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

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

Nofima

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

Nofima

The Norwegian aquaculture industry

- Salmon (and trout)
- Export (2018): 1.1 mill. tons
- Value $7x10^9$ €

- Microbial quality and safety challenges?

Nofima

Listeria monocytogenes and Salmon

Listeria bacteria outbreak: Sainsbury's urgently recall contaminated smoked salmon

Four ill and one dead from Listeria in salmon

Danish fish producer unhappy with food authorities

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

Fatal listeria outbreak attributed to Estonian company

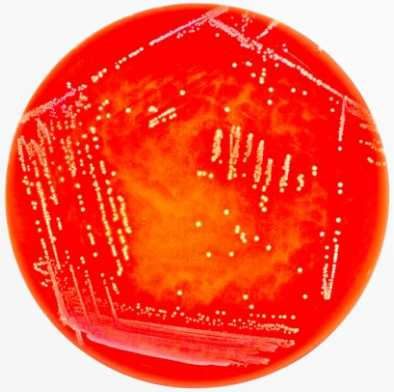
Imported cold-smoked fish products are the source of a long-lasting listeria outbreak in Denmark, which has made nine sick since 2016 and killed two this year.

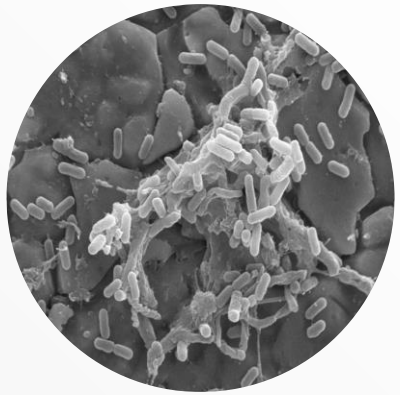
Source: Intrafish media

Nofima

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

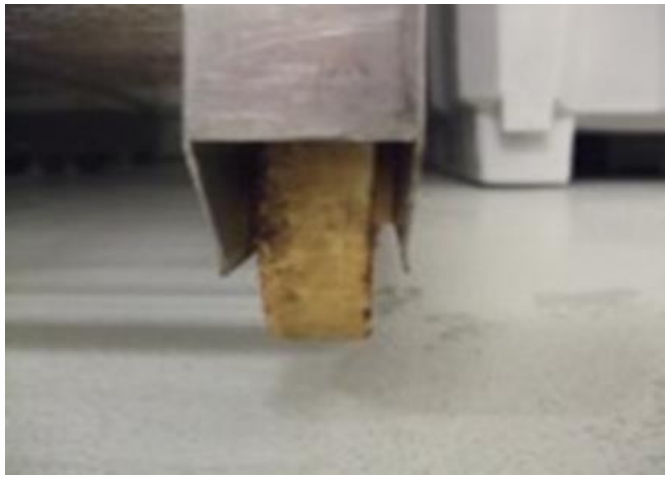




Nofima

Listeria control – is it possible?

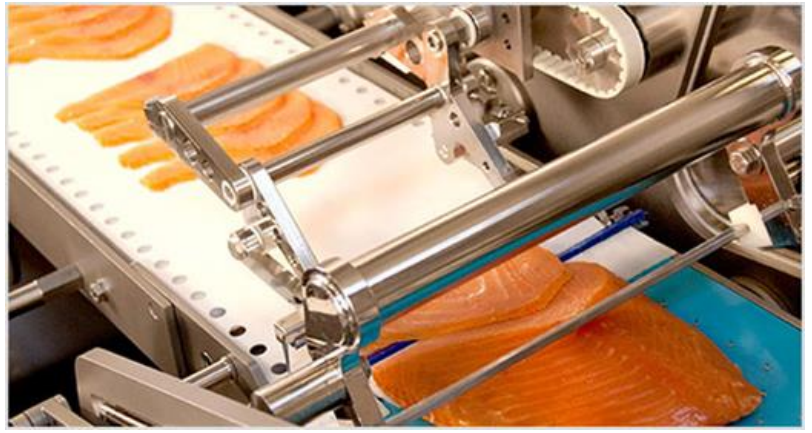
Drains



Wheels on trolleys

Conveyor belts

Dripping
from ceiling



Slicing equipment

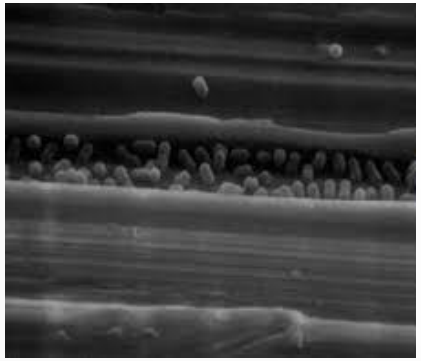
Nofima

Listeria control strategies

Environmental AND raw material/product control

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

Washing and disinfection



Listeria in scratches in stainless steel

Nofima

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

Nofima

Interventions for salmon

Interventions/technologies	Reported effects on Listeria (kill/growth inhibition)	Salmon of relevance for treatment
Chemical		
Organic acids/salts	Growth inhibition	Fresh, smoked
Oxidative compounds	Kill: 0-99% reduction	Fresh
Lauryl arginate	Kill: 0-99% reduction	Smoked
Epsilon polylysine	Kill: 90% reduction	
Liquid smoke	Kill + Growth inhibition	Smoked
Biological		
Bacteriophages	Kill: 50-99.9%	Fresh, smoked
Protective cultures/ bacteriocins	Growth inhibition (Protective cultures) Kill (Bacteriocins)	Fresh, smoked
Physical		
Ultraviolet light (UV-C)	Kill: 0-99% reduction	Fresh, smoked
Pulsed Light	Kill: 90-99% reduction	Fresh, smoked

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

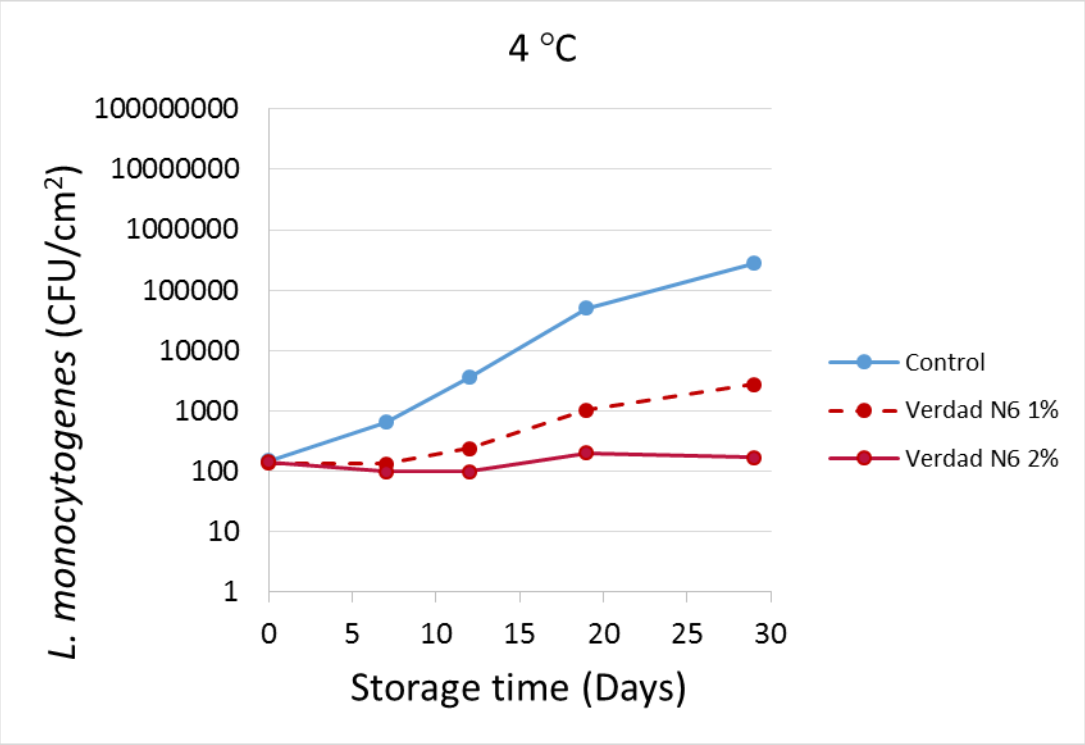
Slicing, contamination and storage of cold smoked salmon

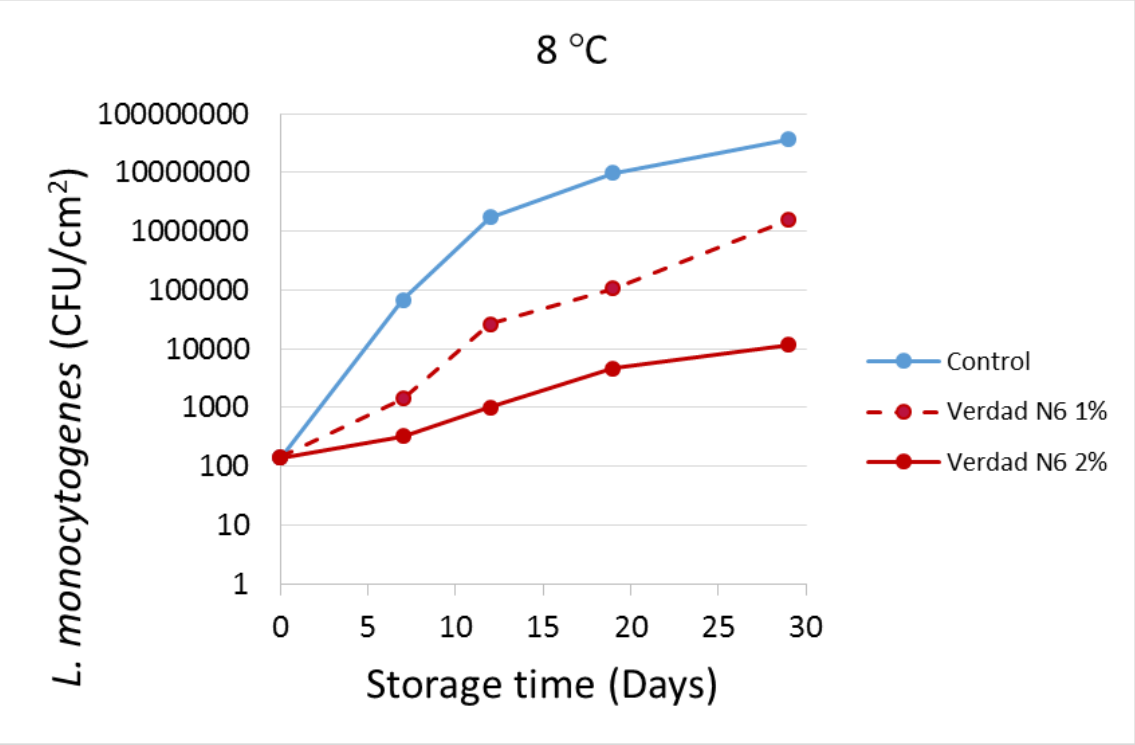
Slicing

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





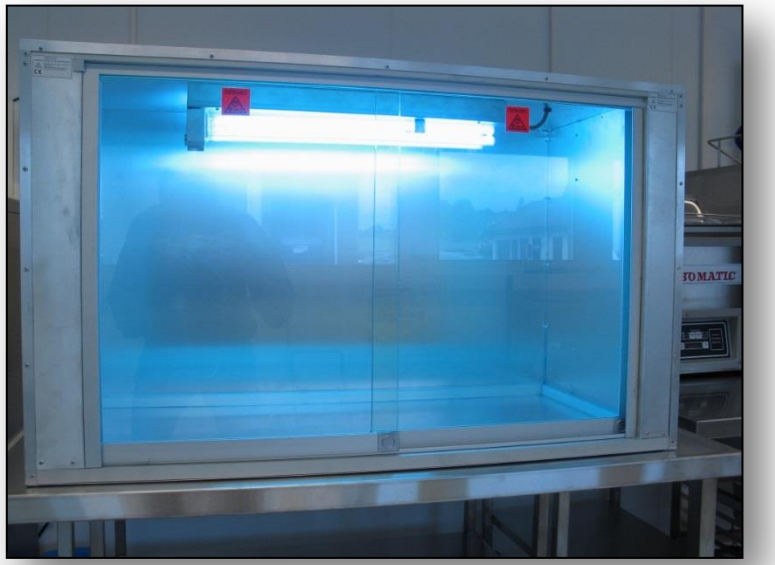
- Growth is reduced with 1 or 2 % organic acid salt
- Growth reduction is temperature dependent
- No killing of Listeria
- No sensory changes (except more intense red with organic acid salt)

Nofima

Heir et al 2019 Int J Food Microbiol

UV-light for Listeria control

Continuous UV-C light



254 nm

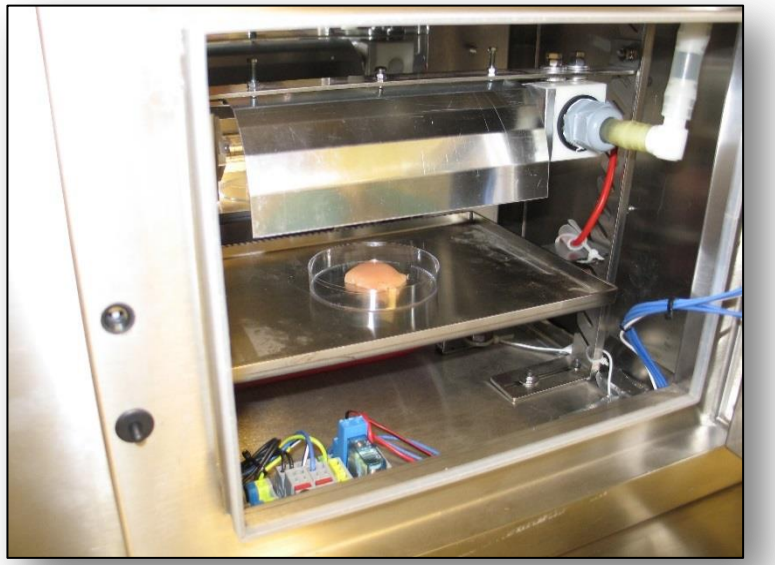
6 cm from light source 10 mW/cm^2

5 s, 10 s, 30 s, 1 min, 5 min

↓ ↓ ↓ ↓ ↓

0.05 0.1 0.3 0.6 3.0 J/cm^2

High intensity pulsed UV light



200-1100 nm 54% in UV spectrum

Single pulse 6.5 cm from light source

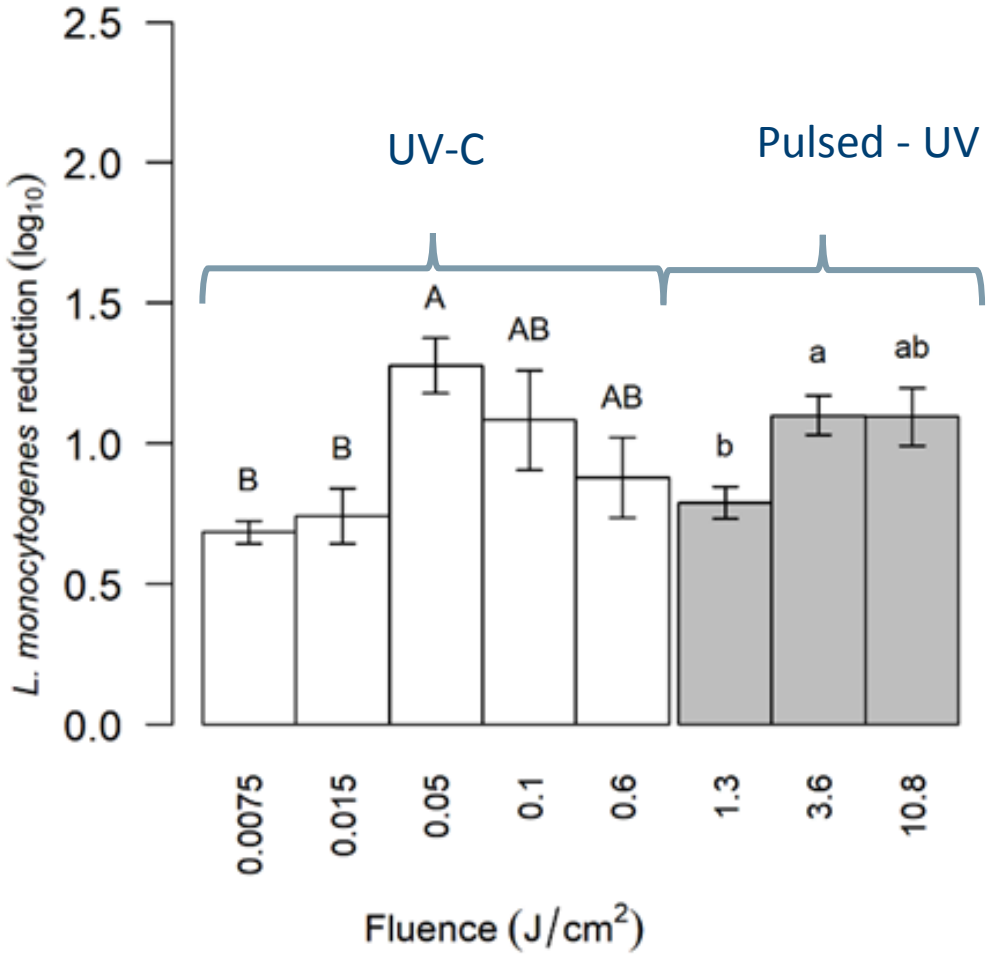
Low pulse (L), High pulse (H), H x 3, H x 5

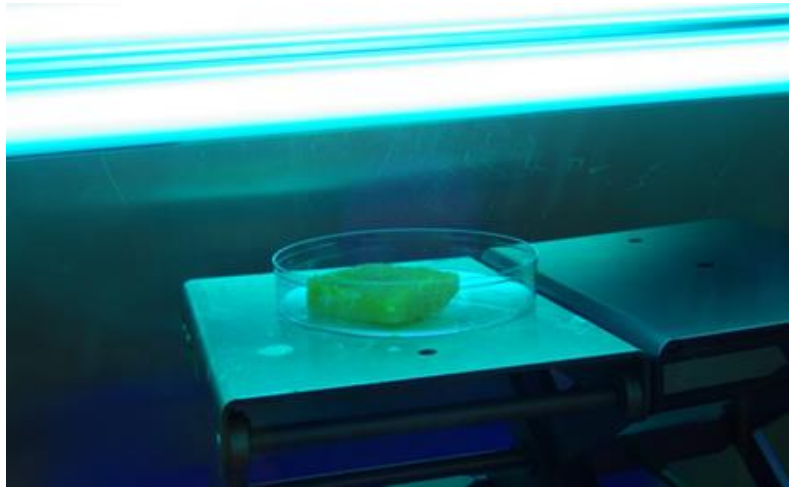
↓ ↓ ↓ ↓

1.25 3.6 10.8 18.0 J/cm^2

Nofima

Reductions of *L. monocytogenes* by UV-C and pulsed UV light on smoked salmon

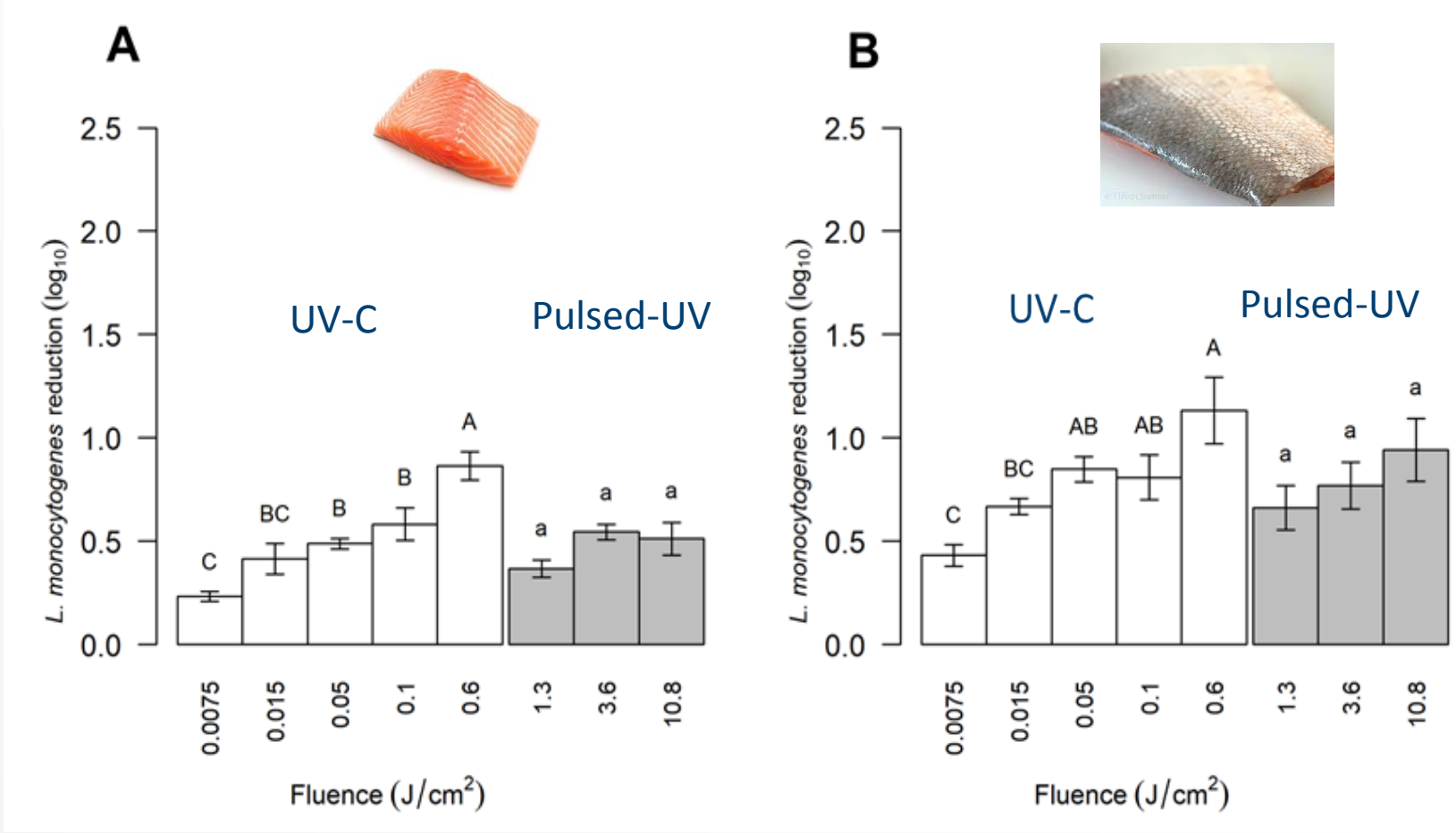




- 0.7 – 1.3 log reduction
- Small differences between UV-C and pulsed UV
- High UV-doses provided no increase in *Listeria* killing

Nofima

Reductions of *L. monocytogenes* by UV-C and pulsed UV light on raw salmon

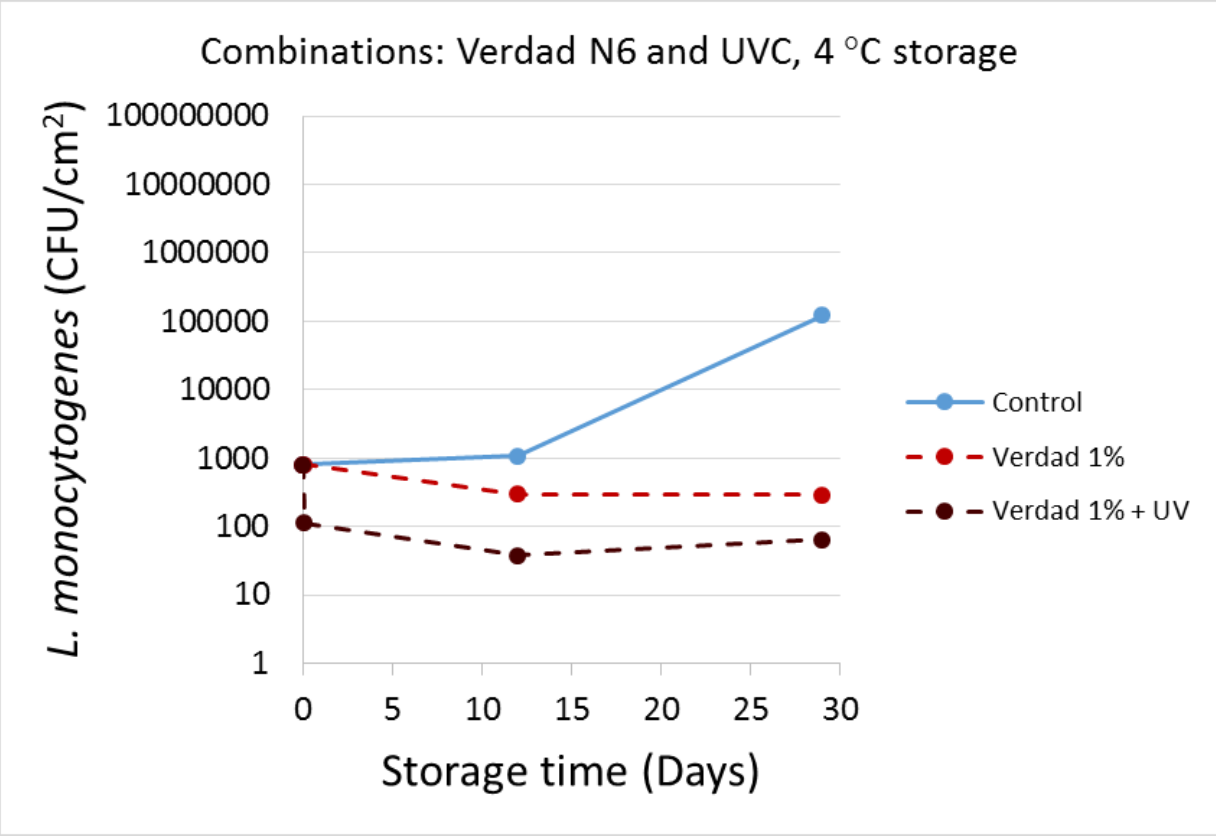


Muscle surface

Skin side

- Up to1 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/cm^2) on unsliced cold-smoked salmon



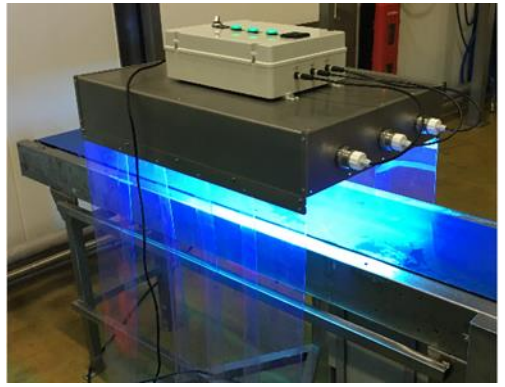
For unsliced salmon

- 1 log (90%) reduction in *L. monocytogenes* obtained by UV-C treatment (50 mJ/cm^2)
- Complete growth inhibition with 1 % Verdad N6

Nofima

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



Nofima

Acknowledgements

Food industry partners

Funding organizations

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

FHF
FISKERI- OG HAVBRUKSNÆRINGENS FORSKNINGSFOND

foodmicropack
Safe food new wrapping

Forskningsmidlene
for jordbruk og matindustri

Norwegian food and salmon industry

The Research Council of Norway

Nofima

….and thank you for your attention!