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)

- The rate of biochemical reactions varies with temperature
- Fast and efficient cooling after harvest is required to reach the optimum temperatures for maintaining quality
- Maintain the cold chain (avoid re-warming)
Passive Pallet Warming/Cooling

FAST COOLING (within 6-8 hours)

Forced-air or pressure cooling also results in more uniform product temperatures
Why Temperature Management is Important for Fruits

#2 is to avoid Chilling Injury

- Fruits of subtropical/tropical origin (e.g., avocado, banana, mango, papaya, etc.)
- Time-temperature relationship
- Maturity and variety influence chilling injury susceptibility and symptoms
Chilling Injury

Fruits & vegetables of subtropical or tropical origin are sensitive to low temperatures

- The temperatures that cause chilling injury fall 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 chilling injury will occur

More mature/riper fruit are less susceptible to chilling injury

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

Mango 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

GROUP II: Chilling Sensitive
IDEAL TRANSIT/STORAGE
High Temp Injury
Optimum Fruit Ripening
Chilling Injury
Freezing Injury

GROUP I: Non-Chilling Sensitive
IDEAL TRANSIT/STORAGE
Heat damage ≥ 95 °F (35 °C) and chilling damage < 56 °F (13.3 °C)

Exposing mature-green bananas for:
- 1 hour at 50 °F (10 °C)
- 5 hours at 53 °F (11.7 °C)
- 24 hours at 54 °F (12.2 °C)
- or 72 hours at 55 °F (12.8 °C)

High Temperature Damage During Ripening

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

1. Before ripening
   - Avoid chilling; precondition fruit

2. During ripening
   - Achieve the best combination of quality attributes

3. After ripening
   - Avoid overripening

Pre-Ripening Temperature Effect on Ripening

- Short cold storage can overcome ethylene needs (e.g., kiwifruit and European pears).
- Practical implications of low or high pre-ripening temperatures.
Product Flow Through the Preconditioning Process

Holding/Cooled Fruit → Warm Packing → Packaging
- Wax & Fungicide
- Segregation

Preconditioning → Forced Air Cooling

e.g., Peaches: 2 days at 65 to 68 °F (18 to 20 °C)

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!
Temperature-related Best Handling Practices (BHPs) for Mangos

- Harvesting and Packinghouse
- Transport
- Importers & DCs
- Retail Stores

Harvest

- Harvest during the cooler parts of the day
- Keep harvested mangos shaded
Transport to the Packinghouse

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

Reception at the Packinghouse

- Minimize delays before unloading
- Unload the fruit to 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 mangos 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 mangos to their optimum storage and transport temperature of 55 °F (12.8 °C).
- Mangos should be held only long enough to accommodate shipping schedules.
Staging and Loading for Transport

- Cool mangos to the shipper-specified carrying temperature before loading refrigerated containers and trailers
- Pre-cool container, then turn off reefer unit
- Load mangos 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 the U.S. varies from 2 days over land from northern Mexico to 3 weeks by ocean from Brazil
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.

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 55 °F (12.8 °C)
  - Turn off refrigeration when the dock is warmer than 55 °F (12.8 °C)
- 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

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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

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**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 55 to 59 °F (12.8 to 15 °C)
- Maintain relative humidity at 90 to 95%
- Scrub ethylene gas from cold room or one fresh air exchange each day
- FIFO (First in, First out) or FEFO (First expired, First out)
Ripening Rooms

- Ripening rooms for bananas, avocados, kiwifruit, tomatoes, stone fruits and European pears can be used to ripen mature (but not already ripening initiated) fruits
- 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) To 100 ppm ethylene</th>
<th>Range of ripening temperatures(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avocado</td>
<td>8 to 48</td>
<td>59-68(^\circ)F (15-20(^\circ)C)</td>
</tr>
<tr>
<td>Banana</td>
<td>24 to 48</td>
<td>58-65(^\circ)F (14-18(^\circ)C)</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>12 to 24</td>
<td>54-72(^\circ)F (12-22(^\circ)C)</td>
</tr>
<tr>
<td>Mango</td>
<td>24 to 48</td>
<td>68-72(^\circ)F (20-22(^\circ)C)</td>
</tr>
<tr>
<td>Pear</td>
<td>24 to 48</td>
<td>68-72(^\circ)F (20-22(^\circ)C)</td>
</tr>
<tr>
<td>Tomato</td>
<td>24 to 72</td>
<td>65-68(^\circ)F (18-20(^\circ)C)</td>
</tr>
</tbody>
</table>

\(^1\) Shorter durations are for more mature fruit
\(^2\) Faster ripening rate at higher temperatures
Re-working Prior to Delivery Shipments

- Do this in the cold storage area, just as for inspections and re-working upon arrival.

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
Importer/Distribution Center

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

Use air bags or bracing for spacing between pallets and between pallets and trailer walls for improved temperature management

- Maintain recommended air temperature
  - Not less than 55 °F (12.8 °C) for unripe mangos
  - Not less than 50 °F (10 °C) for firm-ripe mangos
- Minimize exposure of mangos 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)

Storage in Walk-In Coolers?
- Store all produce at proper temperatures; don’t hold mangos below 50 °F (10 °C)
- If no cooler space at 50 °F or above, store mangos in the back room
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

Stocking, Display Preparation, Rotation

- Avoid “storing” mangos at the store
  - display mangos upon delivery
  - order mangos more frequently
- Display at ambient temp. size, ripeness stage, variety)
- Inspect display several times a day; remove 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 (refer to “Mango Best Handling Practices”)
- Develop a form to record all operations and procedures and when performed
- Include temperature records!

Conclusions

- Choose appropriate temperatures:
  - 55 °F (12.8 °C) to slow ripening and avoid chilling (55° F is always safe)
  - 68 to 72 °F (20 to 22.2 °C) to promote ripening (produces the best color and flavor)
- Maintain the cold chain — when mangos are allowed to warm, shelf life suffers and re-cooling can be slow or even impossible
- Finally, display mangos at room temperature in stores to allow their aroma to develop
Thanks for your attention!

Questions?

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