Freezing of fruit and vegetables

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Freezing - purpose

- Increasing shelf-life
  - To control of microbial and enzymatic activities
- Maintaining quality through transportation and distribution systems
- Convenience to consumer
  - Invention of microwave has helped in growth

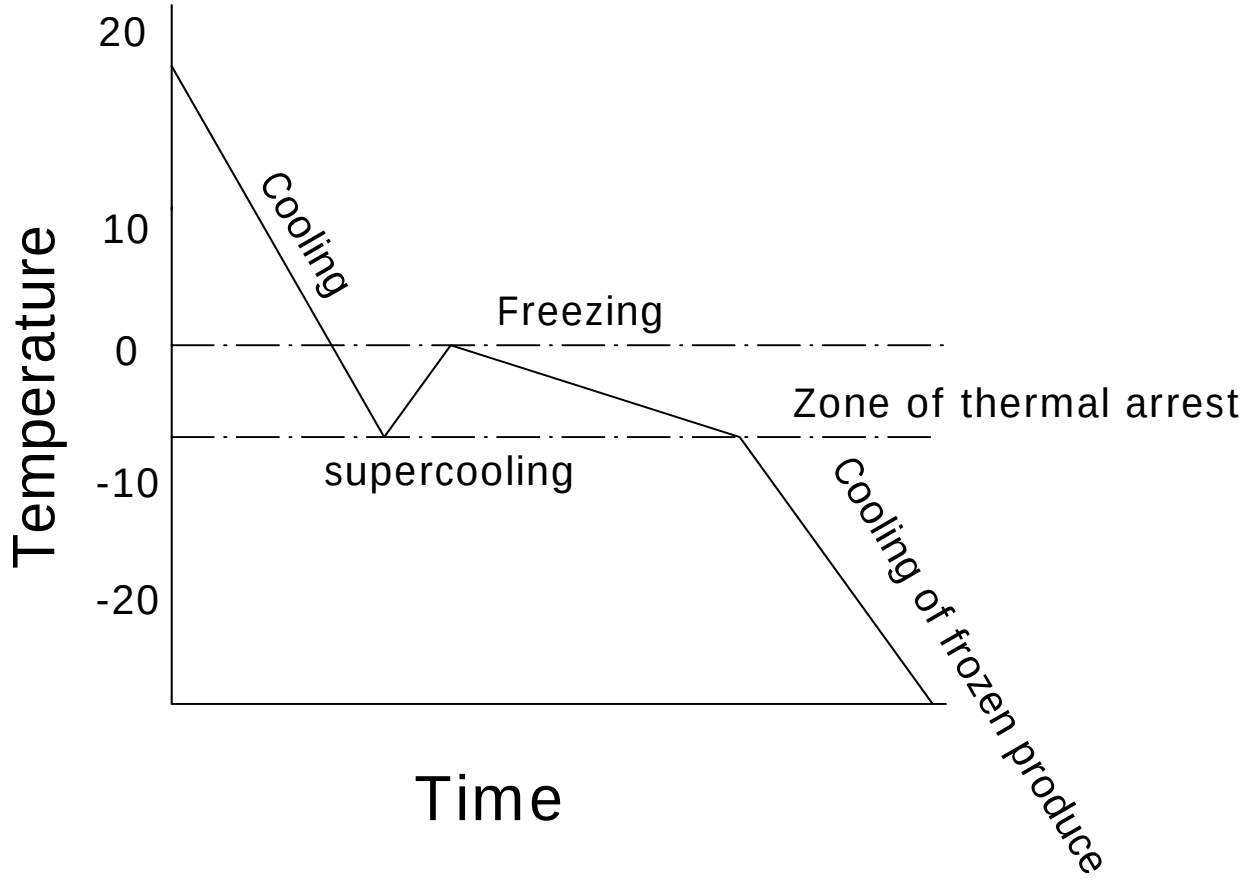
Freezing

- Product close to fresh
- Quality improvement not possible, but preservation is possible
- Deterioration before and after freezing
- Role of raw material quality

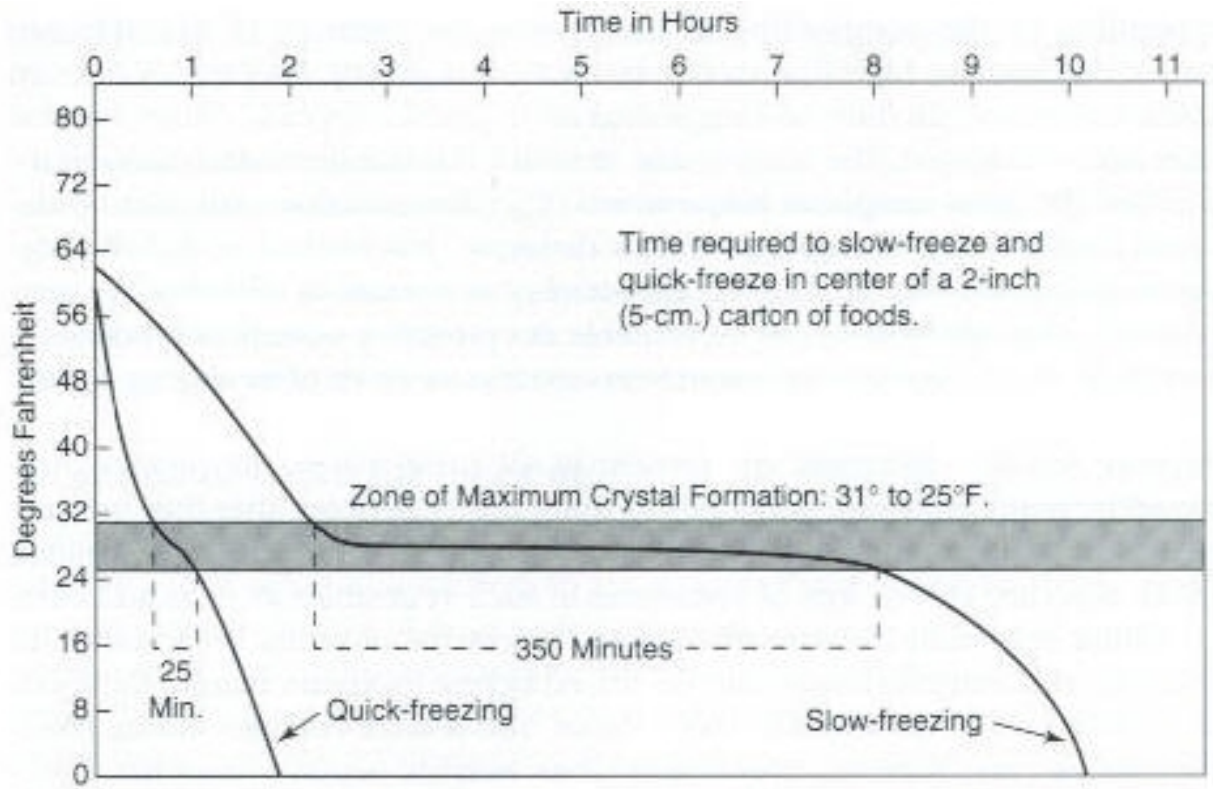
Freezing process

- Temperature is lowered
- Ice crystals begin to form as liquid reaches freezing point (freezing point of water 0°C)
- Formation of ice crystals-concentration of solutes – decrease in freezing point
- Lower temperature further to freezing temperature

Freezing process



Quick versus slow freezing



Bennion & Scheule, 2000. Introductory Foods

Glass transition during freezing

- Before freezing completely, most products experience a glass transition state
- The glass transition temperature, Tg, is the point at which the product becomes a noncrystalline solid rather than a rubbery or leathery fluid. The liquid or unfrozen product becomes so viscous that molecular mobility is basically curtailed.
- Theoretically, this is the temperature at which a frozen system is most stable.
- The greater disparity between the glass transition temperature and the freezer temperature, the more likely that undesirable reactions can occur.
- As long as the glass transition temperature is below the storage temperature some molecules will be mobile, increasing the propensity for undesirable reactions.

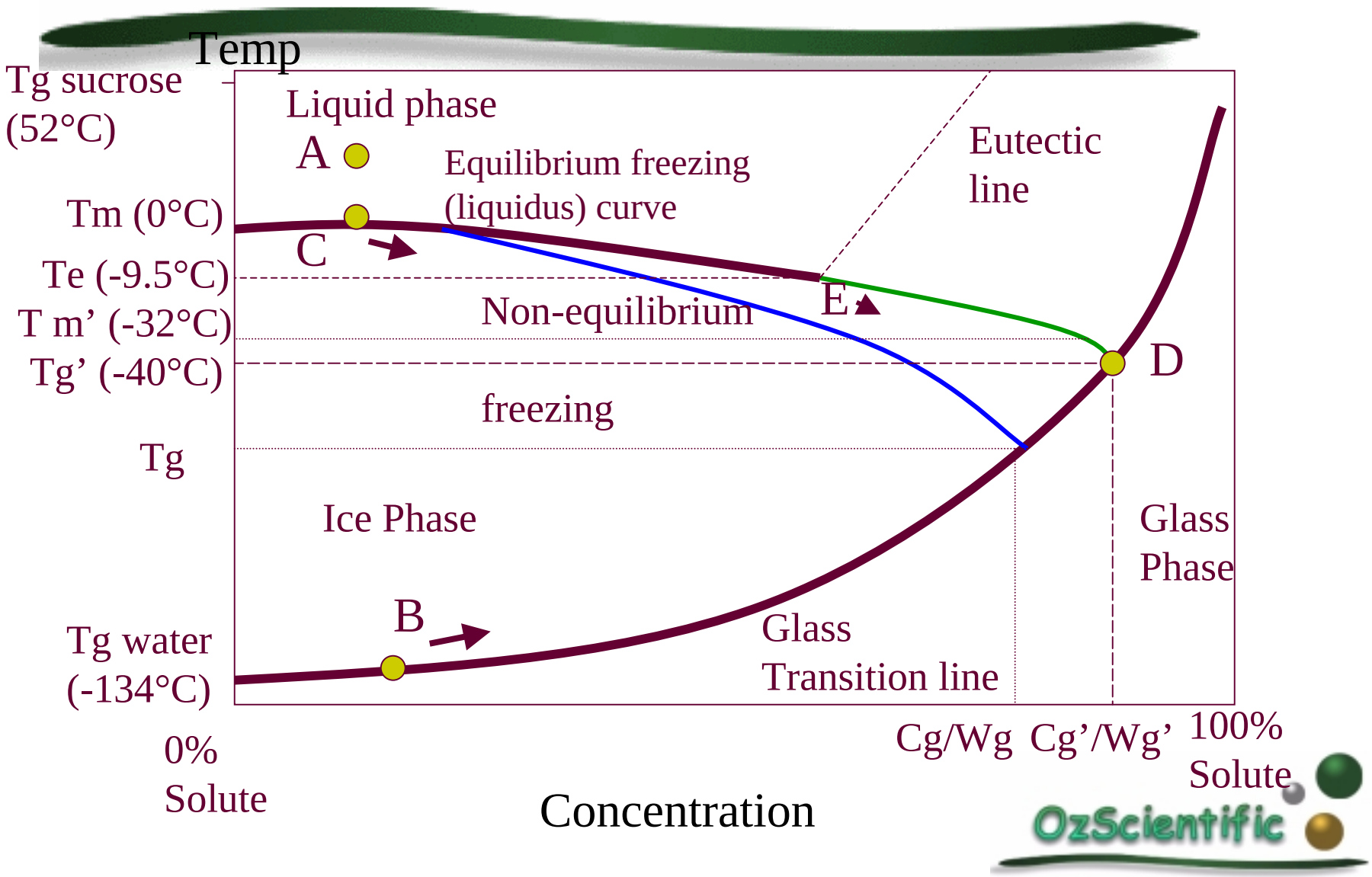
Glass transition temperature

- The glass transition temperature, as well as the freezing point, is a colligative property - that is, it depends on the number of molecules. Adding low-molecular-weight compounds, such as sugar, depresses this temperature because there are more molecules in a given weight. The Tg for a given product is basically a weighted average of molecular weights. It can be measured by a number of means - on a molecular, mechanical or thermal level, all of which may give different figures.

Importance of glass transition in freezing

- Quality losses (e.g. enzymatic reactions and crystallisation) may be greatly reduced at temp close to Tg
- Might be able to predict shelf life of products by using the difference between the storage temperature and Tg
  - Modelling using Williams-Landel-Ferry (WLF) model
- Knowledge of the influence of compositional and environmental factors on Tg may help in developing better products with improved quality and shelf life

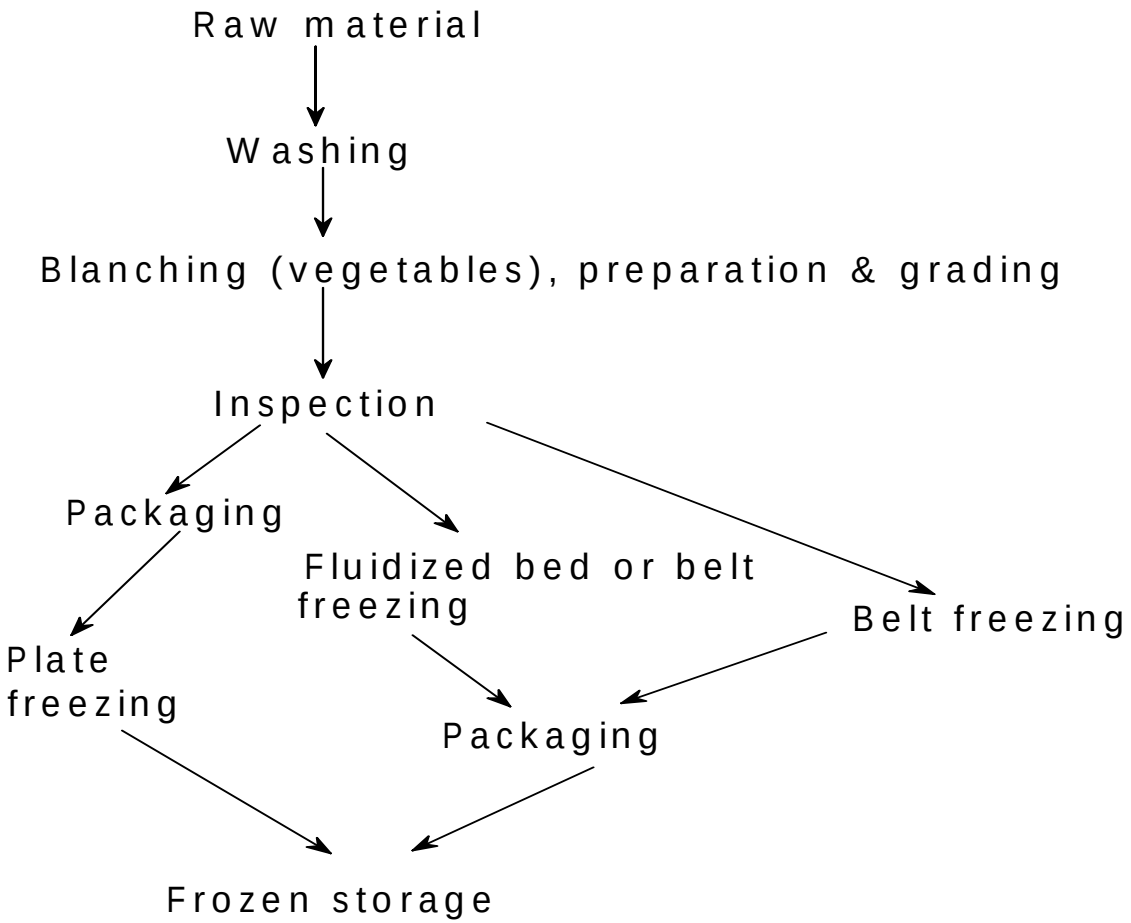
State diagram for carbohydrate solution



State diagram - definitions

- Tg – Glass transition temperature
- Tg' – Glass transition temperature of the maximally freeze concentrated solution
- Tm – Melting temperature of pure water
- Tm' – Temp needed to cause mechanical collapse and ice melting to occur above glass transition
- Te – Eutectic temperature of solute
- Wg' - Amount of unfrozen water

Flow diagram - freezing



Blanching

- Blanching is a cooking technique by which food items are immersed in boiling water for a very brief period of time. The items are removed quickly before they become overcooked
- Blanching is must when freezing vegetables
- Methods: Boiling water or steam

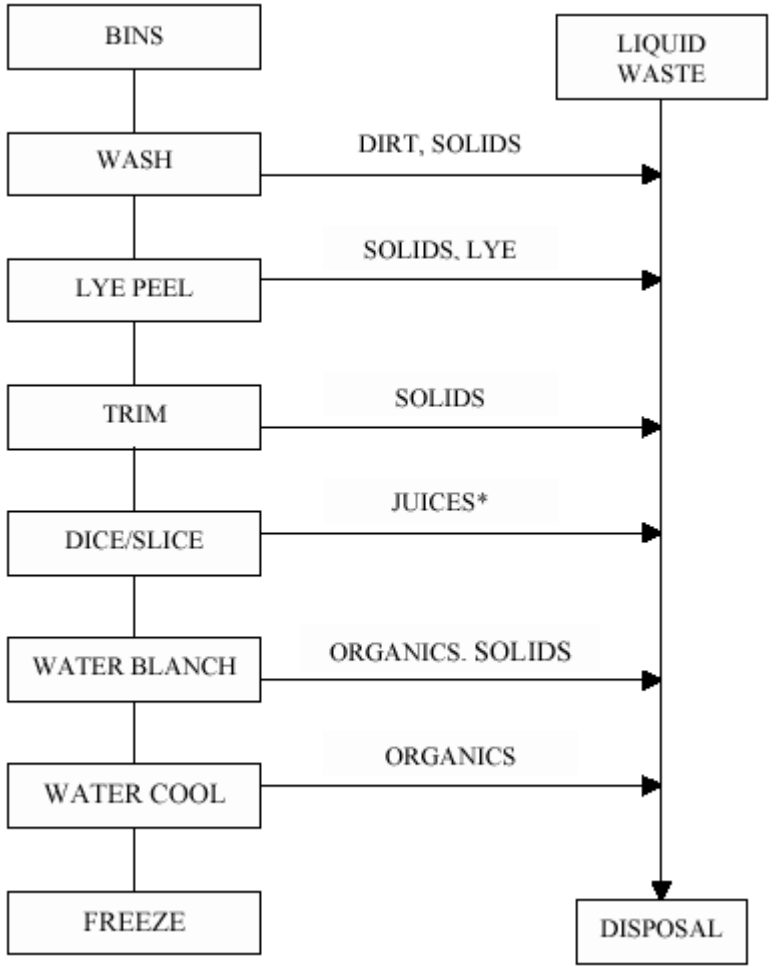
Blanching

- Inactivation of enzymes
  - Otherwise may cause browning, destruction of chlorophyll and carotenoid pigments, development of unpleasant flavours
- Shrinking of tissues
  - Helps in packaging vegetables
- Expulsion of air
  - potential for oxidation reduced
- Decrease in microbial load

Blanching

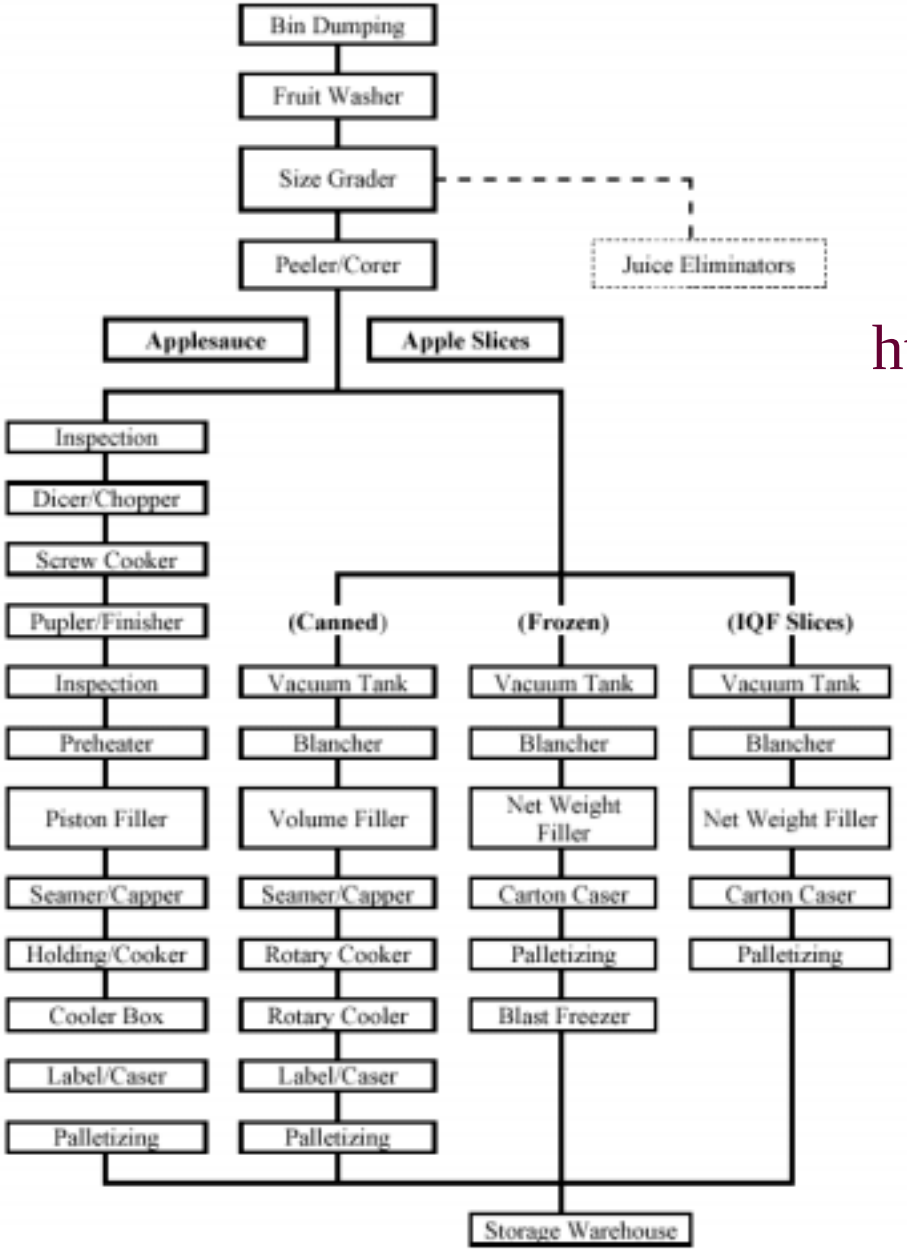
Beans (lima)	2 to 4 minutes
Beans (snap)	3 minutes
Corn on cob	7 to 11 minutes
Corn	4 minutes
Peas (garden or field)	2 minutes
Okra	3 to 4 minutes
Squash	3 minutes

Flow diagram for carrot freezing



http://www.oznet.ksu.edu/

Apple processing flow diagram



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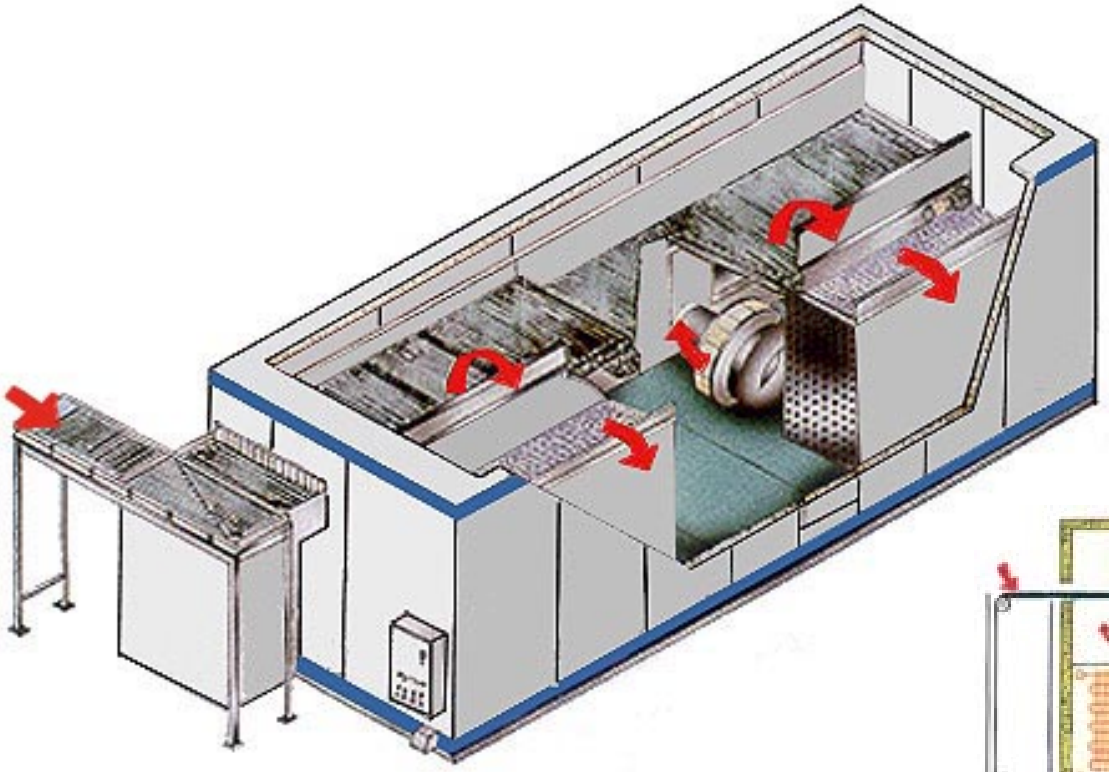
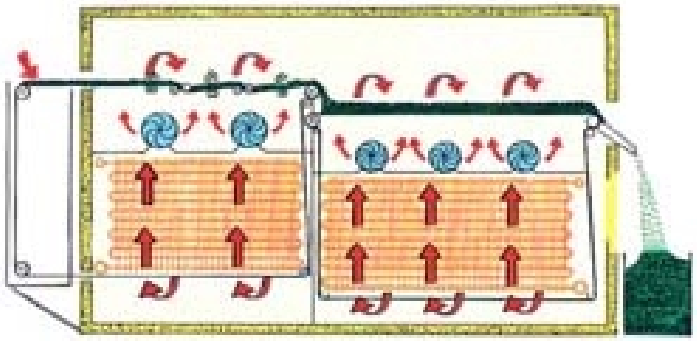
Freezing systems

- Fast
  - Indirect
  - Direct
  - Cyogenic
- Slow

Tunnel Freezer – fluidised bed

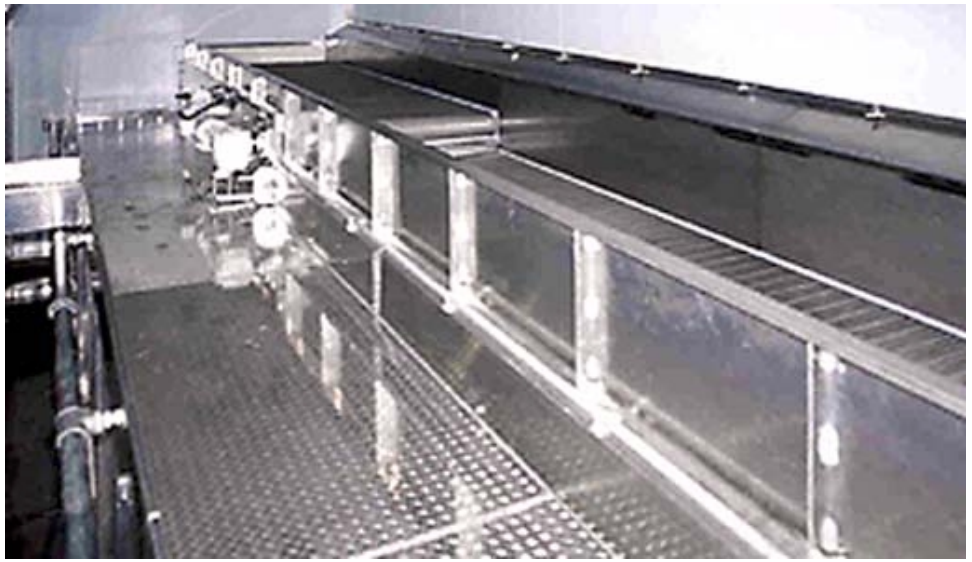




PROCESS FLOW SCHEMATIC

http://www.advancedfreezer.com/

Tunnel Freezer



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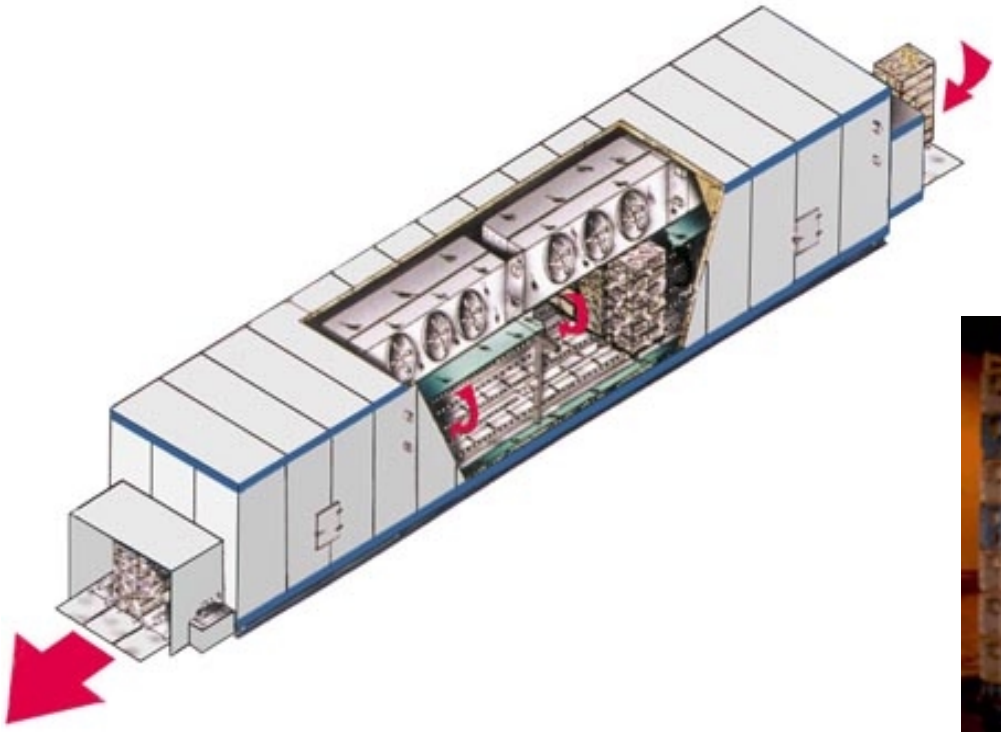
Tunnel Freezer - APPLICATIONS

- This freezer is generally used small product particle range from 3/16 to 2 inch diameter.
- VEGETABLE INDUSTRY- peas, green beans, cut corn, mushrooms, vegetables, French fries, cob corn, diced carrots, diced onion, cut cauliflower, cut broccoli, cut asparagus, Brussels sprouts.
- FRUITS INDUSTRY - blueberries, cranberries, strawberries, cherries, gooseberries, raspberries, diced pineapples, sliced apple.

http://www.advancedfreezer.com/

Drag-trough Freezer



http://www.advancedfreezer.com/

Changes during freezing, storage and thawing

- Formation of ice crystals
  - Partly depends on the nature & state of the food material
  - Rapid freezing – more and smaller crystals – less damage
  - Slow freezing - large and few crystals
  - Affect the texture
  - Decrease in firmness of vegetable and fruit tissues on freezing and thawing
  - Frozen storage stability is greater below glass transition (Tg) temperature

Changes during freezing, storage and thawing

- Enzyme action
  - Freezing inhibits enzyme action but does not destroy the enzymes
  - If not inactivated by blanching – changes can occur in colour, flavour and texture during freezing, storage and thawing
- Non-enzymatic oxidation
  - Residual oxygen can affect fatty materials

Changes during freezing, storage and thawing

- Desiccation
  - If not properly packaged, tend to lose moisture through sublimation – water vapour can form frost inside the package or inside the freezing compartment
  - Freezer burn- dehydration resulting in discolouration, change in texture & off-flavours
- Activity of micro-organisms
  - Activity negligible below –9°C
  - Warming activates micro-organisms

Storage Times for Frozen Foods and Vegetables

- Fruits
  - Most frozen fruits maintain high quality for 8 to 12 months. Unsweetened fruits lose quality faster than those packed in sugar or sugar syrups.
- Vegetables
  - Most vegetables will maintain high quality for 12 to 18 months at –32°C or lower.
- Longer storage of fruits and vegetables than those recommended above will not make the food unfit for use, but will decrease its quality.

Vegetables That Don't Freeze Well

Unblanched Vegetables – except green peppers or onions for seasoning. Within a short time they begin to lose fresh flavor and nutritive value, and have an odd taste. Always blanch vegetables.

Fresh Whole Tomatoes – Water content is so high they collapse when thawing, losing lots of juice. It's better to cook them down before freezing.

Mature, Raw Irish Potatoes – They get mushy after cooking. Bake, mash or parfry for french fries before freezing. Plain cooked potatoes, such as boiled or in stews or potato salad, get spongy.

Lettuce, Cabbage, Celery, Carrot Sticks for eating raw – They lose crispness and get limp and tough when frozen.

Storage life of frozen foods (months)

	-24 C	-18C	-12C
Green beans	24	14	6
Corn	12	8	4
Fruits	12	9	6
French fries	24	12	6

Nutrient Value of Frozen Foods

- Freezing, when properly done, is the method of food preservation which may potentially preserve the greatest quantity of nutrients

Microbial Growth in the Freezer

- No destruction of micro-organisms that are already present in the fruit or vegetable
- Blanching destroys some organisms, there is some decline during freezing but still many survive – sufficient to cause spoilage on thawing

Raw material requirements

- Good quality
- Small celled, high sugar containing freeze well eg raspberries, blackberries
- Fruits (low pH) has low residual enzyme activity than vegetables
- Those with high fat content have low frozen shelf life

Stability of frozen F&V

- Damage to tissues eg damage to starch-water gels
- Loss of rehydration upon thawing
- Loss of texture
- Loss of colour eg degreening due to removal of Mg from the Chlorophyll

Stability of frozen F&V

- Oxidation of fats: rancid odour & flavour
- Desiccation of surface: freezer burn
  - Should be package before frozen storage to avoid

Handling, storage & distribution

- Storage temperature < -10 C
- Packaging
  - Packaging helps in prevention of fat oxidation
- Temperature abuse

Frozen peas

- Frozen foods market
  - Ice cream $975.2 million
  - Vegetable $182 million
  - French fries $43 million
  - Frozen dinners 80.6 million

- 90% of peas are frozen, rest dried and canned

Manufacture of frozen peas

- Harvest at texture of about MI 220-240
  - Starchy peas are over matured and unsuitable for freezing
- Winnowing
- Washing & cleaning and Size grading
- Blanching 1-2 mins in hot water
  - Critical in prevention of flavour and colour deterioration

Manufacture of frozen peas

- Cooling
- De-watering
- Freezing-FBD use the quick method
- Packaging and storage

Freezing fruits

- Most fruits can be frozen satisfactorily, but the quality of the frozen product will vary with the kind of fruit, stage of maturity and type of pack.