Pathogens of Concerns in Aquaponics Systems

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But Aquaponics Products are Safe, Right?
Market Impacts of Foodborne Disease Outbreaks:

Rocky Road Ahead for Cantaloupe After Listeria Outbreak

By HELENA BOTTEMILLER | NOVEMBER 15, 2011

Cantaloupe Prices Drop As Production Ramps Up

By CBSNEWS / CBS/AP / June 10, 2008, 7:16 PM

Tomato Industry Threatened By Outbreak
<table>
<thead>
<tr>
<th>Food Category</th>
<th>Salmonella (N=597)</th>
<th>E. coli O157 (N=170)</th>
<th>Campy (N=161)</th>
<th>Lm (N=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
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<td>Pork</td>
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<td>Chicken</td>
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<td>Turkey</td>
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<td>Other meat &amp; poultry</td>
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<td>Game</td>
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<td>Dairy</td>
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<td>Eggs</td>
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<td>Fish</td>
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<td>Other seafood</td>
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<td>Grains-beans</td>
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<td>Oils-sugars</td>
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<tr>
<td>Fruits</td>
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<tr>
<td>Seeded vegetables</td>
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<tr>
<td>Sprouts</td>
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<tr>
<td>Vegetable row crops</td>
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<tr>
<td>Other produce</td>
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</tbody>
</table>

Model-estimated attribution percentages

IFSAC (2015)
Leafy vegetables
Dairy
Nuts & Fruits
Poultry
Vine vegetables
Beef
Eggs
Pork
Grains & Beans
Root Vegetables
Mollusks
Fish
Oils & Sugars
Crustaceans
Sprouts
Game
Mushrooms

Painter et al. (2013)
Why is Produce Tricky?

- Raw
- Wrinkly
- Sticky
Unanswered Questions Involving Food Safety:

Can food-borne pathogens survive (and grow) in an aquaponics system?

- Warm water
- Food sources
- Lots of biofilms
- No “kill step” with produce
Unanswered Questions Involving Food Safety:

Is fish waste “safer”?

= *E. coli* O157:H7

= *Salmonella* spp.

= ???
What’s Growing Where?
Biologic Filter
General Schematic
Sediment Removal
Mechanical Filtration
Plants in soil-less media
Biologic Filter
Sediment Removal
Total Bacteria Counts at different sites in an Aquaponics System: cells / mL (cells / gram)
So how does bacteria get on leaves?

- Hands
- Aerosols
- Direct water contact
- Internalization (???)
Representative LSCM optical thin section of a lettuce seedling contaminated with E. coli O157:H7/pGFP.

Biofilms - The Problem of Being Sticky

- *Listeria*
- *Salmonella*
- *Aeromonas*
Biofilms Basics

Used with Permission from the Center for Biofilm Engineering.
What Should We Be Concerned About?
Qualitative Risk Assessments

“Risk Ranger”:
The Cast of Characters

- *Listeria monocytogenes*
  - Associated with water and biofilms
  - Grows at refrigerator temperatures
  - Pregnant women and immunocompromised at greatest risk
The Cast of Characters

- *Salmonella* spp.
  - Very common in wild birds and rodents
  - Can contaminate feed
  - Can persist in water or wet, cool environments for months
  - Small infectious dose, nearly everyone is at risk
The Cast of Characters

- Aeromonas hydrophilia
  - Fish and water associated
  - Probably high infectious dose
  - Immunocompromised people may be at risk
The Cast of Characters

- *Vibrio spp.*
  - 3 different species including cholera
- Aquatic bacteria
- Often associated with shellfish
A few non-bacteria...

- **Cryptosporidium**
  - Calves (or people)

- **Cyclospora**
  - Mexican raspberries

- **Giardia**
  - Person - water - person
What is Food Safety Risk?

Can we measure it?
Quantitative Risk Assessments:

FDA-iRISK® 2.0

Salmonella
Listeria
Aeromonas

IN
Aquaponics Lettuce
Aquaponics Basil
Testing Mitigations:

- Good Agricultural Practices at harvest
- UV Disinfection on water entering plants
- Others?
A Few Key Assumptions:

- Population of Minnesota
- $\frac{1}{10}$th of the lettuce and basil people consume is produced aquaponically
Salmonella illnesses

**Lettuce**
- Baseline: 30,000
- UV: 27,000
- GAP: 4,000
- UV & GAP: 4,000

**Basil**
- Baseline: 200
- UV: 200
- GAP: 0
- UV & GAP: 0
Aeromonas illnesses

Lettuce

Baseline UV GAP UV & GAP
Listeria illnesses

![Bar chart showing Lettuce levels for Baseline, UV, GAP, and UV & GAP]
Quantitative Risk Assessment

- Lettuce is a higher risk commodity than Basil
- Best mitigations for common pathogens (Aeromonas) may be different than rare pathogens (Salmonella)
- Don’t count out Salmonella!
- Listeria is a constant threat
A Brief Word on Other Hazards

- Antibiotic and chemical residues
  - Drugs in food animals strictly regulated by the FDA
  - Protocols in other countries may or may not be approved in the U.S.
  - Depends on species and indication
  - Withdrawal times on fish are temperature dependent!

http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/Aquaculture/ucm132954.htm
http://www.fda.gov/AnimalVeterinary/ResourcesforYou/AnimalHealthLiteracy/ucm213944.htm
Aquaponics Biosecurity

- Fish pathogens
  - All in – All out
  - Quarantine
- Plant pathogens
- Human pathogens
  - Feed source
  - Water sources
  - Rodents / Birds
  - Good Agricultural Practices
References:


