Risk Assessment Modeling of \textit{Salmonella} in Almonds

Michelle D. Danyluk

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Danyluk, Harris, and Schaffner, 2006. \textit{JFP} 69:1594-1599
Objectives

1. Estimate the risk of salmonellosis from consumption of raw almonds in the U.S.

2. Evaluate the reduction of salmonellosis after application of process with different levels of process control
Almond Process Flow Diagram

Positive Orchards

Almond Orchard

Harvest

Stockpiles

Huller/Sheller

Handler

Storage

Processing/ Packaging

Reduction of *Salmonella* over time at different temperatures

Reduction treatments (PPO)

Reduction of *Salmonella* over time at different temperatures

Reduction of *Salmonella* over time at different temperatures

Dose response model

Retail

Consumer

*Salmonella* concentrations and frequencies on kernels leaving Huller/Sheller
100% of 46 isolates are *Salmonella* Enteritidis PT 30
**Salmonella concentrations and frequencies on kernels leaving Huller/Sheller**

Survey of Almonds from Huller/Sheller (100 g)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number Positive</th>
<th>% Positive</th>
<th>MPN/100 g</th>
<th>Number MPN &gt;1.2 /100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>42 of 50</td>
<td>84</td>
<td>6.1 – 9.6</td>
<td>4 of 4</td>
</tr>
<tr>
<td>2001</td>
<td>12 of 2003</td>
<td>0.60</td>
<td>Not done</td>
<td>Not done</td>
</tr>
<tr>
<td>2002</td>
<td>24 of 2012</td>
<td>1.2</td>
<td>&lt;1.2 - 2.9</td>
<td>1 of 24</td>
</tr>
<tr>
<td>2003</td>
<td>15 of 1764</td>
<td>0.80</td>
<td>&lt;1.2 - 1.4</td>
<td>3 of 15</td>
</tr>
<tr>
<td>2004</td>
<td>12 of 1643</td>
<td>0.73</td>
<td>&lt;1.2 - 1.4</td>
<td>1 of 12</td>
</tr>
<tr>
<td>2005</td>
<td>18 of 1852</td>
<td>0.97</td>
<td>&lt;1.2 - 1.4</td>
<td>1 of 18</td>
</tr>
</tbody>
</table>

Average 0.87% positive samples per year

Danyluk, Jones, Abd, Schlitt-Dittrich, Jacobs and Harris, *Submitted JFP 08/06*
Reduction of *Salmonella* over time at different temperatures

Calculated reduction is:
- **23°C**: 0.25 log CFU/month
- **4°C**: 0 log CFU/month
- **-20°C**: 0 log CFU/month

Reduction treatments (PPO)

PPO represents a “real world” treatment, that is not a uniform distribution and has a relatively high standard deviation.

Distribution of *Salmonella* Enteritidis PT 30 reduction on almonds following treatment with propylene oxide. Adapted from Danyluk et al. 2005.
Dose response model

• In order to predict disease, a dose response model (β-Poisson distribution) from FAO/WHO (2002) for *Salmonella* was used to predict the probability of illness.

Almond Process Flow Diagram

- **Almond Orchard**
- **Harvest**
- **Stockpiles**
- **Huller/Sheller**
  - **Handler**
  - **Storage**
    - **Processing/ Packaging**
    - **Storage**
      - **Retail**
      - **Consumer**

*Positive Fields*

*Salmonella* concentrations and frequencies on kernels leaving Huller/Sheller

Reduction of *Salmonella* over time at different temperatures

Reduction treatments (PPO)

Reduction of *Salmonella* over time at different temperatures

Dose response model

Reduction of *Salmonella* over time at different temperatures

Included in Risk Assessment
Salmonella concentrations and frequencies on kernels leaving Huller/Sheller

Amount of almonds consumed raw

Reduction of Salmonella over time at different temperatures

Time and temperature of storage

Reduction treatments (PPO)

Time and temperature of storage

Reduction of Salmonella over time at different temperatures

Time and temperature of storage

Reduction of Salmonella over time at different temperatures

Serving size

Time and temperature of storage

Reduction of Salmonella over time at different temperatures

Consumer

Retail

Storage

Processing/ Packaging

Storage

Handler

Huller/Sheller
Model

Initial level of *Salmonella* -

Estimated Reduction =

\[
\text{Pre-process} + \text{Process} + \text{Post-process} + \text{Retail} + \text{Consumer}
\]

= *Salmonella concentration per serving* \(X\) Dose Response model

= Probability of illness per serving \(X\) Servings consumed containing *Salmonella* spp.

= Predicted illness per year

US Consumption of raw almonds (28-g servings)

\(X\)

Positive subsamples

= Servings consumed containing *Salmonella* spp.
Salmonella concentrations and frequencies on kernels leaving Huller/Sheller

Reduction of Salmonella over time at different temperatures

Reduction treatments (PPO)

Reduction of Salmonella over time at different temperatures

Dose response model

Reduction of Salmonella over time at different temperatures

Dose response model

Farming Practices? Weather?

Correlation of field positive to stockpile positives?

Correlation of stockpile positives to kernel of positives?

Dose response model more applicable to dry foods?

Included in Risk Assessment

Almond Process Flow Diagram

Almond Orchard

Positive Fields

Farming Practices? Weather?

Stockpiles

Handler

Storage

Processing/ Packaging

Alternate treatments?

Retail

Consumer

Almond Orchard

Harvest

Stockpiles

Huller/Sheller

Handler

Storage

Processing/ Packaging

Alternate treatments?

Retail

Consumer