New Approaches to Improving Your Profitability by Controlling Spores

3-A SSI 2015 Education Conference
- The Bridge to Hygienic Design
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AGENDA

- Recent history of dairy micro
- Issues preventing improved quality and shelf life
- Technology improvements to increase shelf life
- Potential benefits of new technology
- Potential drawbacks for new technology
- Next steps
Recent History of Fluid Milk Shelf Life

- 1980’s – 10 days – 13 days (typical sanitizer - chlorine, iodine, fatty acid)
- Late 80’s – early 90’s – 16 days (Introduction of 1st peracid sanitizer 1989)
- Late 90’s – 18 – 21 days (Introduction of mixed peracid sanitizer 1996)
- Today – Still at 21 days
Causes of Spoilage

• Gram Negative Bacteria
  • Post pasteurization contamination
• Gram Positive Bacteria
  • Can survive pasteurization
• Heat Tolerant Enzymes
  • Rare occurrence but are due to raw milk issues
As shelf life has increased, gram positive organism issues have too.

Gram Reaction of Fluid Milk Samples Received by Ecolab

<table>
<thead>
<tr>
<th>Year</th>
<th>Negative</th>
<th>Positive</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>86%</td>
<td>14%</td>
<td>0%</td>
</tr>
<tr>
<td>2007</td>
<td>54%</td>
<td>23%</td>
<td>23%</td>
</tr>
<tr>
<td>2008</td>
<td>54%</td>
<td>14%</td>
<td>31%</td>
</tr>
<tr>
<td>2009</td>
<td>78%</td>
<td>14%</td>
<td>8%</td>
</tr>
<tr>
<td>2010</td>
<td>51%</td>
<td>22%</td>
<td>27%</td>
</tr>
<tr>
<td>2011</td>
<td>75%</td>
<td>9%</td>
<td>16%</td>
</tr>
<tr>
<td>2012</td>
<td>73%</td>
<td>9%</td>
<td>18%</td>
</tr>
<tr>
<td>2013</td>
<td>69%</td>
<td>9%</td>
<td>12%</td>
</tr>
<tr>
<td>2014</td>
<td>81%</td>
<td>19%</td>
<td>13%</td>
</tr>
<tr>
<td>2015</td>
<td>75%</td>
<td>6%</td>
<td>13%</td>
</tr>
</tbody>
</table>
Gram Positive organisms show up later than Gram Negatives.
If good quality raw milk gets us to 21 days, how do we get beyond 21 days?

1. Keep it **Cold, Clean and Moving**
2. Sanitation done right all the time every time
3. Eliminate biofilms. *BIOFILMS START FORMING IN 8 HOURS*
Where do heat resistant psychrotrophs (HRP’s) come from?

They originate on the farm and grow in the plant.

Data Courtesy of Darryl Bigalke QMI Systems

**HRP Counts Farm vs Plant**

- **Farm Bulk Tank**
  - Minimum: 400,000
  - Average: 2,700,000
  - Maximum: <10,000

- **Plant Raw Silo**
  - Minimum: <10,000
  - Average: 53,000,000
  - Maximum: 67,000,000
Where do heat resistant psychrotrophs (HRP’s) come from?

Raw Silo temperatures & Rotation

Milky Whey Dairy Raw Silo Wash Frequency

<table>
<thead>
<tr>
<th>Time between washes</th>
<th>% of Washes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>10%</td>
</tr>
<tr>
<td>24 - 48 hrs</td>
<td>71%</td>
</tr>
<tr>
<td>49 - 72 hrs</td>
<td>16%</td>
</tr>
<tr>
<td>&gt;72 hrs</td>
<td>4%</td>
</tr>
</tbody>
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Where do heat resistant psychrotrophs (HRP’s) come from?

One problem is the low level of contamination in the raw milk:

- Dr Mansel Griffiths of the University of Guelph reported the average contamination level of Heat Resistant Psychrotrophs (HRP’s) at 17 cfu/L →

Chances of finding it in a typical 5 mL lab pasteurization (SMEDP 17th edition) sample is approximately 1 in 60

Data Courtesy of Darryl Bigalke QMI Systems
What are build-up points?


“Total Bacterial numbers increased slightly over the initial 8-9 h, then more rapidly, sometimes exponentially, over the remaining period of operation, reaching in excess of one million per mL and exceeding the total bacterial numbers in the raw milk…. A 20 minute caustic miniwash of pasteurisers after 10 h of continuous operation was shown to reduce bacterial numbers in pasteurized milk…”

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What are build-up points?


A 20 minute caustic miniwash of pasteurisers after 10 h of continuous operation was shown to reduce bacterial numbers in pasteurized milk…”

Unfortunately this biofilm is not completely removed by conventional short washes and returns more quickly the second time.
Biofilm Formation

• Vegetative cell population is needed to get spores
• Residual soil acts as hybrid biofilm/soil matrix
• Nooks and Crannies
  – Gasketed joints
  – Valves
  – Plate heat exchangers
  – Evaporators
• Low flow areas
• Biofilms generated/rejuvenated during long runs
• Spores quickly attach and are TENACIOUS
Spores are TENACIOUS

10^2 cfu/ml spores in suspension

316 Stainless Steel coupons
Soaked in dairy plant isolate spore cocktail suspended in milk
Rinsed THOROUGHLY with sterile DI water
Covered in nutrient agar w/ metabolic dye (dark spots)
Spore Adhesion to Stainless Steel

Cleaning with strong caustic DID NOT REMOVE THE SPORES

Peroxide/peracid cleaning removed most of the soil but did not get all the bacterial residue off the surface. (No viable cells recovered)
What are build-up points?
Separator/Clarifier
How does fouling build-up in heat exchangers?

The fouling layer is built-up by two different types of deposit:

- **On the stainless steel surfaces of the pipe a dense mineral deposit layers is formed**
- **On top of this first layer forms a second layer consisting of a matrix of proteins, fat, and carbohydrate depending on process stream**
Caustic Cleaning Details Dairy Example

The influence of NaOH concentration

- High caustic concentrations cause the fouling layer to swell causing gel formation of the protein (rubber-like top layer), thus preventing further penetration of the alkaline cleaning solution into the soil layer.

- Consequently the soil removal takes more time.

- The degree of “polymerisation” depends on NaOH concentration, soil temperature and contact time.
Step-by-Step Cleaning Approach

- **STEP 1:** The pre-treatment product (peroxide/peracid) is circulated through system prior to alkaline wash - active ingredients penetrate the soil layer

- **STEP 2:** Immediately following Step 1, an alkaline detergent is circulated through the system; the rise in pH triggers Step 3

- **STEP 3:** The hydroxide ions interact with the oxygen components, triggering a reaction that ruptures the burnt-on soil matrix into pieces

- **STEP 4:** With the soil removed from the surface and broken into smaller pieces the mixed cleaning solution easily removes the remaining soil
New Cleaning Procedure – Heated Surfaces

- Pre-Rinse
- Alkaline Wash
  - Add peroxide/peracid additive
  - Circulate for 1-2 circuits (time varies with size of equipment)
  - Add caustic and heat to 170° F
- Post Rinse
- Normal acid wash
- Post Rinse
- Sanitize with mixed peracid at 140 degrees
New Procedure – Cold Wall Equipment – Fillers, Lines, Tanks, Trucks

- Prerinse
- Alkaline wash with peroxide/peracid additive
  - Add peroxide/peracid and circulate for 1-2 rounds as it is heating up
  - Add alkaline cleaner as heating continues and wash at normal temperatures
- Post rinse
- Sanitize with mixed peracid sanitizer at 140 degrees
- If needed, cool the surfaces with sanitizer at ambient
Case Study: Skim Milk Evaporator

- **Challenge:**
  - Soiled evaporator that was not passing inspection
  - Fouled and plugged tubes reducing efficiency

- **Results:**
  - Significantly improved cleaning results
  - Reduction in plugging of tubes

Photos: Paul Schacht - Ecolab

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Peroxide Cleaning Program

Benefits

• Penetration of cracks and crevices for better cleaning – helps remove soils in damaged gaskets
• Temperatures above 170° F and alkaline solutions break down peroxide & peracid to give mechanical action
• The oxidizing effect of the additives and the additional mechanical action have shown to remove soils more effectively
• Time savings have been achieved by faster removal of soils
• Significantly lower SPC counts have been documented in powder operations
• Spore related defects have been eliminated in Swiss cheese
• Late blowing defect has been controlled in cheddar cheese

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Peroxdide Cleaning Program

Potential Drawbacks

• Oxidizing effects of products may decrease life of gaskets
  ○ Effect is not likely to be more than the use of nitric acid

• Odor of high temperature peracid may be objectionable
  ○ Watch for improvements in this later this year
Cost Benefits of the Program

- Powder plant was able to make an 8-fold increase in low spore count product. Increased sales dollars by approximately $15,000,000.
- Farm saw LPC counts stabilize. *Monthly Premium was $25,000* when average <50

![Graph showing LPC counts over sample days](image)

- Initial avg. = 88
- With new methods avg. = 37
Farm Program Challenges & Solutions

• Most farms can’t achieve high temperature
  o Even at temperatures below 170 degrees, the peroxide/peracid additive provides oxidizing ability which will remove soils
  o Alternately a low temperature two part cleaner provides mechanical action to achieve better soil removal
• Most farms use a chlorinated alkaline cleaner
  o The peroxide and chlorine produce an “exited oxygen molecule” (singlet oxygen species) that also enhances the soil removal
Where will we go from here?

- Low count powder will become the norm.
- Fluid milk shelf life will start reaching 24 days and beyond. Those that do not increase shelf life will use it to improve overall microbial quality of their products.
- Producers of fresh/soft cheeses will use this technology to improve cleaning, reduce complaints, extend shelf life allowing them to expand their distribution.
- Producers of traditional cheese will be able to reduce defects like slits, large eyes, late blowing, and heterofermentative lactics in their products.
- Yogurt plants will use this to improve soil removal to reduce issues with phage and spoilage organisms.
- Dairy farms will use this to reduce their overall counts to achieve exceptional levels of microbial quality.
- New products will be developed to capitalize on the higher quality raw milk supply.