Strategies for Microbial Control in Food

FOOD INNOVATION GATEWAYS EVENT JUNE 14. 2019
TEAGASC FOOD RESEARCH CENTRE, ASHTOWN

Even Heir, Ph. D.
Senior Research Scientist
even.heir@nofima.no
Nofima - Norwegian Institute of Food, Fisheries and Aquaculture Research

- 390 Employees
- 70x10^6 € Turnover
- Research and contract work for the food, fisheries and aquaculture industry
- Customers from 32 countries
Content

• Lack of control - What are the **consequences**?

• The main challenge for many food producers: *Listeria monocytogenes*

• Some mitigation **tools available** for the food industry
  • Selection criteria?
  • What strategies can be used?
  • What effects can be expected?
  • **Case**: Listeria control in salmon processing

• Conclusions
Bacteria in foods – consequences

• Reduced quality and safety
  • Outbreaks
  • Recalls
  • Food waste

• Recurrent contamination and persistence
  • Where is the source?
  • How to eliminate it?

• Reputation

• Competitiveness

• Economical and legal issues

Large consequences: food industry, consumers, community
Listeria: An increasing challenge for the food industry

- Rise in consumption of risk products (Ready-to-eat)
- Increased size of susceptible population
- Zero tolerance prevalence
- Increasing food recalls
- More outbreaks detected
- Large costs
The Norwegian aquaculture industry

- Salmon (and trout)
- Export (2018): 1.1 mill. tons
- Value $7 \times 10^9$ €

- Microbial quality and safety challenges?
Listeria monocytogenes and Salmon

Listeria bacteria outbreak: Sainsbury's urgently recall contaminated smoked salmon
Four ill and one dead from Listeria in salmon

Two listeria outbreaks caused by smoked fish consumption—using whole-genome sequencing for outbreak investigations

Fatal listeria outbreak attributed to Estonian company
Imported cold-smoked fish products are the source of a long-lasting listeria outbreak in Denmark, which has made nine sick since 2016 and killed two this year.

Source: Intrafish media
The foodborne pathogen *Listeria monocytogenes*

- Ubiquitous in the environment
- Ready-to-eat (RTE) type foods
- Can grow at 4°C
- Causes listeriosis
- ~20% mortality rate
- Persists in production environments
Listeria control – is it possible?

- Drains
- Wheels on trolleys
- Conveyor belts
- Dripping from ceiling
- Slicing equipment
**Listeria control strategies**

- Prevent entry into production facilities
- Prevent establishment
- Reduce cross contamination
- Remove, kill or inhibit growth of *L. monocytogenes* in raw materials and on food products

**Environmental AND raw material/product control**

- Washing and disinfection
- *Listeria* in scratches in stainless steel
Criteria for *Listeria* mitigation strategies on food/fish

- Effect on *L. monocytogenes* (kill + inhibition)
- Robust effect under industry conditions
- Suitable for high throughput processing
- Approved for use
- Consumer acceptance
- No negative sensory effects
- Provide cost-benefit
# Interventions for salmon

<table>
<thead>
<tr>
<th>Interventions/technologies</th>
<th>Reported effects on Listeria (kill/growth inhibition)</th>
<th>Salmon of relevance for treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic acids/salts</td>
<td>Growth inhibition</td>
<td>Fresh, smoked</td>
</tr>
<tr>
<td>Oxidative compounds</td>
<td>Kill: 0-99% reduction</td>
<td>Fresh</td>
</tr>
<tr>
<td>Lauryl arginate</td>
<td>Kill: 0-99% reduction</td>
<td>Smoked</td>
</tr>
<tr>
<td>Epsilon polyllysine</td>
<td>Kill: 90% reduction</td>
<td></td>
</tr>
<tr>
<td>Liquid smoke</td>
<td>Kill + Growth inhibition</td>
<td>Smoked</td>
</tr>
<tr>
<td><strong>Biological</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacteriophages</td>
<td>Kill: 50-99.9%</td>
<td>Fresh, smoked</td>
</tr>
<tr>
<td>Protective cultures/bacteriocins</td>
<td>Growth inhibition (Protective cultures) Kill (Bacteriocins)</td>
<td>Fresh, smoked</td>
</tr>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultraviolet light (UV-C)</td>
<td>Kill: 0-99% reduction</td>
<td>Fresh, smoked</td>
</tr>
<tr>
<td>Pulsed Light</td>
<td>Kill: 90-99% reduction</td>
<td>Fresh, smoked</td>
</tr>
</tbody>
</table>
Organic acid salts for growth inhibition of *Listeria* in cold smoked salmon

- Verdad N6, a «Label Friendly» vinegar fermentate, was added in the salting process

- **Parameters tested**
  - Concentration of Verdad N6
  - Effect of storage temperature
Slicing, contamination and storage of cold smoked salmon

Slicing

Contaminating with *L. monocytogenes*

Vacuum packaging + storage at 4°C and 8°C
Organic acid salts reduce growth of *L. monocytogenes* in sliced cold smoked salmon

- Growth is reduced with 1 or 2% organic acid salt
- Growth reduction is temperature dependent
- No killing of Listeria
- No sensory changes (except more intense red with organic acid salt)
UV-light for Listeria control

**Continuous UV-C light**
- 254 nm
- 6 cm from light source 10 mW/cm²
- 5 s, 10 s, 30 s, 1 min, 5 min
- 0.05, 0.1, 0.3, 0.6, 3.0 J/cm²

**High intensity pulsed UV light**
- 200-1100 nm 54% in UV spectrum
- Single pulse 6.5 cm from light source
- Low pulse (L), High pulse (H), H x 3, H x 5
- 1.25, 3.6, 10.8, 18.0 J/cm²
Reductions of *L. monocytogenes* by UV-C and pulsed UV light on smoked salmon

- 0.7 – 1.3 log reduction
- Small differences between UV-C and pulsed UV
- High UV-doses provided no increase in *Listeria* killing
Reductions of *L. monocytogenes* by UV-C and pulsed UV light on raw salmon

- Up to 1 log (90%) reduction
- Small differences UV-C vs. pulsed UV
- Less reduction on raw muscle than skin side
Killing and growth inhibition by combining Verdad and UV-light (50 mJ/cm²) on unsliced cold-smoked salmon

For unsliced salmon

- 1 log (90%) reduction in *L. monocytogenes* obtained by UV-C treatment (50 mJ/cm²)
- Complete growth inhibition with 1 % Verdad N6
Conclusions

• Several strategies must be employed to prevent *Listeria* in risk foods
• UV light gives limited reduction of *Listeria*, but contamination levels are often low (~ <10 cfu/g), so UV light leads to reduction in risk
• UV kills bacteria on food surfaces, but surviving bacteria may grow
• Fermentates/organic acid salts inhibit *Listeria* growth
• Fermentates/organic acid salts can reduce microbial spoilage
• Combined strategies can be used for effective killing and growth inhibition of microorganisms in foods
• “Label friendly” alternatives exist
  ➢ Extended shelf life
  ➢ Reduced food safety risks
• Testing and optimisation under industry relevant conditions are needed
Acknowledgements

Food industry partners

Funding organizations

Nofima Microbiology Team
Solveig Langsrud
Trond Møretrø
Birgitte Moen
Aslild Holck
Tove Maugesten
Anette W. Åsli
Merete Rusås Jensen
Signe M. Drømtorp
Even Heir

....and thank you for your attention!