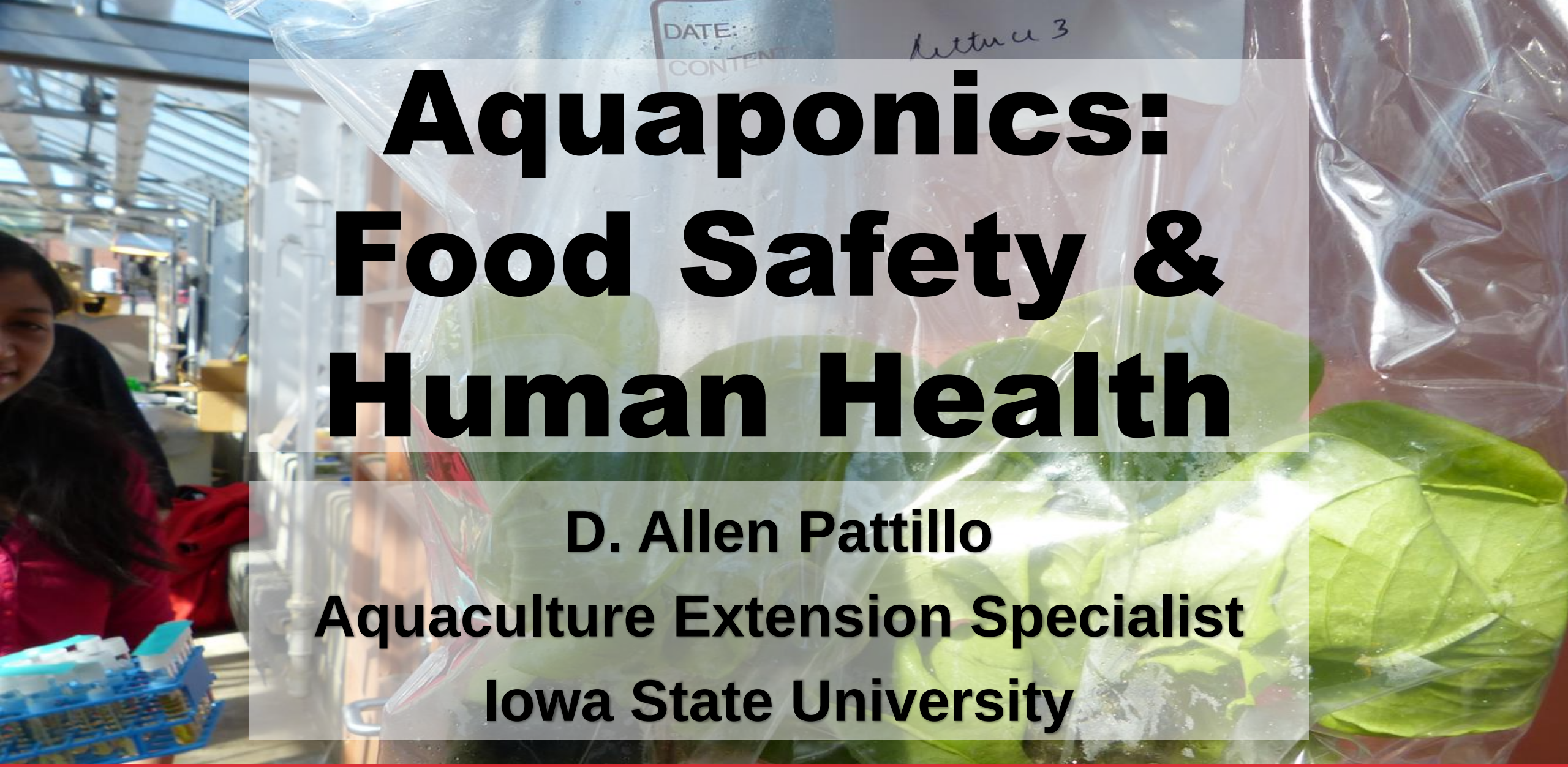

Aquaponics: Food Safety & Human Health

D. Allen Pattillo

Aquaculture Extension Specialist

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Introduction

- **Food safety is a concern**
  - little is known about foodborne diseases in aquaponics systems
- **Foodborne diseases**
  - Annually responsible for 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths
  - Result in $10 - $83 billion in pain and suffering, reduced productivity, and medical costs annually
- **Specific concern with aquaponics**
  - Proximity of fish culture water to edible plant culture

Introduction

- Fish generally not regarded as a food safety threat in aquaponics
  - Temperatures of culture water are low
  - Thought that establishment of pathogens is not promoted
    - (e.g. *Escherichia coli or Salmonella spp.*)
- Potential for survival and growth is really unknown
- Evaluation of this assumption is needed

Who is Responsible for Safe Food?

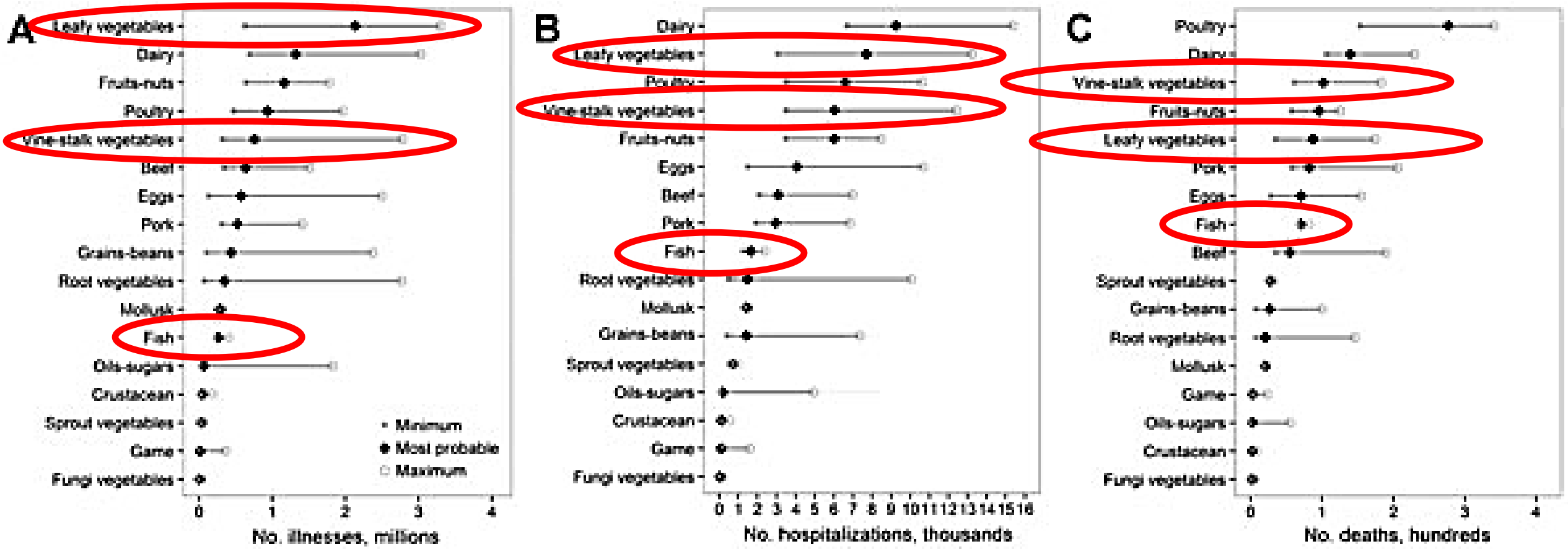
- Producers
- Handlers
- Processors
- Food Suppliers
- Consumers

www.fightbac.org

Aquaponic Food Safety Microbial Threats (Greatest to Least)

1) *Listeria monocytogenes*
2) *Salmonella spp.*
3) *Shiga-toxin E. coli*
4) *Vibrio spp.*
5) *Aeromonas spp.*
6) *Shigella spp.*
7) *Campylobacter spp.*
8) *Pleisomonal shigelloides*
9) *Edwardsiella tarda*
10) *Crypyosporidoum*
11) *Leptospira spp.*

Food Safety Threats (Greatest to Least)



Painter et al. 2013

Why is produce risky?

1. **Raw**
2. **Wrinkly**
   – High Surface Area
3. **Sticky**
   – Covered in Biofilm

Biofilms and Pathogens

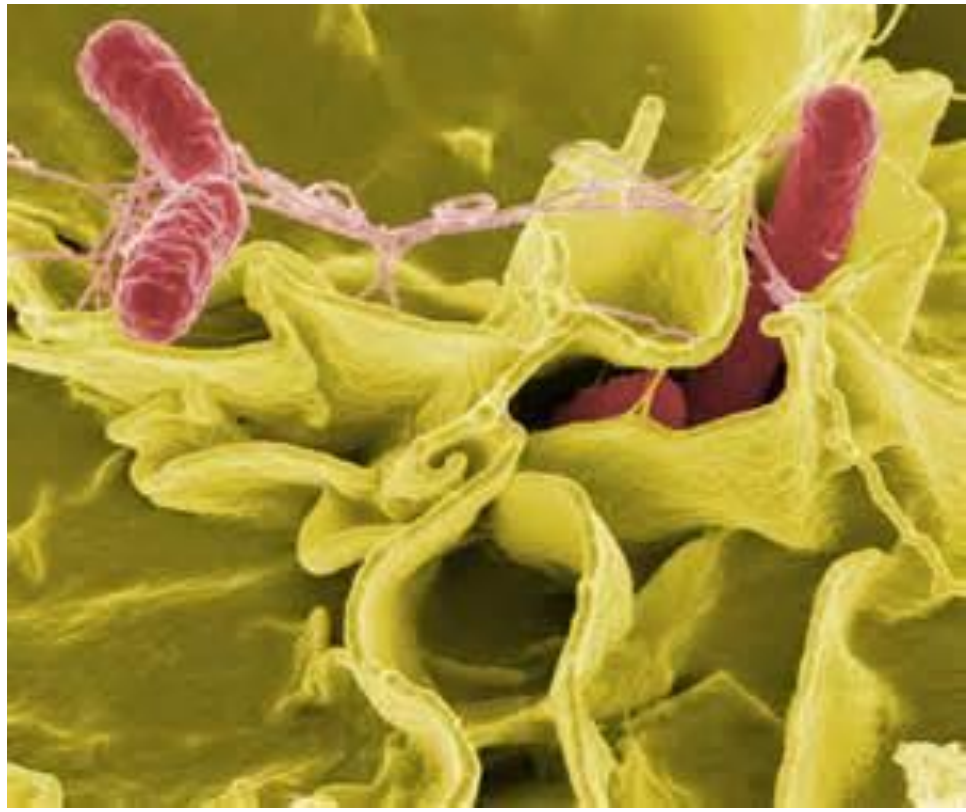
- Plant matter is coated in a living substance called biofilm that contains beneficial and harmful microbes
- Biofilms are sticky and may harbor pathogens like:
  - *Listeria*
  - *Salmonella*
  - *Aeromonas*

Listeria monocytogenes

- Survives with or without oxygen
- Grows well in refrigerator temperatures
- Very highly pathogenic

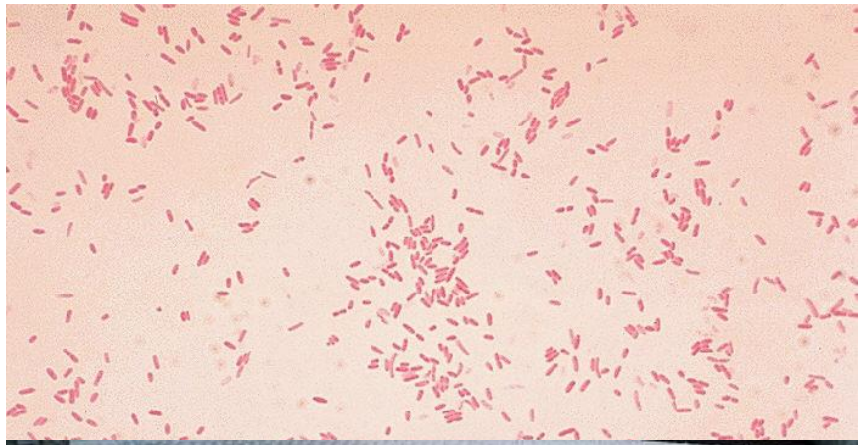
Salmonella spp.

- Very common in wild birds and rodents
- Can persist in water or wet, cool environments for months
- Can contaminate feed



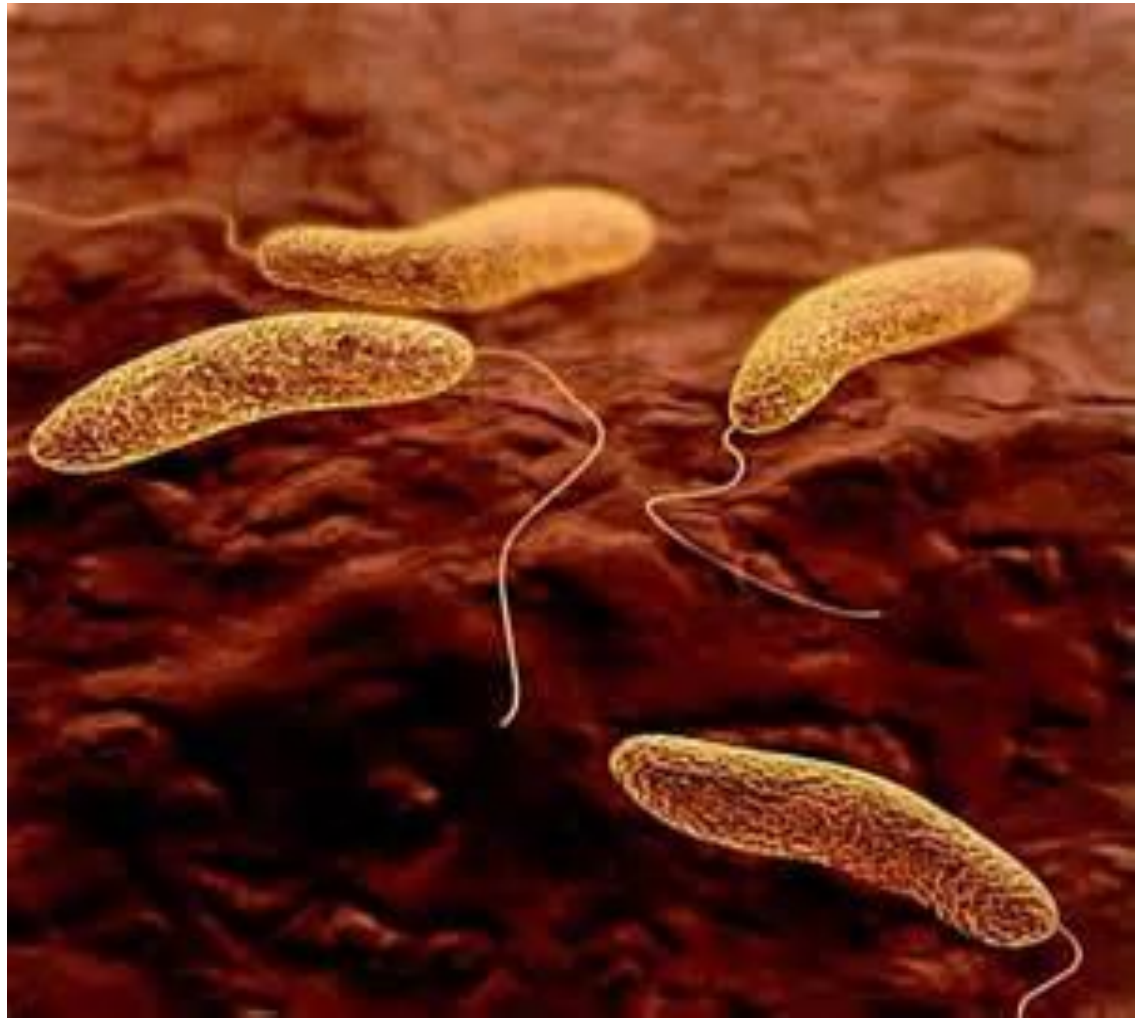
Aeromonas hydrophilia

- Associated with fish and water
- Probably high infectious dose
- Immunocompromised people are at risk



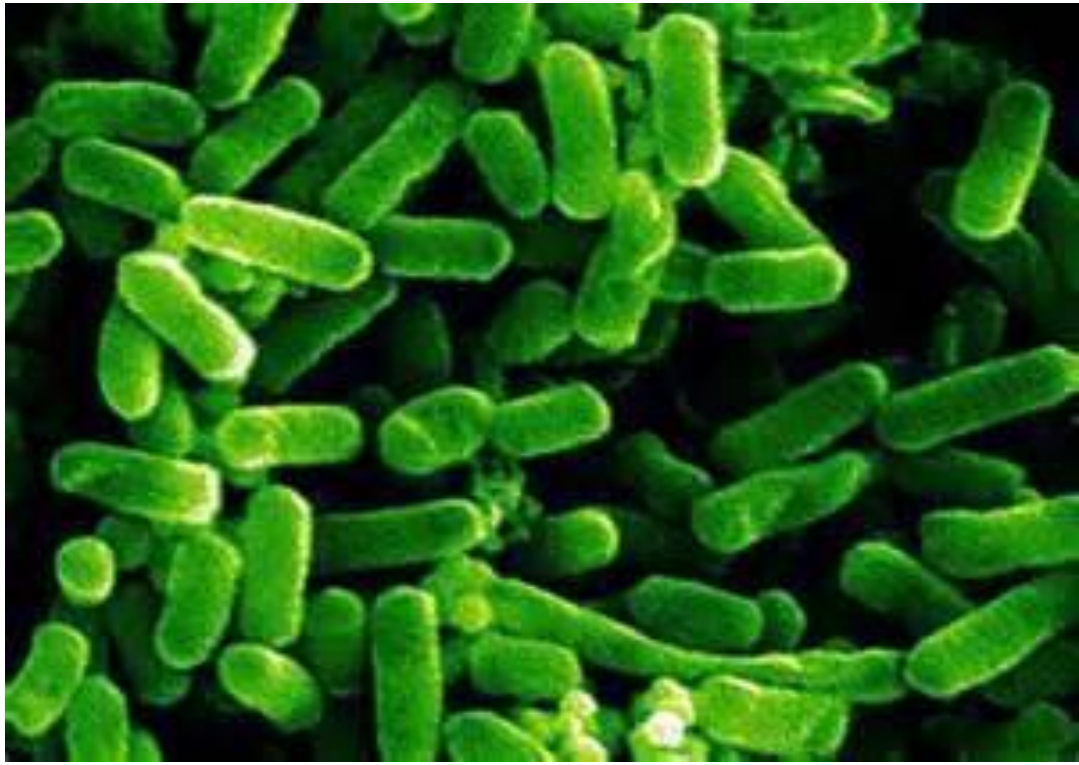
Vibrio spp.

- 3 main species including Cholera
- Aquatic bacteria
- Often associated with shellfish



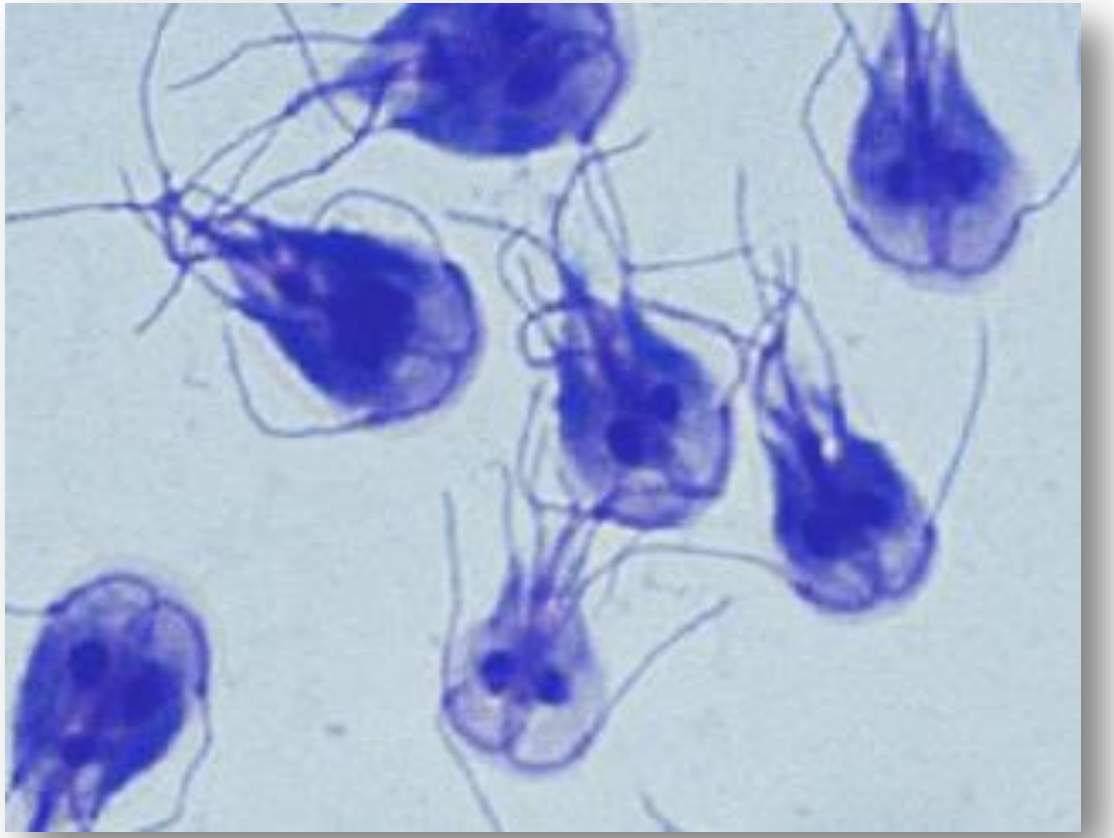
Escherichia coli (O157H7)

- Not carried by fish
  - Cold-blooded
- Contamination likely because of poor employee hygiene



Non-Bacteria

- ***Cryptosporidium***
  - Calves (or people)
- ***Cyclospora***
  - Mexican raspberries
- ***Giardia***
  - Person – water – person
- **Protozoans are Resistant to chlorine!!**



How are pathogens introduced to produce?

- Hands
- Aerosols
- Direct water contact
- Internalization?
  - New study shows *E.coli* actually inside of lettuce plants

Reducing Food Safety Risks

- Good Agricultural Practices (GAPs)
- Use of water and food sterilization methods
  - Ultraviolet Irradiation
  - Ozone
  - Hydrogen peroxide
  - Others

Good Agricultural Practices

GAPs help reduce contamination risks for:

- Soil
- Water
- Hands
- Surfaces

GAPs include:

- Food Safety Plan

PM 1974A – On-farm Food Safety: Guide to Good Agricultural Practices (GAPs)
http://store.extension.iastate.edu/Product/On-farm-Food-Safety-Guide-to-Good-Agricultural-Practices-GAPs

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Food Handling Tips- Health, Hygiene & Hand-washing

- Sick workers should not handle food

- Proper hand-washing techniques to prevent cross-contamination

Sample Handwashing Procedure

1. Rub hands together with soap under running water for 15 seconds (sing 'Happy Birthday' twice).
2. Before turning off water, dry hands with disposable towel.
3. Use towel to turn off faucet.
4. Discard towel.
   If the towel dispenser has a handle, ask staff to wash hands, turn towel crank, wash hands again, use the towel to dry hands, and then use towel to turn off faucets.

PM 1974B – On-farm Food Safety: Food Handling Guide
http://store.extension.iastate.edu/Product/On-farm-Food-Safety-Food-Handling-Guide

Food Handling Tips- Clothing & Footware

- Reducing cross-contamination

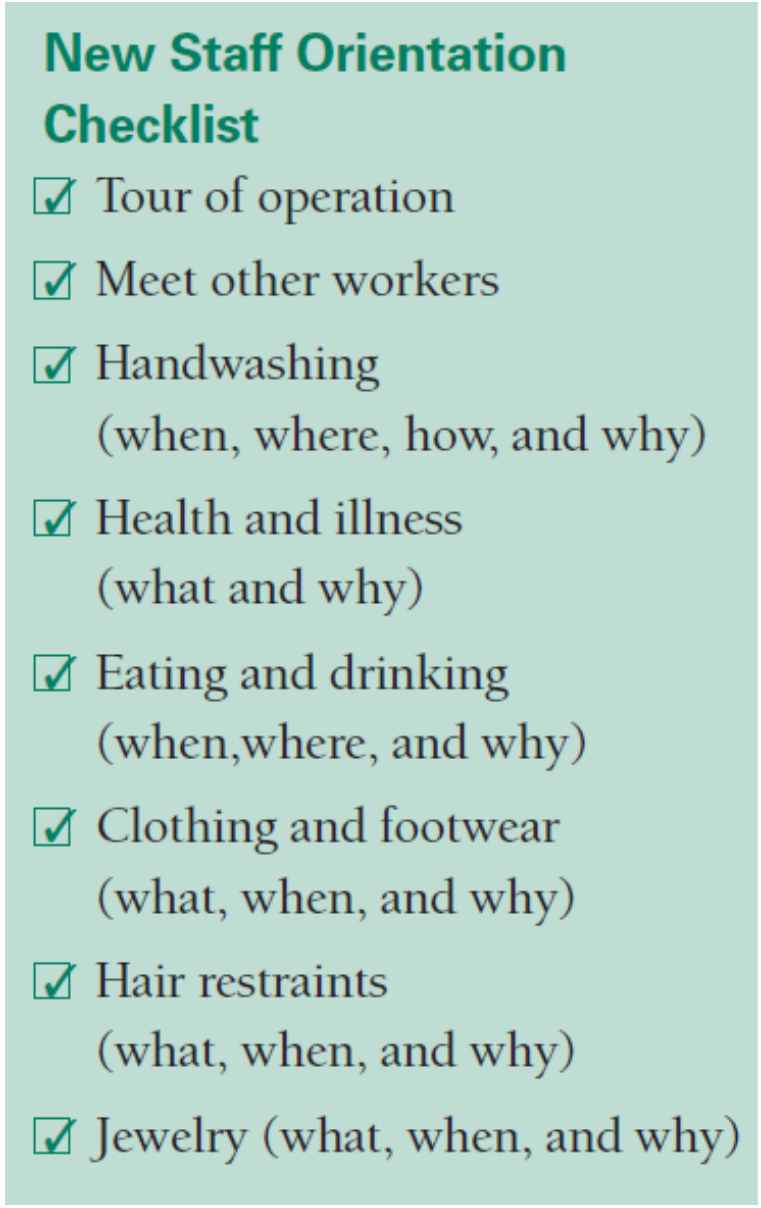
Possible Policies to Reduce Contamination and Cross-Contamination

- Individuals will wash hands when reporting for work and after eating, drinking, smoking, and using the toilet.
- Individuals who are composting or applying manure, weeding, or planting will wash hands and change gloves prior to harvesting ripe product. Because many pathogens live in the soil, failure to wash hands between tasks can cross-contaminate the product. If cloth gloves are worn, separate pairs should be dedicated for each specific use or site. Disposable gloves will be changed between tasks.
- Individuals who harvest, wash, and/or pack product will wash hands and put on a clean apron and gloves after harvesting and before washing or packing.
- Hair restraints must be worn during the washing and packing process. Hats, scarves, hair nets, or other covering that restrains hair can reduce the chance of loose hairs falling on product.
- No jewelry will be worn during washing or packing. Rings with settings, long necklaces, and earrings can pose safety and contamination risks. One exception might be the wearing of a plain wedding band.

PM 1974B – On-farm Food Safety: Food Handling Guide
http://store.extension.iastate.edu/Product/On-farm-Food-Safety-Food-Handling-Guide

Food Handling Tips- Training & Documentation

- Training new workers on GAPs
- Keeping Records



PM 1974B – On-farm Food Safety: Food Handling Guide
http://store.extension.iastate.edu/Product/On-farm-Food-Safety-Food-Handling-Guide

Food Safety Plan

Why have a food safety plan?

- Planning
- Training
- Liability
- Quality Control
- Crisis Management

Benefits of a Food Safety Plan

- Provides operational roadmap for food safety risk reduction
- Offers mechanism for monitoring effectiveness of changes to improve product safety and quality
- Provides structure through which assessment of an operation can occur
- Creates a documentation process to verify production and processing changes
- Serves as a reference for all employees during training and throughout the season

PM 1974A – On-farm Food Safety: Guide to Good Agricultural Practices (GAPs)
http://store.extension.iastate.edu/Product/On-farm-Food-Safety-Guide-to-Good-Agricultural-Practices-GAPs

Food Safety Plan

What goes in a food safety plan?

1. Production steps
2. Hazard analysis
3. Control points
4. Monitoring strategies
5. Adjustment protocols
6. Documentation

Sample Food Safety Plan

Steps 1-2. While assessing your storage facility, you identify the cold storage temperature as a potential risk of promoting bacterial growth.

Step 3. Measuring and recording the temperature routinely is a way of monitoring this risk.

Steps 4-5. Start monitoring and recording temperatures. This is a modification that easily can be implemented with minimal expense and time commitment.

Category	Concentration	Products
Chlorine Bleach	**Produce:** • 100-200 ppm • 200 ppm = 2 table-spoons of 6% hypo chlorite (household bleach) per gallon in warm water (75-120°F) **Surface:** • Typically 50-100 ppm	• Unscented regular strength bleach (6%) • Sanova™ (acidified sodium chlorine
Chlorine dioxide	• Less than 3 ppm in liquid form	• Zep Dominion™
Organic Acids • **Acetic Acid** • **Citric Acid** • **Lactic Acid**	• Vinegars contain less than 8% acetic acid • 8% vinegar with a ratio of 1 part vinegar to 3 parts water • Follow manufacturers' recommendations	• Vinegar at less than 8% acetic acid from an organic source • Veggixide® (citric/lactic acid) • PRO-SAN© LC • FIT (citric acid, grapefruit seed, ethanol)
Hydrogen Peroxide	• Food grade hydrogen peroxide 1-5%; 3% most common • Follow manufacturers' recommendations	Food grade hydrogen peroxide
Peroxyacetic Acid / Peracetic Acid	• Follow manufacturers' recommendations	• Tsunami 100™ (hydrogen peroxide/peroxyacetic acid) • StorOx 2.0 (hydrogen peroxide/peroxyacetic acid) • SaniDate 12.0 (peroxyacetic acid) • StorOx (hydrogen peroxide/peracetic acid)

PM 1974D - Guide to Liquid Sanitizer Washes with Fruit and Vegetables
http://store.extension.iastate.edu/Product/Guide-to-Liquid-Sanitizer-Washes-with-Fruit-and-Vegetables

Aquaponic Food Safety Research at ISU

EFFICACY OF UV-STERILIZATION IN REDUCING FOOD-BORNE PATHOGENS IN AN AQUAPONICS SYSTEM

D. Allen Pattillo*, Angela M. Shaw, Christopher J. Currey, Kun Xie, and Kurt A. Rosentrater

Iowa State University

IOWA STATE UNIVERSITY
Extension and Outreach

Introduction

Use of ultraviolet (UV) radiation for sterilization in recirculating aquaculture

- proven to reduce pathogen loads in water
- No chemical additions needed
  - increasing fish health
  - decreasing need for water exchange

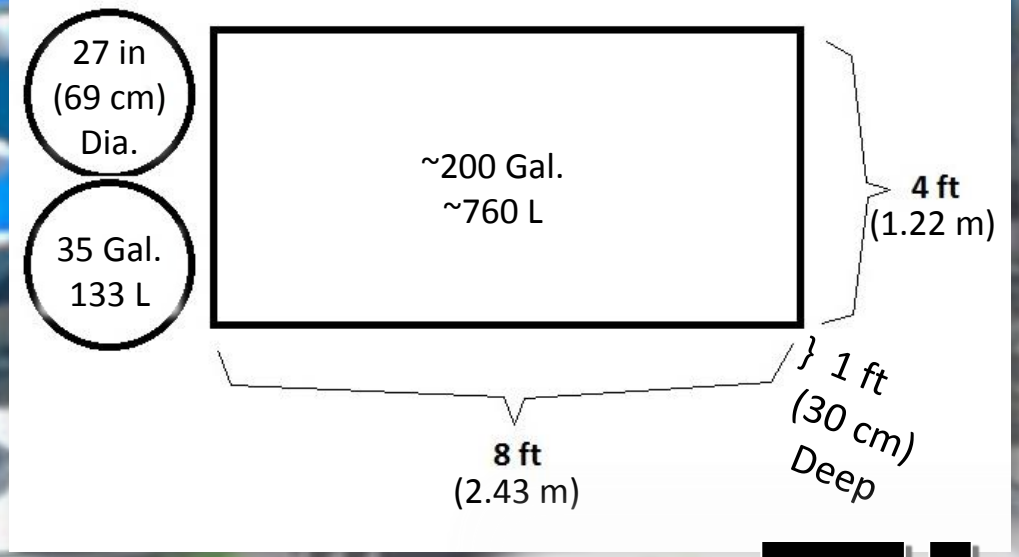
Effective use of a UV sterilizer should reduce abundance of many bacterial and viral pathogens

- reduce probability of cross-contamination between water and plant tissues

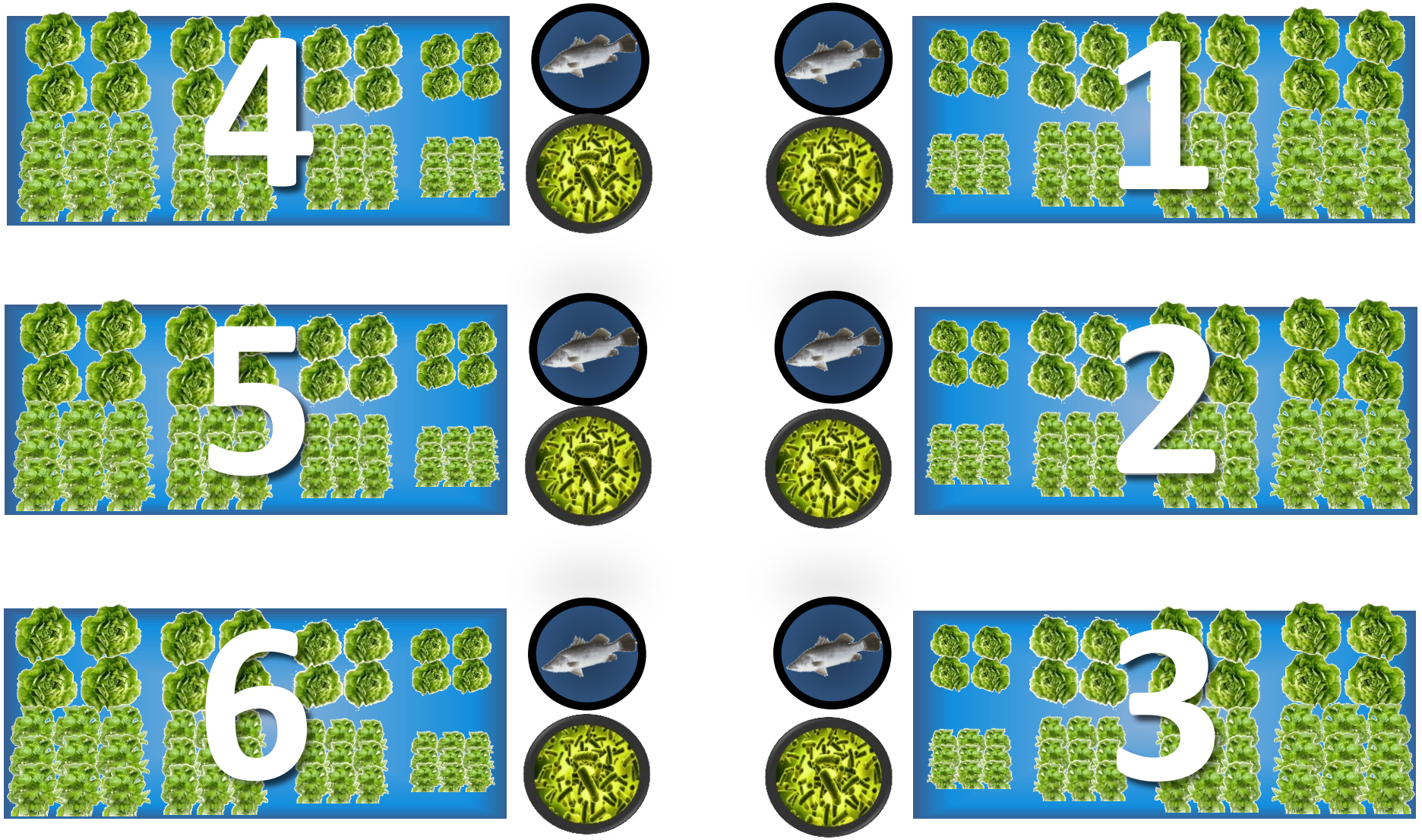
Study Objectives

1) Identify the presence and abundance of pathogens in an aquaponics system

2) Evaluate the efficacy of UV sterilization in suppressing pathogens


27 in
(69 cm)
Dia.
35 Gal.
133 L
~200 Gal.
~760 L
4 ft
(1.22 m)
1 ft
(30 cm)
Deep
8 ft
(2.43 m)

The Systems


4
1
5
2
6
3

Barramundi ▶
(Lates calcarifer)

◀ **Italian Largeleaf Basil**

◀ **Buttercrunch Bibb Lettuce**

Study Design

- Study Period
  - November 11, 2014 – Present
- Plants germinated 4 weeks prior to stocking
- All-male barramundi stocked at 236 ± 63g
- Fish Fed twice daily
- Water quality recorded every morning
- Water chemistry analyzed twice weekly
- $CaCO_3$, $NaHCO_3$, and Fe supplemented as needed

Study Design

Pathogens Evaluated

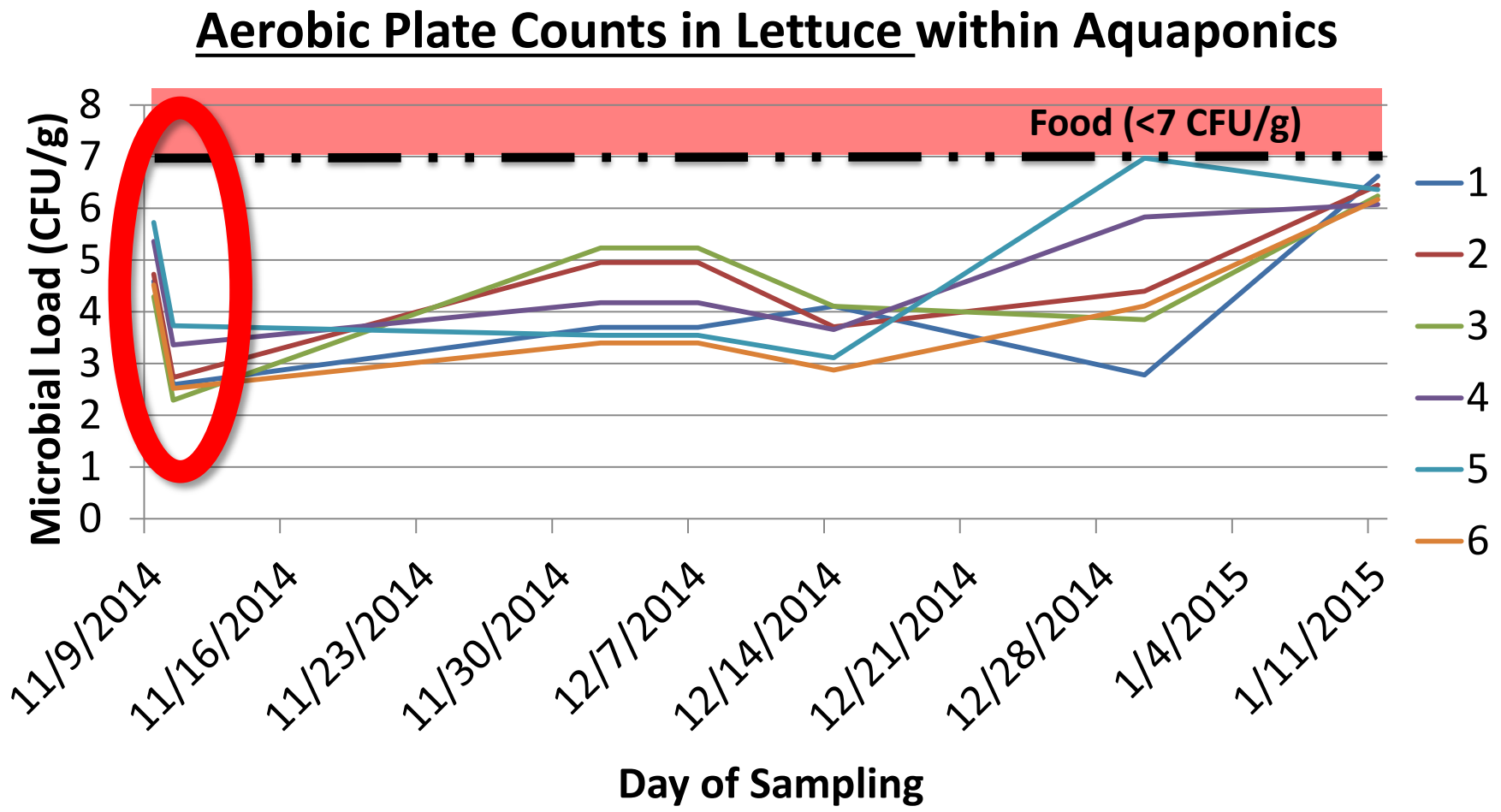
- What?
  - *E. coli/Coliform*
  - *E. coli O157*
  - *Salmonella spp.*
  - *Aeromonas spp.*
- Where?
  - Water
  - Plant
- HOW?
  - AEROBIC PLATE COUNTS
  - COLIFORM COUNTS

Study Results

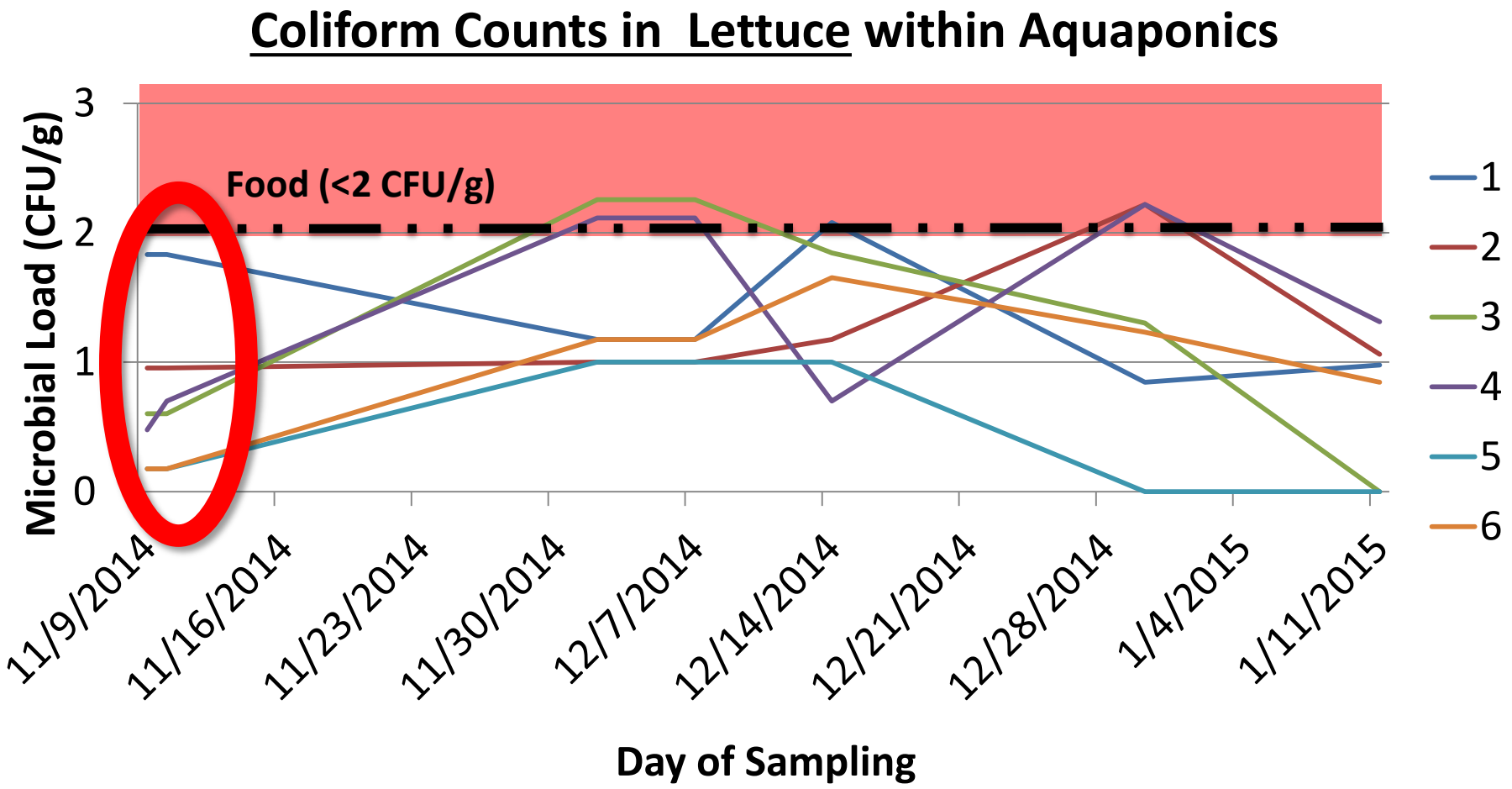
1) Identify the presence and abundance of pathogens in an aquaponics system

2) Evaluate the efficacy of UV sterilization in suppressing pathogens

Microbial Counts in Lettuce

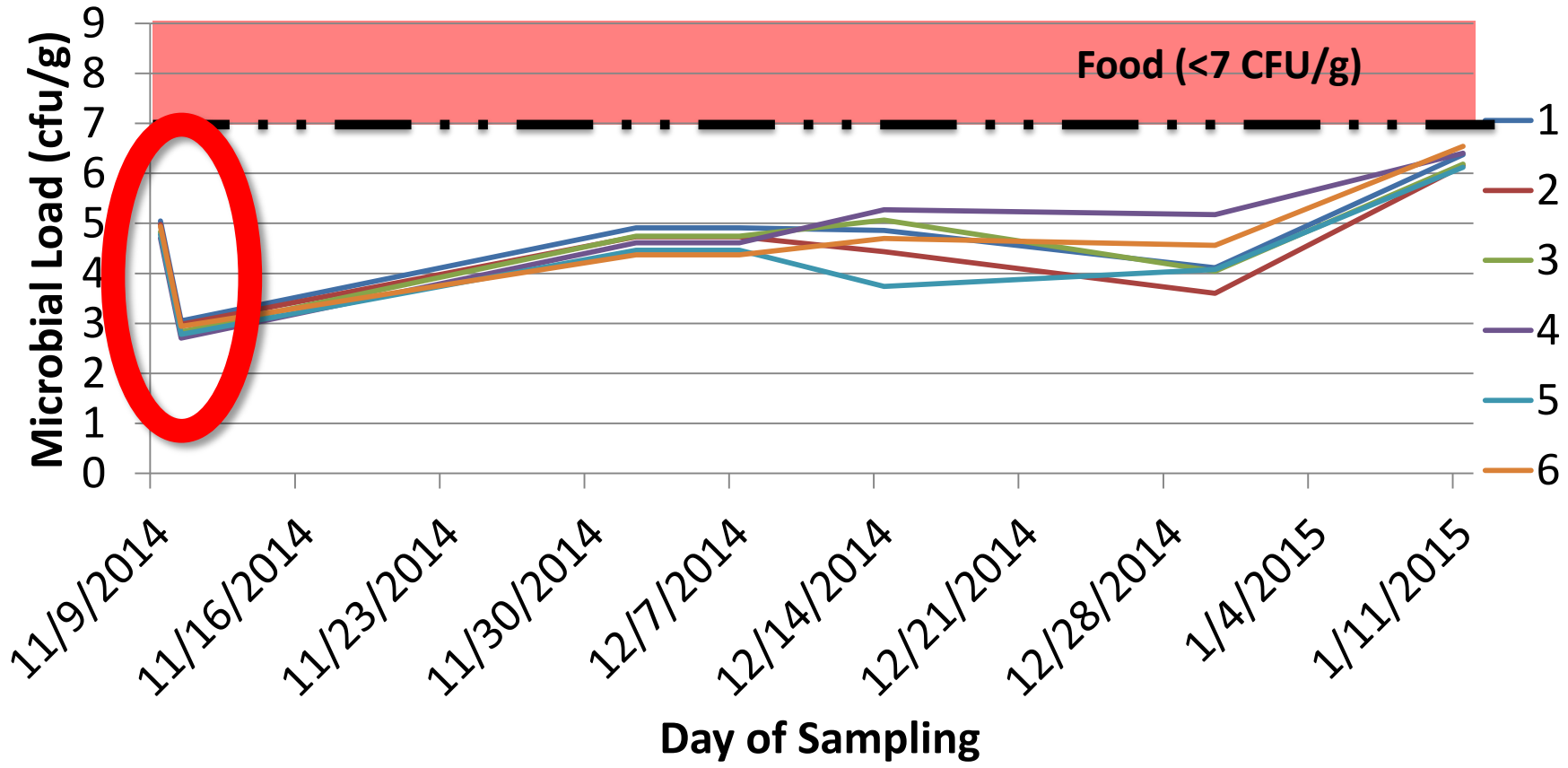


Microbial Counts in Lettuce

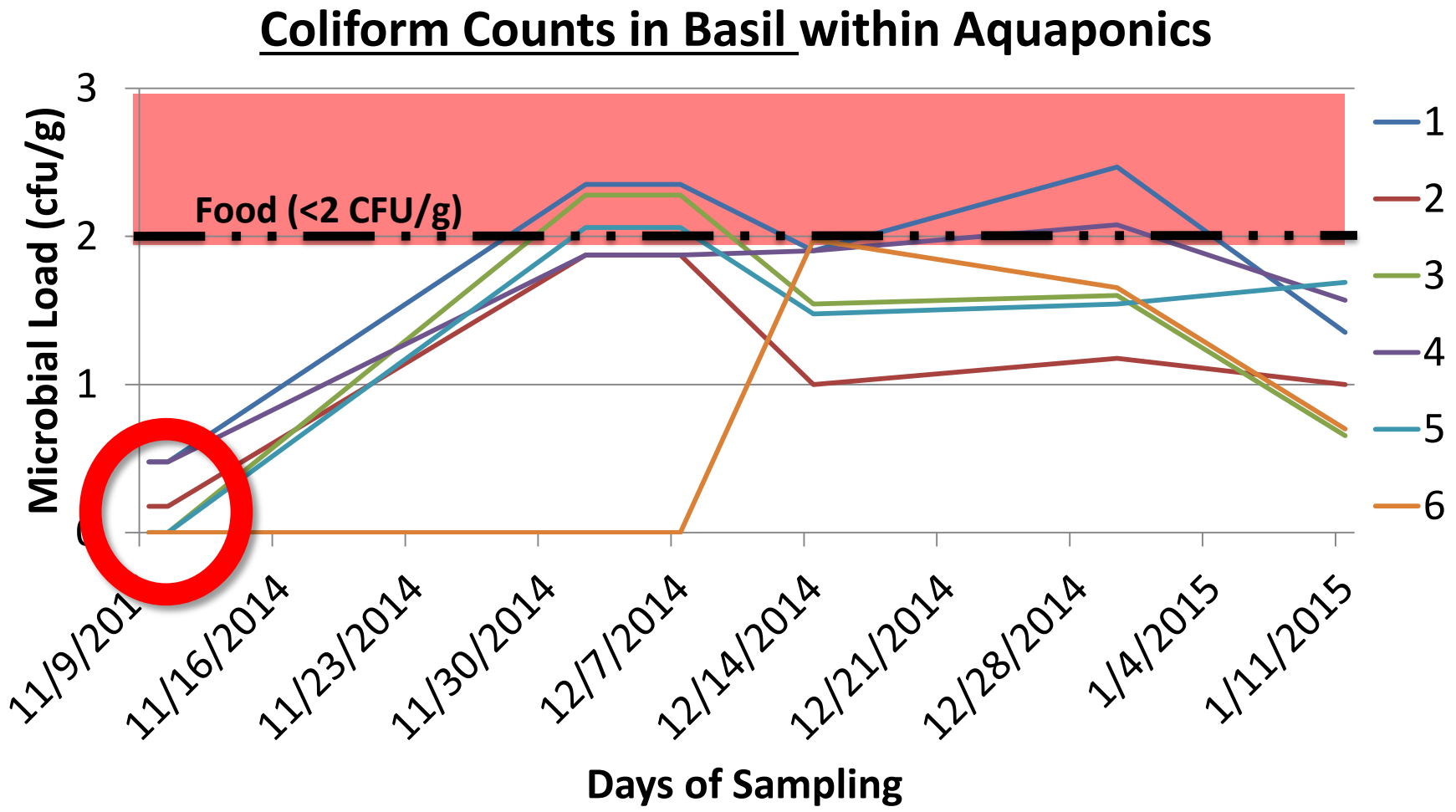


Microbial Counts in Basil

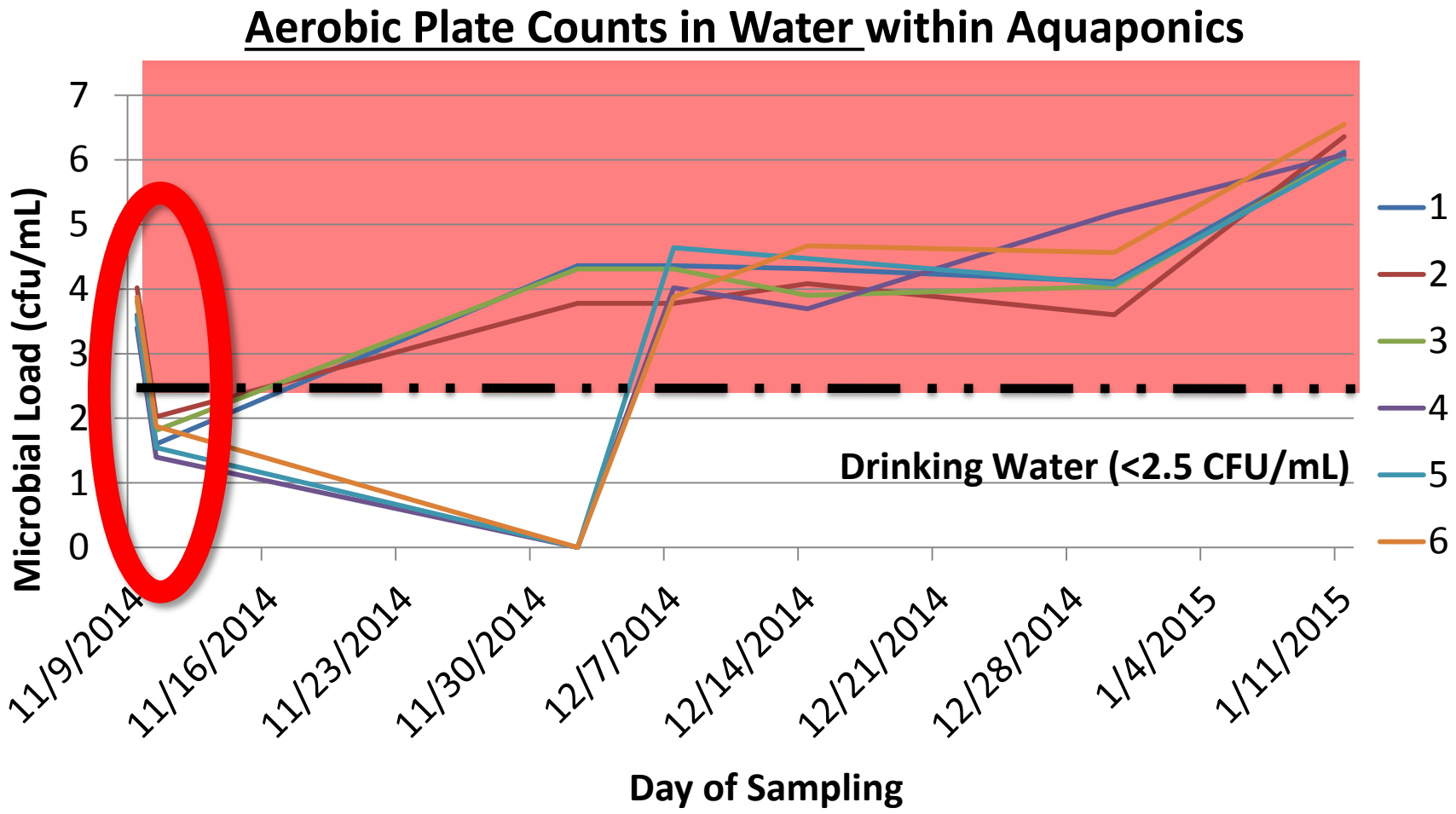
Aerobic Plate Counts in Basil within Aquaponics



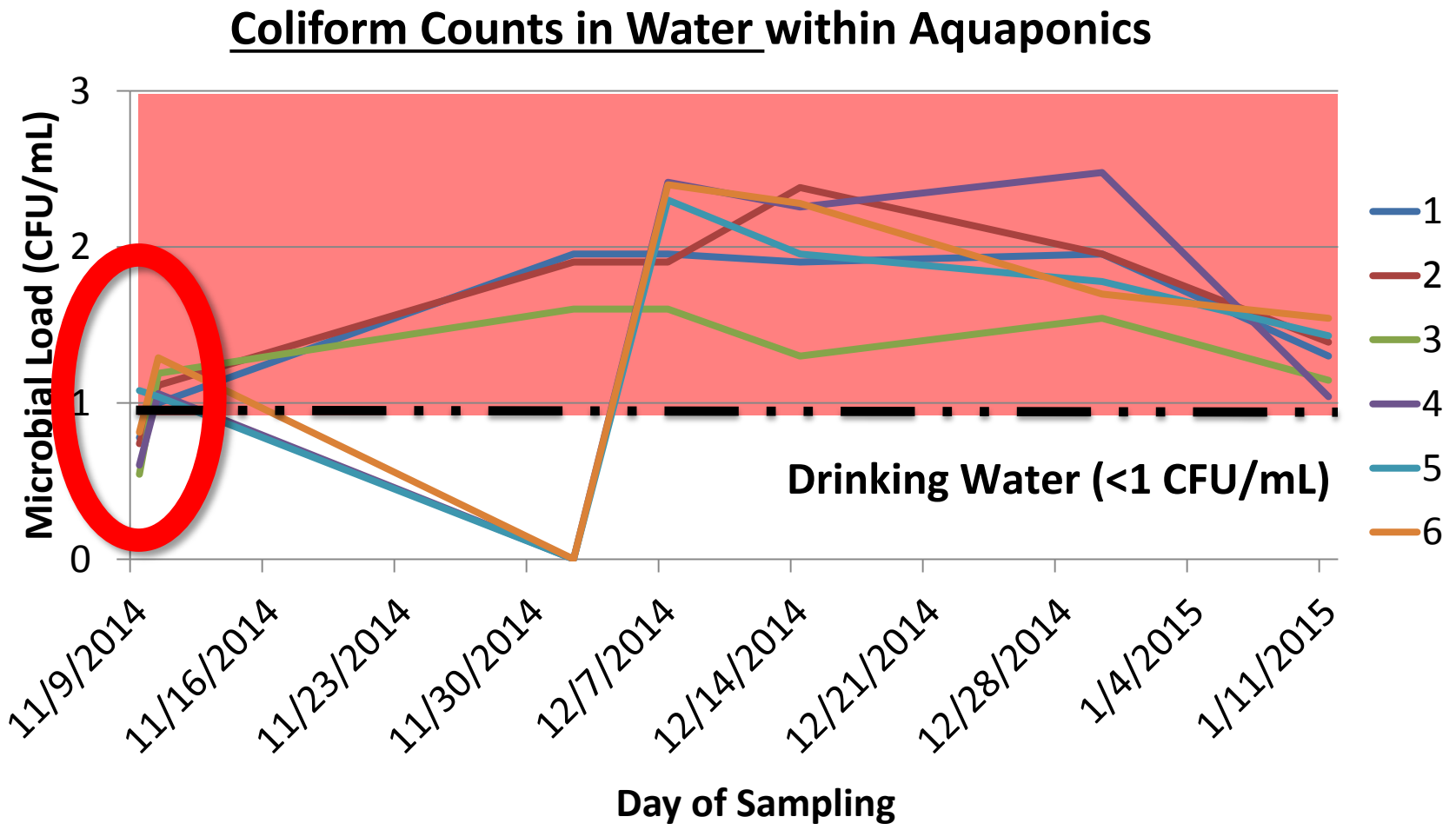
Microbial Counts in Basil



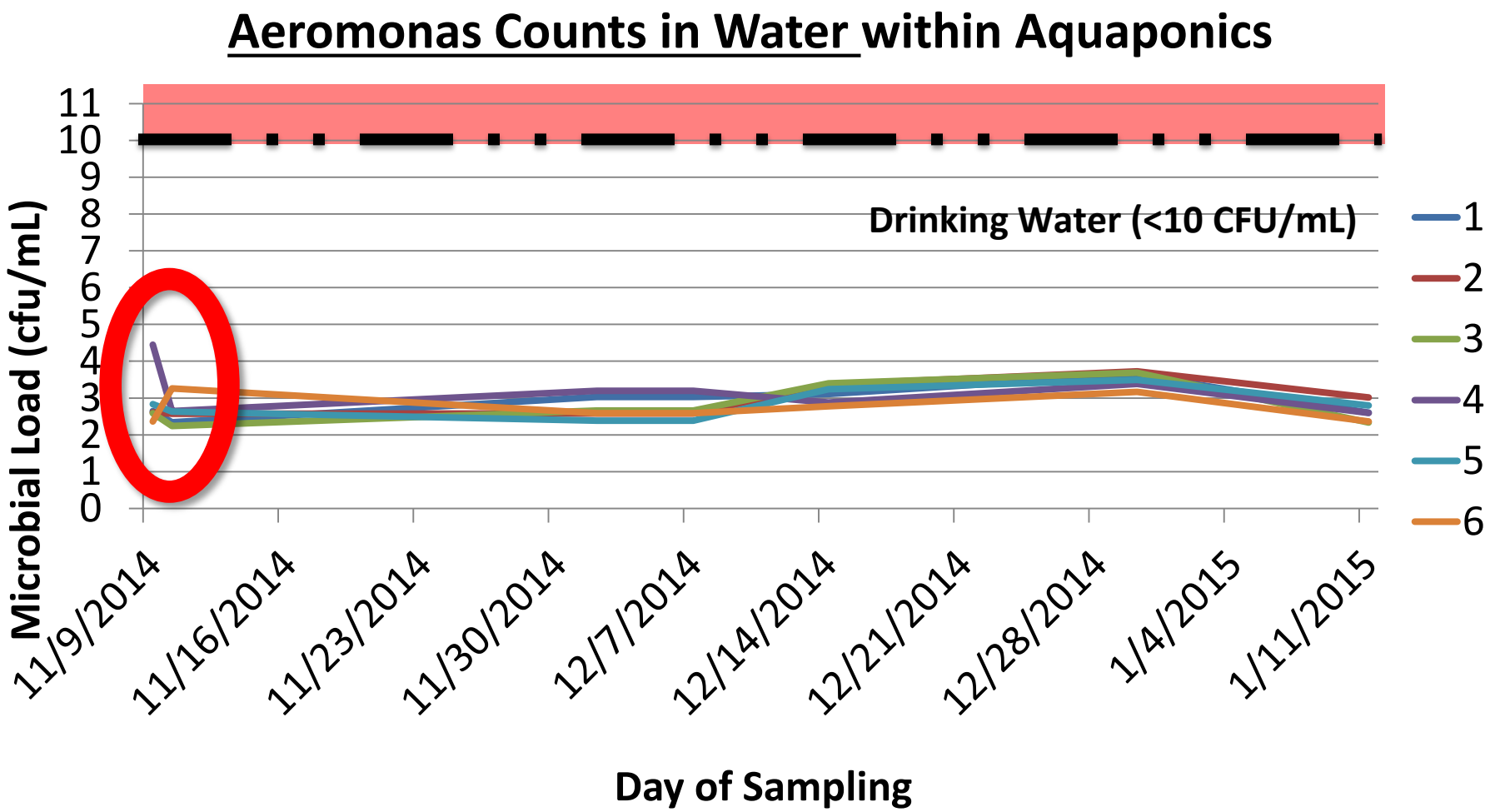
Microbial Counts in Water



Microbial Counts in Water



Microbial Counts in Water



Discussion

1) Identify the **presence** and abundance of pathogens in an aquaponics system

Did we find potential pathogens?

- **Water - Yes**
- **Plants - Yes**

Discussion

1) identify the presence and **abundance** of pathogens in an aquaponics system

How many Pathogens did we find?

Test (log_{10})	Aerobic Plate Counts	Coliform Counts	Aeromonas
Basil (CFU/g)	2.70 - 6.54	0.00 - 2.47	--
Lettuce (CFU/g)	2.29 - 6.97	0.00 - 2.25	--
Water (CFU/mL)	0.00 - 6.55	0.00 - 2.47	2.23 - 4.44

Discussion

2) Evaluate the efficacy of UV sterilization in suppressing pathogens

Did UV reduce water Pathogen loads?

- **Aerobic Plate Counts – Yes, briefly**
- **Coliform Counts – variable results**
- **Aeromonas – Somewhat**
  - **maintained <10 CFU/mL**

Discussion

2) Evaluate the **efficacy of UV sterilization** in suppressing pathogens

Did UV reduce lettuce Pathogen loads?

- **Aerobic Plate Counts – Yes, briefly**
- **Coliform Counts – variable results**

Discussion

2) Evaluate the **efficacy of UV sterilization** in suppressing pathogens

Did UV reduce basil Pathogen loads?

- **Aerobic Plate Counts – Yes, briefly**
- **Coliform Counts - no**

Conclusions

- Aquaponic produce did contain foodborne pathogens
  - at times levels were above the safe threshold
- UV sterilization alone is not enough to eliminate food safety concerns for aquaponics

Conclusions

- Alternative methods must be explored to improve food safety in aquaponics to move the industry forward
- **Potential methods**
  - **Water exchange**
  - **Improved filtration**
  - **O-zone**

Research Sponsors

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Natural
Resource
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Food Safety Resources

- The Ohio State University
  - http://foodsafety.osu.edu/
- Iowa State University
  - http://www.extension.iastate.edu/foodsafety/
- University of Minnesota
  - www.Extension.umn.edu/foodsafety
- Penn State
  - http://extension.psu.edu/food/safety

References

- Painter, J. A. , R. M. Hoekstra, T. Ayers, R. V. Tauxe, C. R. Braden, F. J. Angulo, and P. M. Griffin. 2013. Attribution of Foodborne Illnesses, Hospitalizations, and Deaths to Food Commodities by using Outbreak Data, United States, 1998–2008. Emerging Infectious Diseases. 19, 3. http://wwwnc.cdc.gov/eid/article/19/3/11-1866_article
- Shaw, A., C. Strohbehn, J. Meyer. 2013. PM 1974D - Guide to Liquid Sanitizer Washes with Fruit and Vegetables. http://store.extension.iastate.edu/Product/Guide-to-Liquid-Sanitizer-Washes-with-Fruit-and-Vegetables
- Strohbehn, C., P. A. Domoto. 2013. PM 1974C – On-farm Food Safety: Cleaning and Sanitizing Guide. http://store.extension.iastate.edu/Product/On-farm-Food-Safety-Cleaning-and-Sanitizing-Guide
- Strohbehn C., M. Smith, P. A. Domoto , L. Wilson. 2011. PM 1974B – On-farm Food Safety: Food Handling Guide. http://store.extension.iastate.edu/Product/On-farm-Food-Safety-Food-Handling-Guide
- Strohbehn, C., D. Henroid, J. Ellis , L. Wilson. 2004. PM 1974A – On-farm Food Safety: Guide to Good Agricultural Practices (GAPs). http://store.extension.iastate.edu/Product/On-farm-Food-Safety-Guide-to-Good-Agricultural-Practices-GAPs

Questions?

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