Microbes and Biofilms in the Food Industry

A WEBINAR FROM SFAM AND NBIC

4 February 2021
Food Hygiene Biocides: Regulations & Reality

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Chilled Food Association
SfAM/NBIC Microbes and Biofilms in the Food Industry
4 February 2021
Food Hygiene Biocides Assure
Food Hygiene & Protect Public Health

Used worldwide in disinfectants and sanitisers in households, professional food producers, in foodservice and at retail

Legal and supported in the Biocidal Products Regulation (528/2012)

Regulation (EC) No 396/2005 (pesticides maximum residue levels) does not consider food hygiene assurance uses (until we came along)…
What Are Chilled Foods?
Chilled Prepared Foods

- Entrées (some RTE)
- Dressed salads
- Leafy salads
- Prepared vegetables
- Prepared fruit
- Delicatessen products
- Sandwiches, rolls & wraps
- Sandwich fillings
- Savoury pastries & quiches
- Recipe dishes/kits (ready meals)
- Dips & dressings
- Stir fry kits
- Pizza
- Meal centres
- Meal Accompaniments
- Sushi
- Filled and plain fresh Pasta
- Soups (some RTE)
- Sauces (some RTE)
- Desserts

Items in green = ready to eat (RTE)

EU Microbiological Criteria Rules for *L. monocytogenes* (2073/2005 apply)
Listeria monocytogenes (Lm)

- One of 20 Listeria species
- **Lm is the only species legislated for – human pathogen**
- Widespread in environment: soil, water, animal faeces, vegetation
- Carried by ≤10% of people
- Long incubation period: up to 90 days before symptoms appear

- Grows at refrigerator temperatures (-1.4°C minimum)
- Survives freezing (-18°C)
- Relatively heat resistant (70°C/2 mins for 6-log reduction)
- Grows in low O₂ environments, e.g. vacuum packed foods
- Highly salt tolerant (Min A_w 0.92): survives and grows even in cured foods
- Min pH for growth 4.2-4.3

- **Forms persistent biofilms on surfaces**
  - Resistant to cleaning and disinfection
  - Creates reservoir of contamination
  - Must enforce rigorous hygiene schedules to manage

- Vulnerable groups are particularly susceptible
- Transmission from infected food, the environment, mother to foetus
- **Main cause of death from foodborne illness in the EU**
Robust hygiene systems

- Clean and disinfect – validate and monitor
- Guidance: [www.chilledfood.org/FBIG](http://www.chilledfood.org/FBIG)

Multi-species biofilms: how to avoid unfriendly neighbors
Rendueles & Ghigo: [http://dx.doi.org/10.1111/j.1574-6976.2012.00328.x](http://dx.doi.org/10.1111/j.1574-6976.2012.00328.x)
2018 European Top 5 Foodborne Diseases
Morbidity & Mortality

<table>
<thead>
<tr>
<th>Disease</th>
<th>No. confirmed human cases</th>
<th>Status available (%)</th>
<th>Number of reporting countries</th>
<th>Reported hospitalised cases</th>
<th>Proportion hospitalised (%)</th>
<th>Outcome available (%)</th>
<th>No. reporting MS</th>
<th>Reported Deaths</th>
<th>Case Fatality (%)</th>
<th>Fatality Rate of Lm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacteriosis</td>
<td>246,571</td>
<td>27.7</td>
<td>18</td>
<td>20,848</td>
<td>30.6</td>
<td>72.7</td>
<td>16</td>
<td>60</td>
<td>0.03</td>
<td>520</td>
</tr>
<tr>
<td>Salmonellosis</td>
<td>91,857</td>
<td>43.2</td>
<td>15</td>
<td>16,556</td>
<td>41.7</td>
<td>67.0</td>
<td>17</td>
<td>119</td>
<td>0.19</td>
<td>82</td>
</tr>
<tr>
<td>STEC infections</td>
<td>8,161</td>
<td>37.3</td>
<td>18</td>
<td>1,151</td>
<td>37.8</td>
<td>60.4</td>
<td>20</td>
<td>11</td>
<td>0.22</td>
<td>71</td>
</tr>
<tr>
<td>Yersiniosis</td>
<td>6,699</td>
<td>26.4</td>
<td>14</td>
<td>519</td>
<td>29.3</td>
<td>56.8</td>
<td>15</td>
<td>3</td>
<td>0.08</td>
<td>195</td>
</tr>
<tr>
<td>Listeriosis</td>
<td>2,549</td>
<td>42.4</td>
<td>17</td>
<td>1,049</td>
<td>97.0</td>
<td>57.6</td>
<td>19</td>
<td>229</td>
<td>15.6</td>
<td></td>
</tr>
</tbody>
</table>

* 2017: Listeriosis death rate 345x Campylobacteriosis, 28x STEC
** 2016: Listeriosis death rate 540x Campylobacteriosis, 60x STEC
*** 2015: Listeriosis death rate 590x Campylobacteriosis, 74x STEC


Comparing European Countries’ Listeriosis Rates 2014-18

All rates per 100k population

Sentinel systems:

Belgium: 2015-18 covers 80% population
Spain: 2015-17 no coverage info

Non-EU rates:
South Africa: 1.84 (2017-18)

USA:
0.3
Australia:
0.3*
NZ:
0.6
* incomplete data

US rate data:
https://www.cdc.gov/listeria/technical.html

Australia:

NZ:
Susceptibility of Different Microorganisms to Biocides

- Enveloped viruses
- Gram + bacteria
- Large non-enveloped viruses
- Vegetative fungi and algae
- Gram - bacteria
- Fungal spores
- Small non-enveloped viruses
- Mycobacteria
- Bacterial spores
- Higher resilience to biocides
- Prions

Higher resilience to biocides
Efficacies of Food Hygiene Biocides against *Listeria monocytogenes*

<table>
<thead>
<tr>
<th>Sanitiser type</th>
<th>In absence of protein residues (effective cleaning)</th>
<th>In presence of protein residues (poor cleaning)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. studies reviewed</td>
<td>No. observations</td>
</tr>
<tr>
<td>Halogen</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>Hypochlorite</td>
<td>11</td>
<td>321</td>
</tr>
<tr>
<td>Peracetic acid</td>
<td>6</td>
<td>177</td>
</tr>
<tr>
<td><em>Quaternary ammonium</em></td>
<td>5</td>
<td>59</td>
</tr>
</tbody>
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* Classed as Plant Protection Product by EU and regulated as such, i.e. MRL set
Cleaning (& Disinfection)

• Ensuring food production environment cleanliness is a fundamental requirement of food hygiene legislation (and a Critical Control Point)

• EC General Food Hygiene Regulation 852/2004:

  • Chapter V, 1: All articles, fittings and equipment with which food comes into contact are to: (a) be effectively cleaned and, where necessary, disinfected. Cleaning and disinfection are to take place at a frequency sufficient to avoid any risk of contamination...

  • HACCP principles – Art 5: establish, validate and monitor efficacy of cleaning and disinfection (CCP)
Comparing Lm Prevalence in RTE Foods

- **UK surveys** - higher prevalence in:
  - Food sliced to order (e.g. delicatessens) *cf* pre-packed retail
  - Loose (non-prepacked) foods without clear storage/usage instructions
  - Food from sandwich bars, butchers, convenience shops, bakeries, i.e. produced & sold by smaller businesses
  - **Foods produced by businesses with less well developed hygiene systems resulting in reduced protection from re- or cross-contamination**

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</thead>
<tbody>
<tr>
<td>Cooked sliced meat sold by SMEs &amp; major retailers</td>
<td>1.5%</td>
<td>3.8%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Cooked sliced meat sold by SMEs</td>
<td></td>
<td></td>
<td>5.7%</td>
</tr>
</tbody>
</table>

* 2/3 of ~1600 samples from major retailers  **SMEs = small and medium-sized enterprises

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<th>13088 food samples from EU</th>
<th>Lm prevalence</th>
<th>&gt;100/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish ‘At point of sampling’</td>
<td>10.40%</td>
<td>1.00%</td>
</tr>
<tr>
<td>Fish End of shelf-life</td>
<td>10.30%</td>
<td>1.70%</td>
</tr>
<tr>
<td>Meat End of shelf-life</td>
<td>2.07%</td>
<td>0.43%</td>
</tr>
<tr>
<td>Cheese End of shelf-life</td>
<td>0.47%</td>
<td>0.06%</td>
</tr>
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</table>

EFSA Journal 2013;11(6):3241
What Good Control Looks Like:
UK Chilled Food Industry Lm Data (2008-2019)

- RTE food prevalence (909054 samples):
  - ~0.7% Lm at any point during shelf life, of which
  - 0.0002% present at quantifiable levels, i.e. >20 cfu/g LOQ

- Production environment prevalence (1592459 samples):
  - Food contact surfaces <0.4% Lm (~774k samples)
  - Non-Food contact surfaces ~2% Lm (~818k samples)
Food Hygiene Biocides Regulation

And what *we’ve done about it
Until 2016 no linkage with hygiene rules
**UK Government Roles**
- Local Authorities: hygiene enforcement (no role with biocides)
- HSE: biocides inc biocides enforcement
- FSA: food safety & contaminants

**European Bodies**
- EC: overall policy
- EU Chemicals Agency (ECHA): Biocidal Products Reg
- EU Food Safety Authority (EFSA): food & biocides safety

**Food-related uses:**
- Containers
- Equipment
- Floors etc
- Water
- Hands
- Transport
- Utensils
- Produce washing

* Primary production manufacture, foodservice, hospital catering, retail

+ Brexit!
Pesticides vs Other Biocides

• Terminology:
  • Residues result from intentional addition of the regulated active to a food material - regulated
  • Traces result from unintentional carryover from legitimate use - reality

• Dual use biocides:
  • Why apply Plant Protection Products (PPP) law to materials used to assure hygiene?
  • If a material ever has been used anywhere as a pesticide then MRL will apply
  • 0.01mg/kg default MRL (LOD)
  • Multicomponent/processed products not listed in legislation Annex (PPP law 396/2005) but EU and UK says are within MRLs scope
Chlorate

• Chlorate banned as PPP by EU in 2005
  • BUT arises primarily from hygiene biocides inc mains water, and is heat stable

• Industry data gathering and lobbying since 2012 to achieve workable regulation reflecting the need to protect food hygiene and safety, and public health overall

• Cranfield report for DWI (Oct 2019) found:
  • Chlorate present up to 0.5 mg/kg in water from high risk water treatment works
  • Level is dependent on:
    • Season (highest June-Sept – *E coli* mitigation)
    • Chlorination method (*OSEC & NaOCl* highest risk)
    • Storage tanks’ cleaning frequency

• No legislated EU/UK chlorate maximum in drinking water – until DWD published 23/12/20
  • EU Drinking Water Directive sets max levels (0.25 mg/l)
  • Required to be implemented into MS law in next 2 years (will UK adopt?)
  • If not incorporated into UK law there will be no legal imperative on water companies to monitor and control

* hypochlorite generation from brine electrolysis
Chlorate – New EU MRLs

Reg 2020/749 published 4/6/20
   • Came into effect late June 2020
   • MRLs for different foodstuffs: 0.01 to 0.7 mg/kg
   • Lack of clarity how to apply to e.g. leaf mixed with beetroot

Special case for ‘processed’ foods:
   • In case of exceedance Food Business Operator (FBO) can demonstrate presence to be from legitimate use, i.e. hygiene biocides in e.g. water, washwater, surface disinfection

FBIG submission to HSE (22/5/20) set out:
   • Sources of chlorate in food production
   • Mitigations in place
   • Desired requirement on water industry to mitigate at source and provide data to FBO customers
What can FBOs do to manage chlorate?

Chlorate is difficult and costly to remove from water

- Reverse osmosis technically viable but expensive
- Granular Activated Carbon filters require maintenance
- Anaerobic digestion has some effect, but is slow
- Ion exchange resins and beds are promising, but specialised technique
- **Water should be treated at source to minimise chlorate**

Supply Chain Quality Assurance by FBOs to verify

- Chlorate not being used as a PPP
- Source of chlorate (hygiene biocides) are being mitigated

If water is chlorinated on-site, e.g. produce washing

- Make up fresh solutions
  - Chlorate salts can settle out – do not top up tanks
  - Tank cleaning/refreshing found to be significant factor in DWI report where chlorate levels were high
- Where Sodium hypochlorite is stored in bulk:
  - Clean the tank
  - Ensure deliveries do not cause mixing resulting in elevated levels of chlorate in suspension
  - Consider any interim-tanks or dead-spots in pipework

Chlorate MRLs Compliance Guidance issued by FBIG 2020 onwards
Multicomponent Foods

• Sandwich as an example
  • Bread
  • Butter (or margarine)
  • Produce e.g. vegetables, herbs
  • Protein
  • Dressings

• Sources of biocide traces
  • Animal feed
  • Water
  • Food contact surface disinfectants and sanitisers
Bread Manufacture

Food Contact Surfaces (Sanitised)

Grain milling

Flour Site

Milling

Dough Dividing

Mixing

Proving

Moulding

Conveyor to Proving

Proving

Basing

De-planing

Cooling

Slicing - blades

Wrapping
Butter Manufacture
Fresh Produce Components

- Soil
- Clean Water - Irrigation & Hydroponics
- Cutting - blades
- Washing in clean water
- Food Contact Surfaces at Harvesting - Blades, Conveyors, Crates
- Sanitised Conveyor Surface
Protein Components
(e.g. Chicken)
What’s Next?

Quaternary Ammonium Compounds

• Quats, QACs (e.g. BAC, DDAC)
  • Quats highly effective against Gram positive (e.g. *L. monocytogenes*)
  • EU MRL reduced from 0.5ppm to 0.1 ppm on 12/8/15
  • Sales since reportedly dropped by 50%
  • EU review with aim of setting MRLs
  • Review paused summer 2020 owing to
    • Recognition of lobbying showing importance of QACs in food hygiene and SARS-CoV-2 control, and
    • Lack of reliable methodology to determine at levels proposed – issue with isomers
What Have We Done?

• Secured
  • EC recognition of
    • legal requirement and commercial imperative to protect food hygiene and safety and public health
    • primary sources of chlorate
  • More rational EU chlorate MRLs than LOD and those then proposed in Nov 2015
  • Special case in EU chlorate Regs for processed foods
    • Defined as in 852/2004
    • FBO to show on exceedance that came from legitimate uses

• Developed FBIG and GFSI Guidance
  • Food & Biocides Industry Group (www.chilledfood.org/FBIG)
    • Minimising hygiene biocides traces from cleaning and disinfection - incorporated into GFSIs Chemicals in Food Hygiene
      • https://mygfsi.com/news-and-resources/?fwp_news_topics=food-hygiene&fwp_type=publications

• Chlorate MRLs Compliance:
  • Multicomponent foods
  • Fresh and prepared produce
  • Cured meat, dried milk, butter
  • Soft drinks and fruit juices
  • Dairy products in development
  • Specialist nutrition products in development
What Do We (still) Want?

• Protect public health
  • Continued regulatory recognition of food hygiene imperative

• Rational legislation
  • Non-pesticide hygiene biocides use not regulated via 396/2005
  • Legislation not gold plated to include end products that are not listed in PPP regulations
  • Multicomponent/processed foods recognised as special case
  • Legislation linkage, e.g. QACs MRLs + food hygiene

• Chlorate MRL Compliance
  • FBIG Guidance taken up by UK and EU industry

• Clear and simple enforcement guidance and rationale
  • Recognising hygiene requirements and hygiene biocides traces mitigation measures in place

• Safe, effective and legally viable hygiene biocides leaving minimal traces
The centre of excellence for the chilled food industry

www.chilledfood.org

www.chillededucation.org

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