Reductions of *Listeria monocytogenes* on cold-smoked and raw salmon fillets by UV-C and pulsed UV light

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Criteria for *Listeria* mitigation strategies on salmon

- 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

Holck et al. IFSET 2018
Heir et al. IJFM 2019
<table>
<thead>
<tr>
<th>Interventions/technologies</th>
<th>Reported effects on <em>Listeria</em> (kill/growth inhibition)</th>
<th>Salmon of relevance for treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</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 polylysine</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>Biological</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/</td>
<td>Growth inhibition</td>
<td>Fresh, smoked</td>
</tr>
<tr>
<td>bacteriocins</td>
<td>(Protective cultures)</td>
<td></td>
</tr>
<tr>
<td>(Protective cultures)</td>
<td>Kill (Bacteriocins)</td>
<td></td>
</tr>
<tr>
<td>Physical</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 UV Light</td>
<td>Kill: 90-99% reduction</td>
<td>Fresh, smoked</td>
</tr>
</tbody>
</table>
Testing for reduction of *L. monocytogenes* by UV light

**Spreading of *Listeria* on salmon**

UV treatment

Surviving *Listeria* quantified on petri dishes
**UV-light sources**

**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
- Approx. same reduction for 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 smoked salmon, flat and bent pieces

- Better access to surface crevices on bent pieces?
- No, same results as when flat.
Reductions on smoked salmon of *L. monocytogenes* applied in droplets and after 24 hour attachment

- Importance of *Listeria* remaining on surface (mimicking contamination at slaughterhouse and transport to smoking facility)
- Better kill if *Listeria* suspended in water droplets? (mimicking aerosol contamination)
- Same killing for cells remaining on fish for 24 h
- Better killing in droplets immediately than after 24 h
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
Sensory analyses of UV-C and pulsed UV treated smoked salmon

Consumer test
- 40 consumers
- UV-C and pulsed UV
- Odor and appearance
- No sensory changes

Descriptive test
- Trained sensory panel
- 9 panelists
- UV-C
- 22 attributes
- Insignificant changes
Growth of *L. monocytogenes* on salmon muscle after UV-C treatment

- 0.7 - 0.9 log reduction
- Similar growth rate of UV surviving cells as control cells
- UV treatments => Large extension of shelf life
- Need of growth inhibition in addition to killing

0.050 J/cm² UV-C, vacuum packed, stored at 4°C
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
Regulations on the use of UV light in EU and USA on foods

EU UV-C
- Regulated as novel food (new production process after May 15, 1997, with changes in nutritional value, metabolism or undesirable compounds)
- Approved: milk, bread
- When we asked EU: No UV-C legislation, can be used freely
- UV-C restrictions in Germany: only water, fruit, vegetable products and hard cheeses

EU Pulsed UV (Unclear situation, novel food??)??

USA UV-C
- Limited to high fat containing food, water, juice, milk, baking yeast

USA pulsed UV
- Approved up to 12 J/cm² on food surfaces (FDA)
Possible uses of UV light in the salmon industry

Decontamination of production area
- Air disinfection
- Whole room disinfection

- Disinfection of equipment
  - Conveyor belts, slicing machines,..

Decontamination of food surfaces

UV-C in cheese factory, Portugal
UV lamp for conveyor belts
Conveyor for UV treatment of food
Slicer with UV light at ten positions to reduce cross-contamination of foods

Arrows indicate where the slicer may be contaminated.
UV lights mounted to continuously decontaminate conveyor belts

SterilAir GmbH, Germany
Conclusions

• Listeria is often found on smoked salmon products
• UV light can contribute to *Listeria* reduction
• UV light gives limited reduction, but contamination levels are often low (~1 cfu/g), so UV light leads to reduction in risk
• UV light gives extended shelf life
• UV kills, surviving bacteria may grow
• Growth depends on processing (smoking and temperature)
• UV light (killing) can be used in combination with other growth inhibition strategies
Thank you for your attention