Postharvest Handling for Quality and Freshness

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Transitions…UF/IFAS Extension's role

What went wrong with this shipment???

Goal of Postharvest Technology

Minimize Losses in Postharvest Quality by Retarding Senescence and Decay

Worker removing unsalable produce at a supermarket:

Estimated Postharvest Losses of Fresh Produce in the USA

Current research has largely neglected system-wide produce losses but the estimates developed by the landmark study by NSF-RANN 35 years ago are believed by most industry experts to remain valid. That research developed broad ranges of losses at each stage of the distribution system but taken together reached as high as 16% of all fresh produce, which converts to more than $ 17 billion in 2009.

Estimated ranges of Losses in the Fresh Produce Distribution System

Distribution Activity	**Losses %**
Transportation	2.80 – 5.00
Wholesaling	2.50 – 5.03
Retailing	2.74 – 6.58
System Losses	9.04 – 16.61

Percentage losses are based upon dollar values of losses in each phase of distribution as a percentage of the wholesale value of products entering the distribution system.

From: R. Cook, cited by Kader

Postharvest Losses of Fresh Produce

- **Quantitative losses**
- **Qualitative losses**
  - **Loss of acceptability by consumers**
  - **Loss of caloric and nutritive value**
  - **Loss of edibility**

From, A. Kader

POSTHARVEST PHYSIOLOGY

- ***Processes that affect produce quality***
  - ***Respiratory activity***
  - ***Ethylene production/sensitivity***
  - ***Chilling sensitivity***
  - ***Texture***
  - ***Moisture loss susceptibility***
  - ***Decay susceptibility***

Fruits and Vegetables are Very Diverse

- **Different morphological structures**
- **Composition**
- **Postharvest physiology**

Postharvest Physiology

- **Postharvest life is dependent upon:**
  - **Fruit and vegetable crop – each has different potential postharvest life**
  - **Quality at harvest**
  - **Maintaining quality after harvest starts with temperature control**

Temperature Effects on Fruits and Vegetables:

- **Respiration Rate** – *For each 18°F (10°C) of cooling* it decreases by 1/2 to 2/3, increasing postharvest life by 2- to 3-fold

- **Ripening** – optimal at 68-75°F; lower temperatures extend postharvest life

- **Chilling injury** – Crops of tropical and subtropical origin are injured above freezing & below 41 to 59°F (5 to 15°C)

Temperature Effects on Respiration

- **Optimal Temperature for Respiration:**
  - Peaks from 77 to 86°F (25 to 30°C)
- **Freezing Point:**
  - 28 to 31.8°F (-2 to -0.1°C)
- **Thermal Death:**
  - 113 to 122°F (45 to 50°C)

Respiration

$(CH_2O)_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + 673$ Kcal

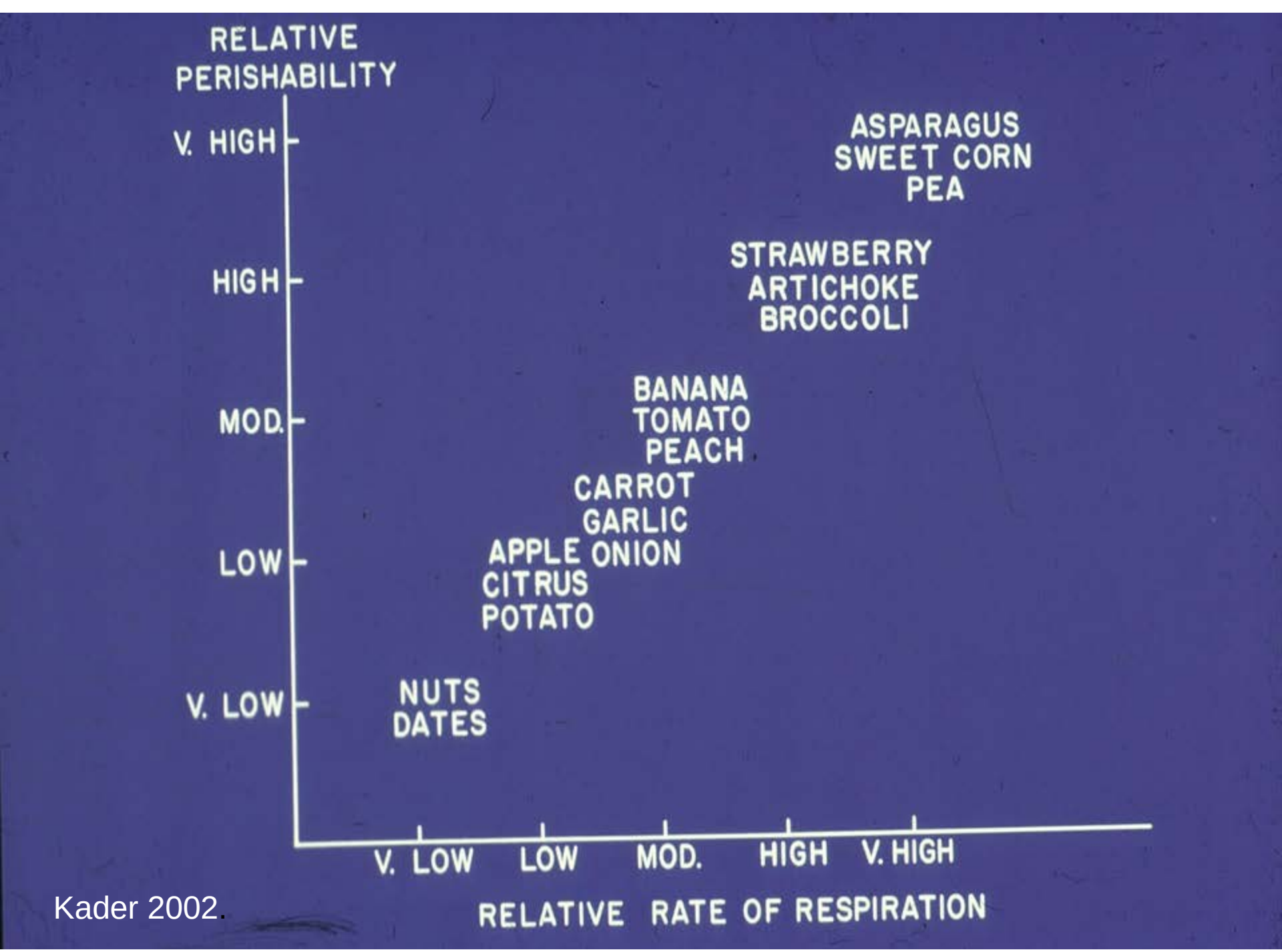
Sugar + Oxygen → Carbon dioxide + Water + Heat energy

By Slowing Respiration, Postharvest Life is Extended

Respiration & Perishability

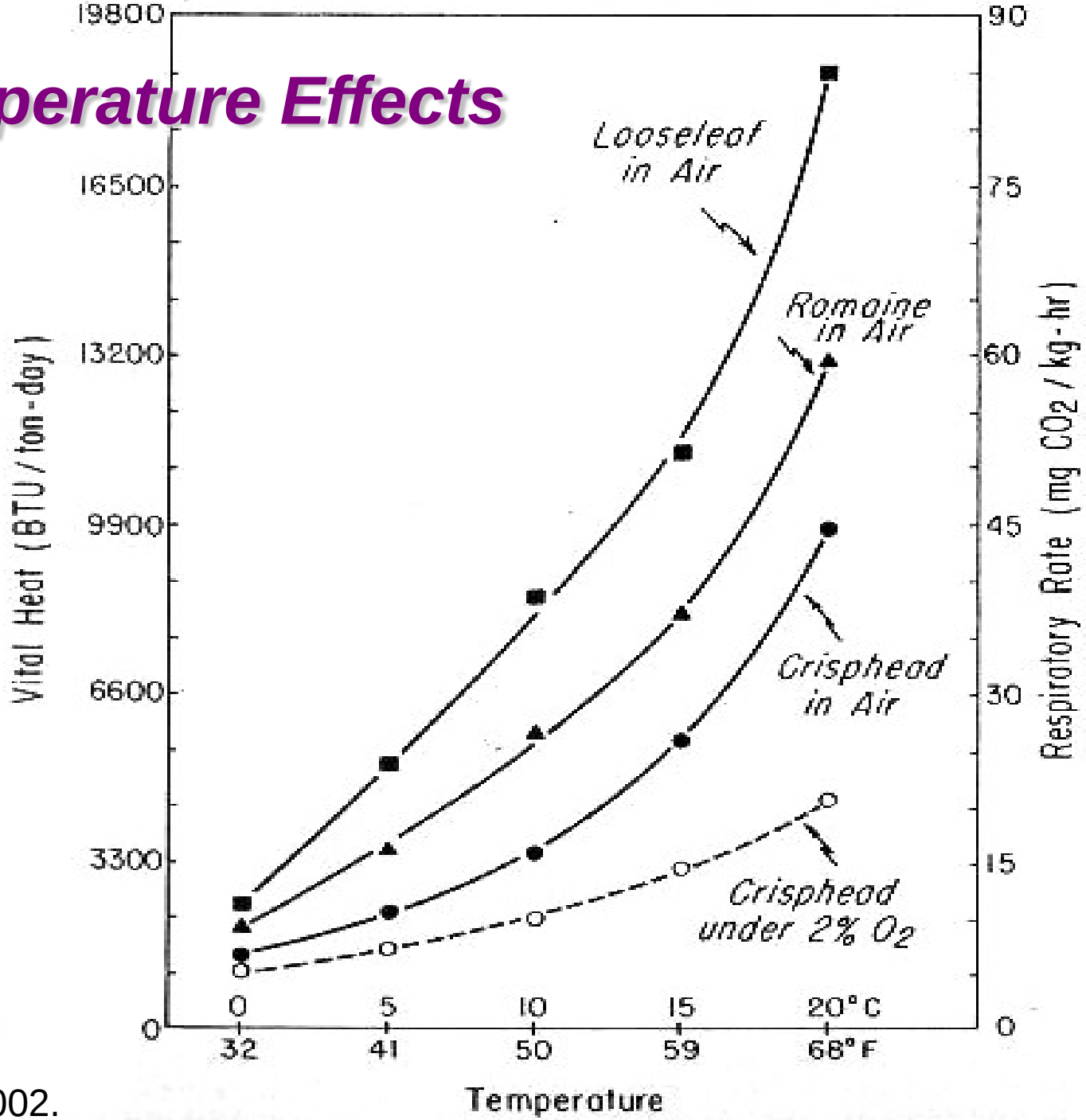
- **Actively growing crops (leafy, stem, floral, immature fruit) have high metabolism**
  - **Very little stored energy reserves**
  - **Short postharvest life**

- **Mature crops (fruits, roots, tubers) have lower metabolism**
  - **Have starch, sugar and/or acid reserves**
  - **Longer postharvest life**


RELATIVE PERISHABILITY
V. HIGH
HIGH
MOD.
LOW
V. LOW
ASPARAGUS
SWEET CORN
PEA
STRAWBERRY
ARTICHOKE
BROCCOLI
BANANA
TOMATO
PEACH
CARROT
GARLIC
APPLE ONION
CITRUS
POTATO
NUTS
DATES
V. LOW
LOW
MOD.
HIGH
V. HIGH
RELATIVE RATE OF RESPIRATION

Kader 2002.

Temperature Effects

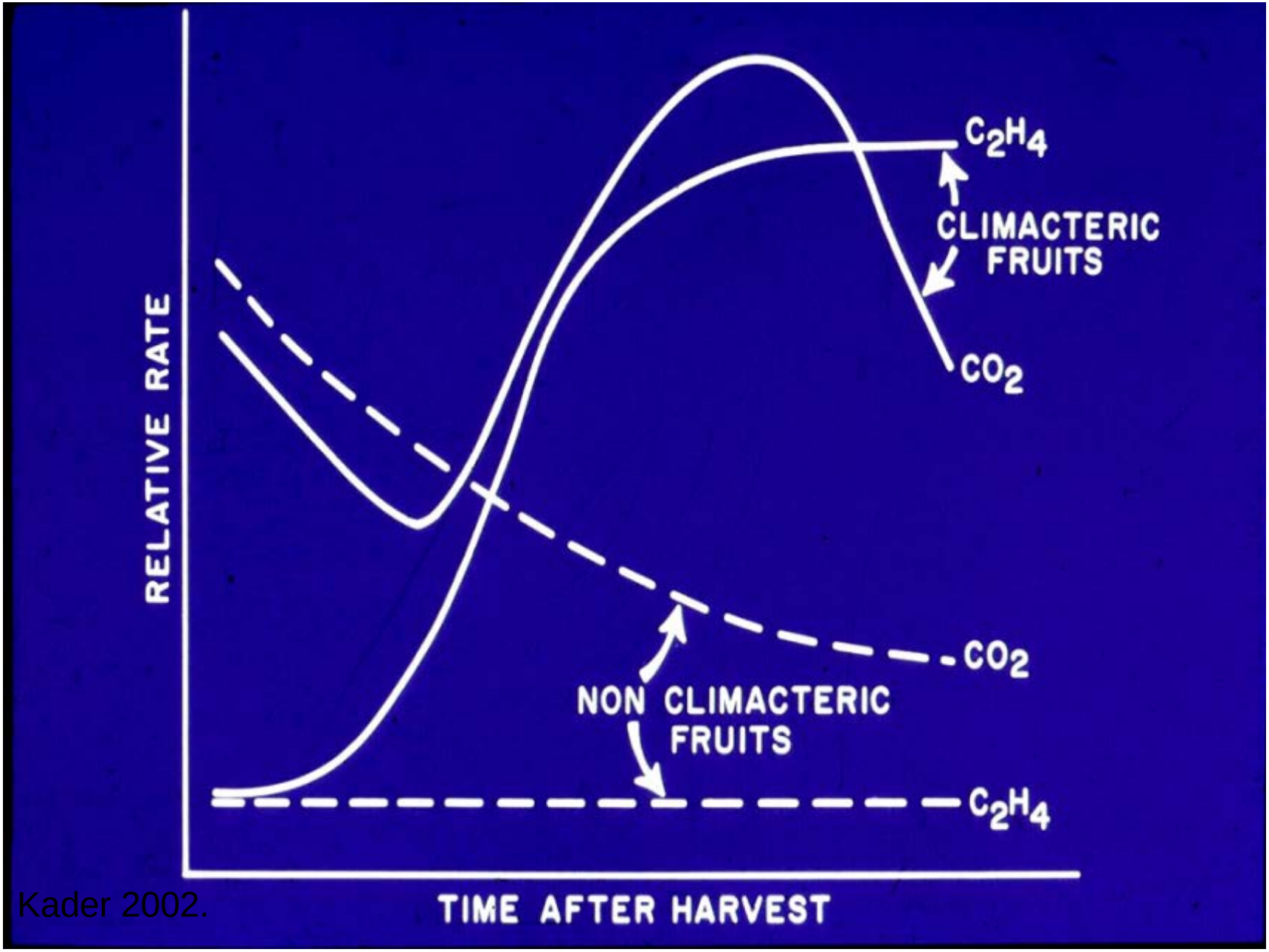


Kader 2002.

Ethylene

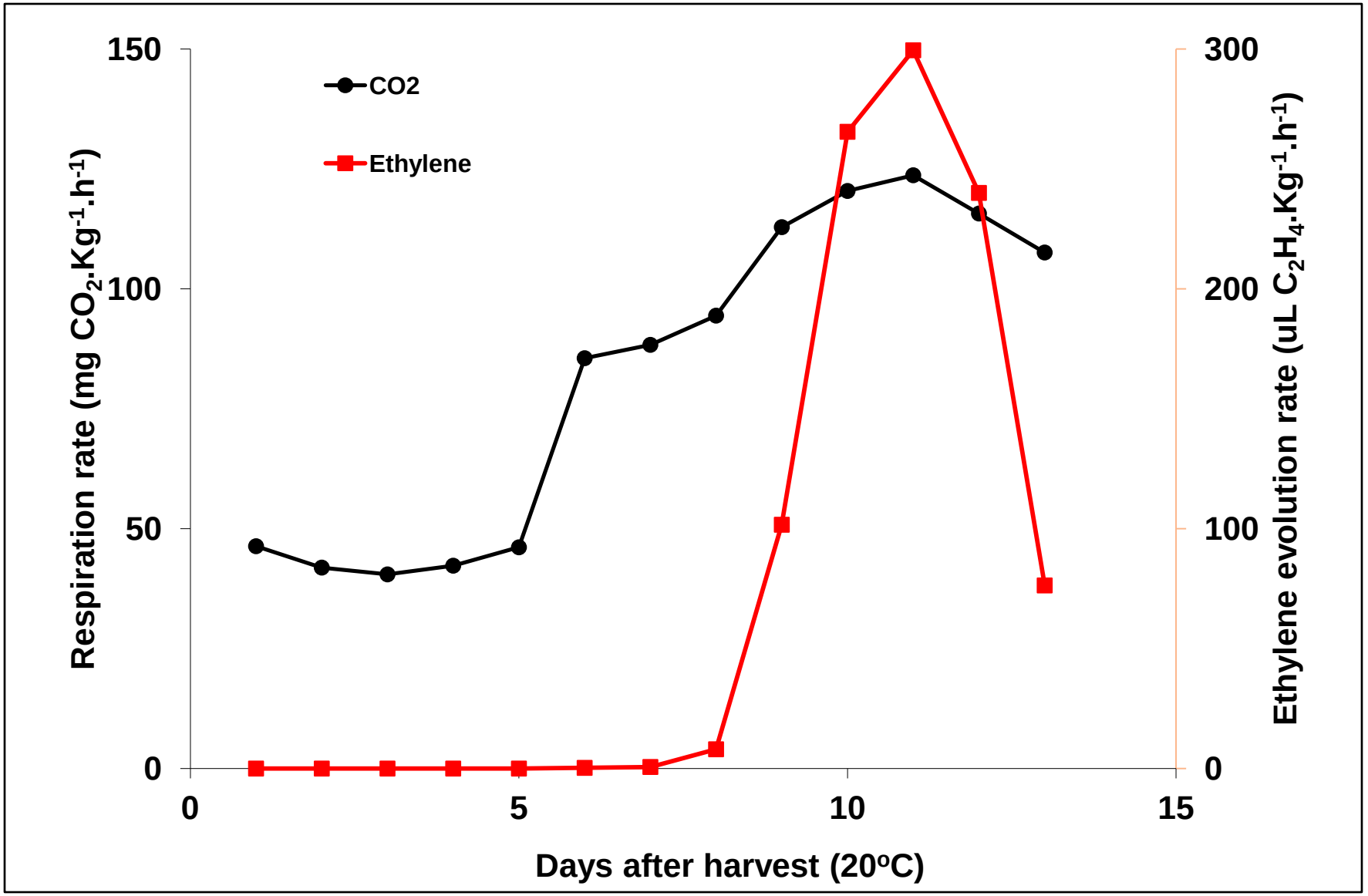
- **Ethylene:**
  - **Natural plant hormone – C_2H_4**
  - **Accelerates respiration and metabolism**
  - **Promotes ripening & senescence**
  - **Promotes development of abscission layer**
  - **Promotes chlorophyll metabolism (degreening in citrus)**

Fruit Ripening



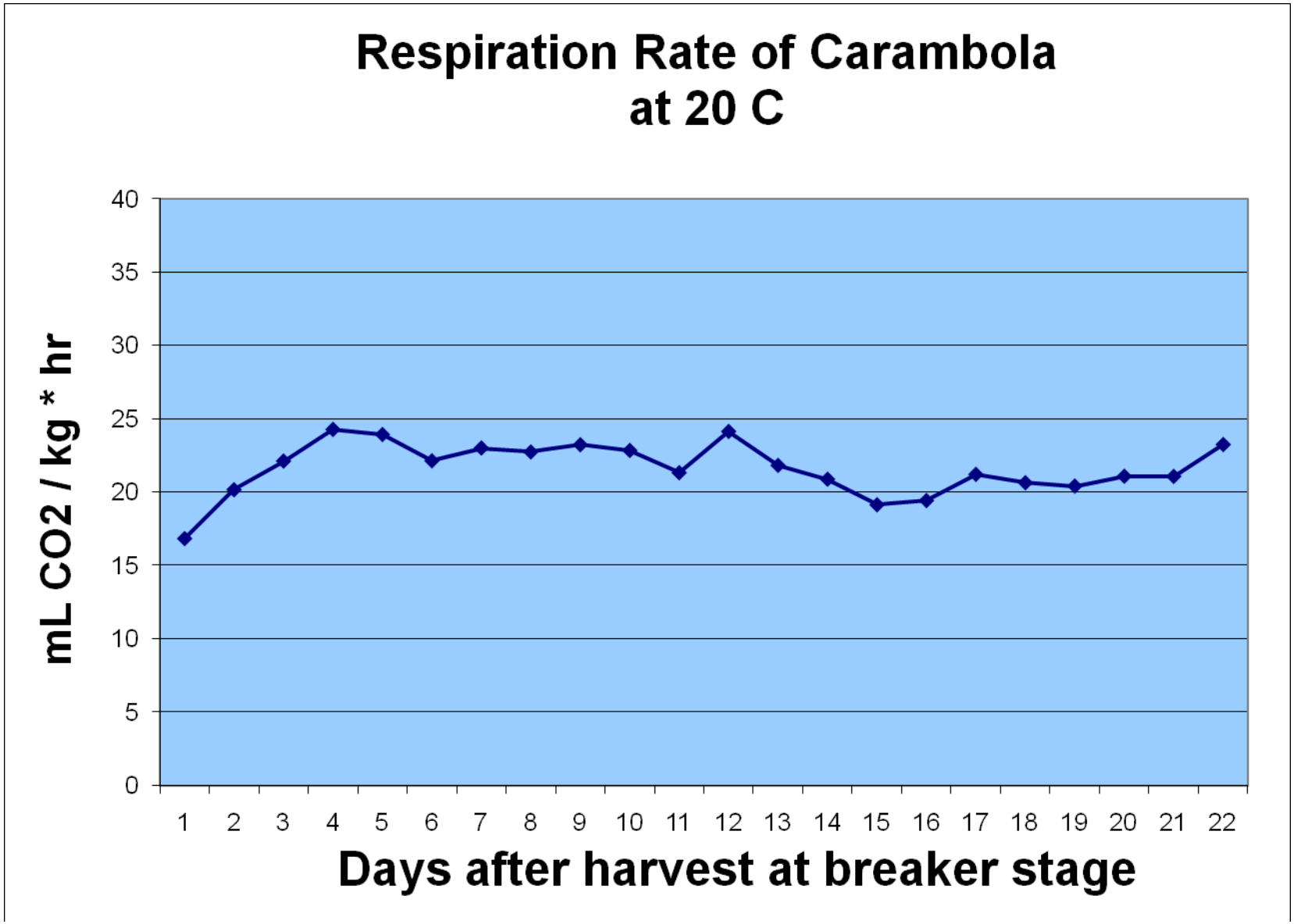
Kader 2002.

Climacteric Ripening Pattern – avocado



M. Pereira

Nonclimacteric Ripening Pattern – carambola



O. Warren

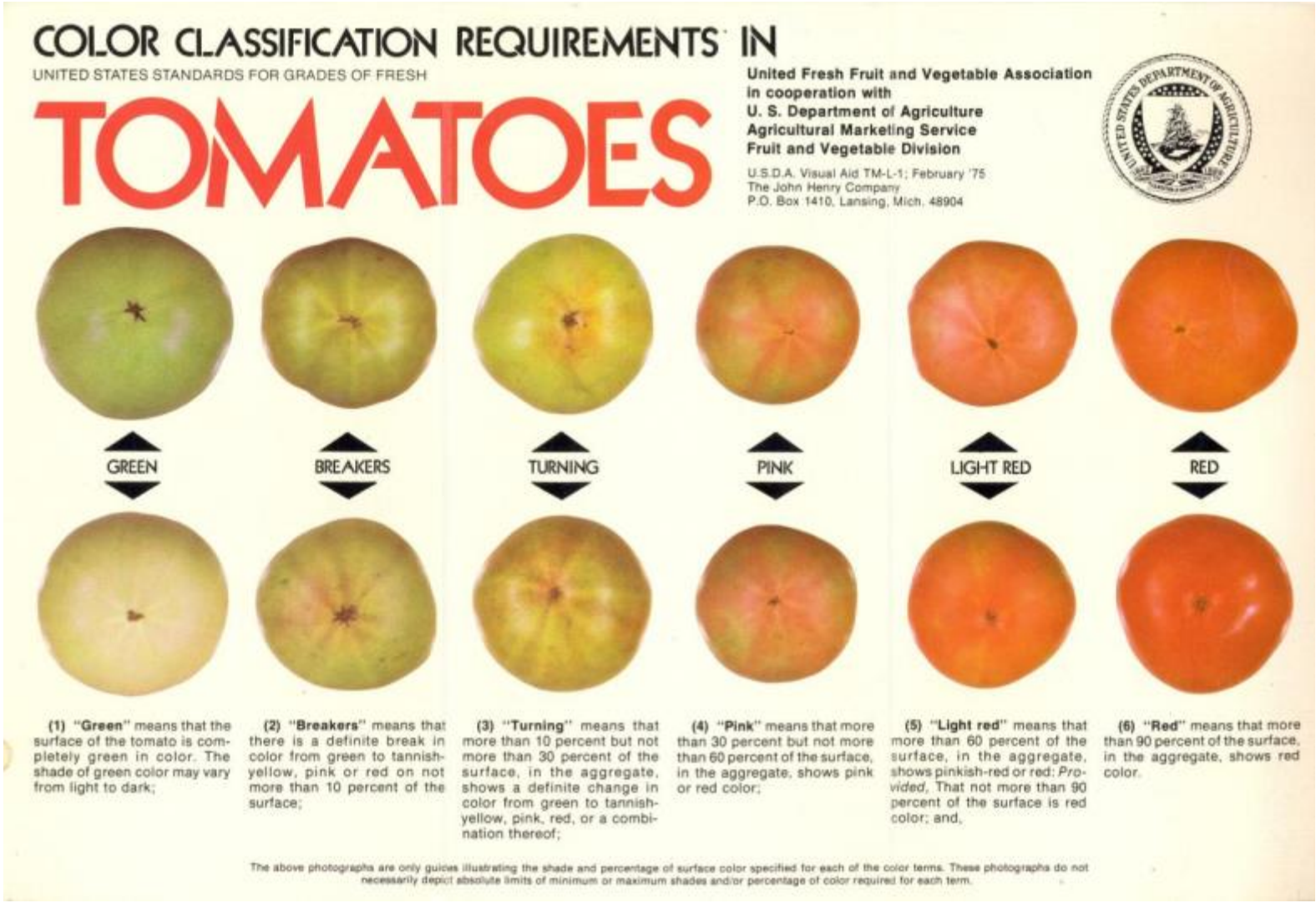
Ethylene: commercial treatments

- Avocado ('Hass' type)
  - 10 to 100 ppm @ 63-68F (17-20C); 12 to 72 hr depending on harvest time
- Banana
  - 1,000 ppm @ 57-64F (14-18C); 4 to 8 days
- Tomato
  - 50 ppm @68-72F (20-22C); 1 to 3 days
- Citrus degreening (non-climacteric)
  - 5 ppm @82-85F (28-29C); 1 to 3 days (Florida)

Tomato Ripeness Stages

Tomato is typically harvested at mature-green stage (1)

U.S.D.A. Grade Standards



Harvest Maturity: papaya

Harvest Maturity

Can be harvested at "color-break stage"

Nutritional Disorders

Blossom-end rot

Environmental Disorders

Gray Wall: Low light, wet weather conditions

Above: at harvest;

Right: after ripening

Brown heart / hollow heart in potato

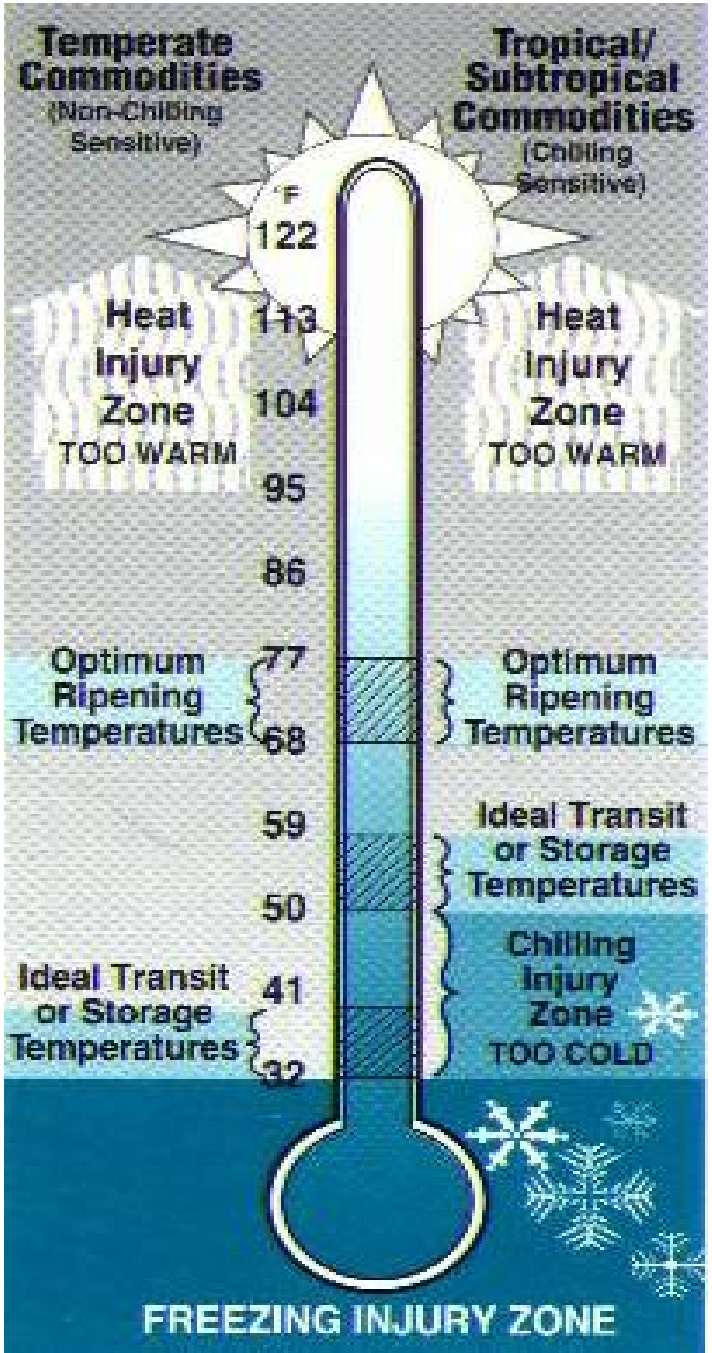
Cool temperatures (<55F; 13C) during tuber formation

Temperature Management: Cool it fast & keep it cool!

- **Lowering the temperature as quickly after harvest as possible:**
  - **Slows respiration and metabolism**
  - **Retains higher nutrient levels**
  - **Slows water loss**
  - **Inhibits microbial growth (< 41°F; 5°C)**
    - **Reduces decay**
    - **Minimizes food safety problems**

Optimal Product Temperature

- There is an optimal postharvest temperature for every product
  - Optimal temperature = Lowest safe temperature to minimize metabolism
- The ideal postharvest temperature often depends on the geographical origin of the crop
- There is also an optimal ripening temperature for fruits for best quality



Temperature Effects on Horticultural Crops

- **Temperate products should be kept at 32-37°F (0 to 3°C)**
- **Tropical/subtropical products should be kept at higher temperatures to avoid chilling injury**
- **All products are harmed by exposure to excessively high or low temperatures**

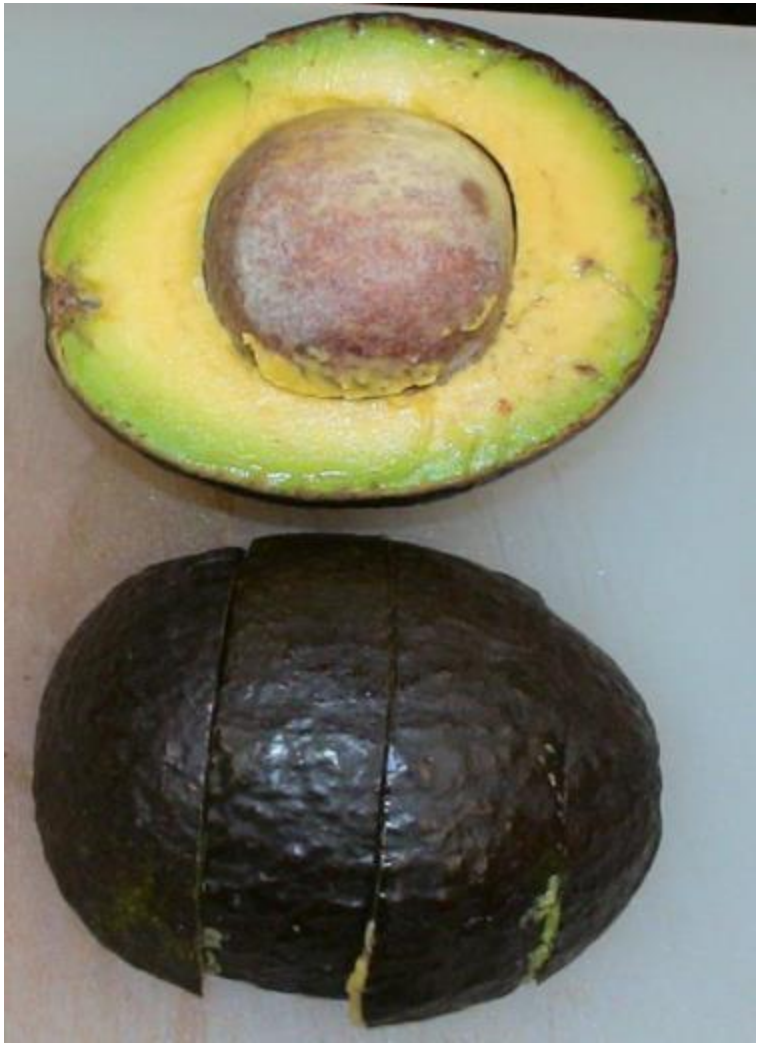
Source: Postharvest Technology Center, U.C. Davis

Chilling Injury

- **Three factors:**
  - **1) Sensitivity of the crop**
    - **Most sensitive (13-15°C): e.g., banana, pineapple, sweetpotato**
    - **Moderately sensitive (8-12°C): e.g., avocado, grapefruit, cucumber, peppers**
    - **Less sensitive (4-7°C): e.g., oranges, tangerines, beans, muskmelons**
  - **2) Exposure temperature**
  - **3) Exposure time**

Chilling Injury in the Field

Chilling Injury in the Field - avocado



‘Booth 8’; exposed to 0^{o}C (Jan 2010)

Mango Chilling Injury

J.K. Brecht

Non-uniform ripening: guava

Thermal injury in mango

Freezing Injury

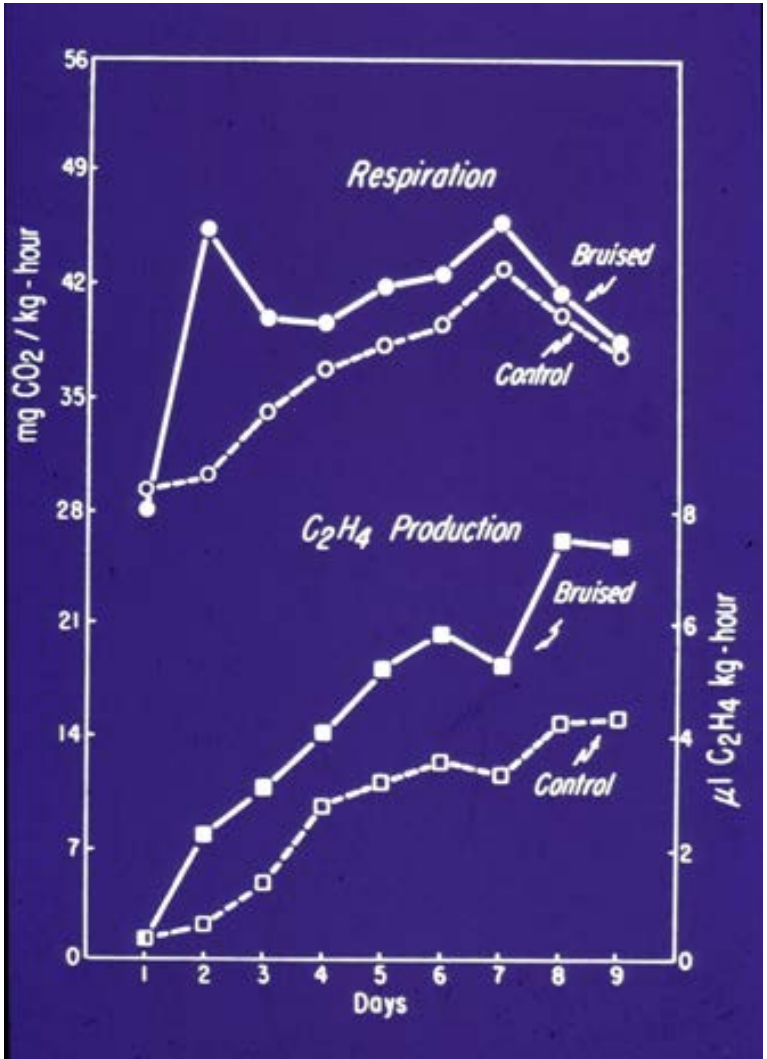
Sprouting

QUALITY MAINTENANCE: Harvest & Handling

Two primary concerns:

- ***Minimize mechanical injury***
- ***Cool rapidly***

Injuries Increase Respiration



- Mature-green tomatoes were dropped 12 inches
- Respiration and ethylene production increased and remained higher throughout ripening

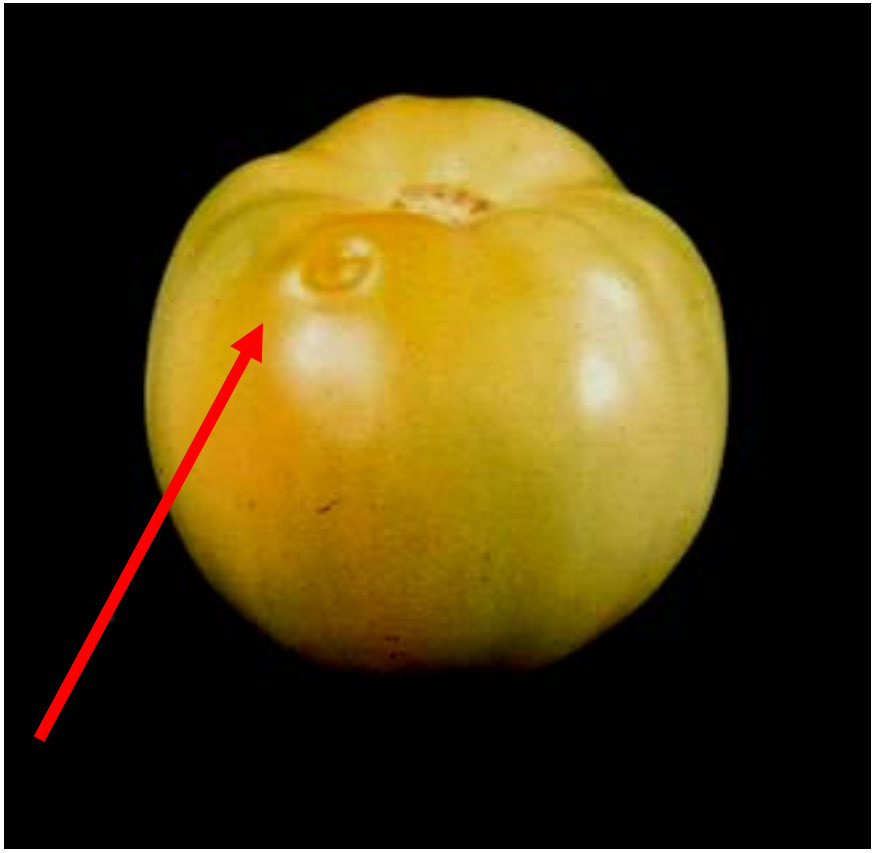
Types of Mechanical Injury

- ***Bruises***
  - ***Impact: Drops***
  - ***Compression: Excessive weight***
  - ***E.g., for bell pepper:***
    - ***Avoid over-fertilizing***
    - ***Harvest above 60°F (15°C)***
    - ***Peppers softer in warmer seasons***
- ***Cuts, Punctures, Abrasion***

Impact Bruises

Impact Injury

- ***Accelerated ripening; decay***



Abrasion at harvest

Abrasion at harvest/ apparent during storage

Harvest & Packing Operations

- Field containers, packing area
- Minimize drop heights (e.g., < 10 cm; 4 in. tomato)
- Pad impact surfaces
- Keep all surfaces clean

Harvest & Packing Operations

Harvest & Packing Operations

Other treatments include:

- ***Washing/drying***
- ***Waxing to reduce abrasions & water loss – e.g., cucumber***
- ***Pack in specialized containers***

These containers look nice, but what about shipping quality??

Field Pack

Strawberries grown in the Dover FL area

Pony reefers were used to transport the strawberries to northern markets. These were actually two crates one built into the other. The outside crate held a layer of ice, and the inside crate held the fruit. Dec. 1926.

(Photo courtesy of GCREC-Dover, also called the Strawberry Lab.)

Wirebound

Wooden Crate

vs.

Corrugated Carton

Reusable Plastic Containers (RPC's)

Display Carton

Temperature Management begins in the field

Strawberries waiting to be transported to be cooled

Cooling Principles

- ***Determine optimal conditions***
  - ***Storage temperature; relative humidity***
  - ***Cooling method; atmosphere***
- ***Rapid Cool within a few hours of harvest (7/8 Cooling)***
- ***Cool efficiently***

Cooling delays can lower postharvest quality

Strawberries cooled within 2 or 4 hours had better quality after 1 week of storage than those with a 6-hour delay to cooling

- **Significantly softer, more shriveled, less attractive color**
- **Lower SSC, acidity, and Vitamin C levels**

Nunes et al., 1995

Cooling rate is determined by the 3 T's:

- **Time of exposure to the cooling medium**
  - **Longer = cooler**

Temperature of the cooling medium

Lower = faster

Turbulence (contact & mixing)

More = faster, more uniform

This is NOT Cooling

In-room Cooling & Packing

Forced-air cooling tunnel: Blower/chiller unit

Forced-air cooling:

Forming the tunnel with 2 rows of pallets


Cold room air is pulled through cartons
Block openings at pallet bases

Portable
Forced-air coolers

Small truck retrofit

Immersion Hydrocooling - lychees

Package Icing

Vacuum Cooling

Once cooled, keep it cool!

Load and unload directly from the cold room

Maintaining the "Cold Chain" during Shipping

Properly load the refrigerated trailer; keep pallets away from sidewalls

In Summary:
Quality Maintenance

- ***Consider crop physiology***
- ***Minimize mechanical injury***
- ***Cool quickly and thoroughly***