Industrial Refrigeration For Food Preservation

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Outlines
• Product Lost
• Fruits & Vegetables
• Fishery

PRODUCT LOST
Product Lost

Causes:-
- Weight loss in storage and freezing
- Chilling injury
- Freezing injury
- Ammonia injury

Weight loss during storage

Factors:-
- Room temperature & temperature fluctuation
- Humidity
- Air flow over the product
- Radiation effects of lighting
- Shape and size of the product
- Type of wrapper

Weight lost during freezing

Factors:-
- Type of freezer
- Freezing time
- Type of product
- Air velocity
- Freezer operating conditions

<table>
<thead>
<tr>
<th>Product</th>
<th>Freezing Method</th>
<th>%weight loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQF shrimp</td>
<td>Air blast</td>
<td>2 to 2.5</td>
</tr>
<tr>
<td>IQF haddock</td>
<td>Air blast</td>
<td>1.2</td>
</tr>
<tr>
<td>IQF haddock</td>
<td>Cryogenic – CO2</td>
<td>0.6</td>
</tr>
<tr>
<td>IQF products</td>
<td>Cryogenic – N2</td>
<td>0.3 to 0.8</td>
</tr>
<tr>
<td>Tray of fillets</td>
<td>Air blast</td>
<td>1.0</td>
</tr>
<tr>
<td>Large fish or blocks</td>
<td>Air blast</td>
<td>0.5</td>
</tr>
<tr>
<td>Blocks of fish</td>
<td>Contact freezer metal to fish contact</td>
<td>0</td>
</tr>
</tbody>
</table>

Chilling Injury
Freezing Injury

Freezing Injury

Freezing

- Large ice crystals damage cell wall

Slow Freezing

- Cell wall has been ruptured

Quick Freezing

- Cell wall intact

Ammonia Injury

FRUITS & VEGETABLES

Fruits & Vegetables

- Pre-cooling method
- Green Bean & Soya Bean
- Shallot (Red Onion)
- Banana Ripening
- Mango
- CA

Vegetables Postharvest General Flow
Fruits Postharvest General Flow at Packinghouse

Fresh fruit
Load into wax m/c
Water spray cleaning
Inspection
Water spray brushing
Surface water removal
Wax emulsion coating with brush & spray
Drying with fan & heater
Grading by size
Packing
Cold storage
Transport

Load into ripening room
Ripening @ desired condition
Unload from ripening room
Packing

Fruits & Vegetables

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Max. transit &amp; shelf life (Days)</th>
<th>Opt. transit temp. (°C)</th>
<th>Highest freezing temp. (°C)</th>
<th>Sensitivity</th>
<th>Container temp. setpoint (°C)</th>
<th>%RH Air Change (cfm)</th>
<th>Ethylene Production Rate Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beans, Green</td>
<td>10-14</td>
<td>7.2</td>
<td>5.0-7.2</td>
<td>90-95</td>
<td>45</td>
<td>Low</td>
<td>S</td>
</tr>
<tr>
<td>Asparagus</td>
<td>10-14</td>
<td>0</td>
<td>-0.6</td>
<td>90-95</td>
<td>20</td>
<td>VL, High</td>
<td>M</td>
</tr>
<tr>
<td>Cabbage (White)</td>
<td>90-180</td>
<td>0</td>
<td>-1.4</td>
<td>95-100</td>
<td>45</td>
<td>VL, High</td>
<td>M</td>
</tr>
<tr>
<td>Cantaloupes</td>
<td>10-14</td>
<td>3.3</td>
<td>-1.2</td>
<td>85-90</td>
<td>45</td>
<td>High</td>
<td>M</td>
</tr>
<tr>
<td>Carrot, Topped</td>
<td>28-180</td>
<td>0</td>
<td>-1.4</td>
<td>95-100</td>
<td>45</td>
<td>VL, Low</td>
<td>M</td>
</tr>
<tr>
<td>Celery</td>
<td>14-28</td>
<td>0</td>
<td>-0.5</td>
<td>90-95</td>
<td>45</td>
<td>VL, M</td>
<td>M</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>10-14</td>
<td>10.0</td>
<td>10.0-11.1</td>
<td>90-95</td>
<td>45</td>
<td>Low, High</td>
<td>M</td>
</tr>
<tr>
<td>Eggplant</td>
<td>10-14</td>
<td>10.0</td>
<td>0.8</td>
<td>90-95</td>
<td>45</td>
<td>Low, Low</td>
<td>M</td>
</tr>
</tbody>
</table>

Pre-cooling Methods for Fresh Produce

- Top Icing
- Hydro Cooling
- Hydair Cooling (air + cold water spray), Wet Air Cooling
- Air Cooling
  - Room Cooling
  - Force Air Cooling
- Vacuum cooling

Top Icing

Hydro Cooling
Hydro-Force Cooler (HAC)

Room Cooling

Recommended Temperature (TD) for Four Classes of Foods (Forced Air Unit Coolers)

<table>
<thead>
<tr>
<th>Class</th>
<th>TD</th>
<th>RH</th>
<th>Suitable for</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7-9°F</td>
<td>90%</td>
<td>Fruits, vegetables, flowers, unpacked ice, chill room</td>
</tr>
<tr>
<td>2</td>
<td>10-12°F</td>
<td>80 - 85%</td>
<td>General cool room, packed products</td>
</tr>
<tr>
<td>3</td>
<td>12-16°F</td>
<td>65 - 80%</td>
<td>Beer, wine, pharmaceuticals, short term packaged products, tomatoes, onions, and tough skin fruits e.g. melons</td>
</tr>
<tr>
<td>4</td>
<td>17-22°F</td>
<td>50 - 65%</td>
<td>Processing rooms, cutting rooms, candies, loading docks</td>
</tr>
</tbody>
</table>

Forced-Air Cooling

Tunnel type FAC using cold-wall system

Force Air Cooling
Vacuum Cooling

Some vegetables that can be vacuum cooled:

• All leafy vegetables
• Any type of lettuce
• Asparagus
• Bell pepper
• Bok choy
• Brussel sprouts
• Cabbage
• Carrots
• Cauliflower
• Celery
• Cucumbers
• Endive
• Escarole

• Green peas
• Leeks
• Mushrooms
• Oriental vegetables
• Parsley
• Prepack coleslaw
• Prepack spinach
• Romaine
• Snap beans
• Spinach
• Squash

Vacuum Cooling

Compare Cooling Methods for Fruits and Vegetables

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Vacuum Cooling</th>
<th>Room Cooling</th>
<th>Forced Air Cooling</th>
<th>Hydro Cooling</th>
<th>Top/Liquid icing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beans/snap</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Broccoli</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabbage</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cantaloupe</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrot</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cucumber</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egg Plant</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Beans &amp; Soya Beans</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

Recommended Cooling Methods for Fruits and Vegetables

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Vacuum Cooling</th>
<th>Room Cooling</th>
<th>Forced Air Cooling</th>
<th>Hydro Cooling</th>
<th>Top/Liquid icing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lettuce</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spinach</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Strawberries</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweetcorn</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet Potatoes</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomatoes</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Beans &amp; Soya Beans</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>
### Green Bean & Soya Bean

<table>
<thead>
<tr>
<th>Beans, Green</th>
<th>Max. transit &amp; Shelf life (Days)</th>
<th>Opt. transit temp. (°C)</th>
<th>Highest freezing temp. (°C)</th>
<th>Recommended container temp. adjusted (°C)</th>
<th>%RH</th>
<th>Air Change (cfm)</th>
<th>Ethylene Production Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10-14</td>
<td>7.2</td>
<td>-0.7</td>
<td>5.0-7.2</td>
<td>90-95</td>
<td>45</td>
<td>Low</td>
</tr>
</tbody>
</table>

### Shallot (Red Onion) Processing

**Harvest**
- Fully mature, well colored, and 1-2 inches in diameter.
- Cure in the sunlight, sacks, or bins, or under cover.
- Shallots are usually hand cleaned, topped and put into bags or bins for storage after the necks and bulbs are well cured.

### Fruits & Vegetables

### Storage
- Store at 0–1 °C and 60-70% RH.
- Should not be placed into deep piles.
- Good air movement is critical.
- 8 to 10 months.
Postharvest Treatments

- Maleic hydrazide (Royal MH-30)
  - Two lb a.i. per acre when bulbs are 
    - fully mature with soft necks and 5 to 8 green leaves 
    - or approximately 50% of the tops have fallen, but are still green.
  - Applied at temperatures below 80 to 85°F.
  - Suggest to use a spray adjuvant in some arid regions.
  - Avoid early sprays before maturity.
  - Do not treat seed shallots.

Banana Ripening

Fruit Ripening

- What is Fruit Ripening?
  - Climacteric Fruits
  - Non-Climacteric Fruits

Climacteric Fruits

- Banana
- Apricot
- Papaya
- Kiwi
- Apple
- Guava
- Pear
- Mango
- Passion Fruit

Non-Climacteric Fruits

- Sapota
- Pear
- Mango
- Passion Fruit
- Guava
- Plum
- Apple
- Figs
- Banana
- Apricot
- Papaya
- Kiwi

Ripening Conditions for Some Kinds of Fruits

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Exposure time (hours)</th>
<th>Range of ripening temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avocado</td>
<td>8-48</td>
<td>59-68°F/ 15-20°C</td>
</tr>
<tr>
<td>Banana</td>
<td>24-48</td>
<td>58-65°F/ 14-18°C</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>12-24</td>
<td>54-70°F/ 12-22°C</td>
</tr>
<tr>
<td>Mango</td>
<td>24-48</td>
<td>68-72°F/ 20-22°C</td>
</tr>
<tr>
<td>Pear</td>
<td>24-48</td>
<td>68-72°F/ 20-22°C</td>
</tr>
<tr>
<td>Tomato</td>
<td>24-72</td>
<td>65-68°F/ 18-20°C</td>
</tr>
</tbody>
</table>

1 Shorter duration for more mature fruit
2 Faster ripening rate at higher temperatures
**Banana Ripening**

Four major factors:-
- Relative Humidity (RH) control
- Ethylene gas
- Temperature control (pulp temperature)
- Air circulation

**Approx. daily pulp temperature desired for bananas scheduled to complete ripening in specified number of days**

<table>
<thead>
<tr>
<th>Ripening schedule</th>
<th>Fruit temperature (°C) on day -</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 1</td>
</tr>
<tr>
<td>4 days</td>
<td>18</td>
</tr>
<tr>
<td>5 days</td>
<td>17</td>
</tr>
<tr>
<td>6 days</td>
<td>17</td>
</tr>
<tr>
<td>7 days</td>
<td>16</td>
</tr>
</tbody>
</table>

**Banana**

<table>
<thead>
<tr>
<th>Max. transit &amp; Shelf life (Days)</th>
<th>Opt. transit temp. (°C)</th>
<th>Highest freezing temp. (°C)</th>
<th>Recommended container temp. optimum (°C)</th>
<th>%RH</th>
<th>Air change (cfm)</th>
<th>Ethylene Production Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana</td>
<td>7-28</td>
<td>14.4</td>
<td>-0.8</td>
<td>13.9-15.4</td>
<td>85-95</td>
<td>45 Medium</td>
</tr>
</tbody>
</table>

Low relative humidity accelerates water loss and appearance of physical damage symptoms on banana.
Mango

<table>
<thead>
<tr>
<th></th>
<th>Max. transit &amp; Shelf life (Days)</th>
<th>Opt. transit temp. (°C)</th>
<th>Highest freezing temp. (°C)</th>
<th>Recommended container temp. (°C)</th>
<th>Safe Air Change (cfm)</th>
<th>Ethylene Production Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mango</td>
<td>14-25</td>
<td>13.3</td>
<td>-0.9</td>
<td>12.2-13.3</td>
<td>85-90</td>
<td>20 Medium</td>
</tr>
</tbody>
</table>

Export Fresh Mangos Process Flow

1. Hand harvest into baskets, nets or buckets
2. Pre-size for hot water treatment & presort defect
3. Hot water quarantine treatment
4. Portable water brush & rinse
5. Pre-size for hot water treatment
6. Hot water quarantine treatment
7. Rest 12-24 hrs at ambient temp.
8. Portable water brush & rinse
9. Transfer to packing line & wax application
10. Grade according to buyer requirements
11. Pack fruit into cartons by size
12. Transfer to packinghouse
13. Dump into chlorinated water
14. Forced Air cooling
15. Select 12-24 hrs at ambient temp.
16. Transfer to packing line & wax application
17. Grade according to buyer requirements
18. (Continued)
Ripen Mangos Process Flow

- Ripen Mangos
- Clean & Rinse
- Peel
- Cut
- Freeze (Air Blast, Tunnel)
- Vacuum Pack
- Cold Storage
- Freeze Dry
- Pack

CONTROL ATMOSPHERE (CA)

Control atmosphere (CA)

Membrane type Nitrogen Generator

PSA type Nitrogen Generator

Control atmosphere (CA)

VPSA type Oxygen Absorbers

Carbon Dioxide Absorbers

Ethylene Scrubber
Control atmosphere (CA)

CA Door

Control atmosphere (CA)

Analyzer

Air bags to equilibrate pressure in controlled atmosphere rooms

**FISHERY**

Fishery

- Freezer Trawler
- Fish
- Surimi
- Shrimp
- Freezing Technology

<table>
<thead>
<tr>
<th>Fish</th>
<th>Max. Frozen &amp; Shelf Life (Days)</th>
<th>Opt. Trans Temp. (°C)</th>
<th>Highest Freezing Temp. (°C)</th>
<th>Min. Relative Humidity</th>
<th>Air Change (cfm)</th>
<th>Ethylene Production Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cod, salmon, sardine, tuna</td>
<td>120-140</td>
<td>-23.3 to -20.5</td>
<td>-23.3 to -20.5</td>
<td>Vents closed</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Cod, pollack, pollock</td>
<td>140-300</td>
<td>-23.3 to -20.5</td>
<td>-23.3 to -20.5</td>
<td>Vents closed</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Shrimp, scallops</td>
<td>120-360</td>
<td>-23.3 to -20.5</td>
<td>-23.3 to -20.5</td>
<td>Vents closed</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Crab, lobster</td>
<td>120-360</td>
<td>-23.3 to -20.5</td>
<td>-23.3 to -20.5</td>
<td>Vents closed</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
**Freezer Trawler**

Ice Machine for trawler
- chip ice from freshwater
- chip ice from fresh or seawater
- liquid ice from seawater

**Fish Processing**

- Receiving (Fresh or Frozen Fish)
- Unpacking
- Thawing (in water)
- Washing & Grading
- Skinning
- Evisceration & removal of valuable by-products (liver, milt)
- Filleting
- Chilling, freezing, salting, drying
- QC
- External Packing

**By-product**

- Rejected fish
- Rejected fish
- Skin
- Guts, head
- Bones, off-cuts reject
- Rejected fish
- Fish meal & fish oil
- Dehydrating
- Packing

**Surimi**

- Raw Material
- Chilled and washed in ice water (6°C)
- Deboner
- Leaching
- Hydraulic press
- Packer
- Contact freezing (-40°C)
- Pressed Meat
- Strainer/Refiner
- Mixing
- Packing
- Cold storage (-18°C to -20°C)

**Fish Fillet**

- Fish Finger

**Fish Finger**
Shrimp Processing

Harvest → Store → De-head → Grade → Peel → Cook → I.Q.F. → Glaze → Weigh → Pack → Store → Ship

Weigh → Place in block tray → Block freeze → Knock out → Glaze

Weigh → Tray pack → Bread → I.Q.F. → Fry → I.Q.F. → Glaze → Weigh → Pick → Store → Ship

Before After

Freezing Technology

- Brine Freezer
- Contact Plate Freezer
- Spiral Freezer
- Tunnel Freezer
- Fluidized Bed Freezer
- Cryogenic Freezer
Cryogenic Freezer

Industrial Refrigeration
For Food Preservation

Q & A
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Tel: +66-2374-4640

Industrial Refrigeration
For Food Preservation
Thank You
For Your Attention.

شاكرين

Kob Khun Ka