

POSTHARVEST AND STORAGE PRACTICES FOR OPTIMUM FRUIT QUALITY

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Overview

1. Quality and Harvest decisions
2. Harvest management
3. Storage techniques
4. Physiological disorders
5. 1-MCP
6. Food safety

1. QUALITY AND HARVEST DECISIONS

Quality

- Size and shape
- Color
- Freedom from blemishes
- No disorders
- Texture and flavor
- Food safety (GlobalGap, HCAAP)

'Quality' means different things to different people

- Grower, storage operator and shipper, retail, consumer
 - Grower – color and flavor
 - Storage operator and shipper – firmness, ability to withstand bruising
 - Retail – uniform appearance
 - Consumer – flavor, texture
- Depends on marketplace
- Depends on storage period

Supermarkets - high quality fruit based on uniformity

New York



Shenyang



But many other markets exist, with different quality requirements

- E.g. Small market

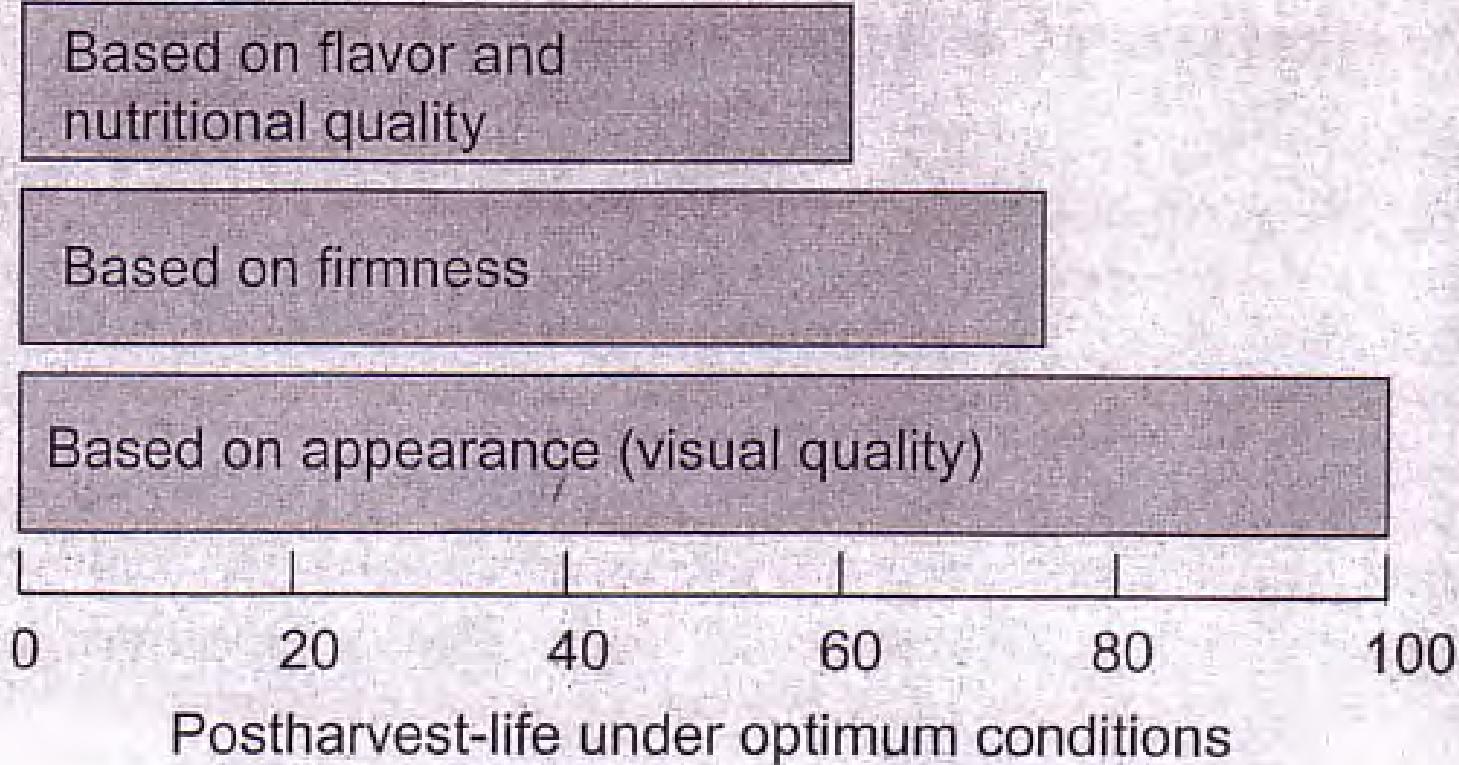


Fruit quality starts in the orchard – starts to be lost from the moment of picking!

Losses after harvest are a function of:

- Variety**
- Harvest maturity**
- Temperature control**
- Storage period**
- Storage conditions (1-MCP, air, CA)**

Quality factors are not lost at the same rate



When to harvest?

- compromise between quality and storability

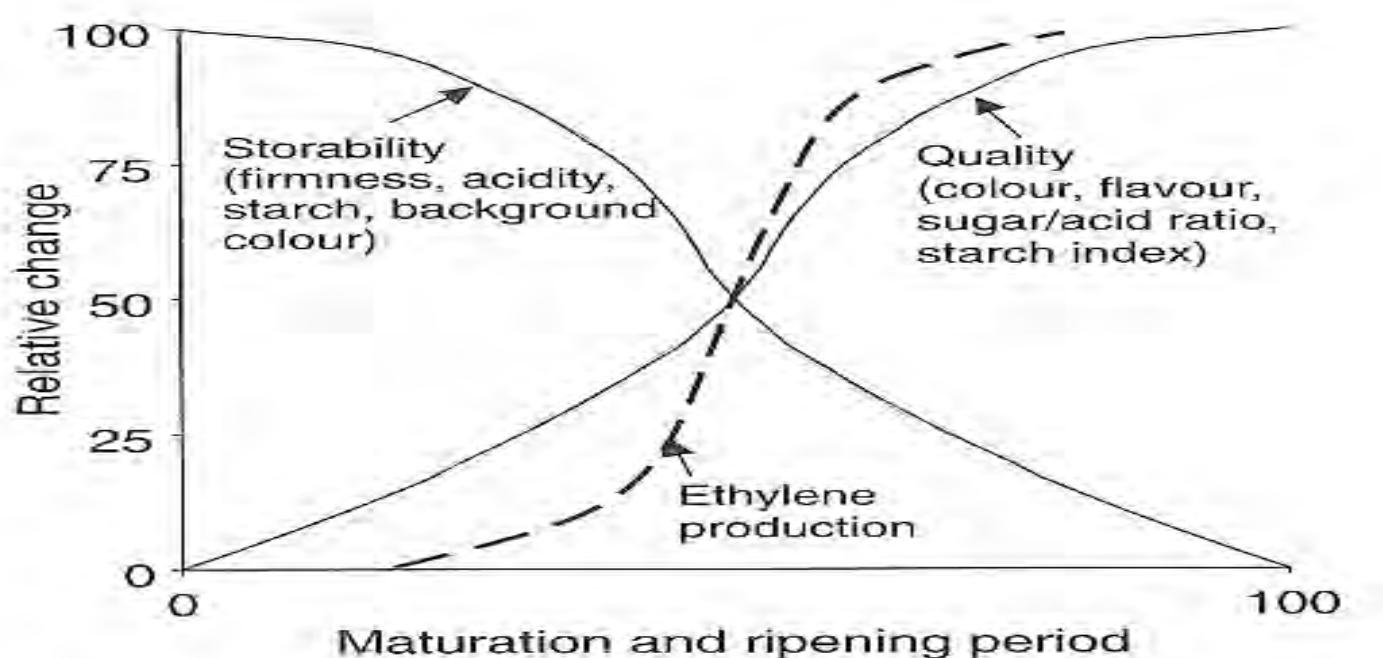


Fig. 23.2. Schematic illustration of the increase in apple-fruit quality during maturation and ripening and concomitant loss of storage potential. An increase in ethylene concentration in the fruit is generally associated with these changes. (Modified from Lau, 1985.)

The harvest date balance is critical

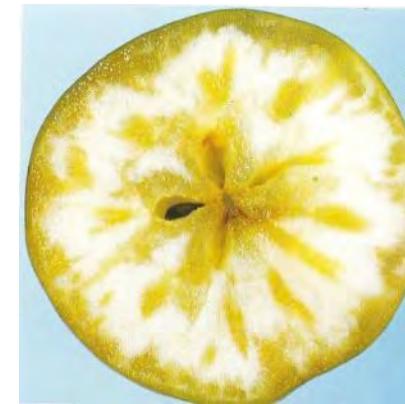
Early harvest

- Less flavor
- Higher bitter pit risk
- Higher scald risk



Late harvest

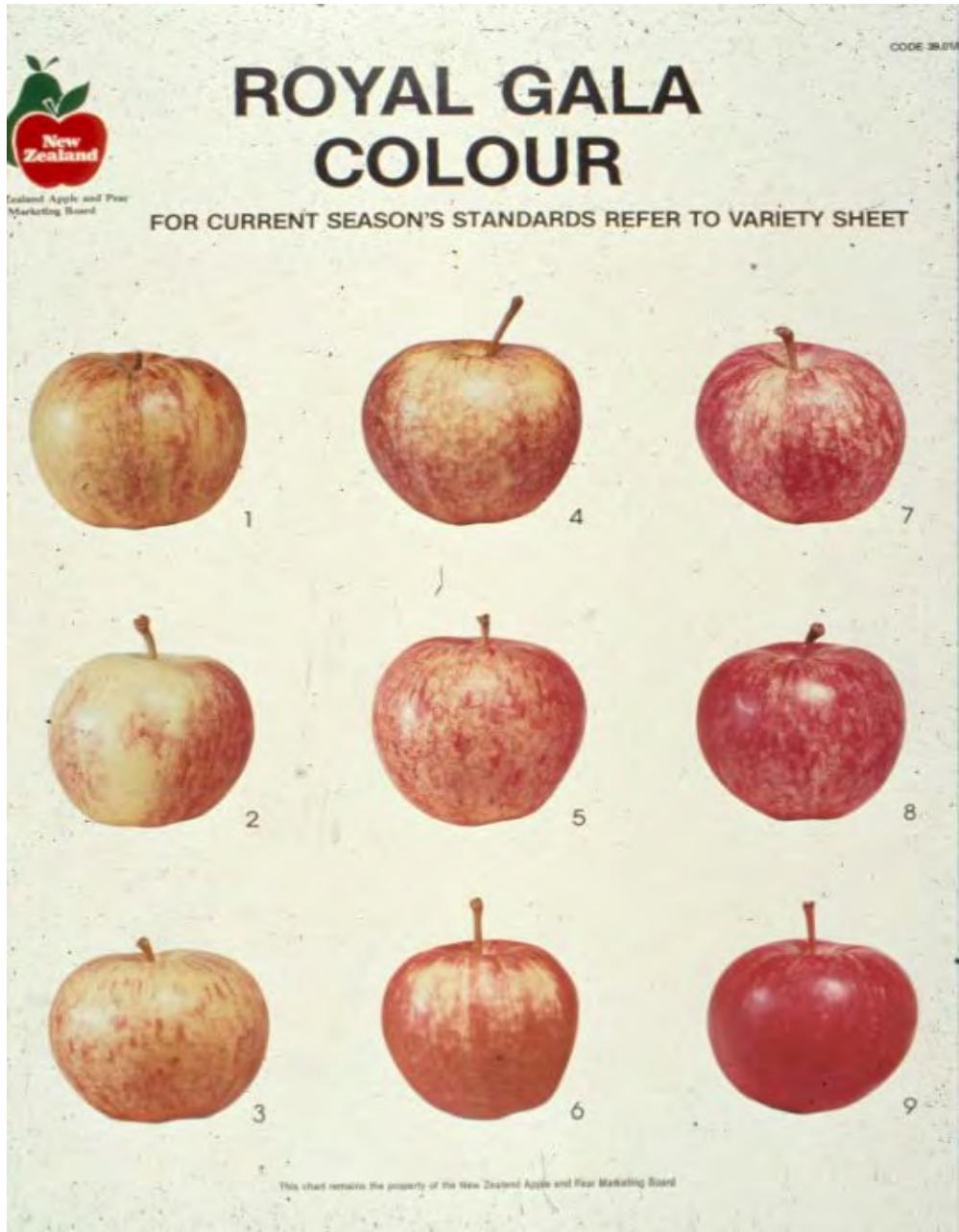
- Softer fruit
- More watercore in fruit at harvest
- Higher senescent breakdown risk
- Shorter storage life



When to harvest?

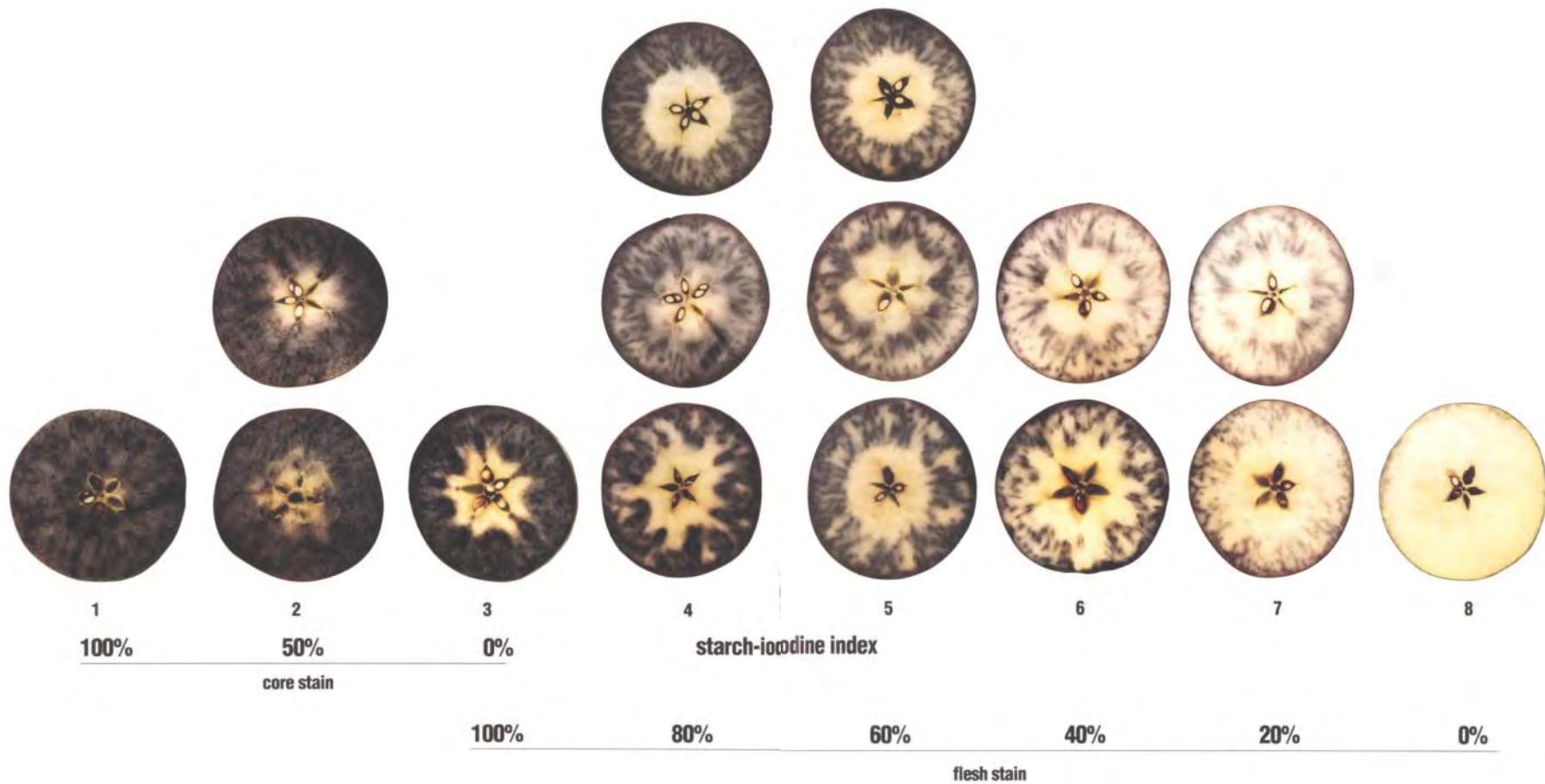
- Flavor
- Red coloration – commercial criterion set by some markets
- Background color – uniform
- Starch index
- Flesh firmness
- Soluble solids concentrations
- Ethylene production

But there is no single indicator – experience and market plans

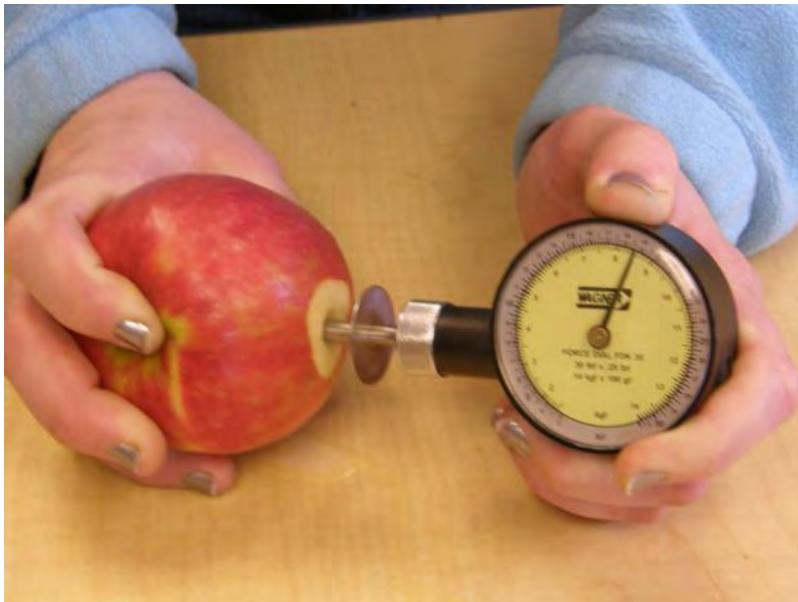


Starch iodine pattern test

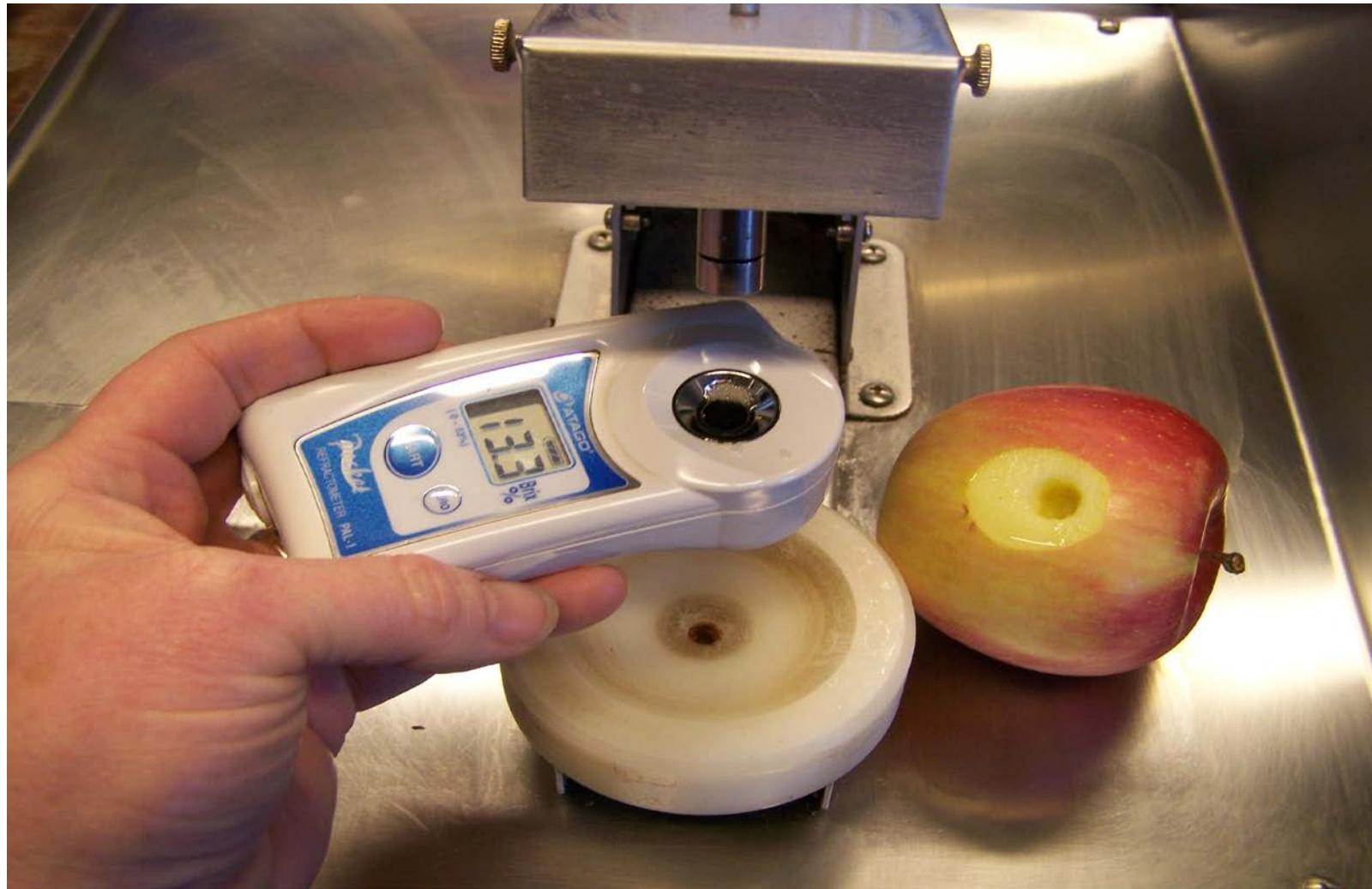




Pressure tester



Soluble solids content



DA Meter



Difference of
absorbance - Indirect
method for measuring
chlorophyll content of
skin

Honeycrisp separation by DA reading



Development of a maturity index

- No universal index for any variety
- Must be developed based on quality after storage
- Will be different according to storage type and storage period (traditional, refrigerated, CA)

Harvest timing and marketing plans

May not be important in 2014 but consolidation will present larger challenges

- Early harvested fruit should be the last fruit sold, and late harvested fruit should be the first fruit sold
- Storage decisions, however, should be based on a marketing plan
- Knowing the storage length desired helps you make decisions
 - Coordination of harvest
 - Investment in storage technologies

Part of solution to small scale is cooperatives

- Requires coordination
- Agreement on decision making
- Requires commitment to quality
- Recognizing that not all fruit are the same
 - for reasons that we cannot fully explain, fruit from different orchards can be variable – therefore marketing plan maybe different

Goal is the develop history of orchard block quality

- Record and maintain records of all harvest indices
- Use these numbers to relate to storage quality
- Use these numbers to confirm/develop optimum for your orchard conditions

2. HARVEST MANAGEMENT

Postharvest management roles in maintaining quality:

- Reduce metabolic rates of processes that result in undesirable changes in color, composition, texture, flavor and nutritional status
- Reduce water loss that can result in loss of marketable weight, shriveling, softening, loss of crispness and nutritional status

- Minimize damage - bruising, friction damage and other mechanical injuries
- Prevent disorder development - physiological and pathological

Respiration – an important principle



High = generally a short storage life

Low = generally a longer storage life

**Therefore, controlling respiration rates should
be a focus of every postharvest activity**

Step one – Harvest and movement of fruit to storage



Major cause of damage during harvest is bruising

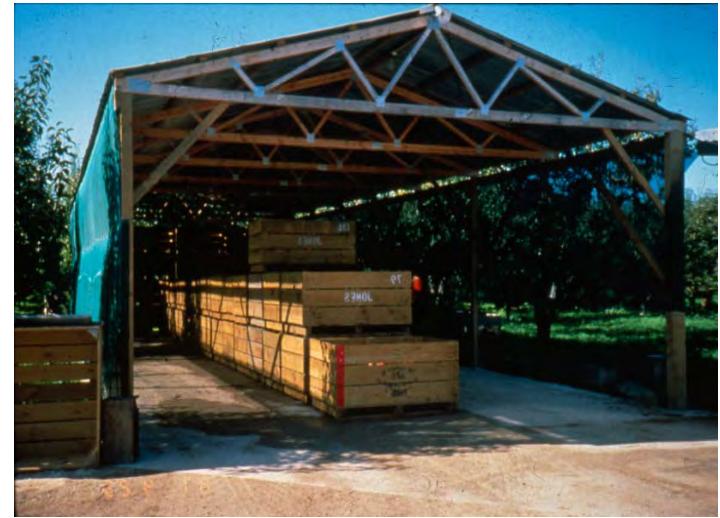
Picker training to :

- 1) Gently harvest and keep stems intact
- 2) Avoid finger bruises
- 3) Avoid impact bruises – should not hear fruit being emptied into bins or bins



Transport to storage

- Minimize the interval between fruit harvest and cooling of fruit – start of the cold chain
- Provide shading – fruit on top of bins can reach 50 °C
- 24 hours at 20 °C after harvest is equivalent to one week less storage life
- Careful transport – repair tracks in orchard, gentle handling



Take home messages

- Quality must be appropriate for the marketplace
- Maturity at harvest must be appropriate for the market
- Harvest management must minimize opportunity for damage to occur, and minimize time between harvest and cold storage

3. STORAGE TECHNIQUES

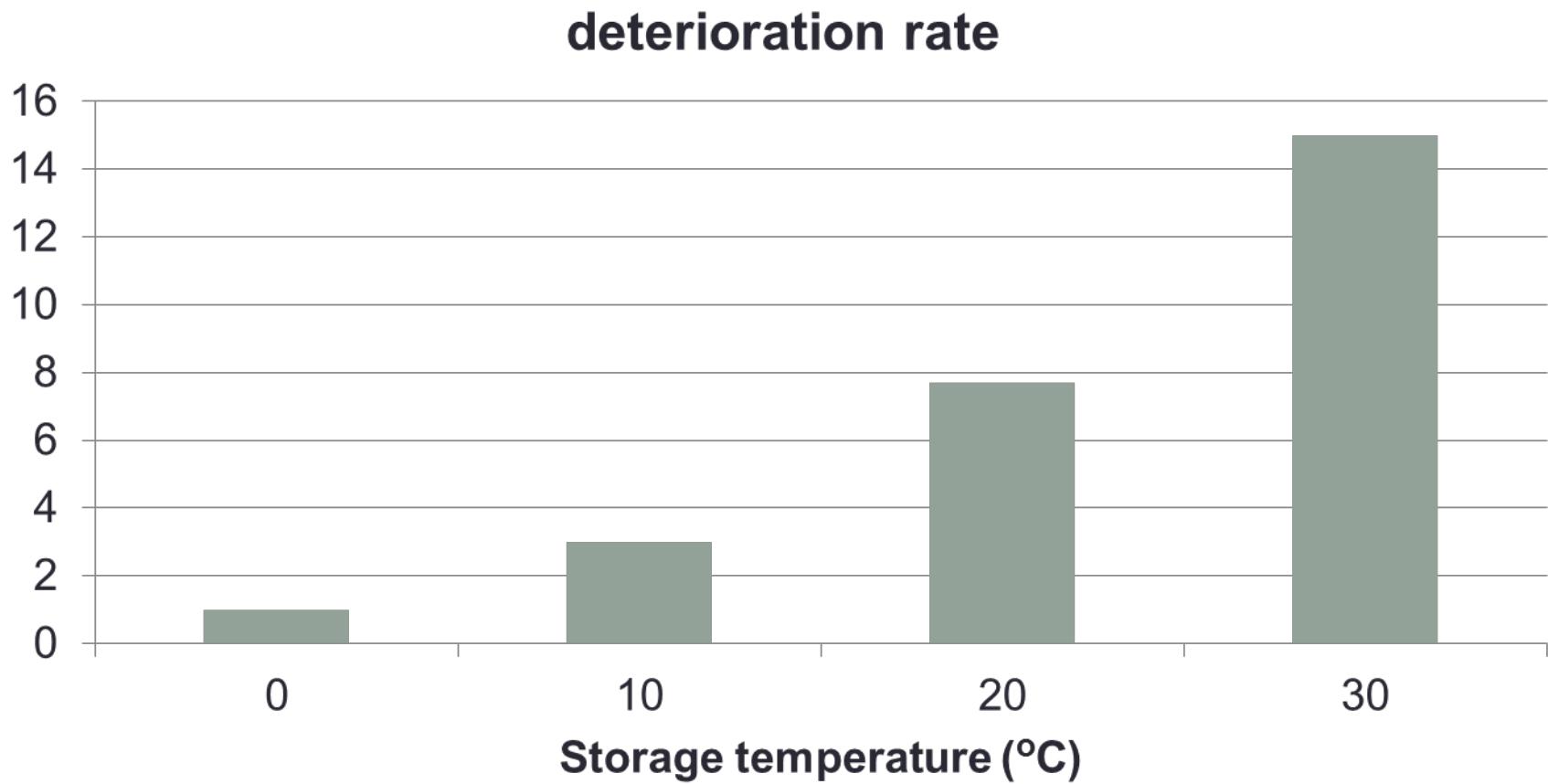
Storage technologies

- Traditional storage (common storage)
- Refrigerated storage
- Controlled atmosphere storage



Plastic tent storage

Effect of storage temperature on relative velocity of deterioration



Cold storage

Traditional

- Kilns, trenches
- Simple and effective
- Maintains temperature in range of 0-6°C
- Storage period can be as long as 5 months, depending on variety

Refrigerated storage

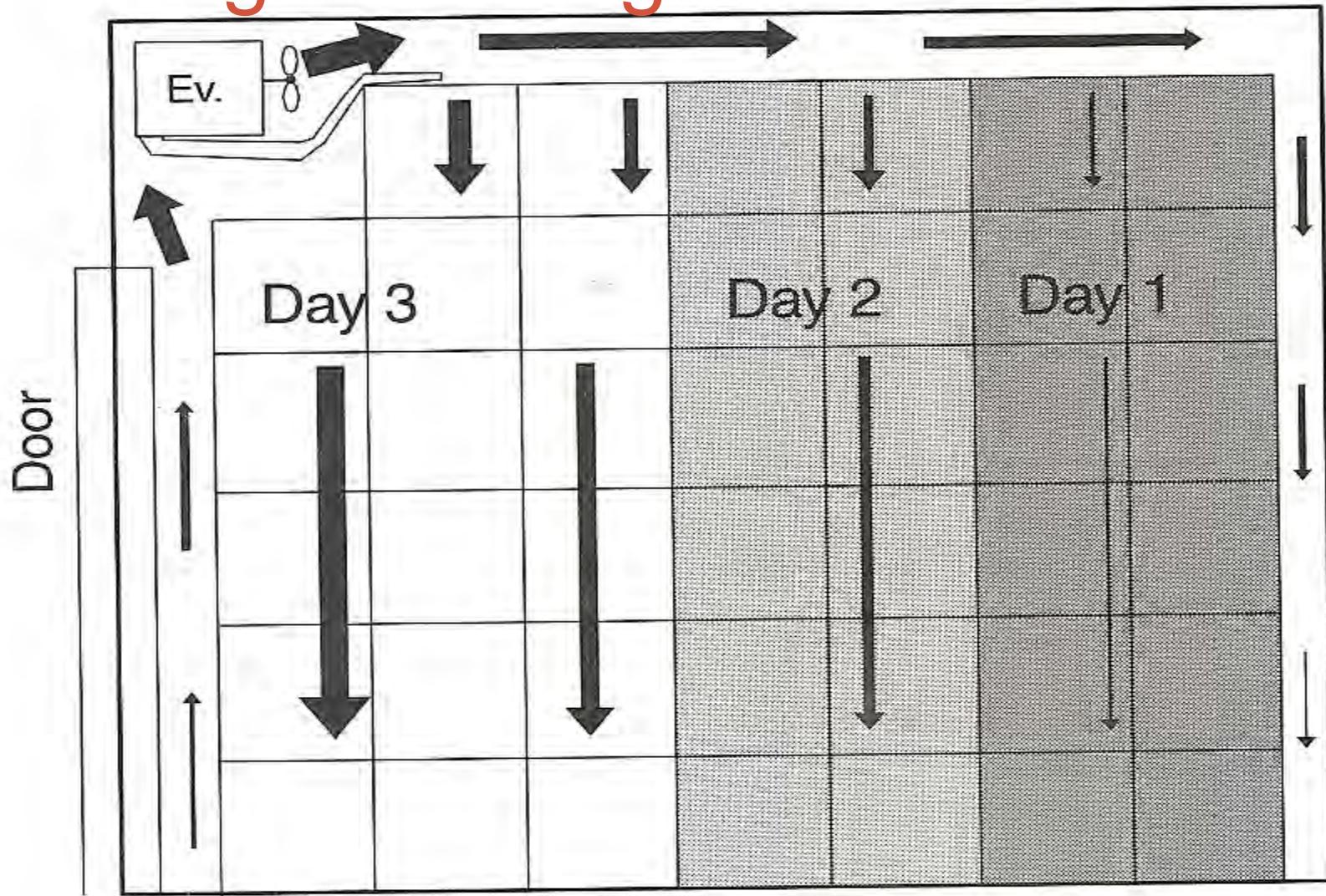
- Mechanical cooling requiring investment and reliable electrical supply
- Storage period can be as high as 6 months depending on variety (note in USA, most fruit are not marketable after 4-5 months of air storage)



Loading refrigerated rooms

- Rapid cooling is the goal
- Cooling of fruit should be as fast as possible, but must not overload the cooling capacity
 - Rapid cooling = less energy reserve lost in respiration, and less water loss
- For CA, maximum of 7 days from date of first harvested fruit to 5% oxygen in room

Loading the storage room



Controlled atmosphere (CA) storage

- Used extensively worldwide including some use in China
- Limitation is high establishment cost
- Buildings and equipment



Large-scale commercial CA storage facility in Fujian province



Medium-scale commercial CA storage facility in Hunan province



湘潭北极制冷设备公司

Nitrogen generators and automatic control Systems



Controlled atmosphere (CA) storage

- Oxygen and carbon dioxide levels in the storage are usually about 2-3%, at 0°C, but varies by variety
- Depending on variety can be stored for 6 to 10 months

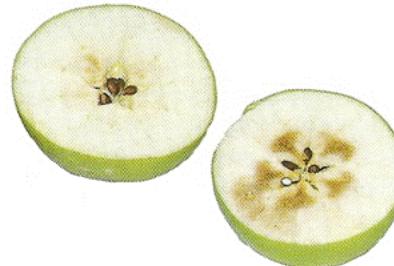
Advantages of CA

- Reduced yellowing and softening
- Reduced storage disorders, e.g. superficial scald

Disadvantages of CA

- Proper management of harvest and storage is much more critical to ensure safety
- Potential for low oxygen injury or carbon dioxide injury

Low Oxygen Injury



Monitoring the fruit

- Samples that are representative of the fruit in the room should checked at monthly intervals at least after January
 - Cut the fruit
 - Look for browning or other disorders
 - Smell for any sign of alcoholic volatiles

Opening the room

- Measure firmness and maintain records of firmness loss during storage, record disorders.
- A typical US storage would be assessing pack-out %, and monitoring exactly what the reasons for loss are.

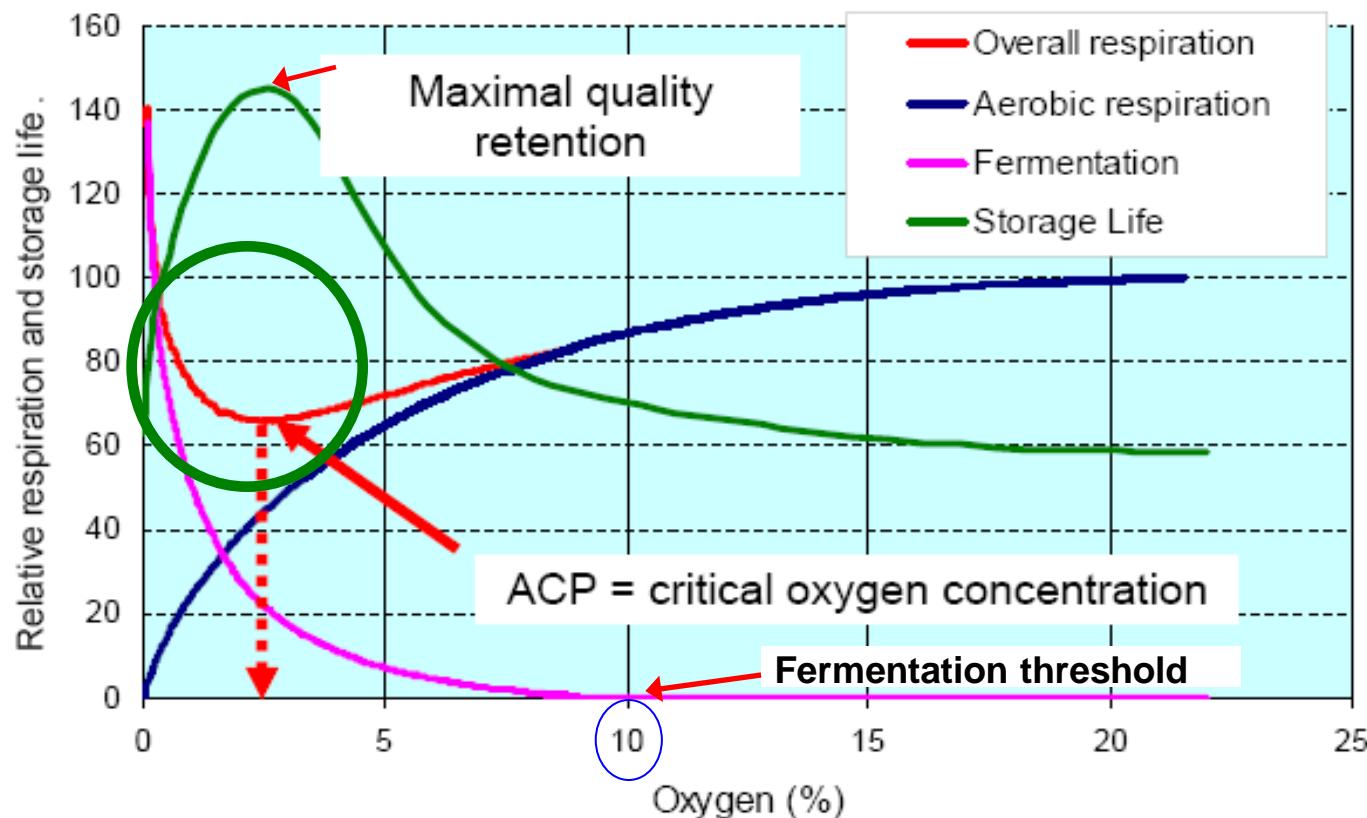
DYNAMIC CONTROLLED ATMOSPHERE (DCA) STORAGE

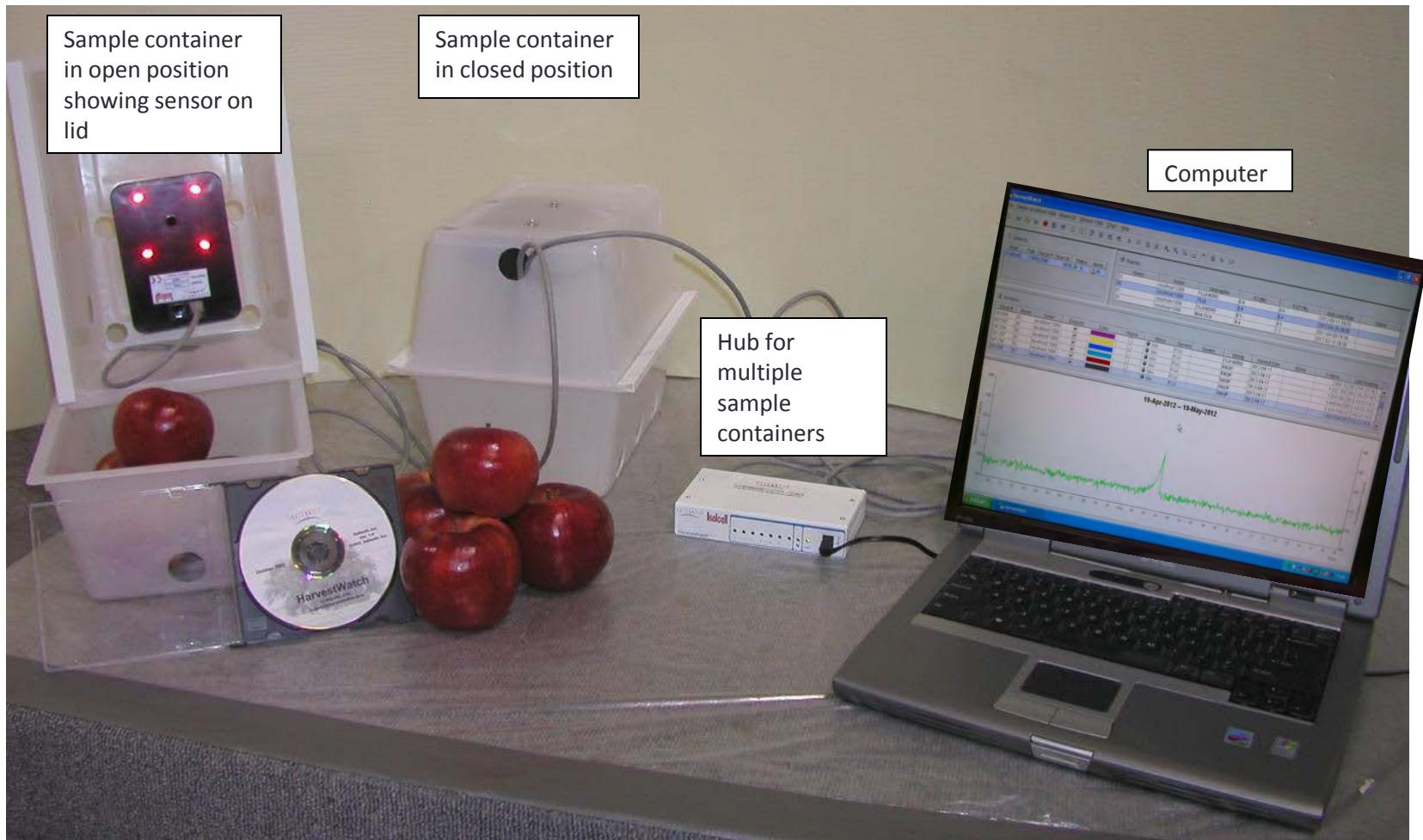
Based on the principle of following changes in fruit metabolism during storage

Different methods – fluorescence, ethanol, respiratory quotient

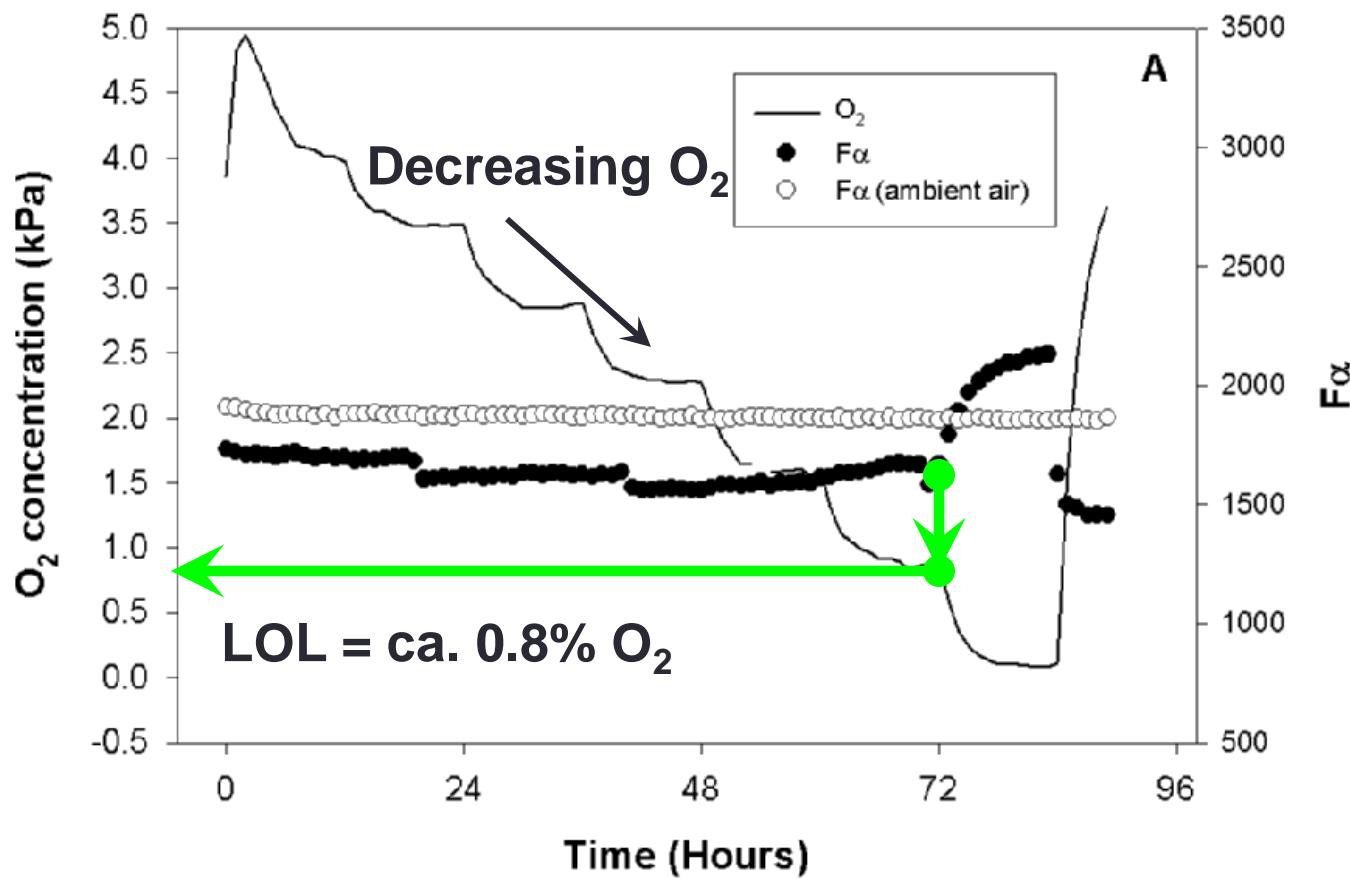
Major uptake of technology in Europe

Maximal quality retention (green line) occurs when the storage O₂ (%) is at Lower O₂ Limit, LOL (= Anaerobic Compensation Point, ACP)





Using HarvestWatch to determine LOL in apple



HarvestWatch containers in storage bins



4. PHYSIOLOGICAL DISORDERS

Superficial scald or storage scald



Variety specific, e.g. Fuji, Red Delicious

Occurrence of superficial scald

- Associated with
 - High nitrogen and low calcium program in orchard
 - Climate – hot, dry and sunny growing environment = higher risk than colder growing climate
 - Early harvest, but ripe fruit are not suitable for storage
 - Longer storage period
 - Slow cooling
 - Poor ventilation
 - Ethylene in storage environment

Overall, not much you can do in the field except get fruit to storage rapidly

Preventing superficial scald

- Rapid cooling of fruit
- Shorter storage periods, especially in air
- Ventilation
- DPA in many countries where registered
- 1-MCP can be very effective

Shriveling/water loss associated with

- Variety – e.g. Golden Delicious is especially prone because of russetted type skin
- Normally higher in air than CA storage because of high relative humidity in CA
- High rates of respiration

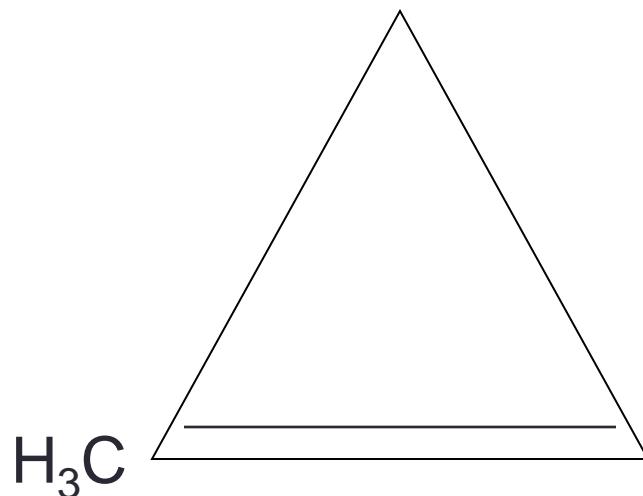
Prevent or reduce by

- Rapid cooling
- Using sheets of plastics over the bins or crates that are on the top layer and most exposed to the evaporators (only after cooling)
- Using plastic instead of wood
 - A dry bin will increase in weight by 9-10% (6.5-7.0 kg) during cold storage
- Bin liners in wooden box pallets
- Reducing condensation or freezing on cooling coils

5. 1-MCP

SMARTFRESH

1-METHYLCYCLOPROPENE (1-MCP)

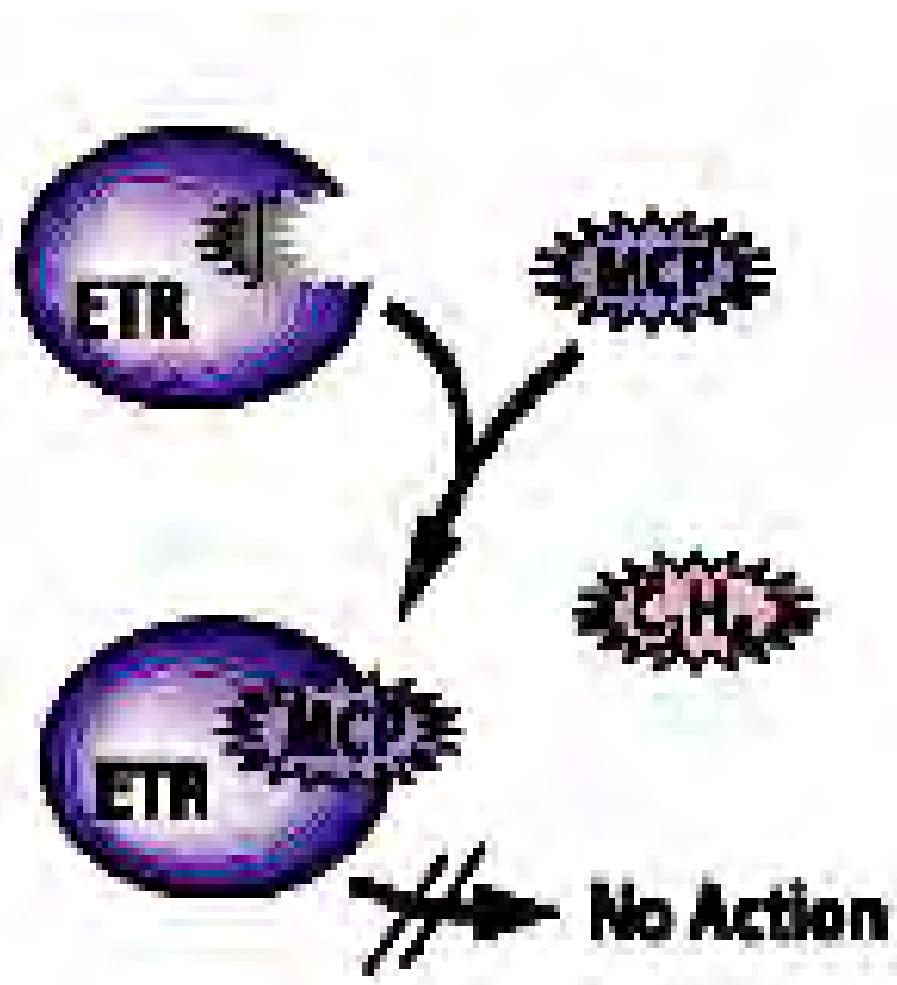


1-methylcyclopropene

(1-MCP); SmartFresh™

- Non-toxic
- Effective at low concentrations (<1ppm)
- Odorless
- Vapor at physiological temperatures

Mode of action



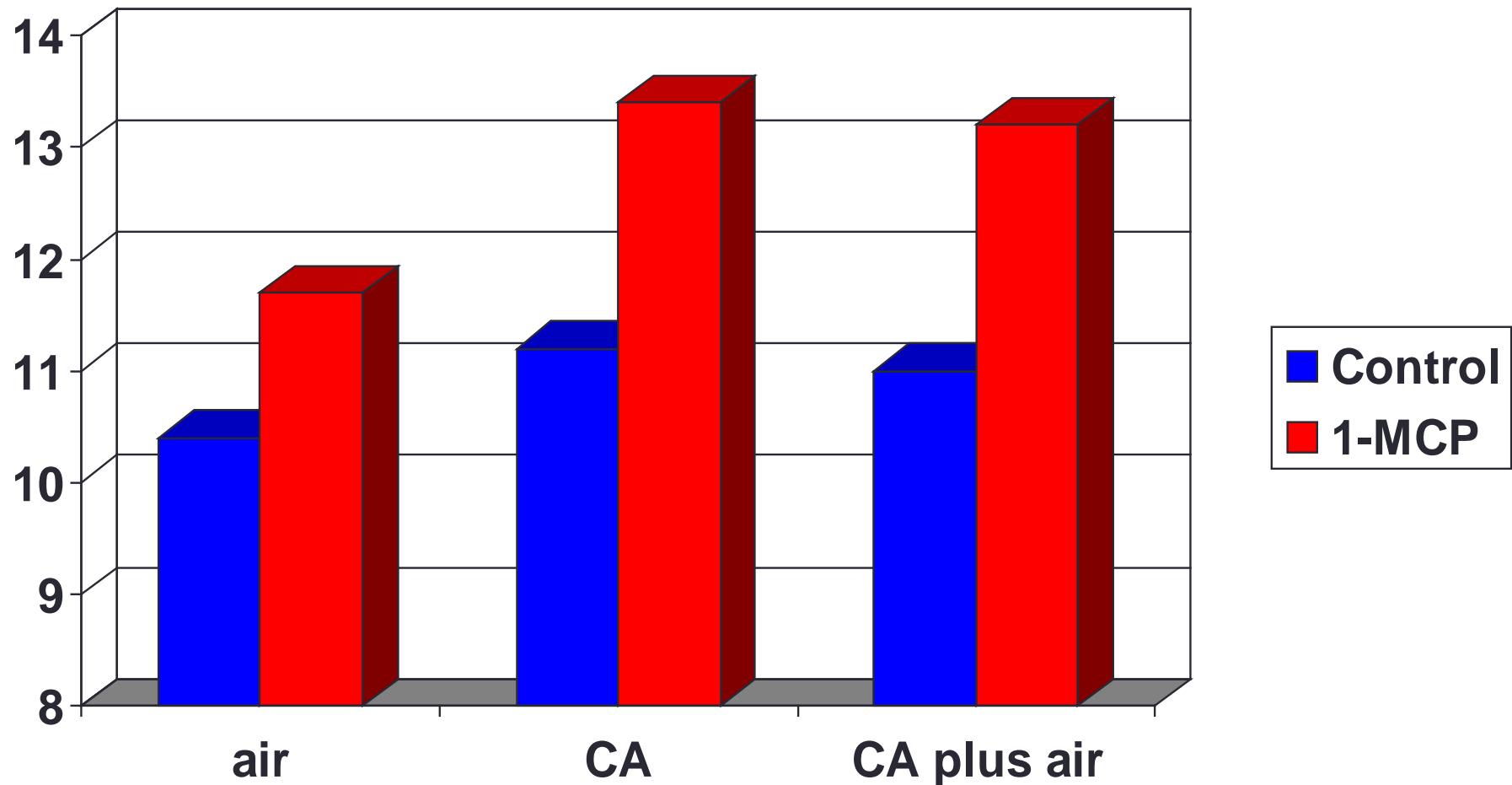
- Binds to the ethylene binding sites on cell membranes
- Stops or slows ripening and senescence processes



- Applied as a gas which is released by adding water to a powder formulation composed of cyclodextran (sugar)

Cortland firmness (lb)

- air, CA [4 months], CA plus air [1 month]



Factors that affect success of SmartFresh

- Variety
- Harvest maturity
- Postharvest handling, e.g. delays between harvest and MCP treatment
- Storage type – traditional, refrigerated, CA

SmartFresh recommendations

- examples of variety differences
- ***Fuji: max harvest to treatment (12)***
- ***Delicious, Gala: max harvest to treatment (7)***
- ***Mutsu: max harvest to treatment (10)***

Benefits

- Maintains firmness and acidity, and can extend storage life
- Possibly permits warmer storage temperatures
- Inhibits senescent disorders and superficial scald



Risks – increased susceptibility to

- Carbon dioxide related disorders
- Can slow down loss of watercore, and therefore breakdown
- Some flesh browning disorders

Usually associated with CA storage



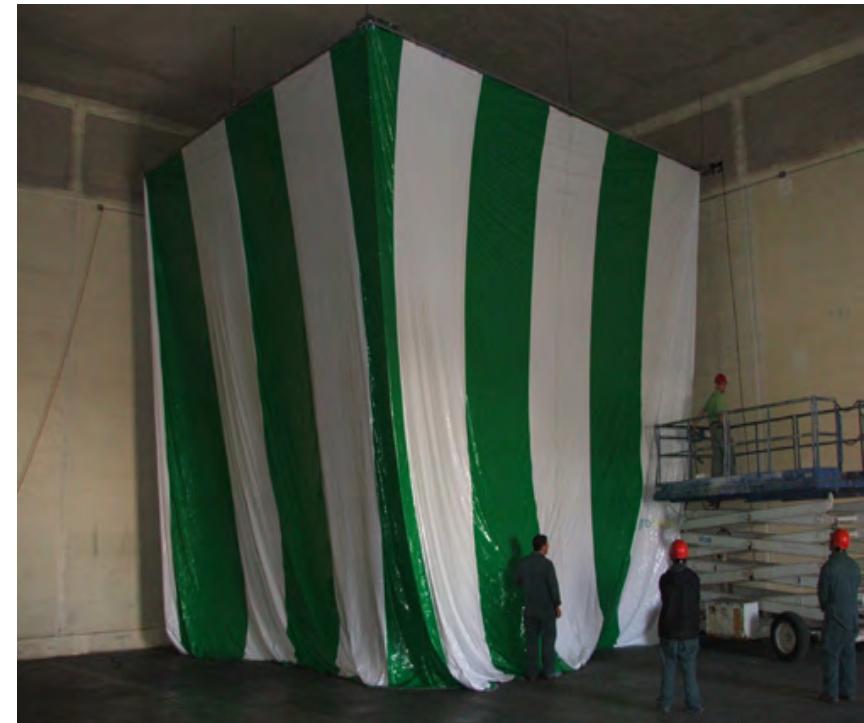
SmartFresh (1-MCP)

- Value is extending storage life and may allow further benefits without investment in CA storages

But:

- Fruit harvest would need to be coordinated and suitable rooms (not leaky) used for application
- the cost/benefit factor is critical

Rapid 1-MCP treatment after harvest – special treatment rooms or tents



Plant growth regulators

Aminoethoxyvinylglycine (AVG)

Plant Growth Regulator

ReTain®

Soluble Powder

FOR USE ON APPLE, PEAR, AND STONE FRUIT (EXCEPT CHERRY)

ACTIVE INGREDIENT:
[S]-trans-2-Amino-4-(2-aminoethoxy)-3-butenoic acid hydrochloride 15%
OTHER INGREDIENTS: 85%
TOTAL: 100%

EPA Reg. No. 73040-45
EPA Est. No. 33702-IA-001 (Lot No. Suffix 'S4')
33087-NJ-1 (Lot No. Suffix 'Q5') List No. 12017

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 6.0 General Application Instructions
 7.0 Compatibility With Other Agricultural Products
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 9.0 Apple and Pear (Except Cherry)
 10.0 Storage and Disposal
 11.0 Notice to User

KEEP OUT OF REACH OF CHILDREN CAUTION

FIRST AID	
If inhaled:	- Move person to fresh air. - If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible. - Call a poison control center or doctor for further treatment advice.
If on skin or clothing:	- Take off contaminated clothing. - Rinse skin immediately with plenty of water for 15-20 minutes. - Call a poison control center or doctor for treatment advice.
AGRICULTURAL USE REQUIREMENTS	
Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170.	



Naphthalene acetic acid (NAA)

FRUITONE®

FOR THINNING AND CONTROL OF FRUITING APPLES AND PEARS. FOR PROMOTING RETURN BLOOM OF APPLES DURING THE FOLLOWING SEASON

ACTIVE INGREDIENT: 1-Naphthaleneacetic Acid, Sodium Salt*	3.3%
INERT INGREDIENTS:	96.7%
Total:	100.0%
<i>*Equivalent to 1.1% of Naphthaleneacetic Acid.</i>	
FOR THE FOLLOWING EMERGENCIES, PHONE 24 HOURS A DAY: TRANSPORTATION CHEM-REC 1-800-424-3350 Other AMVAC 1-323-294-3910	

KEEP OUT OF REACH OF CHILDREN CAUTION STATEMENTS OF PRACTICAL TREATMENT

IF ON SKIN: Flush with water with skin with plenty of water for 15 minutes. Get medical attention if irritation persists.
IF SWALLOWED: Call a poison center or Doctor. Drink 1 or 2 glasses of water. Do not induce vomiting. Do not drink alcohol or eat during or after vomiting. If person is unconscious, do not give anything by mouth and do not induce vomiting.
IF IN EYES: Flush eyes with plenty of water. Call a physician if irritation persists.
IF INHALED: Remove victim from area if not breathing, give artificial respiration, preferably mouth-to-mouth. Give medical attention.

NOTE TO PHYSICIAN: No specific antidote is available. All treatments should be based on observed signs and symptoms of disease in the patient. Overexposure to materials other than this product may have occurred.

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS AND DOMESTIC ANIMALS:
CAUTION: Harmful if absorbed through the skin or eyes, swallowed or inhaled. Avoid contact with skin, eyes, or clothing. Avoid breathing spray mist.

PERSONAL PROTECTIVE EQUIPMENT (PPE)
 Applicators and other handlers must wear:
 - long-sleeved shirt and long pants
 - gloves
 - shoes plus socks
 Follow manufacturer's instructions for cleaning and maintaining PPE. If no such instructions are given, use good practices, as described below:
 - Use respirator or dust mask if handling dust or spray mist.

GENERAL INFORMATION
 Fumone N is an auxin plant hormone for use in fruit production. The response of fruits to an auxin may vary in different years. In reviewing the results, the grower must take into account the particular variety of fruit, the time of application, the weather conditions, the soil type, and the specific requirements of the fruit set before choosing the desired rate and timing for application. Application using sufficient water to ensure complete uniform spray coverage with your specific equipment is important. The recommended rate is 1.1 oz per acre (0.03 liter per hectare).

The appropriate spray volume is determined by the type of equipment used, tree size and density of foliage. Each grower should consider all variables in rate and application timing for each variety and orchard location when establishing the spray program.

EPA Reg. No. 5481-427

EPA Est. No. 5481-CA-1

AMVAC

4100 E. Washington Boulevard
Los Angeles, CA 90023, USA
1-323-294-3010 • www.amvac-chemical.com

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Prevent fruit drop

Harvest and labor management

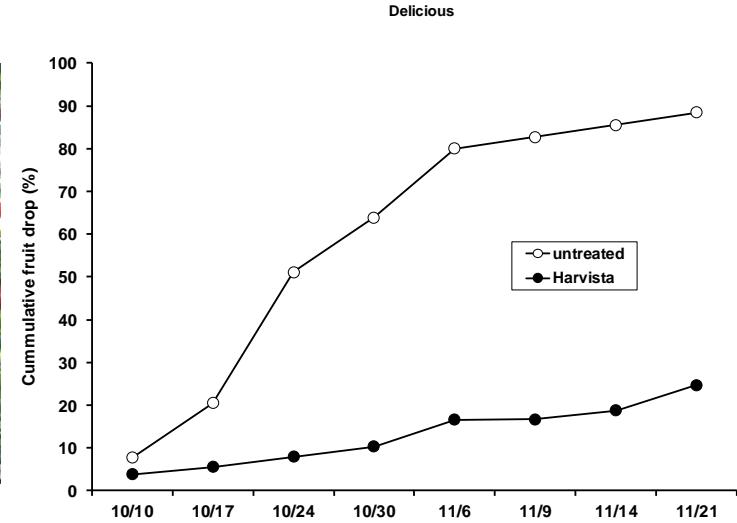
Responses of fruit to SmartFresh

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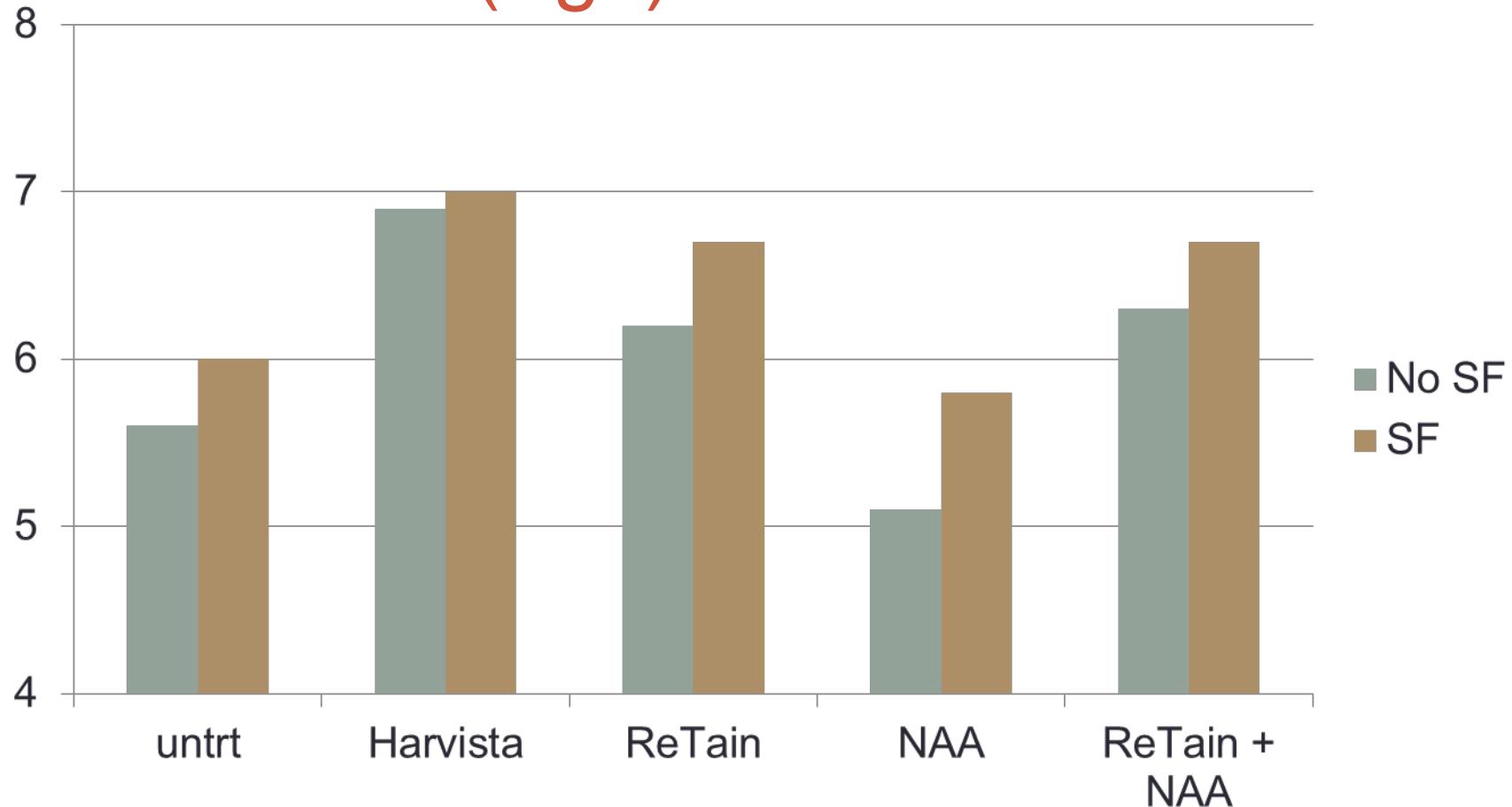
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Harvista

- Preharvest application of 1-MCP

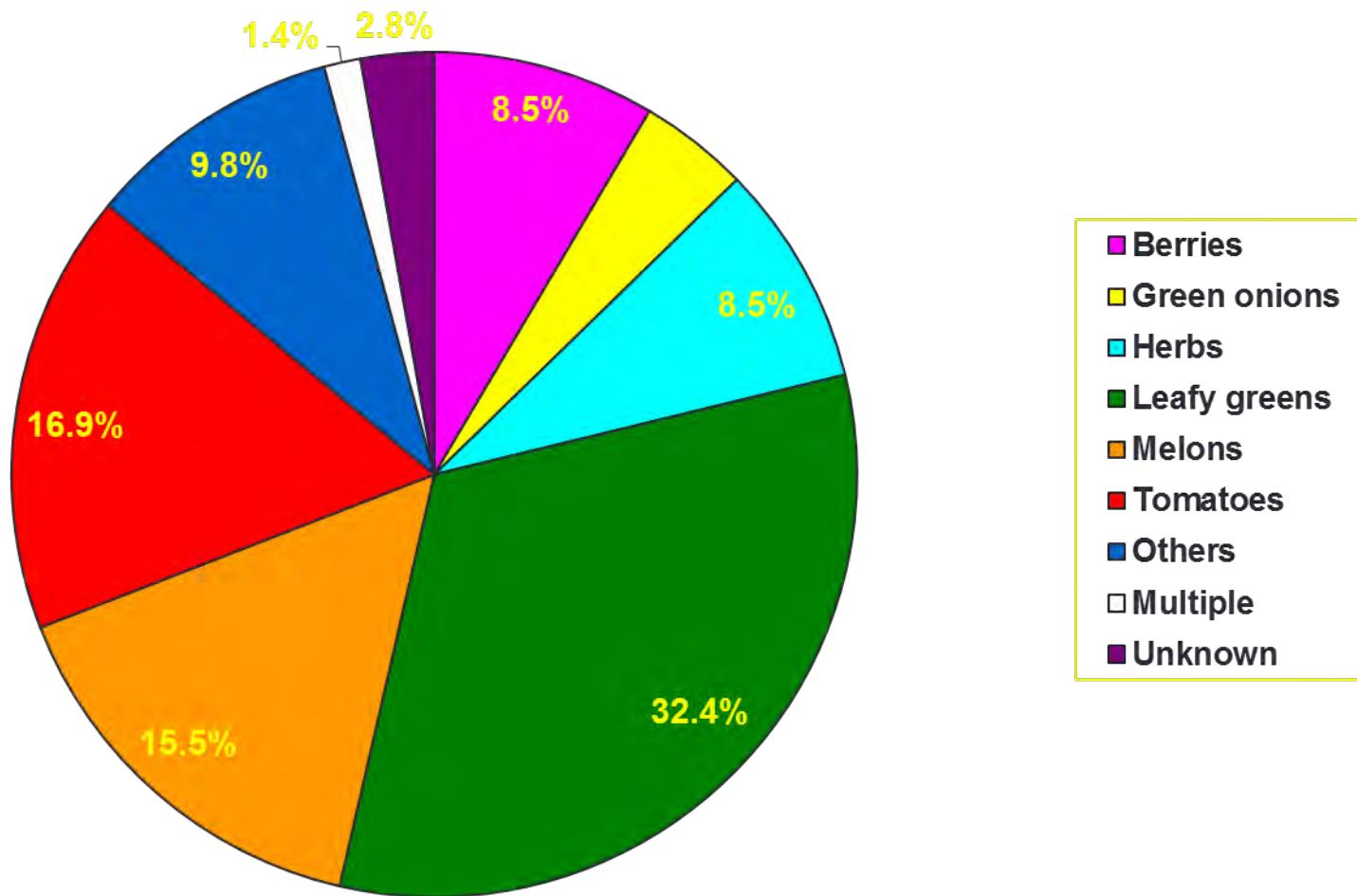


Sept 21 harvest: 4 months CA storage + 1 d – firmness (Kg-f)



6. FOOD SAFETY

Types of produce associated with outbreaks, 1996-2006 (N=71)



DAY 1- WHY FOOD SAFETY SHOULD BE A PRIORITY FOR EVERY FARM



Day 2- Writing Your Individual Farm food Safety Plan



Day 3- Mock Audit at a Participant's Farm



The importance

- Impact marketability and profitability
- Impact regulatory agencies
- Impact industry standards
- Impact consumer confidence
- Impact consumer buying preferences
- Are not easily forgotten

Emphasis is on Good Agricultural Practices (GAPs)

Good Agricultural Practices

- Water quality
- Manure & compost
- Domestic & feral animals
- Field sanitation & transportation
- Packing house sanitation



Food Safety Begins on the Farm

A Grower Self Assessment of Food Safety Risks

Anusuya Rangarajan, Elizabeth A. Bihn, Marvin P. Pritts, and Robert B. Gravani

Cornell University

Department of Food Science • Department of Horticulture • Cornell University • Ithaca, NY 14853



A Comprehensive GAPs effort for Worker Training

- Worker Health
- Worker Hygiene
- Worker Behavior
- Worker Learning
- Worker Training

Basic Harvest Practices

- **Grading and quality during harvest**
- **Cleaning & sanitation of containers**
- **Harvest dry fruits**



Postharvest...

- Soil removal from produce and bins in the field to prevent contaminating wash water or other loads of produce
- Potable water sources for all postharvest operations
- Maintenance of a cold chain to minimize growth of pathogens
- Refrigerated or cold room loading and management
- Cull pile management to remove contamination source

Packing House



- Seal doors and windows
- Keep pallets 1 foot from the walls
- Implement pest and rodent control
- Remove culled product everyday
- Keep garbage bins covered
- Keep outside grounds clear of debris

The extent to which these apply to you will be a function of your market, especially external demands

- Food safety issues will increase not decrease regardless of country
- A huge factor in consumer confidence

QUESTIONS?
