LONDON SOUTH BANK UNIVERSITY

Supercooling as a novel food preservation process

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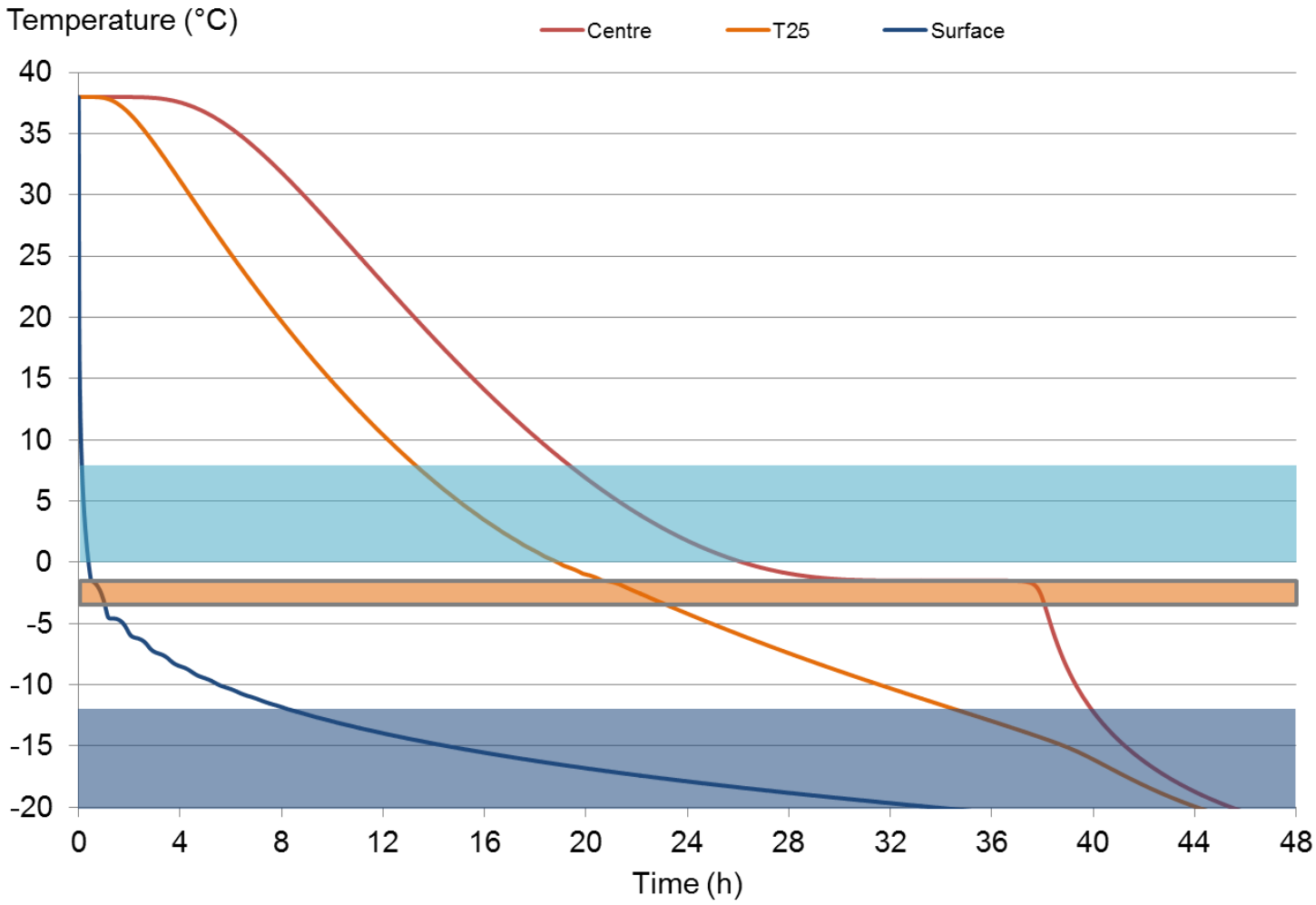
Supercooling



~-1 to -3ºC

No ice

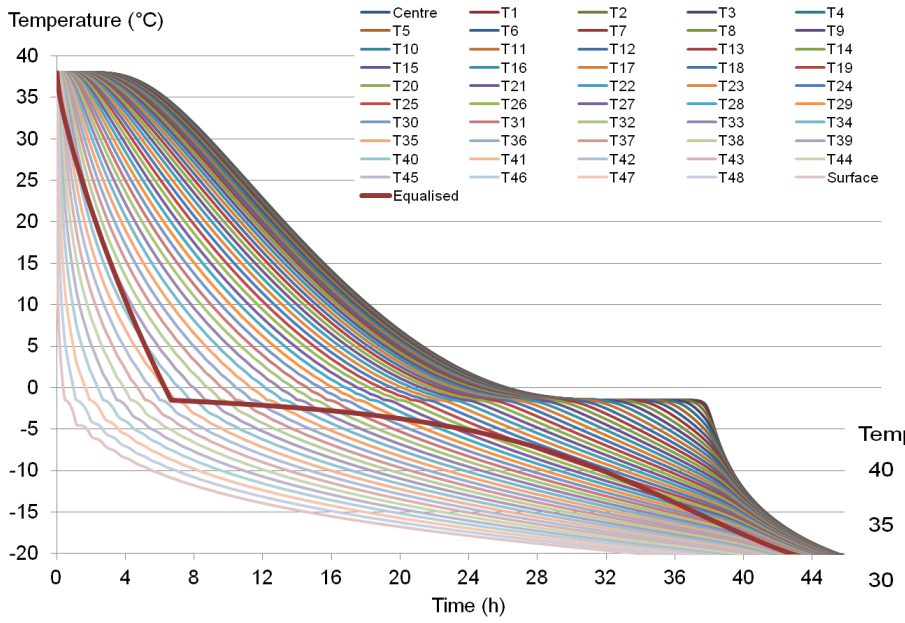
Chilling

Supercooling

Superchilling

Freezing

What is supercooling?

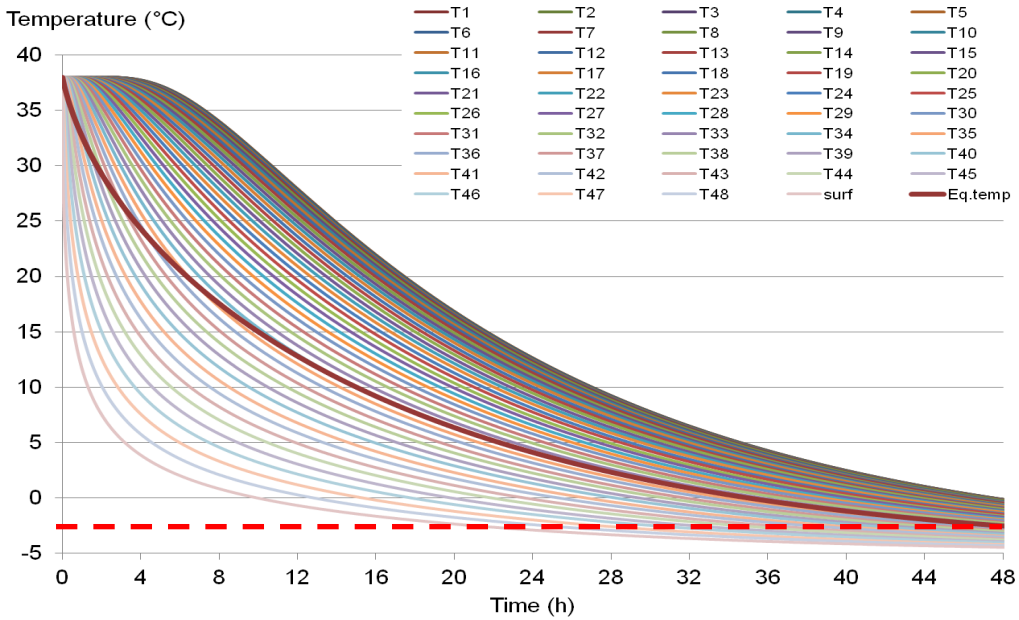


Superchilling

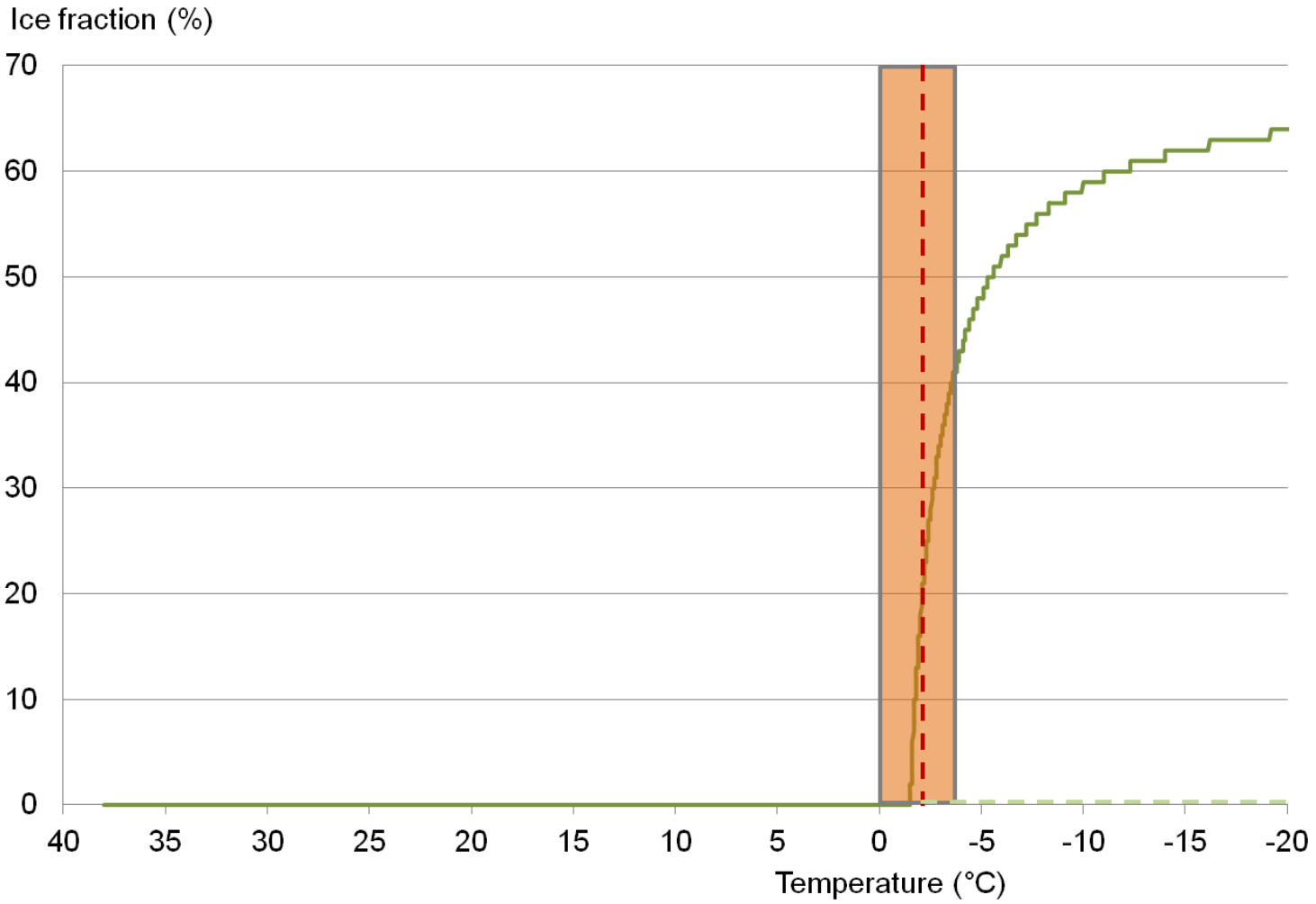
Fast cooling at low temperature, product often equalised

Supercooling

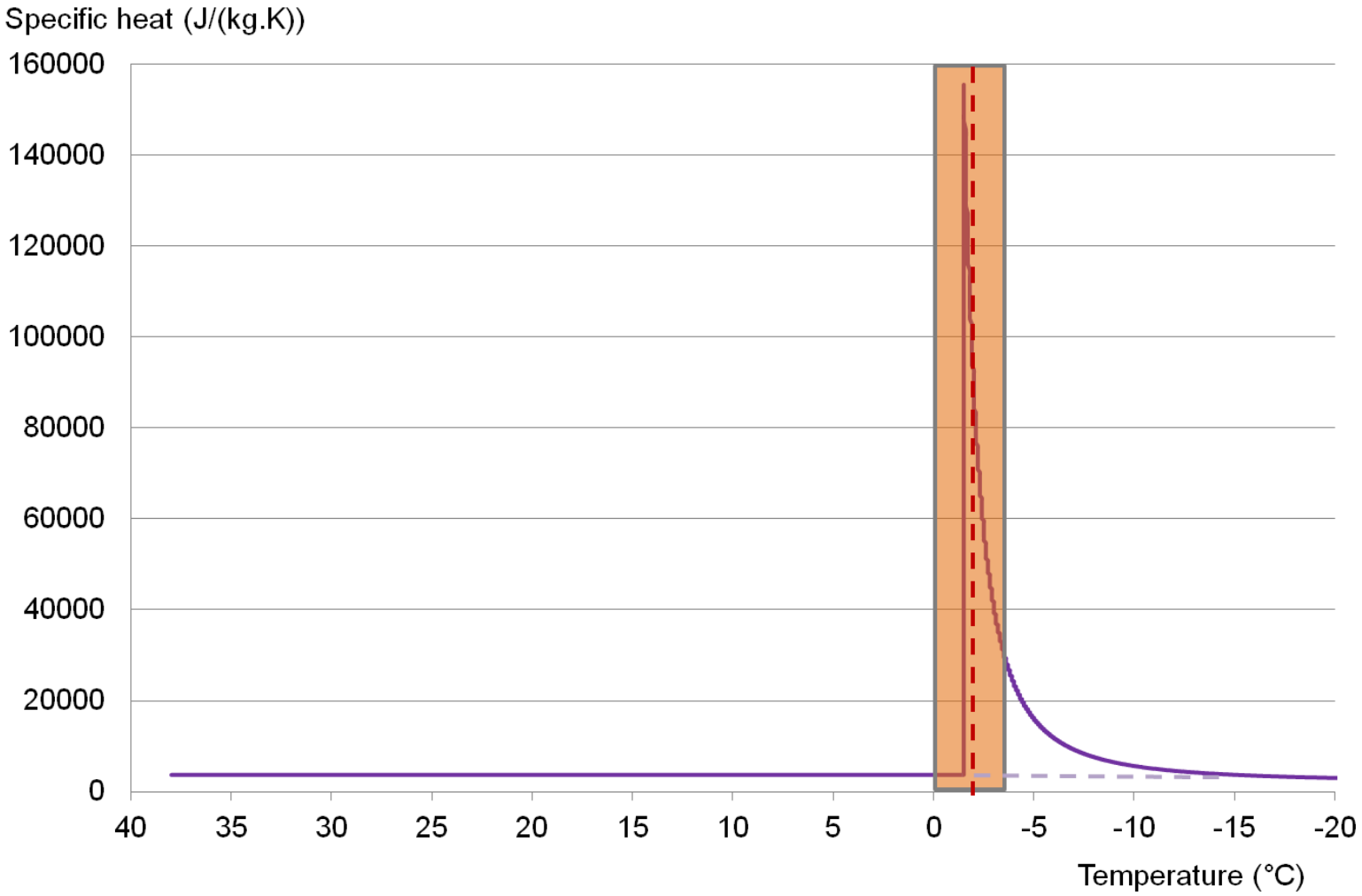
Slow cooling at temperature just below supercooled temperature



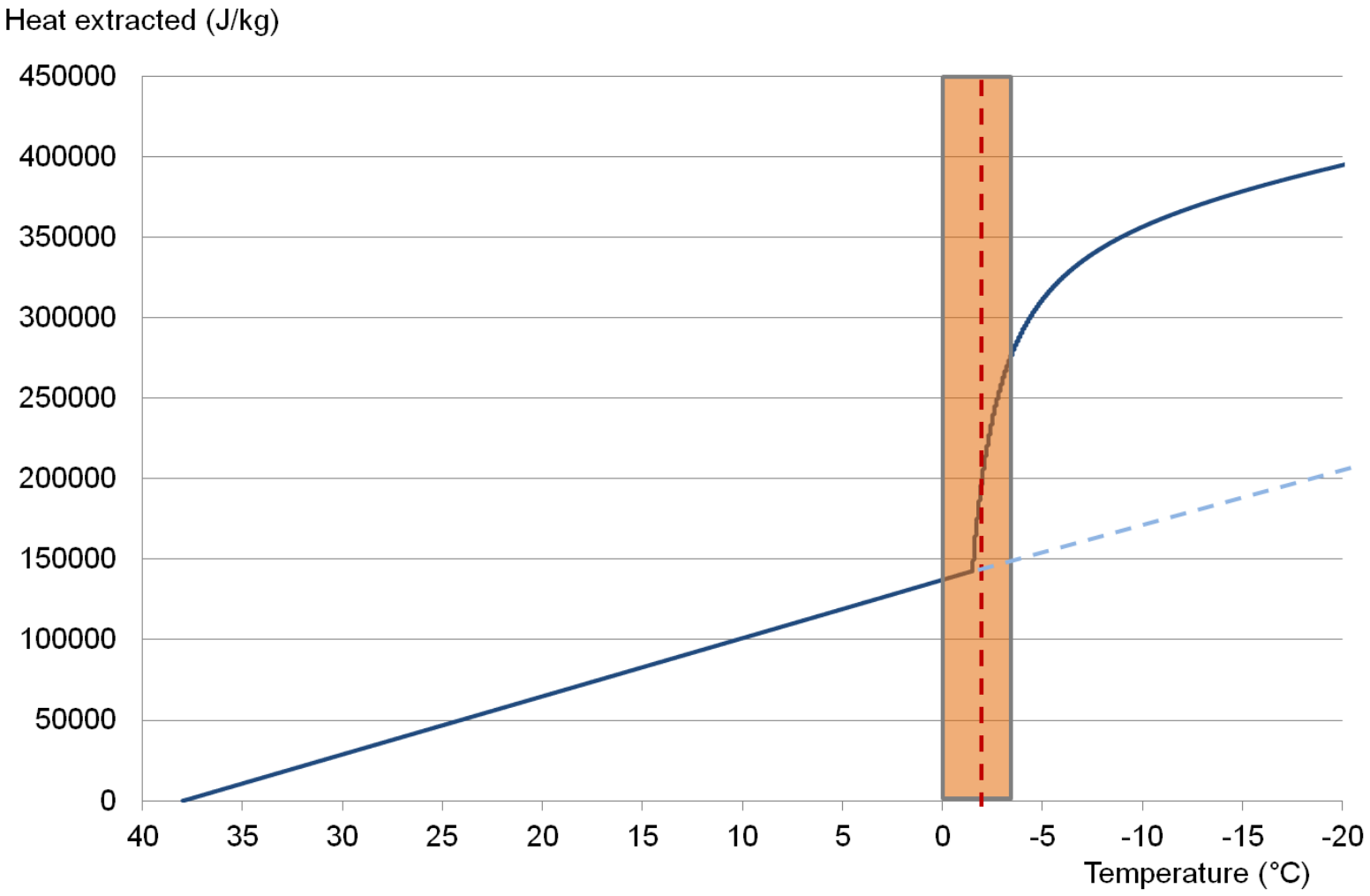
Ice fraction



Specific heat

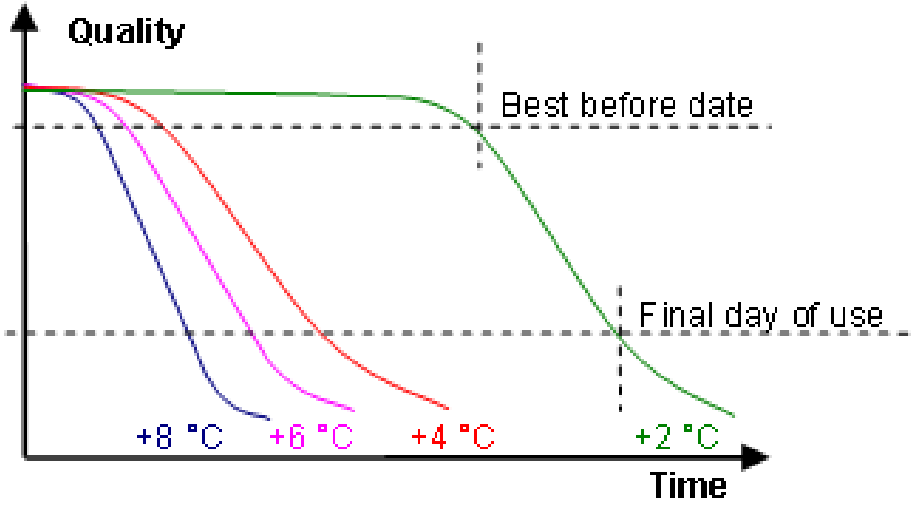


Heat extracted

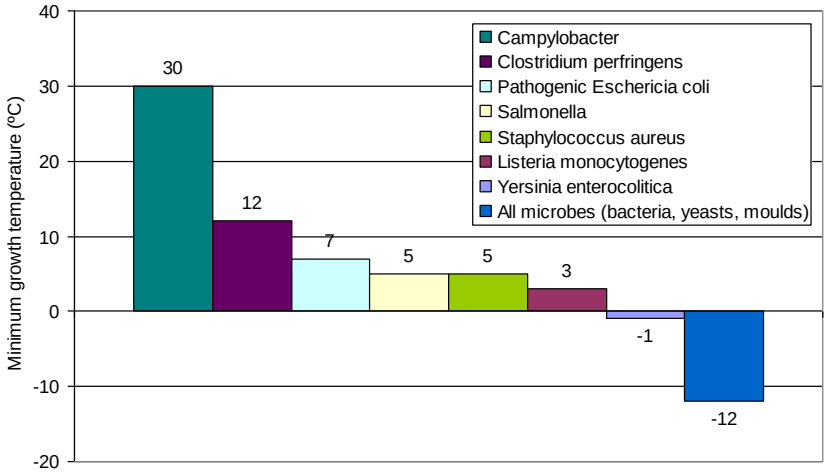


What are the potential benefits?

- Extended duration of cold chain with same final quality and safety as chilled
- Greater shelf life in production and distribution
- More time for the consumer to use the food
- Reduced waste
- Opening up distant markets for non-frozen products
- Potential to distribute supercooled instead of frozen

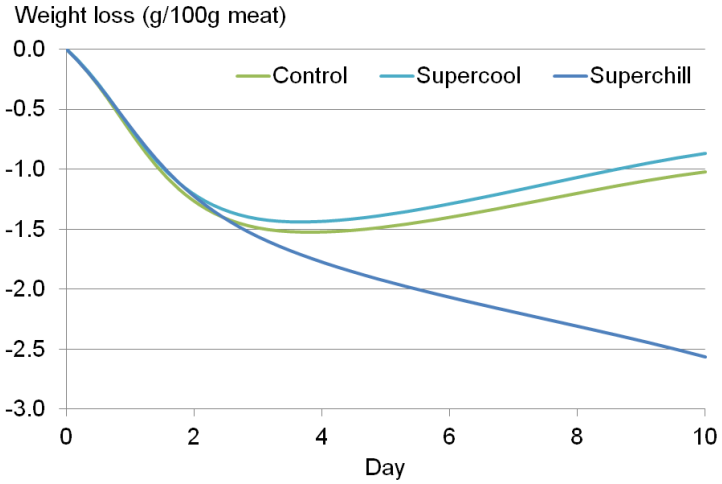


Extended storage life
4ºC to 2ºC doubles storage life
2ºC to -2/-3ºC further increase in storage life

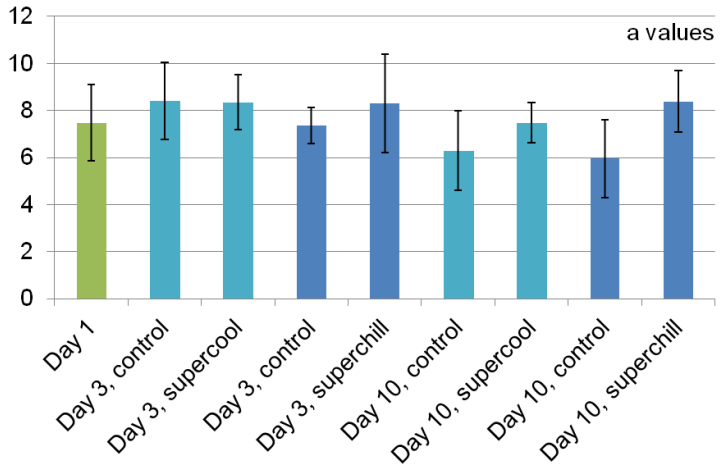


Food safety
<-1ºC few bacteria grow

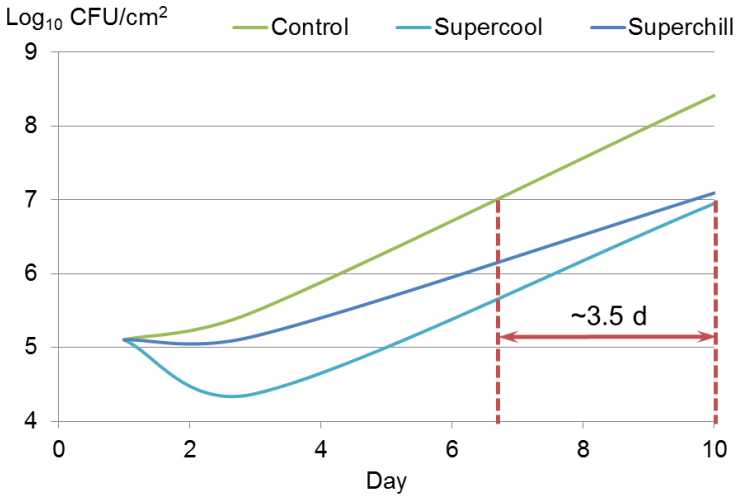
What are the potential benefits (pork)?



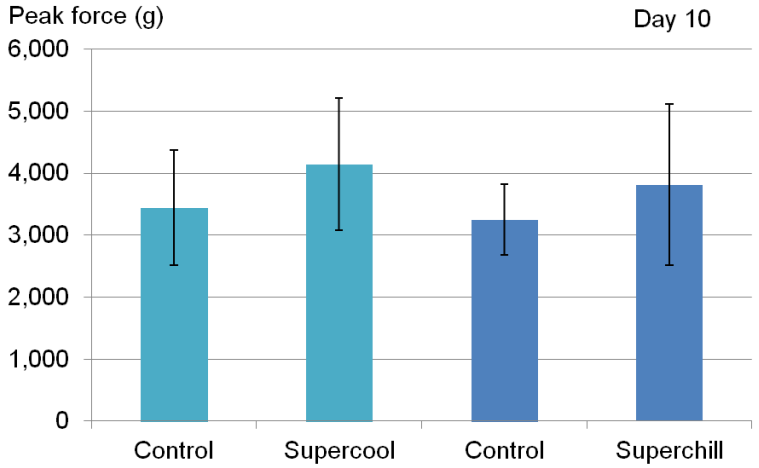
Weight loss



Colour (redness)



Microbiology (TVC)



Texture

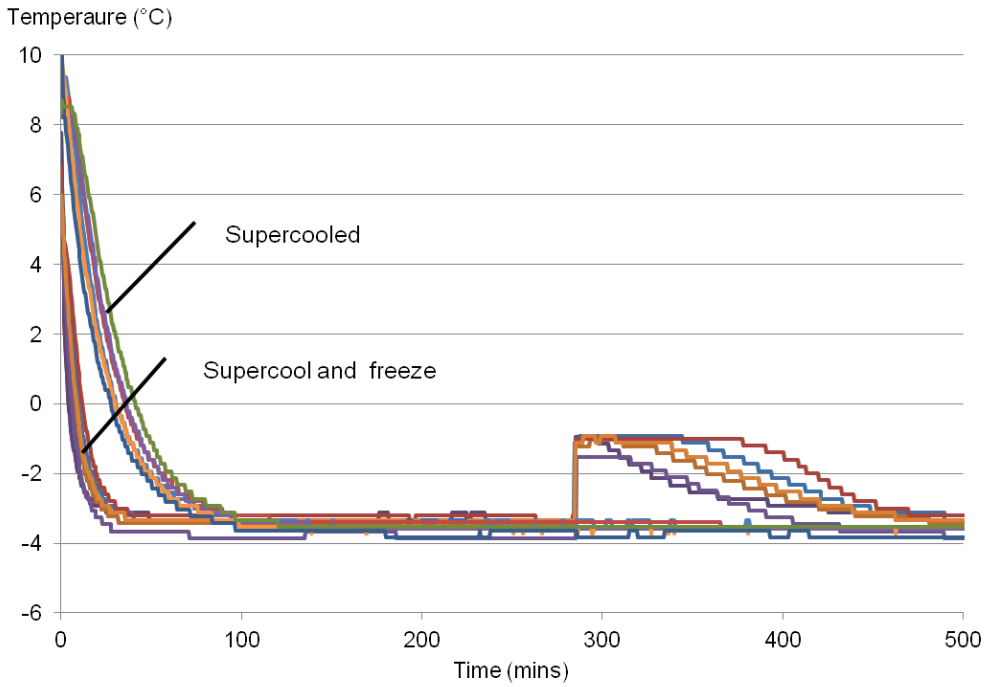
What is the current state of the art?

- Some products naturally supercool
- Cryoprotectants can be used to reduce the chance of nucleation
- Not commercially applied yet due to challenges of avoiding ice nucleation during processing and distribution

	Degrees of supercooling (°C)	Supercooling point (°C)	Reference
Apples	4		Diehl (1924)
Beef	-0.7-1.1	-2.2 to -2.4	Eustace and Bill (1988)
Broccoli	2.3	-4.4	James et al (2011)
Carrot	1.1	-2.7	James et al (2011)
Cauliflower		-6.5 to -9.5	Fuller & Wisniewski (1998)
Cauliflower	3.7	-5.2	James et al (2011)
Cod	3.9	-5.3	James et al (2011)
Garlic	10.3	-13.0	James et al (2009)
Grapes	3		Lucas (1954)
Herring	5.6	-9.2	James et al (2011)
Lamb	-0.5	-2	McGeehin, Sheridan and Butler (1999)
Leek	1.4	-3.3	James et al (2011)
Lemons		-6.1	Lucas (1954)
Oranges	1.5		Lucas (1954)
Parsnip	0.6	-2.8	James et al (2011)
Prawns	3.8-4.6	-5.9 to -6.5	James et al (2011)
Shallot	3.8	-5.4	James et al (2011)
Squid	6.6	-8.6	James et al (2011)
Strawberries		-0.3 to -4.6	Martins and Lopes (2007)
Tomatoes		-4.3 to -4.5	Cox & Moore (1997)

What are the barriers and problems to be overcome?

- Avoiding nucleation of ice
- Diverse factors have been reported to initiate nucleation
- These include vibration, shocks, impurities, rate of cooling, final temperature, and even bacteria
- During commercial handling and transport sometimes difficult to avoid some of these factors
- New equipment and procedures may be required e.g. display cabinets with close temperature control at -2°C



What is the impact of unwanted nucleation?

- If a supercooled product held at -2°C nucleates, its temperature will rise slightly towards its freezing point
- Will then cool back down to -2°C with an ice content of around 15 to 20% (meat/fish)
- In other words, it will become superchilled
- The impact on storage life therefore be negligible
- Any impact on quality small (see superchilling presentation)

Relative costs of supercooling versus chilling?

Versus chilling

- Requires lower temperature (~5 to 10K)
- Some existing equipment could simply be 'turned down'
- Other equipment may need replacing if unable to achieve the lower temperature
- Running at lower temperature increases the energy costs
- Also introduce or increase the need for defrosts

Versus freezing

- Requires higher temperature (~ 15 to 20K)
- Existing equipment would run more efficiently at higher temperatures
- May be oversized in terms of the duty required and could have unnecessary features (e.g. high air velocities)
- The need for defrosts would be reduced

Cold chains:	**Energy estimate (kJ/kg)**	
	Salmon chain	Pork chain
Chilled	3434.0	1144.8
Supercooled	3436.5	1230.7
Superchilled	3603.5	1494.9
Frozen	15783.1	13536.8

Where is supercooling likely to be used in a sustainable cold chain?

- Supercooling is most likely to benefit high value products such as meat and fish
- Implementation would be easiest during production and storage
- Temperature control and avoidance of ice nucleation during transport, retail display and domestic storage would be more difficult
- New equipment may be required for some of these cold chain blocks