Current & Innovative Approaches to Microbiological Food Safety Management

Innovative & Emerging Sanitation & Decontamination Issues in the Food Industry

Katherine MJ Swanson, Ph.D.
Vice President Food Safety

New Delhi, India
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Discussion topics

- Hygiene – essential food safety foundation
- Hygiene improvement drivers
- Cleaning & disinfection evolution
- Expansion of application to direct product treatments

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Hygiene – Essential Food Safety Foundation

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Top 10 Factors Contributing to US Foodborne Illness 1998-2002

	1.	Food at room temp for several hours – 29%
	2.	Bare-hand contact by food handler – 25%
Contamination	3.	Inadequate cleaning of equipment – 22%
	4.	Handling by infected person or carrier – 20%
Growth	5.	Inadequate cold-holding temperature – 19%
	6.	Cross contamination from raw animal products – 12%
Survival	7.	Insufficient cooking – 12%
	8.	Raw ingr. contaminated by animal or environment – 11%
	9.	Slow cooling – 11%
	10.	Inadequate hot-holding time/temperature – 10%

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Source: CDC 2006 MMWR 55(SS10):1-34

Examples of Lapses in Sanitation

- Mexican-style cheese, USA, 1985
  - Listeriosis from cheese contaminated with raw milk
    - 142 confirmed cases, 48 deaths
    - Cost ? – Industry/regulation changing event
    - Executives to jail
      - New England J Med. 1988. 319:823-8.
- *Salmonella* in ice cream, USA, 1993
  - Unpasteurized eggs in same tank truck
    - up to 224,000 people sick
    - 593 confirmed cases
    - 25,000 lawsuits
      - New England J Med. 1996. 334:1281-6

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More Examples

- *Staphylococcus aureus* in low-fat milk, Japan 2000
  - Contamination in production-line value or powdered milk
    - >13,000 cases
    - Police investigation, plant closed, CEO resigned
    - Cost: Market leader lost consumer confidence
      - IASR 2001. 22:185-6
- Norovirus & hurricane Katrina evacuees, US 2005
  - Crowding and inadequate hygiene
    - >1000 evacuees and relief workers ill in the Huston Astrodome
    - Cost: added stress to traumatized people
      - MMWR 2005. 54(40):1016-8.

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Role of Hygiene & Disinfection in Food Safety Objectives (FSO)

- Controlling initial levels (H_o)
  - Supplier programs that minimize contamination
- Reducing a hazard (Σ R)
  - Inactivation on food surfaces
  - Inactivation / reduction on hands
- Controlling increase of the hazard (Σ I)
  - Prevent recontamination from the environment and equipment

$$H_o - \Sigma R + \Sigma I \leq FSO \text{ or } PO$$

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Hygiene Improvement Drivers

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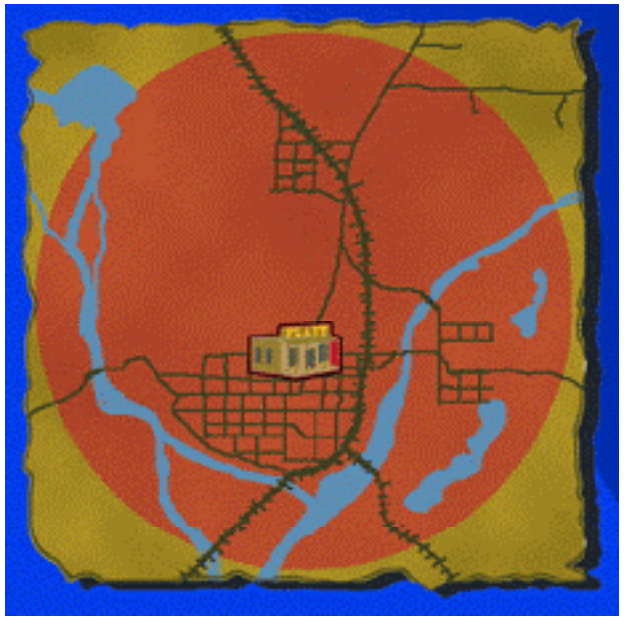
1900s Food Plants

Local production reached limited population



- Small facilities
- Serve local market
  - Hundreds of people
- Quick turnover
- Local regulatory requirements

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Today's Global Food Plants

Can touch the lives of MILLIONS of people

- Large facilities
- Serve the world
  - Millions of people
- Long distribution times
- Multiple regulatory requirements

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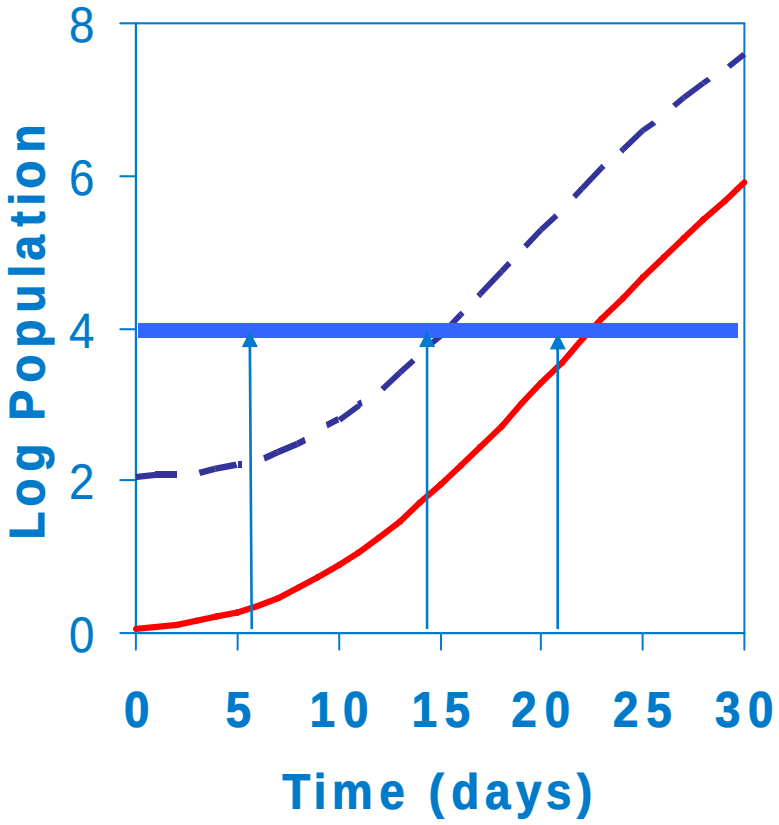
Shelf life extension

May be needed for long distribution

- Extending shelf life provides more time for problems to develop
- Lower initial population (H_0) can increase shelf life
- Improved hygiene can lower initial population



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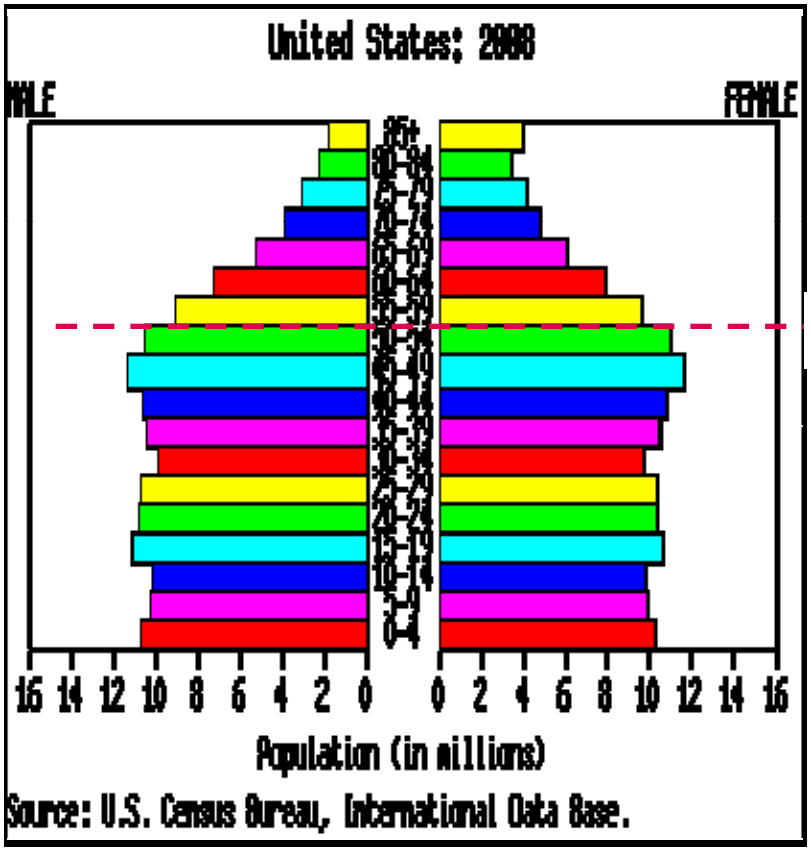
Aging population increases susceptibility



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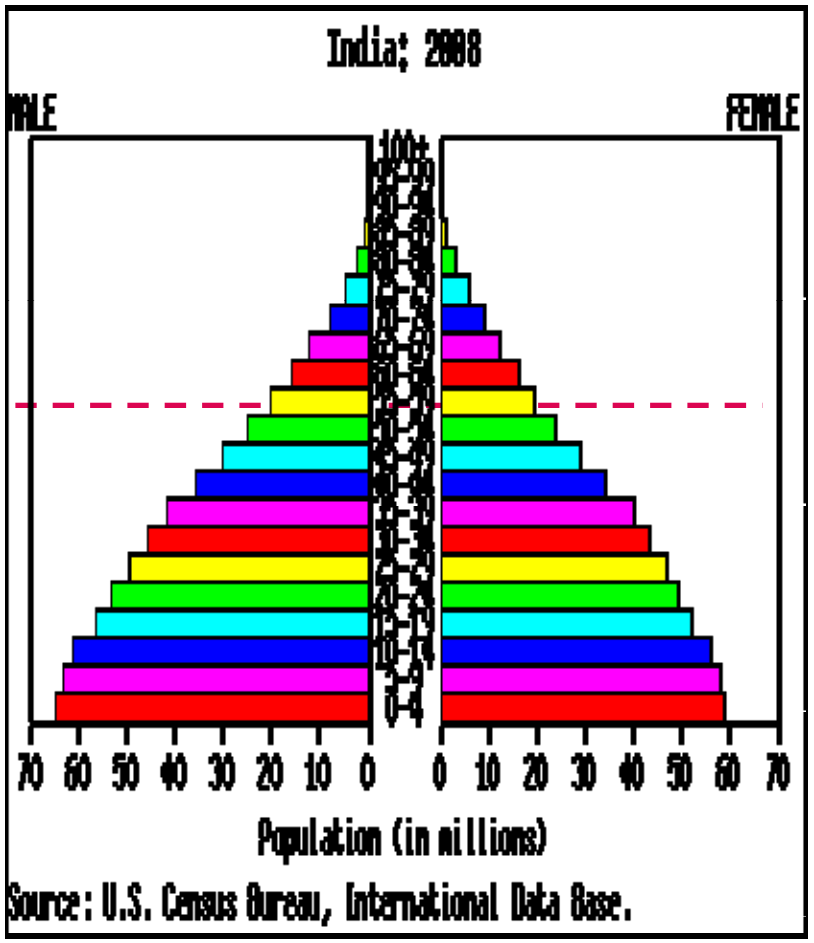

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Environmental contamination can persist

Example: *L. monocytogenes* persistence in manufacturing

Process plant type	Time
Cheese	11 months – 7 years
Fish	Months – 4 years
Ice cream	7 years
Meat	Months – 4 years
Poultry	12 years

Tompkin, J Food Protect. 6(4): 709

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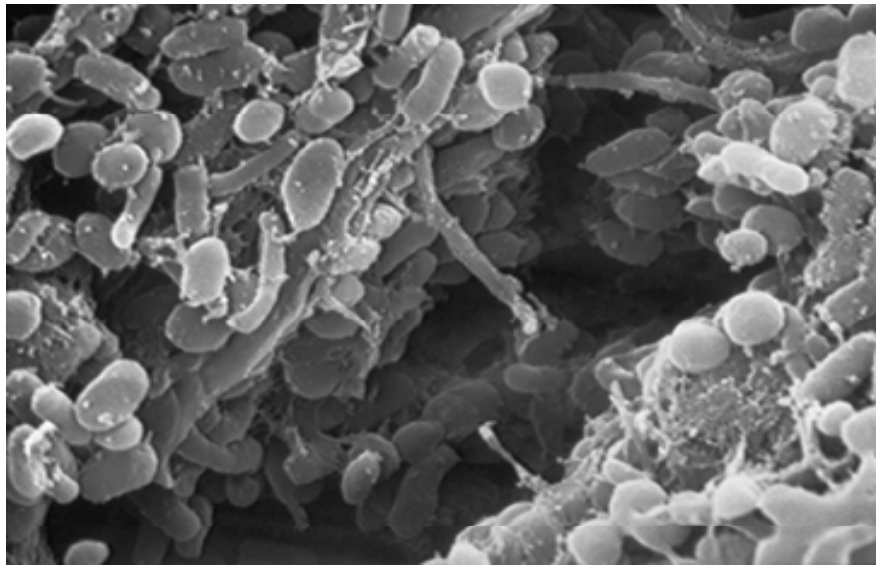
Extending the time between cleaning may allow microbial build up

- Potential development of biofilms
  - Higher populations
  - Resistant organisms
- CLEANING is essential to help prevent formation



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Hygiene Evolution

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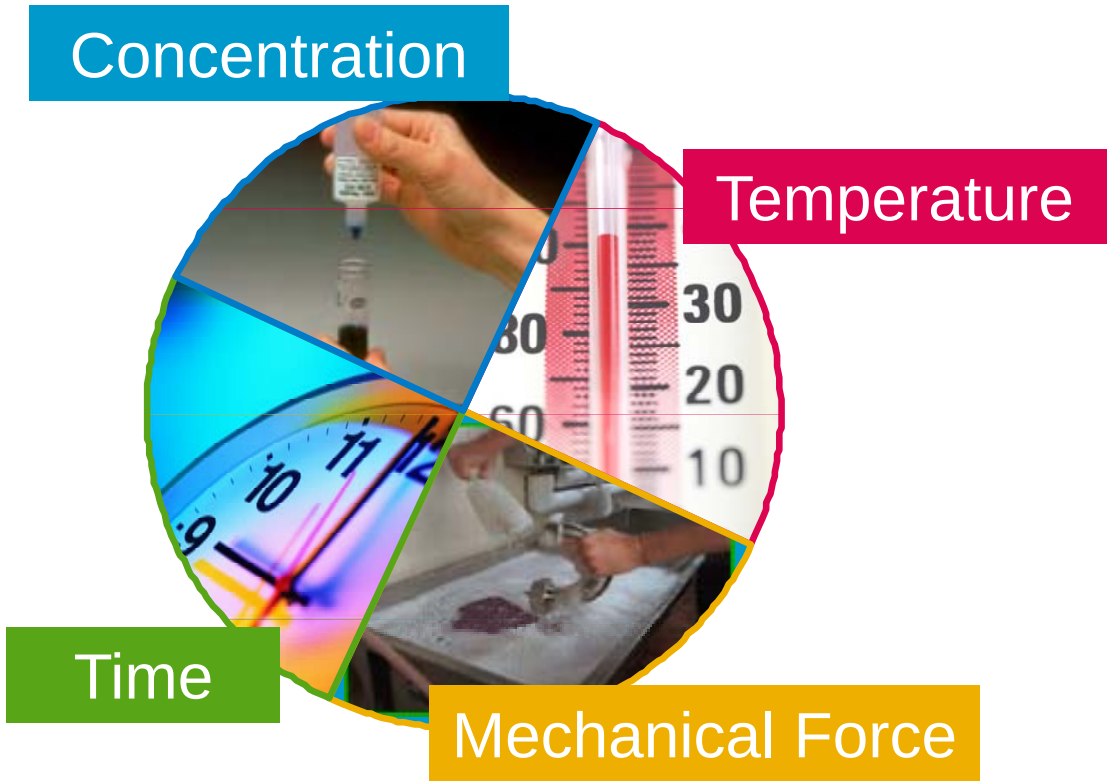
Sanitation 4 x 4

- Pre-rinse
- Wash - remove soil
  - Concentration
  - Temperature
  - Time
  - Mechanical force
- Rinse
- Sanitize
  - Kill microorganisms



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Wet Cleaning Evolution

- Sink, bucket & brush → Clean Out of Place (COP) tanks & Clean In Place (CIP) systems
- Liquids → Foams/Gels
- Direct food treatments

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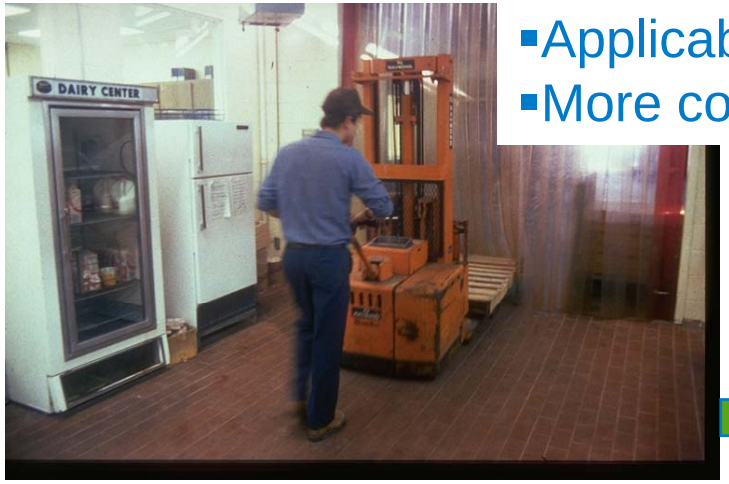
Sanitizer Evolution Example

Traffic patterns linked with contamination transfer

Automated doorway foamers

- Easier maintenance
- Applicable to footwear & wheels
- More consistent coverage



Clean-In-Place (CIP)

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Common Cleaning Issues with Heated Surfaces

- Heat denatures proteins, starches, fats
- Complex soil matrix burned onto surfaces
- Residual soils create a harborage for bacteria
- Residual soils reduce heat-transfer efficiency
- Residual soils contaminate startup process stream

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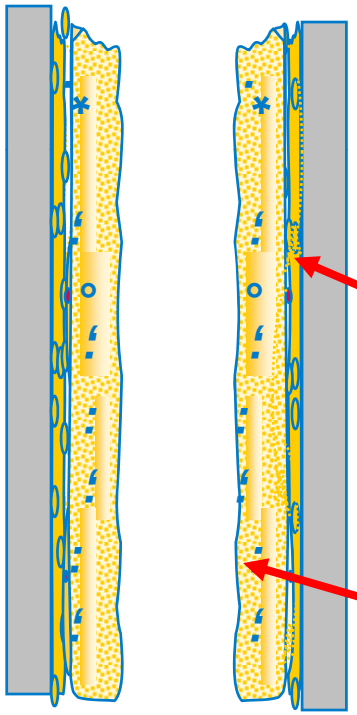
Fouling Mechanism Theory

How does fouling build-up?



- Two different types of deposit:
  - Dense mineral deposit layers on stainless steel pipe surfaces
  - Second layer of protein / fat / carbohydrate matrix depending on product

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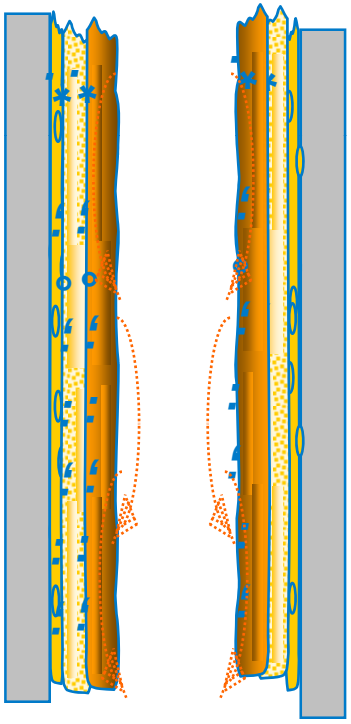
Caustic Cleaning Dairy Example

Influence of NaOH concentration



- High NaOH concentrations cause fouling layer to swell and a protein gel forms (rubber-like top layer)
  - Prevents rapid penetration of the alkaline cleaning solution into the soil layer
  - Soil removal takes more time.
- Degree of “gel formation” depends on NaOH concentration, soil temperature, contact time, and process stream

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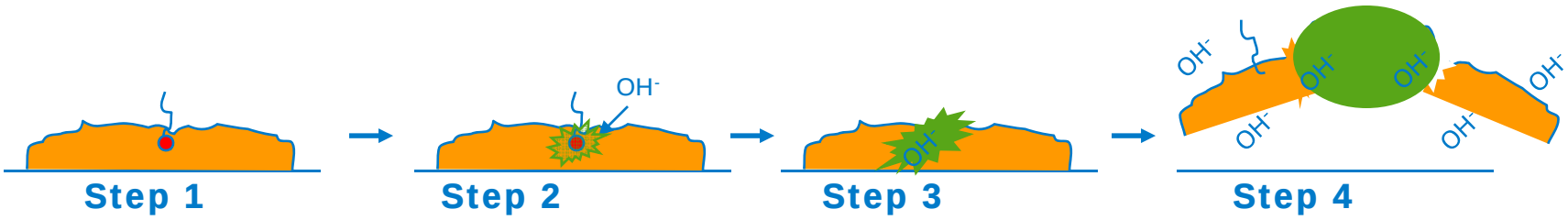
Patented Cleaning Approach for CIP

- STEP 1: Pre-treatment product (oxidizer-based) circulated to penetrate soil layer
- STEP 2: Alkaline detergent circulated and the rise in pH triggers Step 3
- STEP 3: Hydroxide ions interact with oxygen components, triggering rupture of burnt-on soil matrix into pieces
- STEP 4: Cleaning solution easily removes the smaller pieces of soil that are no longer adhering to the surface



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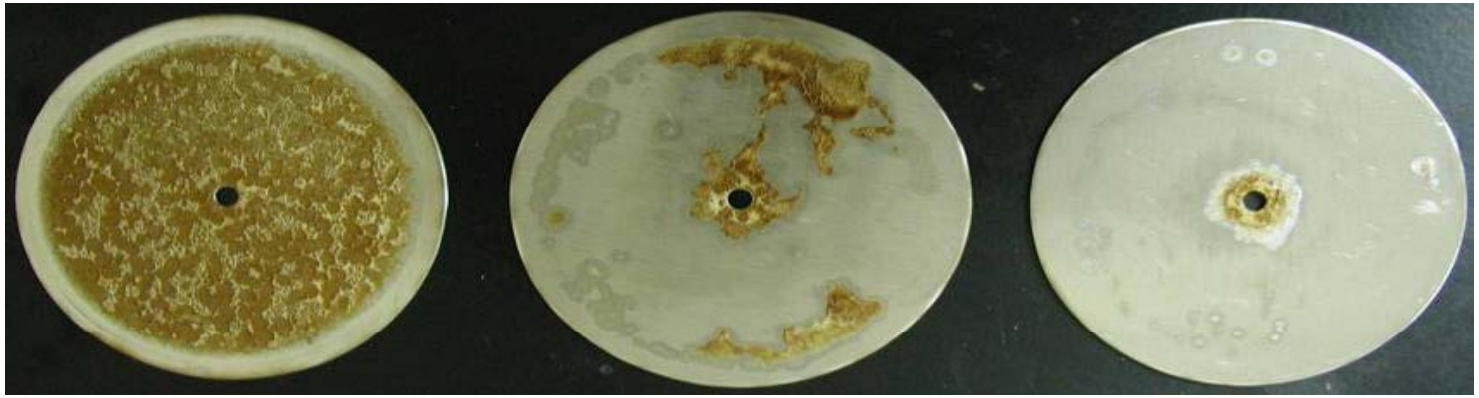
Laboratory Comparison – Dairy Soil

- Milk cooked on to stainless steel disks simulates pasteurizer soils
- 30 minute cleaning
- Standard Cleaning = 2.0% Alkaline Detergent + 1.0% Chelating Agent
- Advanced Cleaning = 0.75% Pretreatment (15min); 1.25% Alkaline Detergent (15min)

Water Control **Standard Cleaning** **Advanced Cleaning**



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Pilot Plant Cleaning Comparison

Pilot Plant Pasteurizer for Raw Milk and Whey

Pilot Scale HTST

Soil before cleaning

Standard

Two-Part

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Customer A – Cleaning Results

No soil remaining – better than previous inspection

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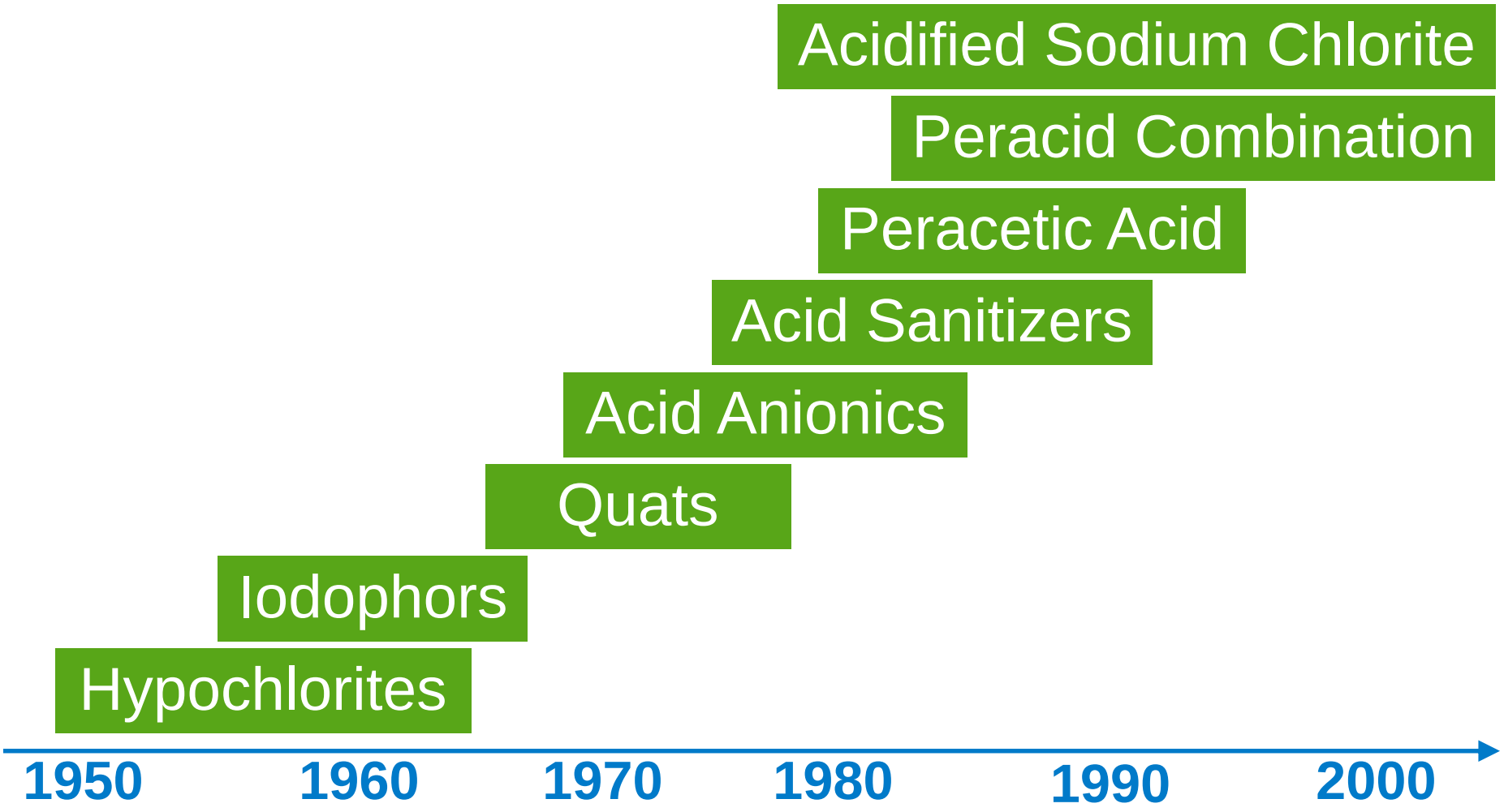
Sanitizer Evolution for Food Use



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There is NO Perfect Sanitizer

	Chlorine	Iodine	Quat	Acid Anionic	Fatty Acid	Peracid
Corrosive (ss)	High	Moderate	None	Low	Low	Low
Temp Sensitivity	Low	High	Moderate	High	Moderate	Low
pH Sensitivity	Moderate	Low	Low	High	High	Low
Foam Level	None	Moderate	Moderate	High	Low	None
Phosphate	None	High	None	High	High	None
Residual Activity	None	None	High	Low	Moderate	None
Soil Load Sensitivity	High	Moderate	Low	Moderate	Moderate	Low

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Follow Regulatory Requirements

Local and importing country requirements may vary

DIRECTIONS FOR USE:
It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Sanitizer Product Label

Acid Liquid Sanitizer
For Food Processing Equipment in Dairies, Dairy Farms and Food Processing Plants

ACTIVE INGREDIENTS:
Hydrogen Peroxide 5.0%
Peroxyacetic Acid 4.4%
Octanoic Acid 2.2%
INERT INGREDIENTS 88.4%

KEEP OUT OF REACH OF CHILDREN
DANGER

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS AND DOMESTIC ANIMALS
DANGER: CORROSIVE. Causes irreversible eye damage and skin burns. May be fatal if inhaled or absorbed through the skin. Harmful if swallowed. Do not get in eyes, on skin or on clothing. Do not breathe vapor or spray mist. Wear protective eyewear (goggles, face shield, or safety glasses), protective clothing and rubber gloves. Wash thoroughly after handling with soap and water, and before eating, drinking, or using tobacco. Remove contaminated clothing and wash clothing before reuse. When spraying or fogging, wear a mask or pesticide respirator jointly approved by Mine Safety and Health Administration and the National Institute for Occupational Safety and Health.
ENVIRONMENTAL HAZARDS
Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of the EPA.
FOR COMMERCIAL USE ONLY
STRONG OXIDIZING AGENT
See back label for Directions for Use.

Ecolab Food & Beverage Division
Ecolab Inc., 370 Wabasha Street N.
St. Paul, Minnesota 55102-1390 U.S.A.

FIRST AID
IF IN EYES: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.
IF ON SKIN OR CLOTHING: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.
IF INHALED: Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible. Call a poison control center or doctor for further treatment advice.
IF SWALLOWED: Call a poison control center or doctor immediately for treatment advice. Have a person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by the poison control center or doctor. Do not give anything by mouth to an unconscious person.
Note to Physician: Probable mucosal damage may contraindicate the use of gastric lavage.
FOR EMERGENCY MEDICAL INFORMATION IN USA OR CANADA, CALL: 1-800-328-8029.
FOR EMERGENCY MEDICAL INFORMATION WORLDWIDE, CALL: 1-651-222-5352 (IN THE USA).
PHYSICAL AND CHEMICAL HAZARDS
Strong Oxidizing Agent: Corrosive. Do not use in concentrated form. Mix only with water according to label instructions. Never bring concentrate in contact with other sanitizers, cleaners or organic substances.

STORAGE & DISPOSAL
DO NOT CONTAMINATE WATER, FOOD OR FEED BY STORAGE OR DISPOSAL.
PESTICIDE STORAGE: Product should be kept cool and in a vented container to avoid any explosion hazard.
PESTICIDE DISPOSAL: Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture or rinsate is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.
CONTAINER DISPOSAL: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.
EPA Reg. No. 1677-156
EPA Est. 60356-IL-1 (2), 1677-IL-2 (J), 1677-NJ-1 (W), 1677-TX-1 (D), 1677-GA-1 (W), 1677-OK-1 (S), 1677-MN-1 (R), 1677-PA-1 (R), 11321-GA-1 (C), 1677-OH-1 (H), 1677-GA-2 (H), 1677-MO-1 (K), 1677-MN-1 (H)
Superscript refers to first letter of date code.

DIRECTIONS FOR USE

Net Contents: 50 U.S. gal/189 L

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From Equipment to Product

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US FoodNet Estimates of Foodborne Illness 1996-2007

Organism	Rate/100,000 Overall 2007	Change*
Salmonella	14.92	8% ↓
Campylobacter	12.79	31% ↓
Shigella	6.26	36% ↓
Cryptosporidium	2.67	Not significant
E. coli O157	1.20	25% ↓
Yersinia	0.36	49% ↓
Vibrio	0.24	Not significant
Listeria monocytogenes	0.27	42% ↓

*Compared to 1996-98 baseline
Source: CDC 2008. Preliminary FoodNet Data MMWR 57(14);366-370

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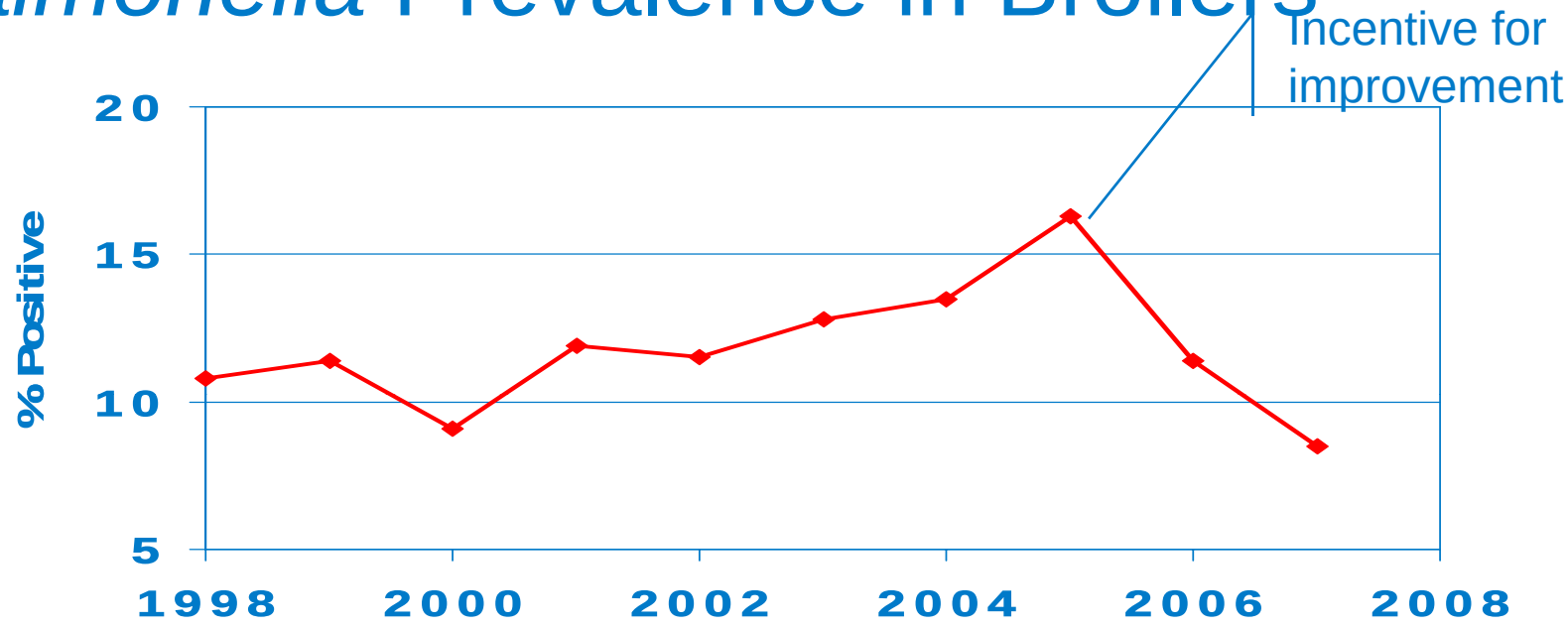
US Department of Agriculture Data on *Salmonella* Prevalence in Broilers



- USDA FSIS
  - "Persistent upward trend in positive verification samples provides reason for concern"
    - USDA Food Safety & Inspection Service, after 2005 data released
  - Targeted 2006 sampling based on reduction of % positive

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US Department of Agriculture
Salmonella Performance Standard for Broilers

- 20% of broilers positive for *Salmonella* over time
- Verification sampling allows 12 of 51 samples to be positive
- Establishment operating at 20% has an 80% chance of meeting the standard

$$H_0 - \sum R + \sum I \leq PO = 20\%$$

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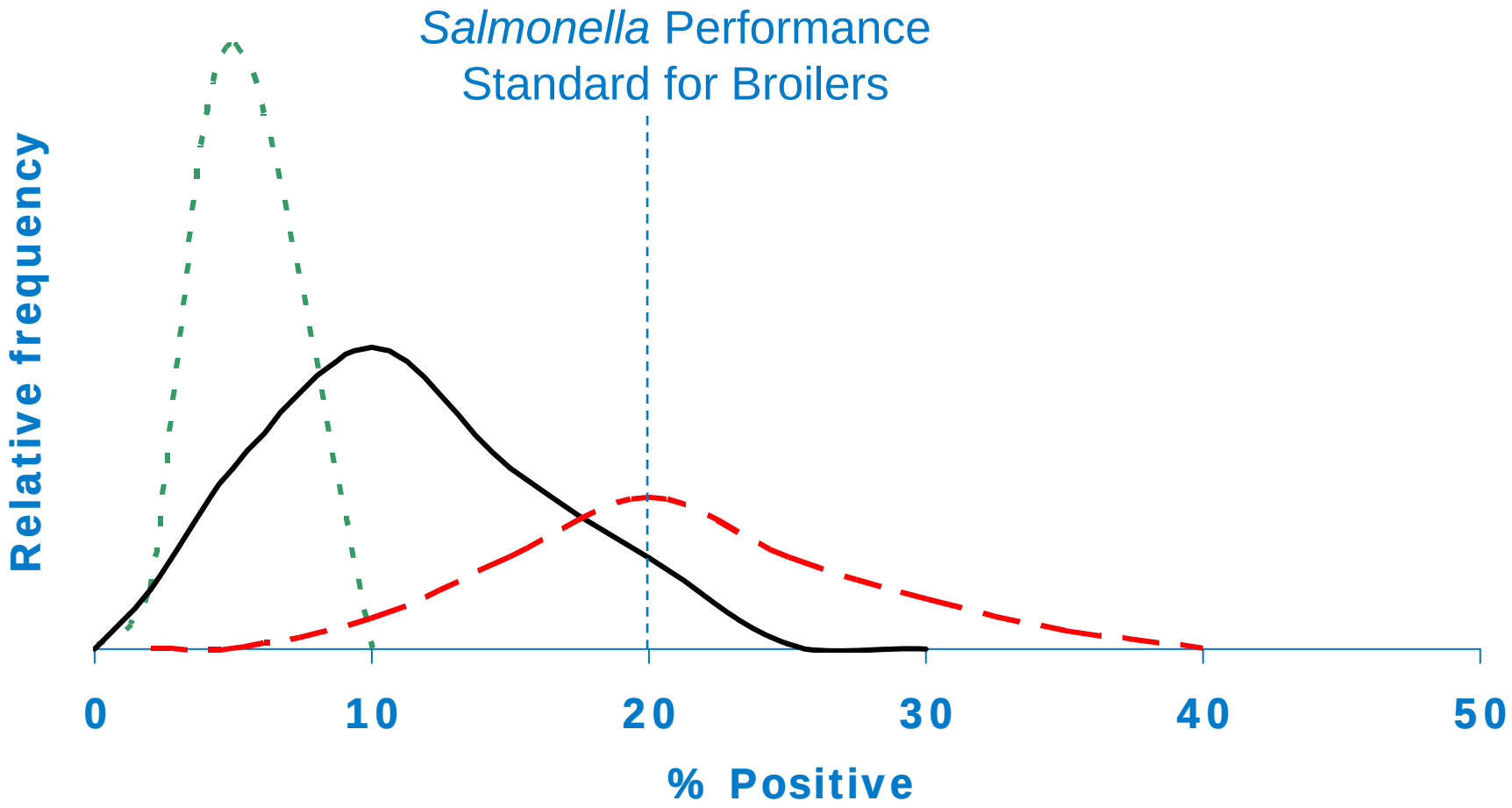
Hypothetical Distribution & Meeting Standard



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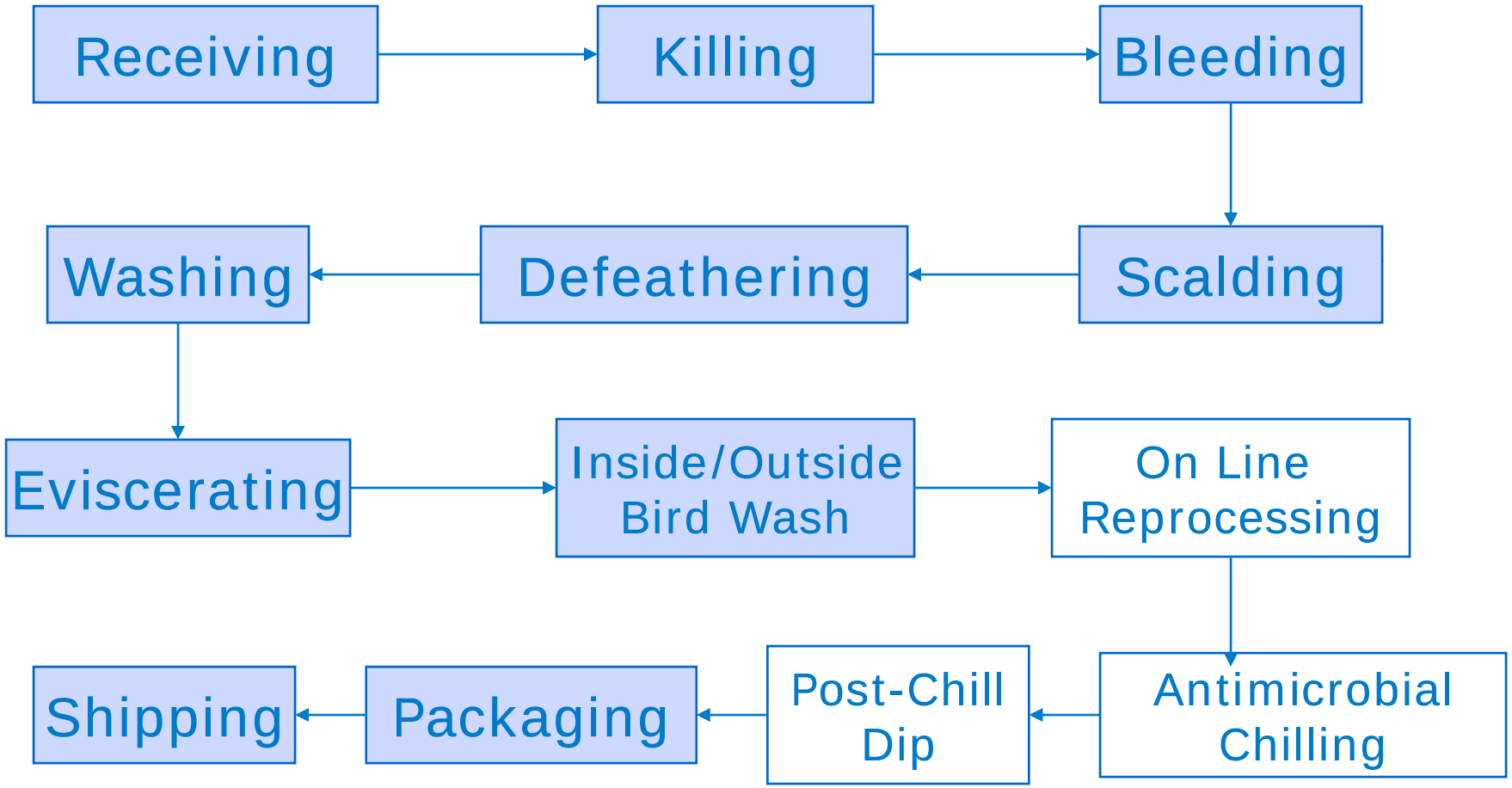
Chicken Process Flow – Antimicrobial Enhancements (light background)



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Major Antimicrobial Treatments

- Hypochlorite
- Tri sodium phosphate (TSP)
- Chlorine dioxide (ClO_2)
- Peracid treatments
- Acidified sodium chlorite (ASC)

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Potential Antimicrobial Treatments in the USA

Process step	Chemical treatment
Inside-outside bird wash	Typically chlorine
On-line reprocessing	Peracid, ASC, TSP, ClO_2
Chiller	Chlorine, peracid, ClO_2
Post-chill spray or dip	ASC, ClO_2

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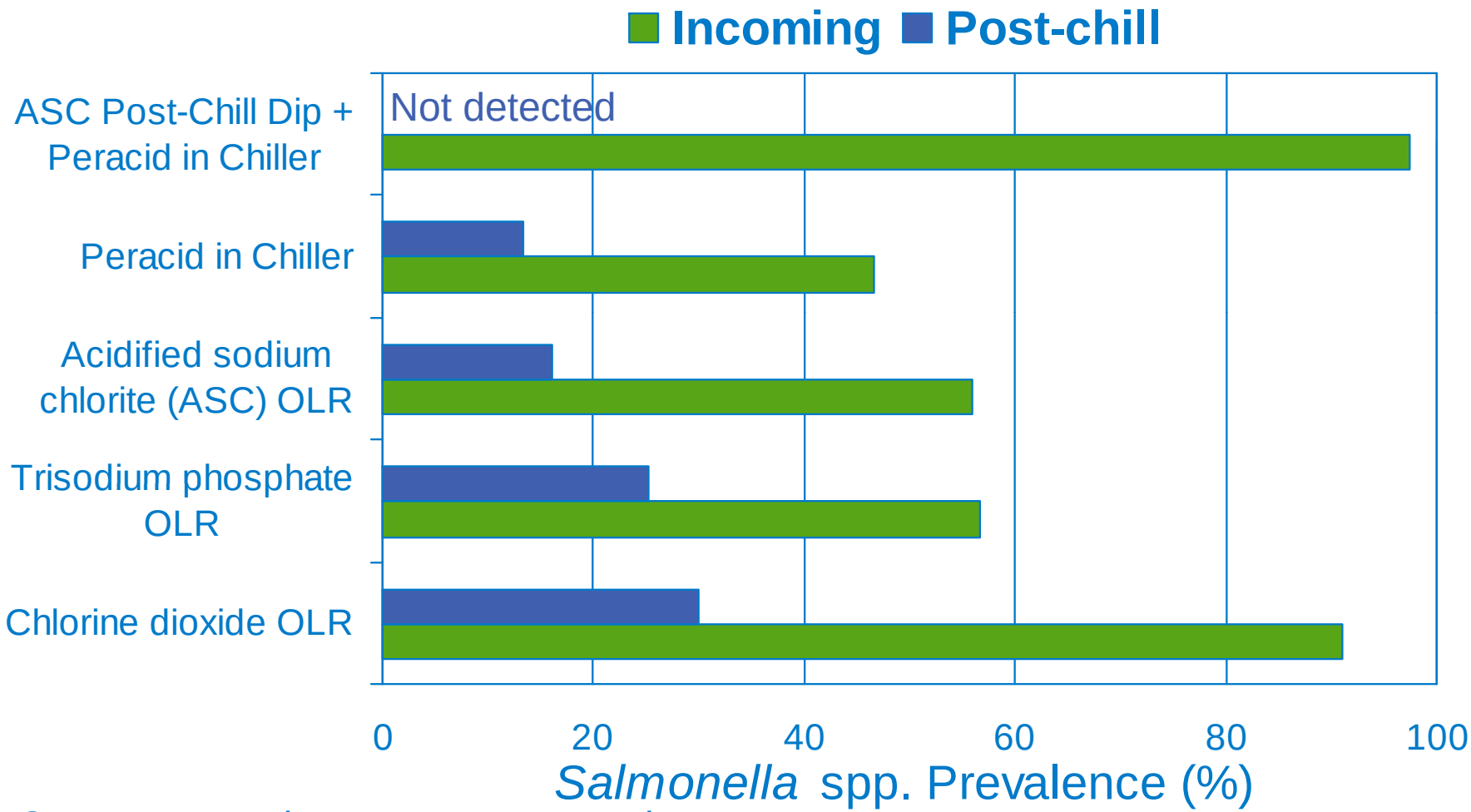
Poultry Plant *Salmonella* Interventions



NOTE: Use requires country approval

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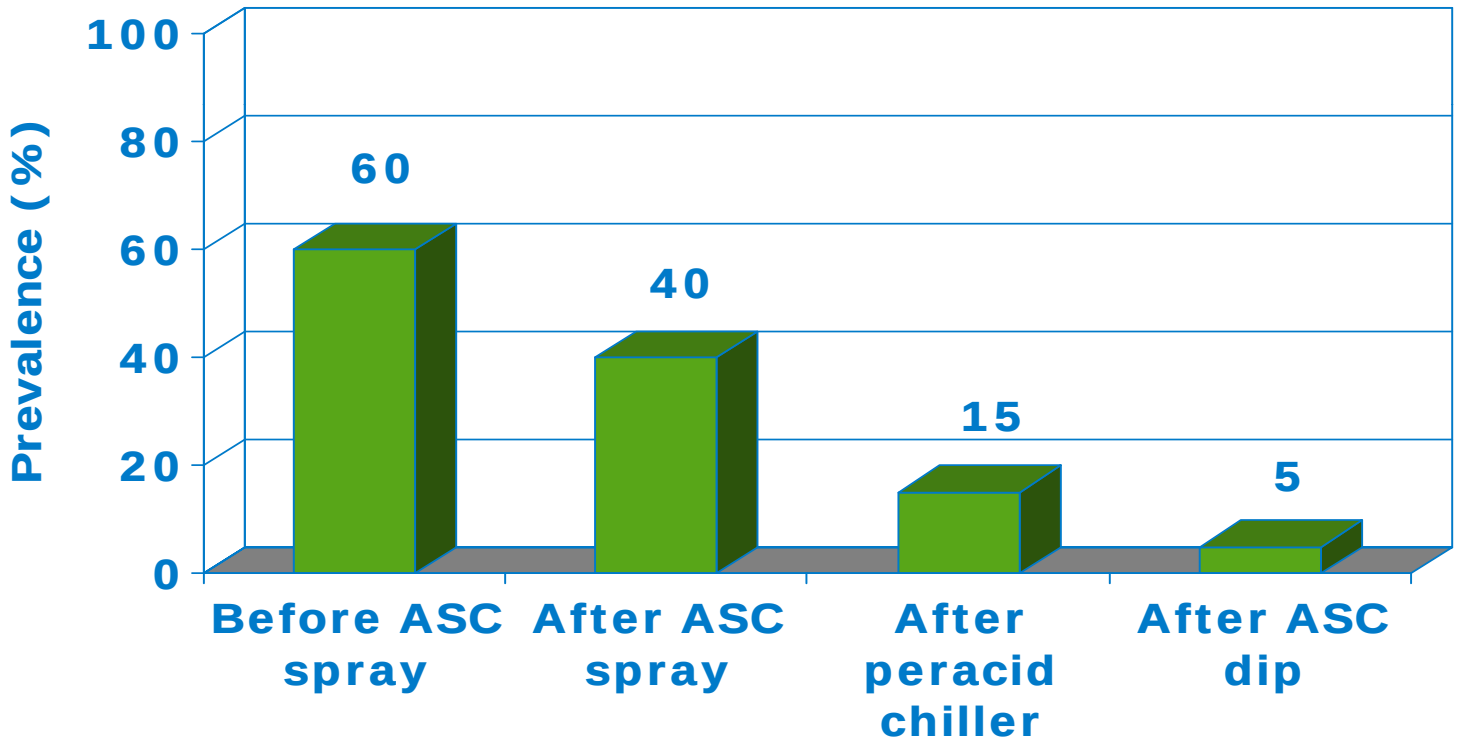
Adapted from: Danilson. 2005. US Poultry & Agr Assoc, Salmonella Control Conference, March 17, 2005

Multi-hurdle antimicrobial treatment

Salmonella prevalence during broiler processing



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Acidified Sodium Chlorite on Chicken Carcasses

Substantial reduction in prevalence and level

Australian commercial operation

	TPC	*E. coli*		*Salmonella*		*Campylobacter*	
	cfu/cm^2	%	cfu/cm^2	%	cfu/cm^2	%	cfu/cm^2
Untreated	2.78	100	1.55	90	-1.80	100	1.59
Treated	1.23	13	-0.64	10	-1.85	23	-2.21
Mean log difference	*1.55*		*2.19*		*0.05*		*3.80*

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Sexton et al 2007. Intl J. Food Microbiol. 115 (2): 252-5

Summary

Increasing importance of hygiene

- Broad distribution magnifies risk
- Shelf life extension magnifies problems
- Aging & immunocompromised population growing
- Environmental harborage must be eliminated
- Operational efficiency (extending run times) requires cleaner systems

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Summary

Cleaning & Disinfecting Systems are Evolving

- Manual to CIP, and soap & water to foam can provide more consistent results with greater efficiency
- There is no perfect cleaner or sanitizer
  - Match it to the equipment, application, and regulatory requirements
- Antimicrobial treatments for food may provide improvements over traditional methods
  - Requires regulatory approval

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