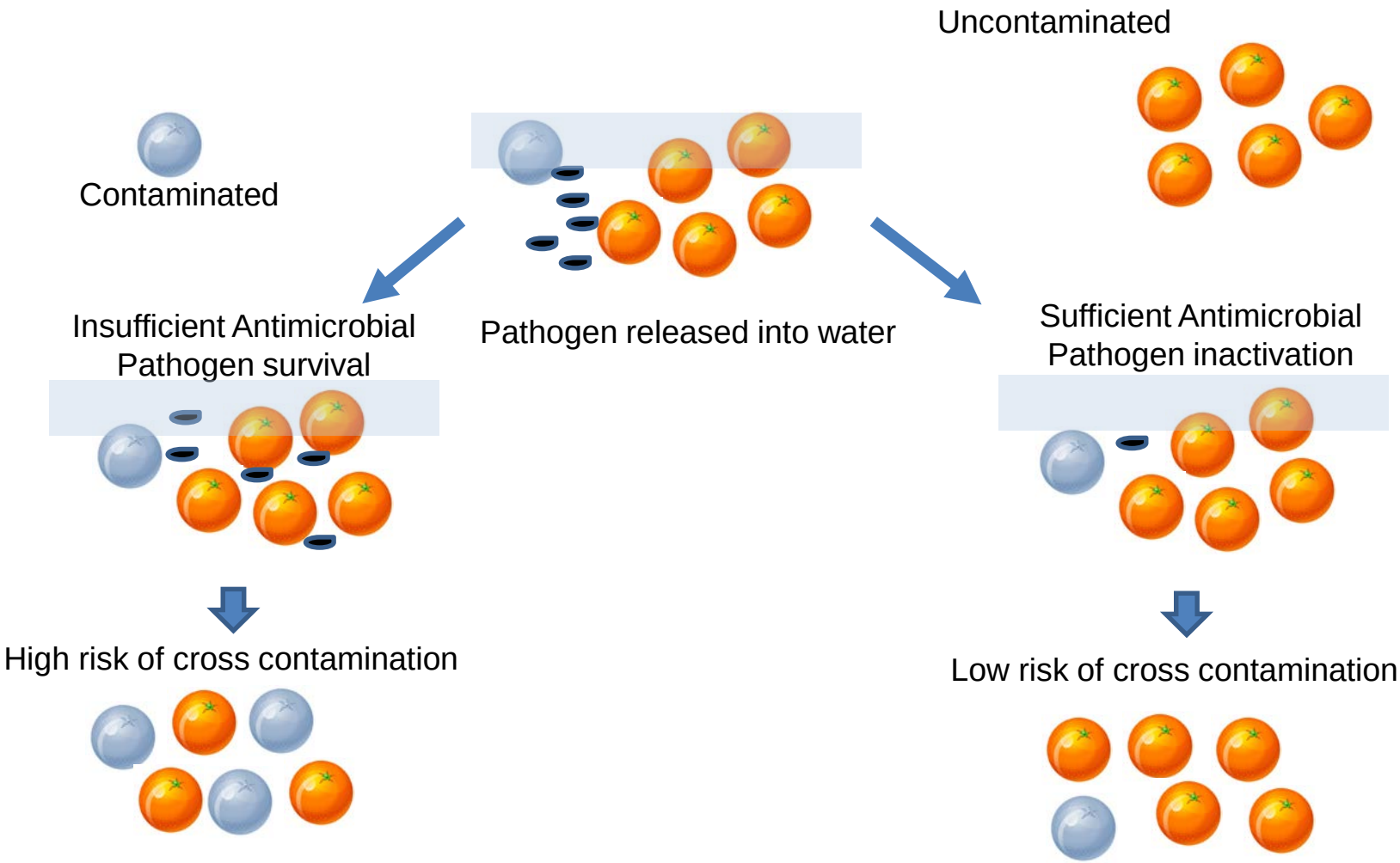
Fresh Citrus Food Safety Fungicide Application

Previous Studies
Citrus packinghouse chemicals

- Under laboratory conditions
- No reduction of *Salmonella*:
  - Imazalil
  - Fludioxonil
  - Pyrimethanil
- Slow reduction of *Salmonella*:
  - Imazalil and potassium phosphite

Unknown/uncharacterized cross contamination risk

Aqueous mediated cross contamination

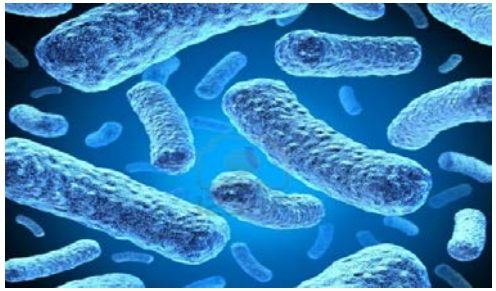


Preventing Cross-Contamination

It's a Race Between

Rate of inactivation

Bacterial detachment from contaminated ~~leaf~~ fruit



Bacterial inactivation in antimicrobial wash

Bacterial attachment to uncontaminated ~~leaf~~ fruit

… and complicated by water quality dynamics affecting antimicrobial effectiveness

Slide courtesy of J. Gorny

Summary of informal survey results. Data were received from five individuals; six participated in the ranking. June-July 2016

Imazalil + PAA								
	IMZ Concentration (ppm)	PAA (ppm)	Temperature	pH	Time of use of solution		Time of Contact with Fruit	
	100, 150, 250, 300, 350, 500	25-85, 30-50, 30-80	60-120, 90-135 (°F)		Tank	Spray and Flooder	Tank	Spray and Flooder
Min	100	25	60	4	1 days	8 h	7 sec	5 sec
Max	500	85	135	7	7 days	3 weeks	1 min	30 sec

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Soda Ash (Tank)					
	Concentration %	Temperature (°F)	pH	Time of use of solution	Time of Contact with Fruit
	1, 2, 3	60, 75, 90, 95, 100, 105, 110, 112, 115 F			
Min	1	60	9.5	6 h	5 sec
Max	3	115	13	3 months	4 min

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Min	1	60	9.5	6 h	5 sec
Max	3	115	13	3 months	4 min

SBC								
	Concentration SBC (%)	Chlorine (ppm)	Temperature (°F)	pH	Time of use of solution		Time of Contact with Fruit	
	1 , 2, 2.5, 3, 4	10, 25, 30, 50, 100, 150, 200	60, 75 ,95, 105, 110, 115	8, 8.3, 9, 9.5, 10	Tank	Spray and Flooder	Tank	Spray and Flooder
Min	1	10	60	8	1 week	4 h	1 min	5 sec
Max	4	200	115	10	3 months	3 days	4 min	22 sec

Recent Results
See other Presentation

Next Steps

Defining Industry Needs

- "Validation"
  - Proving antimicrobial application is sufficient to consistently prevent cross contamination
    - Minimum concentration present at all times in all places
  - Under all conditions of use
    - Product volume, type
    - Impact of time of use (e.g., days, weeks, months)

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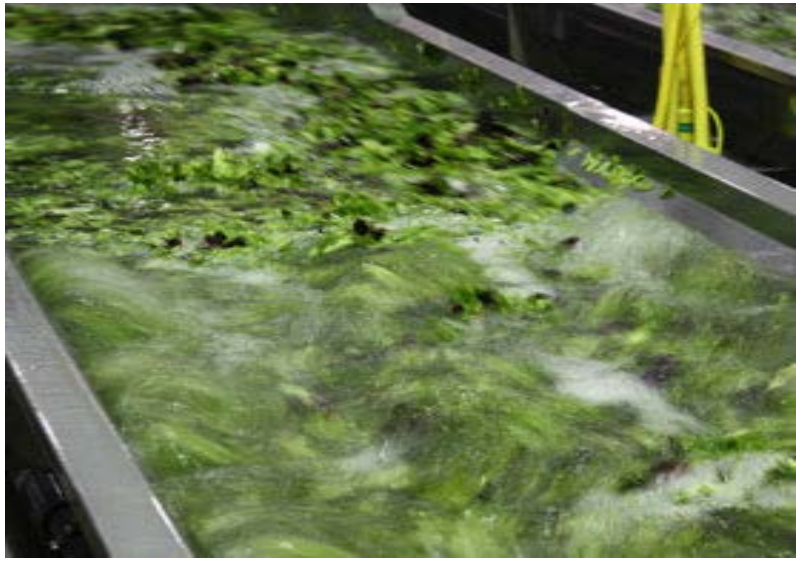
General Interest

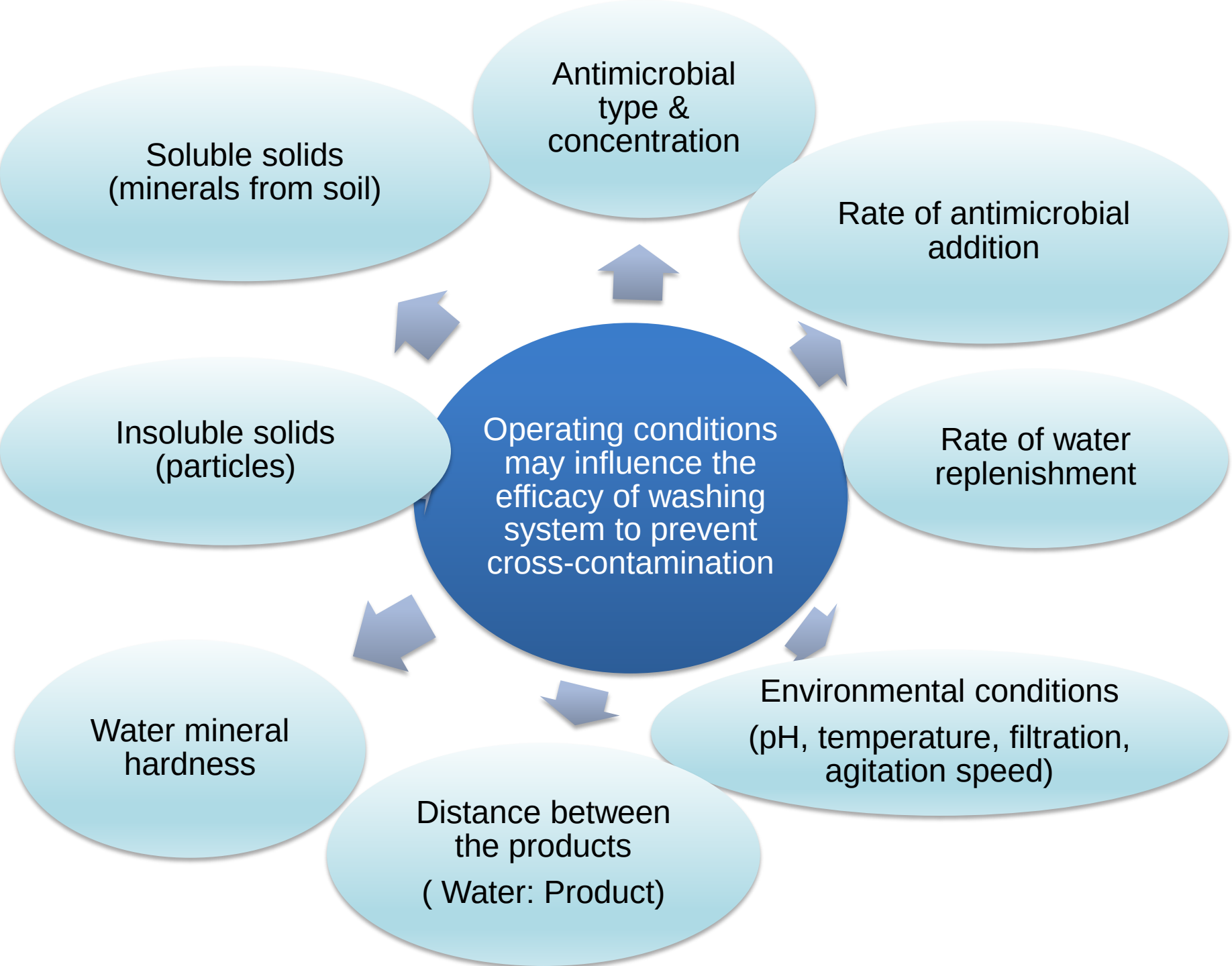
Guidelines To Validate Control of Cross-Contamination during Washing of Fresh-Cut Leafy Vegetables

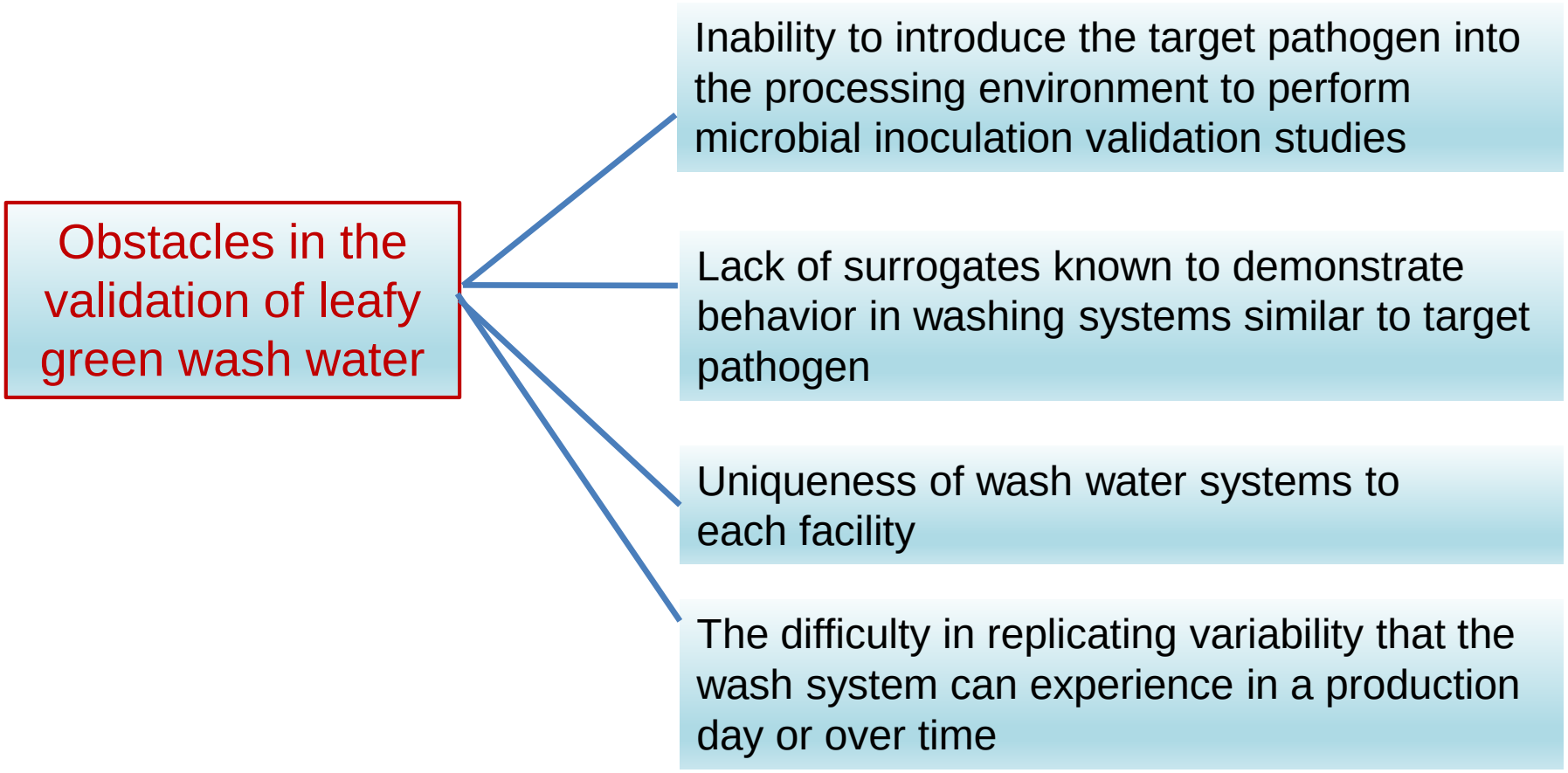
D. GOMBAS,[1] Y. LUO,[2] J. BRENNAN,[3] G. SHERGILL,[4†] R. PETRAN,[5] R. WALSH,[5] H. HAU,[5] K. KHURANA,[6‡] B. ZOMORODI,[7] J. ROSEN,[8] R. VARLEY,[9] AND K. DENG[10*]



Validating Antimicrobial Use

- Target is “absence of cross-contamination”
- Not a clear procedure, e.g. thermal process
- Not a clear performance standard,
  e.g. 5-log reduction in 1 min
- “Safe harbor” conditions not understood


Antimicrobial type & concentration
Soluble solids (minerals from soil)
Rate of antimicrobial addition
Insoluble solids (particles)
Operating conditions may influence the efficacy of washing system to prevent cross-contamination
Rate of water replenishment
Water mineral hardness
Environmental conditions
(pH, temperature, filtration, agitation speed)
Distance between the products
(Water: Product)

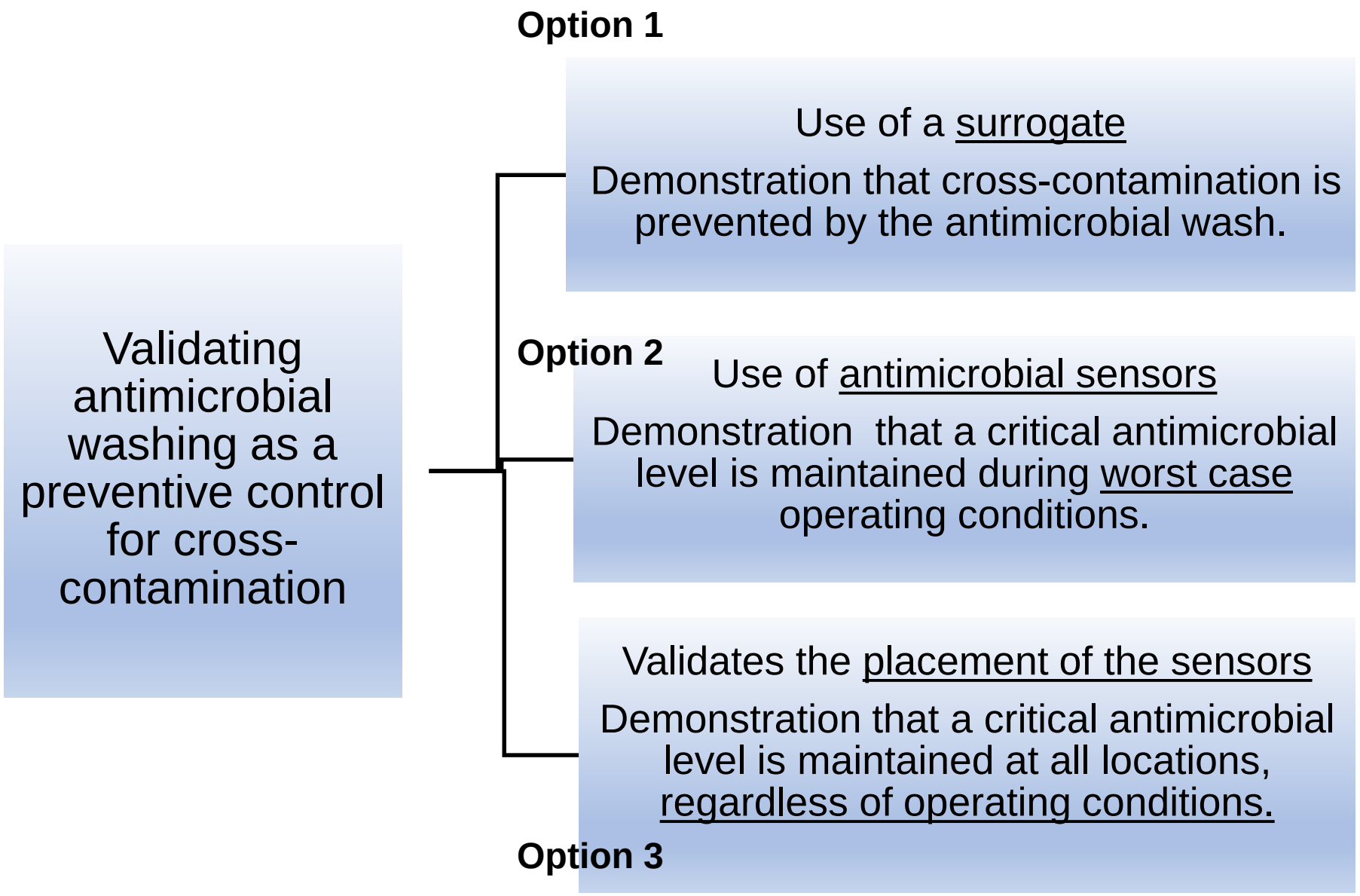

Obstacles in the validation of leafy green wash water
Inability to introduce the target pathogen into the processing environment to perform microbial inoculation validation studies
Lack of surrogates known to demonstrate behavior in washing systems similar to target pathogen
Uniqueness of wash water systems to each facility
The difficulty in replicating variability that the wash system can experience in a production day or over time

Laboratory-based studies
Inhibitory Concentrations

- Influence of
  - Water pH
  - Temperature
  - Organic load
  - Solids level

How can these be defined/replicated?
Range of products/volume/practices

- Defining "worst case" challenge
  - Heterogeneity of industry
  - Multiple products and practices

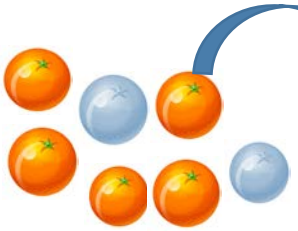

Validating antimicrobial washing as a preventive control for cross-contamination
Option 1
Use of a surrogate
Demonstration that cross-contamination is prevented by the antimicrobial wash.
Option 2
Use of antimicrobial sensors
Demonstration that a critical antimicrobial level is maintained during worst case operating conditions.
Validates the placement of the sensors
Demonstration that a critical antimicrobial level is maintained at all locations, regardless of operating conditions.
Option 3

Option 1:

Microbiological validation using a surrogate

Option 1

Positive Control Test



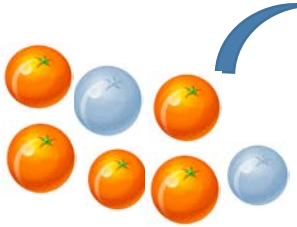
No antimicrobial

beginning of the process (worst-case conditions)

End of the wash process

Collect uninoculated and inoculated product

Negative Control Test



Antimicrobial > Test level

beginning of the process (worst-case conditions)

- Collect uninoculated and inoculated product
- Test the level of surrogate in wash water

Test level

Antimicrobial= Test level

beginning of the process (worst-case conditions)

- Collect uninoculated and inoculated product
- Test the level of surrogate in wash water

Lowest test level where the surrogate is not detectable on all uninoculated samples (3 trials) is the validated "Critical Limit" for antimicrobial feed rate.

Option 2:

Antimicrobial sensor validation

Option 2

Positioning the sensors to map locations with the lowest antimicrobial level during operation (worst case)

Run the system without product or antimicrobial (worst case levels)

Begin product feed (worst case level) minimize the variability and record all variable parameters

Begin the antimicrobial feed rate (lowest level)

Raise it, and wait for equilibrium

Stop when all sensors ≥ established minimum antimicrobial level

The lowest antimicrobial feed rate that achieves equilibrium ≥ the established minimum antimicrobial level at all sensors (in all 3 runs) becomes the "Critical Limit".

Option 3:

Validation of sensor placement for minimum antimicrobial level

Option 3

Positioning the sensors to map locations with the lowest antimicrobial level during operation (normal)

Begin running the system with product and antimicrobial Record all sensor readings

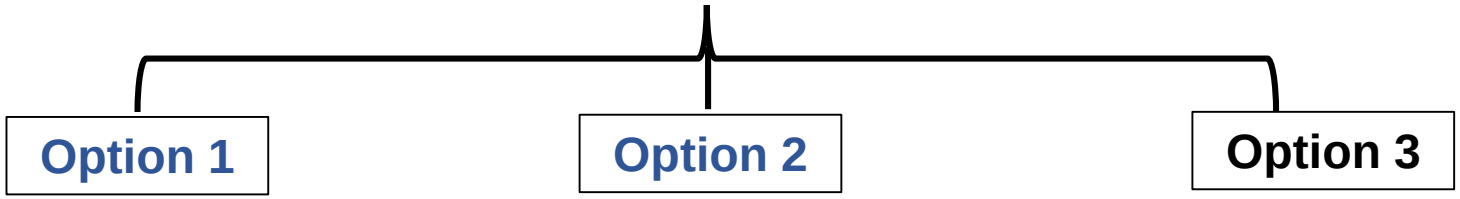
Run the system under multiple conditions of the variable parameters (as many acceptable variable conditions as possible)

The trial is completed when it is confirmed where the lowest level

of antimicrobial exists in the wash system

The highest sensor readings at the monitoring location, when the lowest level sensor was at the established minimum antimicrobial level during the validation trials is the “Critical Limit”.

Monitoring and Verification of Process Controls



Validation of the minimum antimicrobial feed rate under worst case conditions

Antimicrobial feed rate needs to be monitored during normal production (≥ Critical Limit)

Validation of the sensor positioning to monitor the minimum level of antimicrobial

antimicrobial level at the sensor needs to be monitored

Discussion