Why is KOOLJET Different?

Converting Agricultural Waste into Sustainable Profits

KoolJet is Focused on Leading Technologies for Sustainable Food Production. We Focus on Food Freshness and Nutrition Delivered.

- Customer Obsession – We Listen
- Passion for Invention and Innovation
- Commitment to Excellence
- Long-Term Strategic Thinking
- People Come First!

Based in Canada, Customers Worldwide
An Opportunity or **GLOBAL NECESSITY?**
Ready for 2050? UN says NO. Not even close!

How **BIG** is your Real Loss?
Weight • Quality • Reputation • Competitiveness

**6 Key Variables** Make the Difference!

Reducing Deterioration is **Profitable!**
Opportunity and Urgent Necessity!

- Clearly, the world faces a looming and growing agricultural crisis. Yields are not improving fast enough to keep up with projected demands.

- Numerous studies have shown that feeding a more populated and more prosperous world will roughly require a doubling of agricultural production by 2050 translating to a $\sim 2.4\%$ rate of crop production growth per year.

- We find that the top four global crops – maize, rice, wheat, and soybean – are currently witnessing average yield improvements only between 0.9 to 1.6 percent per year, far slower than the required rates.

United Nations, FAO, 2004
The Food Loss - How Big is it?

31% - 133 BILLION POUNDS - WORLDWIDE

Two-thirds of this 133-billion-pound loss occurred in homes, restaurants, and other away-from-home eating places, and one-third occurred in grocery stores and other food retailers. - United Nations Study

• LESS-DEVELOPED COUNTRIES
  • Food loss occurs closer to the farm and retail segments with relatively little wasted by the consumer.
  • These countries tend to have relatively inadequate cold storage, cold-transportation and access to close markets.
  • Intermediate packing and sorting houses lack effective Cold-Chain capabilities.
  • Often utilize sun-drying of grains which increases the risks of pest infestation and damage from unfavorable weather.
  • Access to effective technologies to reduce loss, track inventory and management are often lacking or poorly implemented

• DEVELOPED COUNTRIES
  • A relatively larger share of food loss occurs at the consumer end of the spectrum.
  • Food accounts for a relatively smaller share of household incomes.
  • Demand for wide variety of high-quality, cosmetically appealing.
  • The impact of convenience and snack foods.
  • There is a higher waste associated with restaurant versus home consumption

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Food Loss and Food Waste

- Consumer loss high in developed regions.
- Most loss occurs from Farm to Retail in ALL regions.

20°C versus 40°C

Difference in Waste is around 30%.
Difference in Retailer Shelf Life is Over 100%!

Cold Storage Multiplies Retailers Opportunity!

In less developed regions, relatively less food loss and waste occurs at the consumer level than at earlier stages of the food chain.

Source: Food and Agriculture Organization 2011 report by Gustavsson et al., figure 2. Converted by USDA Economic Research Service authors from kilograms to pounds and bars rearranged.
Cold-Chain Global Megatrend

Food production is **Inadequate for Projected Population Growth**

Post-harvest losses are becoming **Intolerable. Now at 31%!**

Loss Insurance will require **Documented Cold-Chain Integrity** and improved handling processes

**Shift in Focus** to Quality and Nutritional Value **Delivered**.
Take a big bite from huge waste between the Farm and Retailer.

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Factors of Deterioration

HEAT AFFECTS ALL OF THE FACTORS OF HARVEST VALUE LOSS

- **Respiration Rate** – Transpiration uses up plant resources. Get it Cool and Keep it Cool.
- **Water Loss** – Control Relative Humidity and Gas Exchange. Water Loss is cumulative.
- **Physical Damage** – Assure proper handling and eliminate handling processes
- **Microbial and Pathogens** – Affected by heat, water and surface cuts
- **Ethylene Presence** – Assure proper air-flow and mix sensitive products correctly

HEAT DIRECTLY AFFECTS THE COST OF LOSS

- Studies show average of **19-20%** of total value **LOST**.
- Loss Of Quality and Salability
  - Senescence, Water Loss, Shriveling, Rot, Browning, Necrosis, Poor Flavor
  - Represents loss in value invested, infrastructure and profit
  - Cold-chain gaps cause deterioration when products are transferred to warmer climate

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“The storage life of produce varies inversely with the rate of respiration. Products with a high rate of respiration have a shorter shelf life than those with a lower rate of respiration. In plants, respiration increases rapidly with Temperature” Postharvest Laboratory

“Respiration is the metabolic activity of the tissue that also includes the loss of substrate, the synthesis of new compounds, and the release of heat energy. The higher the respiration rate, the more perishable the commodity usually is; that is, the shorter postharvest life it has.” USDA

For every 10°C rise in Temp, **Respiration rises 2 to 3 times!**
## Respiration Rate and Decay

### Temperature Q-10 Value

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Q-10 Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 10°C</td>
<td>2.5 to 4.0</td>
</tr>
<tr>
<td>10 to 20°C</td>
<td>2.0 to 2.5</td>
</tr>
<tr>
<td>20 to 30°C</td>
<td>1.5 to 2.0</td>
</tr>
<tr>
<td>30 to 40°C</td>
<td>1.0 to 1.5</td>
</tr>
</tbody>
</table>

### Temperature Q-10 Value

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Q-10 Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°C to 10°C</td>
<td>2.5 to 4.0</td>
</tr>
<tr>
<td>10°C to 20°C</td>
<td>2.0 to 2.5</td>
</tr>
<tr>
<td>20°C to 30°C</td>
<td>1.5 to 2.0</td>
</tr>
<tr>
<td>30°C to 40°C</td>
<td>1.0 to 1.5</td>
</tr>
</tbody>
</table>

### Relative Velocity of Deterioration

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Relative Velocity of Deterioration</th>
<th>Relative Shelf Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°C</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>10°C</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td>20°C</td>
<td>7.5</td>
<td>13</td>
</tr>
<tr>
<td>30°C</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>40°C</td>
<td>22.5</td>
<td>4</td>
</tr>
</tbody>
</table>

 Authorities in Food-Processing and Agricultural Cooling Technologies
The High Cost of Cooling Delay

Predicted Impact of Delay Hours Before First Cooling - Strawberries

PERCENT MARKETABLE FRUIT

HOURS POST-HARVEST BEFORE INITIAL COOLING

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Importance of Rapid Deep Cooling

THE PHYSIOLOGY OF DETERIORATION
Harvested plants must quickly cooled to their holding temperature, often 0-5°C. They continue life processes and rely on its own resources, generating heat. This is known as “Vital Heat”
• It must use this stored energy as it exchanges oxygen with carbohydrates to produce chemical energy, carbon dioxide, water and heat for its natural life-processes.
• Resource use is **most active immediately after harvest**. Immediate cooling is required to slow these processes in order to obtain superior appearance and nutrition for the longest period.

RAPID FIELD COOLING HAS GREATEST EFFECT - AVOID COLD-CHAIN GAPS
• Rapid field-heat cooling has the highest positive effect on product and nutritional life.
• Negative effects of **Gaps in the Cold-Chain are Cumulative** and increase the **Rate of Decay**.
  • Gaps at the harvest and first critical pre-cooling to remove field heat.
  • Transfer and handling points at the farm and packing house, loading and unloading.
  • Gaps during transportation. Plant and road heat, accumulation of gases inside the load.
  • Temperature variations at the wholesale, packaging and retail customers.
  • Exposing cold fresh vegetables to warm moist air condenses moisture on the produce and invites spore generation and disease.

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Cold-Storage Requirements

Respiration/Decay Rate Versus Storage Temperature

- Asparagus
- Beans, Snap
- Beans, Long
- Beets
- Blueberry
- Broccoli
- Orange
- Spinach
- Squash

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Decay - Holding Time and Temp

Percent of Fruit Showing Decay versus Temperature
Cranberries - After THREE Months

0°C | 32°F

5°C | 41°F

10°C | 50°F

15°C | 59°F

Ben Lear
Franklin
Pilgrim
Stevens

Authors in Food-Processing and Agricultural Cooling Technologies
Decay - Holding Time and Temp

Percent Of Fruit Showing Decay versus Temperature
Cranberries - After FOUR Months

Authors in Food-Processing and Agricultural Cooling Technologies
Decay - Holding Time and Temp

Dollar Cost of LOST Commodities
Cranberries - After **THREE** Months

2,000 Lb Harvest
$0.35 per Pound
$35 per 100Lb Barrel
30% with Decay Discarded

- **5°C | 41°F**
  - Ben Lear: $31.50
  - Franklin: $5.25
  - Pilgrim: $0.00
  - Stevens: $0.00

- **10°C | 50°F**
  - Ben Lear: $175.35
  - Franklin: $107.10
  - Pilgrim: $50.40
  - Stevens: $42.00

- **15°C | 59°F**
  - Ben Lear: $406.35
  - Franklin: $317.10
  - Pilgrim: $227.85
  - Stevens: $95.55

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Decay - Holding Time and Temp

Dollar Cost of LOST Commodities
Cranberries - After **FOUR** Months

- 2,000 Lb Harvest
- $0.35 per Pound
- $35 per 100Lb Barrel
- 30% with Decay Discarded

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Decay - Holding Time and Temp

Dollar Cost of LOST Commodities
Cranberries - After **THREE** Months

- 300,000 Lb Harvest/Warehouse
- $0.35 per Pound
- $35 per 100Lb Barrel
- 30% of Decay Discarded

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Ben Lear</th>
<th>Franklin</th>
<th>Pilgrim</th>
<th>Stevens</th>
</tr>
</thead>
<tbody>
<tr>
<td>5°C / 41°F</td>
<td>$157.50</td>
<td>$945.00</td>
<td>$1,260.00</td>
<td>$2,866.50</td>
</tr>
<tr>
<td>10°C / 50°F</td>
<td>$1,260.00</td>
<td>$3,213.00</td>
<td>$5,260.50</td>
<td>$6,835.50</td>
</tr>
<tr>
<td>15°C / 59°F</td>
<td>$12,190.50</td>
<td>$9,513.00</td>
<td>$6,835.50</td>
<td>$2,866.50</td>
</tr>
</tbody>
</table>

*Authorities in Food-Processing and Agricultural Cooling Technologies*
Decay - Holding Time and Temp

Dollar Cost of LOST Commodities
Cranberries - After FOUR Months

300,000 Lb Harvest/ Warehouse
$0.35 per Pound
$35 per 100Lb Barrel
30% of Decay Discarded

Authors in Food-Processing and Agricultural Cooling Technologies
Decay - Holding Time and Temp

Dollar Cost of LOST Commodities
Cranberries - After **FOUR** Months

400,000 Barrel Country Harvest
$0.35 per Pound
$35 per 100Lb Barrel
30% of Decay Discarded

- **5°C | 41°F**
  - Ben Lear: $2,625.00
  - Franklin: $15,750.00
- **10°C | 50°F**
  - Ben Lear: $21,000.00
  - Franklin: $53,550.00
  - Pilgrim: $87,675.00
- **15°C | 59°F**
  - Ben Lear: $47,775.00
  - Franklin: $113,925.00
  - Pilgrim: $158,550.00
  - Stevens: $203,175.00

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Effective Cold-Chain Technology

• **TEMPERATURE**
  - Field-Heat Pull-Down Rate
  - Holding Temperature

• **RELATIVE HUMIDITY**
  - Adding and Removing Vapor

• **AIR FLOW**
  - Precise Delta-T across the Product
  - Ethylene Balance

• **O₂ and CO₂ BALANCE**
  - Facilitate Respiration Gas Exchange
  - Eliminate O₂ build up

• **SELLABLE SHELF LIFE**
  - Size, Weight and Appearance
  - Color, shrivel, crispness

• **RETIRED NUTRITION**
  - 80% nutrition retained

• **REDUCED RETAILER SCRAP**
  - Reduced decay rate

• **MARKET REPUTATION**
  - Known for quality in the home
  - Ability to store more days

ALLOWS FARMER TO HARVEST AT THE OPTIMUM TIME FOR THE BEST CONSUMER EXPERIENCE

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Temperature and Humidity

**TEMPERATURE**
- Most Important Loss-Prevention factor. Many cold-storage facilities are inadequate.
- Plant deterioration rate increases dramatically with temperature and begins immediately.
- Field Heat removal has disproportional effect on product life, water loss, appearance, nutrition.
- Holding produce in low-temp, high RH environment provides supply-chain flexibility.
- Temperature must be controlled AT THE PLANT TISSUE. Dictates Cold Storage design.
- Air velocity across plants and refrigeration coils control temperature change to less than 1°F.
- Proper cold-storage design prevents freeze and chilling injury using sensitive controls.
- Cold-Chain must have ability to operate at “Safe-Hold” temperatures by commodity.

**HUMIDITY**
- Humidity helps control commodity water loss, reduce shriveling and retain selling weight.
- Control of condensation while delivering very high RH is required for most commodities.
- Contained chamber design with vapor barriers, modern controls and variable air flow maintains high humidity at a given temperature without risk of condensation.
- Sense and control the Vapor Pressure Difference between the commodity and environment.
Cold-Chain Strategies - TIME

**TIME** - This is the ALL CONTROLLING CONSTRAINT

How much TIME is required between a farmer’s harvest and the consumer’s dinner plate? This alone dictates the level of Cold-Chain technology required for a positive NET pay-off to farmer, intermediaries, retailers and consumers. Minutes Matter.

Developing Countries - The Cold Chain Challenge

- Low farm labor costs, manpower and capital to own and operate effective equipment
- Rapid field-heat temperature pull-down is largely not done. Some use sun-drying.
- Need for Education. Handling, Methods, Processes and Equipment operation
- Few local cold-chain resources at harvest. Quick access to proper cooling is lacking or filled.
- Farmers resort to allowing harvest to remain in the field too long due to storage constraints.
- Significantly longer transportation and staging times from farm to market are common.
- Transportation vehicles may not be refrigerated. Some use piles. Loading docks are open.
- Some share open trucks between farmers and deliver to common staging, sorting, holding.
- Some export markets are eliminated due to inability to meet overseas shipment timing.
- Focus on maximizing cold-chain processes beginning at the farm, soon after physical harvest

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Absolute Control over SIX CRITICAL VARIABLES

- **Time** - Level of technology varies with the time available from harvest to markets
- **Temperature** - including Field-Heat Pull-Down rate, oversized evaporator coils
- **Relative Humidity** - often requires adding vapor and adjusting air-flow
- **Air-Flow Rate** - Carefully facilitate gas-exchange at plant tissues, No Condensation
- **Gas Levels** - Oxygen, Co2, Ethylene balance. Effect desired ripening and senescence

**DESIGN REQUIREMENTS**

- Provide Self-Contained Modular Refrigeration Equipment, Zoned, Expandable Storage
- Adequate for **Flexibility**. Differing product temperature profiles, loads, harvest size and timing
- Provide Air-Flow patterns **through the product**, Not Just Around Bins, Use Loading Strategy
- Provide a complete Vapor-Barrier and high quality insulation for the Environment
- Provide Access for loading/unloading and a Sealed Doorway, Automatic Door is Best
- Provide touch-screen PLC controls with sensitive RTD sensors having NIST-Standard calibration
- Use correct Refrigeration System for **Rapid Pull-Down of Field-Heat without Condensation.**
- Measure and Control on Commodity Temperature, Not Return Air Temperature
- **Avoid Variance in Temperature** during Handling, Loading, Transportation. Pre-cool Trucks

**Authorities in Food-Processing and Agricultural Cooling Technologies**
## Common Storage Temperatures

<table>
<thead>
<tr>
<th>Produce Type</th>
<th>0-2°C</th>
<th>32-36°F</th>
<th>4-7°F</th>
<th>40-45°F</th>
<th>7-10°C</th>
<th>45-50°F</th>
<th>13-18°C</th>
<th>55-65°F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vegetables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not ethylene sensitive</td>
<td>Alfalfa, Artichoke, Bean Sprouts, Beet, Radicchio, Shallot, Sweet Corn, Chard, Turnip, Watercress</td>
<td></td>
<td></td>
<td>Calabaza, Haricot Vert, Bell Pepper</td>
<td>Cassava, Jicama, Sweet Potato, Taro, Yam, Tomato, ripe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fruits &amp; Melons</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low ethylene sensitive</td>
<td>Cherry, Blackberry, Blueberry, Coconut, Current, Date, Grape</td>
<td>Cactus Pear, Kumquat, Olive, Pomegranate, Tamarind, Tangerine</td>
<td>Tangelo, Casaba, Cranberry, Grapefruit, Lemon, Lime, Pineapple</td>
<td>Breadfruit, Canisteo, Grapefruit CA,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethylene Producing</td>
<td>Apple, Apricot, Ripe Avocado, Cantaloupe, Cut Fruits, Kiwi, Nectarine, Pear, Plum, Prune, Quince</td>
<td>Feijoa, Guava, Honeydew, Persian Melon</td>
<td>Unriope, Crenshaw Melon, Passion Fruit, Sugar Apple</td>
<td>Banana, Jackfruit, Mango, Mangosteen, Plantain, Sapote</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dry Vegetables</strong></td>
<td>Dry Onion, Garlic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ginger, Pumpkin, Squash</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vegetables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethylene sensitive</td>
<td>Arugula, Asparagus, Endive, Broccoli, Cabbage, Carrot, Cauliflower, Celery, Chard, Onion, Mushroom</td>
<td>Snap Beans, Cactus, Fava Bean, Lima Bean, Potato, Peas</td>
<td>Basil, Cucumber, Eggplant, Kiwano, Chile Pepper, Tomatillo, Watermelon</td>
<td>Early Crop Potato, Mature Green Tomato</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ethylene sensitive Vegetables should not be mixed with Ethylene producing Fruits during transportation and storage.
# Five Common Cooling Methods

<table>
<thead>
<tr>
<th>Room Cooling (20-100 hours)</th>
<th>Forced Air Cooling (1-10 hours)</th>
<th>Hydrocooling (0.1-1 hour)</th>
<th>Flake Ice Cooling (0.1-0.3 hours)</th>
<th>Vacuum Cooling (0.3-2 hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artichoke, Banana, Dry Beans, Beet, Cabbage, Cactus, Cassava, Coconut, Garlic, Ginger, Horseradish, Kumquat, Lime, Lemon, Melons, Onion, Orange, Cucumber, Pineapple, Potato, Pumpkin, Radish, Sweet Potato, Turnip, Watermelon</td>
<td>Avocado, Banana, Berries, Brussel Sprouts, Cassava, Coconut, Cucumber, Eggplant, Fig, Ginger, Grape, Guava, Kiwi, Lima Bean, Mango, Melons, Mushroom, Okra, Orange, Papaya, Passion Fruit, Bell Pepper, Pumpkin, Snap Beans, Snow Peas, Summer Squash, Tangerine, Tomato</td>
<td>Artichoke, Asparagus, Beet, Endive, Broccoli, Brussel Sprouts, Cantaloupe, Cauliflower, Carrot, Celery, Cucumber, Eggplant, Escarole, Kiwi, Leek, Lima Beans, Orange, Parsley, Peas, Pomegranate, Spinach, Sweet Corn, Watercress</td>
<td>Endive, Broccoli, Brussel Sprouts, Carrot, Cauliflower, Cabbage, Escarole, Leek, Lettuce, Lima Beans, Green Onion, Spinach, Snap Peas, Snow Peas, Sweet Corn, Watercress</td>
<td>Endive, Broccoli, Brussel Sprouts, Carrot, Cauliflower, Cabbage, Escarole, Leek, Lettuce, Lima Beans, Mushroom, Snap Peas, Snow Peas, Swiss Chard, Watercress</td>
</tr>
</tbody>
</table>

“Recirculated water must be constantly sanitized to minimize accumulation of decay-causing pathogens.” Thompson et al. 1998
<table>
<thead>
<tr>
<th>Crop</th>
<th>Holding Temp. Degrees C</th>
<th>Relative Humidity</th>
<th>Storage Life, Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>-1 to 4</td>
<td>90-95</td>
<td>30-180</td>
</tr>
<tr>
<td>Apricot</td>
<td>-.5 to 0</td>
<td>90-95</td>
<td>7-21</td>
</tr>
<tr>
<td>Artichoke</td>
<td>0</td>
<td>95-100</td>
<td>14-21</td>
</tr>
<tr>
<td>Asparagus</td>
<td>0 to 2</td>
<td>95-100</td>
<td>14-21</td>
</tr>
<tr>
<td>Avocado</td>
<td>3-13</td>
<td>85-90</td>
<td>14-56</td>
</tr>
<tr>
<td>Banana</td>
<td>13-15</td>
<td>90-95</td>
<td>7-28</td>
</tr>
<tr>
<td>Basil</td>
<td>7-10</td>
<td>85-95</td>
<td>7</td>
</tr>
<tr>
<td>Bean, Dry</td>
<td>4-10</td>
<td>40-50</td>
<td>180-300</td>
</tr>
<tr>
<td>Beet</td>
<td>0</td>
<td>98-100</td>
<td>10-14</td>
</tr>
<tr>
<td>Broccoli</td>
<td>0</td>
<td>95-100</td>
<td>14-21</td>
</tr>
<tr>
<td>Cabbage</td>
<td>0</td>
<td>98-100</td>
<td>150-180</td>
</tr>
<tr>
<td>Carrot</td>
<td>0</td>
<td>98-100</td>
<td>14</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>0</td>
<td>95-95</td>
<td>21-28</td>
</tr>
<tr>
<td>Celery</td>
<td>0</td>
<td>98-100</td>
<td>30-90</td>
</tr>
<tr>
<td>Cherries</td>
<td>-1 to 0.5</td>
<td>90-95</td>
<td>14-21</td>
</tr>
<tr>
<td>Coconut</td>
<td>0-1.5</td>
<td>80-95</td>
<td>30-60</td>
</tr>
<tr>
<td>Eggplant</td>
<td>8-12</td>
<td>90-95</td>
<td>7</td>
</tr>
<tr>
<td>Garlic</td>
<td>0</td>
<td>65-70</td>
<td>180-210</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>10-15</td>
<td>85-90</td>
<td>42-56</td>
</tr>
<tr>
<td>Lemon</td>
<td>9-10</td>
<td>85-90</td>
<td>42-56</td>
</tr>
<tr>
<td>Mushrooms</td>
<td>0-1.5</td>
<td>95</td>
<td>5-7</td>
</tr>
<tr>
<td>Papaya</td>
<td>7-13</td>
<td>85-90</td>
<td>7-21</td>
</tr>
<tr>
<td>Tomato</td>
<td>8-10</td>
<td>90-95</td>
<td>8-10</td>
</tr>
<tr>
<td>Watermelon</td>
<td>16</td>
<td>70-80</td>
<td>60-120</td>
</tr>
</tbody>
</table>
# Temperature Curing for Quality

<table>
<thead>
<tr>
<th>Crop</th>
<th>Improvement</th>
<th>Method</th>
<th>Use</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>Increased firmness</td>
<td>HAT</td>
<td>38°C, 4 days;</td>
<td>Klein &amp; Lurie 1992</td>
</tr>
<tr>
<td>Asparagus</td>
<td>Inhibited curvature</td>
<td>HWT</td>
<td>47°C, 2-5 min</td>
<td>Paull &amp; Chen 1999</td>
</tr>
<tr>
<td>Broccoli</td>
<td>Decreased yellowing</td>
<td>HWT</td>
<td>50°C, 2 min</td>
<td>Forney 1995</td>
</tr>
<tr>
<td>Collard</td>
<td>Decreased yellowing</td>
<td>HAT</td>
<td>45°C, 30 min</td>
<td>Wang 1998</td>
</tr>
<tr>
<td>Onions</td>
<td>Inhibited elongation</td>
<td>HWT</td>
<td>55°C, 2 min</td>
<td>Hong et al. 2000</td>
</tr>
<tr>
<td>Guava</td>
<td>Decreased softening</td>
<td>HWT</td>
<td>46°C, 35 min</td>
<td>McGuire 1997</td>
</tr>
<tr>
<td>Kale</td>
<td>Decreased yellowing</td>
<td>HAT</td>
<td>40°C, 60 min</td>
<td>Wang 1998</td>
</tr>
</tbody>
</table>

Rangann et al. 1998

**KoolJet can integrate Temperature Curing Regimes into our Products**

*Authorities in Food-Processing and Agricultural Cooling Technologies*
## Pest and Pathogen Control

**Fruit Flies**  | **Fruit Treated**  | **Method**  | **Use**  | **Reference**  
--- | --- | --- | --- | ---  
Caribbean | Grapefruit, Mango, Orange | HAT 52°C, 125 min | Klein & Lurie 1992  
Medit | Avocado, Mango, Papaya | HAT 40°C, 24 hours | Paull & Chen 1999  
Mexican | Grapefruit | HAT 44°C, 2 hours | Forney 1995  
Oriental | Cucumber | HAT 46°C, 1 hour | Wang 1998  
Rose Beetle | Lemon | HAT 40°C, 10 hours | Hong et al. 2000  
Mealy Bug | Apples | HWT 46°C, 35 min | McGuire 1997  
Spider Mite | Kiwi | HAT 44°C, 211 min | Wang 1998  

Ref. USDA 2016, Susan Lurie and Joshua D. Klein

HWT: hot water treatment  
HAT: high-temperature forced-air treatment

**KoolJet can integrate Temperature Curing Regimes into our Products**

*Authorities in Food-Processing and Agricultural Cooling Technologies*
Control of **Oxygen, Carbon-Dioxide and Ethylene**

- Causes produce to experience longer shelf life with higher nutrients.
- Slows plant respiration to conserve the use of available nutrients and energy.
- Maintaining a low Oxygen level helps to preserve plant nutrients.
- Ethylene is a natural gas produced during ripening and affects the Rate of Decay. Prevents Ethylene buildup using catalytic absorbers for removal to 1 part per billion!
- Ethylene Absorbers eliminate fungal growth and bacteria.
CA Environments modify the concentration of atmospheric gases. CA supplements cold-storage temperature and RH management by further reducing tissue respiration and ethylene production rates. CA is an effective Insect and Pathogen counter-measure without using chemicals and pesticides.

Oxygen and Carbon-Dioxide Balance | Ethylene Balance | Temperature Curing

- An effective fungicidal CA treatment raises CO2 above 10-15%
- An effective insecticidal CA reduces O2 to under 2% and/or raise CO2 above 40%
- Ethylene action can be inhibited by elevating CO2 levels
- CA slows down cell wall degrading enzyme activity and toughening of vegetables
- Ascorbic acid and other vitamins are better retained, resulting in improved flavor
- Chilling injury and some storage disorders can be alleviated by CA
- CA inhibits development of botrytis rot on strawberries, cherries, and other perishables
- Atmospheric modifications are especially suitable for long distance transportation
- Semi-permeable product packaging is used for CA shipments
From Problems to Solutions

- **Cold-Chain is as Strong as its Weakest Link**
  - Processes and Handling Methods results in mechanical damage and rapid deterioration
  - Cold Storage at Correct Temperature and RH decreases transpiration rate and decay
  - Transportation in Low-Temp, High-RH Cold-Chain Modules maintains integrity of Cold-Chain
  - High-humidity Control affects water loss, shrivel rate and appearance
  - Proper Air Flow Through the Product for proper oxygen, CO2 and ethylene gas exchange

- **Cold-Chain Investments Reduce Revenue Loss**
  - Preserve shelf-life, sellable weight, appearance, flavor and nutrition. Benefit to Markets
  - Variability along the Supply Chain Kills Plant Tissues and Profits. Minutes Actually Matter
  - Precise Temperature and RH Control and Containment eliminates use of chemical pesticides.

10%-15% Direct Loss in Value due to poor Cold-Chain

UC Davis

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Cold-Chain Solutions

HYDROCOOLING and FORCED-AIR COOLING

- Cost-Effective Flexible Approach
- Engineered for Agricultural Use
- Effective Field-Heat Removal
- Effective Gas Exchange Air Volume
- Energy Efficient Modular Designs
- Designed for Easy Installation

Authorities in Food-Processing and Agricultural Cooling Technologies
Rapid Hydro-Cooling of Field Heat

- Chillers and Complete Systems. Central and Portable
- Includes High-Volume Pumping and Debris Strainers
- Easy Access for Cleaning and Service

Authorities in Food-Processing and Agricultural Cooling Technologies
Blast Freezers Cool Products Quickly

- **Ultra-Low Temp** - Freezer systems maintain a working temperature of -4°F (-20°C). If necessary, the building temperature can be lowered to -22°F (-30°C). We have designs to MINUS 70°

- **Stop Bacteria** - Blast Freezers are designed for rapid freezing of product. Rapid freezing helps prevent bacteria in food produce.

- **Independent Circuits** – Two independent refrigeration circuits, provide greater System Reliability and Operating Cost Efficiency.
Cold-Storage Warehouse Cooling

Tunnel and Forced-Air Cooling
Cold-Storage Warehouses
Greenhouse Cooling Systems
Rapid Pull-Down and Hold Modes
Zoned Temperature Control
Blast-Freezer Systems
Through-the-Wall Designs
Multiple Circuits that Save Energy!

Authorities in Food-Processing and Agricultural Cooling Technologies
Agricultural Cooling is Specialized

- **High Pull-Down-Rate is Critical** for maximizing product life. Utilize dual-circuit staging to reduce energy during holding temperature mode. Seal room air leaks.
- Cooling perishables requires operation at *ultra-low temperatures down to -75F* and *high CFM air volume*. Optimal *humidity up to 98%* is also required.
- Coils use flat fins, are oversized and designed with wide fin-spacing to reduce pressure loss and frost build-up. This *reduces fan horsepower for high velocity air*.
- Defrost cycles are disruptive to the Cold-Chain. Design a *hot-gas nozzle bypass to shorten the defrost times*.
- All piping and drain pans must be well insulated to *avoid condensation dripping*.
- Use only *food-grade rust-proof materials* for system components in the air stream.
- The freezer system must be designed for *rapid disassembly for frequent cleaning and technician access to key components*.
Cold-Storage with FREE-COOLING

- Fully Automatic Free-Cooling Operation
- Allows Outside-Air to Assist Mechanical Cooling
- Self-Contained Through-the-Wall System
- Designed for Agricultural Temperatures and Flows
- Energy Efficient Engineering
Easy Through-the-Door Cooling

Unitized Split Refrigeration System

- Effective, Reliable Through-the-Wall or Door System.
- Powerful and Energy-Efficient Fan Cooling.
- System minimizes the moisture loss from the product and maximizes product shelf life.
- Axial fans include deep venturi for higher air-throw.
- Evaporator coil is designed for ultra-high humidity.
- GREATLY Simplified installation and service access.
- NO field assembly needed – Save Thousands!
- Panel-mounted disconnect saves electrical install cost.
- Very simple and quick to relocate if needed.
- Dual-circuit designs effect rapid pull-down and holding temps at maximum energy efficiency.
- Premium components for maximum uptime.
- Variable speed condenser fans match ambient conditions to save energy cost.
Easy Through-the-Wall Cooling

Effective Cold-Storage Cooling
Modern and Easy to service
Simple unitized installation
No exposed refrigerant piping

Authorities in Food-Processing and Agricultural Cooling Technologies
Self-Contained Rooftop mounted refrigeration systems
Wine Production Chiller Systems

- Wine Chillers and Pumping Systems for cooling winery process tanks
- Designed to serve wine tank farms at different temperatures and intervals
- The fermentation process can be stopped at any desired temperature
- KoolJet systems are effective for cold stabilization wine processing
- When tank temperatures are reached, KoolJet stages refrigeration compressors, saving up to 40% in energy!
Dedicated Cold-Chain Solutions

HYDROCOOLING SYSTEMS
Blast-Freezers
Forced Air Systems
Tunnel Cooling
Cold-Chain Modules
Cold-Storage Rooms
Winery Chilling Systems
Modular Systems
Pumping Stations
Heat Transfer Skids