What can the almond industry learn from recent outbreaks of *E. coli* gastroenteritis in flour and nut butters?

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Outline

- Overview of foodborne illnesses with low moisture foods
- Recalls
- Outbreaks
- What do we know in almonds
  - Prevalence
  - Survival during storage
  - Desiccation tolerance
  - Thermal tolerance
**Salmonella - salmonellosis**

- **Infectious dose**
  - Low (dependent)
- **Incubation period**
  - 12 to 72 hours
- **Symptoms**
  - Diarrhea, fever, abdominal cramps, vomiting
  - Death can occur with infants and elderly/sick
- **Duration**
  - 4 to 7 days
- **Long-term impacts**
  - Reactive arthritis

**Listeria monocytogenes (LM) - listeriosis (one type of illness)**

- **Infectious dose**
  - Maybe thousands, dependent
- **Incubation period**
  - 3 to 70 days
- **Symptoms**
  - Fever, stiff neck, confusion, weakness, vomiting, sometimes preceded by diarrhea
  - Death can occur (pregnant women lose baby), elderly, weakened immune systems
- **Duration**
  - Days to weeks
- **Long-term impacts**
  - A Listeria infection can lead to meningitis, an inflammation of the membranes surrounding the brain
Enterohemorrhagic *E. coli* gastroenteritis - (EHEC or STEC)

- **Infectious dose**
  - Low (dependent)
- **Incubation period**
  - 1 to 10 days
- **Symptoms**
  - Severe diarrhea, often bloody, severe abdominal pain, vomiting
    - Hemolytic uremic syndrome (HUS) – 5 to 10%
    - Toxins destroy red blood cells and damage kidneys
  - Death can occur with young children and elderly
- **Duration**
  - 5 to 10 days
  - HUS can happen after a week
- **Long-term impacts**
  - HUS can lead to severe outcomes including need for kidney transplant, multi-organ damage

Hazard Analysis

- **Must be written**
  - Prepared or preparation overseen by qualified individual
- **Must identify and evaluate:**
  - Known or reasonably foreseeable hazards for each type of food
  - Based on experience, illness data, scientific reports, and other information
- **Determine whether there are any hazards requiring a preventive control.**
Severity and probability in the absence of preventive controls

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Severity</th>
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<tbody>
<tr>
<td>Low</td>
<td>Low</td>
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<tr>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>GMP</td>
</tr>
<tr>
<td>Low</td>
<td>GMP</td>
</tr>
</tbody>
</table>
Recalls U.S.

- \textit{Salmonella}
- \textit{E. coli O157:H7}
- \textit{Listeria monocytogenes}
  - Mixed products with almonds (2017)


Salmonellosis – tree nuts

- Almonds – raw (U.S. source)
  - 2000-01, Canada/U.S.
  - 2003-04, U.S./Canada
  - 2006, Sweden
- Almonds - raw (Australia source)
  - 2012, Australia
- Hazelnuts (inshell, U.S.)
  - 2016
- Pine nuts - raw (Turkey)
  - 2011, U.S.
- Pistachios - raw and roasted? (U.S.)
  - 2009 (1 case), 2013, 2016
Salmonellosis
Nut butters and other products

- Peanuts
  - 94-95, 01, 06 (boiled – GA), 10
- Cashew cheese – raw (SE Asia)
  - 2013, U.S.
- Peanut butter
  - 1996 (Australia)
  - 2006-07*, 09*, 12, 14 (U.S. source)
- Peanut/almond butter
  - 2014 (U.S.)
- Sprouted tree nut spreads
  - 2015 (U.S.)

Enterohemorrhagic E. coli O157:H7 gastroenteritis

- Inshell hazelnuts (U.S.)
  - 2011, US/Canada
- Walnuts – raw (U.S.)
  - 2011, Canada (linked)

Harris, L. J., M. Palumbo, L. R. Beuchat, and M. D. Danyluk. 2017. Outbreaks of foodborne illness associated with the consumption of tree nuts, peanuts, and sesame seeds [table and references]. In Outbreaks from tree nuts, peanuts, and sesame seeds. Available at: http://ucfoodsafety.ucdavis.edu/Nuts_and_Nut_Pastes.
Enterohemorrhagic *E. coli* O157:H7 gastroenteritis

- Rice cake (2011, Japan)
  - Contamination during manufacturing most likely

- Soy nut butter (2017, U.S.)
  - Contamination at co-packer (Dixie Dew) suspected
    - Registration suspended March 27 at Dixie Dew
  - 483 inspection report – must read
  - 32 cases 12 states
  - 12 people hospitalized, 9 HUS
  - 26 under 18 years old

To find 483 Google: “Dixie Dew 483 FDA”
To find suspension Google: “Dixie Dew Suspension FDA”
Flour

- 2008-2009 New Zealand
  - *Salmonella Typhimurium*
    - 67 cases
- 2009 U.S., 31 states
  - Enterohemorrhagic *E. coli O157:H7* gastroenteritis
    - 80 cases, raw cookie dough (flour implicated)
  - Enterohemorrhagic *E. coli O121/O26* gastroenteritis
    - 63 cases
- 2016 – 2017 AND 2017 Canada
  - Enterohemorrhagic *E. coli O121* gastroenteritis
    - 30 AND 6 cases

Special case: seed sprouts

- Numerous significant outbreaks worldwide early 1990s to present
  - *Salmonella, E. coli O157:H7, E. coli O104:H4*
- Sprouted seeds are high moisture food
  - Source: the seed
    - e.g., alfalfa, clover, fenugreek, radish
    - “Chia” – 2014 (also flour)
- Extended pathogen survival in the low-moisture seeds
- Sprouting enriches for the pathogen
How many undetected outbreaks?  

- Common serovar of *Salmonella*
- Smaller number of unclustered cases
- Geographically disperse
- Temporally separated
- Contaminated ingredient

Isaacs et al., 2005. JFP

Advances in Detection Methodology

**PulseNet** connects the dots to detect foodborne outbreaks and prevent over 270,000 illnesses from *Salmonella*, *E. coli* and *Listeria* every year.
What do we know?

**E. coli O157:H7 – survey data**

- **California Almonds 2013**
  - 977 samples of 375 g
  - NONE POSITIVE
  - Unpublished

- **California Inshell Walnuts 2011, 2012, 2013**
  - 3,839 samples of 375 g
  - NONE POSITIVE
  - Davidson et al., 2015

Survival of *Salmonella, E. coli O157:H7*, and *L. monocytogenes* on stored almonds

*Salmonella* survives as well or better


Survival of *Salmonella, E. coli O157:H7*, and *L. monocytogenes* on stored pistachios

*Salmonella* survives as well or better

Kimber et al., 2012
**E. coli O157:H7 and L. monocytogenes Isolates used in thermal resistance studies**

<table>
<thead>
<tr>
<th>Strain</th>
<th>Comment</th>
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<tbody>
<tr>
<td><em>Enterococcus faecium</em> NRRL 2354</td>
<td>Surrogate for Process Validation</td>
</tr>
<tr>
<td><em>Salmonella Enteritidis</em> PT 30</td>
<td>2001 Raw Almond Outbreak</td>
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<tr>
<td><em>E. coli</em> O157:H7 LJH557</td>
<td>Apple cider outbreak, clinical</td>
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<tr>
<td><em>E. coli</em> O157:H7 LJH643</td>
<td>Cantaloupe outbreak, clinical</td>
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<tr>
<td><em>E. coli</em> O157:H7 LJH1186</td>
<td>Spinach outbreak, clinical</td>
</tr>
<tr>
<td><em>E. coli</em> O157:H7 LJH1357</td>
<td>Cookie dough outbreak, food isolate</td>
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<tr>
<td><em>E. coli</em> O157:H7 PT 4 LJH1380</td>
<td>Walnut outbreak, clinical</td>
</tr>
<tr>
<td><em>L. monocytogenes</em> (4b) LJH512</td>
<td>Cabbage outbreak, food isolate</td>
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<tr>
<td><em>L. monocytogenes</em> (4b) LJH552</td>
<td>Tomatoes</td>
</tr>
<tr>
<td><em>L. monocytogenes</em> LJH1422</td>
<td>Raw diced yellow onions, recall</td>
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<tr>
<td><em>L. monocytogenes</em> LJH1424</td>
<td>Celery processing facility</td>
</tr>
<tr>
<td><em>L. monocytogenes</em> PTVS 308</td>
<td>Cantaloupe outbreak, food isolate</td>
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</tbody>
</table>

**Post-inoculation drying and equilibration**

(3 days at 23°C + 2 days at 45% RH and 25°C)

![Graph showing reduction in Log CFU/g](image)
Screening:
Hot oil (250°F/121°C for 1 min; n = 3); Initial a_w: 0.48 ± 0.01

Reduction of *E. coli* O157:H7 1380
Listeria monocytogenes 1422 and *Salmonella* Enteritidis PT30
on almonds: water at 176°F
*Salmonella* survives as well or better

Harris, unpublished
Reduction of *E. coli O157:H7* 1380, *Listeria monocytogenes* 1422 and *Salmonella Enteritidis* PT30 on almonds: oil at 250°C

*Salmonella* survives as well or better

![Graph showing log N/N₀ vs. treatment time (min)]

Harris, unpublished

Resources
www.ucfoodsafety.ucdavis.edu/Low_Moisture_Foods/

Low Moisture Foods

Grocery Manufacturer's Association (GMA)

The grocery manufacturer's association plays an active role in developing and promoting comprehensive food safety initiatives for the food industry and provides support to the industry with regard to compliance with federal, state and local regulations. The following documents were generated in partnership with the food industry:

- Facility Design Checklist (will open as MS Excel spreadsheet.)
- GMA Equipment Design Checklist for Low Moisture Foods (will open as MS Excel spreadsheet.)
- *Salmonella Control Guidance* (PDF 540 KB)
- *Anthrax in Salmonella Guidelines* (PDF 201 KB)
- Technical Guidance and Tools
- Guidelines for Validation of Consumer Cooking Instructions for Not-Ready-to-Eat (NRE) Products

Cereals and Grains
Summary

- Foodborne illness in low moisture foods
  - Dominated by Salmonella
  - Increasingly associated with EHEC/STEC
  - Recalls associated with L. monocytogenes
- In almonds
  - Prevalence of E. coli O157:H7 appears to be low
  - E. coli O157:H7 and L. monocytogenes
    - Survival appears to be less than Salmonella
    - Thermal tolerance appears to be no more than Salmonella
- Copy of 2015 IAFP poster will be made available through ABC