Technologies to improve food safety of Raw Meat

Keith Warriner

Department of Food Science

University of Guelph

ONTARIO FOOD PROTECTION ASSOCIATION

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56th Annual Meeting
Thursday November 20th, 2014
Mississauga Convention Center, 75 Derry Rd W, Mississauga

Dr Martin Appelt –CFIA

Dr Gavin Downing-OMAF

Dr Rick Holley-UoM

Dr Charmine Kuran- Health Canada

Peter Gould- DFO

Tom Graham-CFIA

Dr Kathleen Glass-UoW-M

Dr Emma Allen-Vercoe-UoG

Jennifer McCreary – NSF-GFTC

Pathogens of Concern

- Virus: Hepatitis E, Calicivirus, Norovirus
- Parasites: *Cryptosporidium, Giardia, Toxoplasma, Trichinella, Taenia*
- Bacterial: Shiga Toxin producing *Escherichia coli* (STEC), *Salmonella*, *Campylobacter jejuni*, *Listeria monocytogenes*, *Staphylococcus aureus*, *Yersina enterolitica*

- Endospore formers: *Clostridium botulinium, C perfringens, C difficile*

Most contamination is on the surface but not always

June 14, 2014 | Updated : June 14, 2014 | 12:35 pm

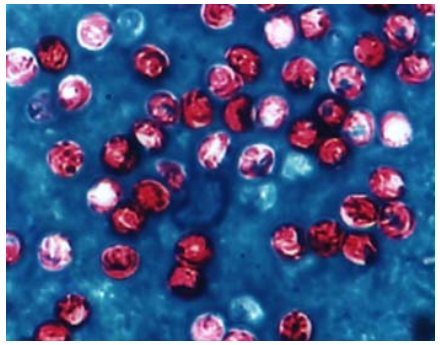
Toronto restaurants flout regulations to serve raw pork

By Staff
Torstar News Service

Jesse Grasso, head chef at The Black Hoof which serves rare pork dishes [illegible] regulations prohibiting it.

Parasites

Giardia



Cryptosporidium

Ascaris

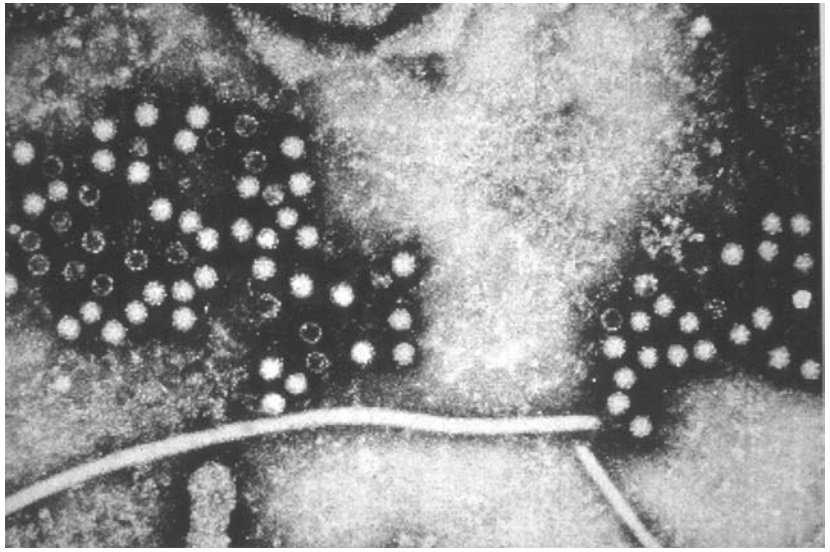
Swine Influenza

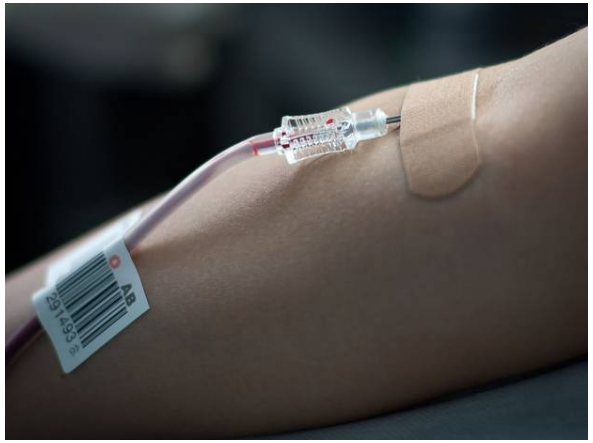
Trichinella

Hepatitis E

- Young adults (30-60%)
- High mortality in pregnant women (30-50%)
- Endemic within pork production (30% carriage)
- Liver: No chronic phase (2% fatality rate)

>60, 000 carriers (UK)





Farming Practices EU vs North America

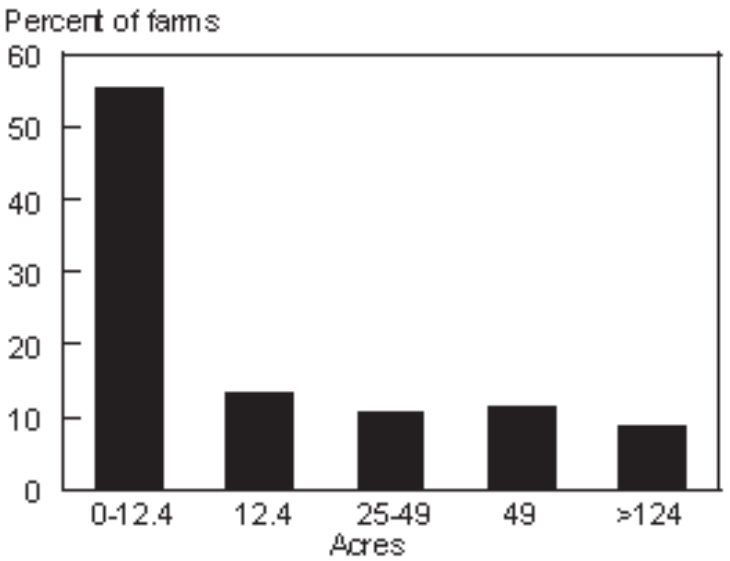
Europe

- Non-intervention
- Small production and processing
- Subsidized
- Net importer
- Preventative approach
  - GAP
  - GMP
  - HACCP

North America

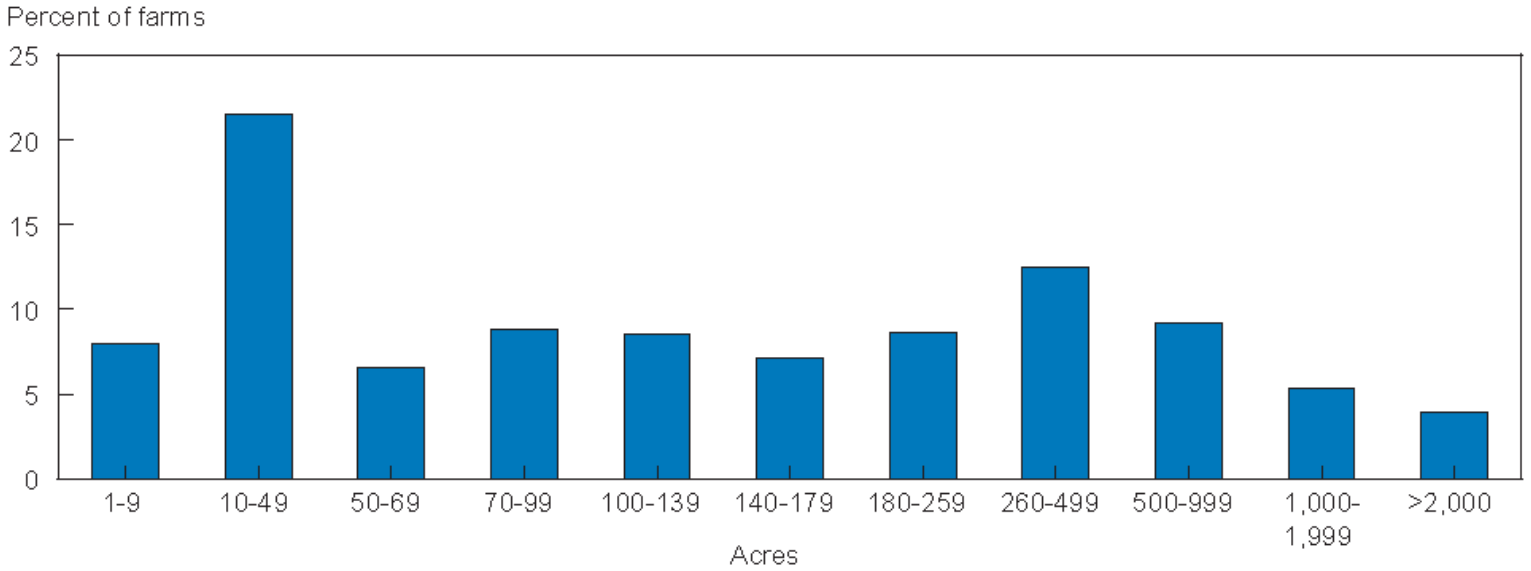
- Major producer
- Growth promoters
- Intensive farming
- Intervention based HACCP

EU distribution of farms by size, 1997

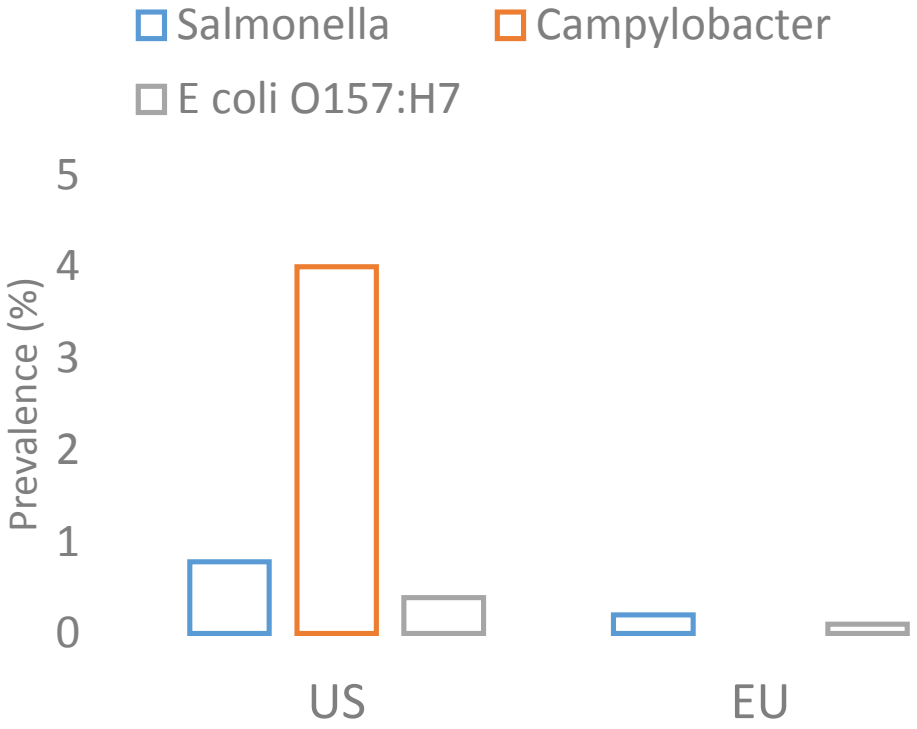


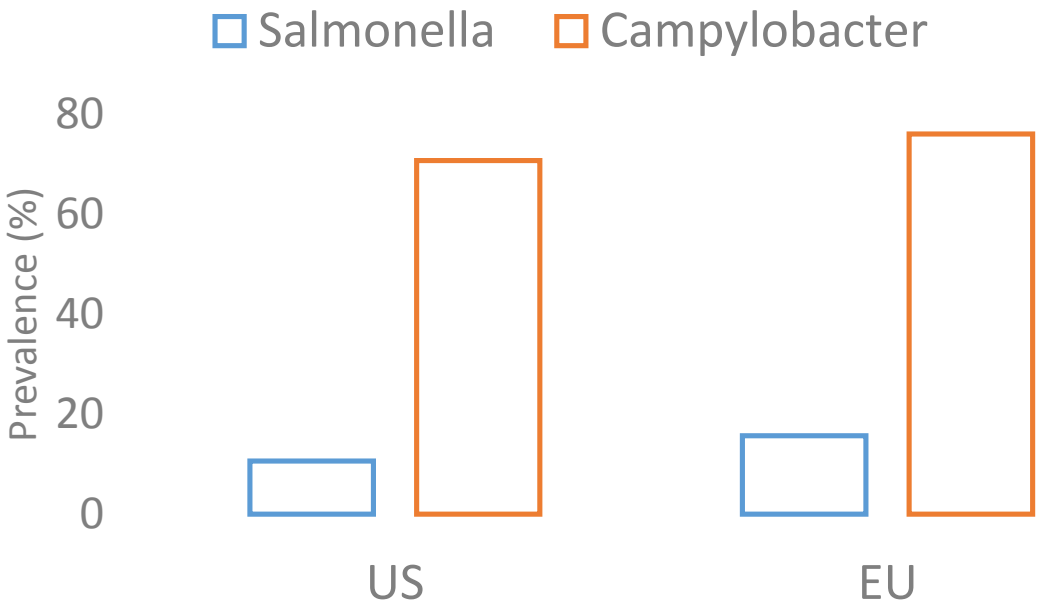
Source: European Commission.

U.S. distribution of farms by size, 1997



Source:National Agricultural Statistics Service, USDA .

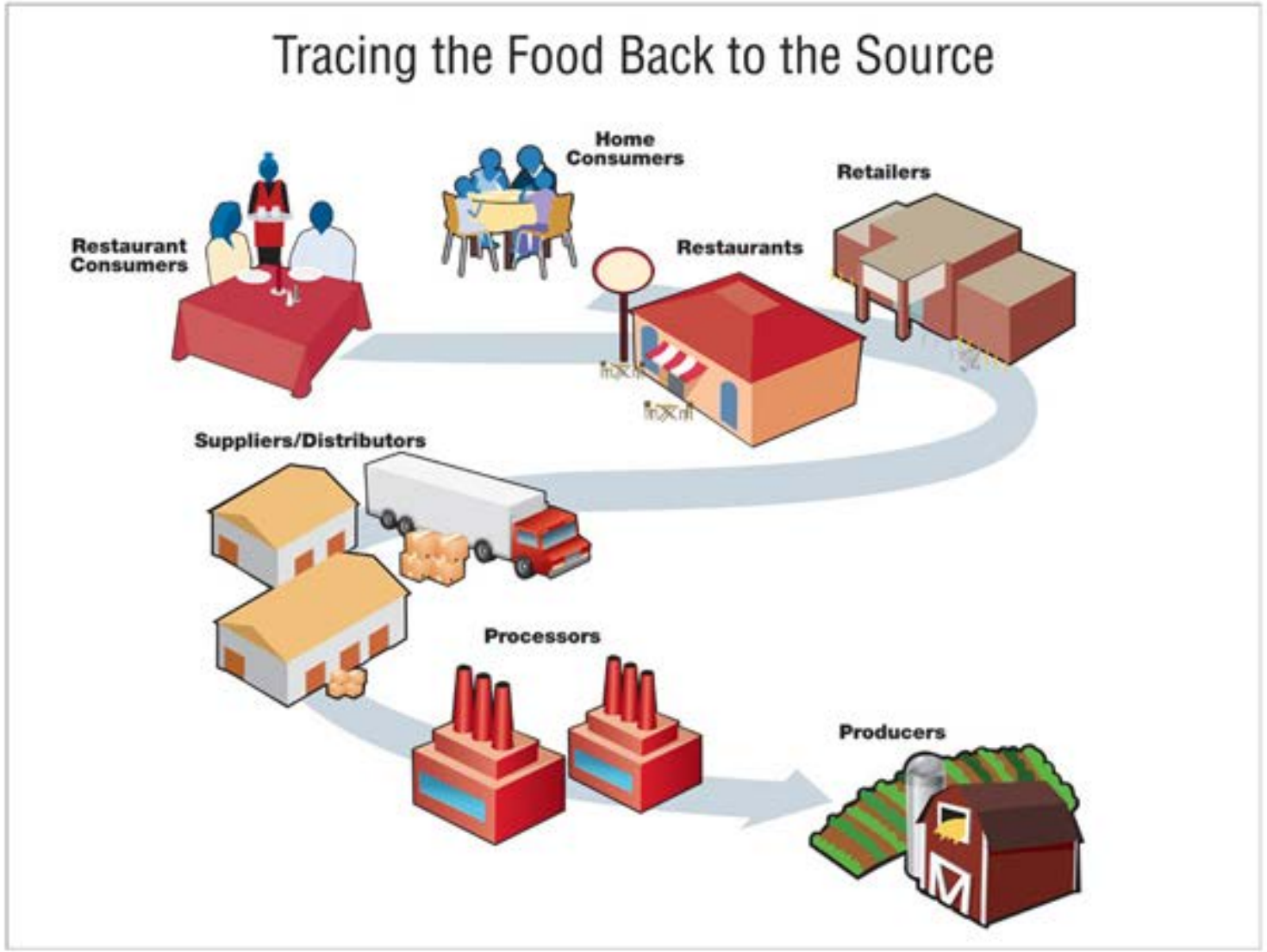

Salmonella
Campylobacter
E coli O157:H7
Prevalence (%)
5
4
3
2
1
0
US
EU


Salmonella
Campylobacter
Prevalence (%)
80
60
40
20
0
US
EU

Sources of Contamination and Dissemination Routes

Pathogen Reduction Interventions in Meat Chain

- On-farm
- Processing
- Retail and food service

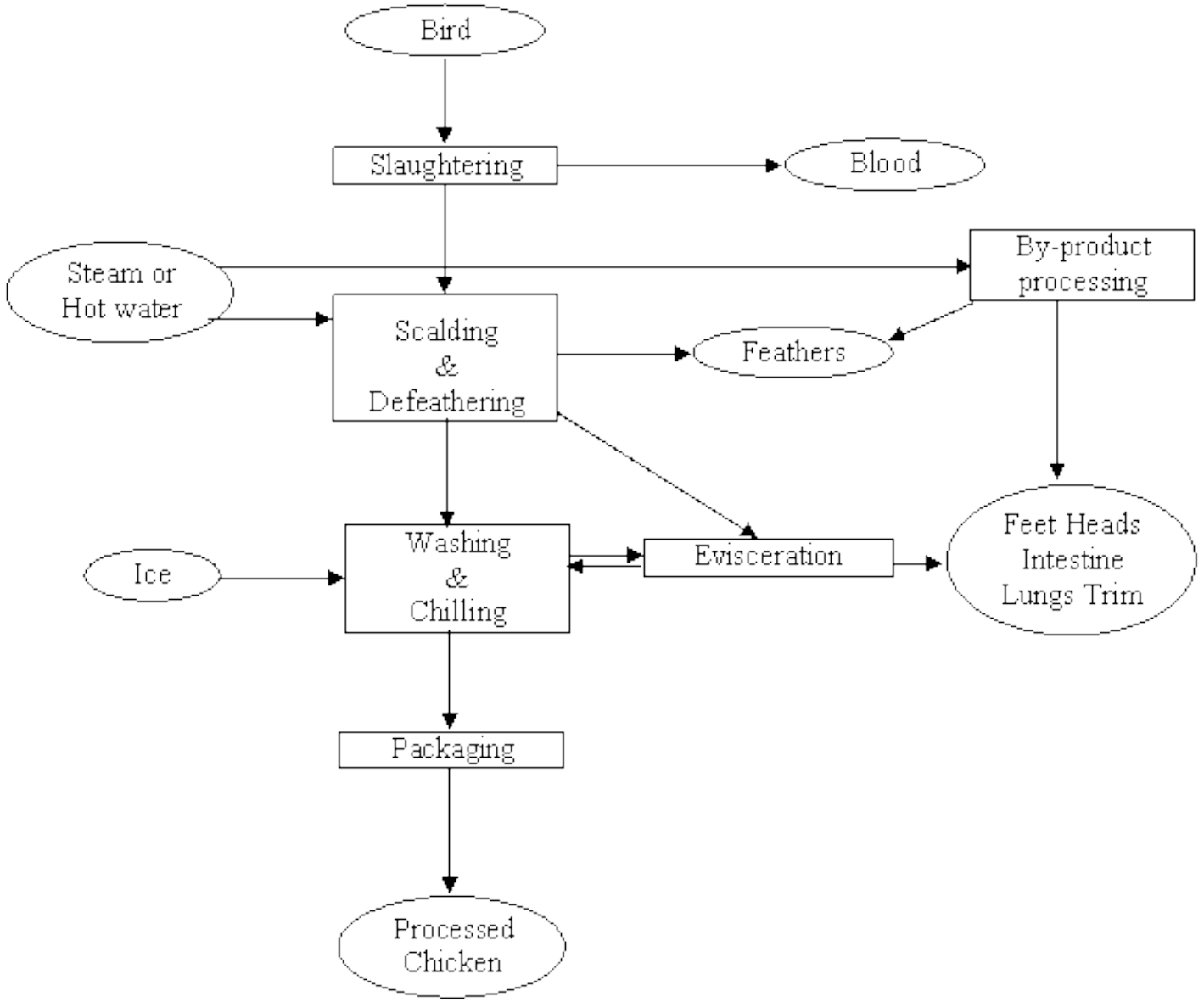


On-farm interventions

- Water quality: Electrolyzed water
- Feed: HACCP certification
- Housing: manure removal system
- Wildlife exclusion
- Animal density
- Probiotics and prebiotics
- Vaccination

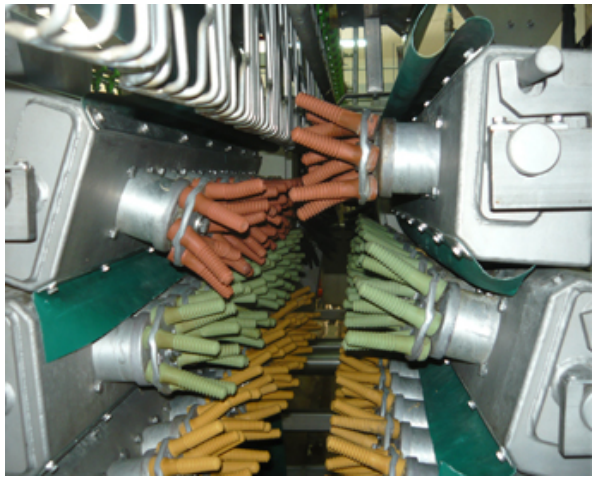
Processing

Poultry Processing



Poultry Processing

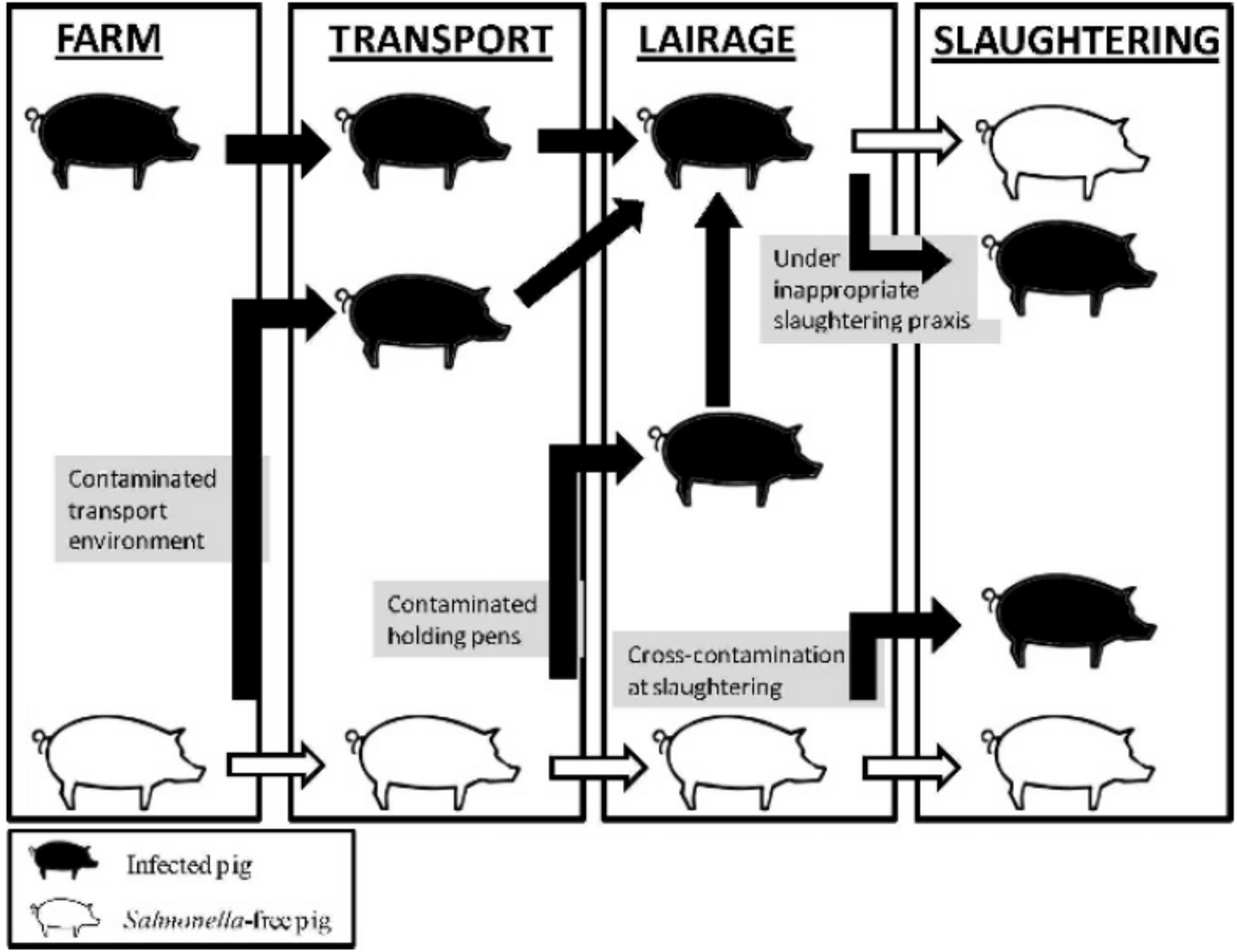
- Scald tank
  - Counter current water flow
  - Temp >50°C
  - Sanitizers (limited selection)

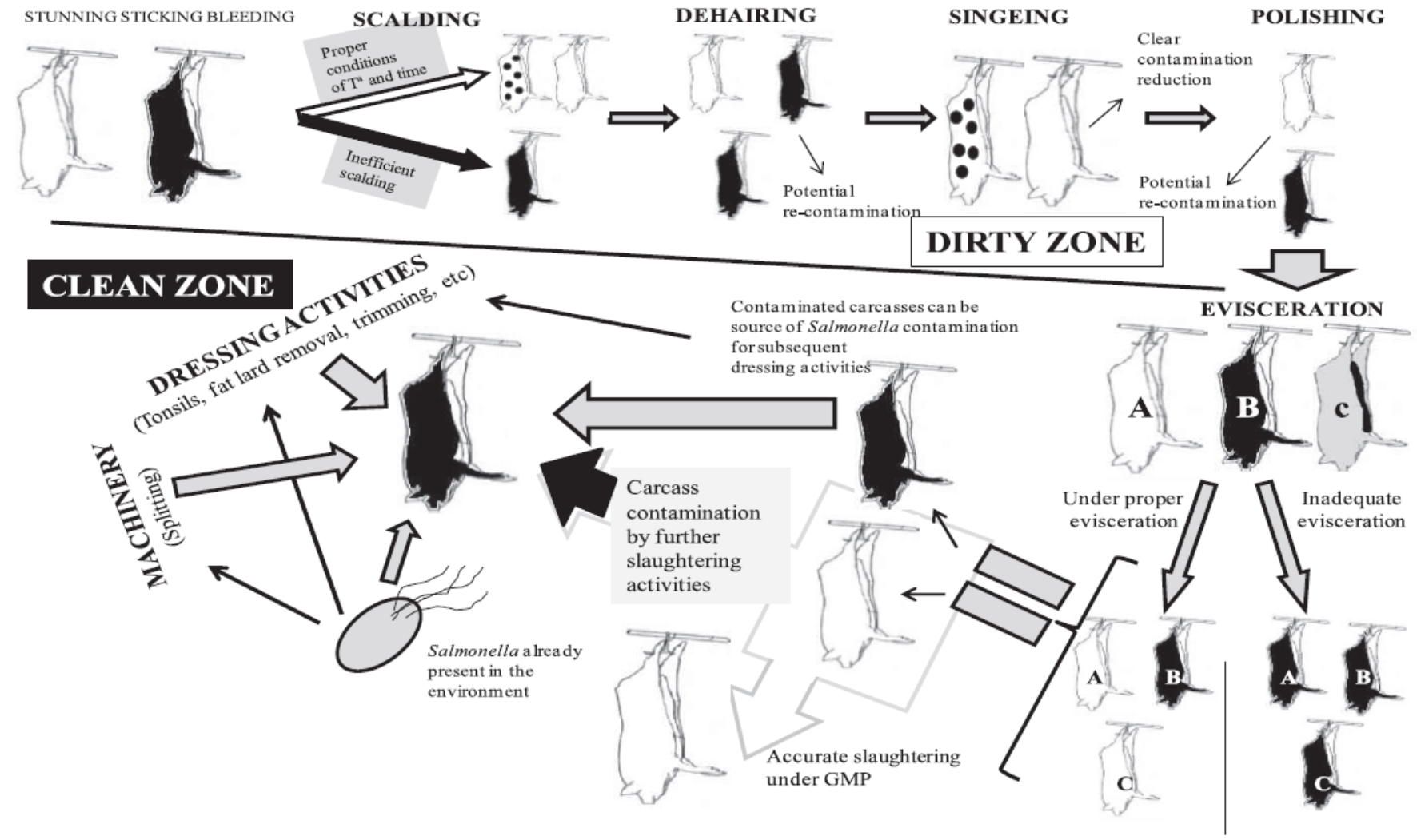


Chill tanks

- 50 ppm chlorine pH 7 (Only in US)
- Counter-flow
- Fresh water recharging
- Air chilling using ozone

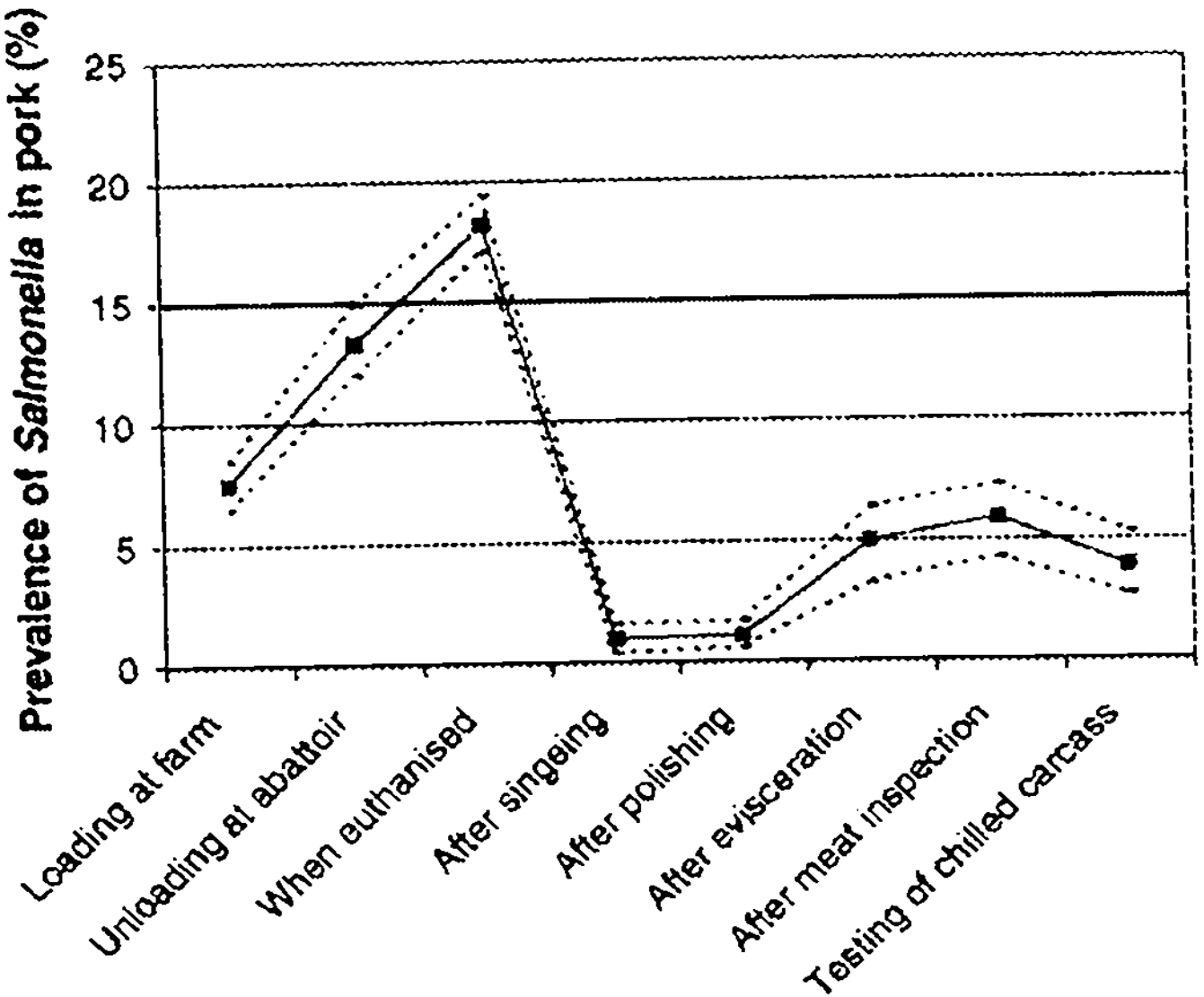
Pork Processing





Arguello et al., 2013

Simulated *Salmonella* Prevalence

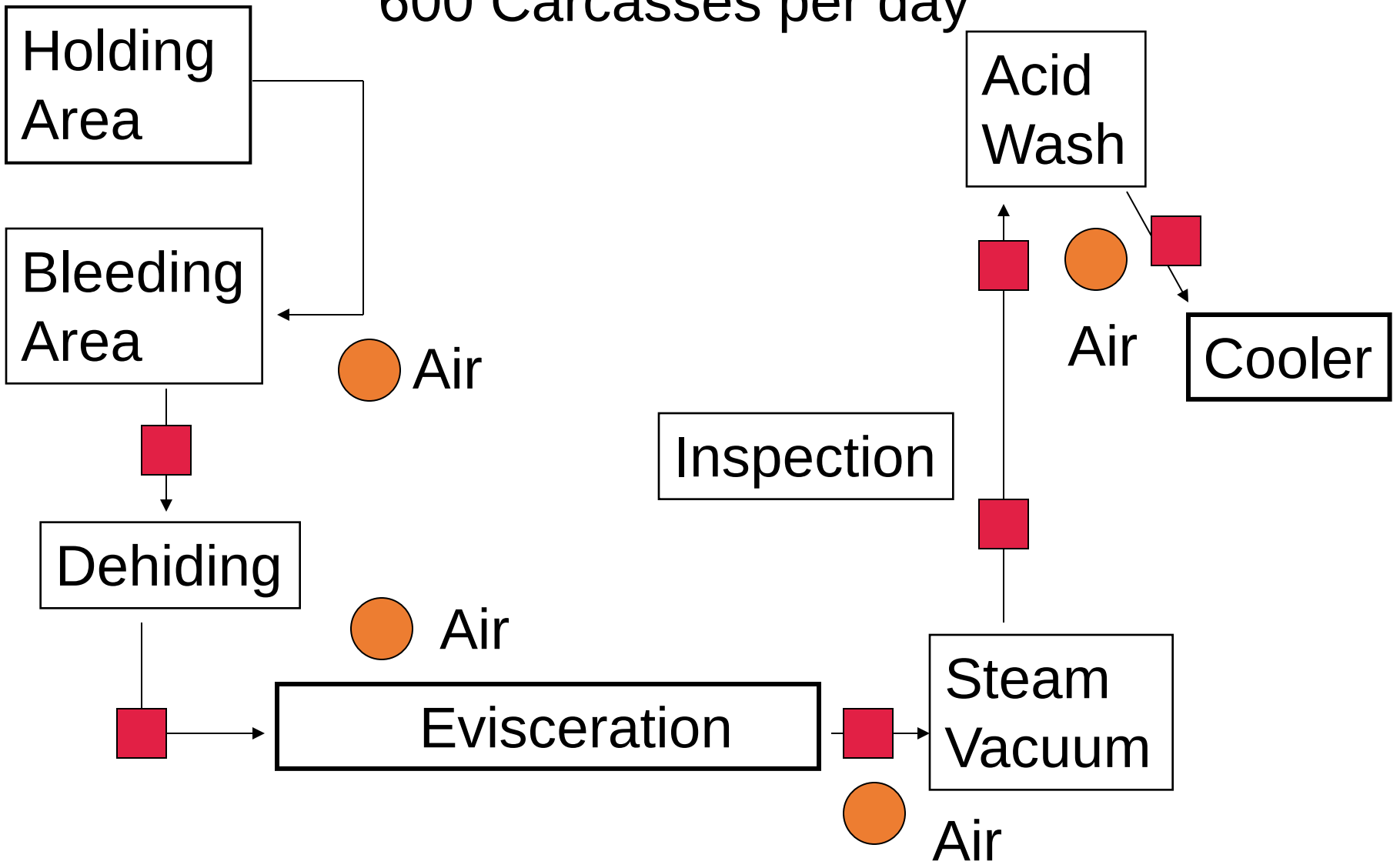


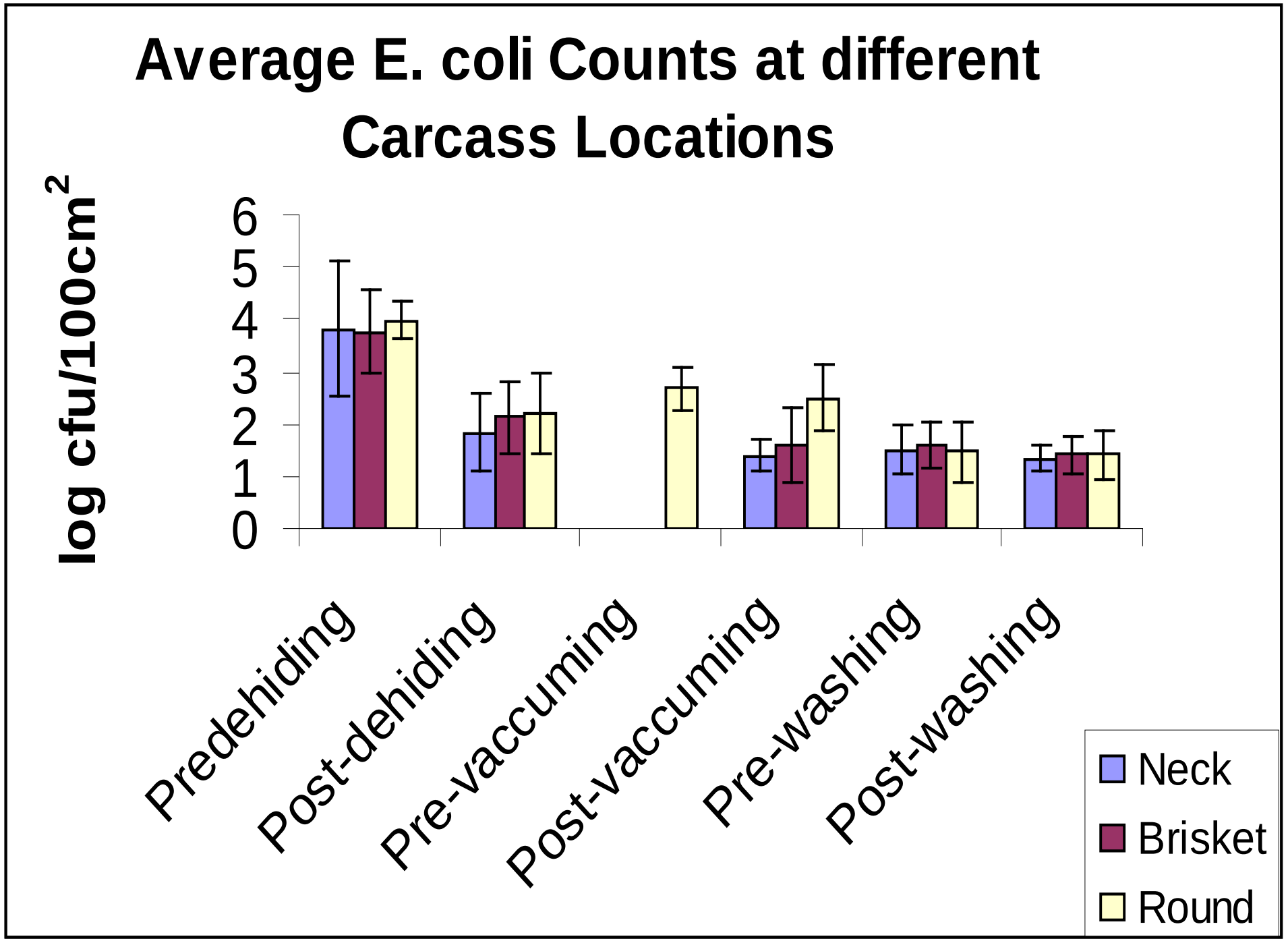
Stun and Dehide

Evisceration and Splitting

Large Capacity Beef Slaughter Line

600 Carcasses per day




Average E. coli Counts at different Carcass Locations
log cfu/100cm2
0
1
2
3
4
5
6
Predehiding
Post-dehiding
Pre-vaccuming
Post-vaccuming
Pre-washing
Post-washing
Neck
Brisket
Round

Interventions in Meat Processing

Carcass Decontamination

Physical

Chemical

Biological

Pre-Processing Interventions

- Live wash: Water or chlorinated warm water
- Chemical dehairing (sodium sulfide)

1

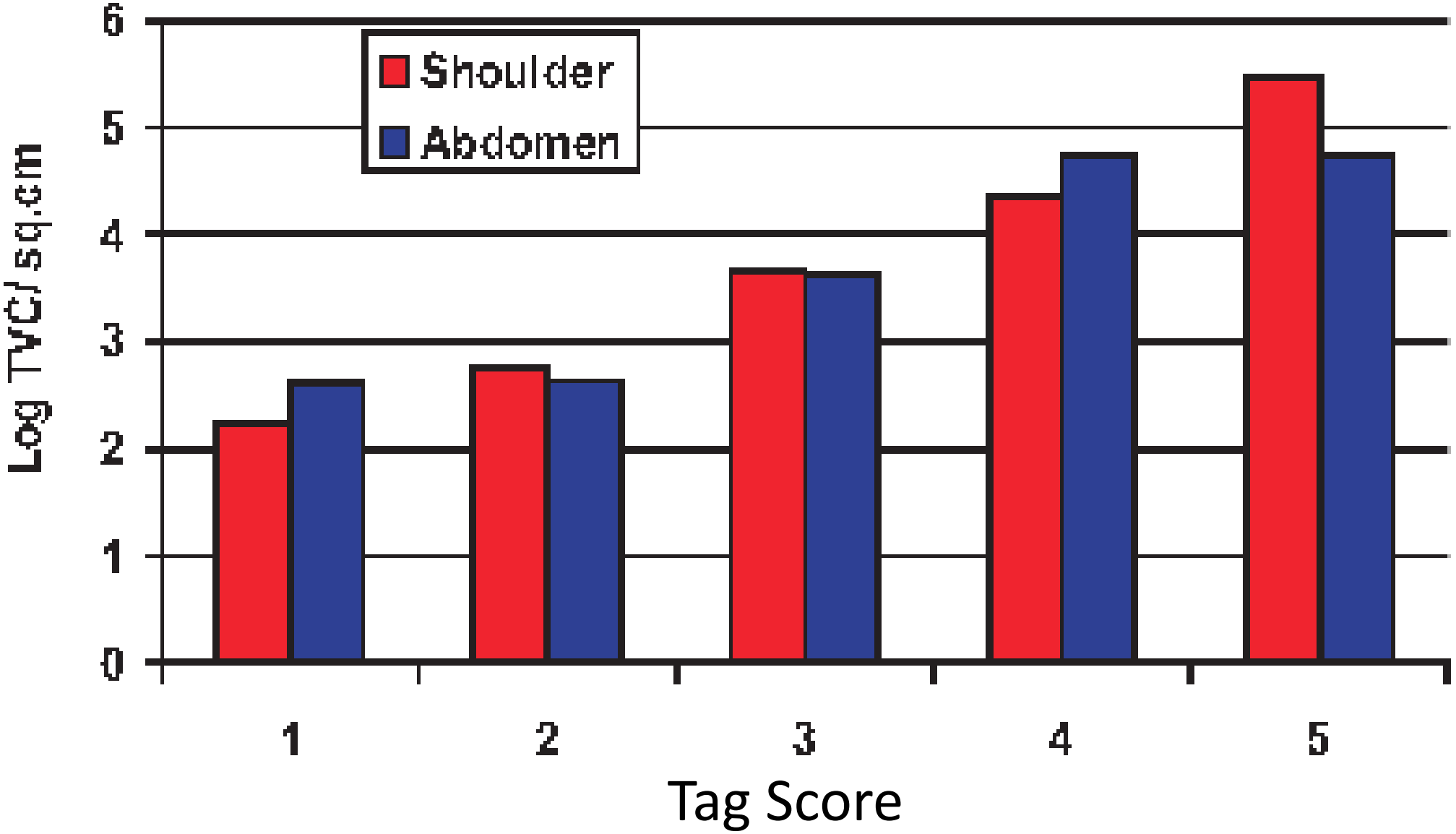
3

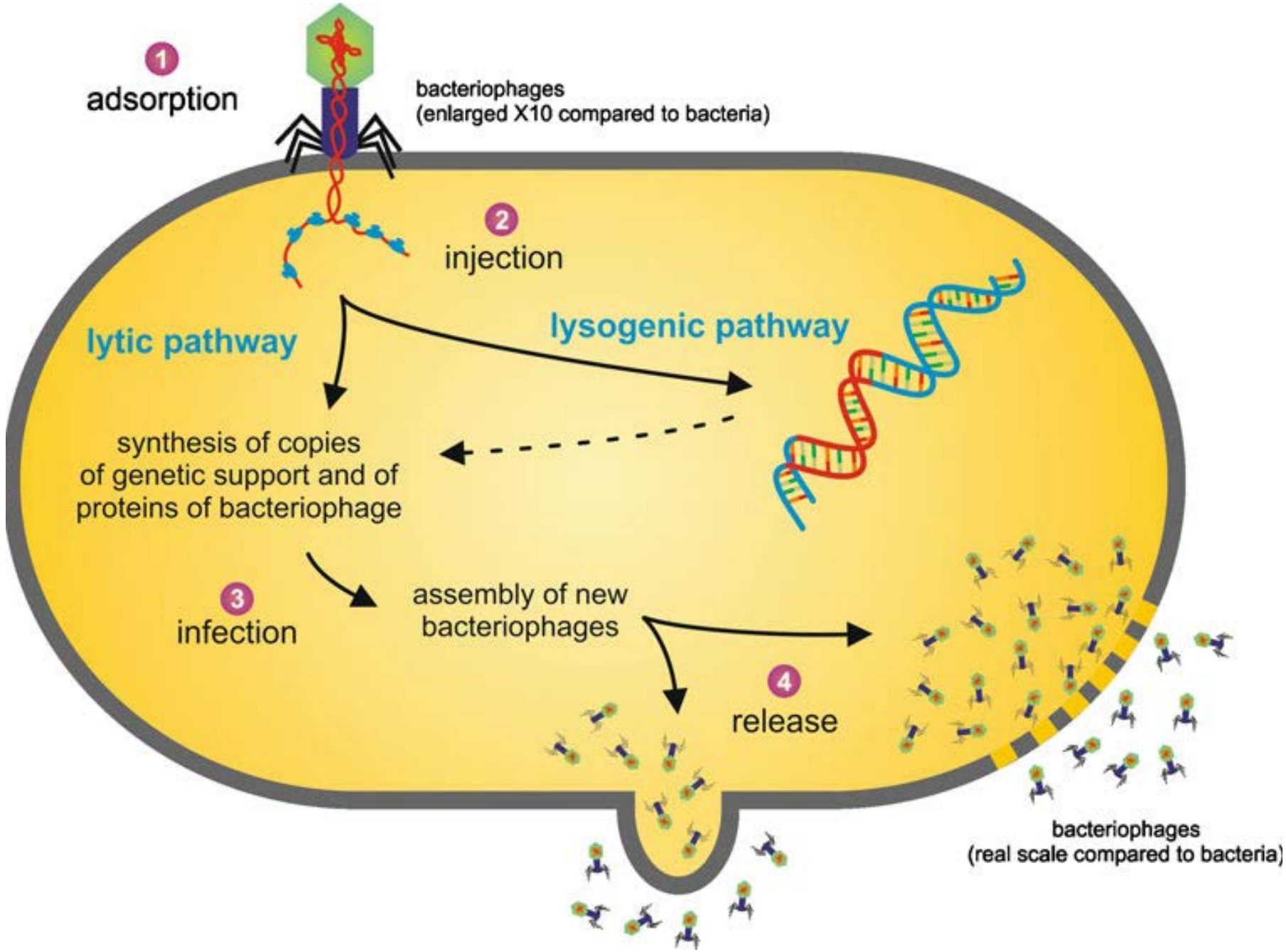
5

2

4

Animals cleanliness and carcase microbiology

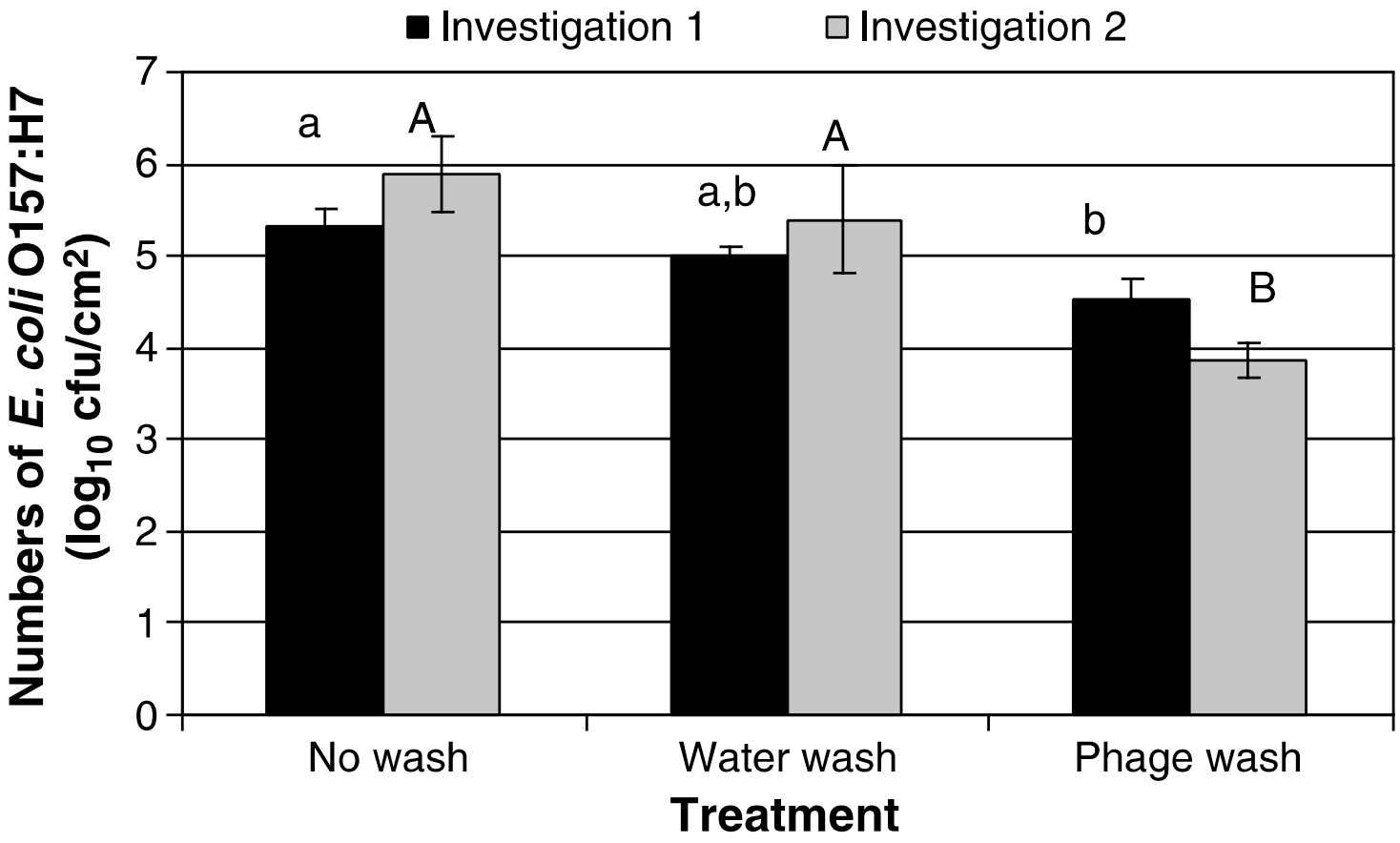



1
adsorption
bacteriophages
(enlarged X10 compared to bacteria)
2
injection
lytic pathway
lysogenic pathway
synthesis of copies
of genetic support and of
proteins of bacteriophage
3
infection
assembly of new
bacteriophages
4
release
bacteriophages
(real scale compared to bacteria)

Bio-sanitizers

- Applied in animal environment
- Hide/skin treatment
- Direct application on foods

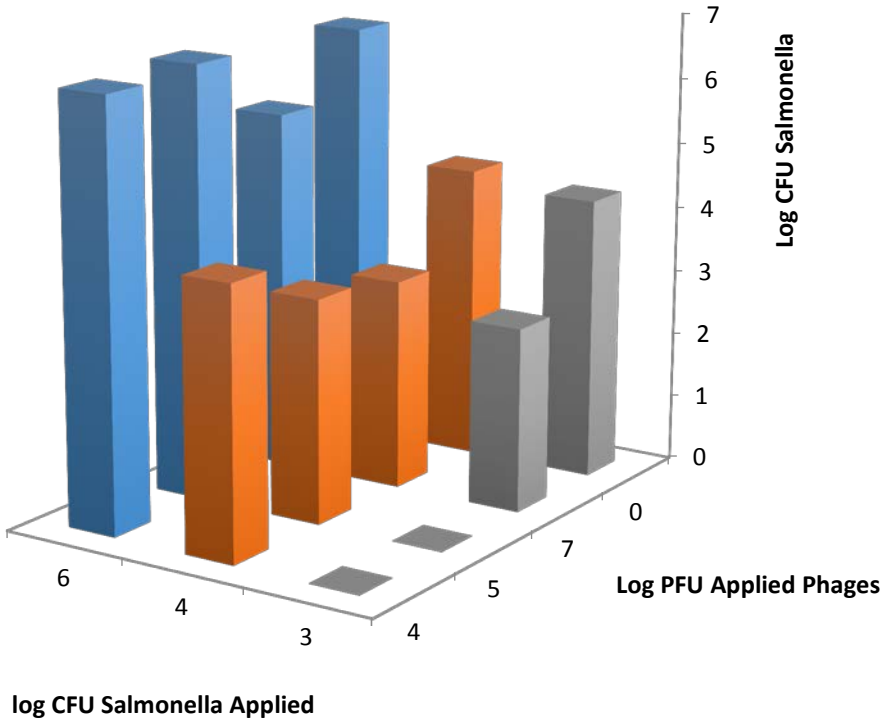
E coli O157 Phages on Hides of Cattle



Goffey et al., 2011

Control of *Salmonella* on Pig Skin

- *Salmonella* applied to pig skin
- Spray with phages
- Only effective with MOI>10



Hooton et al., 2011

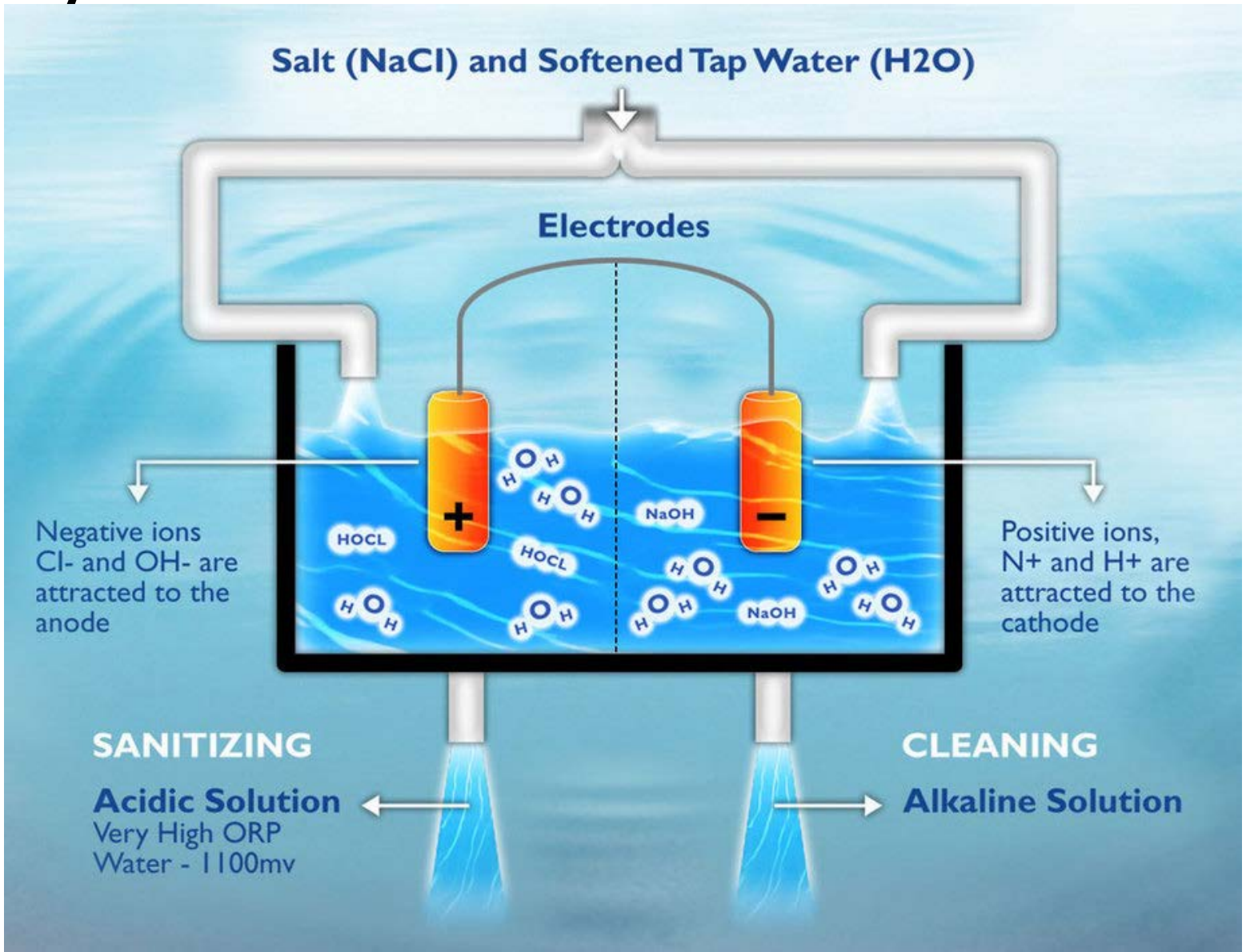
Hide/Skin Bacteriophages Treatment

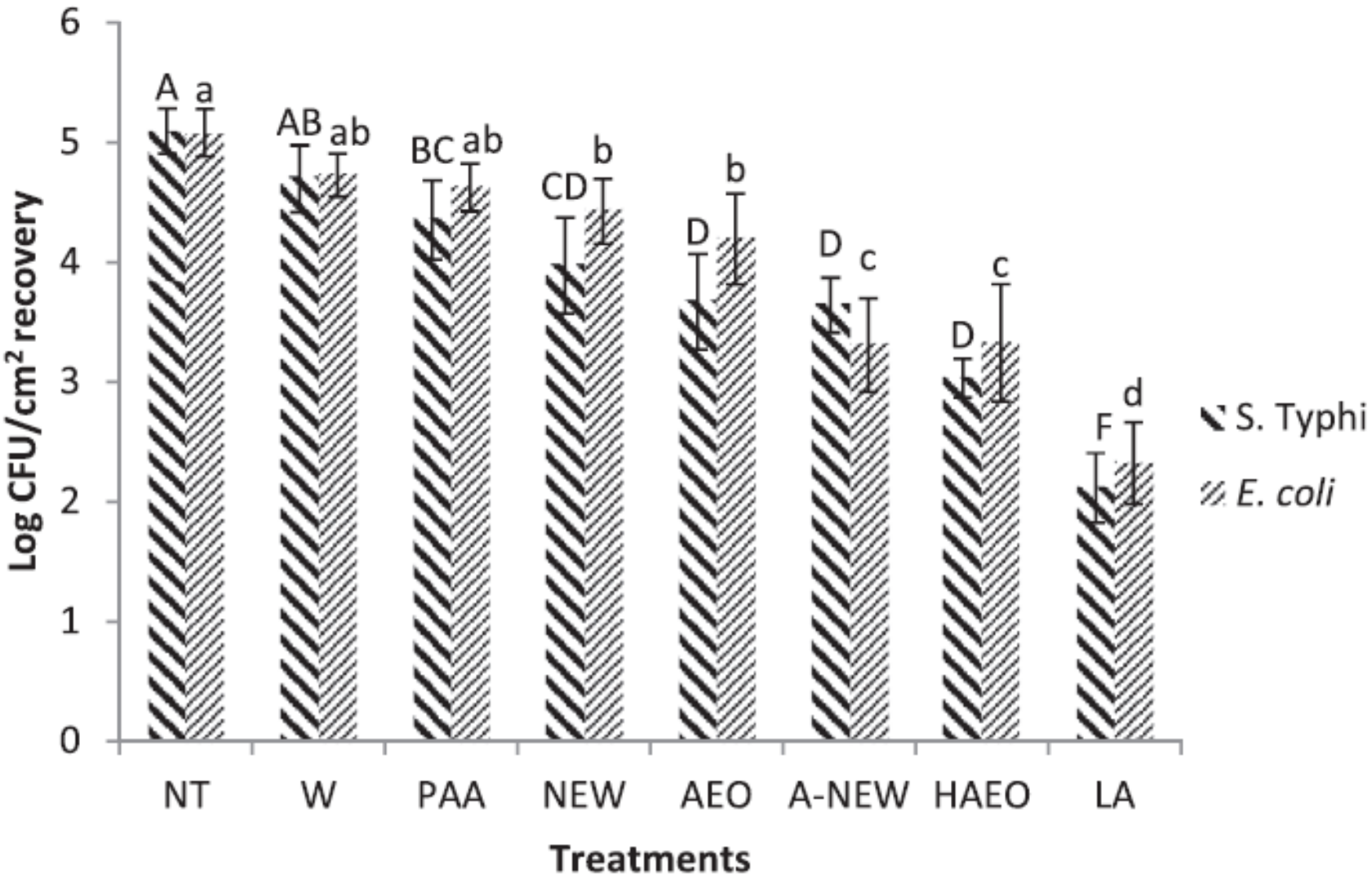
Surface	Target	MOI	Log Reduction	Reference
Cattle Hide	*E. coli* O157	10,000	1.5	Coffey et al., 2003
Poultry	*Campylobacter*	100, 000	2.0	Goode et al 2003
Poultry	*Pseudomonas*	1000	2.0	Greer, 1982
Pig skin	*Salmonella*	10	4.0	Hotton et al., 2011


2003 6 5


2003 6 5

Electrolysed Water





NT: Not treated

W: Water

PAA: Peroxyacetic Acid

NEW: Neutral EO water

AEO: Alkaline EO water

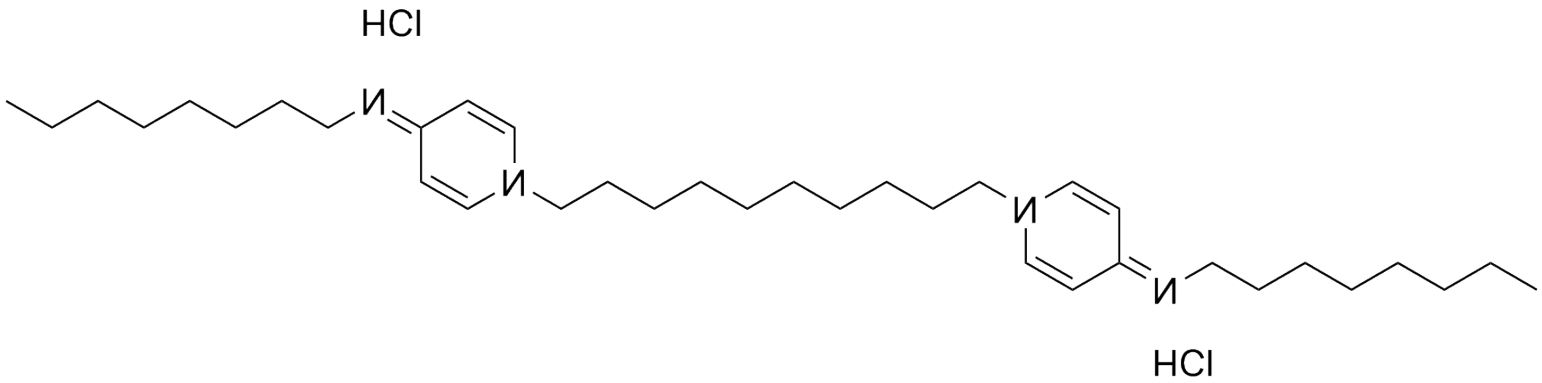
A-NEW: AEO followed by NEW

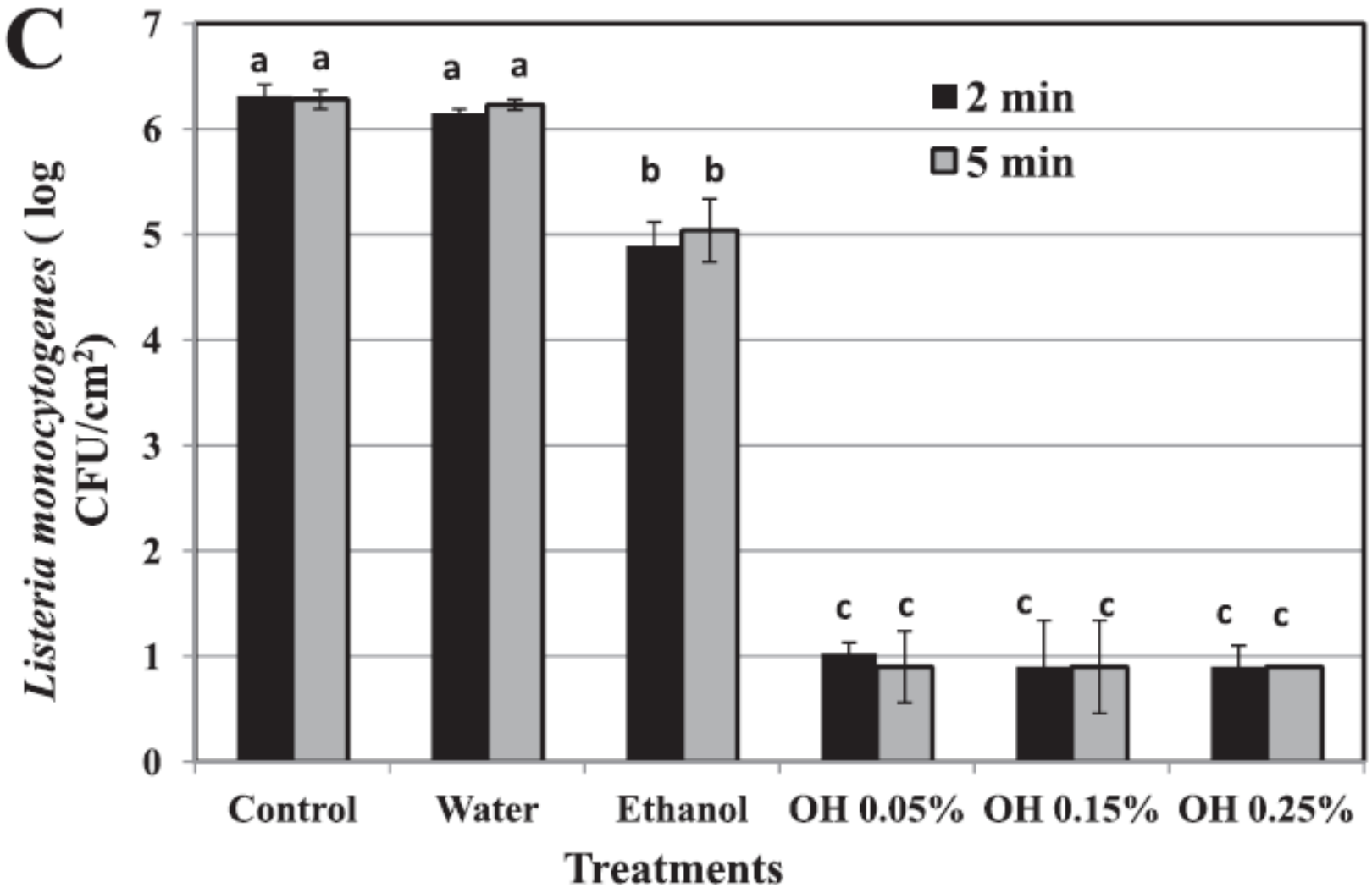
HAEO: Hot alkali EO

LA: Lactic acid

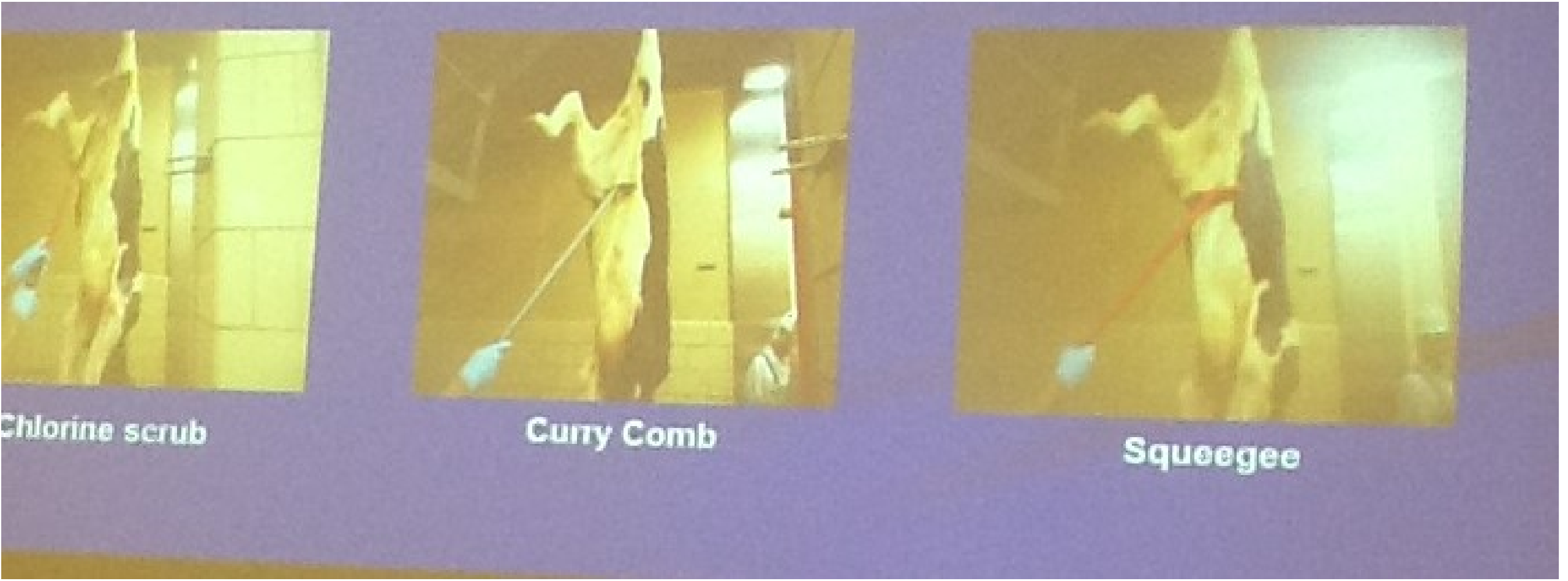
Jadeja and Hung, 2014

Octenidine



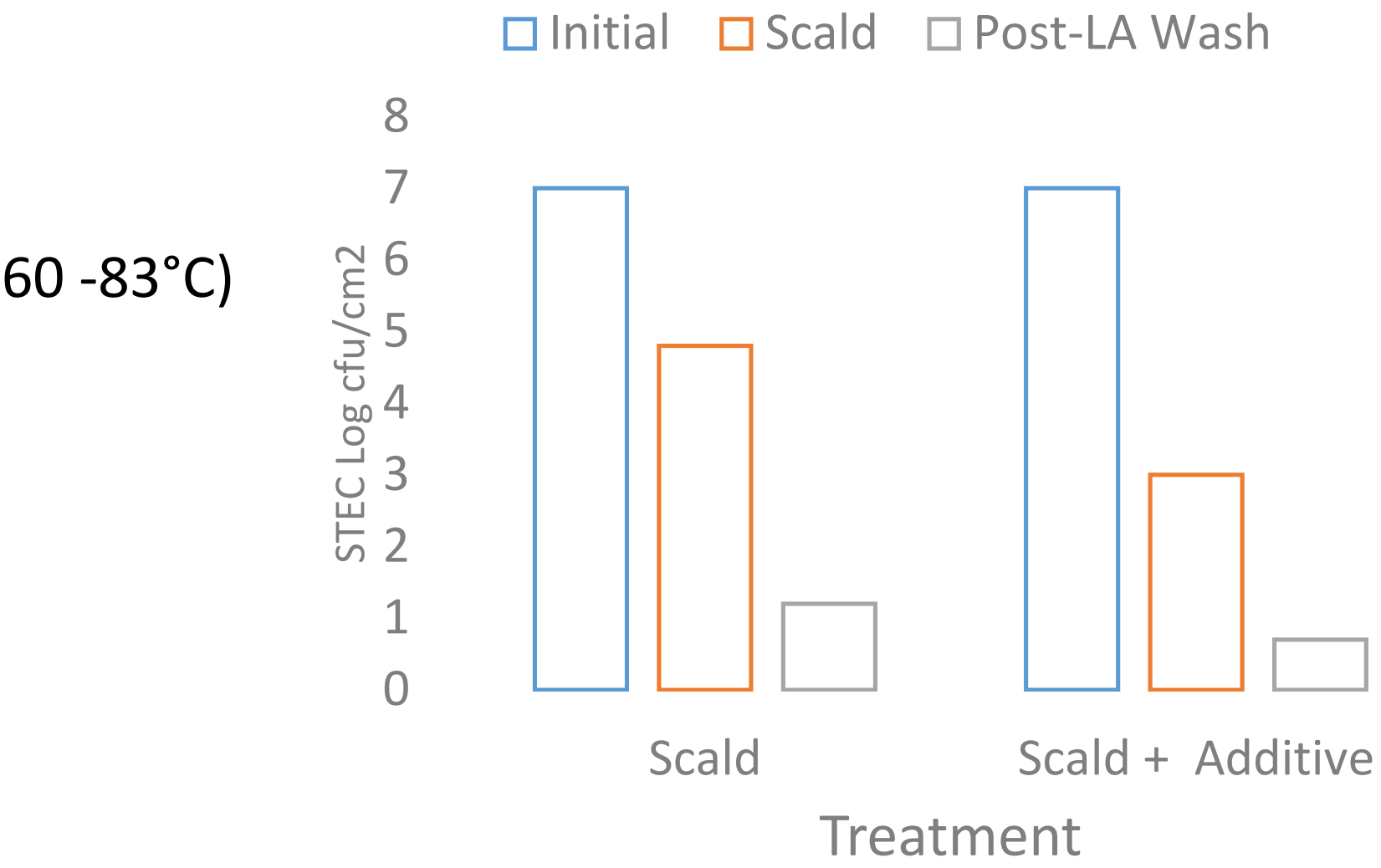


Baskaran et al (2012)


Chlorine scrub
Curry Comb
Squeegee

On-hide Water Wash

- Birko HardScald
- Hot water dip or spray (60 -83°C)
- Strong alkali
  - Antimicrobial
  - Hair removal



Mechanical Hide Puller

Aerosols reduced by pinning back hide

Post-hide removal lactic acid (5%) wash

Large Capacity Slaughter House

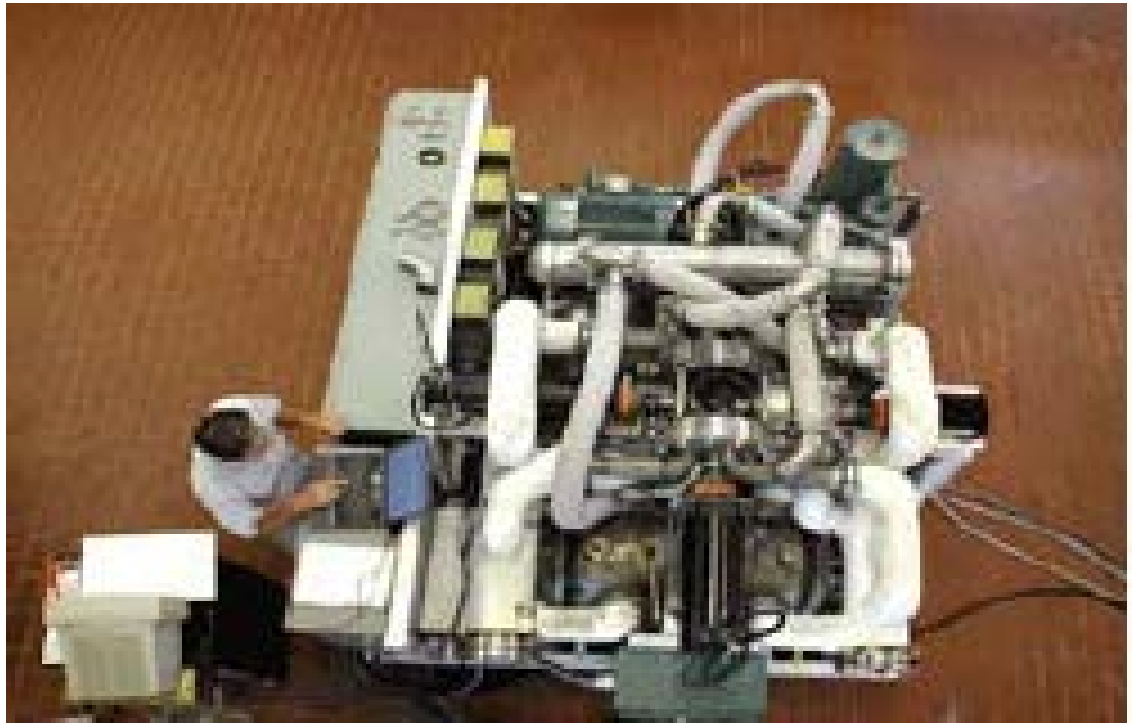
Steam Vacuum
of Round

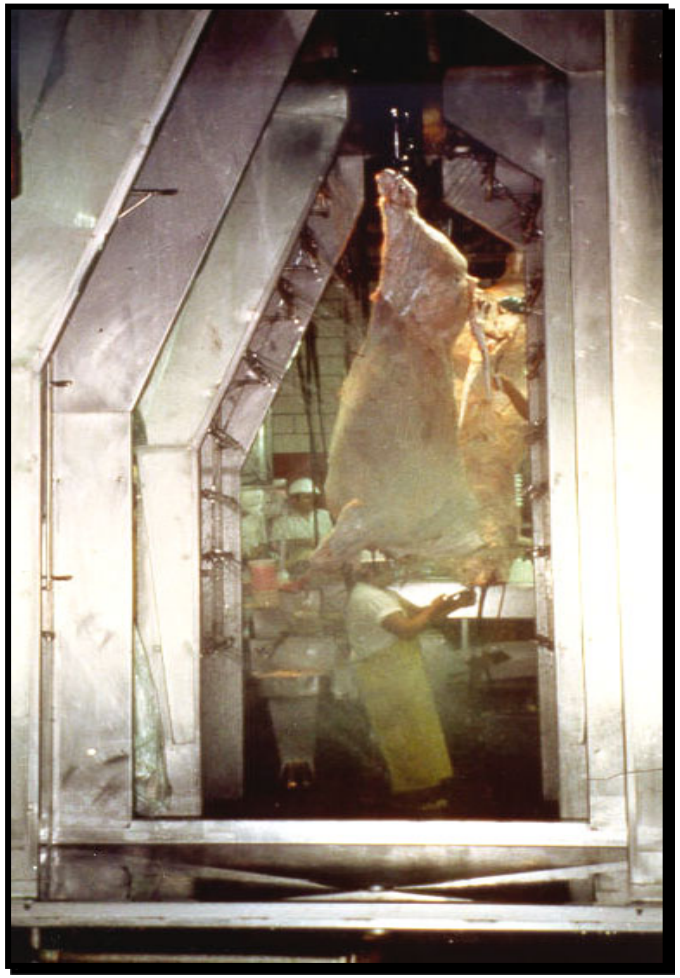
Post-Slaughter Acid Wash

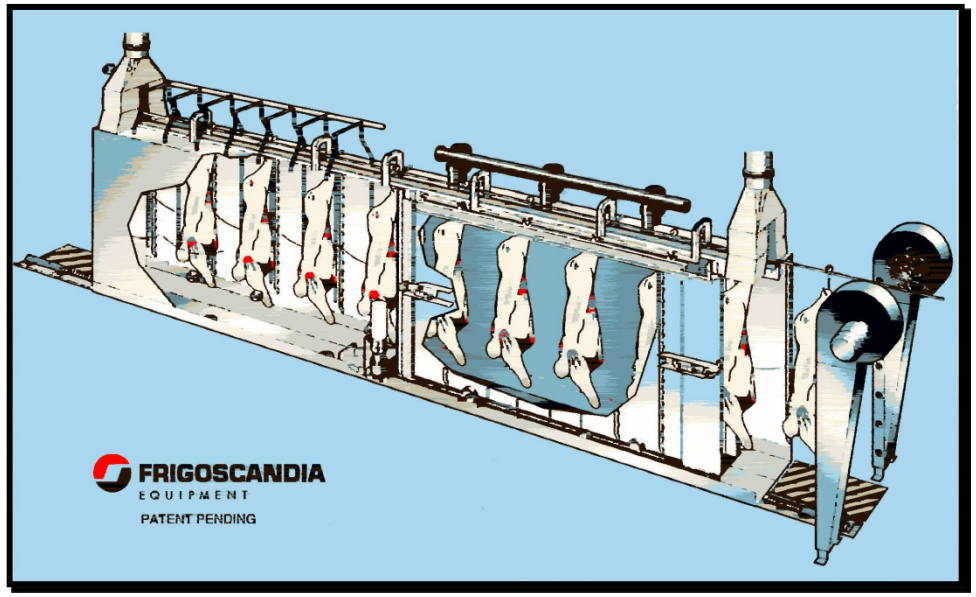
Vacuum-Steam-Vacuum Pasteurization (VSV)

- Vacuum: Remove air & surface moisture
- Steam: Thermal Inactivation
- Vacuum: Remove condensed steam & cooling

- 1s Treatment
  - Meat
  - Fruit
  - Vegetables







- Sprays
  - Organic acids - lactic, acetic
- Temperature
  - Hot water
  - Steam vacuum
  - Steam pasteurization

Log Count Reductions on Meat

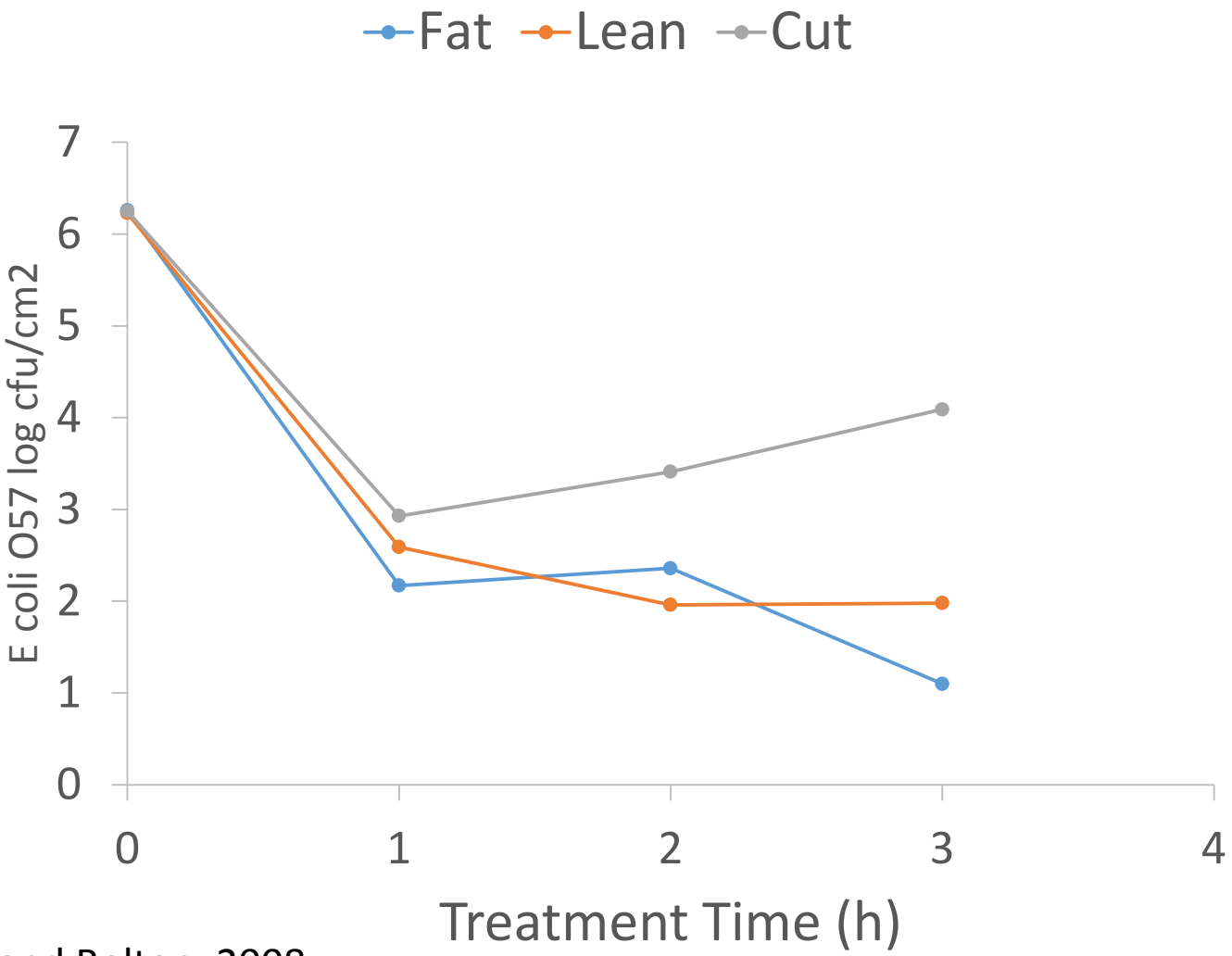
Treatment	Treatment conditions	LCR cfu
Hot Water	80C 5-15 s	1 – 3
Steam	80 - 95C 5 - 15s	1- 2
VSV	70C 1s	1.0 – 1.8

Chemical Treatments

- Chlorine
- Ozonated water
- Electrolyzed water
- Organic acids (2.5-5%)
- Lauric arginate
- Acidified Sodium Chlorite (ASC)-citric acid activated
- Peroxyacetic acid
- Trisodium phosphate
- Hydrogen peroxide
- Sodium bisulfate
- Potassium sorbate
- Cetylpyridinium chlorine
- Chlorine dioxide
- Dibromo-5,5 dimethylhydabtoin
- Activated lactoferrin

Lactic Immune Surface Adhesion Limitation (LactiSAL)

- Milk serum apo-proteins and free fatty acids
  - Lactoferrin
  - Lipases
  - Butyric
  - Caproic
  - Caprylic
  - Lauric
- Effective against *Salmonella* and *E. coli* O157:H7
- Cost?

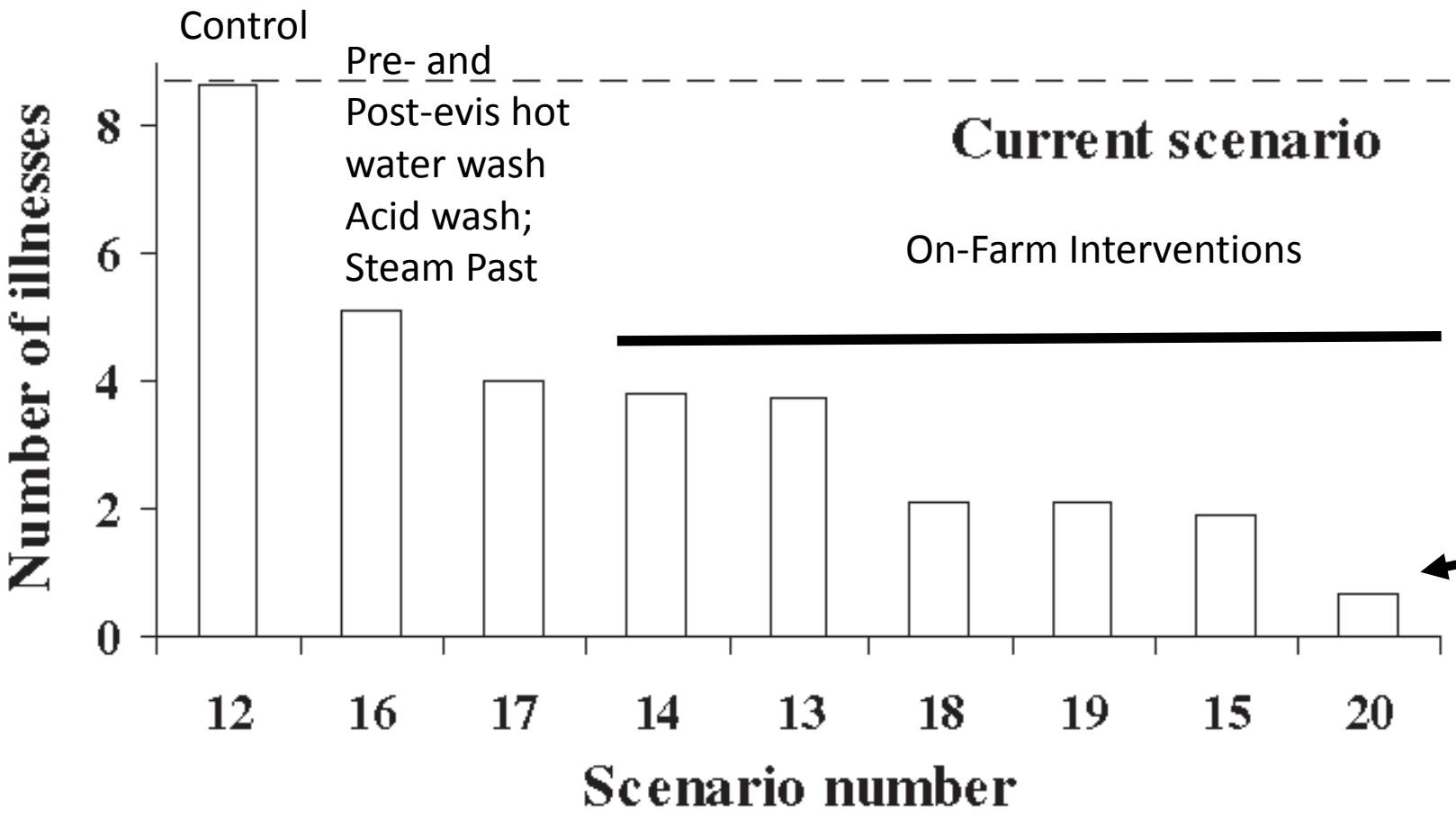


Pearce and Bolton, 2008

Food commodity	Surface decontamination treatment[a]	Typical bacterial reduction log cfu[b]
Raw meat	Hot water 80–95°C; 5–15 sec	1–3
	Steam 80–93°C; 5–15 sec	1–2
	Microwave; 30 sec	0.2–0.8
	Irradiation 2–3 kGy	3–5
	UV 4 J cm^{2}	0.5–1.0
	High-pressure processing 400 MPa; 50°C	>5
	Electrolyzed water; acidic fraction	1–2
	Ozonated water	0.6–2
	Chlorine	0.7–1.5
	Organic acid washes 1–30% v/v	0.4–2.4

Carcass Decontamination

Sanitizer	Concentration	Log Reduction cfu
Hypochlorite	50 ppm 10s	1-2
Electrolyzed water	Acid Fraction	1.0-2.0
Ozonated water	2 ppm	0.6-2
Organic acid washes	1-3%	0.4 – 2.4
Organic acid	2% 10 psi 90 s	2-4



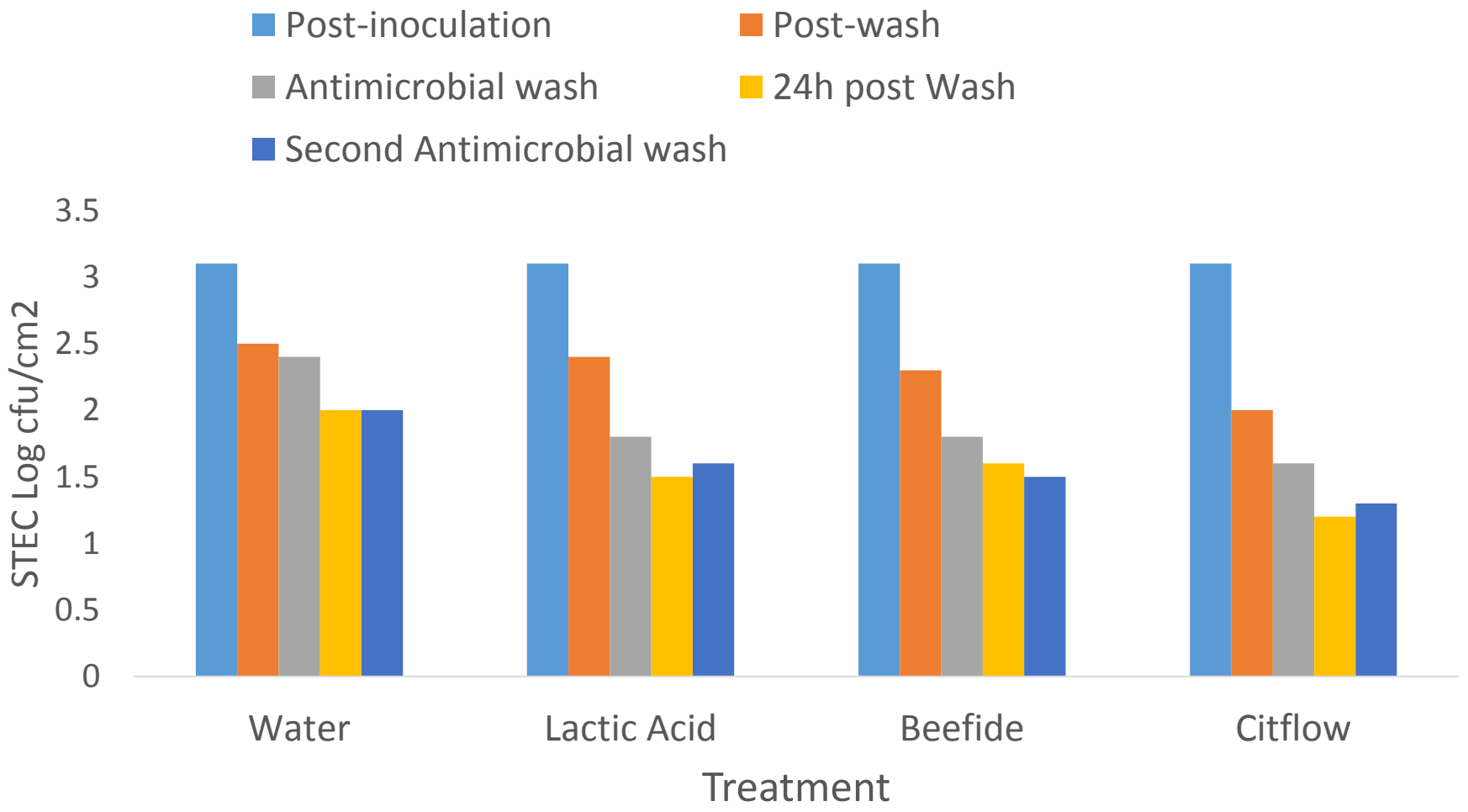
Vaccination:
Processing
Interventions_

Smith et al., 2013

Innovations in Carcass Decontamination

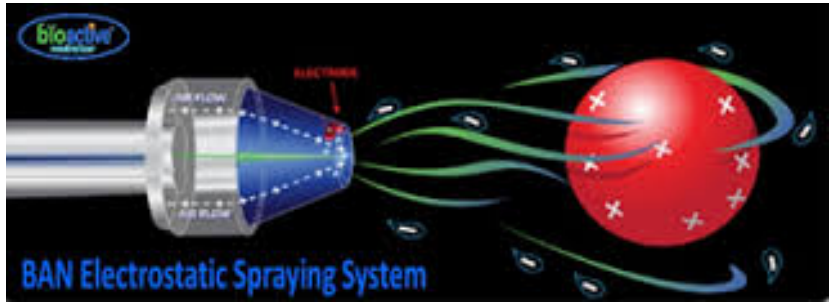
- Beefxide (pH 2.3; lactic acid & citric acid blend)
- Citflow (pH 1.2, HCl & citric acid blend)
- Electrostatic spraying
- Flaming

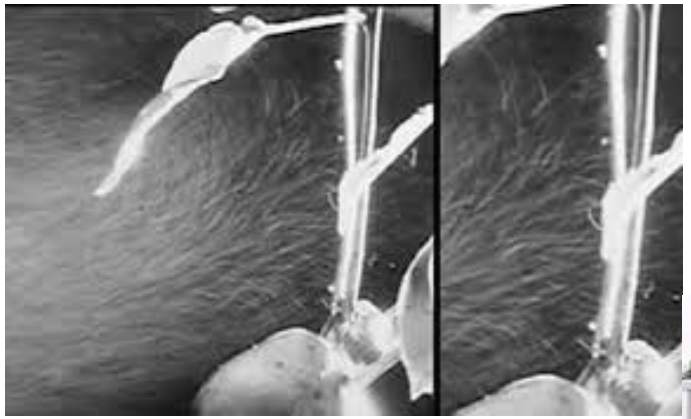
Decontamination of Veal Carcasses



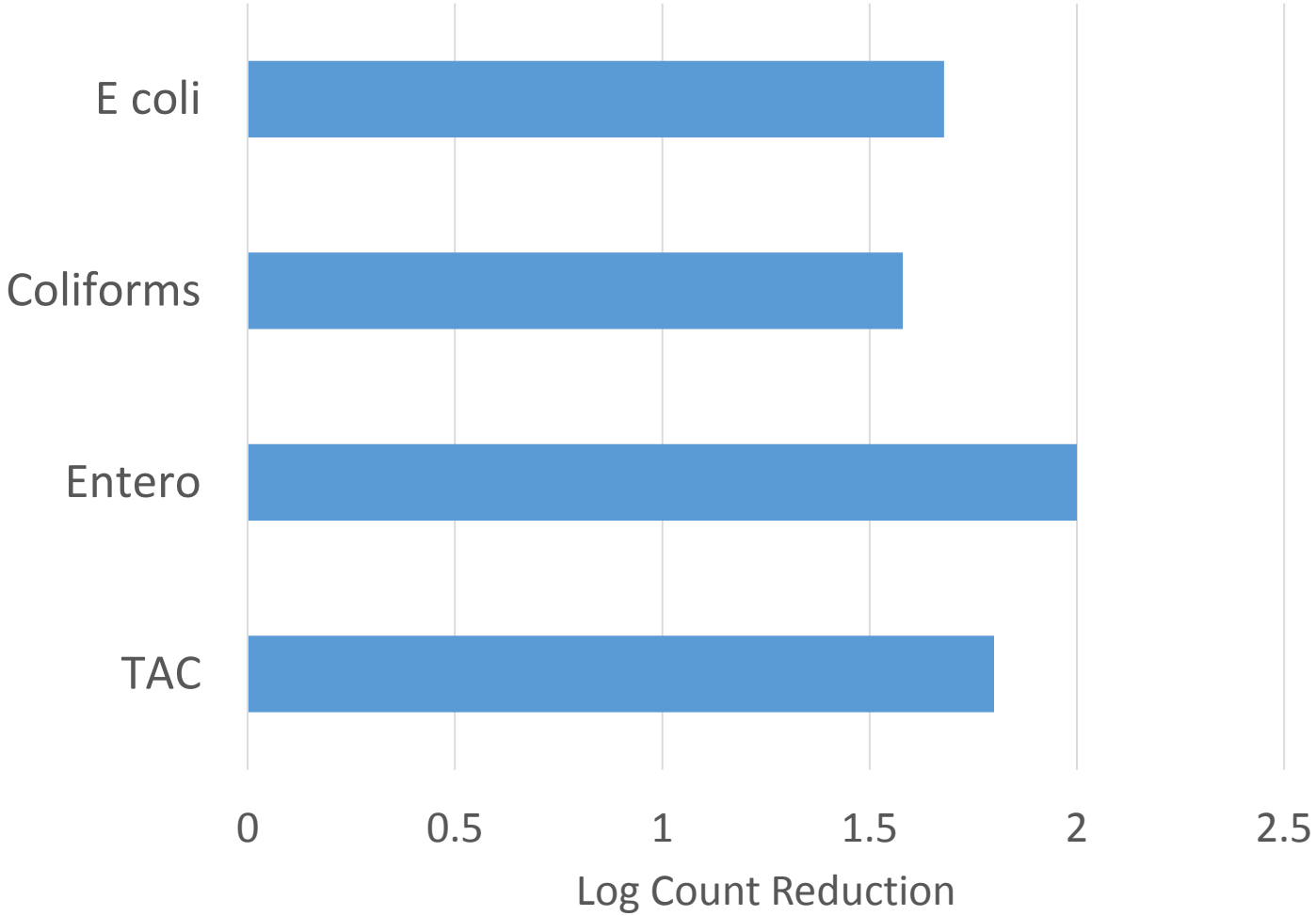
Electrostatic Carcass Sprays

- Containment of spray
- Efficient coverage
- Previous application in the produce sector
- Potential application for carcass decontamination



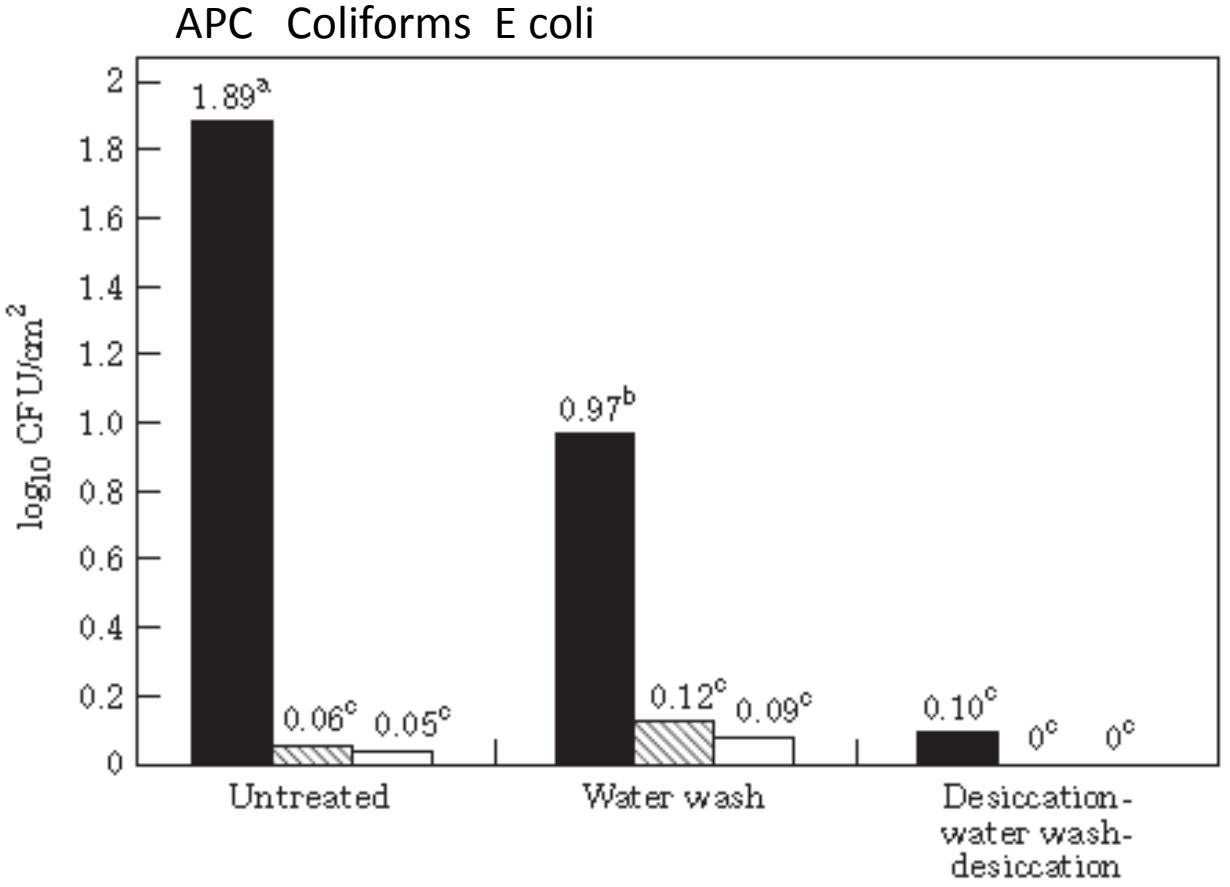


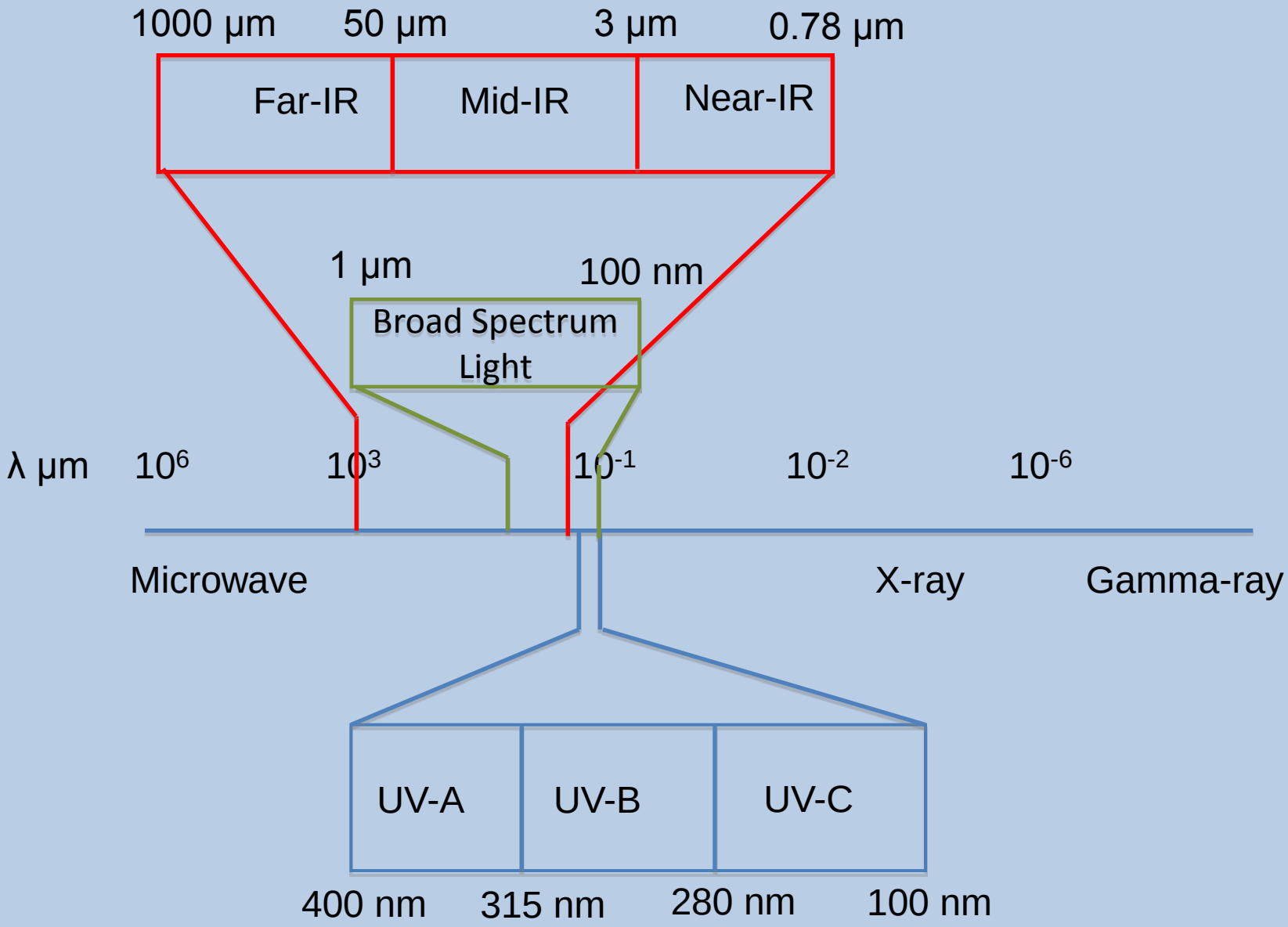
Flaming (Beef Carcasses)



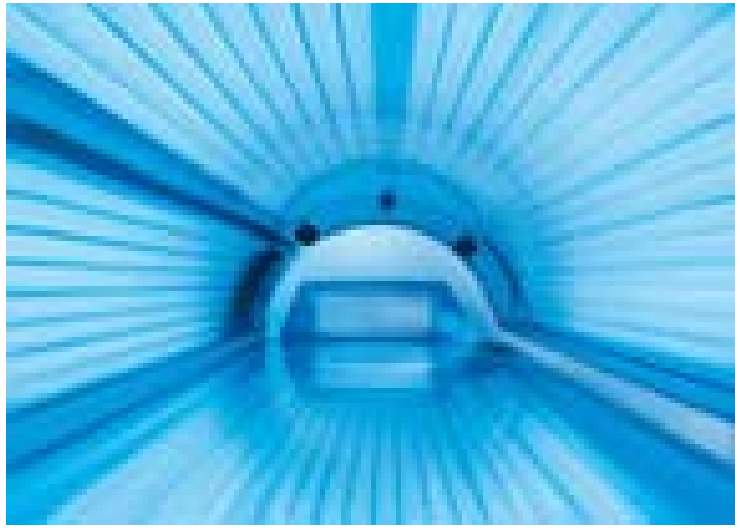
Dry Heating

- Dry heat 300 – 400C for 15s
- Surface drying
- Limited efficacy
- Log reductions increased when used in combination with anti-microbial sprays

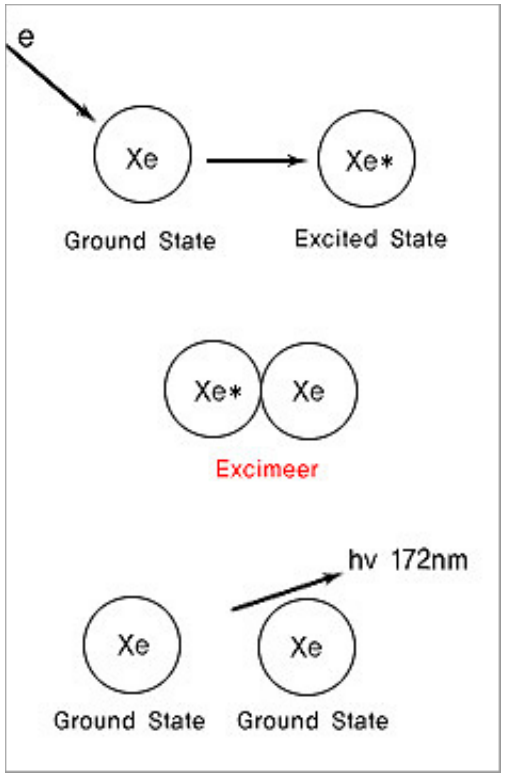


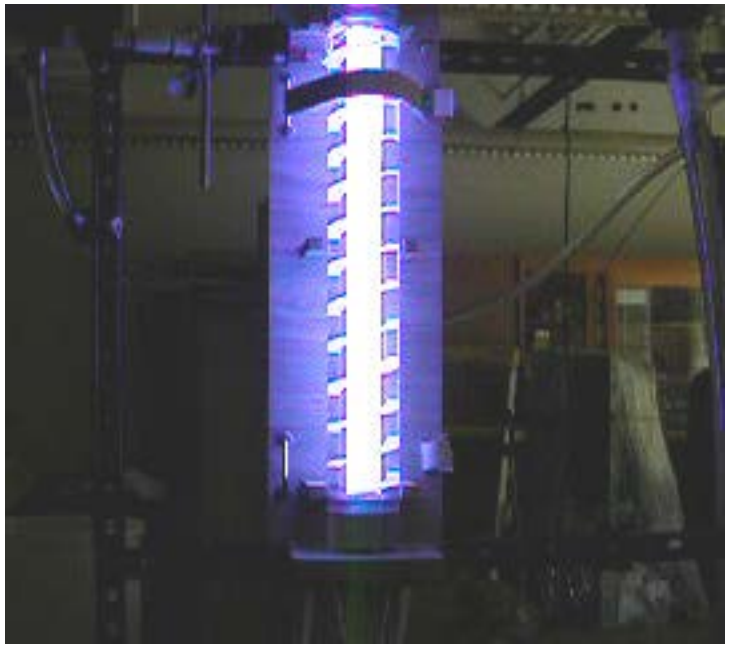

1000 µm
50 µm
3 µm
0.78 µm
Far-IR
Mid-IR
Near-IR
1 µm
100 nm
Broad Spectrum Light
λ µm
10^6
10^3
10^-1
10^-2
10^-6
Microwave
X-ray
Gamma-ray
UV-A
UV-B
UV-C
400 nm
315 nm
280 nm
100 nm


Thanks,
Mail Carrier



Excimer Lamps



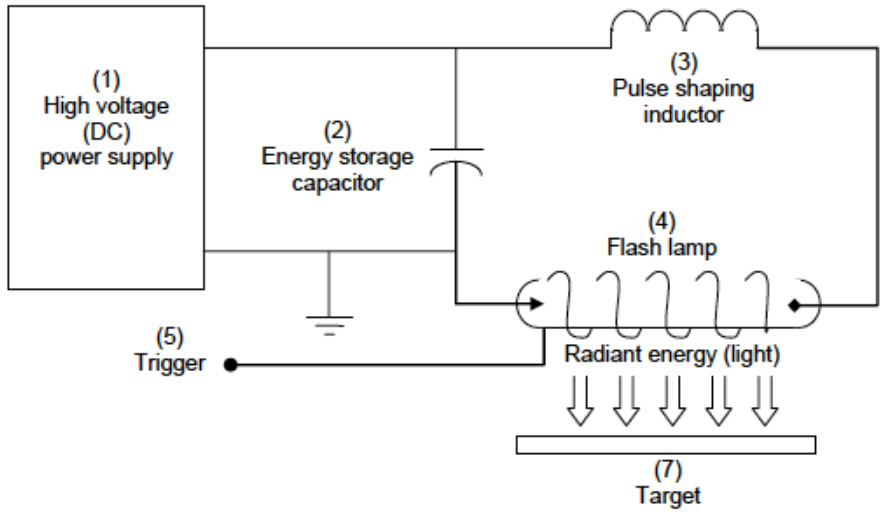


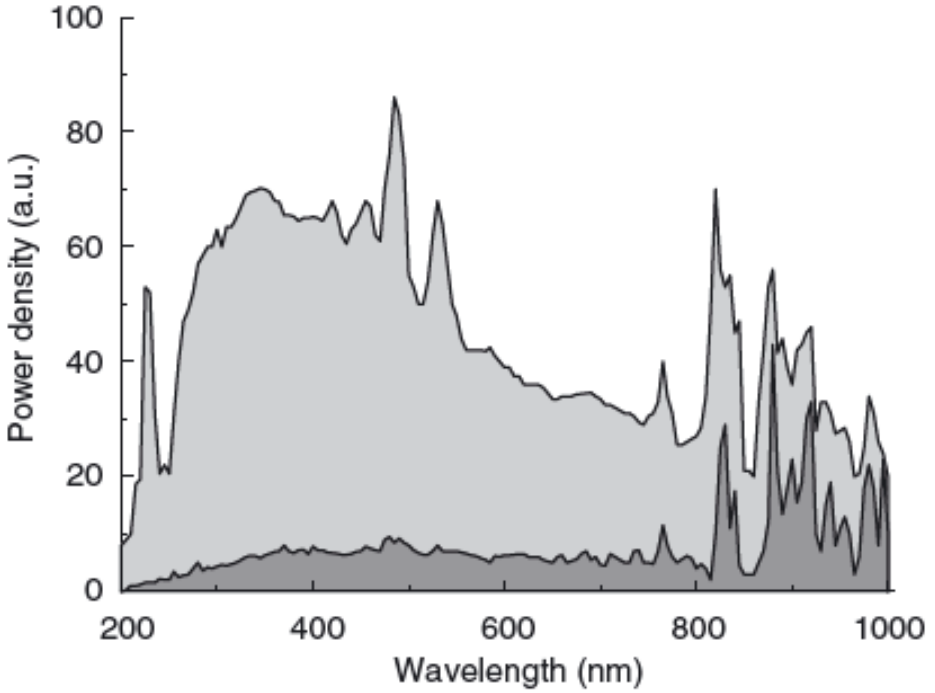
High intensity UV
Less power input
Low temperature

Pulsed Light

High intensity (1000 W/cm2) Short Pulses (1μs – 0.1s)

Xenon discharge lamps



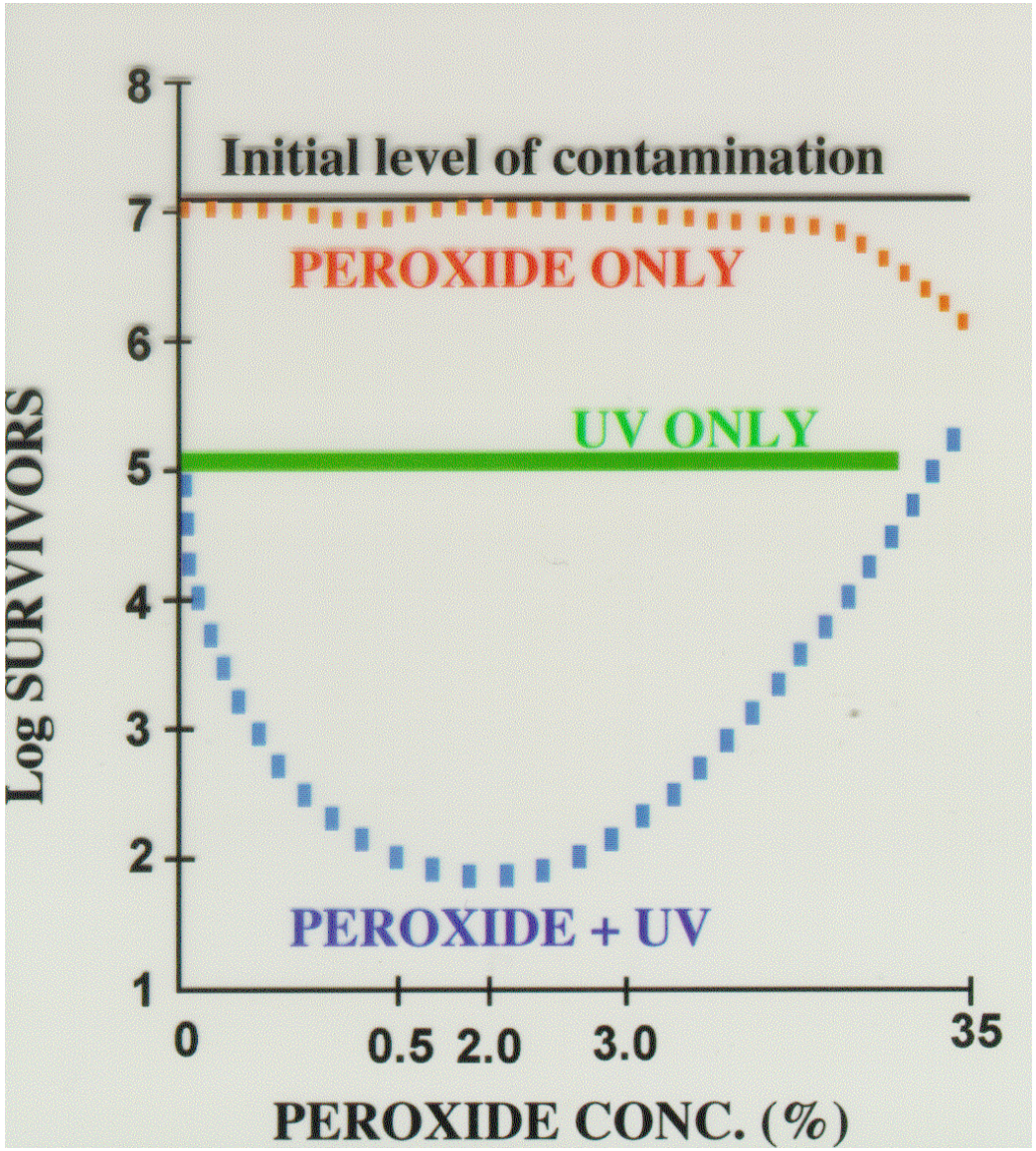


UV-light Based Treatments

- Uneven surface
- Protective niches
- 1-3 log cfu reduction

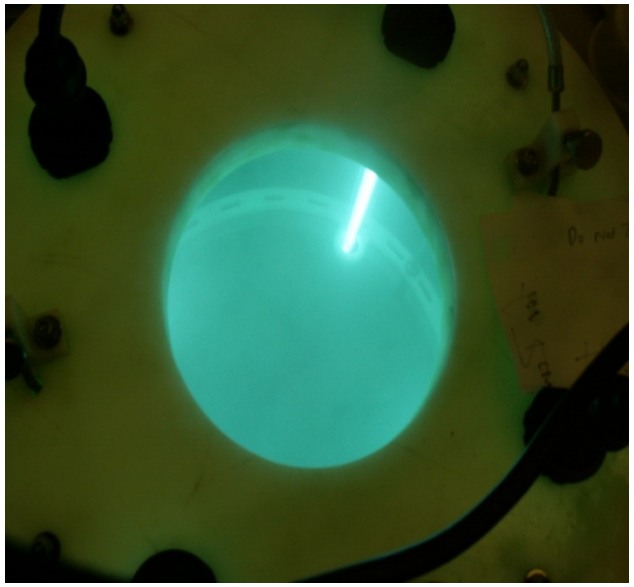
- No evidence of toxin photoproducts
- Used in combination with other treatments.

Synergistic Action of UV and Hydrogen Peroxide



UV:Hydrogen Peroxide (Advanced Oxidative Process)

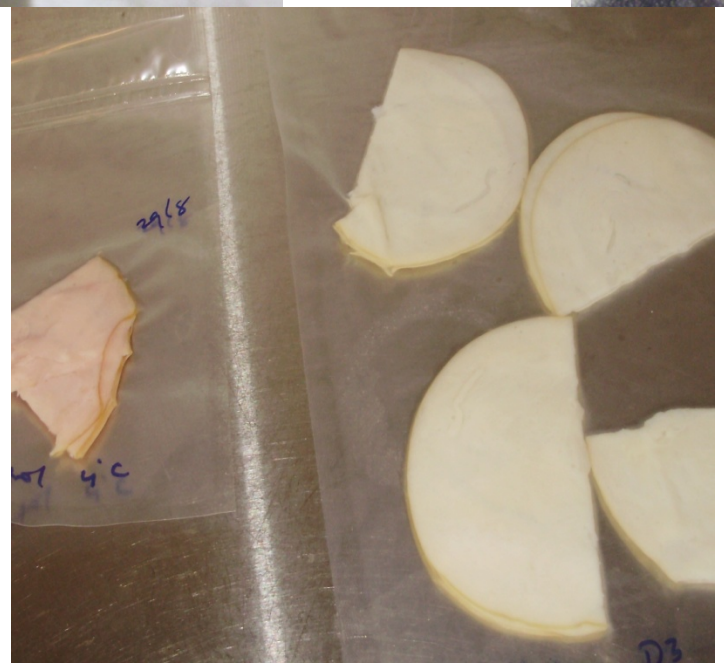
H_2O_2 → $O^{\cdot}$ $HO^{\cdot}$



A

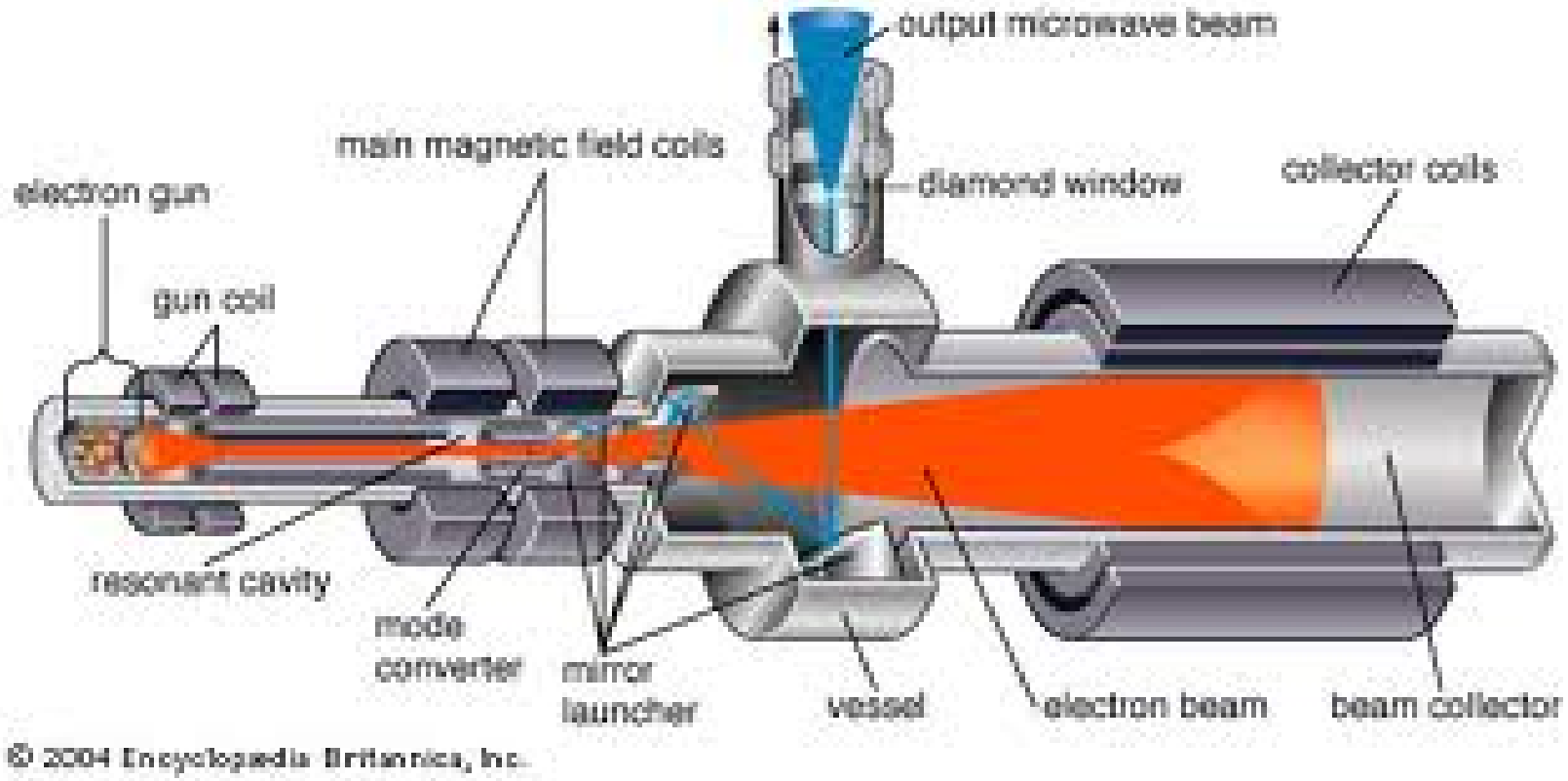
B

C



Gyrotron: High Frequency Microwave Amplifier

$$P = N\hbar(\omega_{n,n+1}\rho_{n,n+1} - \omega_{n,n-1}\rho_{n,n-1})$$



Gyrotron

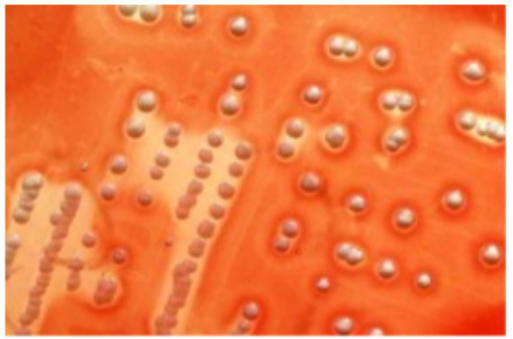
- High energy microwaves (MW)
- High frequency (170 GHz)
- Long wavelength
- Rapid heating (600C within 1s)
- Low penetration (<1mm)
- No need to label
- 5 log reduction (no peer review papers)

News *Aug 28, 2012*

Microwave meat decontamination technology patent filed

comments: 0 views: 498 label: Health / Diseases

Gyrotron Technology has filed a provisional patent application for its technology for decontaminating carcasses and other foodstuffs. The company said this technology was successfully tested on the laboratory scale and independently verified.



During those tests, heating the surface of meat for a small fraction of a second with a gyrotron, which is a very powerful source of high-frequency microwaves, reportedly cut the bacteria count on that surface by a factor of greater than 300,000, without compromising meat appearance.

Potential advantages of GYTI's technology include a drastic decrease in bacteria count; an environmentally friendly process that would sharply reduce water consumption and eliminate the use of certain chemicals in existing decontamination processes; significant cost savings in the decontamination process; and prolonged shelf-life for raw meat.

Gyrotron

- Rapid heating low penetration
- No change in color or texture
- 2m^2 treatment area <1s
- Comparable performance to electron beams
- Processing aid

- Cost?
- Maintenance?

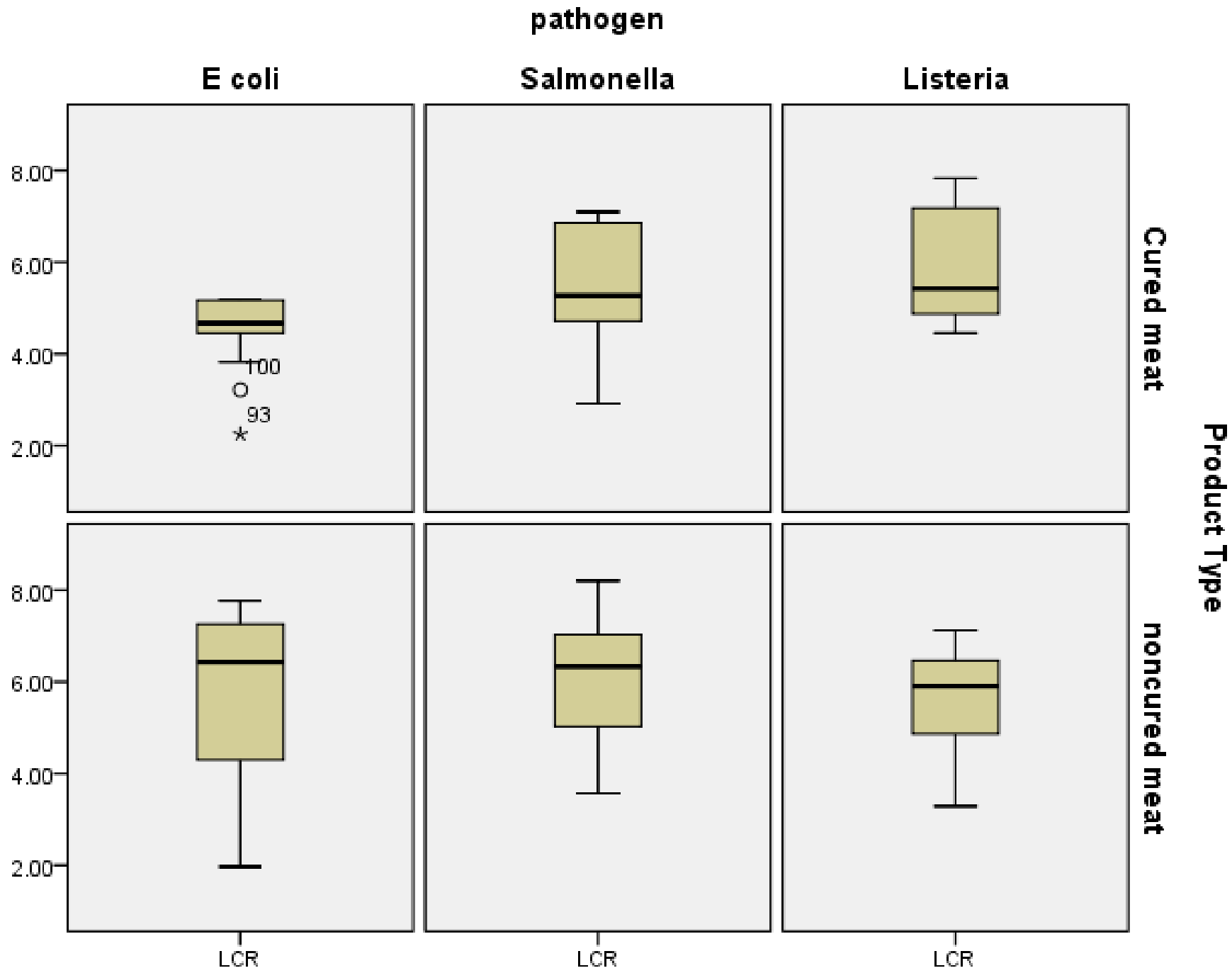
Carcass Decontamination

Method	Treatment	LCR cfu
UV	4 J cm^{-2}	0.5 – 1.0
Pulsed Light	5.6J per pulse; 16 Pulses	0.24-0.91
AOP	1% H_2O_2 19 mJ cm^{-2} UV	1-2
Microwave	1s	5

High Pressure Processing

Gridpath Solutions Inc

NC Hyperbaric


pathogen
E coli
Salmonella
Listeria
8.00
6.00
4.00
2.00
100
93
Cured meat
noncured meat
Product Type
LCR
LCR
LCR

New Technologies

- Novel food designation
- Canada
- New Zealand and Australia
- China
- EU

- Not process but the food product
- Validation of most tolerant pathogen likely to be encountered
- Demonstrate no negative effects
- EU: More restricted on decontamination techniques that can be applied

Consumer Outreach

Plan to name and shame supermarkets selling chicken contaminated with dangerous food poisoning bug ditched after pressure from retailers

- Plan would have seen stores selling chicken with campylobacter bug named
- Idea has now been scraped by the FSA following pressure from retailers
- Data on number of contaminated birds will be released without naming retailers
- Supermarket chicken named the biggest cause of food poisoning in the UK

By Sean Poulter, Consumer Affairs Editor

Published: 16:31 GMT, 22 July 2014 | Updated: 17:58 GMT, 22 July 2014

Consumer Education

- Sanitation
- Food storage
- Minimize cross-contamination events
- Thermometers to verify adequate cooking

Food Standards Agency UK

- Don’t wash chicken

- Coordinated media campaign
  - Public health units
  - TV
  - News outlets
  - Twitter
  - Facebook
  - National and International

>20 million goggle hits
Simple message but reinforced

Blade/Needle/Mechanically Tenderized Beef

Year	Meat	Cases
2000	Needle-tenderized	2
2003	Needle Injected Marinade	11
2004	Needle Injected Marinade	4
2007	Needle Injected Marinade	124
2009	Blade Tenderized	17
2012	Needle-tenderized	5

Conclusion

- North America reliance on interventions due to nature of production systems
- No golden bullet: Combination of methods throughout the chain
- Aqueous based washes: Water usage Wastewater treatment
- Novel technologies
  - Commercial feasibility
  - Effect on meat quality
  - Efficacy
- Consumer outreach of increasing importance

Acknowledgements

- Azadeh Namvar
- Xe Yi
- Micreos-Bacteriophages
- OMAF Food Safety and Innovation program
  - Meat decontamination using Advanced Oxidative Process
  - Application of bacteriophages to control Salmonella in pigs and production environment.