Cold Preservation Technology

Quality of Frozen Foods

Freezing rate and quality

- Controlling the freezing process, including careful pre-freezing preparation and post freezing storage of the product, is an important aspect of achieving a high-quality product.
- An important factor in the quality of frozen foods is the freezing rate.
- Fast freezing produces better quality frozen food than
- slow freezing.
- The rate of freezing of plant tissue is important because it determines the size of the ice crystals, cell dehydration, and damage to the cell walls.
- Ice crystal structure is crucial for the preservation of the quality of frozen products.

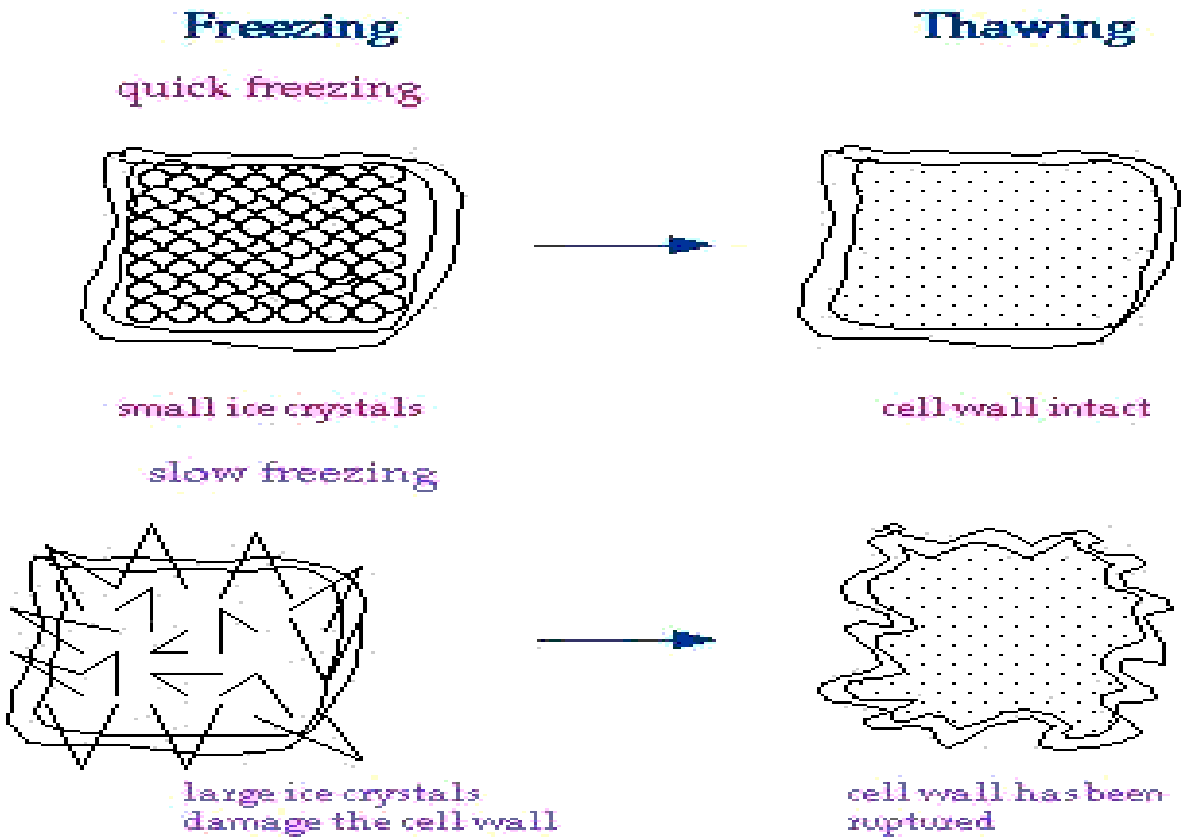
- In the case of animal tissue, the concentration of salt within the cells is higher than that in the extracellular region.
- Consequently, freezing will start outside the cells due to the freezing point depression induced by the solute concentration in the cells.
- As soon as ice appears, the solute concentration rises.
- This is a characteristic phenomenon of freeze concentration. At some point, osmotic pressure difference causes water to flow through the semipermeable cells to the extracellular region to balance the chemical potentials.
- This dehydration of the cell is accompanied by shrinkage of the cell, which is not normally lethal.

- The freezing rate affects this process because rapid freezing results in less cell dehydration (since water has less time to diffuse out of the cell), less breakage of cell walls, and less textural damage.
- The more rapid the crystallization, the smaller the ice crystals, and the lesser the damage caused by the process of freeze concentration.

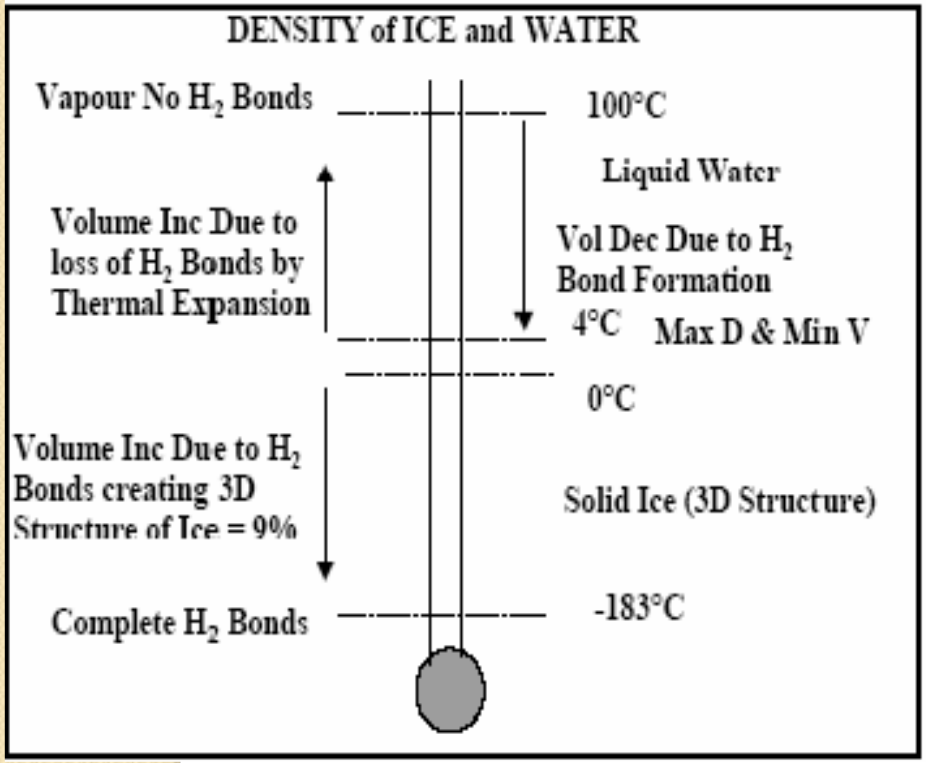
In the case of plant tissue;

- Large ice crystals can cause mechanical damage to cell walls in addition to cell dehydration.

Rapid freezing versus slow freezing

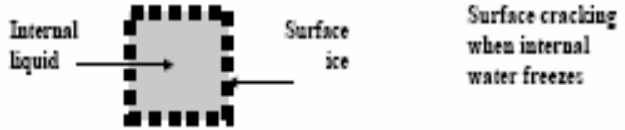


Physical effects of freezing



PHYSICAL EFFECTS OF FREEZING
(continued)

3. Recrystallisation (crystals grow during freezing)
   - slow freezing
   - greater during storage
4. Temp gradients



5. Fast freezing rate can damage small pieces

Microbiology of Frozen Foods

- Growth of microorganisms is temperature dependent.
- •No pathogens can grow around ≈5ºC.
- •No microorganisms growth < -5º.

- Freezing cannot kill pathogens if food is already contaminated !!!!!!!!!!!!

However:

- Some microorganisms are killed
- Some are injured
- Some are OK

Microbiology of Frozen Foods

- During freezing and storage no problem

After thawing

- controlled (no problem)
- uncontrolled (food safety issues)

NUMBER OF BUGS SURVIVING FREEZING DEPENDS ON

- 1.Number of bugs
- 2.Type of bug
- 3.Storage temperature
- 4.Method of measurement
- 5.Temperature fluctuations→decrease

Microbiology of Frozen Foods

SUMMARY

Need to:

- •control initial load
- •freeze rapidly
- •store at -18°C (constant)
- •thaw rapidly (low temperature)
- •use immediately, or
  - *store≈5°C
  - *cook

Freezing of Foods

- Pre-freezing
- Freezing
- Storage
- Thawing

- Fruits and Vegetables
- •Frozen fruits
- •Poultry and meats
- •Seafood
- •Dairy
- •Bakery
- •Prepared foods

Pre-freezing foods for fruits and vegetables

- Need to control enzymatic reaction
- Chemical or heat
- Fruits
  - –Ascorbic acid
  - –Sulfur dioxide
  - –Citric acid
- Osmoconcentration of fruits
  - –Add sucrose or sugar-syrup
- Vegetables
  - –Blanching

Pretreatments for freezing

Blanching

- Most vegetables and some fruits are blanched before freezing.

Blanching:

- the permeability of cell membranes,
- destroys cell turgor,
- removes intercellular air,
- filling these spaces with water, and
- establishes a continuous liquid phase.

Blanching has also other advantages, such as:

*destruction of microorganisms, and

*wilting of leafy vegetables assisting packaging

**Properly blanched vegetables have a long shelf life at frozen food temperatures.

Blanching

- Blanching of fruits may be detrimental in many cases, resulting in (a) rapid discoloration by enzymatic browning,

  (b) loss of texture,

  (c) formation of cooked taste,

  (d) some loss of soluble solids, especially in water blanching, and

  (e) adverse environmental impact due to energy requirements and disposal of used water.

- After blanching process, vegetables should be cooled, rapidly.
- Excess water should be drained after cooling.
- Most frozen vegetables (except corn) are cooked directly without thawing.
- Cooking time for frozen vegetables is shorter than the fresh vegetables. They are half cooked due to the boiling done before freezing.

Mainly frozen vegetables

- Spinach,
- chard,
- cabbage,
- cauliflower,
- beans,
- carrots, peas, broccoli, potatoes, okra, corn, asparagus, kidney beans
- peas,
- broccoli,
- potatoes,
- okra,
- corn,
- asparagus,
- kidney beans

Osmotic concentration

- Partial removal of water by osmotic treatment to freezing is recognized as convenient for reducing cellular damage of fruits and vegetables, which causes softness after thawing.

Sugar or sugar solution

- Many fruits are treated with sugar or sugar syrup and frozen for better texture and flavor.
- Some fruits can be frozen without sugar, but the loss of vitamin C is higher in these fruits.
- The amount of sugar to be added depends on the sweetness of the fruit and the taste preference of the consumer.
- Generally, 40% syrup is recommended for most fruits.
- Dilute syrups should be preferred for fruits with moderate flavor so that they do not mask the flavor.
- Intense syrups should be preferred for fruits with sour taste.

Pre-freezing of muscle foods

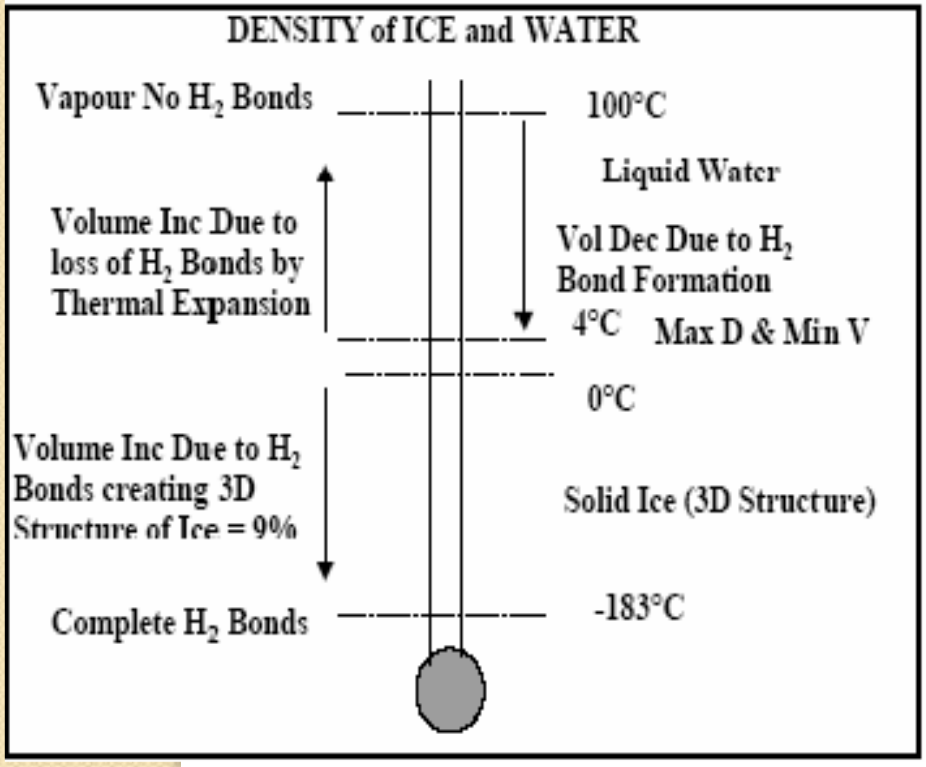
Seafood

- •Prepared to freeze
- •Injected w/ cryoprotectant
- •Otherwise added cryoprotectant+ marinade (tumble) or cryoprotectant+ breading

Poultry

- Prepared
- Injected or tumbled
- Frozen

Physical effects of freezing



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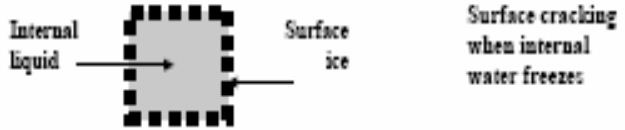

5. Fast freezing rate can damage small pieces

Volume changes

- The volume of ice is 9% greater than the volume of water.

- Expansion of foods after freezing would be expected and depends on:
  - –Moisture content
  - –Cell arrangement
  - –Concentration of solutes (higher concentration less expansion)
  - –Freezer temperature

Physical changes and quality

Free and bound water

Two types of water in food:

- Free
- Bound (unfreezable) water
- A major cause of product degradation is the amount of unfrozen water present in the frozen matrix.
- Unfrozen water is reactive, particularly during frozen storage, rendering the product susceptible to deteriorative and enzymatic reactions and limiting its frozen shelf life.
- Generally, unfreezable water molecules in aqueous solution are immobilized translationally or rotationally by solutes.

Cracking

- Although fast freezing has advantages, some products will crack or even shatter if exposed directly to extremely low temperature for a long period of time.

The two proposed mechanisms to explain cracking:

1. Volume expansion
2. Contraction and expansion
3. Internal stress

Physical changes and quality
Weight loss

- Dehydration or weight loss should be regarded as an important quality parameter for frozen unpacked foods, mainly in animal tissue.
- Foods lose moisture during the freezing process because their surface is exposed to heat and a moisture gradient exists within the environment.
- Weight loss of meat during freezing and frozen storage is between 0.28%–2.98% during the freezing process.

Physical changes and quality Recrystallization

- Ice crystals are relatively unstable
- Undergo metamorphic change
- Shape
- Size
- Orientation
- Number
- Causes quality loss in food

- Occurs because systems move towards a state of equilibrium
- Migratory recrystallization
- Major type recrystallization in food
- Caused by a fluctuation (2-3^{o}C) in storage temperature

Migratory recrystallization

- Surface of food warms
- •Ice on the surface partially melts
- •Larger crystals become smaller
- •Crystals less than 2mm disappear
- •Increases vapor pressure on the surface
- •Moisture migrates to lower pressure
- Causes food on the surface to dehydrate
- •When temperature drops water vapor joins existing ice crystals