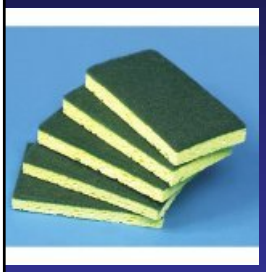
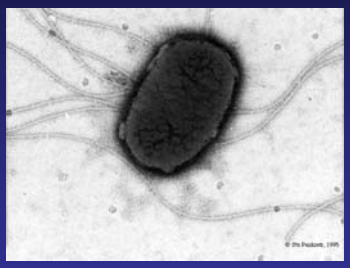
Overview of sanitizers currently in use with emphasis on pre-operation sanitation to ensure that pathogens do not survive





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Introduction

- Numerous microorganisms can adhere to processing equipment surfaces
- They may concentrate and grow in crevices or joints with rubber gaskets that remain moist
- Wear on surfaces may significantly impact the ability of microbes to adhere
- Any remaining food material left on surfaces provides a growth medium for bacteria
- Proper cleaning and sanitation are essential for elimination of pathogens

Proper cleaning of meat and poultry processing plants:

1. Pick up large pieces of extraneous material and transfer it to trash cans
2. Cover all electrical connections
3. Pre-rinse all soiled areas with 50-55°C water
4. Apply alkaline cleaner through a centralized or portable foam system using 50-55°C water
5. Allow 5-20 minute exposure (although a foam system requires less labor, a high pressure system is more effective for penetrating hard to reach areas)
6. Rinse all ceilings, walls and equipment within 20 minutes of application of cleaner
7. Inspect all equipment and surfaces, touch up as necessary
8. Apply sanitizer

Marriott, 1989

Commonly used cleaning materials

- **Alkaline detergents**
  - Strong alkaline cleaners-strong dissolving power, may remove cooked on material
    - Sodium hydroxide, nitrous oxide : silicon dioxide
  - Heavy duty alkaline cleaners-have moderate dissolving power
    - Sodium silicate, sodium hexametaphosphate, trisodium phosphate
  - Mild alkaline cleaners-used for hand cleaning lightly soiled areas
    - Sodium carbonate
- **Acid detergents**
  - Strong acid cleaners-used to remove encrusted surface matter and clean scale
    - Hydrochloric, hydrofluoric, sulfamic, sulfuric, phosphoric acids
  - Mild acid cleaners
    - Hydroxyacetic, acetic, gluconic acids
- **Synthetic detergents**
  - Lower surface tension, increases wetting
  - Quaternary ammonia
- **Soaps**
  - Not used much in industry because they do not work well in hard water
- **Combinations** (alkaline chlorinated cleanser)

Marriott, 1989

Commonly used Sanitizing Agents

- Quaternary ammonia in various forms and mixtures
- Various chlorinated compounds
  - Bleach (industrial strength-11%)
  - Chlorine dioxide
- Iodine compounds
- Encapsulated lysozyme
- Ozone
- Steam
- Hydrogen peroxide vapor
- Peroxyacetic acid (peracetic acid)
- Cetylpyridinium chloride (novel)

Characteristics of commonly used sanitizers

Characteristic	Chlorine	Iodophors	Acids	Quats
Germ kill	Good	Vegetative cell	Good	Selective
Toxicity	None	Dep. on wetting agent	Dep. on wetting ag.	Moderate
Stability	Varies with temp	Varies with temp	Excellent	Excellent
Speed	Fast	Fast	Fast	Fast
Penetration	Poor	Good	Good	Excellent
Film forming	None	None to sl.	None	Yes
Binding to organics	High	Moderate	Low	Low
Affected by water	Low pH and iron	High pH	High pH	Yes
Ease of meas.	Excellent	Excellent	Excellent	Excellent
Ease of use	Excellent	Excellent	High foam	High foam
Odor	Chlorine	Iodine	Some	None
Taste	Chlorine	Iodine	None	None
Effect on skin	Some	None	None	None
Corrosive	Extensive on steel	Not to stainless	Bad on mild steel	None
Cost	Low	Low	Moderate	Moderate

Lentsch (1979)

Specific areas or conditions where particular sanitizers are recommended

Area or Condition	Recommended Sanitizer	Concentration (ppm)
Aluminum Equipment	Iodophor	25
Bacteriostatic Film	Quat, acid-anionic	200 or 100
CIP Cleaning	Acid, Act. chlorine, iodophor	130
Concrete Floors	Act. chlorine, quat	1000 to 2000 or 500 to 800
Film Formation Prevention	Acid, iodophor	130
Fogging	Active chlorine	800 to 1000
Hand Dip (production)	Iodophor	25
Hand Sanitizer (washroom)	Iodophor, phenolic	25 or 2 to 3 %
Hard Water	Acid, iodophor	130 or 25

Lentsch (1979)

Specific areas or conditions where particular sanitizers are recommended

Area or Condition	Recommended Sanitizer	Concentration (ppm)
High iron water	Iodophor	25
Long shelf life	Iodophor, Quat	
Low cost	Hypochlorite	
Noncorrosive	Iodophor, Quat	
Odor control	Quat	200
Organic matter stab.	Quat	200
Plastic crates	Iodophor	25
Porous surface	Active chlorine	200
Processing equip. (Alum.)	Quat	200

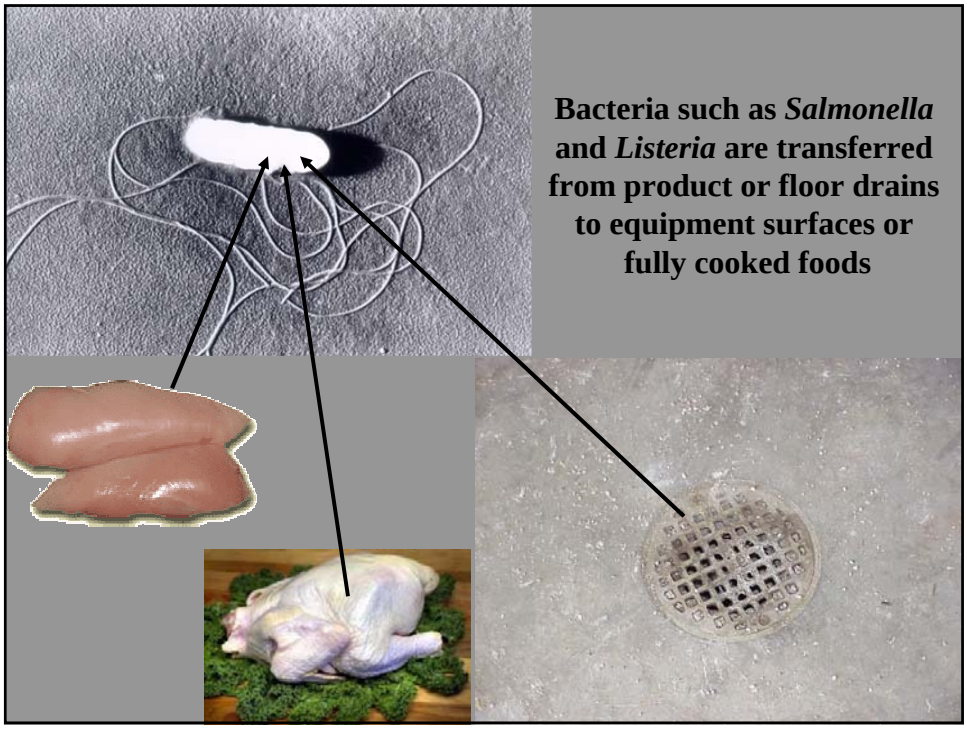
Lentsch (1979)

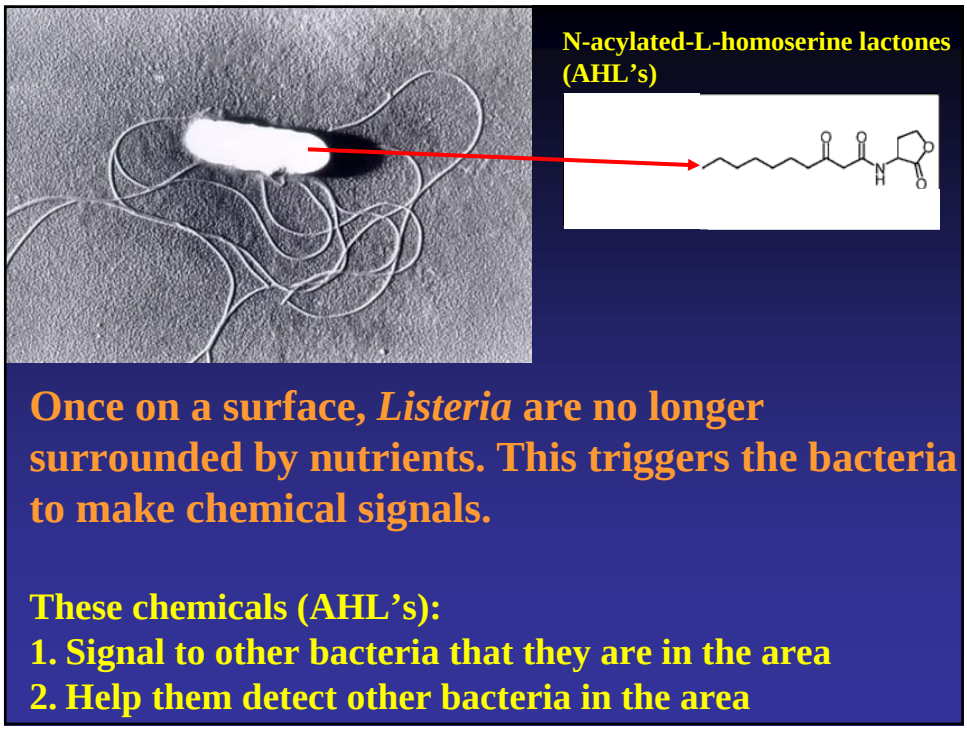
Specific areas or conditions where particular sanitizers are recommended

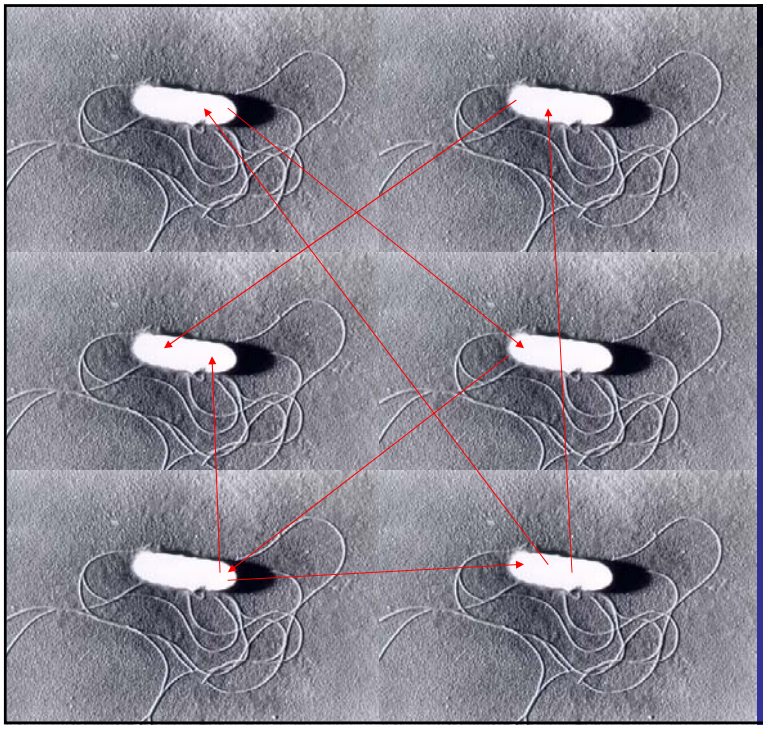
Area or Condition	Recommended Sanitizer	Concentration (ppm)
Processing equip. (stainless)	Acid, act. chlorine, iodophor	130 or 200 or 25
Rubber belts	Iodophor	25
Tile walls	Iodophor	25
Visual control	Iodophor	25
Walls	Act. chlorine, quat	200 or 200
Water treatment	Act. chlorine	20
Wood crates	Act. chlorine	1000
Conveyor lubricant	Glutaraldehyde	Per manufact. sugg.

Lentsch (1979)

Biofilms


Bacteria such as *Salmonella* and *Listeria* are transferred from product or floor drains to equipment surfaces or fully cooked foods


N-acylated-L-homoserine lactones (AHL's)
Once on a surface, *Listeria* are no longer surrounded by nutrients. This triggers the bacteria to make chemical signals.
These chemicals (AHL's):
1. Signal to other bacteria that they are in the area
2. Help them detect other bacteria in the area



The *Listeria* then signal one another using these AHL molecules

This is called "Quorum Sensing"

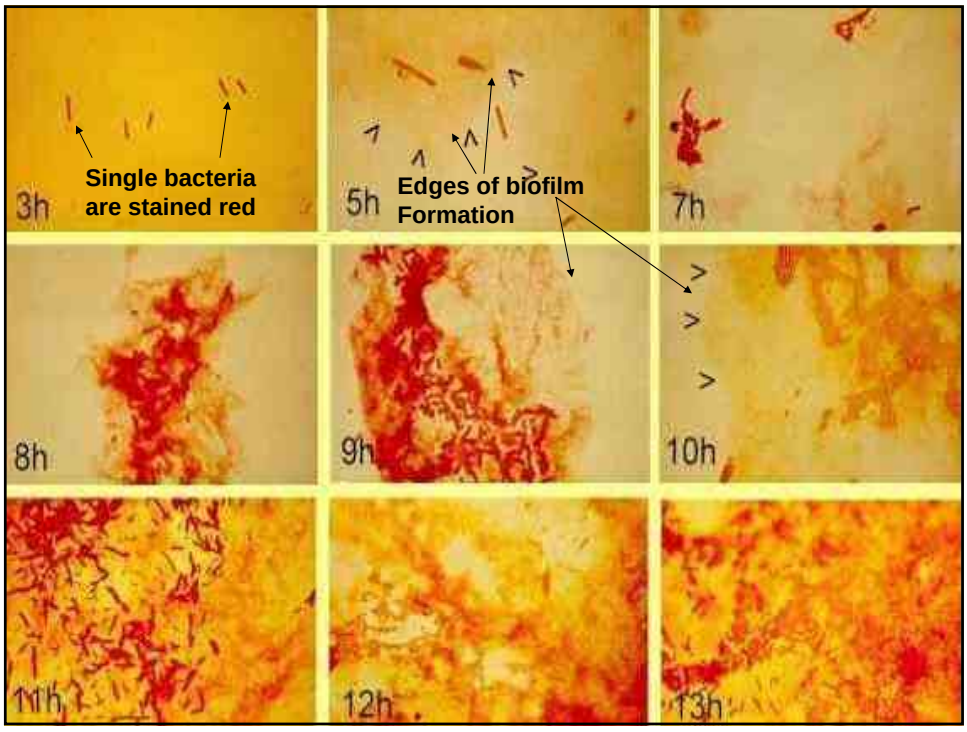
***Salmonella, E.coli* and *Pseudomonas* do this as well**

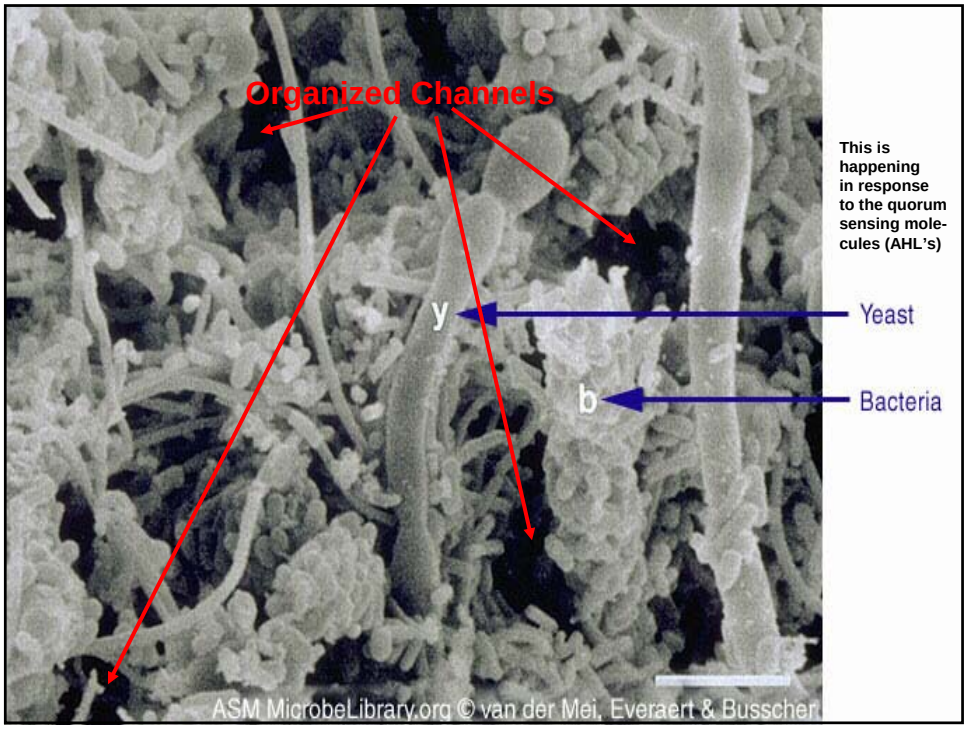
Quorum Sensing

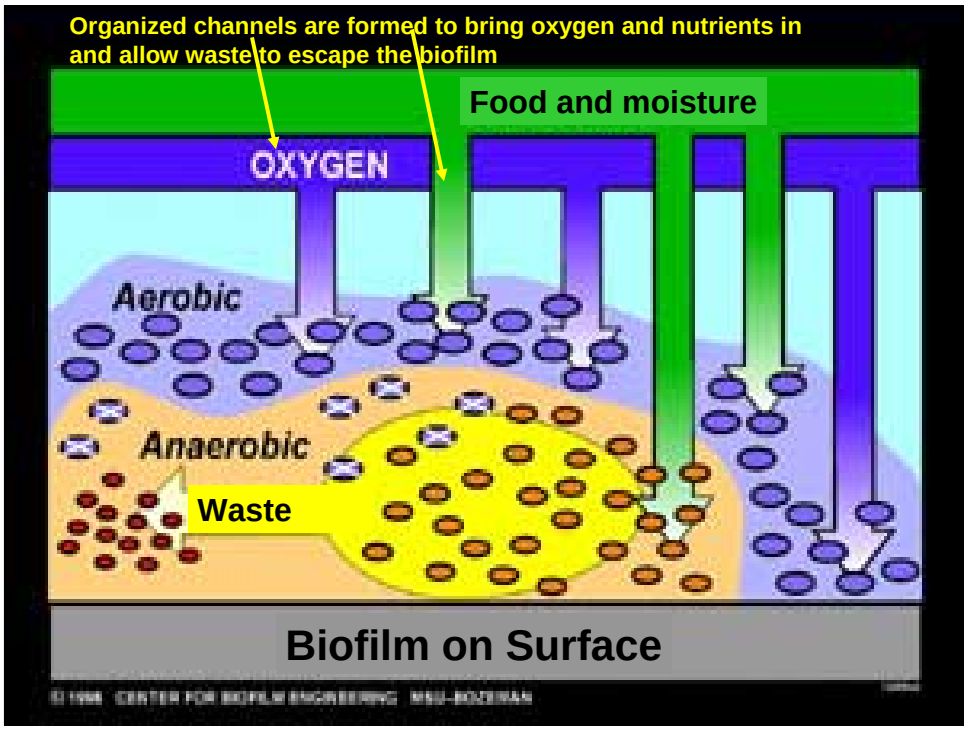
- **The chemical signals (AHL's) are then used to tell other bacteria "<u>we are starving and we must respond</u>"**
- **The bacteria begin to produce a protective covering (biofilm or glycocalyx) to:**
  - **Protect themselves**
  - **Prepare an organized communal structure**
    - **Very similar to an ant mound**

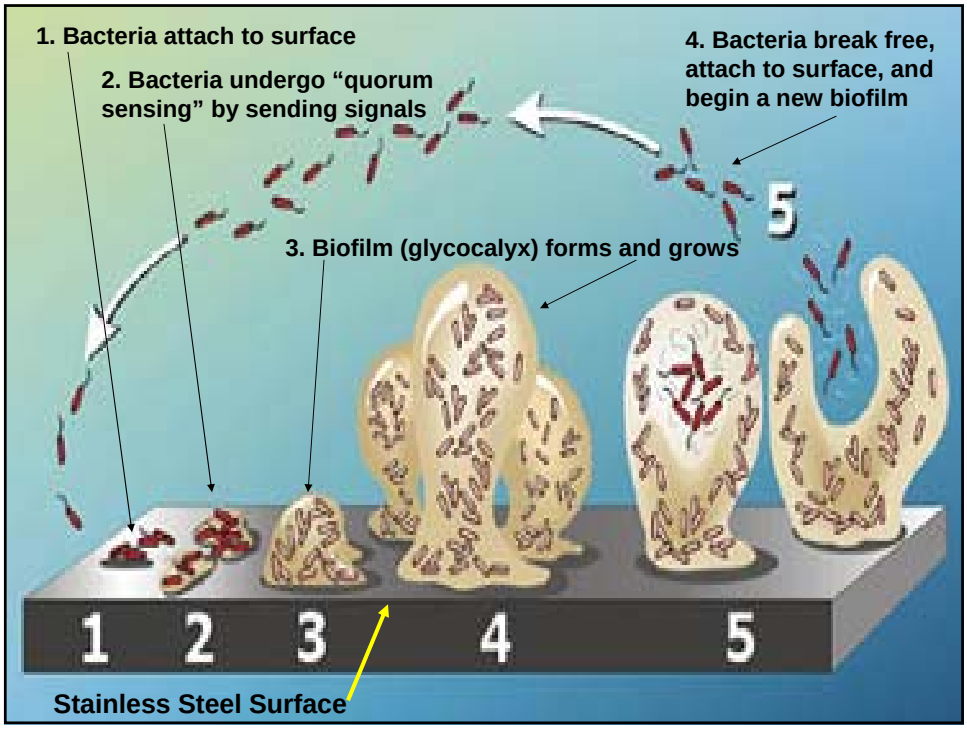
What is a biofilm?

- In early stages, a biofilm is comprised of a cell layer attached to a surface
- The cells grow and divide, forming a dense mat numerous layers thick
- These bacteria use quorum sensing to signal each other to reorganize, thereby forming an array of pillars and irregular surface structures
- These structures are connected by convoluted channels that deliver food and remove waste
- The biofilm produces a glycocalyx matrix shielding them from the environment and preventing sanitizers from killing them




Organized Channels
This is happening in response to the quorum sensing molecules (AHL's)
y
Yeast
b
Bacteria
ASM MicrobeLibrary.org © van der Mei, Everaert & Busscher


Organized channels are formed to bring oxygen and nutrients in and allow waste to escape the biofilm
Food and moisture
OXYGEN
Aerobic
Anaerobic
Waste
Biofilm on Surface



Why is this important?

- **When bacteria are encased in biofilms, they are very difficult to kill (Only 10-60% elimination)**
- **Most cleaning programs involve 4 days with alkaline cleaner and 1 day with an acid cleaner**
- **Jessen and Lammert (2001) found that the effect of detergents on biofilms was negligible, whereas the most efficient disinfectants were able to eliminate *L. monocytogenes***
- **Very high strength and long reaction times were required**
- **Acid disinfectants composed of hydrogen peroxide and peracetic acid were more efficient than chlorine compounds**
- **Similar results are reported from some researchers (Carpentier & Cerf, 1993; Bourion & Cerf, 1996; Fatemi & Frank, 1999), while others find the same efficacy of the two disinfectants (Frank & Koffi, 1990) or even the opposite efficacy (Rossini & Gaylarde, 2000).**

Biofilm elimination recommendations

- Parkar et al. (2003) found that chemicals that attack the polysaccharide matrix of the biofilm were particularly effective in killing and removing cells in a biofilm
- Treatment of either the biofilm or a clean stainless steel surface with lysozyme killed biofilm cells and prevented the attachment of any bacteria exposed to the surface
- The authors suggested that lysozyme may have potential as an alternative control method for biofilms of bacteria

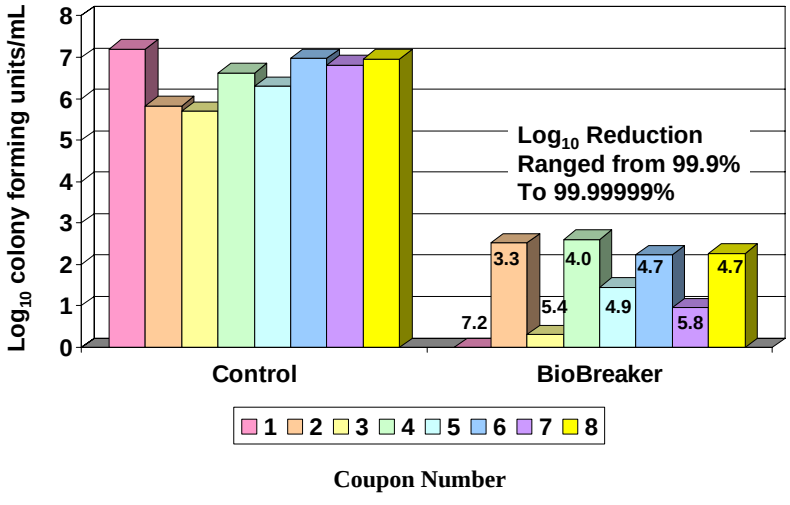
Biofilm elimination recommendations

- Gibson et al. (1999) reported that cleaning produced a 0.91 log reduction
- High pressure spray and a mechanical floor scrubber, which use a high degree of mechanical action, were most effective for removing biofilms
- Cleaning trials with biofilms of *Pseudomonas aeruginosa* or *Staphylococcus aureus* showed that spraying with water pressure above 17.2 bar did not increase efficacy
- Increasing spray time did not affect biofilms
- Alkaline, acidic or neutral detergents did not increase the removal of biofilms
- However, the acidic and alkaline products affected the viability of *Staph. aureus* and *Ps. aeruginosa*, minimizing the potential for the spread of contamination

Biofilm elimination recommendations

- Russell (2004) was able to dramatically reduce fully formed of *Listeria monocytogenes* on stainless steel coupons using an all natural (consumable) product
- The BioBreaker product was applied using electrostatic spraying
- Log_{10} reductions ranged from 3.3 to 7.2 when compared to controls
- BioBreaker caused the *Listeria* biofilm to float off of the surface of the coupon

The Effect of BioBreaker on *Listeria monocytogenes* in a fully formed biofilm

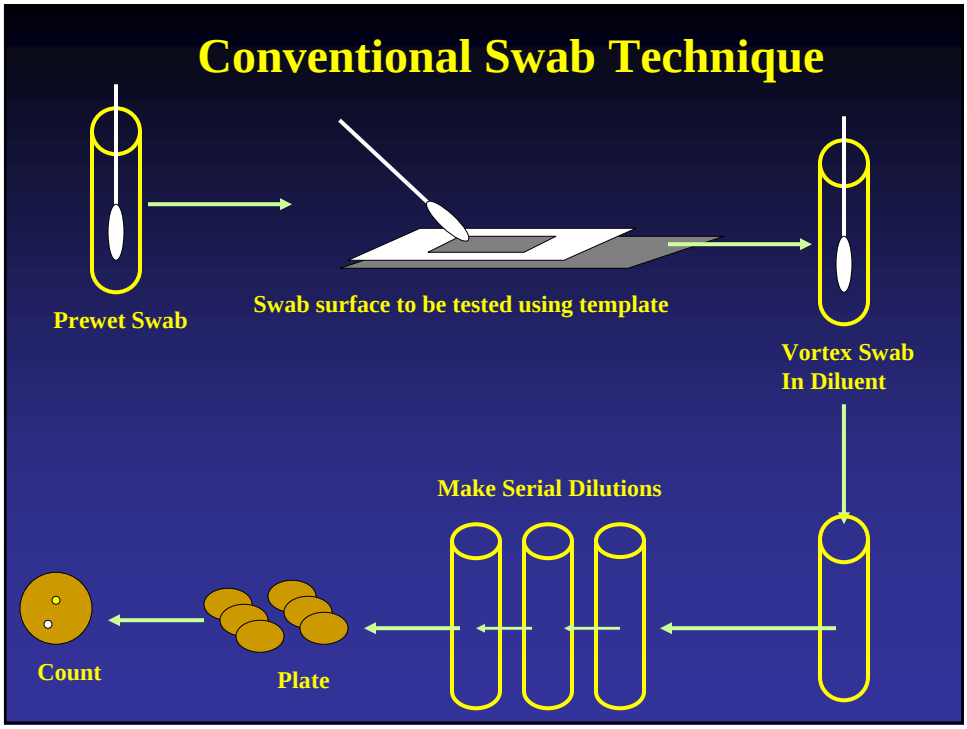


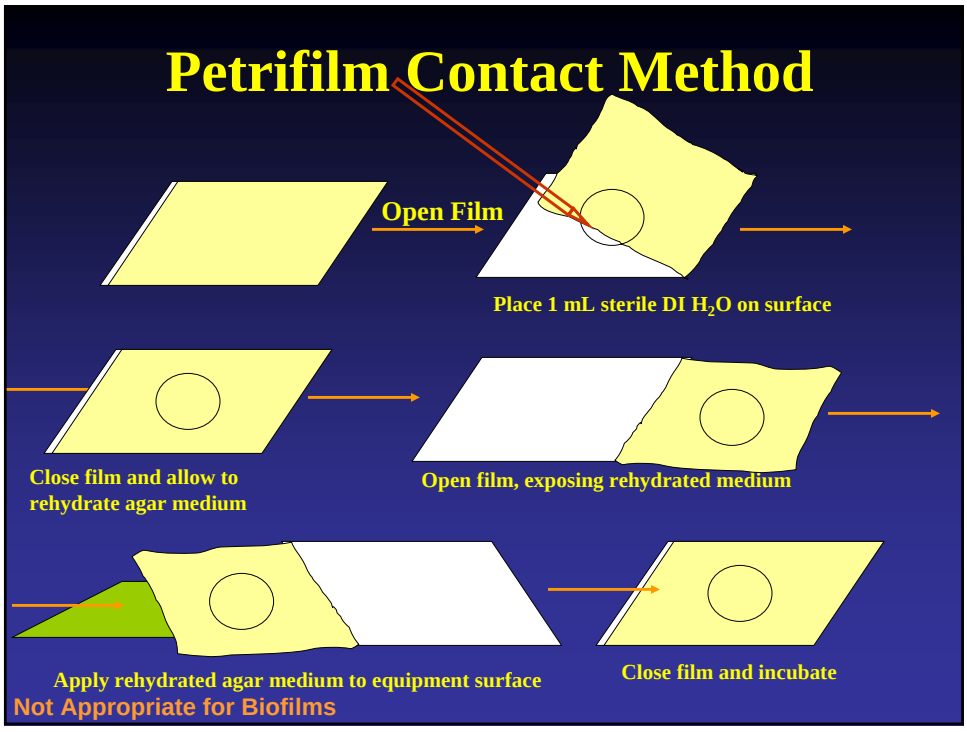
Testing for Biofilms

- Sampling is very difficult because they adhere to equipment so tightly
- Scraping or high pressure swabbing techniques are recommended

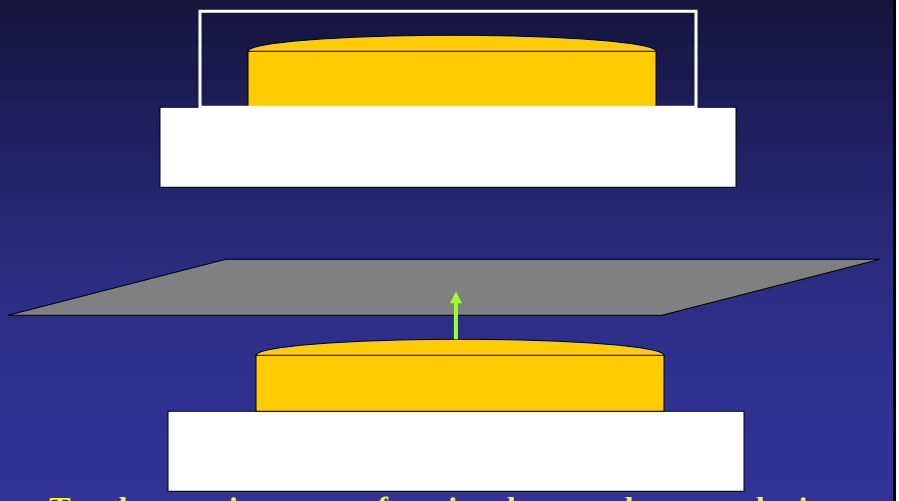
Monitoring Cleaning and Sanitation

- Traditional microbiological methods are very slow (48 h)
  - Provide a retrospective assessment of cleanliness
  - Do not fit in with a HACCP program
- Rapid, real-time methods are much more appropriate and are less expensive


Conventional Swab Technique
Prewet Swab
Swab surface to be tested using template
Vortex Swab
In Diluent
Make Serial Dilutions
Count
Plate


Petrifilm Contact Method
Open Film
Place 1 mL sterile DI H_2O on surface
Close film and allow to
rehydrate agar medium
Open film, exposing rehydrated medium
Apply rehydrated agar medium to equipment surface
Close film and incubate
Not Appropriate for Biofilms

RODAC Plate



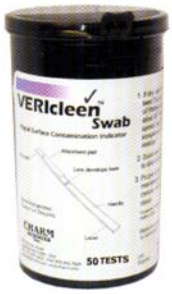
Touch to equipment surface, incubate, and count colonies

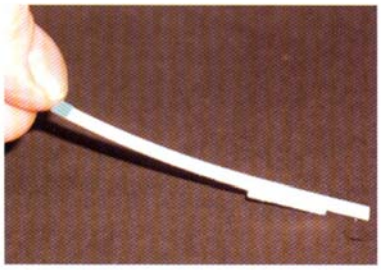
Not Appropriate for Biofilms

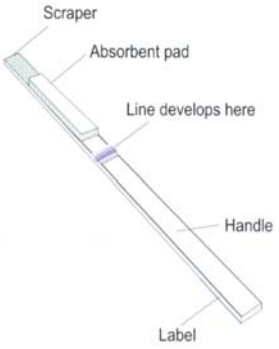
Hycheck

Not Appropriate for Biofilms

Vericleen Carbohydrate and Protein test strips
Charm Sciences





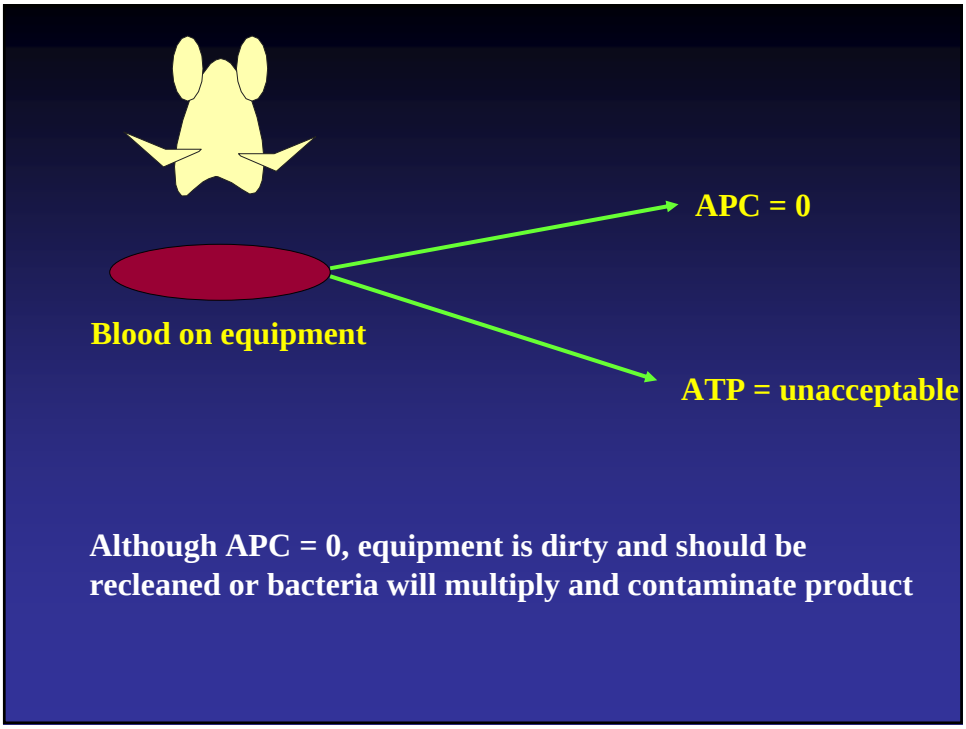


Not Appropriate for Biofilms

Hygiena Carbohydrate color test strips

Charm LUM-T

BioControl Lightning



Although APC = 0, equipment is dirty and should be recleaned or bacteria will multiply and contaminate product

Conclusions

- Proper cleaning and sanitizing is essential in preventing the cross-contamination of pathogenic bacteria from equipment to food products
- Choosing the proper chemical for the food matrix is important
- Biofilm formation is a serious problem because they are difficult to eliminate
- Microbiological monitoring programs should be real time and not retrospective