IAFP’s Foundations of Produce Safety in Hydroponic and Aquaponic Operations

Organized by: The Fruit and Vegetable Safety and Quality PDG

Moderator: Gretchen Wall, International Fresh Produce Association Chair of the Fruit and Vegetable Safety and Quality PDG

Sponsored by the IAFP Foundation

Please consider making a contribution

This webinar is being recorded and will be available to IAFP members within one week.
Webinar Housekeeping

• It is important to note that all opinions and statements are those of the individual making the presentation and not necessarily the opinion or view of IAFP.

• All attendees are muted. Questions should be submitted to the presenters during the presentation via the Questions section at the right of the screen. Questions will be answered at the end of the presentations.

• This webinar is being recorded and will be available for access by IAFP members at www.foodprotection.org within one week.
IAFP Fruit & Vegetable Safety & Quality PDG Updates

• Elections for Vice Chair – coming soon!
  • Nominations can be sent to Gretchen (gwall@freshproduce.com)

• IAFP Pittsburgh, PA – FVSQ PDG Meeting
  • Sunday, July 31, 2022 from 1-3 PM ET in Room 406
  • Development of annual PDG meeting agenda – send your ideas to Gretchen (gwall@freshproduce.com) or Kristin (Kristin.Esch@fda.hhs.gov)

• Other ideas, announcements, opportunities for learning?
  • Feel free to share directly via IAFP Connect or send to Gretchen/Kristin to share with group
Gretchen Wall, M.S.
Chair of Food Safety Education PDG
Director, Food Safety & Quality International Fresh Produce Association

Gretchen is the Director of Food Safety and Quality at the International Fresh Produce Association (IFPA) which was created from the transformation of the legacy associations Produce Marketing Association (PMA) and United Fresh Produce Association (United Fresh). She supports IFPA members and industry stakeholders by providing technical support, educational opportunities, and science-based information on all aspects of product safety and quality from farm to fork.

Gretchen’s background in food science and food safety enables her to assist a wide variety of food producers as they navigate complex regulatory requirements and market demands. Her background in education and extension at Cornell University’s Produce Safety Alliance allows her to guide growers and packers toward practical and achievable food safety outcomes, foster long-term business viability, and work towards achieving public health goals.

Gretchen earned her M.S. in Interdisciplinary Studies in Food Science and Safety at Colorado State University and her B.S. in Food Science at The Pennsylvania State University. She is the current Chair of the International Association of Food Protection’s (IAFP) Fruit and Vegetable Safety and Quality Professional Development Group and a Provisional Subject Matter Expert for the Center for Produce Safety (CPS) Technical Committee.
Today’s Panelist

Sean Fogarty, Research Specialist
Northeast Center to Advance Food Safety (NECAFS)

Sean Fogarty is a Research Specialist at the Northeast Center to Advance Food Safety (NECAFS), which is a regional food safety hub based at University of Vermont Extension. Before joining NECAFS, he earned a B.S. in Sustainable Agriculture and Food Systems at the University of New Hampshire (UNH) as a non-traditional student while also holding several research assistant and technician positions contributing to long-term ecological and agricultural research projects. He then earned an M.S. in Agricultural Sciences from UNH, where his thesis research focused on water quality and produce safety in coupled aquaponic systems. In his current role at NECAFS, Sean is contributing to regional and national research efforts and the development of educational resources regarding produce safety in hydroponic and aquaponic operations for growers, regulatory officials, extension educators, and other stakeholders.
Webinar Outline

• Learning Objectives

• Attendee Poll

• Presentation – Learning Objectives:
  1. What do hydroponic and aquaponic operations look like?
  2. What are key produce safety considerations in hydroponic and aquaponic operations? (Applying the IPS pyramid in HP/AP)
  3. What are the primary considerations relevant to FSMA Produce Safety Rule compliance in hydroponic and aquaponic operations? (Applying the PSR in HP/AP)

• Discussion / Q&A
Learning Objectives

1. Understand what hydroponic and aquaponic (HP/AP) operations look like and the amount of diversity among operations.

2. Gain awareness of key topic areas relevant to produce safety in HP/AP operations.

3. Understand the primary considerations relevant to PSR compliance in HP/AP operations.

4. Participants share questions, experiences, and perceived educational and research needs, contributing to discussion and future programming and materials development.
Attendee Poll
Learning Objective 1:

What do hydroponic and aquaponic operations look like?

- Hydroponic system types
- Defining Aquaponics
- Diversity of operations
Definitions To Remember

**Hydroponics**
Soil-free plant farming

**Aquaponics**
Fish farming + soil-free plant farming

**Aquaculture**
Fish Farming

HP/AP = Hydroponics and Aquaponics

PC: Todd Guerdat
Hydroponic System Types

• Nutrient Film Technique (NFT)
• Flood and Drain (aka ebb and flow, ebb and flood)
• Deep Water Culture (DWC), aka floating raft
• Media-Filled Beds (MFB) – Common in aquaponics
• Drip Irrigation
• Less common:
  • Vertical towers
  • Wicking beds
  • Aeroponics

And on, and on, and on...
Hydroponic System Types

Flood and drain (ebb and flow)

Nutrient Film Technique (NFT)
Flood and Drain Bok Choi Production
Flood and Drain: Baby Greens
Flood and Drain: Carrots
Nutrient Film (NFT) Batch Lettuce Production
Deep Water Culture (DWC)

1. Images of hydroponic systems in a greenhouse.
2. Images of lettuce grown in hydroponic systems.
3. Image of a person harvesting lettuce.
4. Image of a person checking the roots of lettuce.

PC: Nicholas van der Wal
PC: Sean Fogarty

Foundations of Produce Safety in Hydroponic and Aquaponic Operations – IAFP webinar Spring 2022
Drip Irrigation: Slab

PC: Backyard Farms
Media-Filled Beds (MFB)

PC: Canopy Farms
Aquaponics

Nutrient cycling among fish, bacteria, and plants – through the medium of water.
Fish in Aquaponics

• Fish do not typically host human enteropathogens.

AND

• The concentrations of human pathogens found in fish feces generally reflect those in the surrounding environment.

SO...

• Fish in aquaponics do not pose a direct produce safety hazard.

HOWEVER,

• Fish waste is rich in nutrients and may provide habitat for introduced pathogens if not managed properly.
Aquaponic Approaches

**Coupled**
Water recirculates
fish → plants → fish

**Decoupled**
Water flows one direction
fish → plants

Figures: Todd Guerdat
Coupled Aquaponics @ UNH (Experimental)
Coupled Aquaponics @ UNH: Waste Treatment

Fish + plant effluent → Sump → Bio-filter

PC: Sean Fogarty
Diversity of operations

Indoor → Outdoor
High tech → Low tech
Small scale → Large scale
Learning Objective 2:

What are key produce safety considerations in hydroponic and aquaponic operations?

- Integrated Produce Safety (IPS)
  - Engineering and System Design
  - Human – System Interaction
  - Biological Control
  - Chemical Control
Holistic Approaches to Crop Management

Integrated Pest Management (IPM) Triangle

Figure: Slunge et al., 2015
Integrated Produce Safety (IPS) Triangle

Value per unit labor or other investment

- **Engineering & System Design**
  - Planning and decisions made before system startup that influence water quality, fish health, and crop health.

- **Human – System Interaction**
  - Methods and systems—including SOP development, training, implementation, and supervision—that influence how personnel interact with the production environment.

- **Biological Control**
  - Use of biological agents—usually microorganisms—to prevent pathogen growth or treat contaminated water.

- **Chemical Control**
  - Use of chemical agents to prevent pathogen growth or treat contaminated water.

Preventive
Indirect

Reactive
Direct
Integrated Produce Safety (IPS) Triangle

Engineering & System Design
- Planning and decisions made before system startup that influence water quality, fish health, and crop health.

Human – System Interaction
- Methods and systems—including SOP development, training, implementation, and supervision—that influence how personnel interact with the production environment.

Biological Control
- Use of biological agents—usually microorganisms—to prevent pathogen growth or treat contaminated water.

Chemical Control
- Use of chemical agents to prevent pathogen growth or treat contaminated water.
Integrated Produce Safety (IPS) Triangle

Engineering & System Design

- Planning and decisions made before system startup that influence water quality, fish health, and crop health.

Biological Control
- Use of biological agents—usually microorganisms—to prevent pathogen growth or treat contaminated water.

Chemical Control
- Use of chemical agents to prevent pathogen growth or treat contaminated water.
Hydroponic System Types: Water Volume and Cleanability

- **Low Relative water volume**
  - **Low Cleanability**
    - Media-Filled Beds (MFB)
  - **High Cleanability**
    - Nutrient Film Technique (NFT)

- **High Relative water volume**
  - **Low Cleanability**
    - Deep Water Culture (DWC)
  - **High Cleanability**
    - Flood and Drain (ebb and flow)

- **Drip Irrigation**

---

Foundations of Produce Safety in Hydroponic and Aquaponic Operations – IAFP webinar Spring 2022
Foundations of Produce Safety in Hydroponic and Aquaponic Operations – IAFP webinar Spring 2022

**Integrated Produce Safety (IPS) Triangle**

**Engineering & System Design**
- Planning and decisions made before system startup that influence water quality, fish health, and crop health.

**Human – System Interaction**
- Methods and systems—including SOP development, training, implementation, and supervision—that influence how personnel interact with the production environment.

**Biological Control**
- Use of biological agents—usually microorganisms—to prevent pathogen growth or treat contaminated water.

**Chemical Control**
- Use of chemical agents to prevent pathogen growth or treat contaminated water.
Human – System Interaction: Activity Logs

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>DO Tank A (mg/L)</th>
<th>Temp Tank A (°C)</th>
<th>DO Tank B (mg/L)</th>
<th>Temp Tank B (°C)</th>
<th>EC (μS/cm)</th>
<th>pH</th>
<th>Alkalinity (mg/L as CaCO₃)</th>
<th>NH₄-N (mg/L)</th>
<th>NO₂-N (mg/L)</th>
<th>NO₃-N (mg/L)</th>
<th>Fe</th>
<th>Bicarb Added (g)</th>
<th>Feed Tank A/B (g)</th>
<th>Feed Calc Day #</th>
<th># of Fish per Tank</th>
<th>Initials</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Dec</td>
<td></td>
<td>&gt;5.0mg/L</td>
<td>&gt;24°C</td>
<td>&gt;5.0mg/L</td>
<td>&gt;24°C</td>
<td>1.8μS/cm</td>
<td>6.7</td>
<td>7.2</td>
<td>&lt;1.0mg/L</td>
<td>&lt;0.1mg/L</td>
<td>150mg/L</td>
<td>&gt;1.8mg/L</td>
<td>13</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-Dec</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Human – System Interaction: Visitors

1. Visitors **must** be made aware of the farm food safety plan.
2. If visitors are going to touch or otherwise interact with a system, they **must** receive the same training as personnel who perform similar functions.
Integrated Produce Safety (IPS) Triangle

- Engineering & System Design
  - Planning and decisions made before system startup that influence water quality, fish health, and crop health.

- Human – System Interaction
  - Methods and systems—including SOP development, training, implementation, and supervision—that influence how personnel interact with the production environment.

- Biological Control
  - Use of biological agents—usually microorganisms—to prevent pathogen growth or treat contaminated water.

- Chemical Control
  - Use of chemical agents to prevent pathogen growth or treat contaminated water.

Value per unit labor or other investment

Preventive
Indirect

Reactive
Direct
Integrated Produce Safety (IPS) Triangle

**Engineering & System Design**
- Planning and decisions made before system startup that influence water quality, fish health, and crop health.

**Human – System Interaction**
- Methods and systems—including SOP development, training, implementation, and supervision—that influence how personnel interact with the production environment.

**Biological Control**
- Use of biological agents—usually microorganisms—to prevent pathogen growth or treat contaminated water.

**Chemical Control**
- Use of chemical agents to prevent pathogen growth or treat contaminated water.

Value per unit labor or other investment

Preventive
- Indirect

Reactive
- Direct
Learning Objective 3:

What are the primary considerations relevant to FSMA Produce Safety Rule compliance in hydroponic and aquaponic operations?

• Ag Water Rule
• Wildlife
• Operator and Personnel Training
• BrightFarms outbreak
Is it Ag Water?
Contact between water and edible portion
Ag Water Classification: Municipal, ground, or surface?

PC: Canopy Farms
Proposed Ag Water Rule:
Ag Water Systems

- Ag Water System (AWS) = “a source of ag water, the water distribution system, any building or structure that is part of the water distribution system, and any equipment used for application of ag water to covered produce”

- HP/AP systems = AWS

- Proposed rule would require annual inspection of all AWS
Testing Ag Water
How often is enough?

• Surface water testing – frequency suggested in proposed rule:
  • 20 samples within first 2 – 4 years
  • 5 samples per year after that

• The flexibility built into the proposed rule would require growers to determine appropriate testing programs based on their own unique situations.

• This may mean that HP/AP growers should test more frequently than the proposed rule’s suggestions for surface water.

• Consider a hydroponic greens operation that harvests weekly, 52 weeks a year.
  • Is an average of 5 samples per year adequate in HP/AP?
  • If not, what would be?
<table>
<thead>
<tr>
<th>Determination</th>
<th>Proposed outcome</th>
<th>Applicability to HP/AP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water is not safe or of adequate sanitary quality for intended use(s).</td>
<td>Immediately discontinue use And take corrective measures before resuming use.</td>
<td>Takeaway:</td>
</tr>
<tr>
<td>≥1 known or foreseeable hazard related to animal activity, BSAAOs, or untreated human waste</td>
<td>Implement mitigation measures promptly, and no later than the same growing season</td>
<td>The proposed implementation timeline for mitigation measures is designed for field agriculture.</td>
</tr>
<tr>
<td>≥1 known or foreseeable hazard not related to animal activity, BSAAOs, or untreated human waste</td>
<td>Implement mitigation measures as soon as practicable and no later than the following year Or Test as part of assessment and implement appropriate measures, as needed, accordingly</td>
<td>HP/AP operations should inspect systems often and implement mitigation measures as soon as possible following recognition of a hazard, due to:</td>
</tr>
<tr>
<td>No known or foreseeable hazards for which mitigation is necessary</td>
<td>Inspect and adequately maintain the water system(s) ≥1 time per year</td>
<td>• Continuous nature of production</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• recirculation of water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Lack of time interval between irrigation and harvest</td>
</tr>
</tbody>
</table>

- Again, consider a hydroponic greens operation that harvests weekly, 52 weeks a year.
Wildlife

• Crops and production water may attract wildlife if they are not effectively excluded.

• Fish in aquaponics, while not an inherent produce safety risk, create secondary hazards:
  1. Attraction of predators to fish tanks
  2. Attraction of scavengers to uneaten fish feed on and around fish tanks
Training HP/AP operators and personnel in produce safety

- Many of the fundamentals of PS training are the same as in field ag.
- PS training for HP/AP should be tailored to the particular hazards and control points in HP/AP to effectively minimize risk.
- Emphasize co-benefits of sanitation and hygiene practices -- where GAPs align with produce safety goals and the law
Outbreak!

*Salmonella* Typhimurium from hydroponic lettuce

- 31 illnesses and 4 hospitalizations in 4 states
- June to August, 2021

**FDA Investigation**
- Deep Water Culture (DWC) with floating rafts in plastic-lined grow ponds at ground level
- Firm reported treating water with PAA when generic *E. coli* was detected in weekly water samples.
- Growth media was stored outdoors and unsecured.
- Leaves that contacted water were not systematically excluded from harvest and packing.
- Condensate from chillers was dripping on produce.
- Nearby stormwater retention basin contained *Salmonella Typhimurium*, but no specific contamination route was observed.
- Cleaning and sanitizing of equipment, tools, and buildings was not adequately documented.
- Investigation did not identify the specific source or route for lettuce contamination.
Discussion
Contact Information

Sean Fogarty  Sean.Z.Fogarty@uvm.edu
Gretchen Wall  gwall@freshproduce.com
Be sure to follow us on social media

International Association for Food Protection

@IAFPFOOD

IAFP Food

International-association-for-food-protection
This webinar is being recorded and will be available for access by IAFP members at www.foodprotection.org within one week.

Not a Member? We encourage you to join today. For more information go to: www.FoodProtection.org/membership/

All IAFP webinars are supported by the IAFP Foundation with no charge to participants.

Please consider making a donation to the IAFP Foundation so we can continue to provide quality information to food safety professionals.