific food vehicles will be identified; processing food facilities will be WGS fingerprint profiled
  ▲ Pathogens obtained from retail food samples will implicate food processors in foodborne outbreaks

Industry Challenges in Providing Safe Foods

- Need for “bullet-proofing” fresh produce from foodborne pathogen contamination
  ▲ Produce is a leading vehicle of foodborne illness, with fresh-cut leafy greens and melons of particular concern
  ▲ Cantaloupe is prone to pathogen contamination, and many commonly used sanitizers are not fully effective in mitigating pathogen contamination, especially at the stem scar
Industry Challenges in Providing Safe Foods

- **Aquaculture farming** will become a dominant global food production practice.
  - Excessive use of **antimicrobials** critical to human therapy for disease control and use of raw animal manure and human feces as primary nutrient source has global ramifications regarding antimicrobial-resistant microbes and pathogen contamination.

Industry Challenges in Providing Safe Foods

- **Unintended consumer uses of foods** will continue to increase with growing consumer interest in raw or undercooked, natural (no preservatives) foods that can be prepared quickly. This is being accelerated by the use of social media disseminating misinformation.

Industry Challenges in Providing Safe Foods

- **“Natural” foods** that do not contain antimicrobial preservatives may be a disaster in the making, depending on the food’s ability to support the growth of pathogens and spoilage microbes and storage temperature and time
  - Consumer abuse is unavoidable