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Developments in chilling, (super-cooling, super-chilling) and freezing systems

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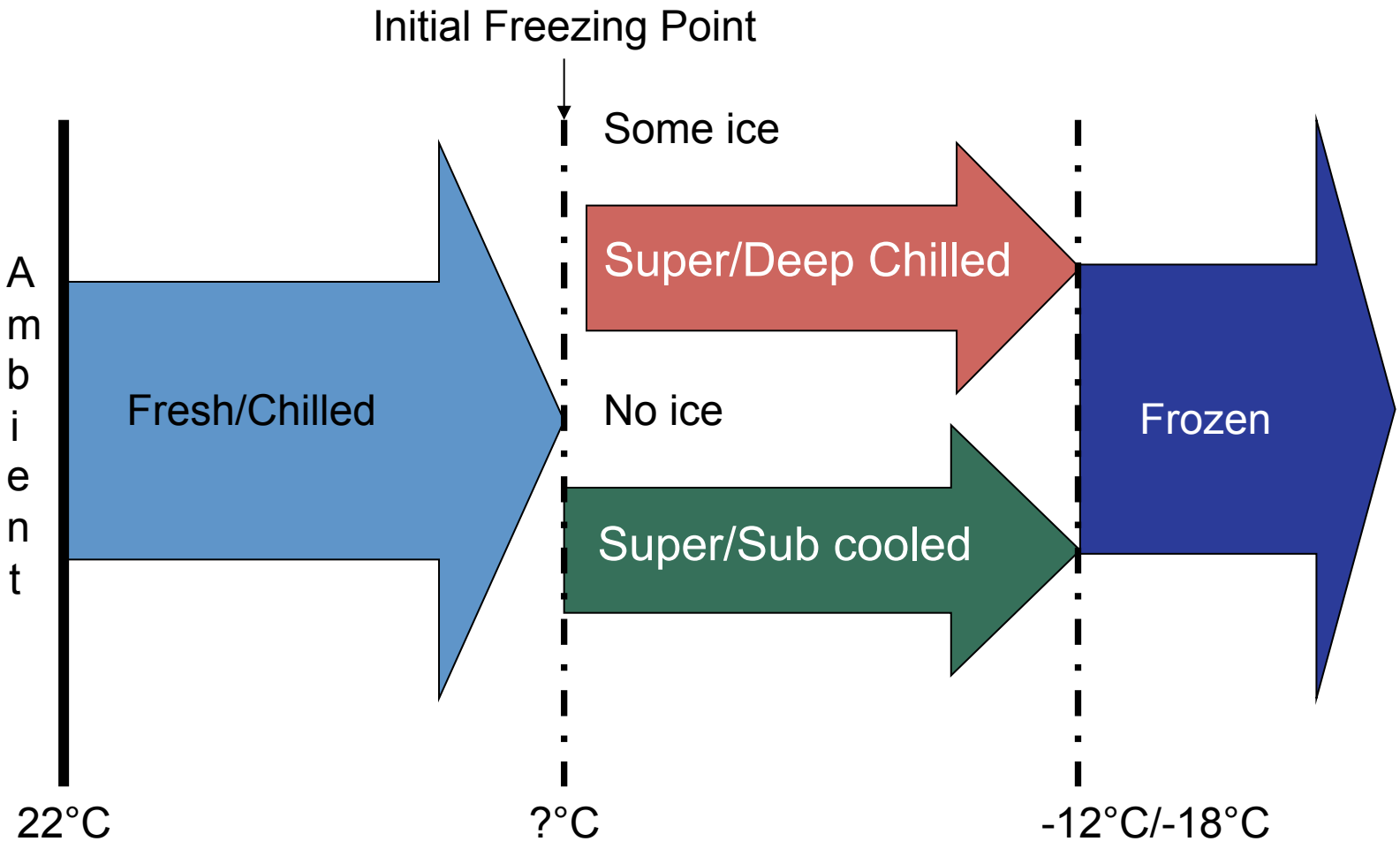
Chilling - Freezing

- Drivers for change
  - Extending storage-life/ shelf-life
    - New markets
    - More flexibility
  - Improving quality
  - Energy
    - Cost
    - Corporate responsibility
  - GWP
    - Refrigerants
- Barriers
  - Understanding
  - Legislation
    - Definitions

State of food at different temperatures



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Chilled

- Fish: Reference temperature 0°C, temperature of melting ice
- Lower the temperature, longer the shelf-life
- Minimum chilled temperature: just above freezing point?
- International transport red meat
  - Very close to freezing point: -1.5°C
  - Very tight control: ±0.2°C

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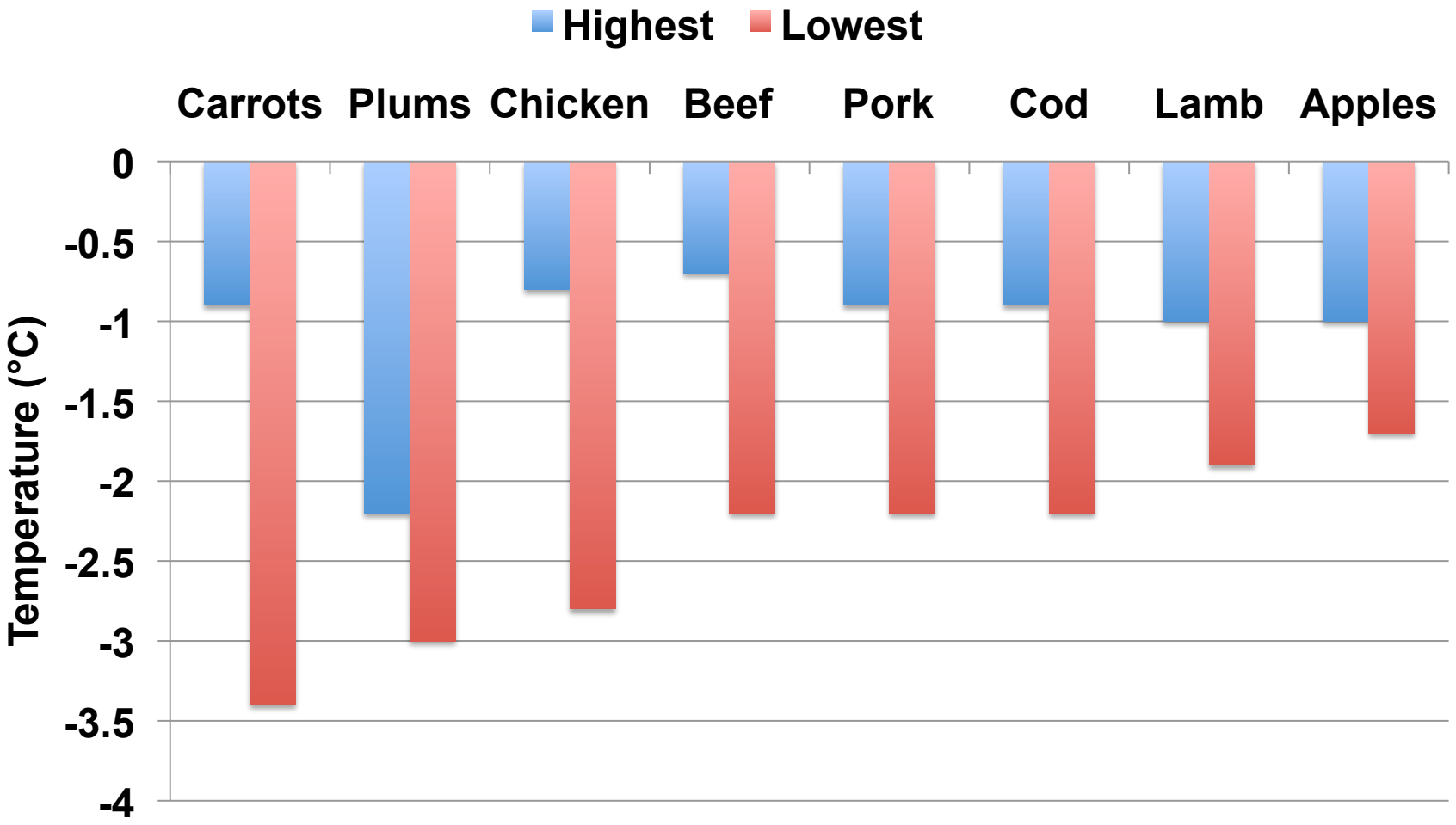
Published Initial Freezing Points (°C)



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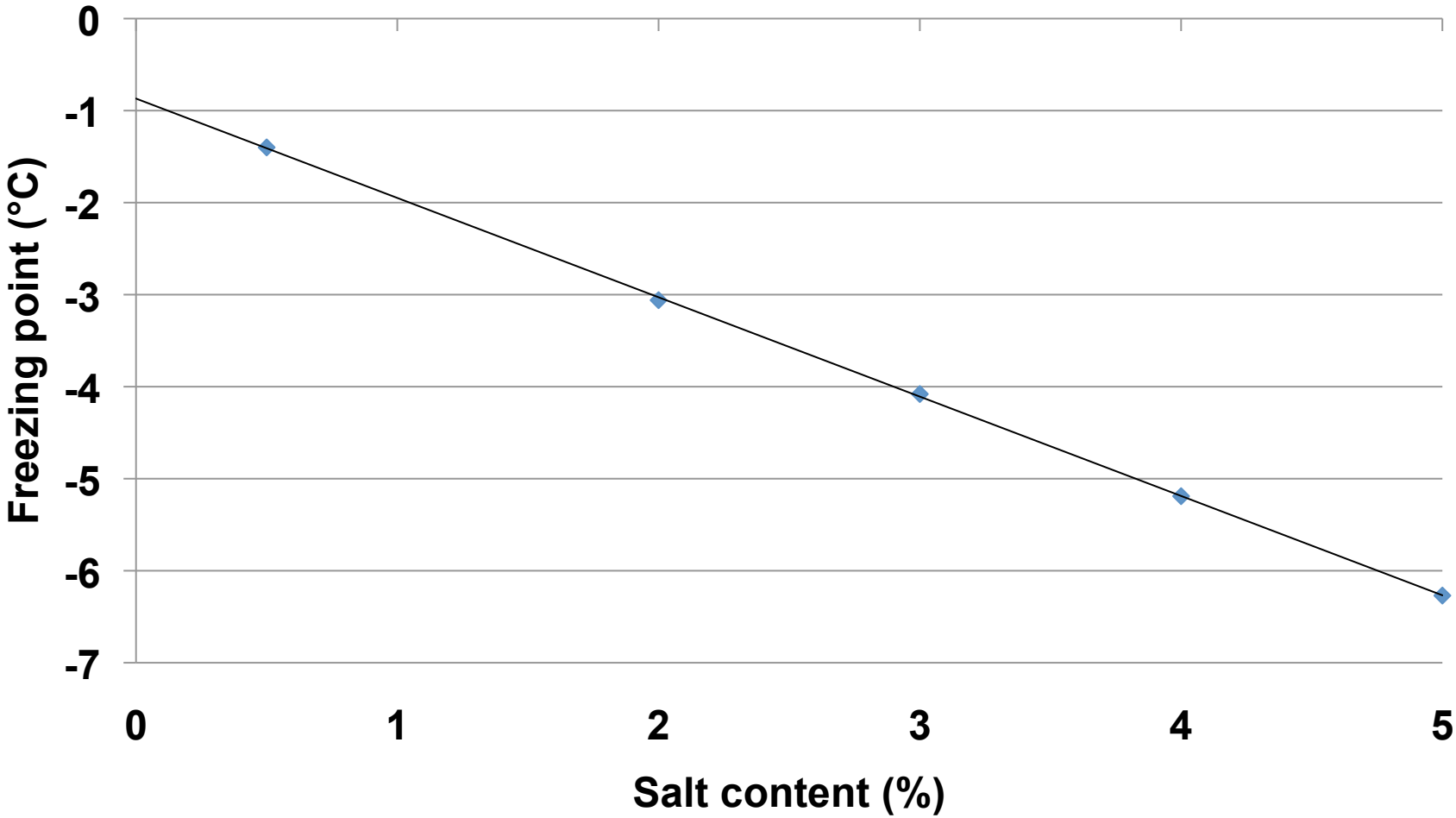
Relationship between salt content and freezing point



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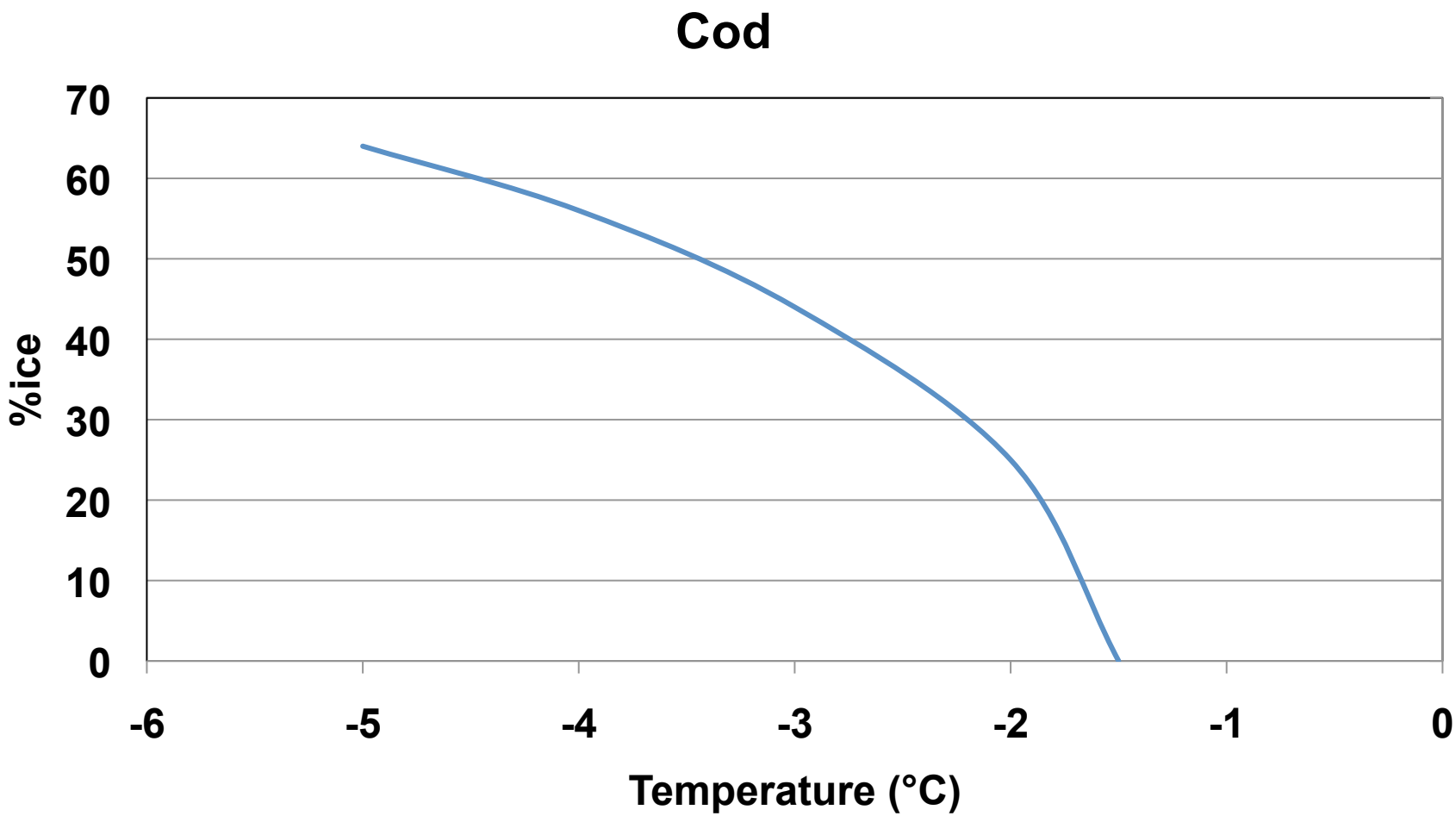
Ice content in -1°C to -5°C range



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Super/Deep chilling - Partial freezing

- Chilling and storage at temperatures ‘just’ below initial freezing point
  - Low enough to substantially reduce bacterial action
  - High enough to prevent ice crystal growth that will cause structural damage?
- Typical temperature range for fish
  - -2 to -5°C
- 30 to 60% ice content

Super/Deep chilling - Partial freezing

- A great deal of interest for fish
- History of use in USA for ‘Deep chilled poultry’
  - Above -3.8°C legally chilled
- Used for turkey meat in USA (- 3.3 to -4.4°C) and in UK
- South American interest for meat and meat products

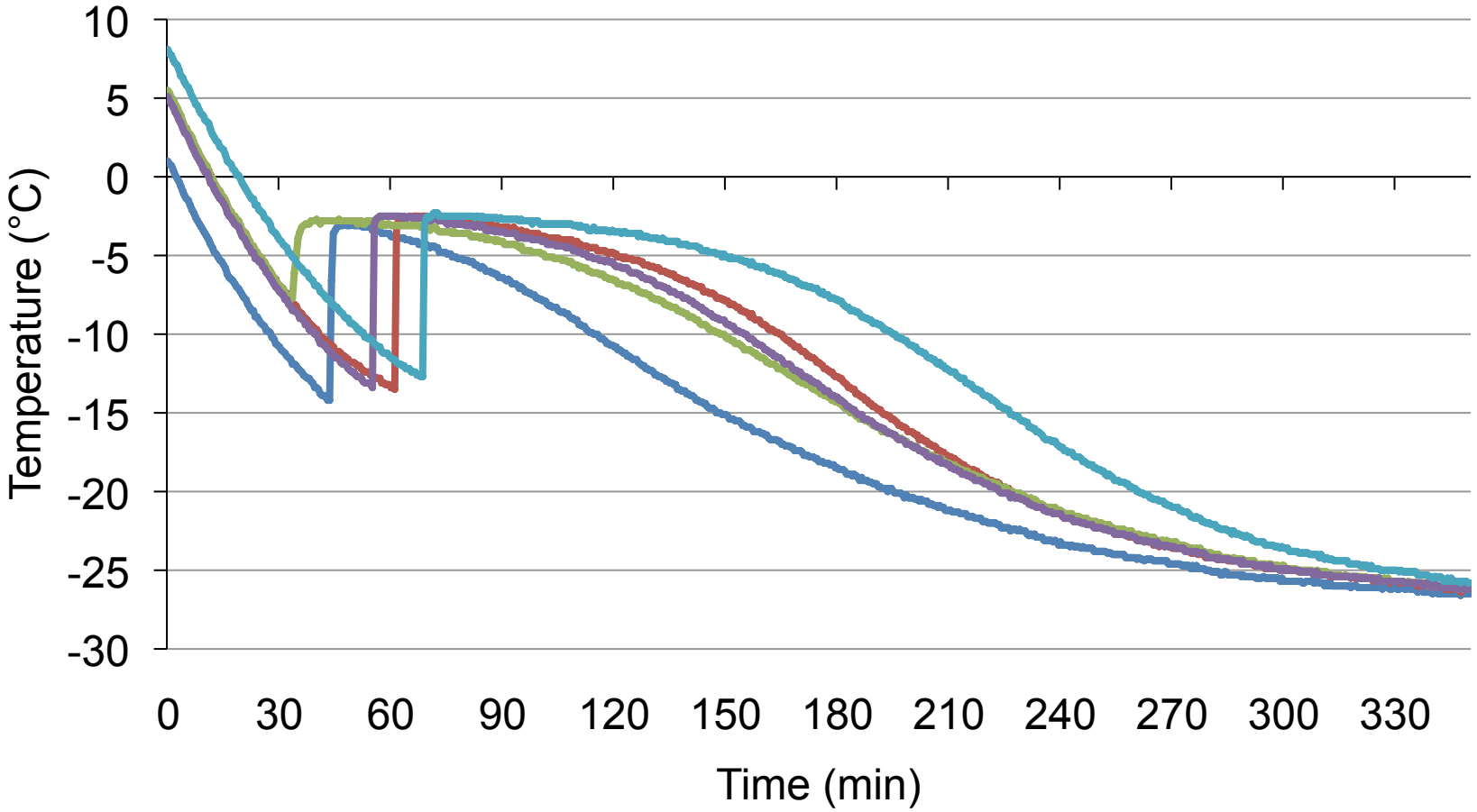
Why interest now?

- Ability to extend shelf life from days to weeks
- No detrimental quality affects of freezing?
- Presence of ice helps maintain cold chain
- Energy efficient if replacing freezing
- Extends/develops high quality market for some products
- Need to declare as ‘previously frozen’?

Garlic enquiry

- Company importing garlic at -6°C
- Declared as “frozen”
- Questioned by Customs since little sign of “damage”

Freezing curve - garlic



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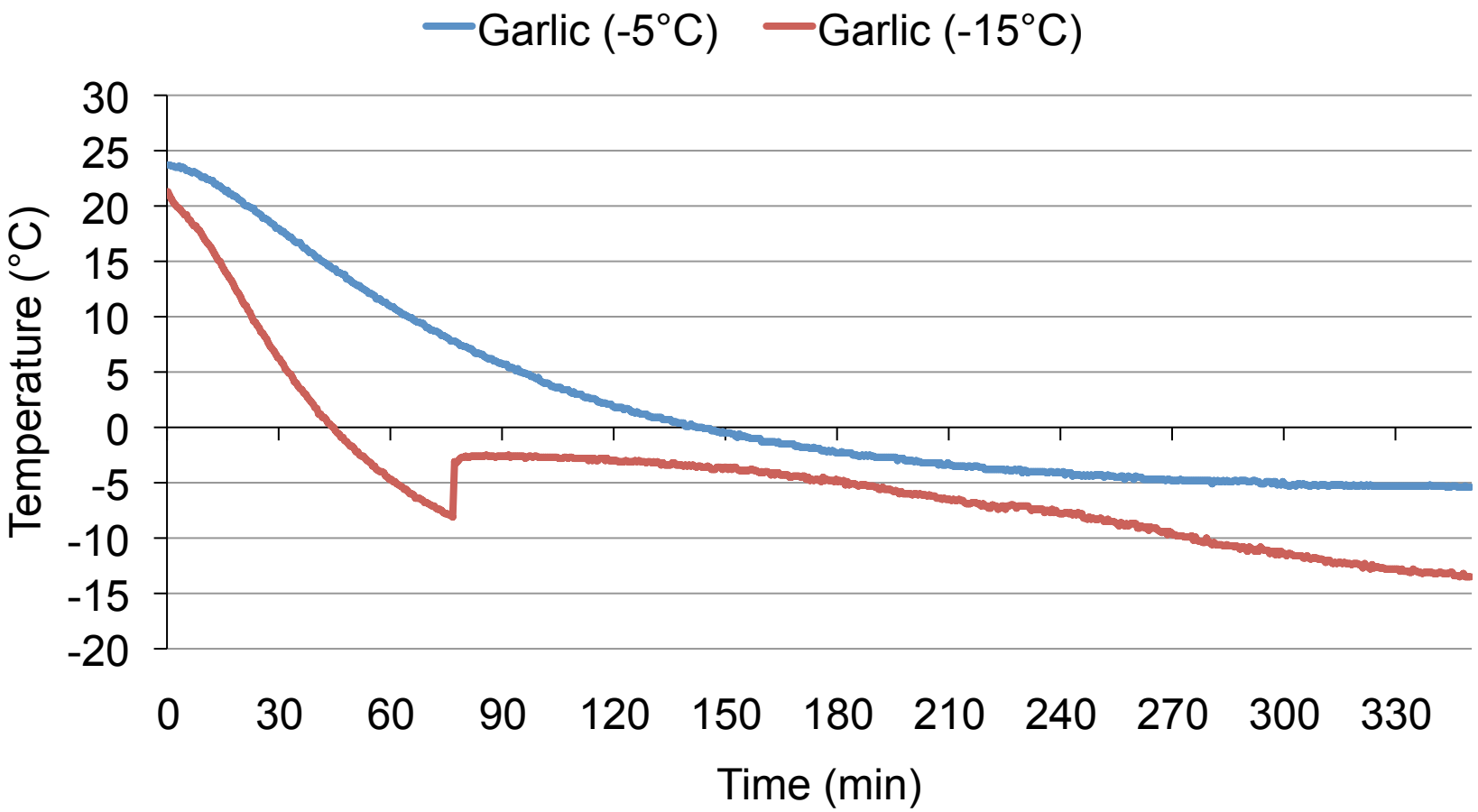
Super-, Sub-cooling Garlic cloves



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Ambient, chilled, supercooled (-6°C), frozen (-30°C)

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Super-cooling in fish

Sample	Freezing point (°C)	Super-cooling point (°C)
Prawns (previously frozen) – “jumbo”	-2.1	-5.9
Prawns (previously frozen) – “large”	-1.9	-6.5
Cod	-1.4	-5.3
Herring	-3.6	-9.2
Squid	-2.0	-8.6

Requires “slow” controlled cooling at air temperatures between <-12°C
Currently not stable

Development of super-, sub-cooling technology

- Potential:
  - Substantially extend the high quality shelf life of unprocessed and processed foods without freezing?
  - Rapid nucleation of ice throughout product on freezing – smaller ice crystals, no ice front?
    - Basis of novel freezing technologies such as pressure-shift and magnetic resonance (CAS)
- Need to:
  - Identify key conditions
  - Optimise cooling and regeneration processes
  - Quantify quality and safety

Effect on current legislation

- Previous wording
  - “frozen throughout”
- New wording
  - “irreversible changes …., in particular to the structure of the cells”
  - “no longer in the natural state” (after having thawed out)

Why does -18°C = frozen

Simple answer:

-18°C ≈ 0 F

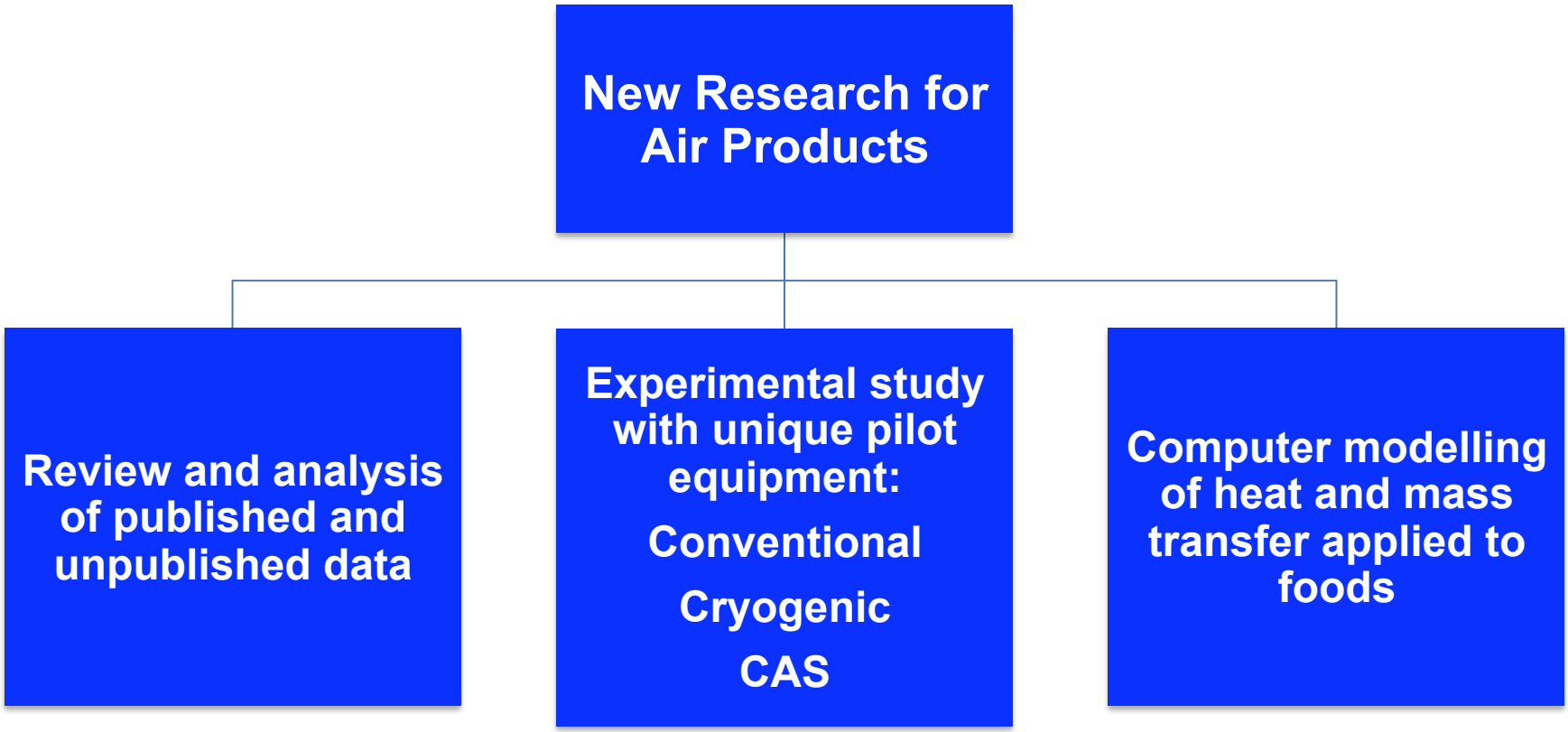
- No safety issues below -12°C (-5°C)
- Provided there is good temperature control many foods can be stored at -12°C with no loss of quality
- Adjustment of 1°C = 1 to 4% energy saving

Freezing

- Freezing affects food quality?
- Large ice crystals bad?
- Small ice crystals good?
- Slow freezing bad?
- Rapid freezing good?

- Yes, no, maybe!

Separate belief from fact



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Energy

Energy: What is the purpose of the factory/plant?

- Input
  - Raw materials (amount/temperature)
  - Packaging
- Output
  - Packaged finished product (amount/ temperature)
- Purpose
  - Transform input into output in the most cost effective manner

Input and Output

Input

- 350 tonnes at -20°C
- 125 tonnes at 0°C

Output

- 400 tonnes at 3°C
- 75 tonnes at 12°C

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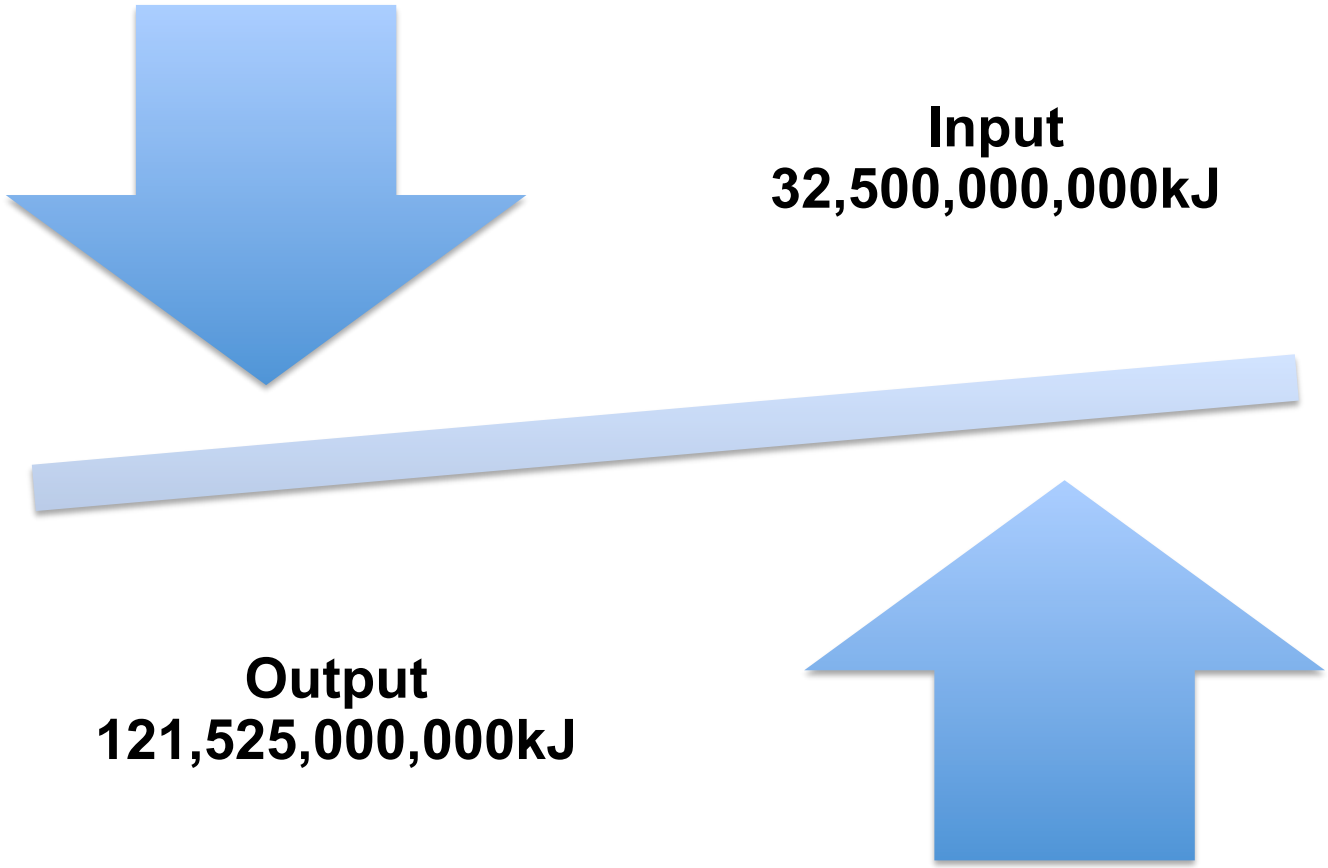
Heat energy in product



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Question

Why are refrigeration systems required if the food has to gain heat?

“Cost 600,000 euro per year”

Thank you

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