Industrial Refrigeration
For Food Preservation

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Fellow – ASHRAE
Distinguished Lecturer (DL)
and 2009-2011 Student Activities Committee of
ASHRAE USA

Sawasdee Ka

آداب عرض ہے
ādāb arz hai

Sawasdee Ka
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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

Percentage of Weight (Moisture) Loss from Fruits and Vegetable that Affects Produce Quality after Harvest

<table>
<thead>
<tr>
<th>Product</th>
<th>Weight Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beans (broad, runner, snap)</td>
<td>6.0, 5.0, 41.0%</td>
</tr>
<tr>
<td>Broccoli</td>
<td>4.0</td>
</tr>
<tr>
<td>Cabbage</td>
<td>8.0</td>
</tr>
<tr>
<td>Carrots (mature, young)</td>
<td>8.0, 4.0</td>
</tr>
<tr>
<td>Celery</td>
<td>10.0</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>5</td>
</tr>
<tr>
<td>Lettuce</td>
<td>3.7</td>
</tr>
<tr>
<td>Onions</td>
<td>10.0</td>
</tr>
<tr>
<td>Potatoes</td>
<td>7.0</td>
</tr>
<tr>
<td>Spinach</td>
<td>3.0</td>
</tr>
<tr>
<td>Sweet Corn</td>
<td>7.0</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>7.0</td>
</tr>
</tbody>
</table>
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
Weight lost during freezing

<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>
Freezing Injury

Freezing Injury

Freezing
- Large ice crystals damage cell wall

Quick Freezing
- Small ice crystals

Thawing
- Cell wall intact

Slow Freezing
- Cell wall has been ruptured
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 & 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>Recomm. container temp. setpoint (°C)</th>
<th>%RH</th>
<th>Air Change (cfm)</th>
<th>Ethylene Production Rate</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beans, Green</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>
<td>M</td>
</tr>
<tr>
<td>Broccoli</td>
<td>10-14</td>
<td>0</td>
<td>-0.6</td>
<td>0-1.1</td>
<td>90-95</td>
<td>20</td>
<td>VL</td>
<td>High</td>
</tr>
<tr>
<td>Cabbage (White)</td>
<td>90-180</td>
<td>0</td>
<td>-1.4</td>
<td>0-1.1</td>
<td>95-100</td>
<td>45</td>
<td>VL</td>
<td>High</td>
</tr>
<tr>
<td>Cantaloupes</td>
<td>10-14</td>
<td>3.3</td>
<td>-1.2</td>
<td>2.2-5.0</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>0-1.1</td>
<td>95-100</td>
<td>15</td>
<td>VL</td>
<td>Low</td>
</tr>
<tr>
<td>Celery</td>
<td>14-28</td>
<td>0</td>
<td>-0.5</td>
<td>0-1.1</td>
<td>90-95</td>
<td>45</td>
<td>VL</td>
<td>M</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>10-14</td>
<td>10.0</td>
<td>-0.5</td>
<td>10.0-11.1</td>
<td>90-95</td>
<td>45</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Eggplant</td>
<td>10-14</td>
<td>10.0</td>
<td>-0.8</td>
<td>10.0-12.2</td>
<td>90-95</td>
<td>15</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>
## 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>Recommended container temp. setpoint (°C)</th>
<th>%RH</th>
<th>Air Change (cfm)</th>
<th>Ethylene Production Rate</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lettuce (butterhead)</td>
<td>8-12</td>
<td>0</td>
<td>-</td>
<td>0-1.1</td>
<td>90-95</td>
<td>45</td>
<td>Low</td>
<td>M</td>
</tr>
<tr>
<td>Onions, Green</td>
<td>7-10</td>
<td>0</td>
<td>-0.9</td>
<td>0-1.1</td>
<td>95-100</td>
<td>20</td>
<td>VL</td>
<td>Low</td>
</tr>
<tr>
<td>Onions, Dry</td>
<td>30-180</td>
<td>0</td>
<td>-0.8</td>
<td>0-1.1</td>
<td>65-75</td>
<td>20</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Spinach</td>
<td>10-14</td>
<td>0</td>
<td>-0.3</td>
<td>0-1.1</td>
<td>95-100</td>
<td>45</td>
<td>VL</td>
<td>High</td>
</tr>
<tr>
<td>Strawberries</td>
<td>5-10</td>
<td>-0.5</td>
<td>-0.3</td>
<td>0-1.1</td>
<td>90-95</td>
<td>20</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Sweet Corn</td>
<td>4-6</td>
<td>0</td>
<td>-0.6</td>
<td>0-1.1</td>
<td>90-95</td>
<td>15</td>
<td>VL</td>
<td>Low</td>
</tr>
<tr>
<td>Tomatoes, breaker to light pink</td>
<td>7-14</td>
<td>10.0</td>
<td>-0.5</td>
<td>10.0-11.1</td>
<td>90-95</td>
<td>45</td>
<td>M</td>
<td>High</td>
</tr>
</tbody>
</table>

### Pre-cooling Methods for Fresh Produce

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

Hydro Cooling
Hydro Cooling

Continuous Flow Shower Type Hydrocooler

Hydro Cooling

Batch Hydrocooler
Hydro Cooling

Continuous Flow Immersion Type Hydrocooler

Hydro Cooling

Thermal Storage Immersion Hydrocooler
Hydrair Cooling System, Wet Air Cooling System

Evaporative Condenser
Compressor
Ice Chiller & Water Tank

Wet Air Cooler

Cold, Humid Air

Produce

Cold Room

Ice Water

Hydrair Cooling System, Wet Air Cooling System
Hydro-Force Cooler (HAC)

Hydro-Force Cooler (HAC)

High Humidity Air Supply

Drift Eliminator
Evaporator
Circulate Pump

Water Spray
Air In
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></td>
<td>(~5°C)</td>
<td></td>
<td></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></td>
<td>(~7°C)</td>
<td></td>
<td></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></td>
<td>(~9°C)</td>
<td></td>
<td></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>
<tr>
<td></td>
<td>(~12°C)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Forced-Air Cooling

Tunnel type FAC using cold-wall system

Force Air Cooling
Force Air Cooling

Canvas System
Force Air Cooling

Canvas Free System

Force Air Cooling

Air Bag (Vertical Air Circulation)
Vacuum Cooling

Typical schematic of a vacuum cooler

Vacuum Cooling

[Image of a vacuum cooling system]

[Image of a vacuum cooling unit in use]
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
- Radishes
- Romaine
- Snap beans
- Spinach
- Squash
### Compare Cooling Methods for Fruits and Vegetables

<table>
<thead>
<tr>
<th></th>
<th>Room Cooling</th>
<th>Vacuum Cooling</th>
<th>FAC</th>
<th>Hydro Cooling</th>
<th>Top/Liquid icing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical cooling time (hr)</td>
<td>20 to 100</td>
<td>0.3 to 2.0</td>
<td>1 to 10</td>
<td>0.1 to 1.0</td>
<td>0.1 to 0.3</td>
</tr>
<tr>
<td>Product moisture loss (%)</td>
<td>0.1 to 2.0</td>
<td>2.0 to 4.0</td>
<td>0.1 to 2.0</td>
<td>0 to 0.5</td>
<td>No data</td>
</tr>
<tr>
<td>Water contact with product</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes, unless bagged</td>
</tr>
<tr>
<td>Potential for decay contamination</td>
<td>Low</td>
<td>none</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Capital cost</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Water-resistant packing needed</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Portable</td>
<td>No</td>
<td>Common</td>
<td>Sometimes</td>
<td>Rarely done</td>
<td>Common</td>
</tr>
<tr>
<td>Feasibility of in-line cooling</td>
<td>No</td>
<td>No</td>
<td>Rarely done</td>
<td>Yes</td>
<td>Rarely done</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>Beans/snap</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Broccoli</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabbage</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Cantaloupe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Carrot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Celery</td>
<td>Y</td>
<td></td>
<td></td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Cucumbers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egg Plant</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Onions</td>
<td></td>
<td></td>
<td></td>
<td></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></td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spinach</td>
<td>Y</td>
<td></td>
<td></td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Strawberries</td>
<td></td>
<td>Y</td>
<td></td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Sweet-corn</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Sweet-potatoes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Tomatoes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

**Green Been & Soya Been**
Green Been & Soya Been

<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. setpoint (°C)</th>
<th>%RH</th>
<th>Air Change (cfm)</th>
<th>Ethylene Production Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beans, Green</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>
</tr>
</tbody>
</table>

Green Been & Soya Been

- Weighing
- Quality Control (Sampling)
- Bulk Storage (Wet Air, FAC)
- Blowing Foreign Material
- Washing (Sand, Mud)
- Sorting, Size Grading
- Trimming (Tail, Head)
- Cleaning
- Blanching
- Quick Chilling (By Chilled Water)
- Fluidize Bed Freezing (IQF)
- Weighing & Packing
- Cold Store
- Export

Cold Store

Export
**Shallot (Red Onion) Processing**

<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>Recom. container temp. setpoint (°C)</th>
<th>%RH</th>
<th>Air Change (cfm)</th>
<th>Ethylene Production Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onions, Green</td>
<td>7-10</td>
<td>0</td>
<td>-0.9</td>
<td>0-1.1</td>
<td>95-100</td>
<td>20</td>
<td>Very Low</td>
</tr>
<tr>
<td>Onions, Dry</td>
<td>30-180</td>
<td>0</td>
<td>-0.8</td>
<td>0-1.1</td>
<td>65-75</td>
<td>20</td>
<td>Medium</td>
</tr>
</tbody>
</table>
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.

Storage

- Store at 0~1 °C and 60-70% RH.
- Should not be place 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

- Sapota
- Pear
- Mango
- Passion Fruit
- Guava
- Plum
- Figs
- Apple
- Kiwi
- banana
- Apricot
- Papaya
- Sapota
## Non-Climacteric 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>59-68ºF/15-20ºC</td>
</tr>
<tr>
<td>Banana</td>
<td>24-48</td>
<td>58-65ºF/14-18ºC</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>12-24</td>
<td>54-72ºF/12-22ºC</td>
</tr>
<tr>
<td>Mango</td>
<td>24-48</td>
<td>68-72ºF/20-22ºC</td>
</tr>
<tr>
<td>Pear</td>
<td>24-48</td>
<td>68-72ºF/20-22ºC</td>
</tr>
<tr>
<td>Tomato</td>
<td>24-72</td>
<td>65-68ºF/18-20ºC</td>
</tr>
</tbody>
</table>

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

---

**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. setpoint (°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>13.9-15.6</td>
<td>85-95</td>
<td>45</td>
</tr>
</tbody>
</table>

- Opt. = Optimal
- %RH = Relative Humidity
Banana Ripening

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

Low relative humidity accelerates water loss and appearance of physical damage symptoms on banana
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 Ripening**

1. **Green bananas**
2. **Load into ripening room**
3. Refrigerate for 12-16 hrs until pulp (core) temp. reaches 15-17°C, 90%RH
4. **Close room and control atmosphere @15-17°C (3-4 days), 75%RH**
5. **Vent ethylene**
6. **Discharge Ethylene into room to 0.1% concentrate (1 day)**
Banana Ripening
Banana Ripening

Mango
Mango

<table>
<thead>
<tr>
<th></th>
<th>Max. transit temp. (°C)</th>
<th>Opt. transit temp. (°C)</th>
<th>Highest freezing temp. (°C)</th>
<th>Recommended container temp. setpoint (°C)</th>
<th>%RH</th>
<th>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</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Export Fresh Mangos Process Flow

1. **Hand harvest into baskets, nets or buckets**
2. **Remove latex**
3. **Transfer to field lug boxes (shaded)**
4. **Transfer to packinghouse**
5. **Hot water quarantine treatment**
6. **Pre-size for hot water treatment**
7. **Resort defect**
8. **Portable water brush & rinse**
9. **Dump into chlorinated water**
10. **Hydro cooling**
11. **Rest 12-24 hrs at ambient temp.**
12. **Transfer to packing line & wax application**
13. **Grade according to buyer requirements**
14. **Move pallets to cold storage room prior to shipping**
15. **Forced Air cooling**
16. **Palletizing & strapping**
17. **Pack fruit into cartons by size**
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

Control atmosphere (CA)

Ethylene Scrubber
Control atmosphere (CA)

CA Door

Control atmosphere (CA)

Analyzer
Control atmosphere (CA)

Air bags to equilibrate pressure in controlled atmosphere rooms

FISHERY
Fishery

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

Frozen fish

<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>Recomm. container temp. setpoint (°C)</th>
<th>%RH</th>
<th>Air Change (cfm)</th>
<th>Ethylene Production Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatty (carp, 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></td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Lean (cod, pollock, perch)</td>
<td>240-300</td>
<td>-23.3 to -20.5</td>
<td>-23.3 to -20.5</td>
<td>Vents closed</td>
<td></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></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></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
- Washing
- Chilling, freezing, salting, drying
- QC
- External Packing

By-product
- By-product material
- Fish meal & fish oil Process
- Dehydrating
- packing
Fish Processing

- Fish Fillet
- Surimi
- Fish Finger

Surimi

1. Raw Material
2. Chilled and washed in ice water (6°C)
3. Heading and Gutting
4. Washed in ice water (6°C)
5. Deboner
6. Leaching
7. Hydraulic press
8. Pressed Meat
9. Strainer/Refiner
10. Mixing
11. Packing
12. Contact freezing (-40°C)
13. Packing
14. Cold storage (-18°C to -20°C)
15. Cold storage (-18°C to -20°C)
Shrimp Processing

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

Weigh → Tray pack → Freeze → Overwrap

Dust → Batter → Bread → Fry → I.Q.F.

Place in block tray → Block freeze → Knock out → Glaze
Freezing Technology

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

Brine Freezer
Brine Freezer

Before After

Brine Freezer

Before After
Air Blast Freezer

Contact Plate Freezer
Spiral Freezer

Tunnel Freezer
Fluidized Bed Freezer

Fluidized Bed Freezer
Cryogenic Freezer

Industrial Refrigeration
For Food Preservation

Q & A

For more information please email to
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Tel: +66-2374-4640
Industrial Refrigeration
For Food Preservation

Thank You
For Your Attention.