Ripening Temperature Management

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Why Ripen?

Why Temperature Management is Important for Fruits

#1 is to prolong **Shelf Life** ( = maintain initial quality)

- Slow down ripening (The rate of biochemical reactions varies with temperature)
- Quickly reach the optimum temperature to maintain quality (Requires fast and efficient cooling after harvest)
- Maintain the cold chain (Avoid re-warming)
Passive Pallet Warming/Cooling

7.5 hours
10 hours
81 hours
62 hours

Figure from C. Crisosto

FAST COOLING
(within 6-8 hours)

Forced-air or pressure cooling also results in more uniform product temperatures

Forced-air Cooling

Banana Pressure Ripening

(Forced-air or Pressure Cooling applied to ripening)
Why Temperature Management is Important for Fruits

#2 is to avoid Chilling Injury (CI)
- Fruits of subtropical/tropical origin (e.g., avocado, banana, mango, papaya, tomato, etc.)
- Time-temperature relationship for CI
- Maturity and variety influence CI susceptibility and symptoms

Chilling Injury

Fruits & vegetables of subtropical or tropical origin are sensitive to low temperatures
- The temperatures that cause CI are usually below 45 to 59°F (7.2 to 15°C), depending on the species and variety
  ➢ 45 to 59°F are the “threshold” temperatures, at or above which no CI will occur

More mature/riper fruit are less susceptible to chilling injury

(Note: this is the purpose of stone fruit preconditioning)

Chilling Injury Symptoms

1. Loss of aroma develops first and may never be recovered
2. Lenticel discoloration is the earliest visual symptom
3. Skin discoloration (gray or brown appearance) and vascular browning are the next symptoms
4. Scald-like skin collapse, pitting, & internal browning appear last

Why Temperature Management is Important for Fruits

#3 is to manage Ripening
- Temperature influences ripening changes
  - Color (which pigments are favored)
  - Texture (enzymatic cell wall changes)
  - Flavor (taste and aroma compounds biosynthesis)
- There are different optimum ripening temperatures for different fruits to achieve optimum quality
- Higher temperatures can inhibit ripening or cause heat injury
High Temp Injury

Optimum Fruit Ripening

GROUP II: Chilling Sensitive

GROUP I: Non-Chilling Sensitive

IDEAL TRANSIT/STORAGE

Chilling Injury

Freezing Injury

High Temperature Damage During Ripening

Heat damage >95°F (35°C) ⇔ Chilling damage <56°F (13.3°C)

Chilling injury results if mature-green bananas are exposed for:
- 1 hour at 58°F (10°C),
- 5 hours at 55°F (11.7°C),
- 24 hours at 54°F (12.2°C), or
- 72 hours at 55°F (12.8°C)

> 56°F (13.3°C) is the chilling threshold (no injury)

When Is Temperature Management Important with Regard to a Ripening Program?

1. Before ripening
   - To avoid CI; to precondition fruit

2. During ripening
   - To achieve the best combination of quality attributes

3. After ripening
   - Avoid over-ripening; extend shelf life
Pre-Ripening Temperature Effect on Ripening

- A cold storage period can overcome ethylene needs (e.g., kiwifruit and European pears).
- Practical implications of low or high pre-ripening temperatures.

Post-Ripening Temperature Management

Unless you want the fruit to continue ripening, store them at their **lowest safe temperature** until ready for retail display:

- 32°F (0°C) for non-chilling sensitive fruits
- 36 to 58°F (2.2 to 14.4°C) for chilling sensitive fruits (the specific temperature depends on the type of fruit)
- These are lower temperatures than for the unripe fruit!

Product Flow Through the Preconditioning Process

- Holding/Cooled Fruit
- Warm Packing
- Packaging: Wax & Fungicide, Segregation
- Preconditioning: e.g., Peaches: 2 days at 65 to 68°F (18 to 20°C)
- Forced Air Cooling

Temperature-related Best Handling Practices (BHPs) From Farm to Consumer

- Harvesting and Packinghouse
- Transport
- Importers & DCs
- Retail Stores
Harvest
- Harvest during the cooler parts of the day
- Keep harvested fruit shaded

Transport to the Packinghouse
- Minimize delays after harvest
- Cover the fruit to protect them from the sun

Reception at the Packinghouse
- Minimize delays before unloading
- Unload the fruit in a shaded area and handle them in the order they are received

Hot Water Quarantine Treatment
- Mangos exported to the U.S. must be immersed in 115 °F (46.1 °C) water for 65 to 110 minutes depending on variety and fruit size in USDA APHIS-certified hot water treatment systems
Hydrocooling & Staging for Packing

- After heat treatment, the mangos (now at 46 °C) should be cooled in water that is no cooler than 70 °F (21.1 °C) as prescribed by APHIS.
- Stage the fruit in a shaded area.

Sorting & Packing

- The most important temperature management practice during this step is to minimize the time for sorting & packing.

Forced-air Cooling & Refrigerated Storage

- Quickly cool fruit to their optimum storage and transport temperature [55°F (12.8°C) for mangos].
- Fruit may be stored, or held only long enough to accommodate shipping schedules.

Staging and Loading for Transport

- Cool fruit to the shipper-specified carrying temperature before loading refrigerated containers and trailers.
- Pre-cool container, then turn off reefer unit.
- Load container to facilitate airflow.
- Install temperature recorders (front, middle, rear).
Transport to the U.S.

- Marine containers are accumulated and held at port container facilities until loaded onto a vessel.
- The transit time to reach market can vary from a few days to several weeks.

Mango shipment from Sinaloa, Mexico to Texas (2 days); setpoint 50°F (10°C)

- Fruit pulp temperatures ranged from 7°C to 29°C when loaded into the trailer.

Mango shipment from Brazil to New Jersey (20 days); setpoint 50°F (10°C)

- Fruit pulp temperatures ranged from 9°C to 11°C when loaded into the container.

Importer/Distribution Center

Unloading on Arrival

- Refrigerated dock
  - Leave trailer refrigeration running when the dock is at or below trailer set point
  - Turn off refrigeration when the dock is warmer than the trailer set point
- Move pallets directly from the dock to the cold storage area
- Inspect fruit in the cold storage area prior to placing the pallets on racks.
**Importer/Distribution Center**

**Initial Inspection**
- Immediately measure pulp temperature
- 1 or 2 QC inspectors for uniform results
- Sample procedure
  - By lot: variety, grade
  - By location: front, middle, rear, top, center, bottom on both sides
- Photograph fruit, cartons, pallets

**Importer/Distribution Center**

**Re-working fruit**
- Do this in a refrigerated area
- Follow BHPs for food safety (hygiene)
- Handle the fruit gently
- Return the fruit to the same boxes to maintain trace-back

**Importer/Distribution Center**

**Storage**
- Store pallets on racks at optimum temperature for the fruit
- Maintain relative humidity at 90 to 95%
- Scrub ethylene gas from cold room or achieve one fresh air exchange each day
- FIFO (First in, First out) or FEFO (First expired, First out)

**Ripening Rooms**
- Ripening rooms for bananas can be used to ripen avocados, kiwifruit, mangos, melons, papayas, European pears, and tomatoes
- Ethylene gas applied to initiate ripening
- Pressurized or forced-air ripening rooms quickly reach and then maintain uniform fruit temperatures
### Best Conditions for Ripening Different Fruits

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Exposure time (hours)(^1)</th>
<th>Range of ripening temperatures(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avocado</td>
<td>8 to 48</td>
<td>59-68°F (15-20°C)</td>
</tr>
<tr>
<td>Banana</td>
<td>24 to 48</td>
<td>58-65°F (14-18°C)</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>12 to 24</td>
<td>54-72°F (12-22°C)</td>
</tr>
<tr>
<td>Mango</td>
<td>24 to 48</td>
<td>68-72°F (20-22°C)</td>
</tr>
<tr>
<td>Pear</td>
<td>24 to 48</td>
<td>68-72°F (20-22°C)</td>
</tr>
<tr>
<td>Tomato</td>
<td>24 to 72</td>
<td>65-68°F (18-20°C)</td>
</tr>
</tbody>
</table>

\(^1\) Shorter durations are for more mature fruit

\(^2\) Faster ripening occurs at higher temperatures within the range

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### Importer/Distribution Center

#### Staging for Delivery Shipments
- Use a refrigerated staging area – 55 to 59°F (12.8 to 15°C)
- If the dock area cannot be properly refrigerated, stage loads in the cold storage area
- Protect the dock/staging area from the sun
- Load pallets directly from a refrigerated area into the trailer to avoid warming

#### Loading Trailers
- Inspect each trailer for cleanliness; clean and sanitize if necessary
- Schedule routine trailer inspections for damage, water leaks, reefer unit operation
- Develop a loading plan to ensure best location for mixed loads with regard to temperature requirements
**Importer/Distribution Center**

**Loading Trailers**
- Use air bags or bracing for spacing between pallets and between pallets and trailer walls for improved temperature management
- Maintain recommended temperature settings
- Minimize exposure of fruit to outside temperatures during loading and unloading

**Retail Store**

**Unloading/Holding on Docks**
- Educate personnel about produce temperature requirements and proper temperature management
- Minimize the time when trailer doors are open during unloading
- Designate someone to be responsible for product placement (back room or cooler?)
- Perform QC inspection upon delivery (provide prompt feedback of inspection results to the DC)

**Retail Store**

**Storage in Walk-In Coolers?**
- Store all fruits at proper temperatures
  - Avoid chilling temperatures (use back room instead of cooler)

**Retail Store**

**Walk-In Coolers**
- Produce manager should regularly inspect back room and cooler area
  - Minimize time that walk-in cooler doors are open
  - Use strip curtains on walk-in cooler doors
  - Properly place calibrated thermometers in back room and cooler
Retail Store

Stocking, Display Preparation, Rotation
- Avoid “storing” fruits at the store
  - display fruit upon delivery
  - order more frequently
- Display at ambient temp. (by size, ripeness stage, variety)
- Inspect the displays several times a day; remove any out-of-grade fruit

A Note on Recordkeeping

Keeping records is an important part of a quality assurance program
- Assign an employee for the quality control (QC) program
- Prepare a list of all operations and procedures
- Develop a list to record all operations and procedures and when performed
- Include temperature records!

Conclusions

- Choose appropriate temperatures:
  - Optimum storage temperatures to slow ripening and avoid chilling injury
  - Optimum ripening temperatures produce the best color and flavor
- Maintain the cold chain — when fruit are allowed to warm, shelf life suffers and re-cooling can be slow or even impossible
- Displaying ripe fruits at room temperature in stores allows their aroma to develop

Thanks for your attention!

Questions?
~
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