Module 7.1

Superchilling

General Aspects and Potential of the technology

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Outline

1. Background
2. Superchilling
3. Superchilling methods
4. Technologies for superchilling
5. Industrial benefits
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7. Consumer benefits
8. Challenges
9. Future potentials
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Learning Outcomes

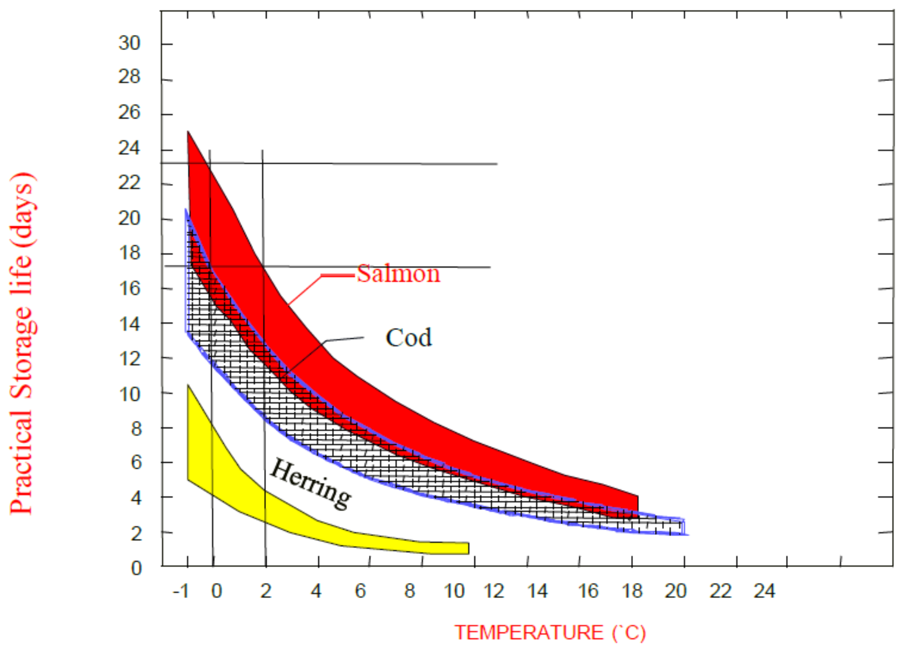
- ⇨ What is superchilling?
- ⇨ What is the potential of the technology?
  - **From a producer perspective**
  - **From a consumper perspective**
- ⇨ How products canbe processed into superchilled products.
- ⇨ How much ice content commonly is achieved in superchilling.
- ⇨ What shelf life extensions can be expected for superchilled products?

Background I

- Described already in the 1920’s by Le Danois
- In 1970’s and 1980’s: transportation of fish at sea- low temperatures increased the shelf-life
- Continuous development of the concept during the last 20 years
- Norwegian food industry is currently taking on the superchilling concept but only for “in-house” use for;
  - ✓ Expand shelf life to ease production and storage planning
  - ✓ Extend the sales period for fresh product (meat)
  - ✓ Increase product yield and quality of fish fillets
- Advantages related to prolonged shelf life is not fully exploited

Background II

- The general accepted shelf-life depends on the storage temperature and temperature fluctuation

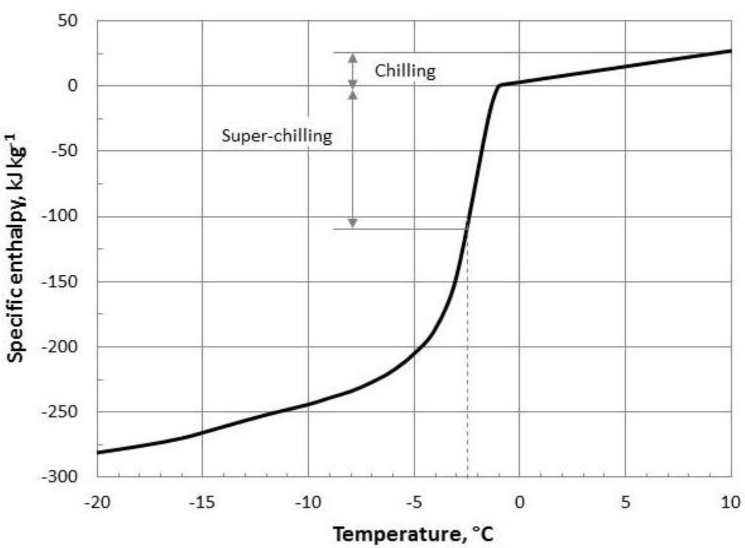


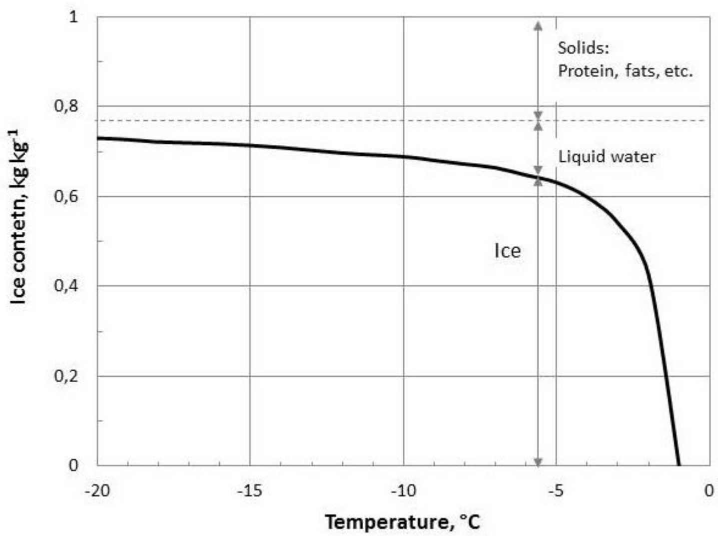
Practical storage life for some important fish species (Nordtvedt, 2009)

Background III

Superchilling *in short*

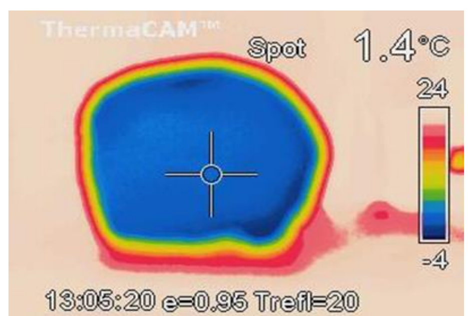
- Ice content of 5% to 20%
- Stable storage temperature
- Non-frozen appearance





Superchilling I

- Superchilling is a method used to extend the self-life of products without reducing the quality
- Product temperature is reduced 1-2 ºC below $T_{i,\ product}$ (Initial freezing point of the product)
- Different superchillings methods
- Cold air at low temperature, high speed and short time seem to be the most interesting superchilling method
- The result is a small thin layer of ice formed at the surface - "shell freezing"

Superchilling II

- The ice formed in the surface will absorb heat from the interior and will eventually reach equilibrium
- The water that is transformed to ice and is used to protect the product from heat impact instead of using surrounding ice (e.g. fresh fish)
- Ice fraction between 5 and 30 % ok for fish, but vary with product
- 10 to 15 % ice-fraction is “normal”
- Superchilling reduces microbiological growth and expands the product shelf life

Chilled cod fillets

Superchilled cod fillets

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Superchilling III

Storage temperature vs. ice fraction

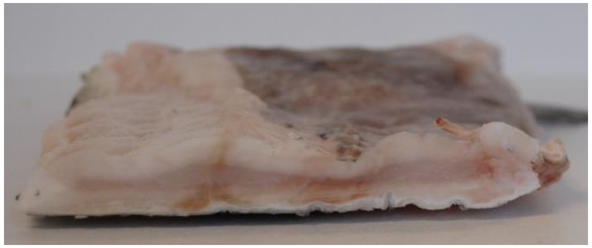
Product	Storage temperature (superchilled)	Ice fraction	Initial freezing point
Salmon filet	-1.8 °C	6.3 %	-1.6 °C
	-2.2 °C	18.2 %	
	-2.6 °C	26.9 %	
Trout	-2.2 °C	8.2 %	-2.0 °C
	-2.6 °C	21.8 %	
	-3.0 °C	27.0 %	
Mackerel	-1.8 °C	6.3 %	-1.6 °C
	-2.2 °C	18.2 %	
	-2.6 °C	29.3 %	
Herring	-1.8 °C	4.0 %	-1.6 °C
	-2.2 °C	11.6 %	
	-2.6 °C	18.7 %	
Cod (aquaculture)	-1.2 °C	10.2 %	-1.0 °C
	-1.6 °C	27.9 %	
	-2.0 °C	38.6 %	
Beef, lean (Valentas 1997)	-1.0 °C	5 %	n.a.
	-2.0 °C	45 %	

Superchilling methods I

Ice fraction is the key

- Scientifically
  - Developing/evaluating measuring methods
  - Relationship quality (sensorial, technical and bio-chemical) vs. ice fraction status and history
  - Developing advanced dynamic process control

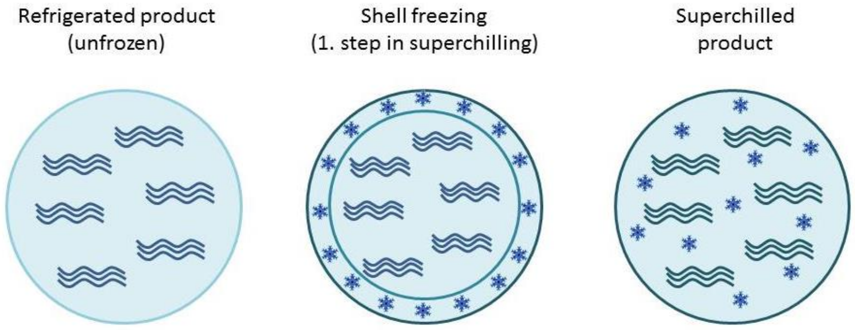
- Commercial
  - Product focus
  - Developing simple process control
  - Equipment evaluation
  - Stable storage facilities
  - Logistics



Superchilling methods II

There are different methods for performing superchilling- even today:

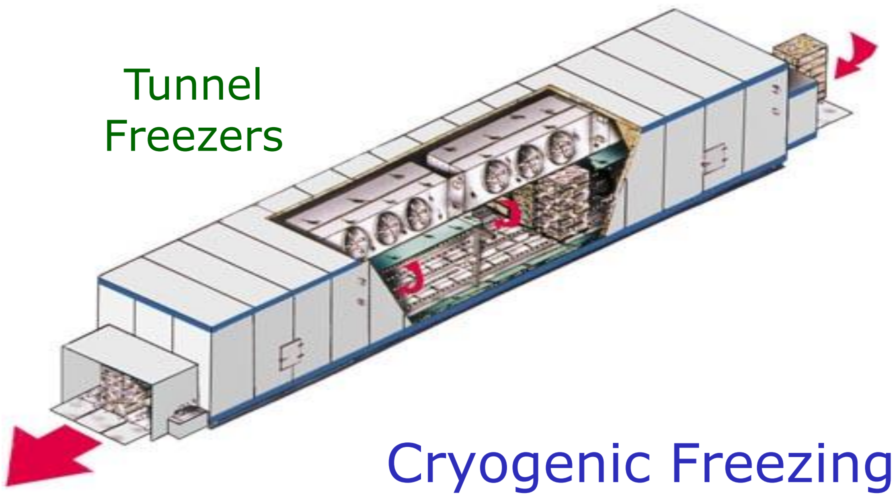
- Superchilled storage of foods *without* any pre-treatment
- Superschilled storage after *initial surface freezing* followed by temperature equalization
- Practical superchilling methods:
  - Refrigerated sea water (RSW)
  - Air blast tunnels
  - Contact chilling
- Initial surface freezing causes a more predictable ice-content in the product



Technologies for superchilling I

Air-blast Freezing Systems

Tunnel Freezers



Impingement Systems

Cryogenic Freezing Systems

Liquid nitrogen spraying

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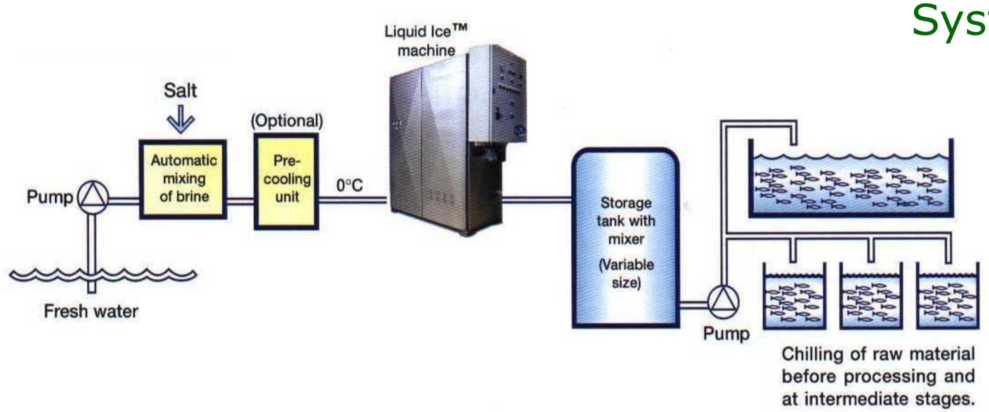
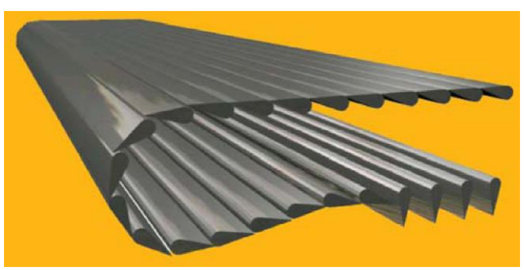
Technologies for superchilling II

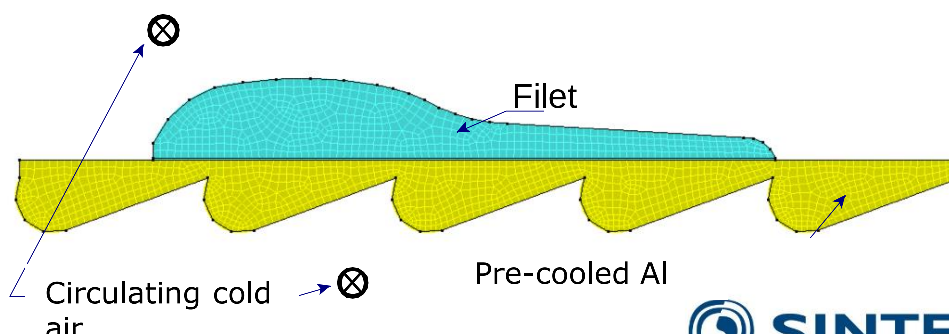
Ice slurry as cooling agent

Land-based Systems



CBC - Combined Blast Contact chiller





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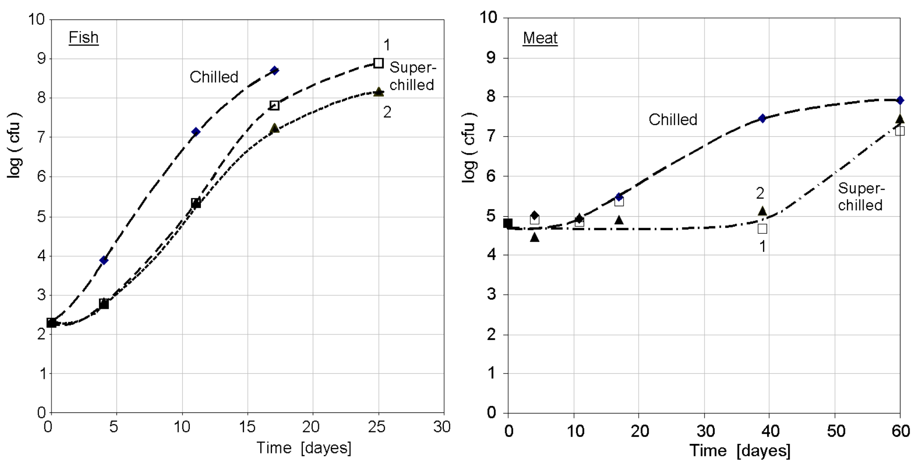
Industrial Benefits I

Shelf-life

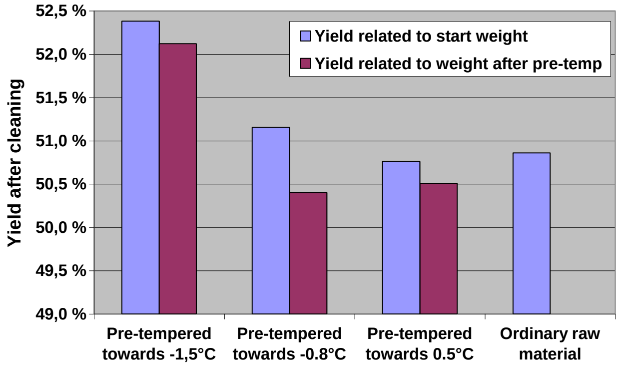
- Longer "fresh sale" period. Stock up before compagins
- Seasonal demand for only parts of the animals; ham, cutlets
- Superchilling reduces the demand for freezing (up to 40%)- more sold as fresh
- Reduction of total energy use for refrigeration



Industrial Benefits II

Increased yield

- Fish fillets are slightly more firm before trimming and more fish meat is wasted
- Research shows increased yield up to +1.5 % in fish fillet production



Environmental benefits I

Reduced CO_2 eqv.

- No need for ice in fresh fish boxes during transportation
- From Norway: 900 trucks* with fresh fish each week with approx. 25-30% ice
- 23 % reduction in CO_2 eqv. Changing from ice chilled fish transportation towards superchilled fish tranpsortation
  - Fewer trucks are needed
  - Less flake-ice production

* In 2014

Environmental benefits II

- The reduced need for packaging and transport of ice in a system applying superchilling will compensate for the environmental impacts of a significant higher energy demand in superchilled production.
- Chilled fillets have ca 30 % higher impact potentials than superchilled fillets for all environmental impact categories. This number is a direct reflection of the ice content in the boxes with chilled fillets.
- The ice is the most important parameter in this assessment
- Transportation by truck and packaging material are by far the two biggest contributors to the impact potential in both systems.
- The potential for reducing the impact on global worming (GWP) is ca 77 925 tons of CO2-equivialens per year. Corresponds to the annual emissions of roughly 24 000 cars.

Environmental benefits III

Reduced food waste

- Higher yield
- Double shelf-life reduces waste (>30 % today)
- Reduced demand of freezing

Some reported shelf-life extentions

Product	Superchilled storage temperature	Increase shelf life compare to conventional refrigeration
Cod fillets (farmed)	-2.2 °C	+ 14 days
Pork roast	-2.0 °C	+ 14 weeks
Atlantic salmon (farmed)	-1.4 °C and -3.6 °C	+ 17 – 21 days
Chicken	n.a.	+ 15 days
Lamb-leg, fresh	-1.6 °C	+ 19 days

Consumer benefits I

Food Quality

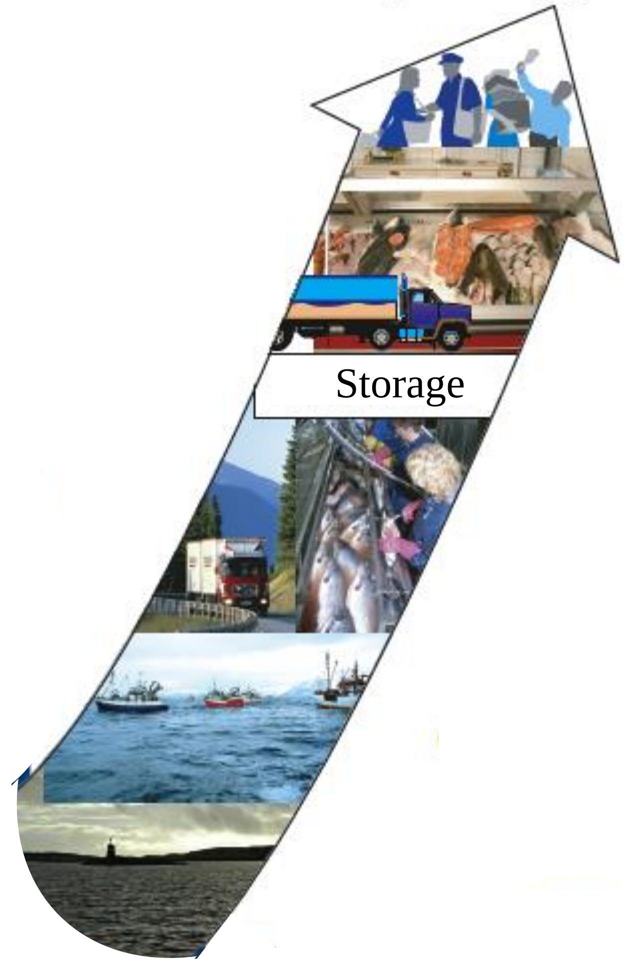
- Prolonged shelf-life
- Fresh quality- no significant difference in drip loss, colour, pH, protein degradation and sensory

Food Safety

- Longer shelf-life

Food Waste

- Doubled shelf-life reduces waste



Challenges with superchilling

- Food quality - Increased pressure drip-loss for some products
- Food waste - potenitial for superchilling not utilized today. More investigation regarding superchilling cold chain and use of PCM is needed
- Higher energi use than than traditional chilling, but lower than freezing
- Stringent demands for temperature control - Ice content in the products is sensitive for temperature variations
- Foods are inhomogeneous, both regarding water content, composition and size
- The technology is not suited for all products
- Need for flexible superchilling equipment and dynamic process control for optimization
- Need for energy efficient refirgeration systems and utilization of surplus heat
- Need for highly skilled personell at the production plants, and more challenges further out in the cold chain
- Consumer involvement and approval is important

Future potential

In short term there is a high potential for the traditional meat/poultry- and fish industry AND for the organic product market

Industry

- Reduced demand for freezing, more sold as fresh
- Stock-up before campaigns.
- Increased yield in fish industry
- No ice during transport of fresh fish

Consumer

- Reduced waste
- Longer shelf-life

Conclusions

- **Superchilling enable safe, high quality and long term storage of foods**
- **Main advantages are**
  1. Extended shelf life
  2. Increased production capacity
  3. Increased yield and profit
  4. Simplified production planning
  5. New products and markets
  6. Environmental friendly cold chain
  7. Can be adapted to a wide range of products: Meat, fish, poultry…

References

- **Nordvedt, T.S.** (2009) *Superkjøling av fisk- en litteratirstudie og prosjektoveriskt.* In SINTEF Energiprosesser AS, Trondheim 20.
- **Claussen, I.C.** (2011) *Literature review and experimental data of chilled, superchilled/supercooled fish quality and safety models.* Deliverable D3.2.4.3 FRISBEE Food Refrigeration Innovations for Safety, Consumers' Benefit, Environmental Impact and Energy Optimisation Along the Cold Chain in Europe
- **Haugland, A.** (2006) *SUPERCHILLING – innovative processing of fresh fish* NFTC, Trondheim 7-8 august 2006