Hazard-based thermal and chemical interventions for beef and pigs USA experience

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USDA

USMARC

Showing Animals Respect and Kindness since 1965

RIBMINS

Working Groups 2 and 3

Training school on farm and abattoir inter[illegible]ions in a risk-based meat safety assura[illegible]e system

Virtual Event June 20-22, 2022.

Meat Safety and Quality Research Unit

Focus on control, prevention and detection of foodborne pathogens entering the meat chain


In Animals



Transport and During Processing

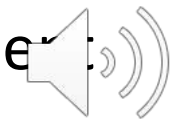

In Finished Products



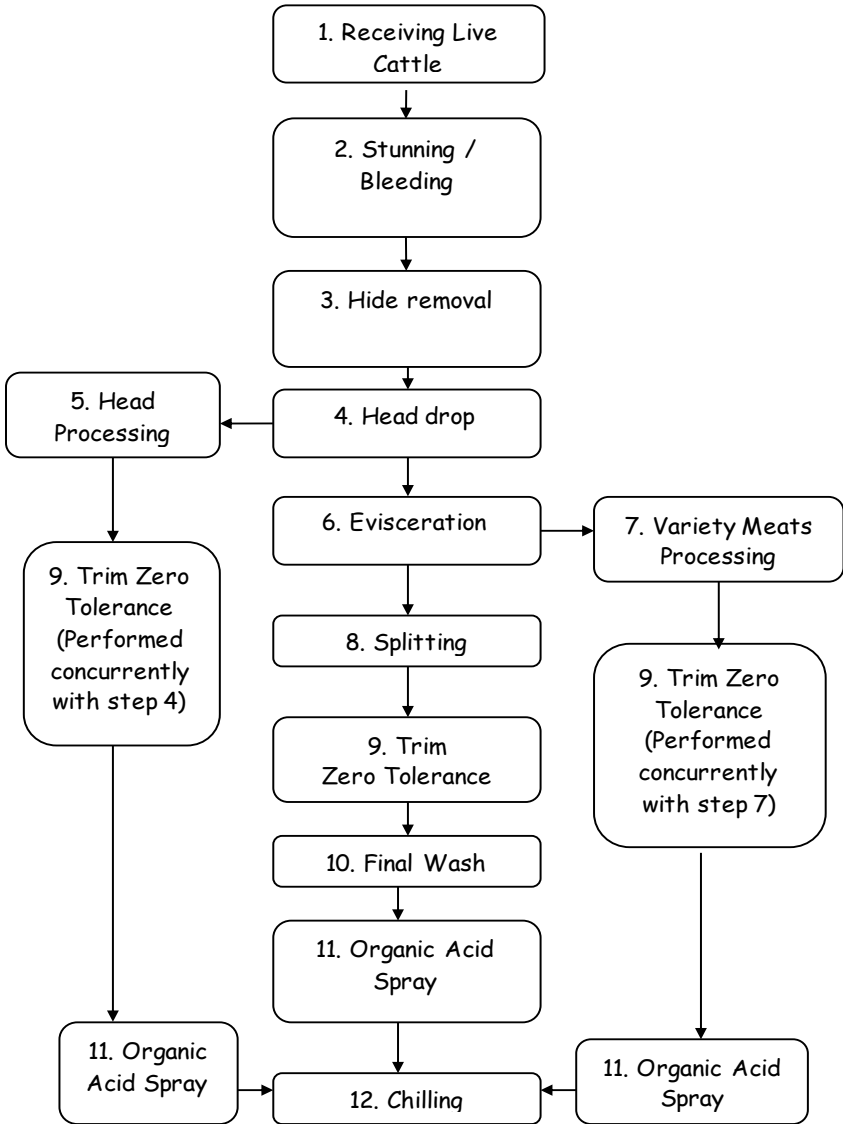


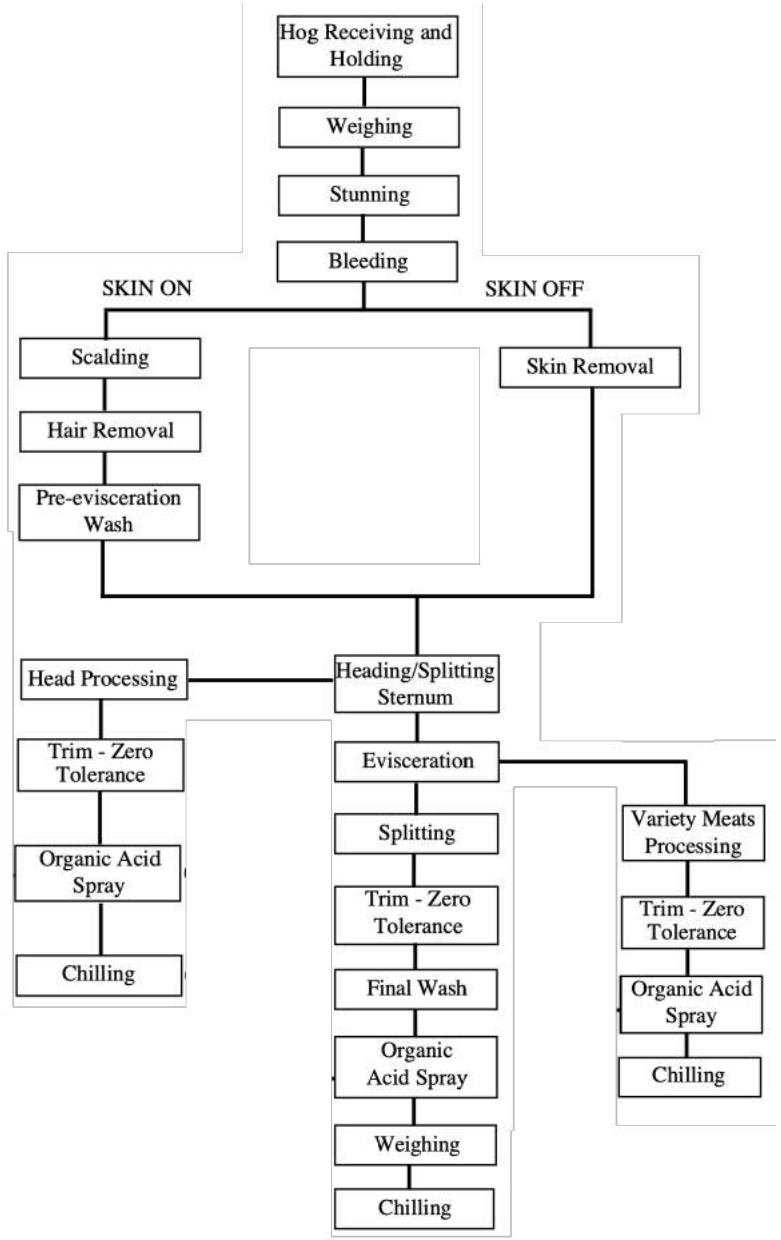
Thermal and chemical interventions used for beef and pork processing

- Points where interventions are applied
- Types of interventions
  - Thermal
  - Chemical
- Validating/Monitoring interventions are effective
  - Measurements
  - What is meant by “effective”
- Practical examples
  - On-line examples
  - Laboratory examples
  - How to evaluate a published study before using it as a supporting document



Beef and Pork Processing Flow Diagrams





U Wisc – Madison, Center for Meat Process Validation

Texas A&M University - Rosenthal Meat Science and Technology Center

Points to apply interventions to reduce contamination







Focus on harvest and processing steps that are most likely to contribute to carcass contamination

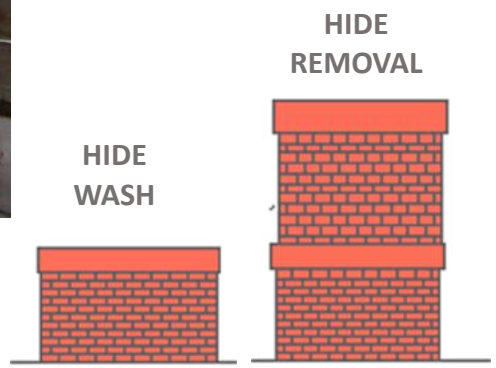
Pork Slaughter Systems Use a Multiple Hurdle Approach

- Skins – scalded and dehaired
- Pre-Evisceration Carcass Treatment
- Final Carcass Cleansing
- Rapid Blast Chilling

"The hurdle approach involves combining several mitigating approaches, each of which is insufficient on its own, to control or even eliminate pathogens in food products." **– Mogren et al 2018, Front Microbiol 9:1965**

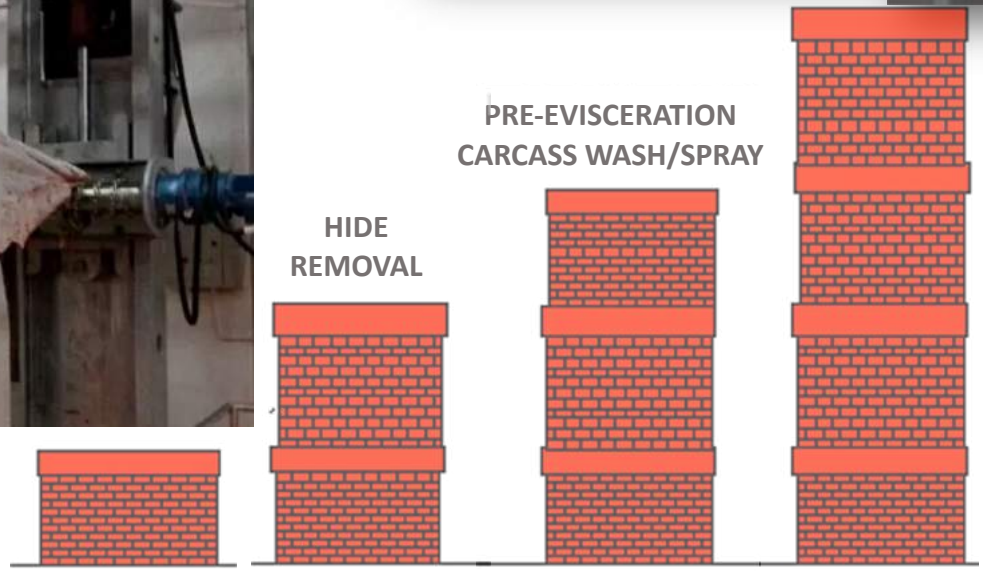
Beef Slaughter Systems Use a Multiple Hurdle Approach

- Hides



Beef Slaughter Systems Use a Multiple Hurdle Approach

- Hides
- Pre-Evisceration Carcass Treatment
- Knife trimming



Treatment of Final Carcasses

- Evisceration and splitting can lead to contamination
- Final washes and interventions applied
- In some cases, treatments continue during chilling

Spray chill water or blast chill fogging applied to final carcass may contain an antimicrobial

Thermal and chemical interventions used for beef and pork processing

- Points where interventions are applied
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Anywhere contamination may occur should be immediately followed by a treatment to remove contaminants before they can adhere to the carcass

Common thermal and chemical interventions

- FSIS Directive 7120.1
  - Safe and Suitable Ingredients Used in the Production of Meat, Poultry, and Egg Products
- “Ingredient” versus a “Processing Aid”
  - Ingredients must be listed on product label, but not processing aids
  - Processing aids are:
    - Added during the processing of a food but removed in some manner from the food before it is packaged
    - Converted into constituents normally present in the food, and do not significantly increase the amount of the constituents naturally found in the food
    - Present in the finished food at insignificant levels and do not have any technical or functional effect in that food

Common thermal and ns

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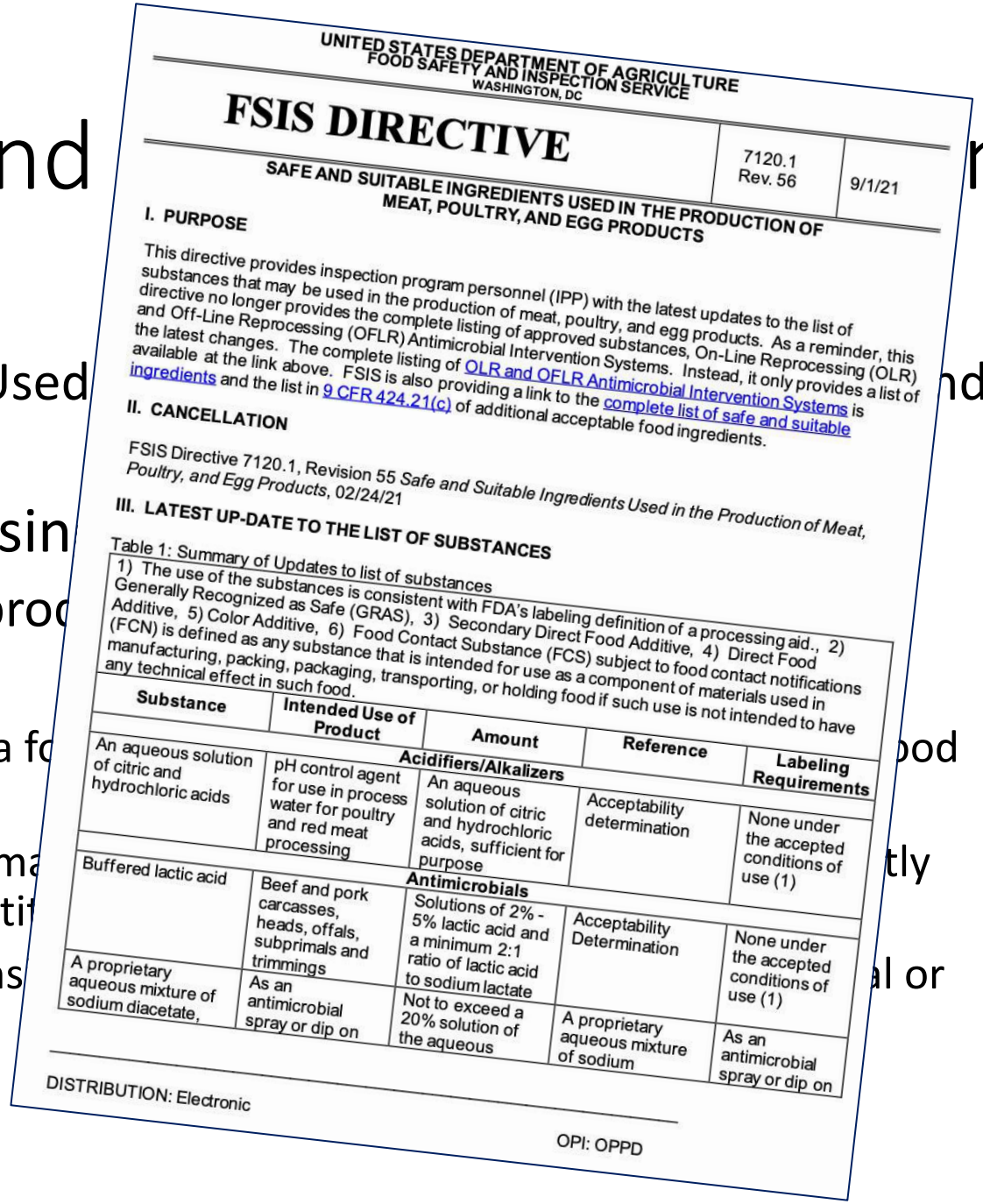


UNITED STATES DEPARTMENT OF AGRICULTURE
FOOD SAFETY AND INSPECTION SERVICE
WASHINGTON, DC

FSIS DIRECTIVE | 7120.1 Rev. 56 | 9/1/21

SAFE AND SUITABLE INGREDIENTS USED IN THE PRODUCTION OF MEAT, POULTRY, AND EGG PRODUCTS

I. PURPOSE

This directive provides inspection program personnel (IPP) with the latest updates to the list of substances that may be used in the production of meat, poultry, and egg products. As a reminder, this directive no longer provides the complete listing of approved substances, On-Line Reprocessing (OLR) and Off-Line Reprocessing (OFLR) Antimicrobial Intervention Systems. Instead, it only provides a list of the latest changes. The complete listing of OLR and OFLR Antimicrobial Intervention Systems is available at the link above. FSIS is also providing a link to the complete list of safe and suitable ingredients and the list in 9 CFR 424.21(c) of additional acceptable food ingredients.

II. CANCELLATION

FSIS Directive 7120.1, Revision 55 *Safe and Suitable Ingredients Used in the Production of Meat, Poultry, and Egg Products*, 02/24/21

III. LATEST UP-DATE TO THE LIST OF SUBSTANCES

Table 1: Summary of Updates to list of substances

1) The use of the substances is consistent with FDA's labeling definition of a processing aid., 2) Generally Recognized as Safe (GRAS), 3) Secondary Direct Food Additive, 4) Direct Food Additive, 5) Color Additive, 6) Food Contact Substance (FCS) subject to food contact notifications (FCN) is defined as any substance that is intended for use as a component of materials used in manufacturing, packing, packaging, transporting, or holding food if such use is not intended to have any technical effect in such food.

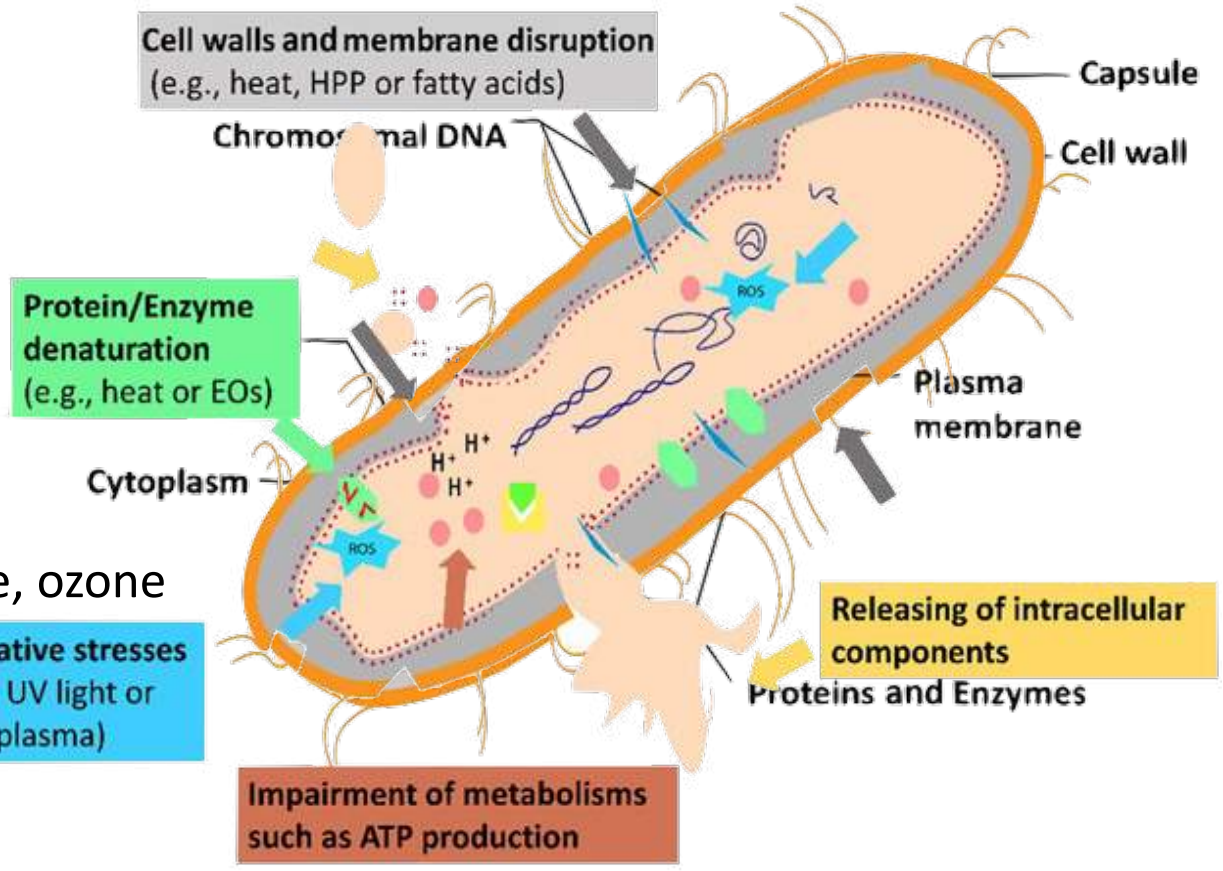
Substance	Intended Use of Product	Amount	Reference	Labeling Requirements
Acidifiers/Alkalizers				
An aqueous solution of citric and hydrochloric acids	pH control agent for use in process water for poultry and red meat processing	An aqueous solution of citric and hydrochloric acids, sufficient for purpose	Acceptability determination	None under the accepted conditions of use (1)
Antimicrobials				
Buffered lactic acid	Beef and pork carcasses, heads, offals, subprimals and trimmings	Solutions of 2% - 5% lactic acid and a minimum 2:1 ratio of lactic acid to sodium lactate	Acceptability Determination	None under the accepted conditions of use (1)
A proprietary aqueous mixture of sodium diacetate,	As an antimicrobial spray or dip on	Not to exceed a 20% solution of the aqueous	A proprietary aqueous mixture of sodium	As an antimicrobial spray or dip on

DISTRIBUTION: Electronic

OPI: OPPD

Common thermal and chemical interventions

- Thermal interventions
  - Steam
  - Hot water (~80C)
- Chemical interventions
  - Organic acids
    - lactic, acetic, peroxyacetic, and citric acids
  - Oxidizers
    - chlorine, bromine, acidified sodium chlorate, ozone
  - Quaternary ammonium compounds
    - cetylpyridinium chloride (CPC)
  - Alkali agents
    - trisodium phosphate, sodium hydroxide



Zhang et al. 2020. Comp Rev Food Sci Food Safety 19(4):2110-2138

What organisms do these interventions target?

- Pathogens
  - *Escherichia coli*
  - *Salmonella Enteritidis*
  - *Listeria monocytogenes*
  - *Staphylococcus aureus*
  - *Bacillus cereus*
  - *Clostridium perfringens*
  - *Campylobacter jejuni*
- Spoilage organisms

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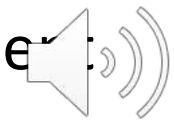


What measures can be used to monitor an intervention or antimicrobial treatment

- Indicator bacteria
  - Aerobic Plate Count Bacteria (APC)
  - Enterobacteriaceae Counts (EBC)
  - Coliform Counts (CF)
  - *E. coli* Counts (ECC)
  - Concentration (CFU/cm^2)
- Pathogens
  - *E. coli* and *Salmonella*
  - Prevalence (%)
  - Concentration (CFU/cm^2)

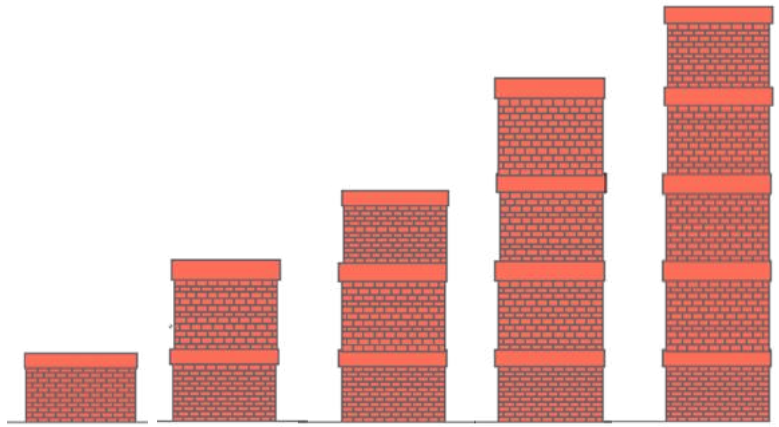
- Measure online before and after intervention
- May be too low to measure at final carcass

- May be present on early carcasses
- Concentrations usually too low to measure
- Often used in inoculation studies to validate treatments

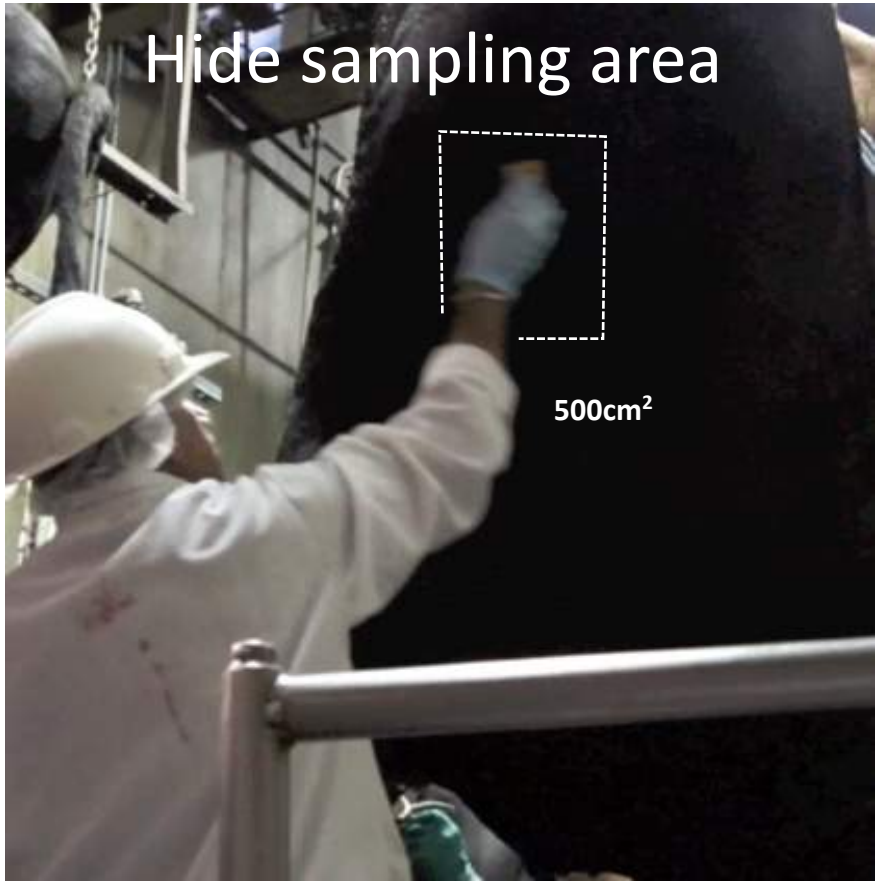
What measures can be used to monitor an intervention or antimicrobial treatment

- Online in processing plant
  - APC
  - EBC
  - *E. coli* /coliforms
  - Pathogen prevalence / concentration
- In lab running inoculation study
  - APC, EBC, EC, CF
  - Pathogens: STEC, *Salmonella*, *Listeria*
- The reduction in the concentration of bacteria after a treatment allows us to say how "effective" it is
  - >1 $\log_{10}$ CFU reduction or killing 90% or more of bacteria

A proper sample must first be collected before and after the treatment to measure its effect

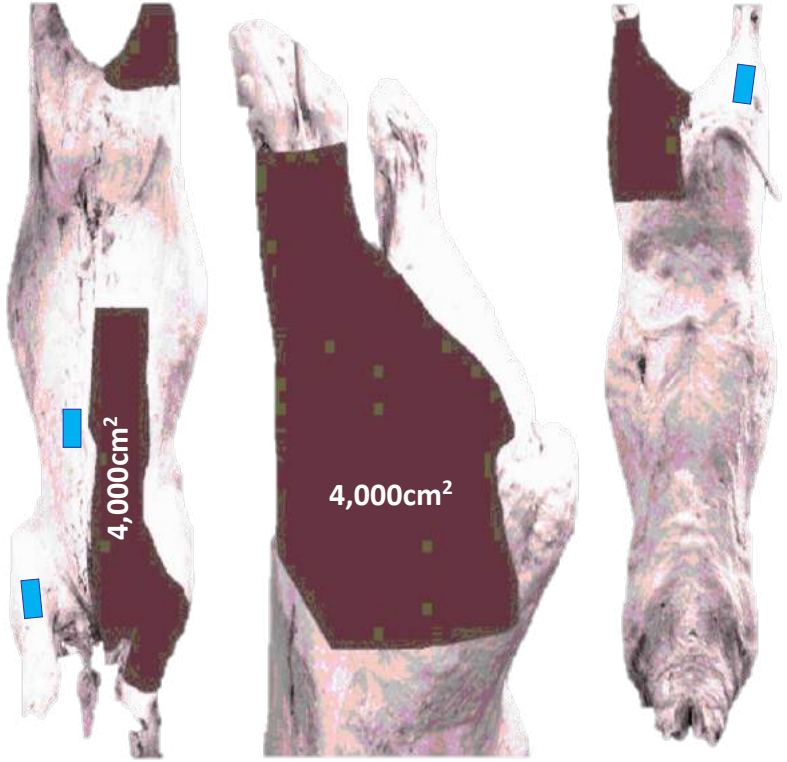


Sample collection online during processing



Boxed area represent location and area hide samples are collected.

Carcass sampling areas



Shaded areas represent where carcass sponge samples are collected

Alternately, three **100cm²** areas (hock/round, midline, and shank/neck) may be collected

Larger sample areas provide greater organism recovery, to better measure prevalence or concentration

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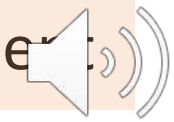

Thermal and chemical interventions used during pork slaughter

- Scalding and dehairing
  - Before: skin at stunning
  - After: postscald at pre-evisceration
- Pre-Evisceration carcass treatment
- Final carcass wash and lactic acid spray
  - Final carcasses (Plant B used -30C blast chill)

- Concentrations of indicator organisms (APC and EBC) at each point

TABLE 1 APC and EBC[a] on pork carcasses by sample site, processing plant, and season

		APC count (log_{10} CFU/100 cm^2)			EBC count (log_{10} CFU/100 cm^2)		
Season[b]	Plant	Skin[c]	Postscald[d]	Final[e]	Skin	Postscald	Final
	A	6.50b	3.91a	2.48a	4.41a	2.28a	0.88a
	B	6.93a	3.53b	2.22b	4.37a	1.50b	0.49b
Winter		6.27y	3.28x	1.92y	4.06y	1.66y	0.49y
Spring		6.79x	2.85z	1.80y	4.51x	1.85x	0.51y
Summer		7.85w	5.59w	3.15w	5.01w	2.56w	1.02w
Fall		5.95z	3.05y	2.53x	3.99z	1.77xy	0.73x

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- Concentrations of indicator organisms (APC and EBC) at each point
- Prevalence of *E. coli* (Shiga toxin E. coli; STEC) detected at each point

TABLE 2 Prevalence[a,i] of STEC[b] and EHEC[c] in samples collected from pork processing as determined by PCR[d]

Season[e]	Plant	No. of samples	% of STEC-positive samples			% of EHEC-positive samples		
			Skin[f]	Postscald[g]	Final[h]	Skin	Postscald	Final
All		1,536	85.3	17.5	5.4			
	A	768	81.3y	13.8y	8.2x			
	B	768	89.3x	21.2x	2.6y			
Winter		384	41.7r	20.3q	3.6qr			
Spring		384	100.0q	11.2r	3.4r			
Summer		384	99.5q	19.0q	7.6q			
Fall		384	100.0q	19.5q	7.0qr			

Thermal and chemical interventions used during beef slaughter

Lactic acid and hot water wash treatments of pre-evisceration beef carcasses

Log_{10} APC/100cm^2	Lactic Acid (n = 256)	Hot Water (n = 256)	Sequential (n = 256)
Before Treatment	6.1	6.2	6.4
After Treatment	4.5	3.5	4.2
Reduction	1.6	2.7	2.2
P value	0.001	0.001	0.001

Bosilevac 2006

Thermal and chemical interventions used during beef slaughter

Lactic acid and hot water wash treatments of pre-evisceration beef carcasses

Percent (%) Prevalence of *E. coli* O157:H7	Lactic Acid (n = 256)	Hot Water (n = 256)	Sequential (n = 256)
Before Treatment	31%	27%	19%
After Treatment	20%	5%	4%
Reduction	35%	81%	79%
P value	0.01	0.001	0.001

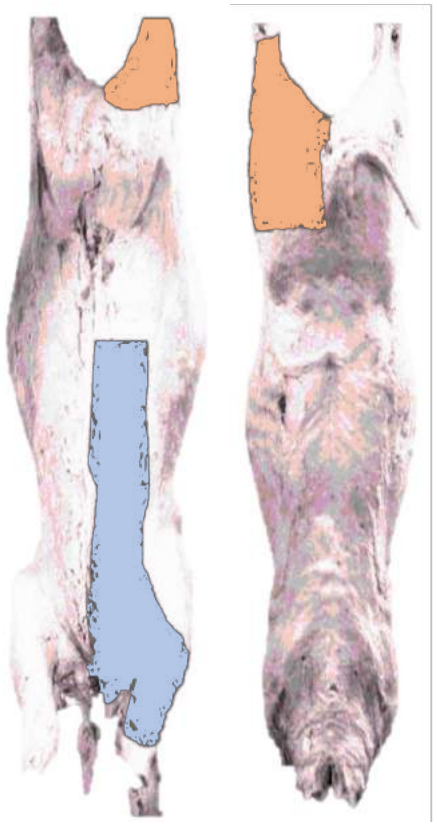
Bosilevac 2006

Chemical interventions used during beef slaughter

- Examples of sample collection that may impact chemical intervention measurements
  - Location on the carcass sampled
  - The type of sponge or swab used to collect the sample
  - Buffers used to neutralize chemical interventions
- Online beef carcass results

Chemical interventions used during beef slaughter

- Locations on a carcass
  - Top: inside and outside round
  - Bottom: navel-plate-brisket-foreshank
  - Beef carcasses before and after a pre-evisceration wash and peroxyacetic acid (PAA) or lactic acid sprays.
  - Measure APC, EBC, Coliforms, and *E. coli*

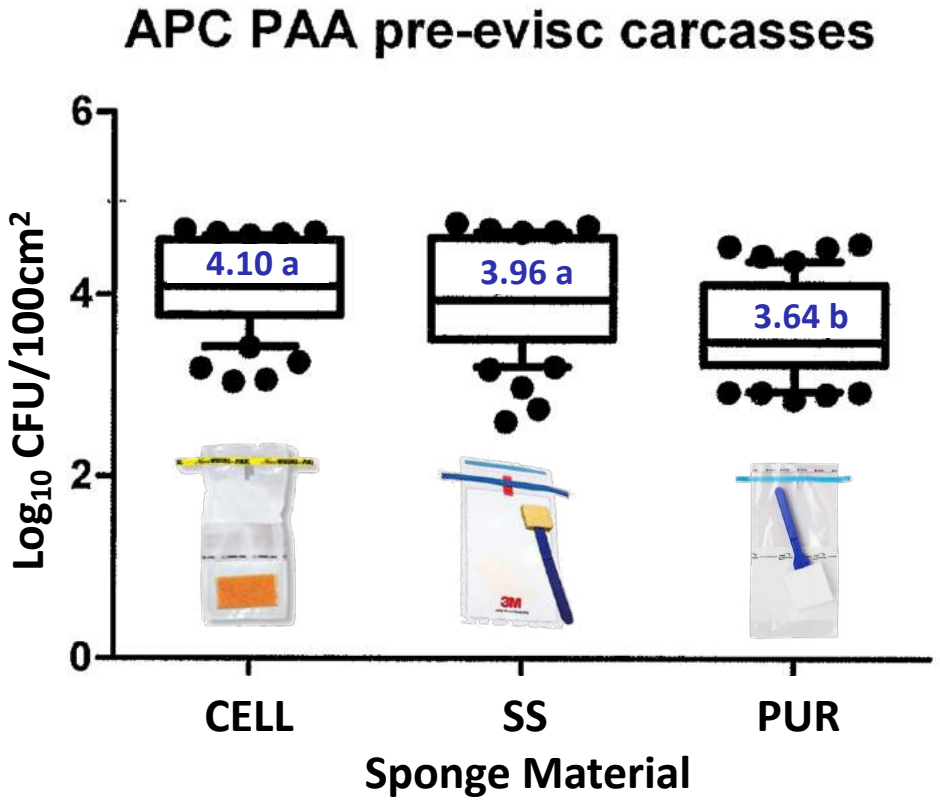


Mean log_{10} CFU/100 cm^2 of indicator bacteria by sample site

Sample	APC	EBC	Coliforms	*E. coli*
	Pre – intervention			
Top	5.9 B	2.2 B	2.0 A	1.8 AB
Bottom	6.1 B	1.7 C	1.8 AB	1.7 B
Combined	6.4 A	2.9 A	2.1 A	1.9 A
	Post – intervention			
Top	5.3 C	1.3 CD	1.6 BC	1.4 C
Bottom	4.3 D	-0.8 E	0.2 D	-0.3 D
Combined	5.3 C	1.1 D	1.6 C	1.3 C
	Reduction			
Top	0.6	0.9	0.4	0.4
Bottom	1.8	2.5	1.6	2.0
Combined	1.1	1.8	0.5	0.9

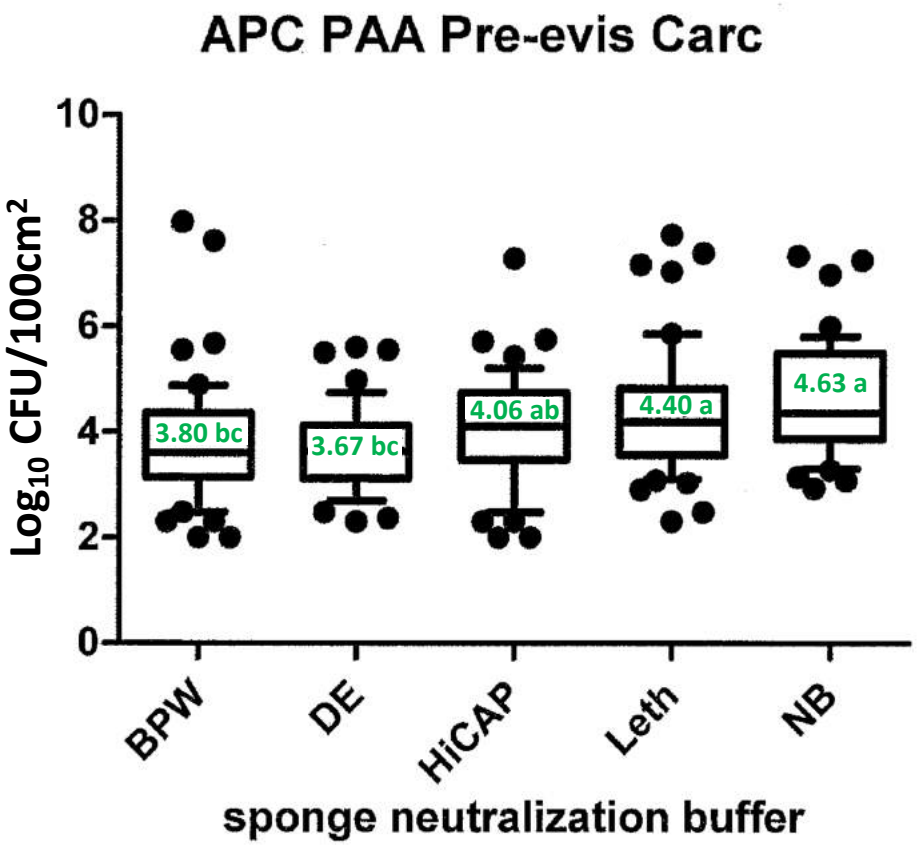
Chemical interventions used during beef slaughter

- Sponges and swabs
  - Beef carcasses after a pre-evisceration wash and peroxyacetic acid (PAA) spray
  - Measure APC collected from 2,000 cm^2 along brisket/midline
  - Cellulose sponges (CELL)
  - Cellulose sponges on a handle (a.k.a.: sponge on stick; SS)
  - Polyurethane sponges on a handle (PUR)



Chemical interventions used during beef slaughter

- Neutralization Buffers
  - Beef carcasses after a pre-evisceration wash and peroxyacetic acid (PAA) spray
  - Measure APC collected from 2,000 cm^2 along brisket/midline
  - Buffered Peptone Water (BPW)
  - Dey-Engley Neutralizing Broth (DE)
  - High Capacity Neutralizing Broth (HiCap™)
  - Letheen Broth (Leth)
  - Difco™ Neutralizing Buffer (NB)



Chemical interventions used during beef slaughter

- Neutralization Buffers
  - Finished beef carcasses entering cooler after a hot water wash and lactic acid (LA) spray
  - Measure APC collected from 2,000 cm^2 along brisket/midline
  - Buffered Peptone Water (BPW)
  - Dey-Engley Neutralizing Broth (DE)
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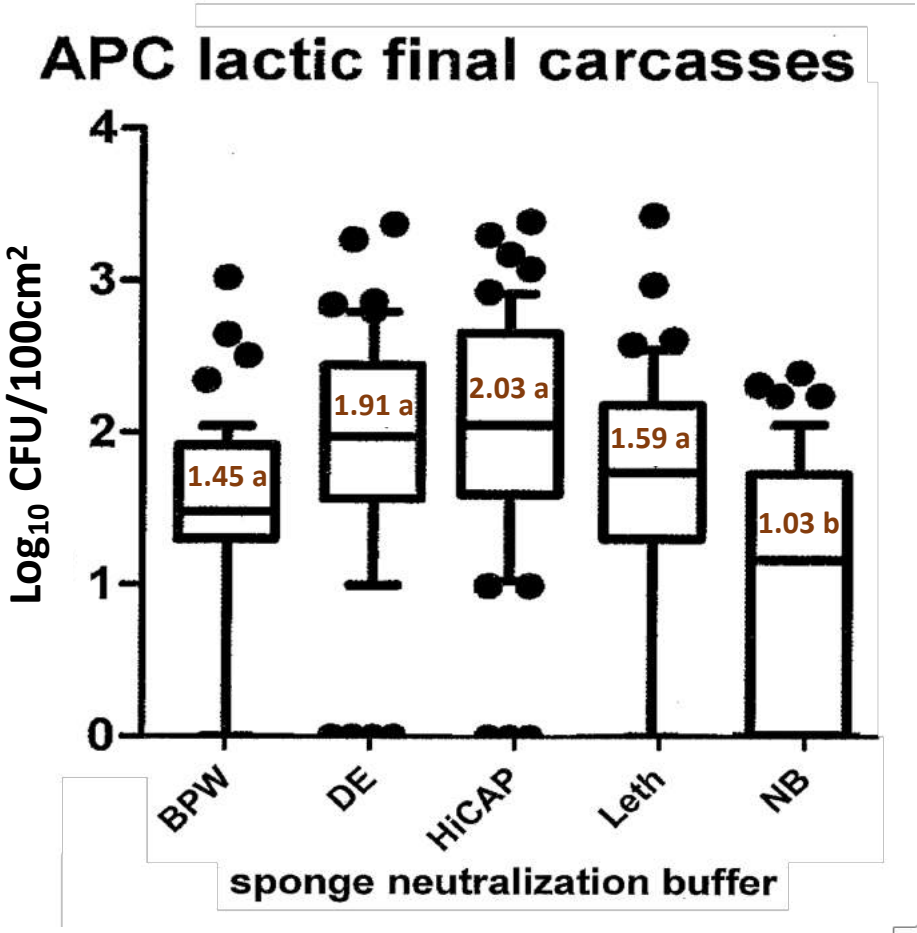
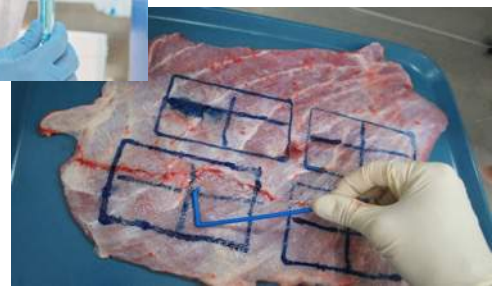


Chemical interventions used during beef slaughter

- Examples of sample collecti[illegible]hat may[illegible]t chemical i[illegible] measurements
  - Location[illegible]e [illegible]rca[illegible]mp
  - The type [illegible]r[illegible] u[illegible]o col
  - Buffers use[illegible]ize chemical inte[illegible]
- Online beef carcass results
  - Locations on a carcass are not equally contaminated
  - Sponges are not all the same
  - Buffers are not all the same
- As long as a consistent sampling plan using like materials is maintained, then results can be compared over time to monitor interventions are remaining effective

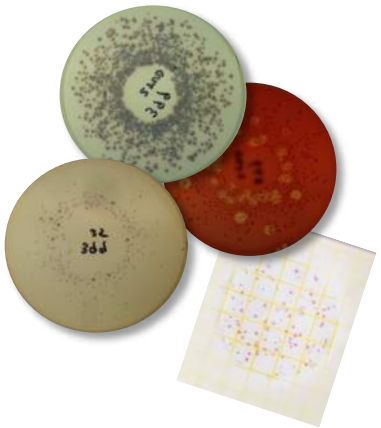
Carcass surface inoculation studies allow best estimate of on-line efficacy of an intervention

Inoculate



Treat

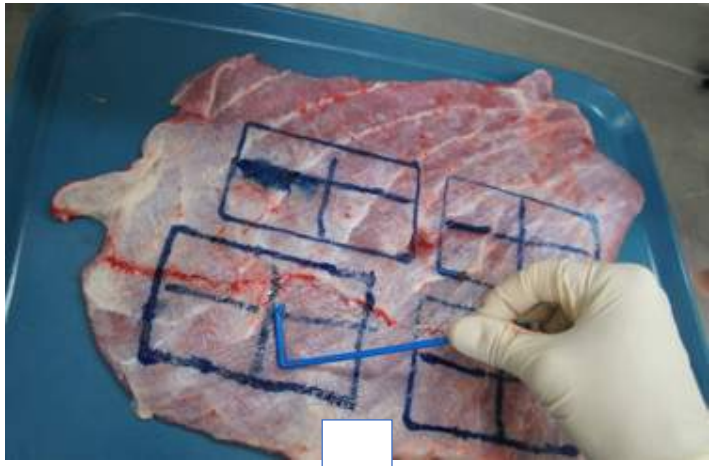
Collect samples and plate



Record results

Pooled strains diluted in beef purge provide simultaneous measurement of STEC groups, Salmonella serovars*, Listeria species, and indicator organisms.*

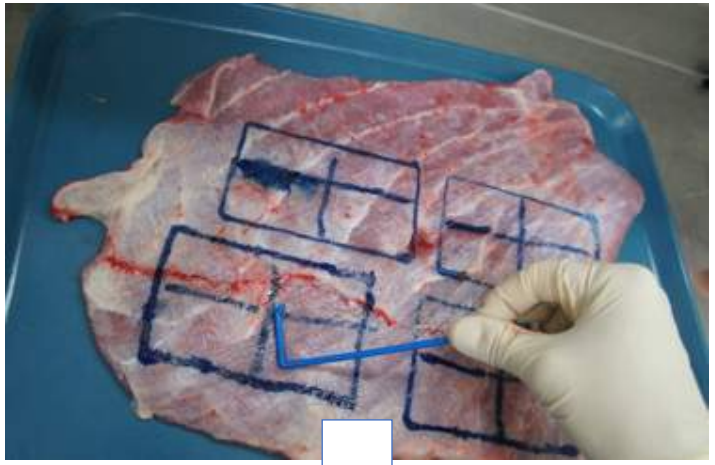
Evaluating Published Results of Inoculation Studies

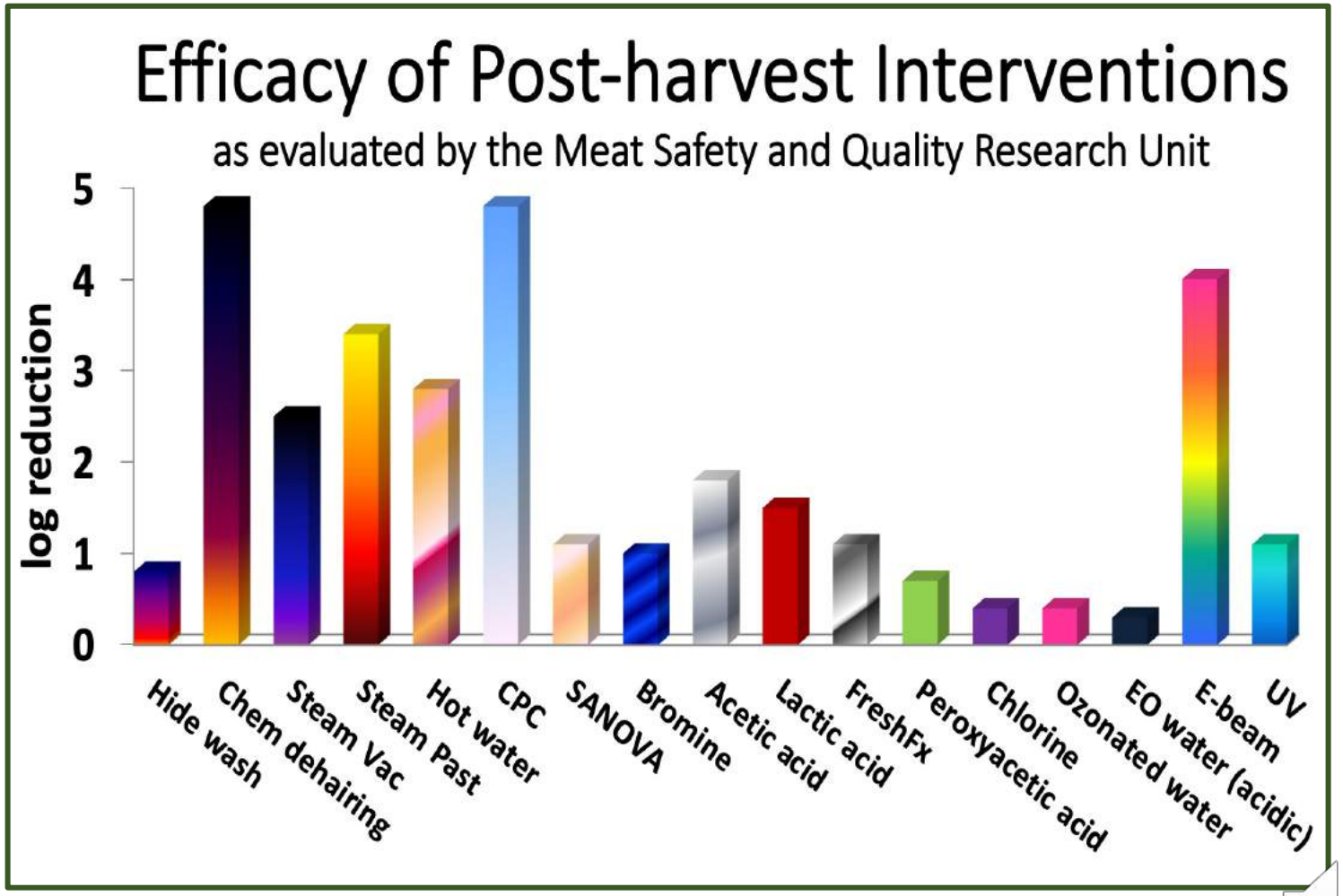


Treatment	Log_{10} Reduction			
	O157	Sal	APC	EBC
ASC	1.0	1.6	1.1	1.1
PAA	1.5	0.9	1.1	-
BR	1.0	0.8	0.8	0.8
FX	1.4	1.7	1.4	1.6
LA	2.3	2.6	1.4	-
HW	4.0	4.3	2.9	-

ASC = acidified sodium chlorite; PAA = peroxyacetic acid;
BR = bromine; FX = FreshFx ; LA = lactic acid ; HW = hot water

Evaluating Published Results of Inoculation Studies





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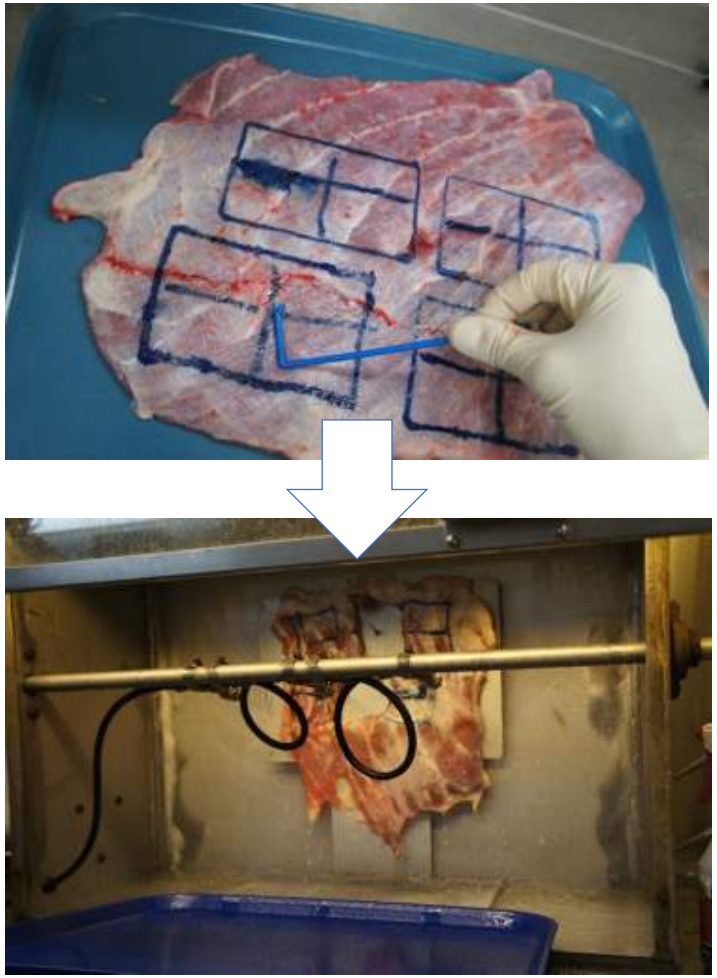

Treatment conditions

- 15-20 psi for 15 sec
- Hot water; 85°C at nozzles
- Lactic acid; 4%, pH = 2.3
- Peroxyacetic acid; 200 ppm, pH = 2.8 (Inspexx™)
- Bromine compounds; 300ppm (Bromitize™, H2B™)
- Acidified sodium chlorite; 1000 ppm, pH =2.4 (Sanova™)
- Citric/phosphoric/hydrochloric acid blend; 2% pH = 1.7 (FreshFX™)

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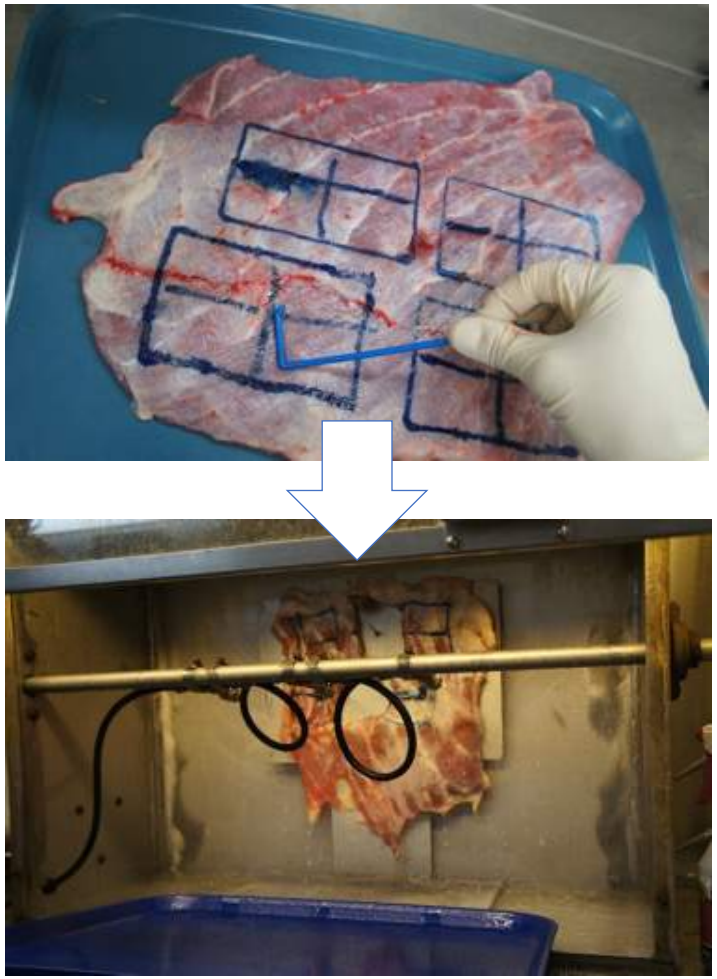

Treatment conditions

- 15-20 psi for 15 sec
- H
- L
- P xx™)
- B H2B™)
- A 4
  (
- Citric/phosphoric/hydrochloric acid blend; 2% pH = 1.7 (FreshFX™)

It is essential that before relying on a published report to support your use of a thermal or chemical intervention, you ensure the reported parameters match how you will be applying it. If not, you should perform your own validation study to show efficacy

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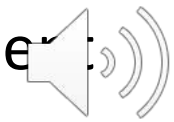
  - Measurements
  - What is meant by “effective”
- Practical examples
  - On-line examples
  - Laboratory examples
  - How to evaluate a published study before using it as a supporting document



Questions?