Best Quality Practices for Small-scale Manufacturing and Scooping Operations

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NATIONAL CENTRE FOR DAIRY EDUCATION – AUSTRALIA –

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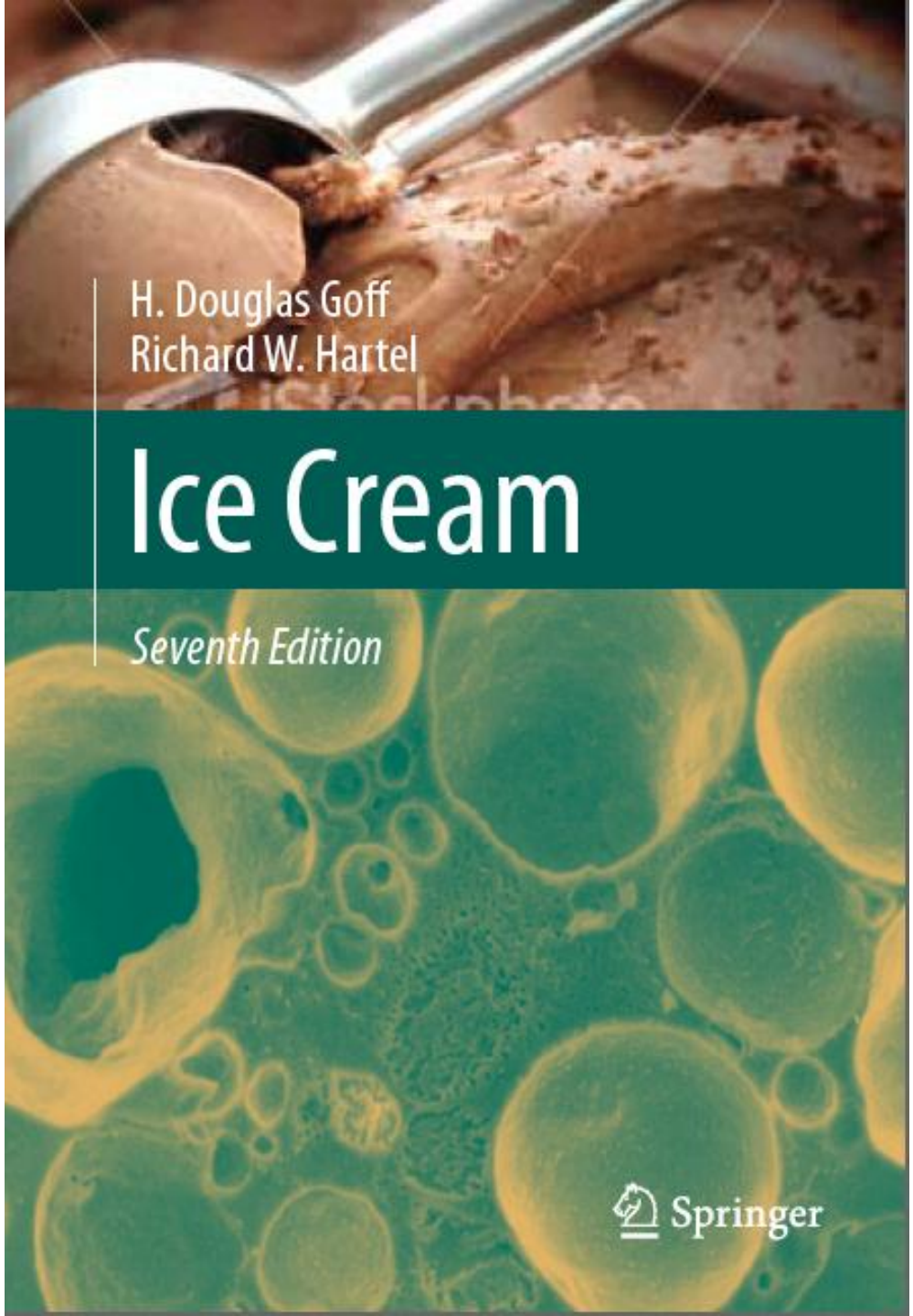
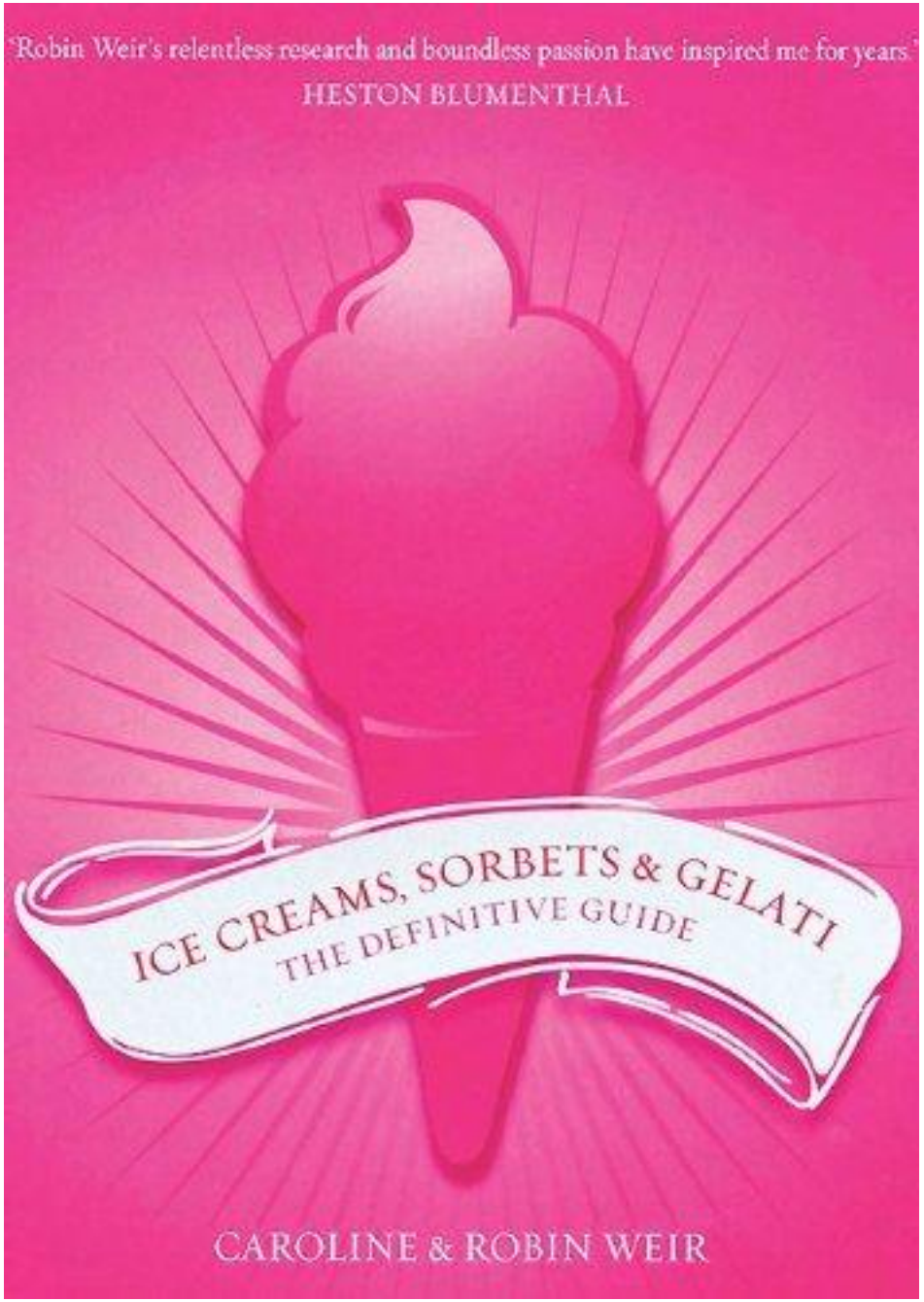


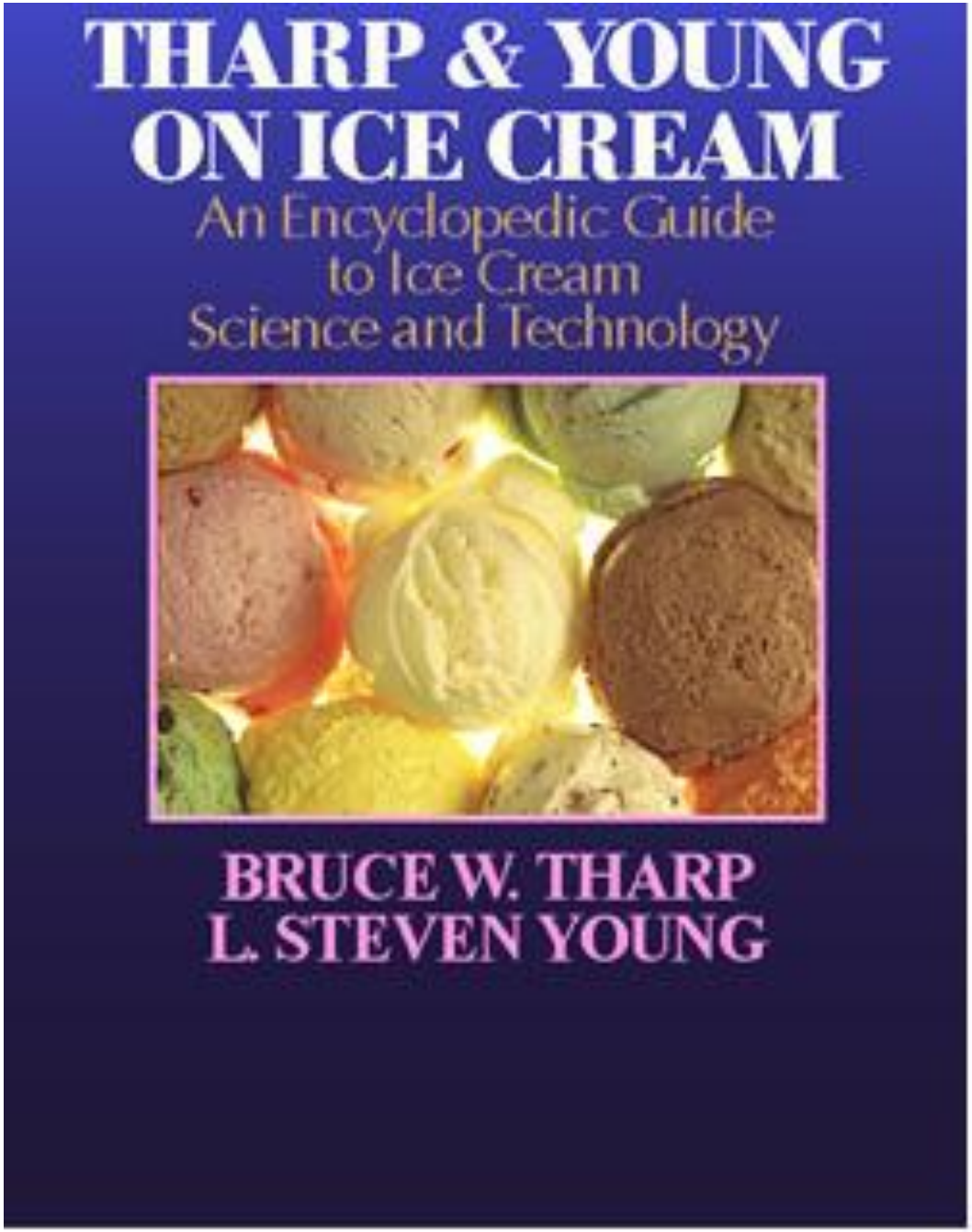
www.springer.com
(search for Ice Cream)
Feb., 2013



Grub Street, London
2010

onicecream.com

Dr. Bruce Tharp & Dr. Steven Young



Destech, Inc.
Fall, 2012

Outline

- Ice cream recipe development for batch-freezer operations
  - Should I make my own mix?
- Optimal storage conditions for maximal shelf-life in scooping operations
- Open discussion

ICE CREAM MANUFACTURE

Formulation

-Fat
-Milk SNF
-Sweetener
-Stabilizer
-Emulsifier
-Water

Blending

liquid ingredients

dry ingredients

Batch Pasteurization → Homogenization → Cooling

Continuous Pasteurization/Homogenization/Cooling

air incorporation

Continuous Freezing

Batch Freezing/Whipping

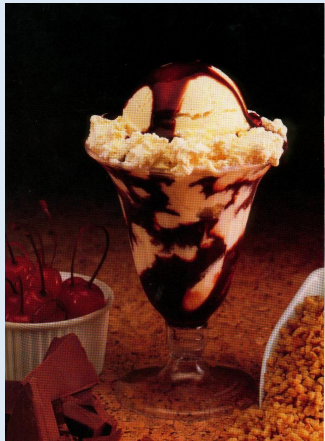
Ageing

Flavour/Colour addition

Particulate addition

Packaging

Hardening → Storage/Distribution



Ice Cream Mix Composition

- Milk Fat (5% - 10%) - 16%
- Milk solids-not-fat 9% - 12%
- Sweeteners
  - Sucrose 10% - 14%
  - Glucose solids 4% - 5%
- Stabilizers 0% - 0.4%
- Emulsifiers 0% - 0.25%
- Water 55% - 70%

Ice Cream Mix Composition

- **Milk Fat (5% - 10%) – 16%**
  - Generally cream is used
  - Less need for homogenization with high-fat mixes
  - Less overrun/yield with high-fat mixes
  - With mid- to lower-fat mixes, if you don't homogenize the mix, homogenized cream (up to 20% fat) can be used

Ice Cream Mix Composition

- **Milk solids-not-fat 9% - 12%**
  - Generally from condensed skim or skim powder in a premium formula
  - Some also from milk and cream, which must be accounted for in recipe

Ice Cream Mix Composition

- **Sweeteners**
  - **Sucrose** **10% - 14%**
  - **Glucose solids** **4% - 5%**

  - **Glucose solids from hydrolyzed starch, adds body/texture/viscosity; not as sweet as sucrose**

Ice Cream Mix Composition

- **Stabilizers** **0% - 0.4%**
- **Emulsifiers** **0% - 0.25%**
- **Water** **55% - 70%**
  - **Traditional ingredients were gelatin, egg yolks**
  - **A stabilizer/emulsifier blend can be purchased to meet the needs of your formula/distribution**
  - **Water from cream and milk, or added.**

Batch freezers

- 3-40 L
- Air or water cooled condensors
- 10-20 minutes/batch to achieve -5° C draw temperature and 50-70% overrun

Advantages

- Small quantity
- Less expensive
- More flexibility

Disadvantages

- Limited quantity
- Incorporation of ripples and particulates can be difficult
- Hand packing

Taylor Freezers

Model 220
20L barrel

Model C118
12L barrel
Automated operation

Model 104
3L barrel
Table-top

Carpigiani 20 L

Technogel 40 L

Flavouring

- Goal: Sufficient high-quality ingredients for good flavour and balance
- Market share: it may be easy to make it, but is anyone going to buy it?
- Flavoured mix.
- Particulates: Batch freezer addition vs. hand mixing.

Outline

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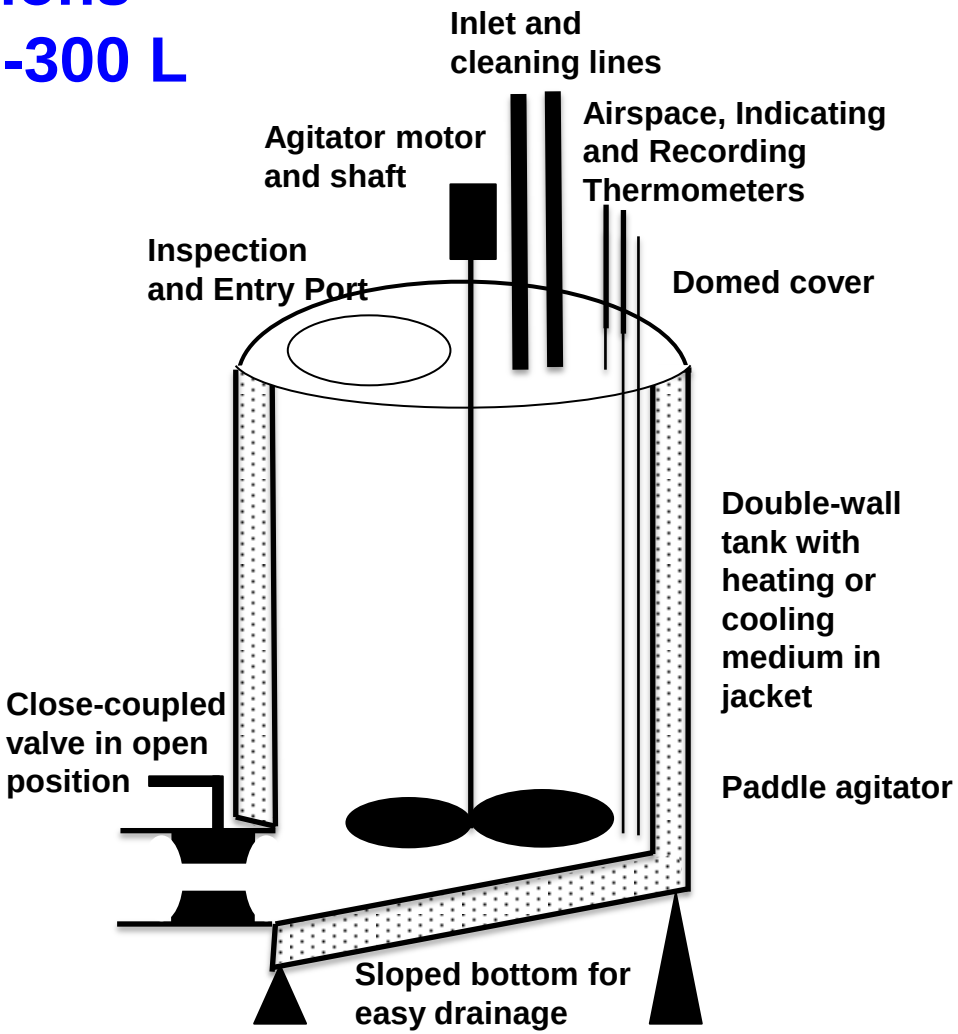
Pasteurization

- **Batch : ≥69°C (156° F) / ≥30 min.**

- **Kills pathogens if raw milk, cream or eggs are used; guarantee of food safety**
- **Reduces total bacterial numbers**
- **Hydrates proteins & stabilizers, if dried ingredients are used**

Batch Pasteurizer

- **Small operations could be 100-300 L**



Steam Kettle

- 20-50 L

Double boiler

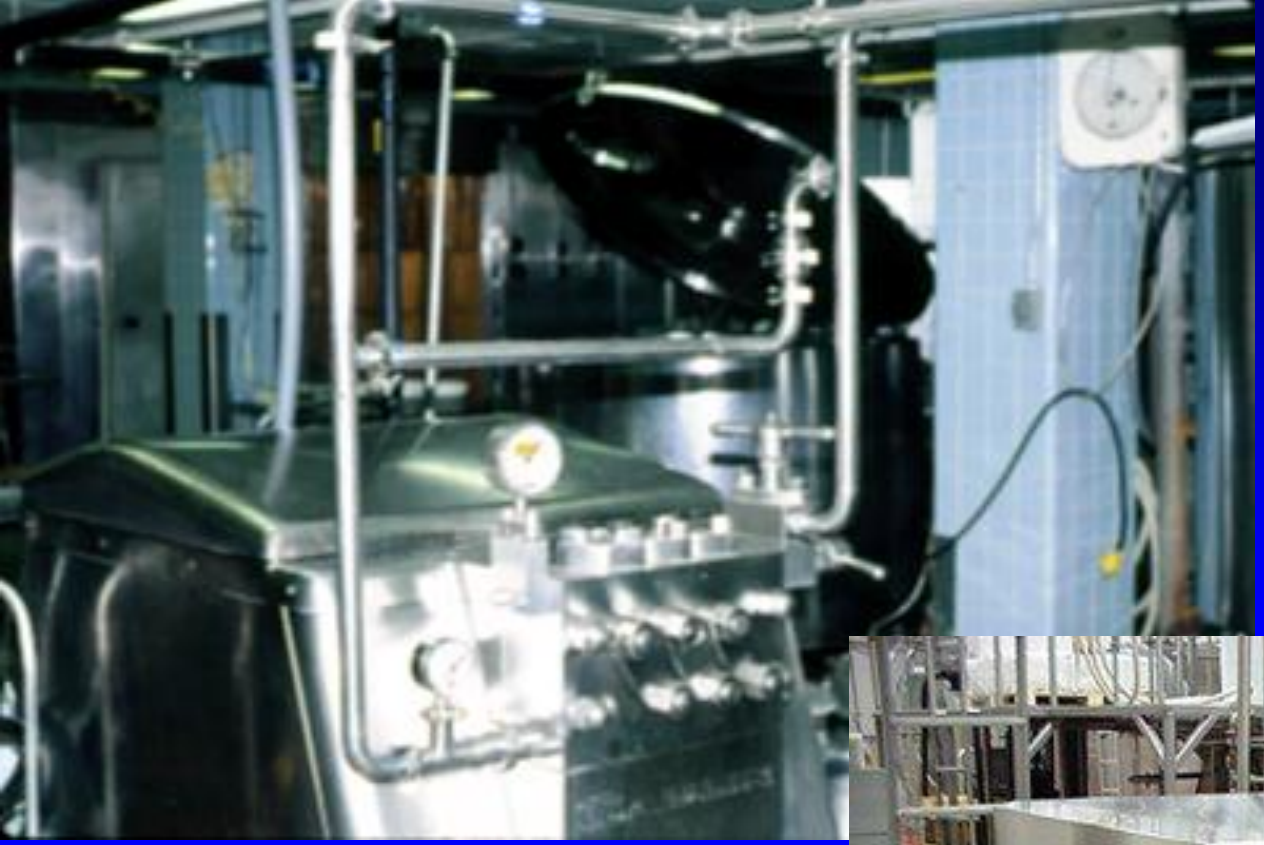
- Over a gas hot plate
- 8-20 L

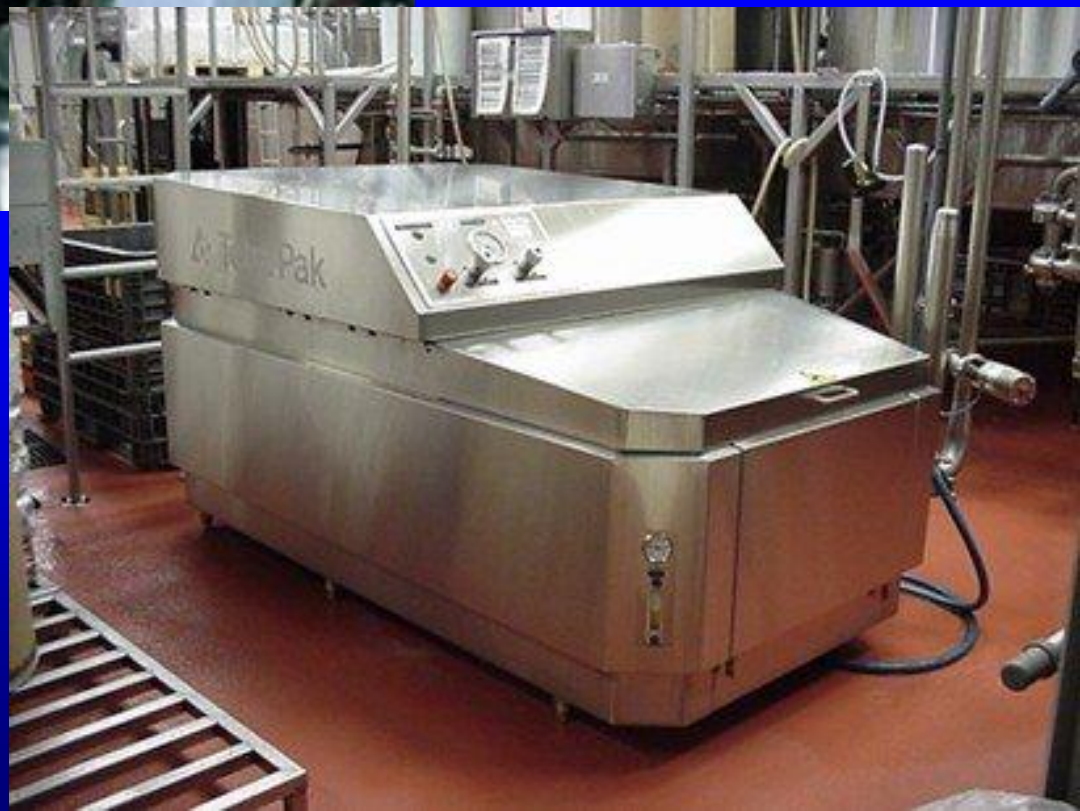
Homogenization

- **The purposes of homogenization**
  - **Reduces the size of fat globules so they won't separate out in milk or cream**
  - **In mix, makes possible the use of butter, frozen cream, etc.**
  - **In ice cream, helps to establish fat structure, which provides a smoother texture, allows for a higher overrun, and slows down the melt (structural collapse) rate.**

Homogenization

- **Do you need to homogenize mix?**
  - **Maybe not, if you are using fresh cream, have a high fat and total solids content in the mix, are using batch freezing, and don't have any meltdown or texture issues.**
  - **Homogenized cream?**





www.technogel.com

Hoyer Promix

Outline

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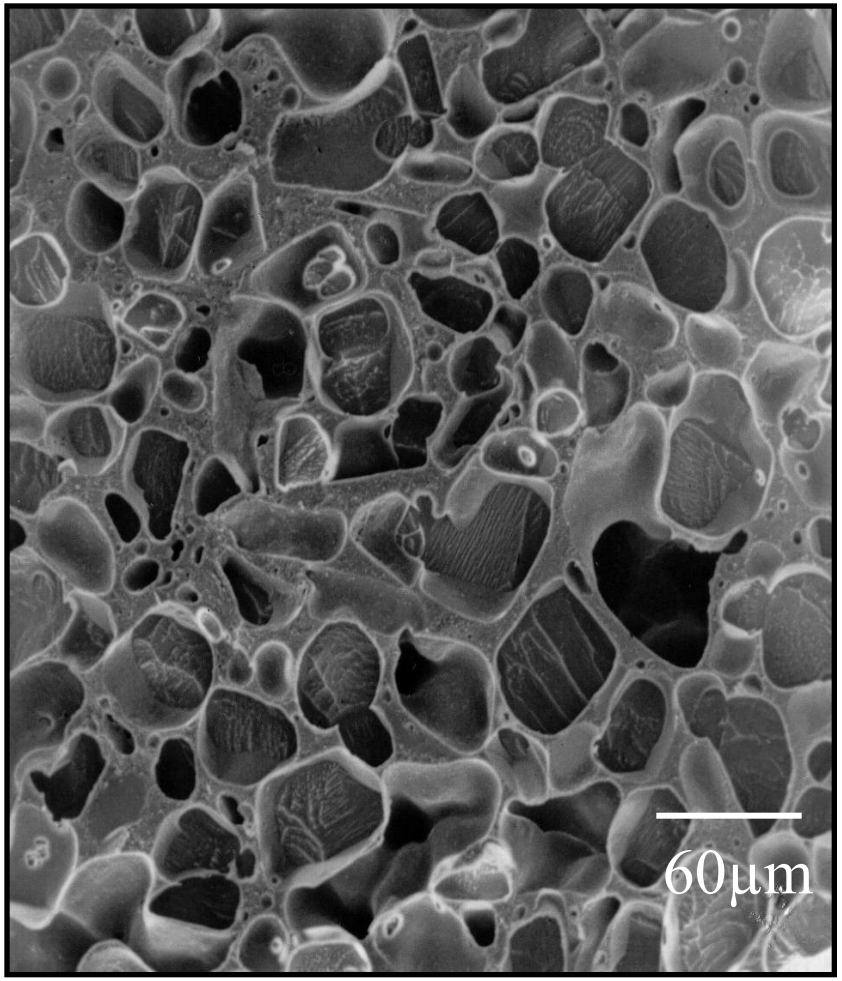
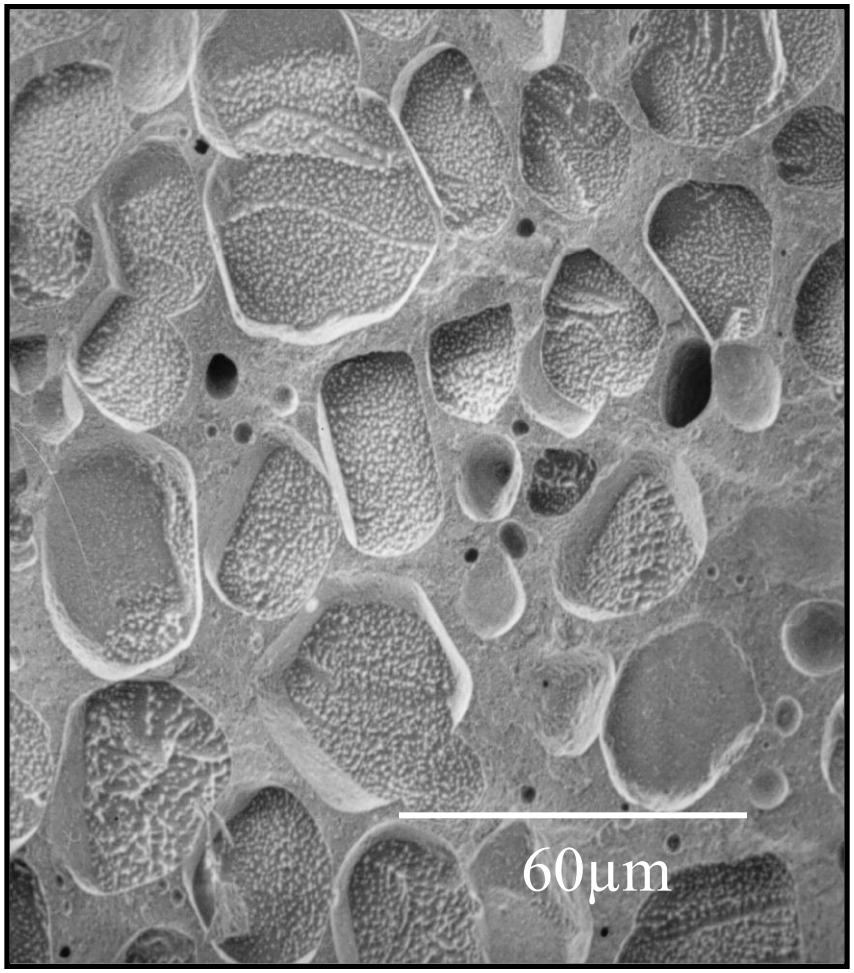
Food Freezing: conversion of water to ice

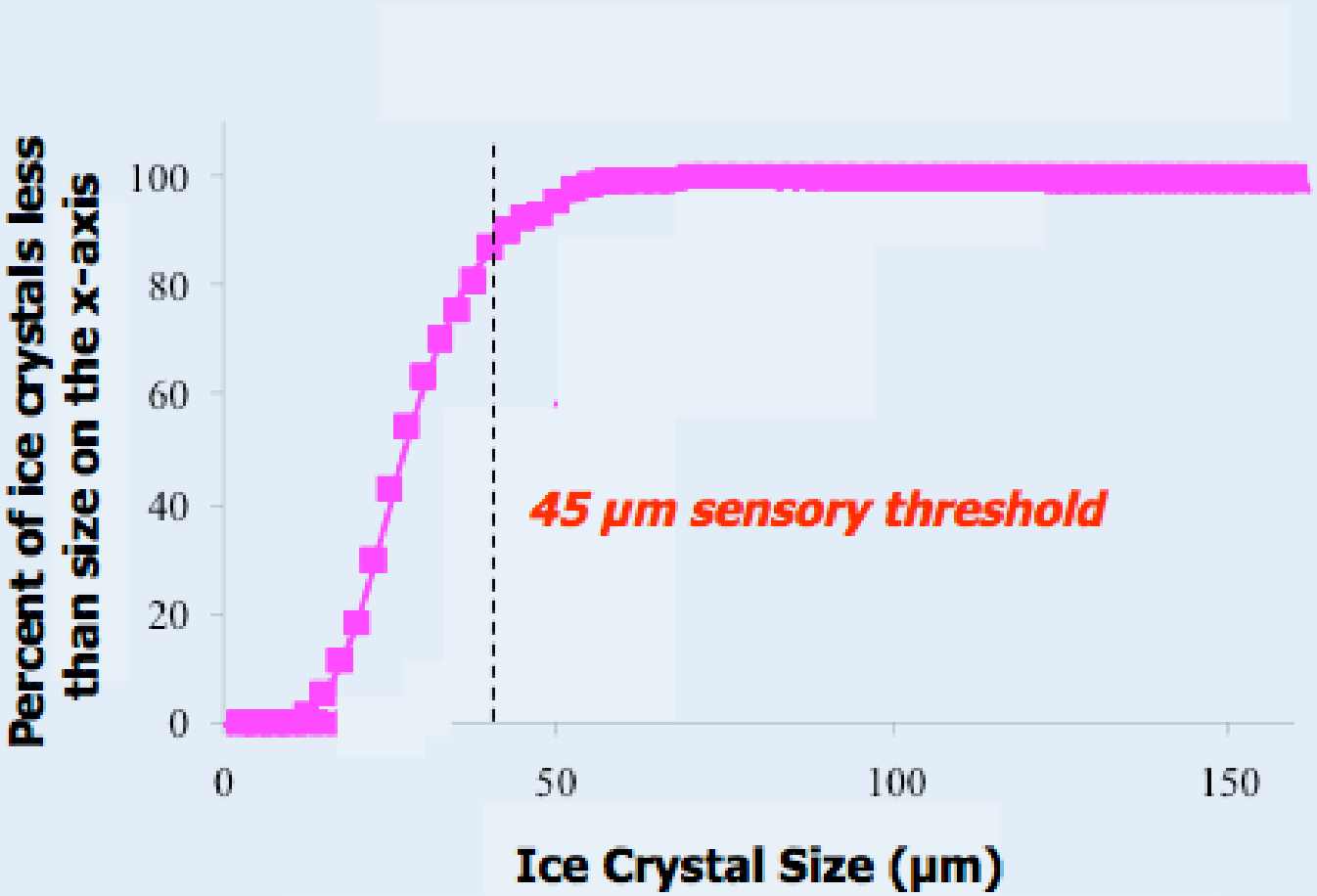
- Initial ice crystal size distribution is controlled by freezing and hardening equipment
  - Small crystals: smooth texture
- Freeze-concentration of the sugars - controls ice content/hardness
  - More sugar: softer ice cream
- Ice Recrystallization and Heat shock
  - Controlled by adding stabilizers and minimizing temperature fluctuations

Ice crystals in freshly hardened ice cream





Ice crystal size cumulative distribution in fresh ice cream



Food Freezing: conversion of water to ice

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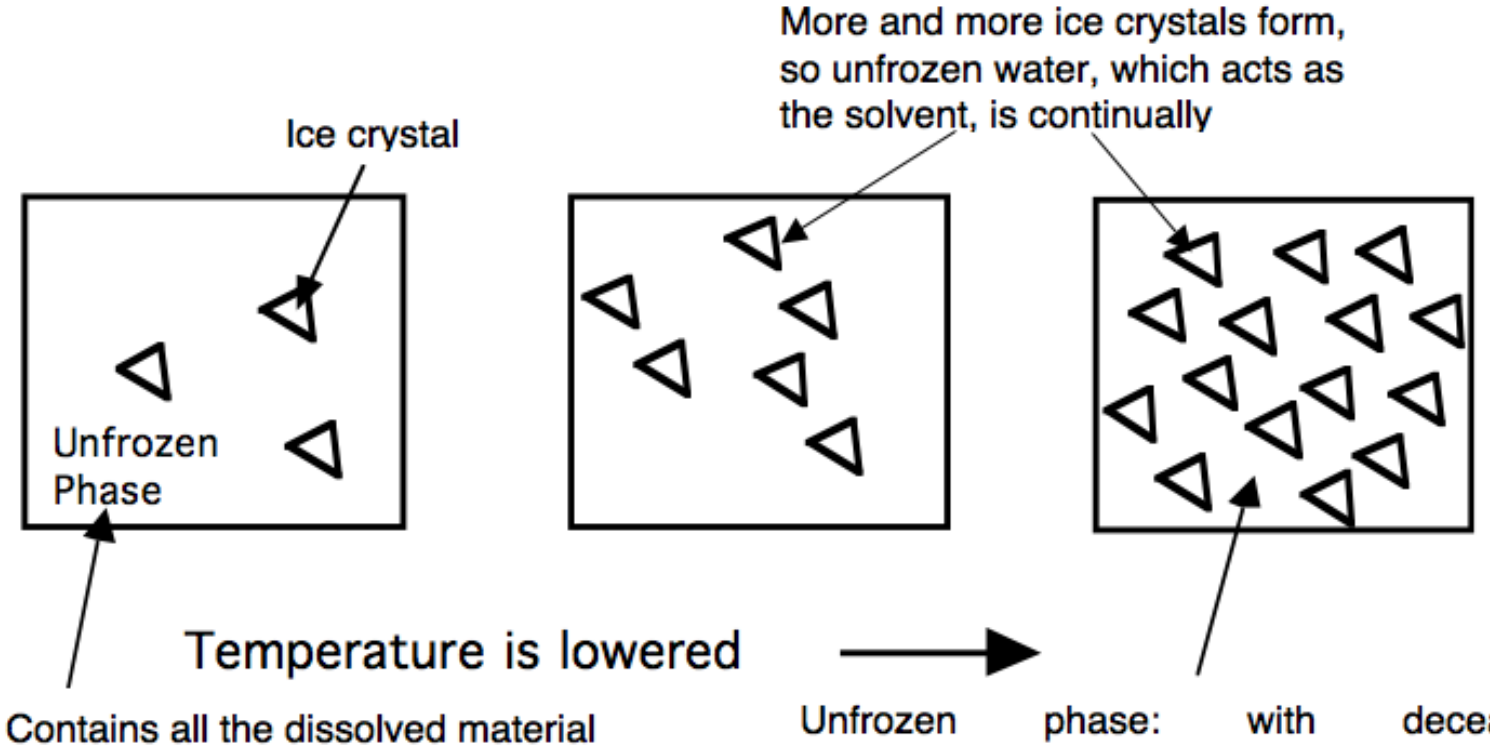
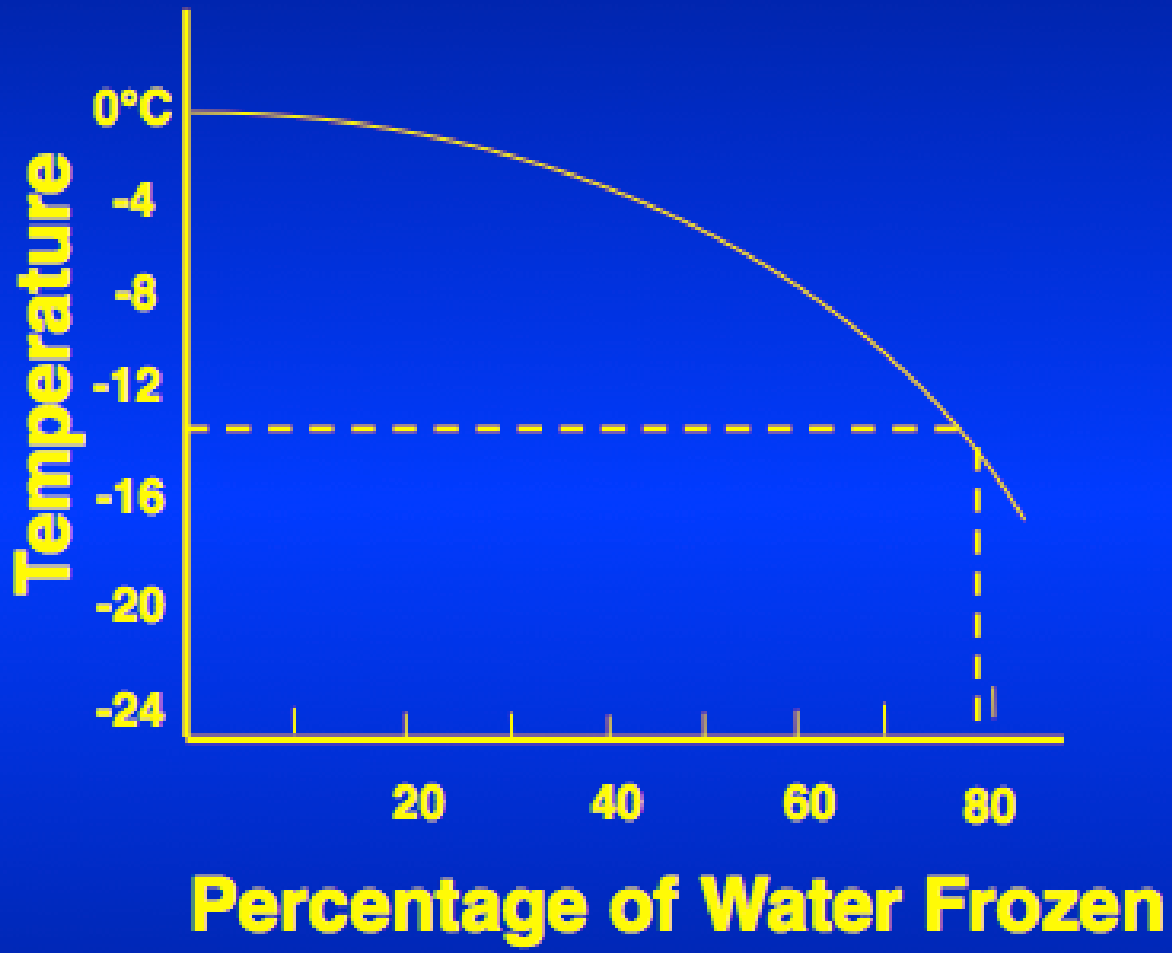
Freeze-concentration of the sugars establishes the ice : unfrozen water ratio at any given temperature



The Freezing Curve



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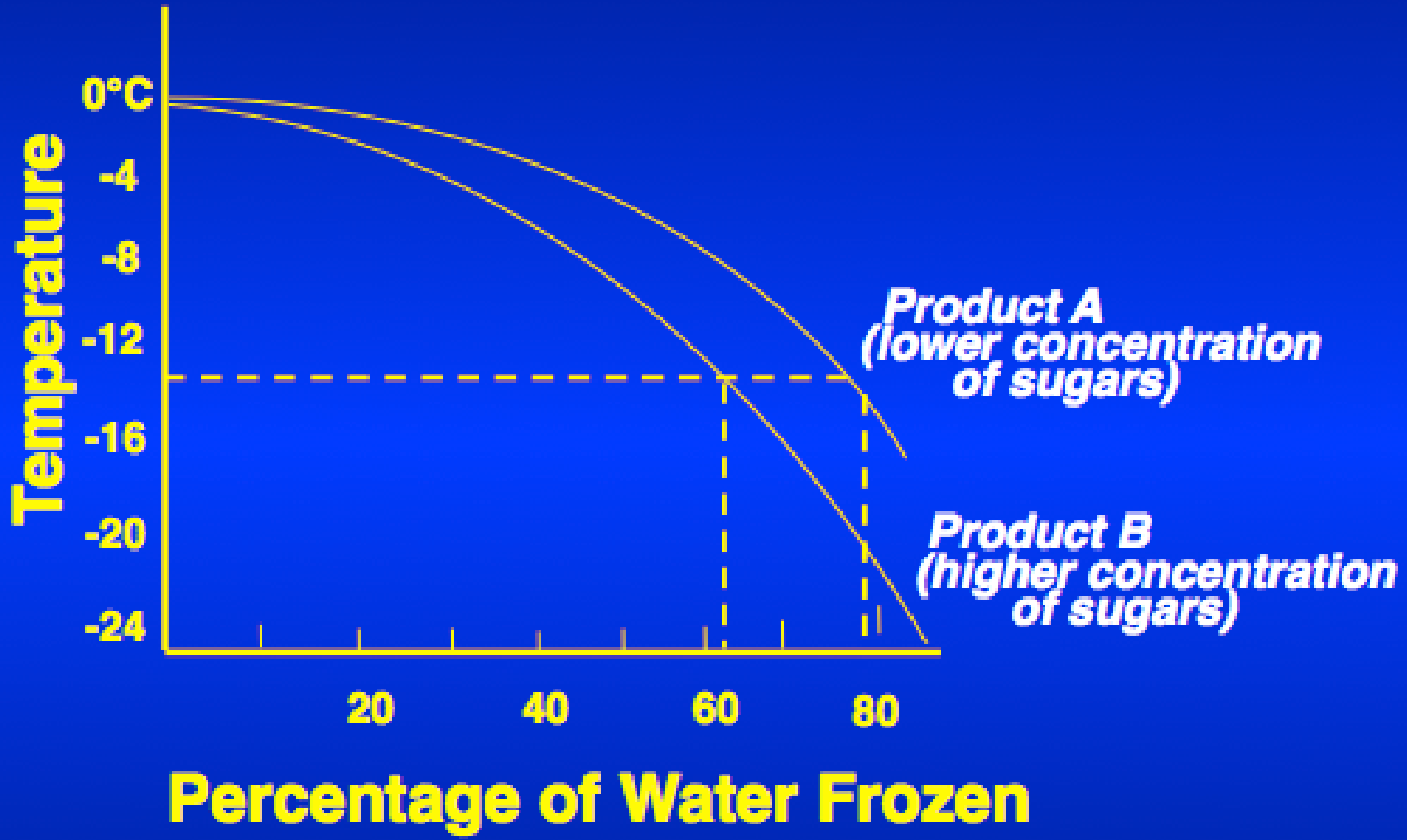
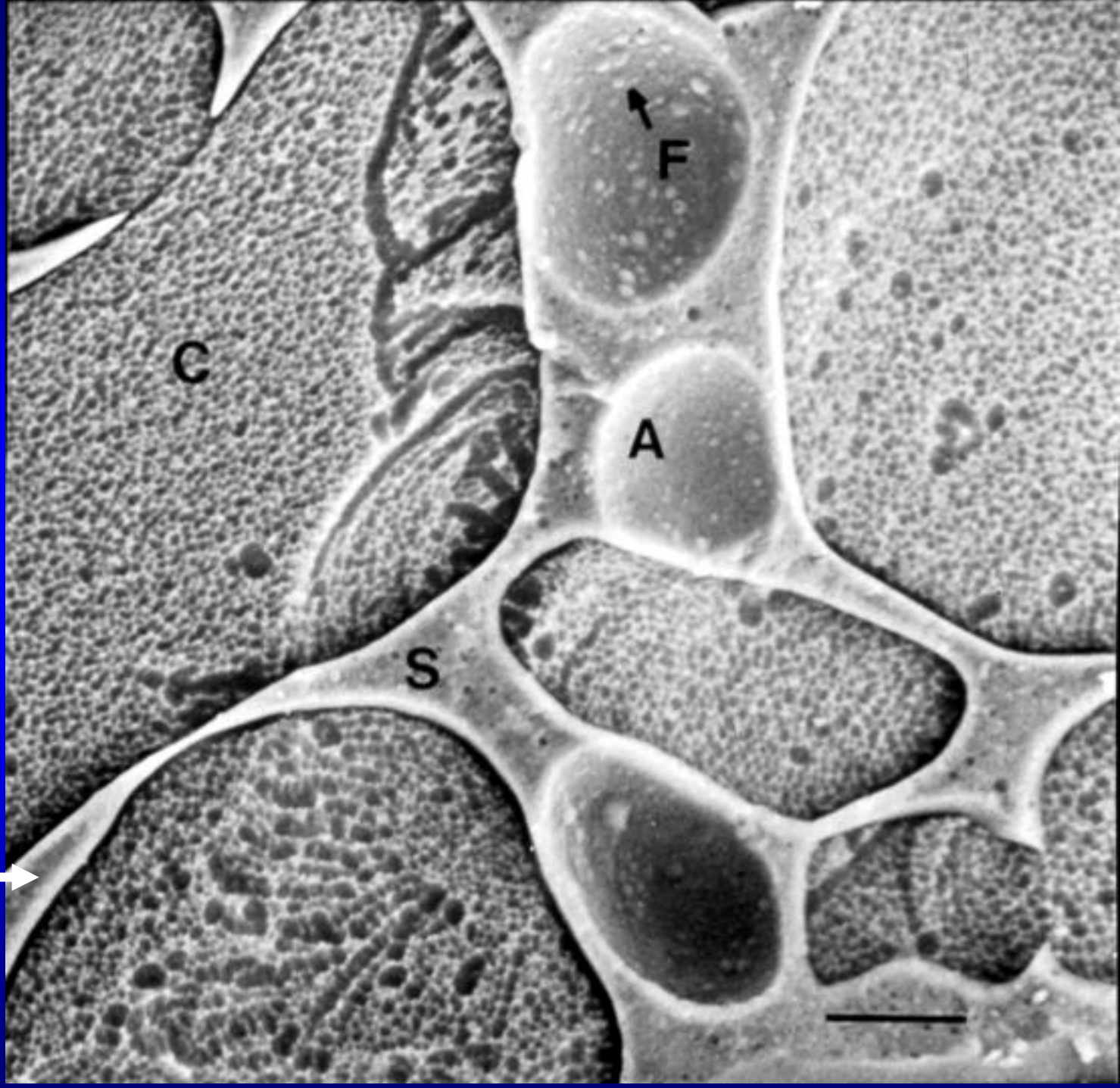


The unfrozen phase: expands and shrinks with temperature (equilibrium with the ice);



Hardening

- Goal: -25°C core temperature in 4 hours or less
- Need specialized equipment

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MASTER ICE

Freezer specifically for the workshop, with static-RS or ventilated refrigeration-RV, for storage (static refrigeration version) and for hardening and storage (ventilated refrigeration version) of ice cream and frozen dessert products.

More information

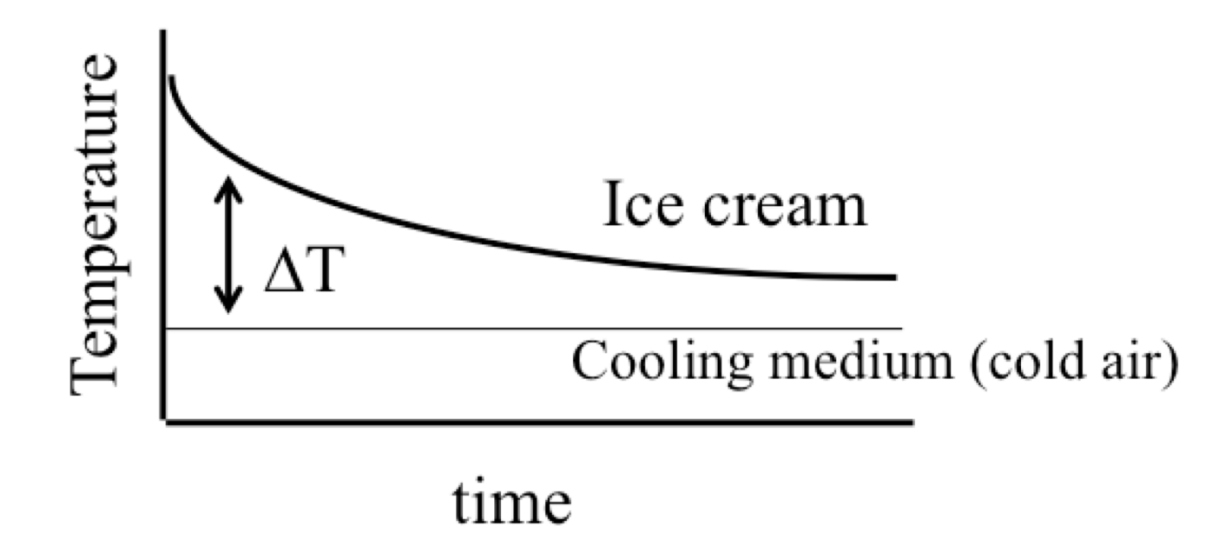
Rate of Heat Transfer =

Heat Transfer co-efficient x area x temperature difference

$$Q = U \quad A \quad \Delta T$$

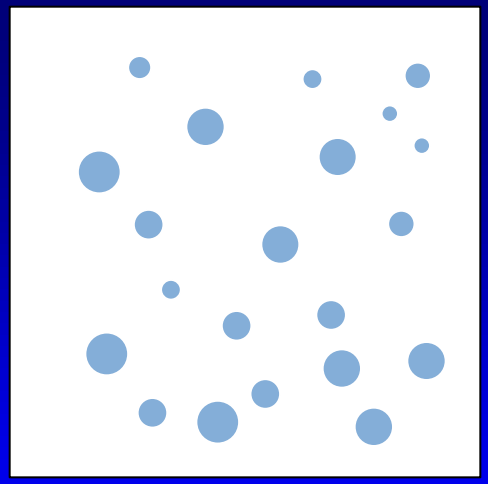
Factors affecting hardening

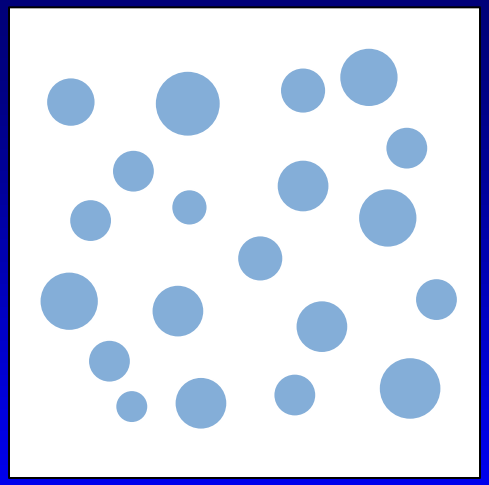
- **Temperature of hardening freezer - the colder the temperature, the faster the hardening, the smoother the product. Maintain high ΔT.**



Factors affecting hardening

- **Temperature of hardening freezer - the colder the temperature, the faster the hardening, the smoother the product. Maintain high ΔT.**
- **Circulation of air - increases convective heat transfer.**
- **Temperature of ice cream when placed in the hardening freezer - the colder the ice cream at draw , the faster the hardening; - must get through packaging fast.**
- **Size of container**
- **Composition of ice cream - related to freezing pt. depression.**
- **Method of stacking containers to allow air circulation - no 'dead air' spaces (round vs. square packages).**



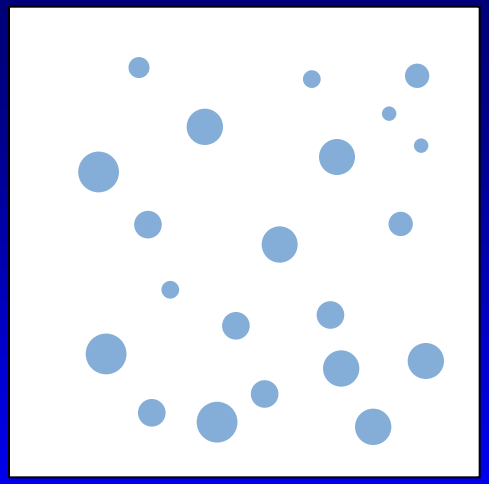


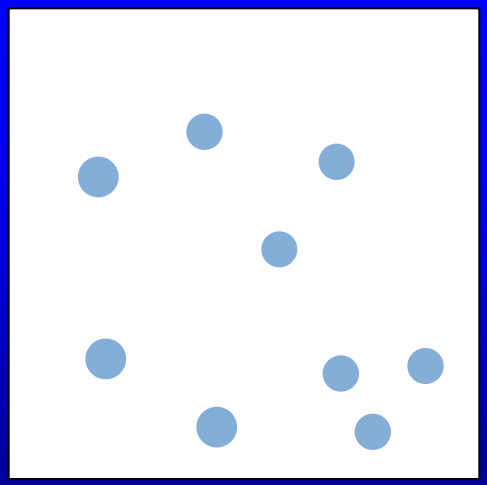
Ice crystals after draw at -5° C

- **Crystals are small and numerous**

Ice crystals after rapid hardening to -25° C

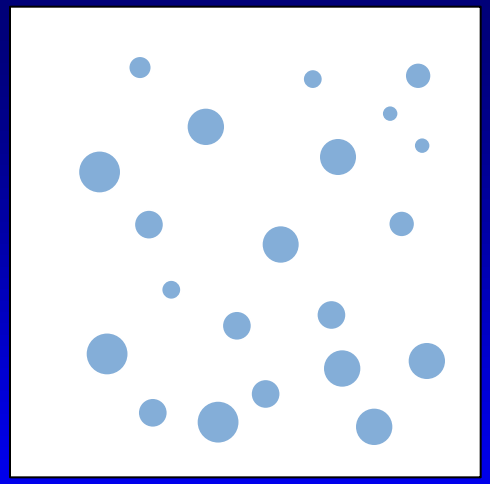
- **No further nucleation**
- **Crystal size increases**
- **Crystal numbers preserved**

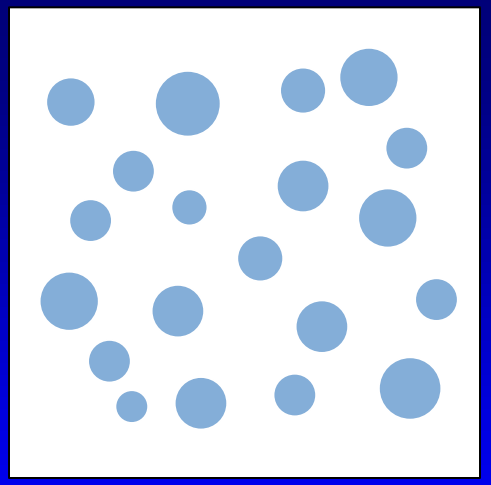




Ice cream warms up before hardening

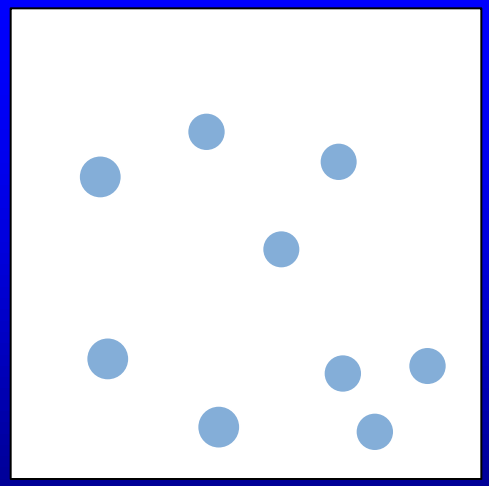
- **Smallest crystals melt**

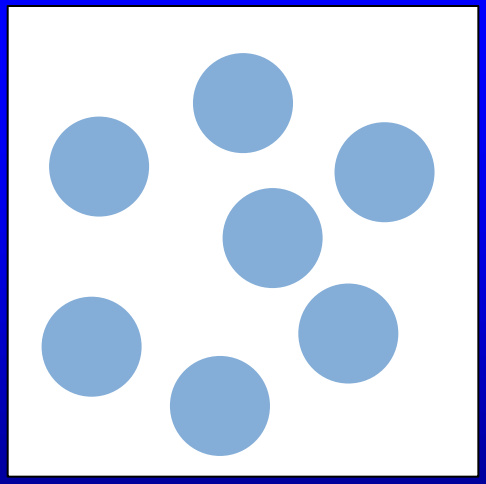




(heat shock)

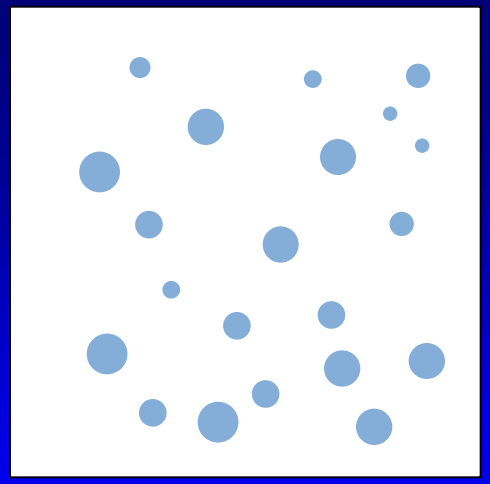
(same ice phase volume)

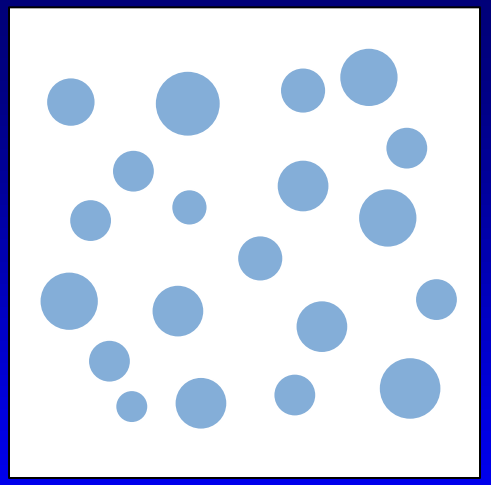




Hardening to -25° C

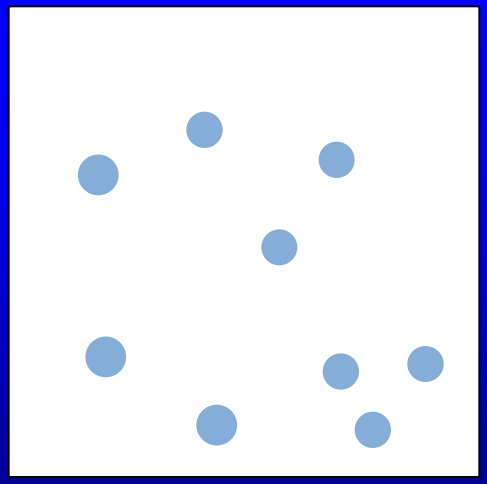
- No further nucleation
- Crystal size increases to larger size than above
- Crystal numbers reduced

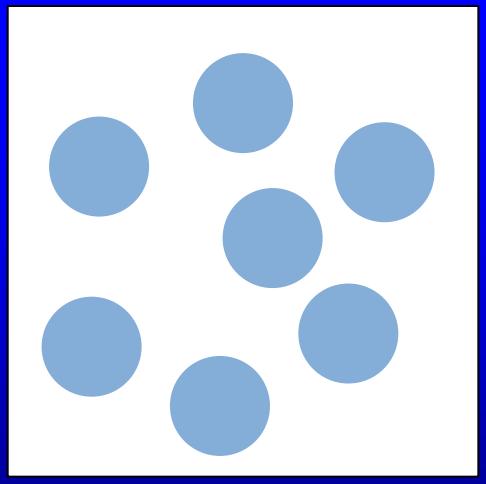




Slow Hardening to -25° C

- Recrystallization during hardening
- Crystal size increases to larger sizes than above
- Crystal numbers reduced

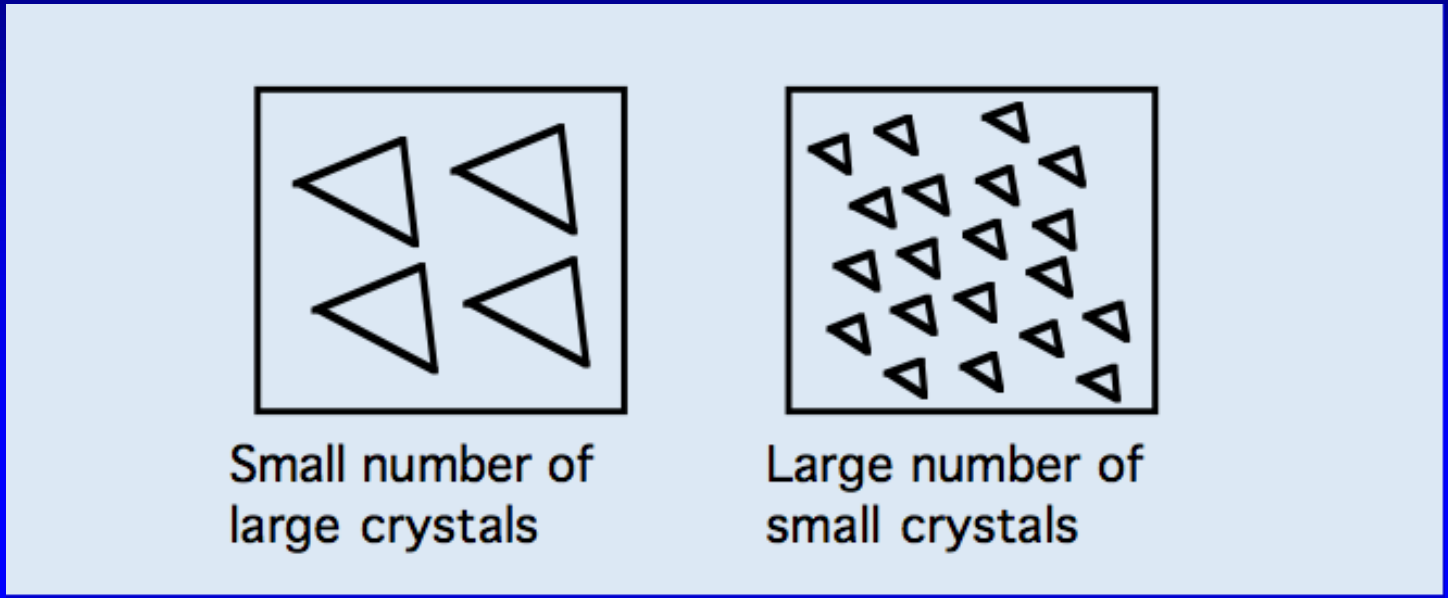




Food Freezing: conversion of water to ice

- Initial ice crystal size distribution is controlled by freezing and hardening equipment
  - Small crystals: smooth texture
- Freeze-concentration of the sugars - controls ice content/hardness
  - More sugar: softer ice cream
- Ice Recrystallization and Heat shock
  - Controlled by adding stabilizers and minimizing temperature fluctuations

Recrystallization of ice in ice cream

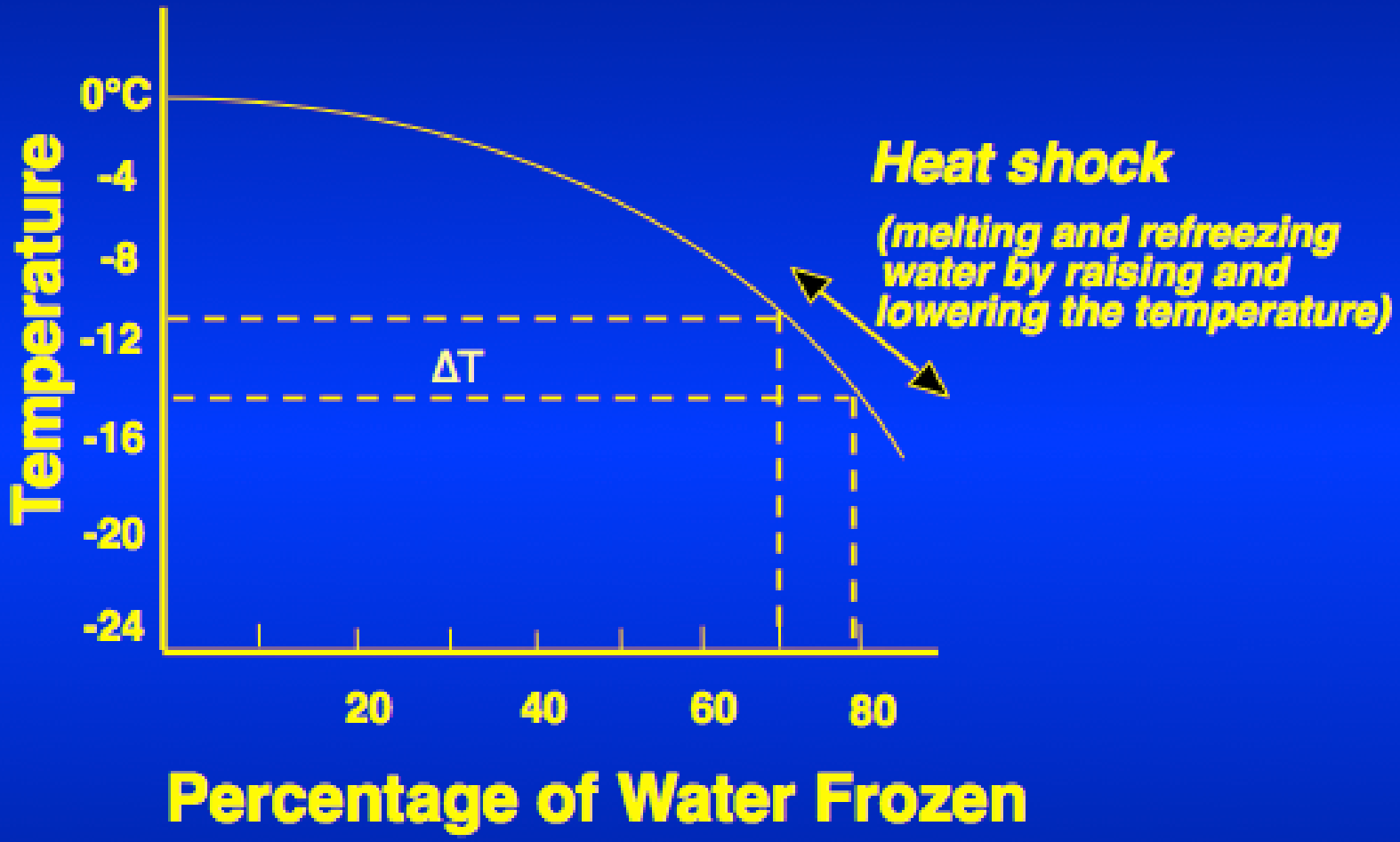


Moving towards a more stable state, never goes in reverse!

Change is slow at low temperature but speeds up dramatically at higher temperatures.

Change is slow at constant temperature but speeds up dramatically with temperature fluctuations.

The Freezing Curve



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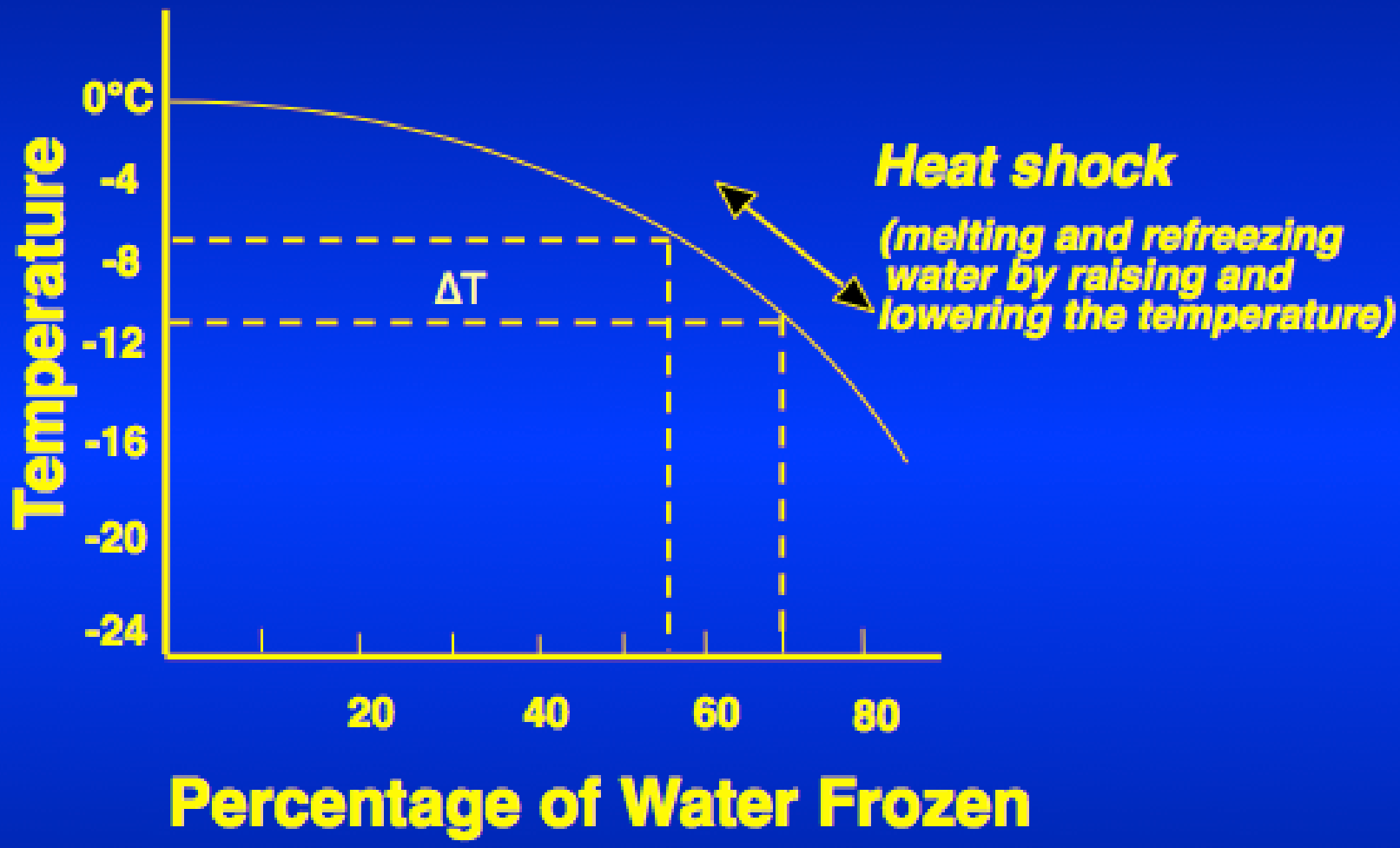
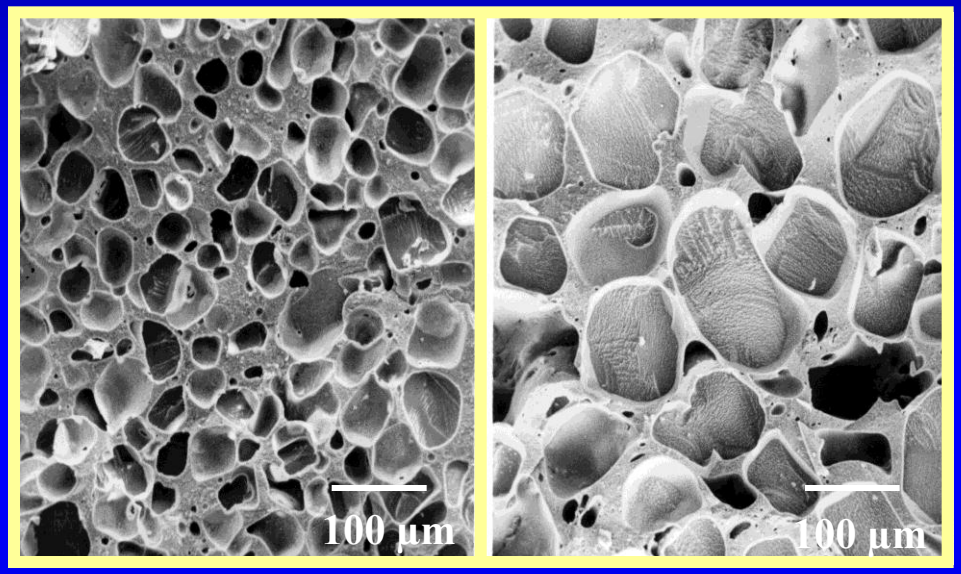
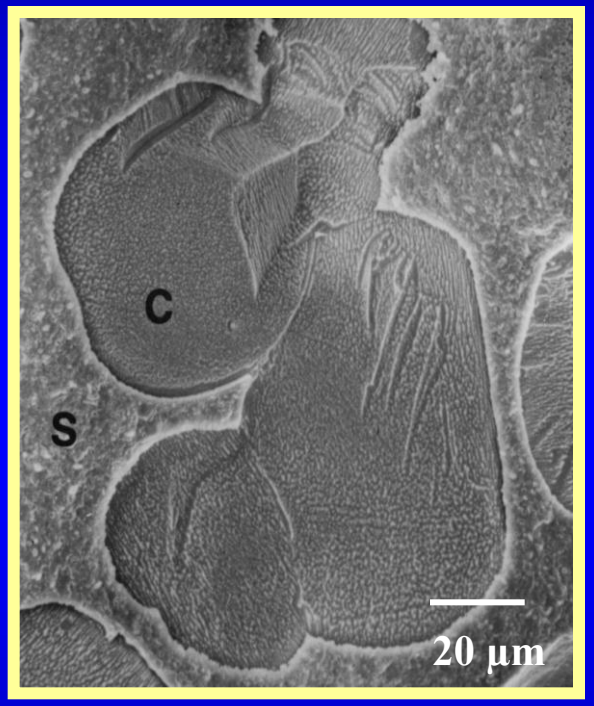


Ice cream: the effects of heat shock



Before *After*

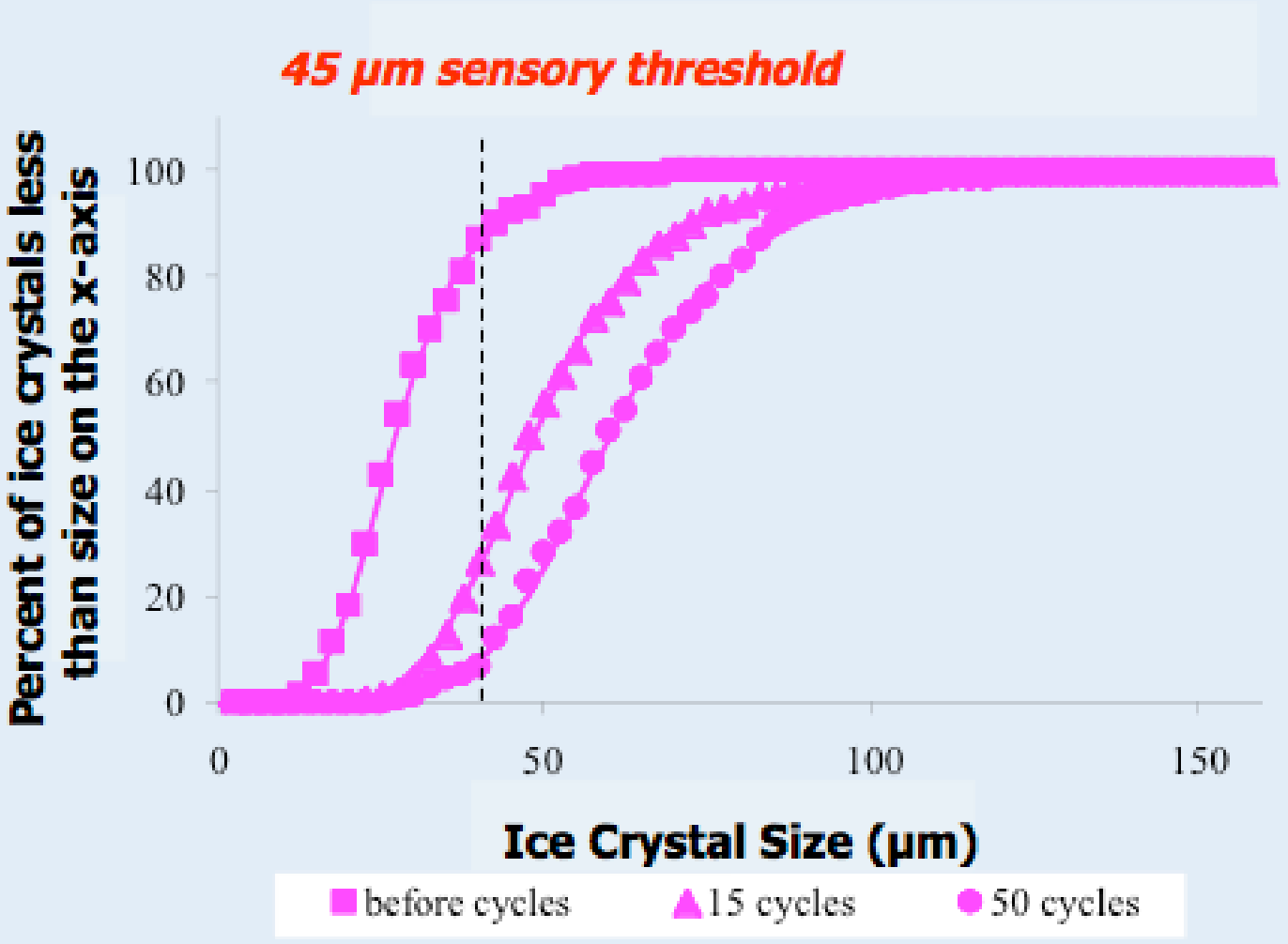
Recrystallization



Accretion

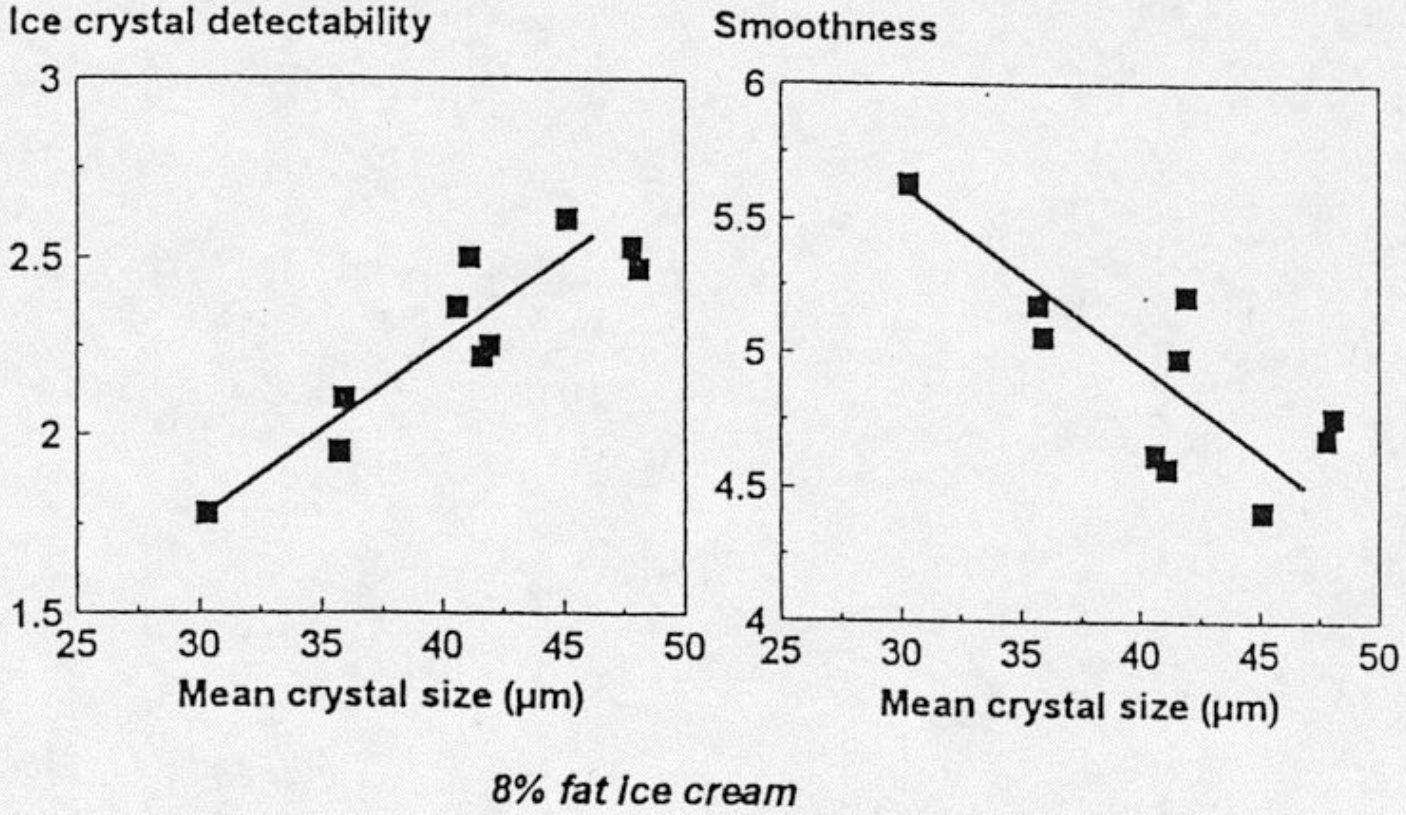
Caldwell and Goff, 1992

Ice crystal size cumulative distribution in fresh and stored ice cream



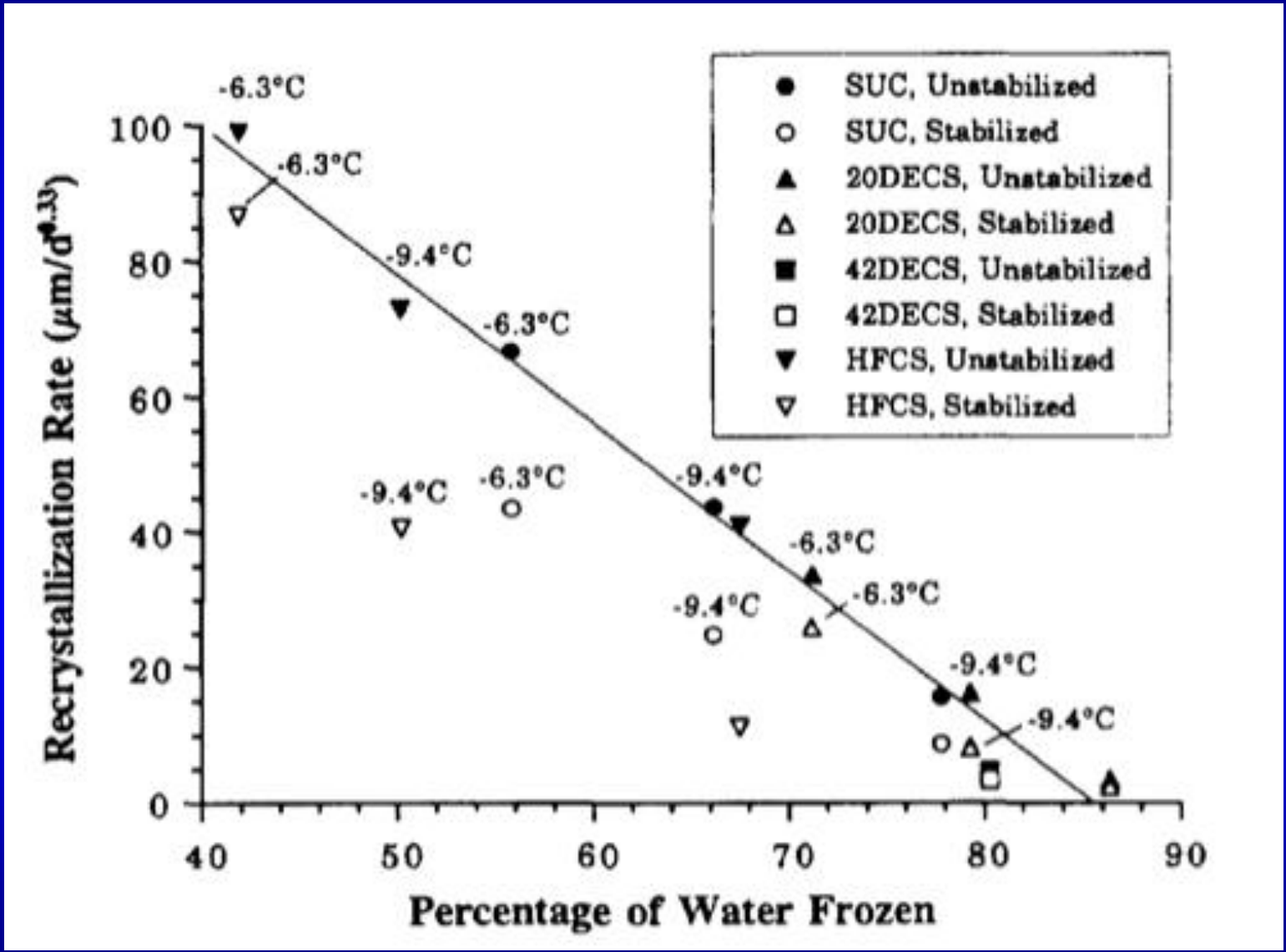
-10°C/12 hrs; -20°C, 12 hrs

Sensory quality depends on ice crystal size



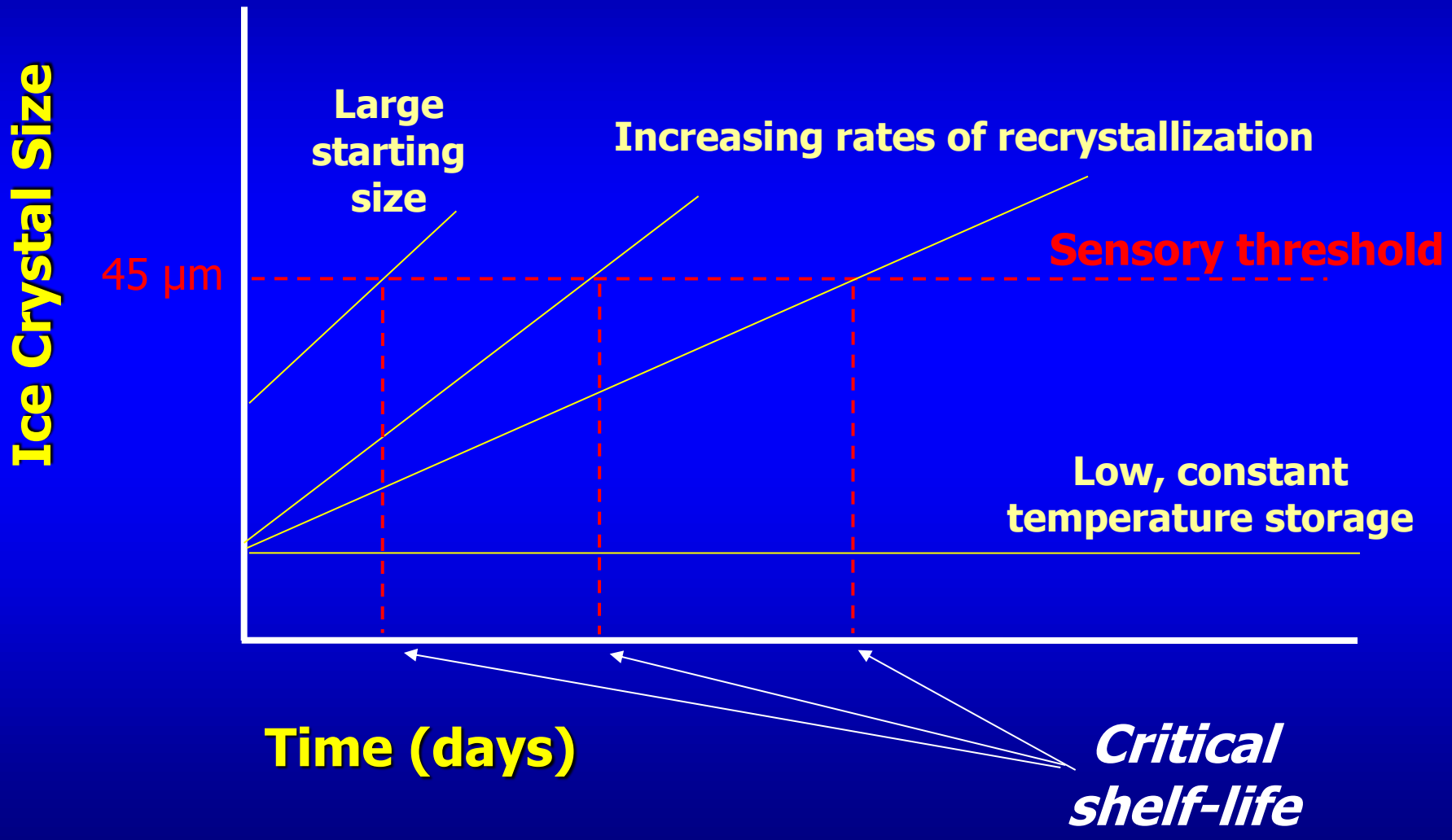
Adapted from Russell et al., J. Food Eng., 39: 179-191 (1999).

Recrystallization rate depends on storage temperature, freeze-concentration and stabilizers!

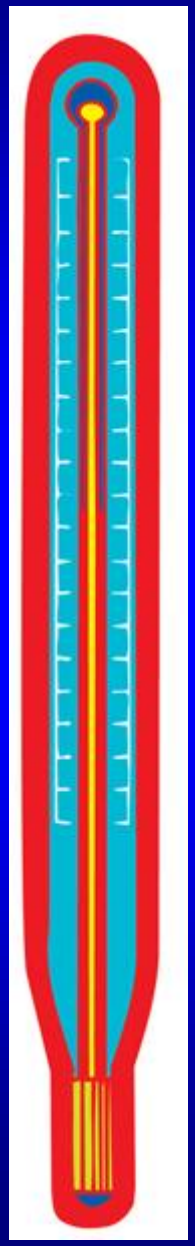


Hagiwara and Hartel, 1996

Ice Cream Shelf-Life



Ice Cream Shelf-Life



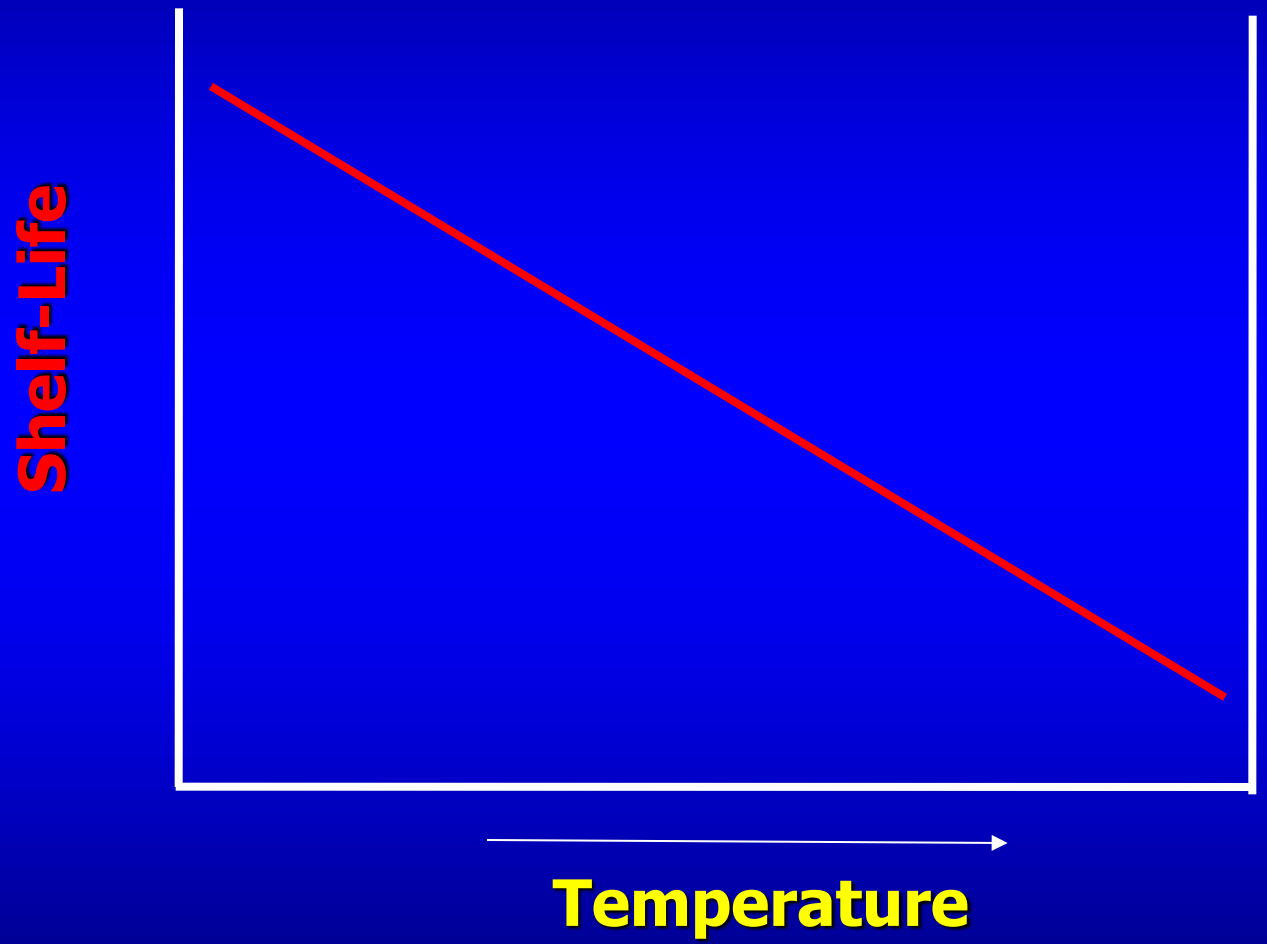
-10° C	hours
-15° C	1-2 days
-20° C	1-2 weeks
-25° C	Several weeks
-30° C	Several months

But, depends also on freeze-concentration (sugars), stabilizers, initial starting size of crystals (manufacturing conditions), and temperature fluctuations.

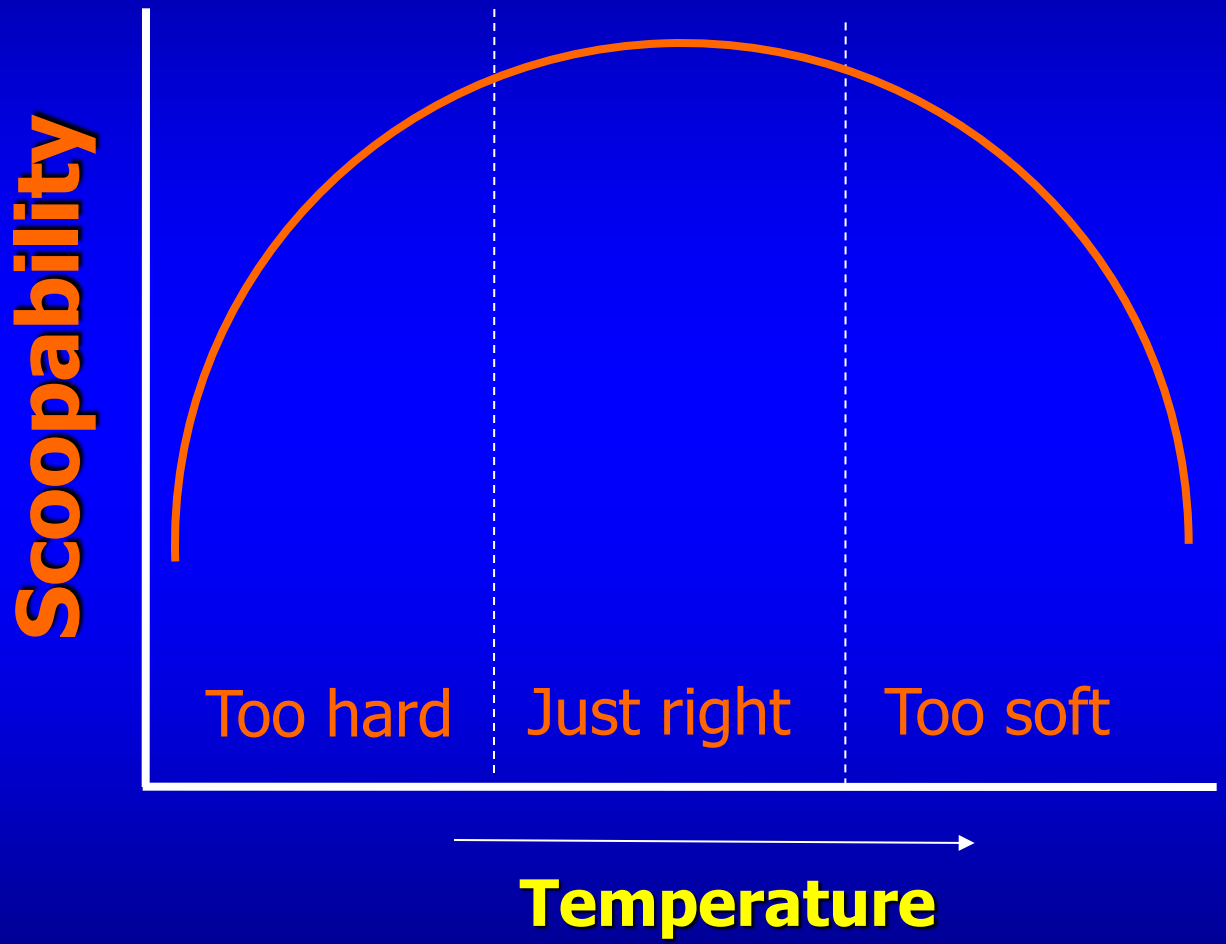
Summary: Freezing concepts

- Fast freezing = small crystals; small crystals = smooth texture
- Solutes freeze-concentrate, dictates ice phase volume as a function of temperature (freezing curve); ice phase volume affects firmness, scoopability
- Solutes in unfrozen phase can go through a glass transition; storage at T<Tg = long term stability
- At T>Tg, small ice crystals are unstable and recrystallize; recrystallization causes coarsening of texture, loss of smoothness, limits shelf life

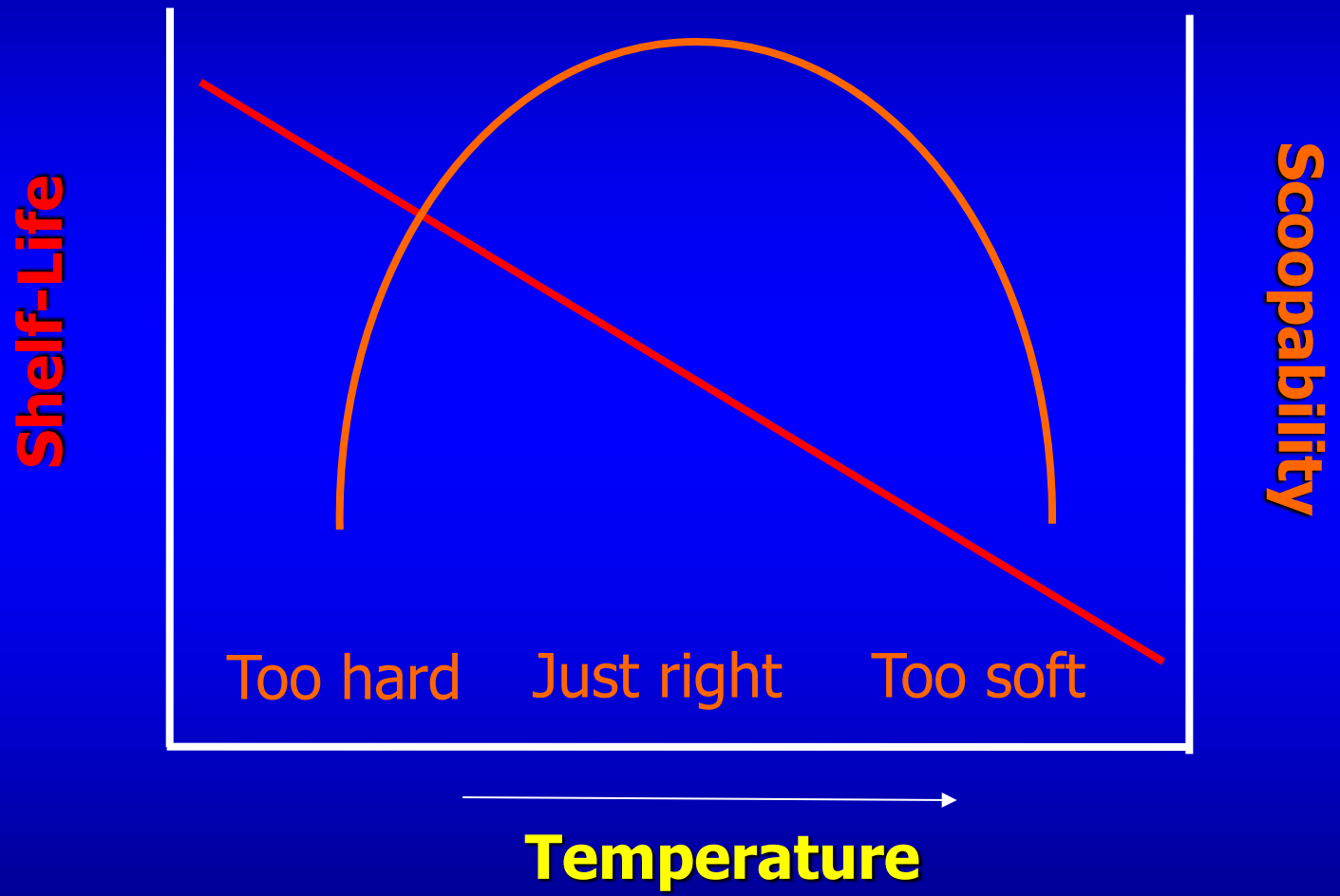
What is the optimum cabinet temperature ?



What is the optimum scooping temperature ?

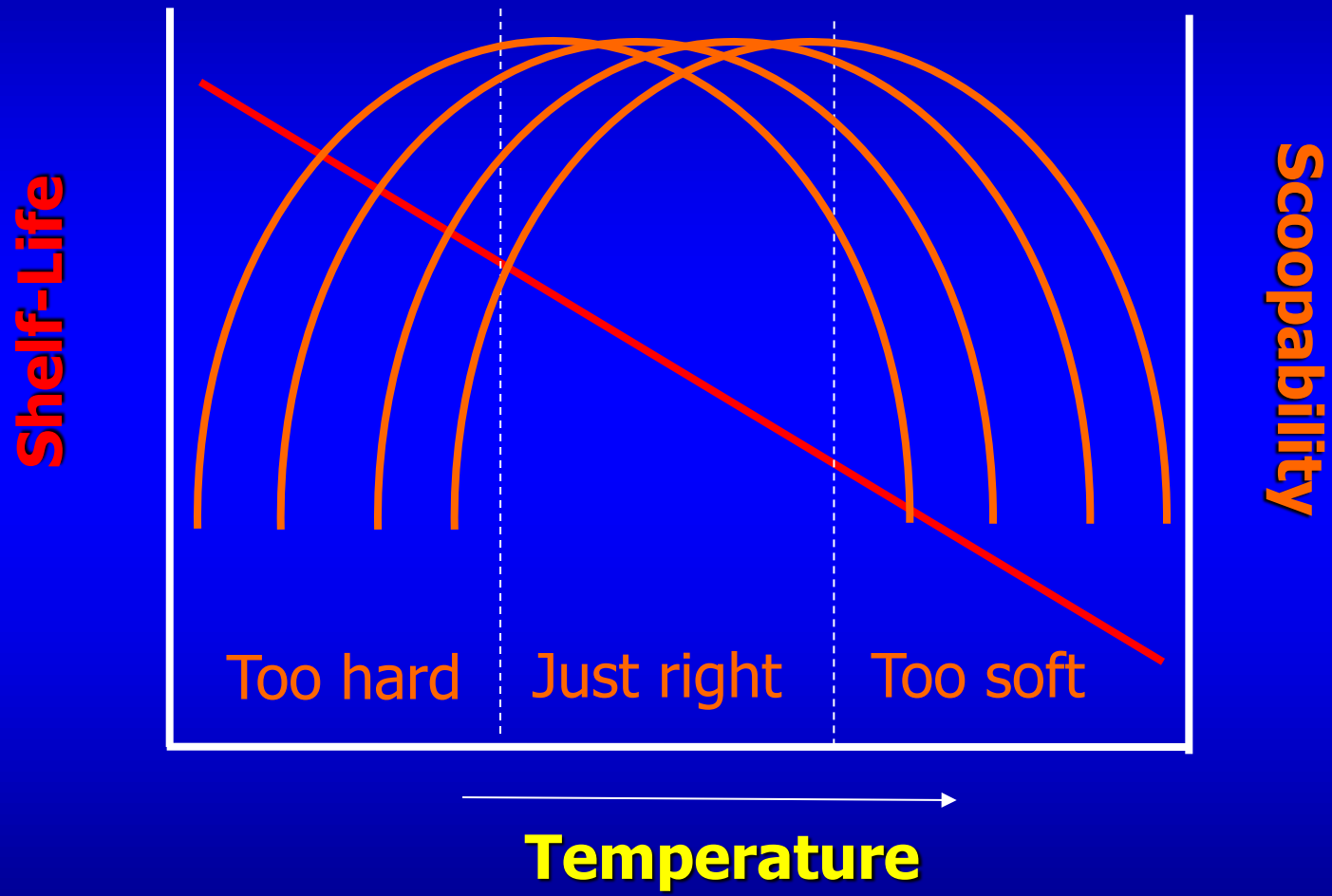


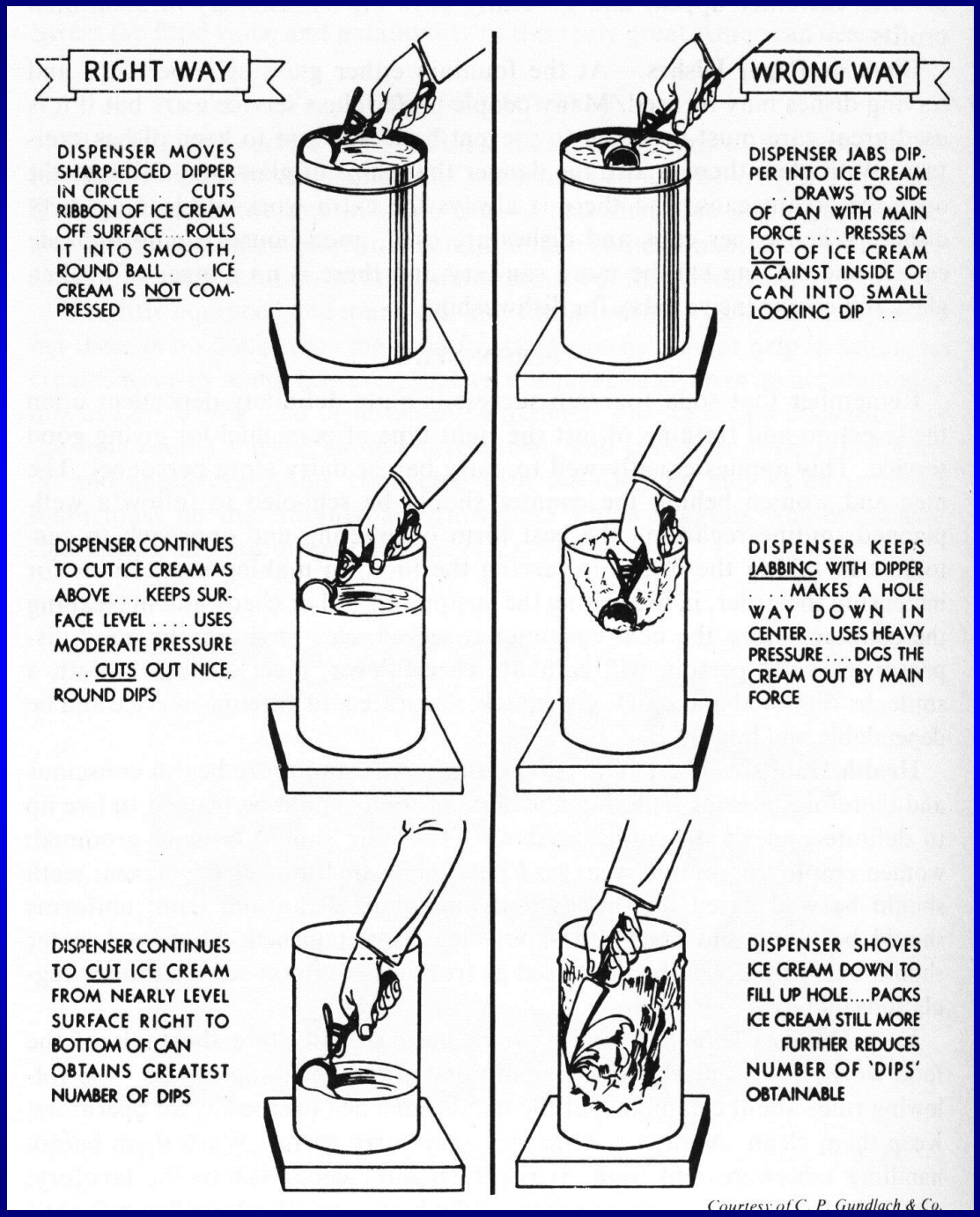
Optimum scooping temperature leads to short shelf-life !



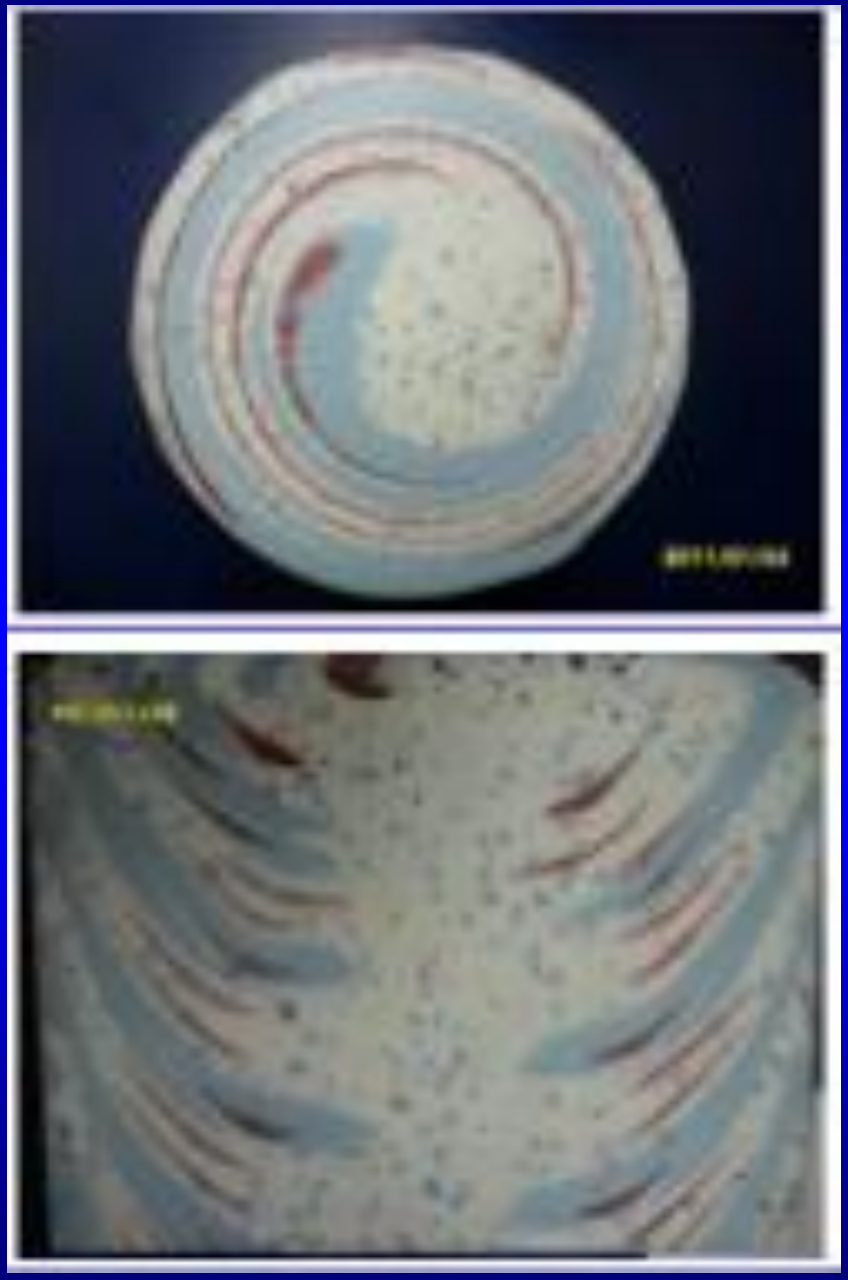
Optimum scooping temperature leads to short shelf-life !

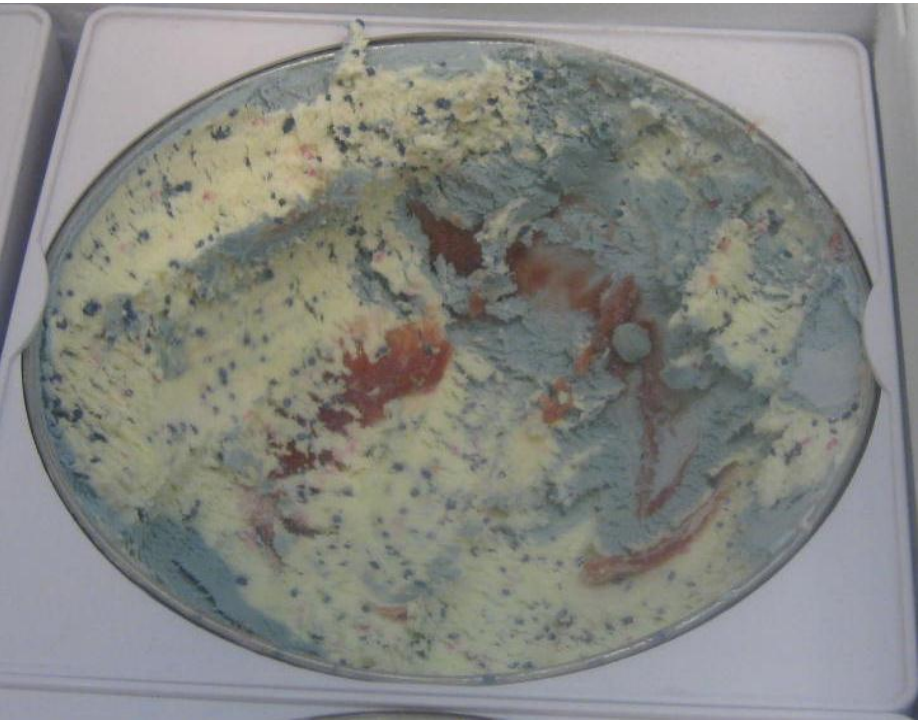
Products with differing levels of freezing point depression





Marshall, Goff and Hartel, 2003





What does it take to make good ice cream?

- Good quality ingredients and balanced formulations
- Desirable flavours
- Rapid freezing and hardening
- Good control of cold-chain

What can go wrong?

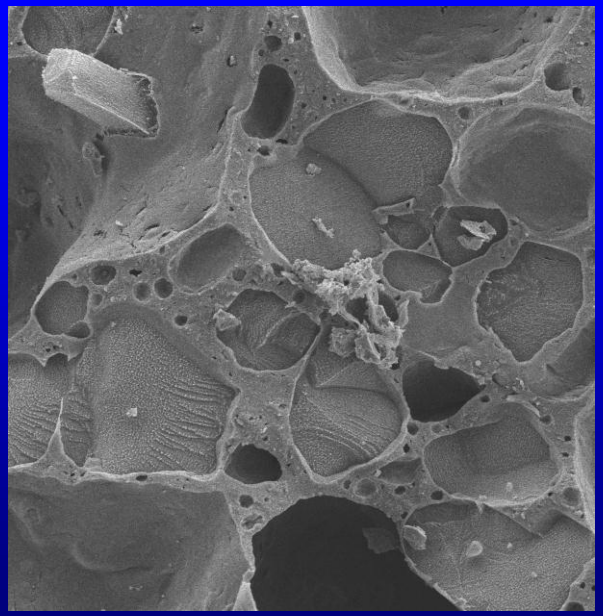
- Coarse/icy textures
- Sandiness
- Shrinkage
- Flavour issues: oxidation, rancidity

Lactose:

- Milk sugar
- Not very soluble
- Can crystallize in ice cream
  - Crystals are hard and dissolve slowly
  - 16 µm detection threshold

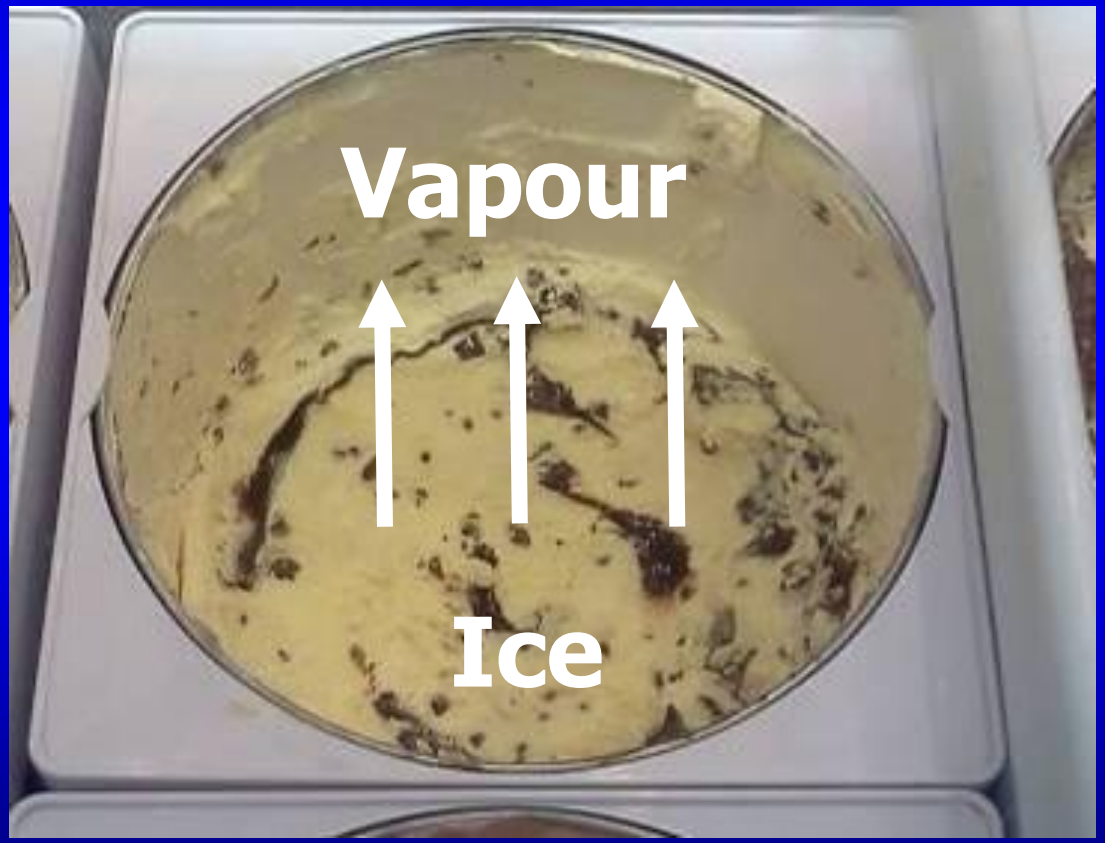
Sandiness

- **Sandy Texture:**
  - **lactose crystals that do not dissolve readily and produce a rough or gritty sensation in the mouth.**
  - **can be distinguished from "iciness" because the lactose crystals do not melt in your mouth.**
  - **usually prevented from crystallizing by stabilizers and low temperature.**



Shrinkage

Surface sublimation and formation of dry, gummy, discoloured layers

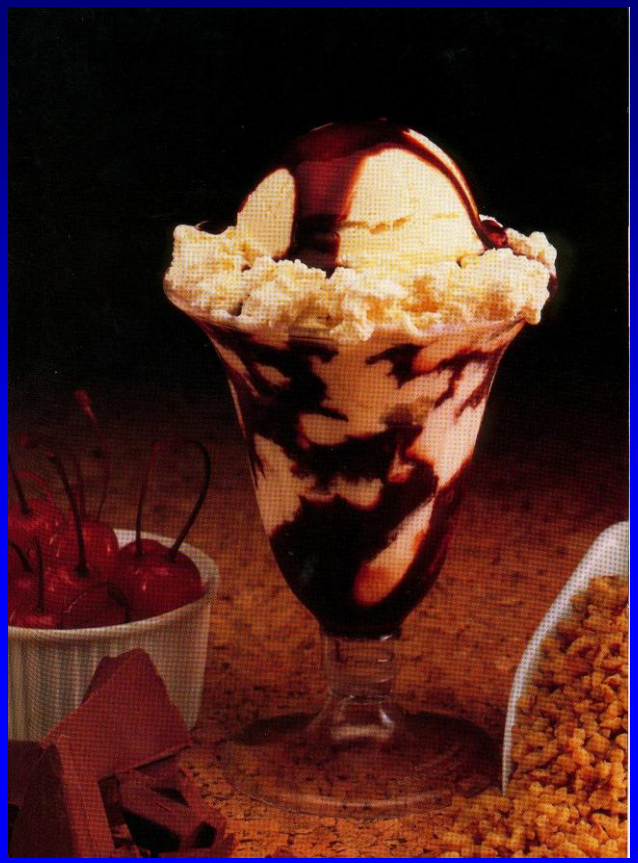


Prevention:

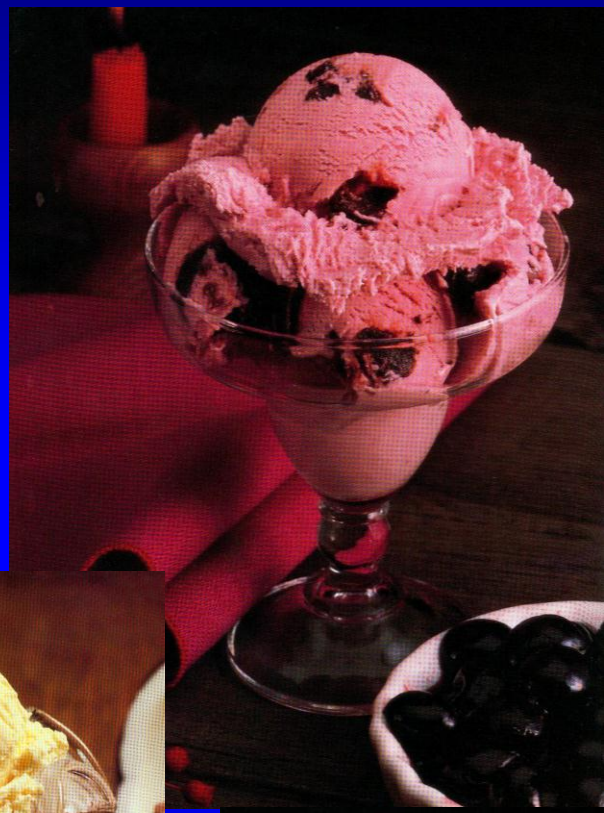
-Minimize headspace (cutting tubs?, surface covers)

-Stabilizers

-Low temperature storage



Quality is the goal!



Outline

- Ice cream recipe development for batch-freezer operations
  - Should I make my own mix?
- Optimal storage conditions for maximal shelf-life in scooping operations
- Open discussion