Adapting Technology to Extend Postharvest Quality

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Why is quality important???

1. Eat five portions per day
2. High in vitamins, antioxidants (pigments, phenolics)
3. Low in carbohydrates
4. Natural fibers

Source: Emory Report

Today's Focus:

- *How can we employ technology to minimize mechanical damage during harvest operations?*

  - ***Factors affecting postharvest quality and shelf life***
    - *Fragile nature of fresh produce / USDA/AMS grade standards*
    - *Increasing scarcity of labor*
    - *Harvest operations*
    - *Packing operations*
    - *Shipping operations*

MECHANICAL HARVEST

- Most effective for once-over harvests
- Commonly used for:
  - Roots, tubers, rhizomes (cushioned by soil)
  - Leafy crops (some protection from outer leaves
  - Crops destined for processing (processed quickly)

Advantages of mechanical harvest

- Has high harvest efficiency
- Fewer labor management issues
- Reduces fatigue for workers

Making mechanical harvest efficient

- Requires higher skilled workers
- Machines require regular servicing
- Production techniques may need to be changed to conform to the harvester
- Uniform crop stands and harvest maturity are essential
- Machines must be used as much as possible for best return on investment

Disadvantages of mechanical harvest

Higher losses due to excessive injury to crop

Machines may become obsolete before being paid off

Harvest rate may exceed subsequent handling capability, causing down time

Example: A pepper packing line used an optical sizer – it was too fast for the hand packing operation.

- Today's Focus:
  How can we employ technology to minimize mechanical damage during harvest operations?

We will consider these crops

Tomato

Blueberry

Strawberry

Tomato Harvest and Fruit Quality

- Commercial tomatoes are hand-harvested at mature-green stage
- After packing, they are ripened prior to shipping

But first…a quick review of tomato ripening…

U.S.D.A. Grade Standards

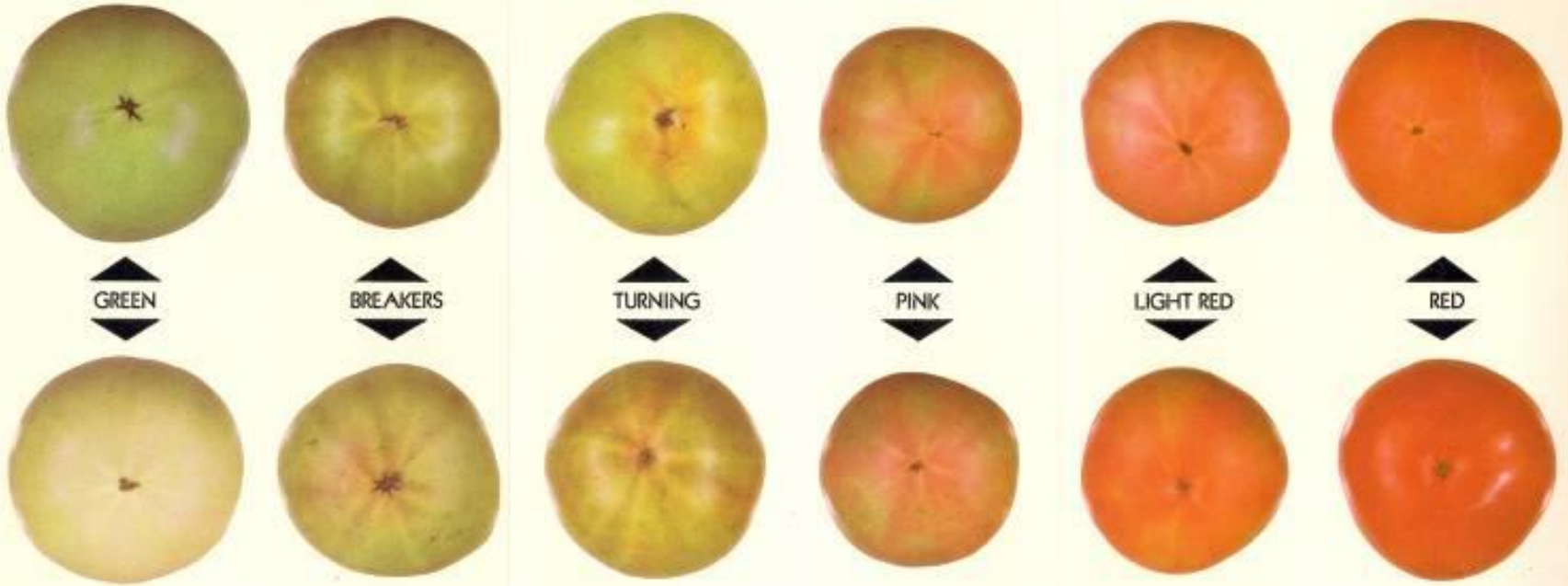
COLOR CLASSIFICATION REQUIREMENTS IN

UNITED STATES STANDARDS FOR GRADES OF FRESH

TOMATOES

United Fresh Fruit and Vegetable Association
in cooperation with
U. S. Department of Agriculture
Agricultural Marketing Service
Fruit and Vegetable Division

U.S.D.A. Visual Aid TM-L-1; February '75
The John Henry Company
P.O. Box 1410, Lansing, Mich. 48904



(1) "**Green**" means that the surface of the tomato is completely green in color. The shade of green color may vary from light to dark;

(2) "**Breakers**" means that there is a definite break in color from green to tannish-yellow, pink or red on not more than 10 percent of the surface;

(3) "**Turning**" means that more than 10 percent but not more than 30 percent of the surface, in the aggregate, shows a definite change in color from green to tannish-yellow, pink, red, or a combination thereof;

(4) "**Pink**" means that more than 30 percent but not more than 60 percent of the surface, in the aggregate, shows pink or red color;

(5) "**Light red**" means that more than 60 percent of the surface, in the aggregate, shows pinkish-red or red: *Provided*, That not more than 90 percent of the surface is red color; and,

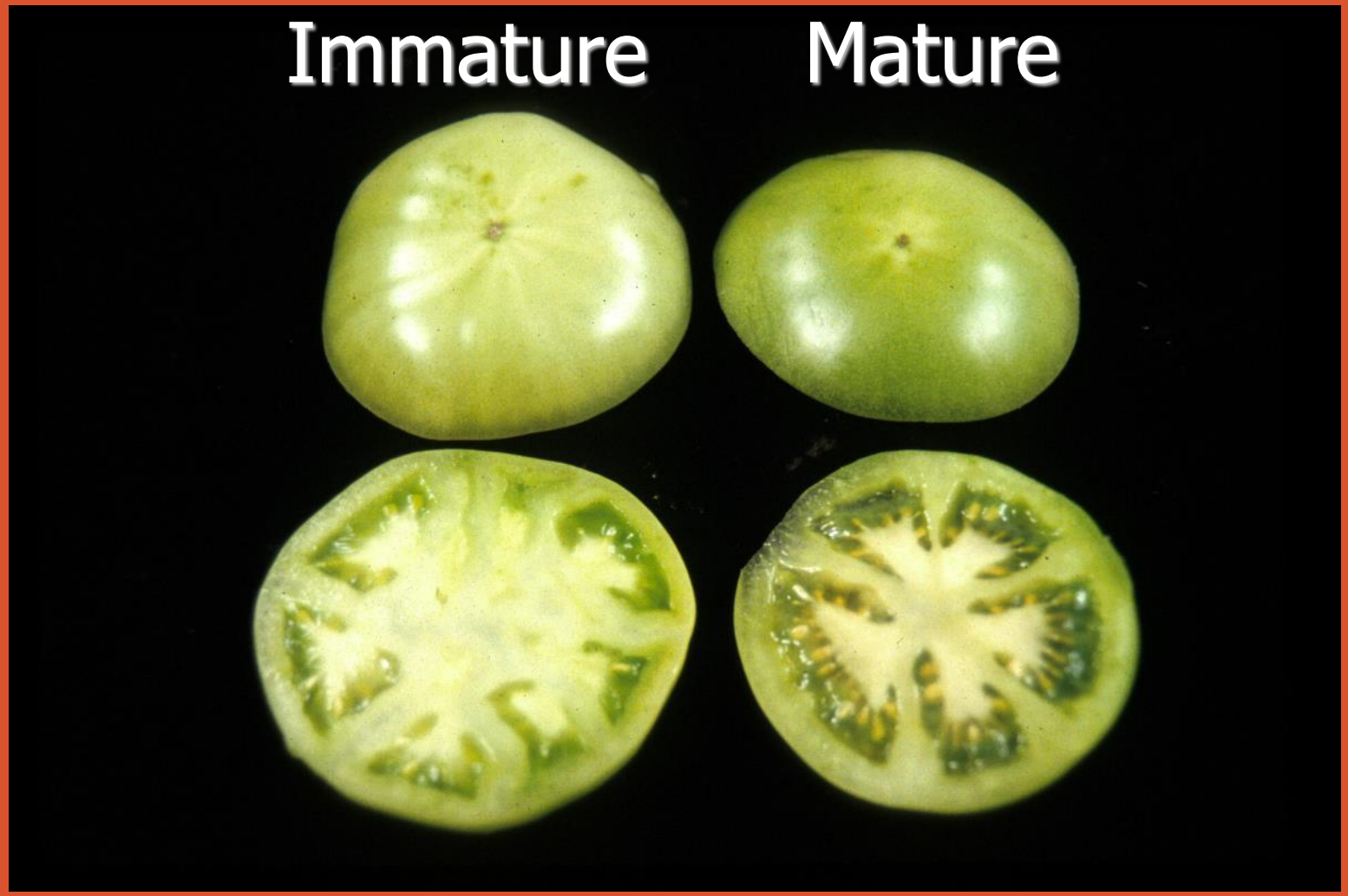
(6) "**Red**" means that more than 90 percent of the surface, in the aggregate, shows red color.

The above photographs are only guides illustrating the shade and percentage of surface color specified for each of the color terms. These photographs do not necessarily depict absolute limits of minimum or maximum shades and/or percentage of color required for each term.

Green Tomato Maturity Ratings

Determining Harvest Maturity Is Not Easy

Harvest Maturity



Sensory panel results from “difference from control” for ripe, round tomatoes (green-harvested)*

		Days to Reach Breaker Stage (in 100 ppm ethylene)		
	Pr > F	**1 day**	**3 days**	**5 days****
Agriset-761	>0.0008	**3.85 a**	6.65 b	6.80 b

* Difference from control ratings were based on a 12-point hedonic scale with verbal descriptors ranging from: 1 = no difference to 12 = very different.

**However, several panelists described “unpleasant”, “metallic”, “strange”, and “lingering off-flavors/off-odors” in fruits treated for 5 days - later supported by aroma volatile tests. (F. Maul, 1998)

SUMMARY

Using ethylene to sort high-quality round tomatoes:

- Harvest at green stage
- Presort to remove ≥breaker stage and defects
- Treat with ethylene for 3 days (100 ppm)
  - Remove premium-quality tomatoes (high flavor)
- Treat with ethylene for 2 more days
  - Remove food-service grade tomatoes (acceptable flavor
- Discard remaining green tomatoes

Mechanical injury during harvest and handling operations

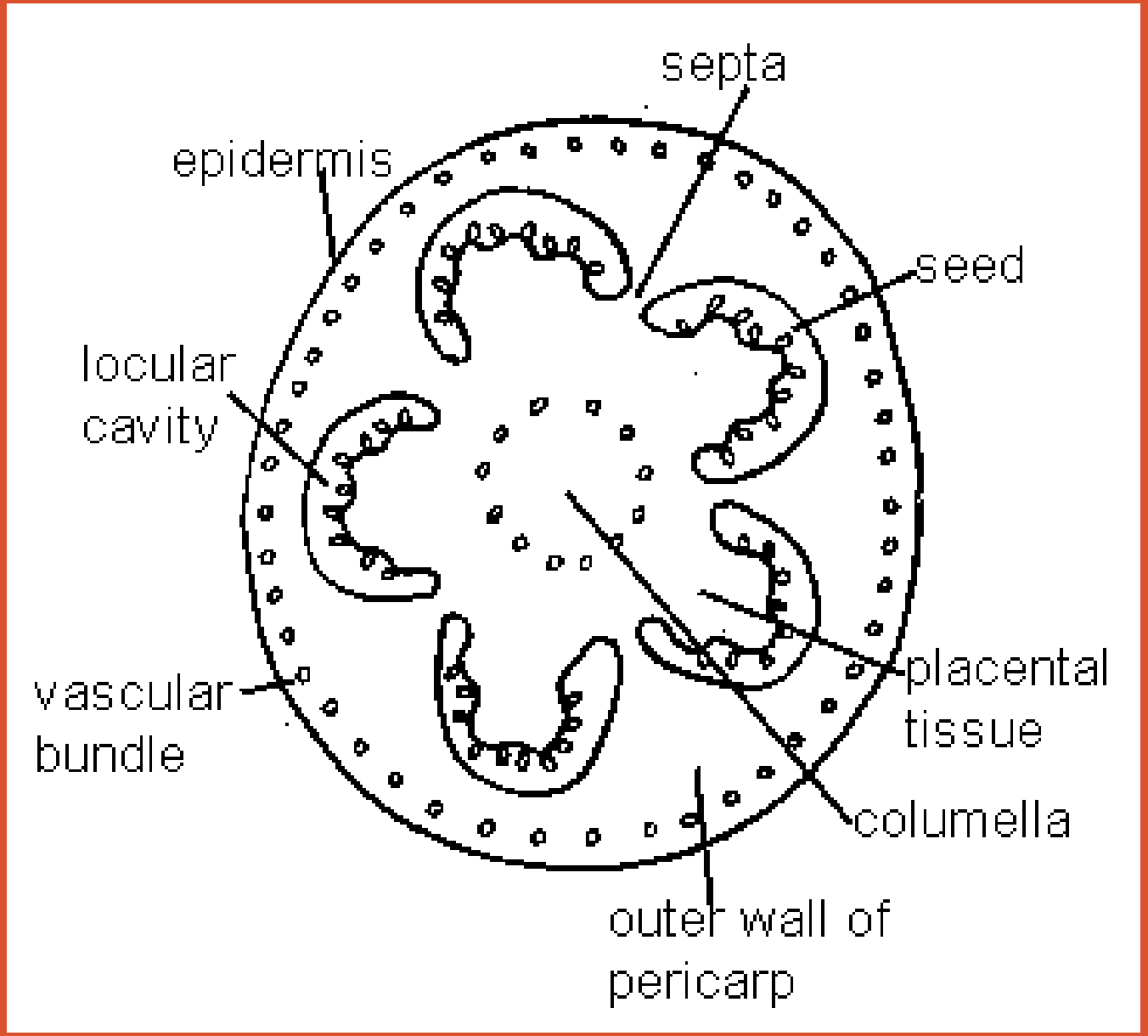
Mechanical Injury

Injuries Accelerate Ripening

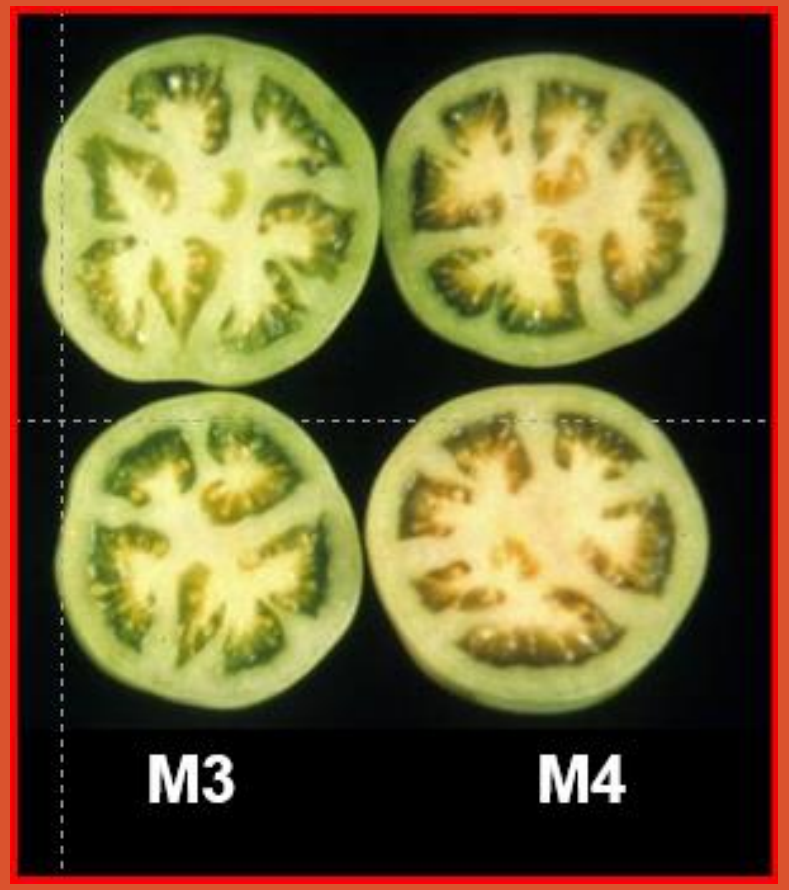
Injuries Lead to Decay


Harvest Bruises Promote Decay

Internal structure



https://labs.plb.ucdavis.edu/rost/tomato/Reproductive/anat.html



Internal Bruising: Most sensitive injury for tomato

Internal Bruising: pericarp removed

Internal Bruising Summary

- 1 drop from 4 inches can cause IB
- Most IB occurs during harvest and during packing - drop into carton
- Breaker-stage round tomato are more sensitive to IB than green stage

Negative effects of impacts on tomato quality. ('Solarset')

Parameter	Pericarp	Locular Gel
Total carotenoids	=	↓
Chlorophyll	↑	↑
Vitamin C	↓	↓
Total Soluble Sugars	=	=
Titratable acidity	=	↓
Soluble solids (Brix)	=	=
Viscosity (cm/sec)	-----	↓

C. Moretti, 1998

New Technologies for Harvesting

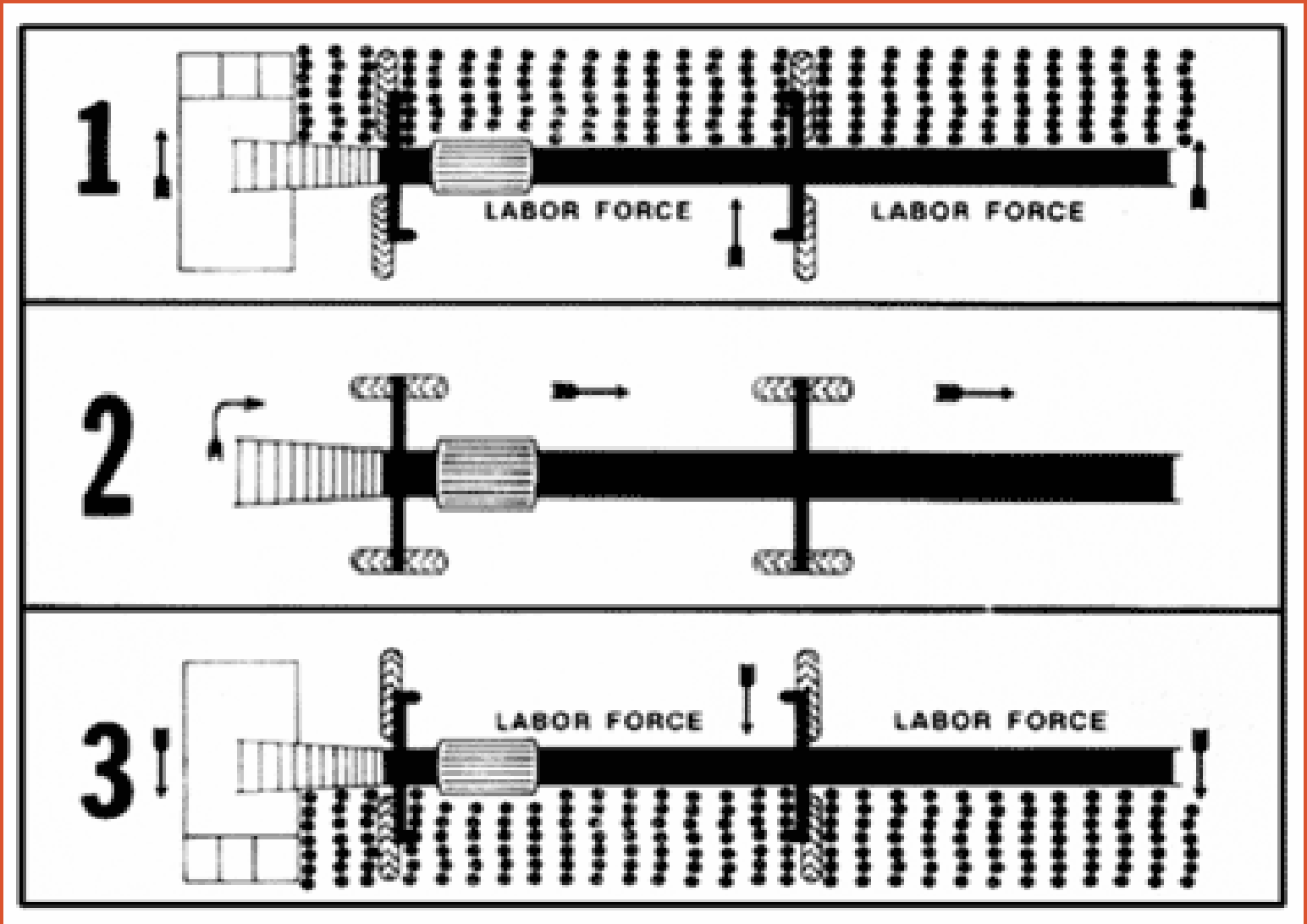
- Roma tomatoes for processing have been mechanically harvested form more than 30 years
- Once-over; ripe fruit
- Fresh market presents different challenges

Increasing Hand-Harvest Efficiency: harvest aids

Tractor-mounted conveyor belts (left), accompanying trailer for in-field packing or bulk bin filling.

Increasing Harvest Efficiency

Self-propelled, over-the-row conveyor systems



Top view of harvest system

Ramsay Highlander, Inc., Salinas CA

Short walking distance to conveyor

- "On-board" sorting and trash removal
- Potential sanitation and rinse step

Blueberry harvest & postharvest quality

- Fruit receive more than 10 primary impacts during harvest and handling
- Several more impacts occur on the packing line

Bruising from impacts during handling

Transitioning to mechanical harvest

<u>Traditional uses:</u>

- Last harvest only
- Soft fruit - send for processing
- Low price

Transitioning to mechanical harvest

<u>Challenges to pick for fresh market:</u>

- Southern highbush varieties were too soft
- Harvesters had significant drop heights
- Mixture of ripeness stages harvested

Fruit missed by mechanical harvest: bloom removed by harvester tines

Delays to harvest: effects on fruit quality

Objective: Evaluate blueberry quality when:

- Hand-picked upon reaching blue color stage
- Machine-picked 7 days later
- ‘Meadowlark’, ‘Farthing’, ‘Sweetcrisp’

Evaluated:

- Day of harvest – at packing
- After 7 and 14 days of storage

Packout Quality: hand vs. machine harvest

Meadowlark

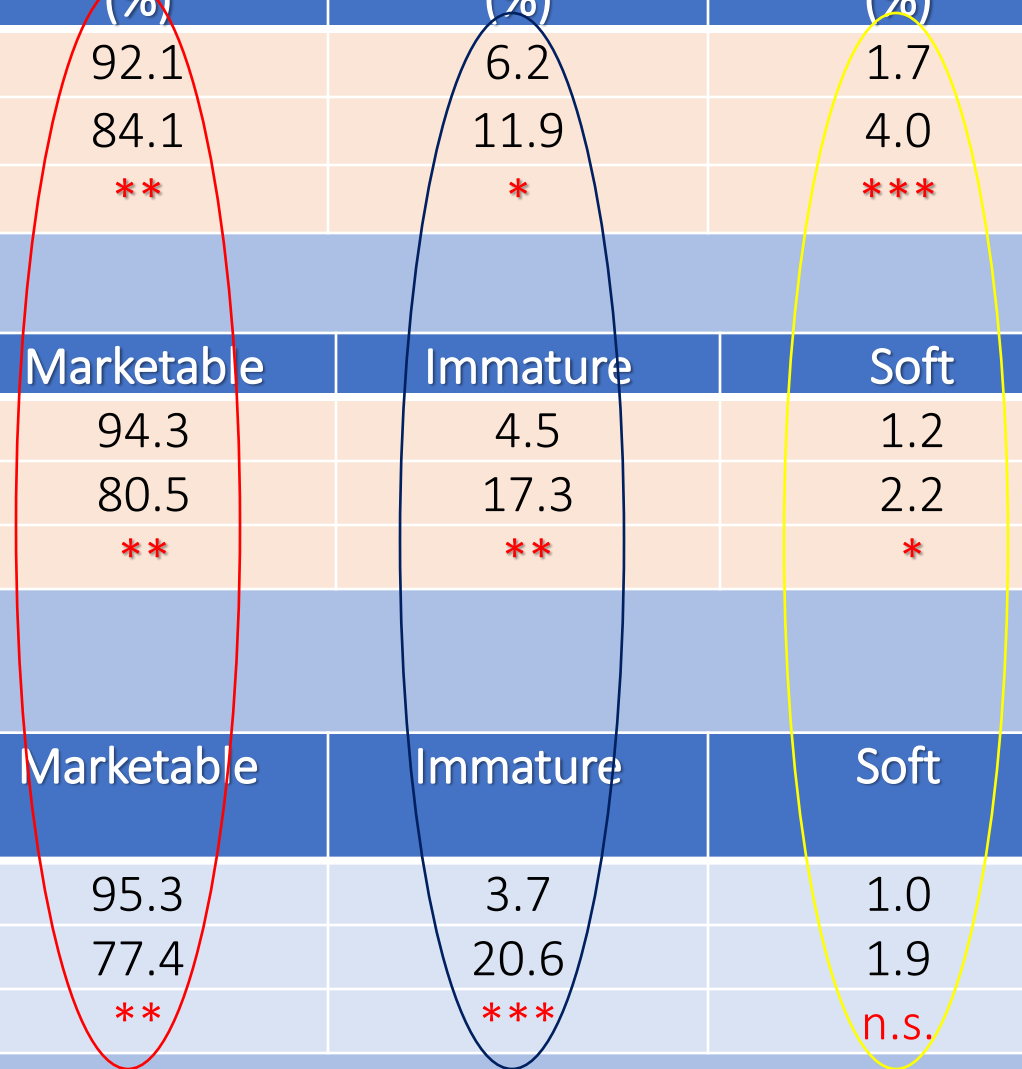
Harvest Method	Marketable (%)	Immature (%)	Soft (%)
Hand	92.1	6.2	1.7
Machine	84.1	11.9	4.0
Significance	**	*	***

Farthing

Harvest Method	Marketable	Immature	Soft
Hand	94.3	4.5	1.2
Machine	80.5	17.3	2.2
Significance	**	**	*

Sweetcrisp

Harvest Method	Marketable	Immature	Soft
Hand	95.3	3.7	1.0
Machine	77.4	20.6	1.9
Significance	**	***	n.s.



Visual Quality During Storage

	Hand Harvested and Stored						Mech. Harvested and Stored					
	7 days			14 days			7 days			14 days		
Cultivar	App* Rate	Soft %	Shr %	App Rate	Soft %	Shr %	App Rate	Soft %	Shr %	App Rate	Soft %	Shr %
Harvest 1												
M-lark	4.0	15.0	30.0	2.0	10.0	90.0	4.0	25.0	37.5	2.0	32.5	90.0
Farth.	4.0	10.0	17.5	3.0	30.0	27.5	4.0	25.0	5.0	2.0	75.0	50.0
Swtcrsp	4.0	10.0	10.0	2.9	15.0	50.0	4.0	42.5	15.0	2.0	70.0	70.0

*Visual Appearance Rating; 5=field fresh; 3=limit of marketability

Transitioning to mechanical harvest

<u>UGA-led study to modify harvester:</u>

- Reduce impacts onto hard surfaces
- Quantify bruise incidence and severity compared to hand harvest

Transitioning to mechanical harvest

<u>UGA-led study to modify harvester:</u>

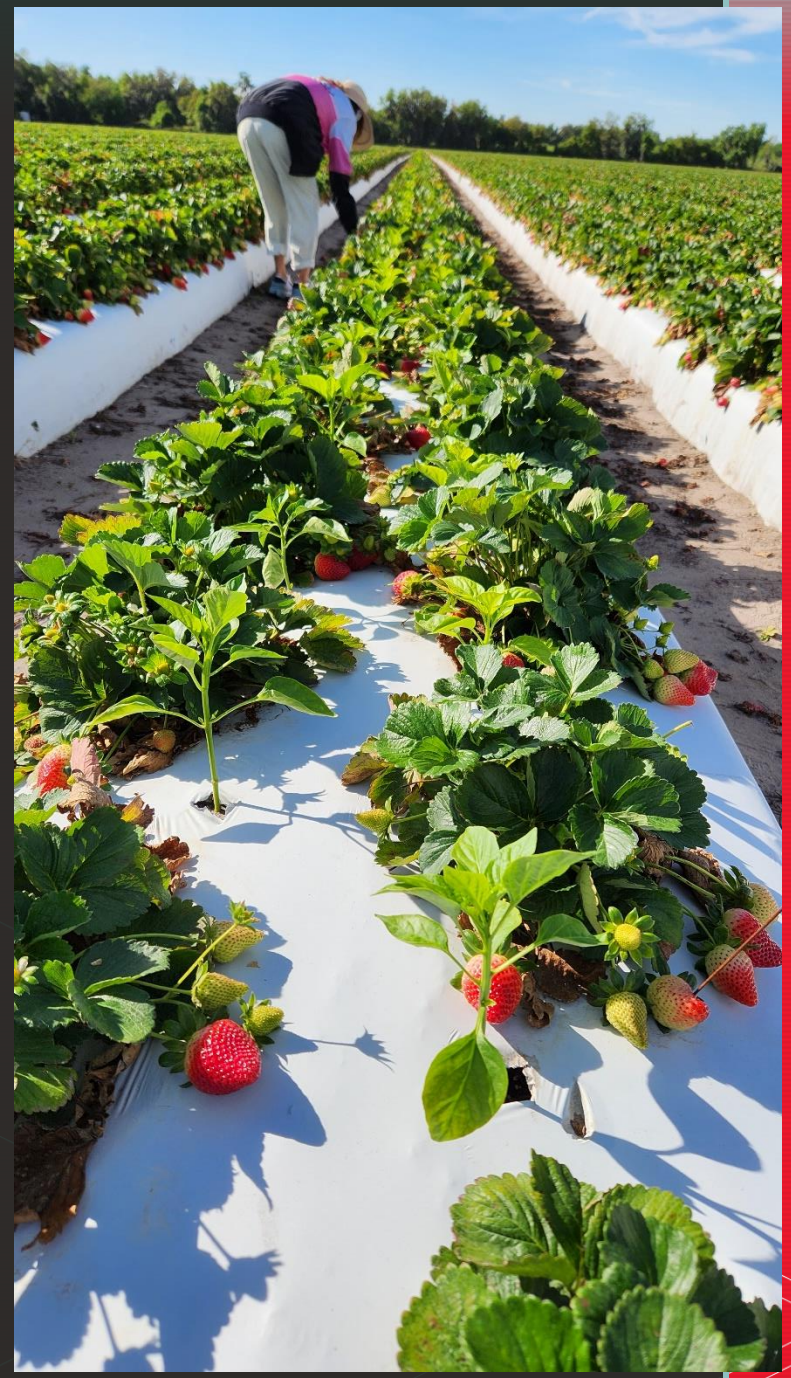
- Padding installed over hard conveyors
- Change hard catch plates for padded plates

Current Status of Mechanical Har

[More growers are
crop](#)

- New varieties are
  harvesters
- Machines are m
  speed, shaker s
- Harvesting wee
  pick infrequent

Strawberry Harvest and Postharvest Quality



Delicate crops are often field-packed

Harvest directly into consumer pack (clamshell)

Strawberry morphology: Five zones

Swollen receptable tissue supporting the achenes, the true fruits

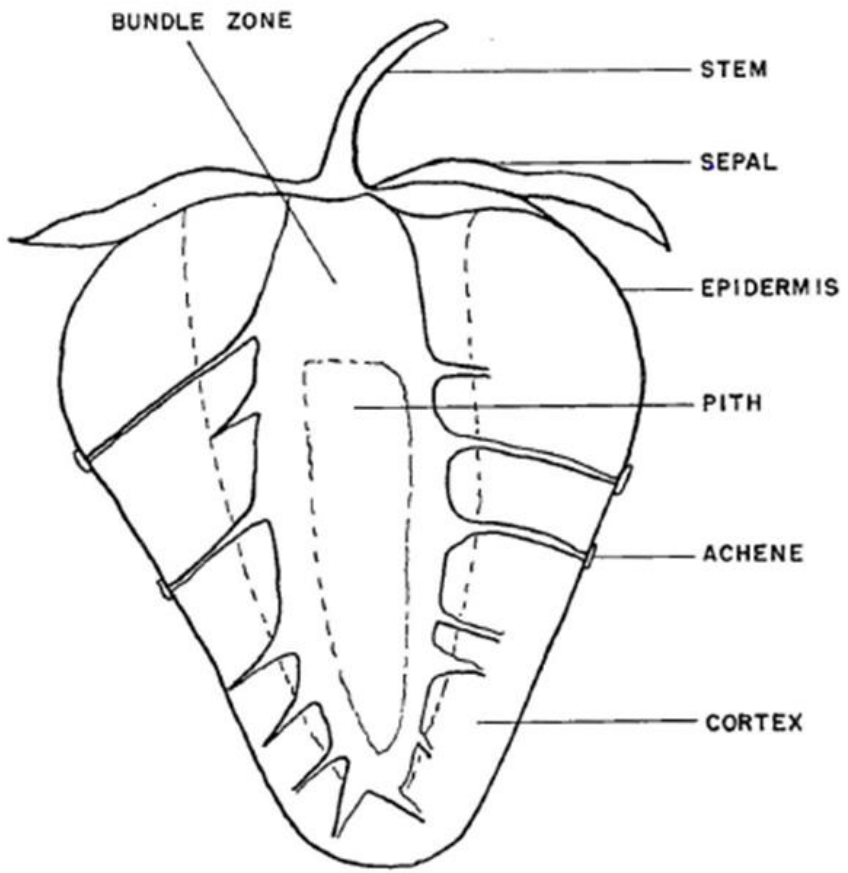
Epidermis: polygonal cells (stomata)

Hypodermis: meristematic cells; no interstitial air spaces

Cortex: rounded cells (true flesh); contains interstitial air spaces

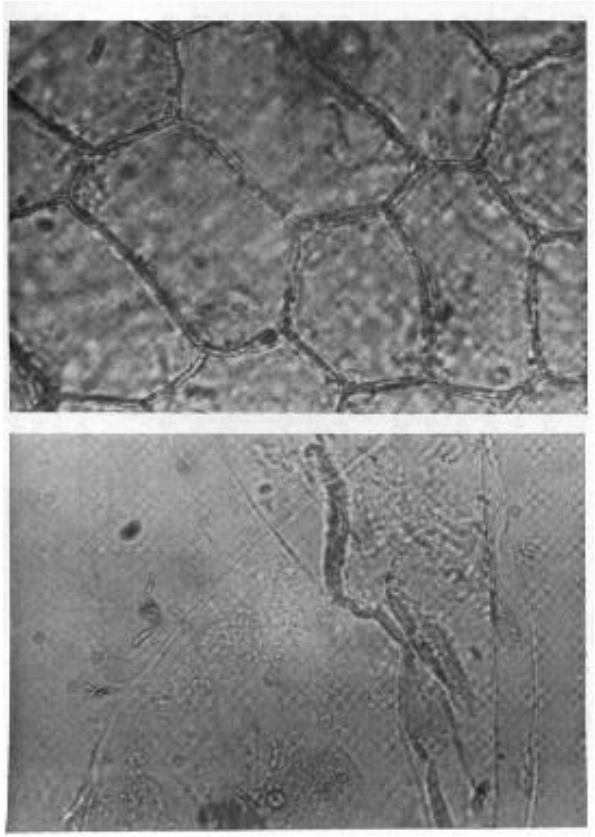
Bundle zone: conducting tissues (xylem, phloem

Pith: thin-walled cells that can separate during fruit expansion



Szczesniak and Smith, 1969

Why so perishable?



Nonclimacteric fruit: harvested at ripe stage

During ripening:

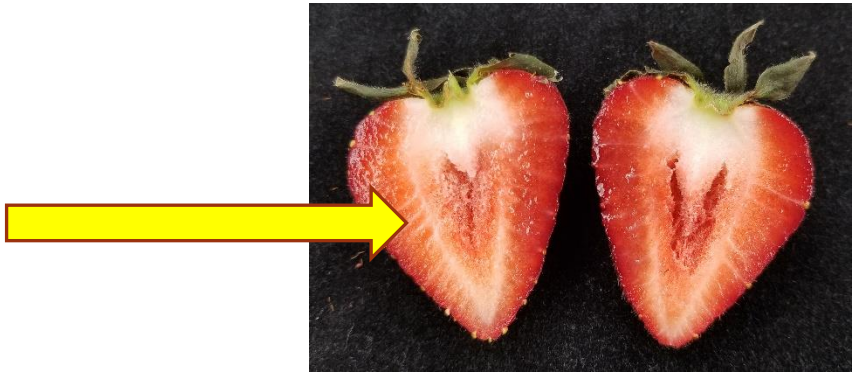
- Cells enlarge and cell walls become thinner
  - TOP Image: Epidermal cells
  - BOTTOM Image: Cortex cells becoming less organized (Szczesniak and Smith, 1969)
- Cellulase activity increases (Abeles & Takeda, 1990)

All contribute to fruit softening and fragility

Challenges at harvest

Fruit shape, size and ripeness stage

- Varies from conical to elongated to spherical to flattened



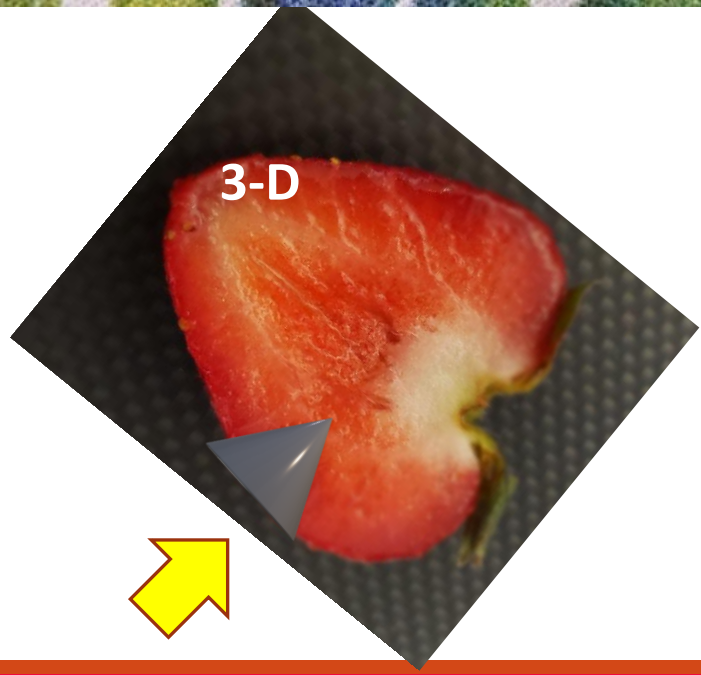
Internal structure

- May have void space during rapid cell expansion

Bruise concepts

Bruise develops when force exerted on the fruit exceeds its cellular integrity

- Impact energy dissipates through tissue (like my phone screen protector!)
- Disrupts epidermal layer, facilitating moisture loss
- Cells rupture, contents spilled into intercellular air spaces (watersoaking)

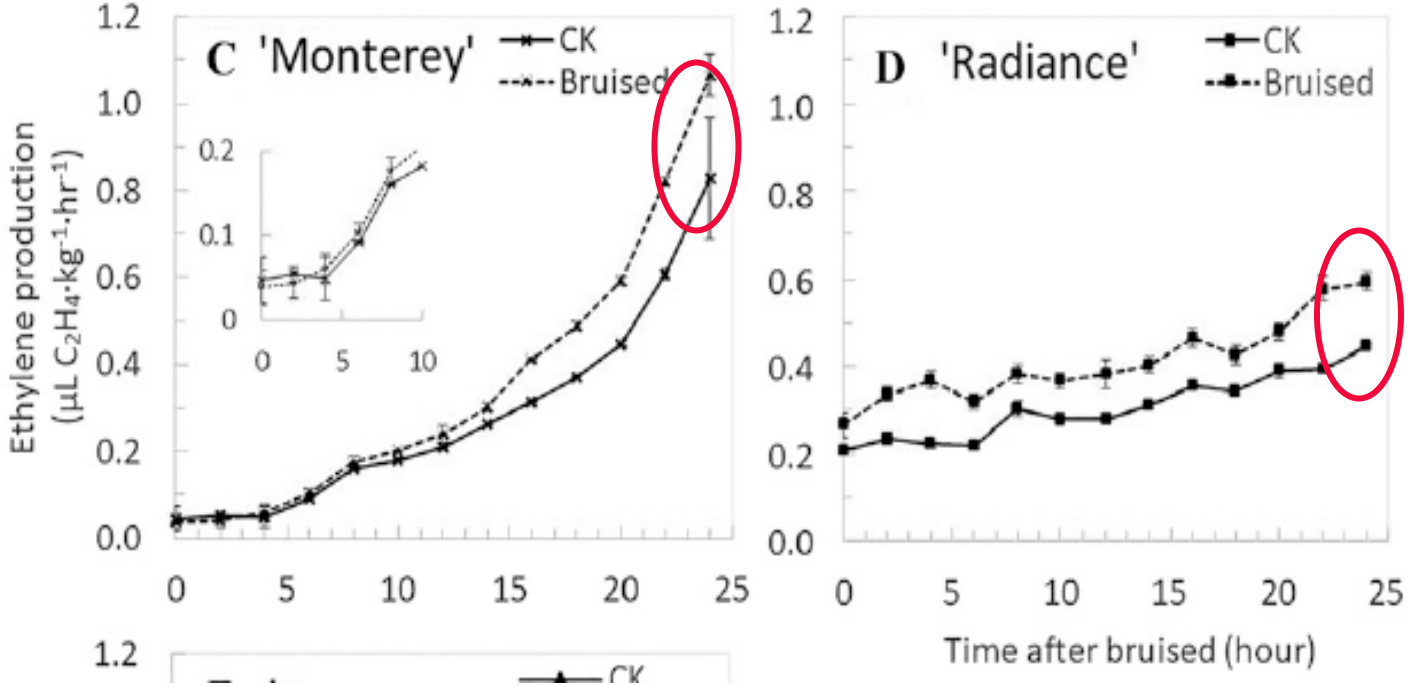


Bruise concepts

<u>Impact bruise</u>: a sudden event

- Drop onto a hard surface
- Being struck by a hard object
- Consequences:
  - Increased respiration, ethylene production, leading to accelerated fruit softening
  - Increased moisture loss during storage

Impact and ethylene production



(Chang and Brecht, 2020)

Bruise concepts

<u>Compression bruise</u>:

Static load (constant pressure) ruptures cells over time

- At harvest – picker holds several fruits in hand; can compress them
- Clamshell can be overfilled

Compression from fruit-to-fruit contact

Current strategies for quality maintenance

- Manually harvested
- Field-packed
- Forced-air cooled to near 1 °C, 2 to 3 hours after harvest
- Drawbacks:
  - Labor can be inefficient
  - Carrying filled flat to truck
  - >25% of time walking back & forth

Strawberry Harvest Aid

Picking

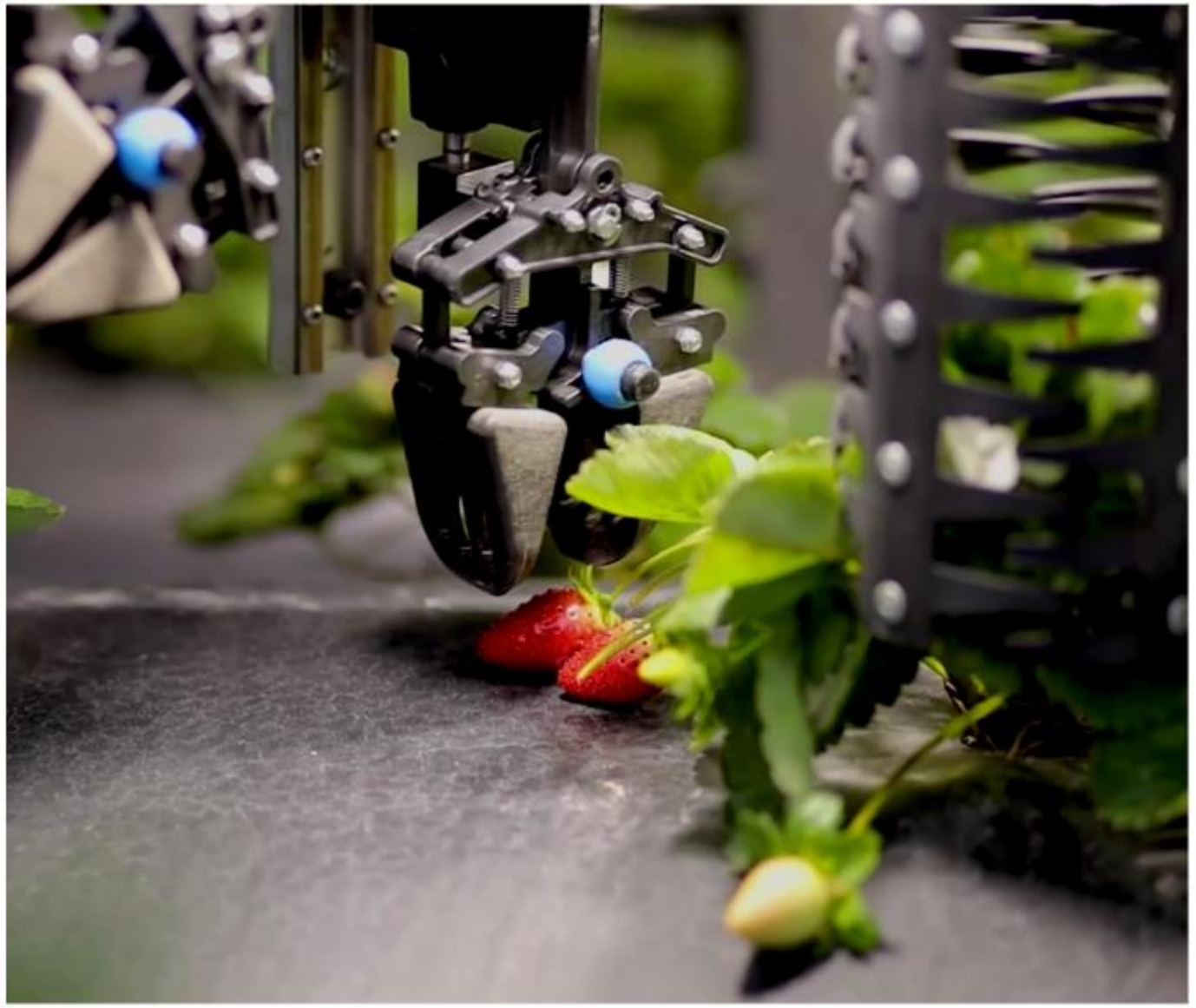
Loading

Robotic Harvesting

- Harvest CROO Robotics
  - Florida-based

  https://youtu.be/AO1mZrB5XK
- Agrobot – from Spain

  https://youtu.be/VJRoco8U
- Sweeper pepper harvester
- https://youtu.be/5chk9Sory



Harvest CROO robot about to pick a ripe strawberry

Autonomous Field Transport Platforms

- Burro Robots
- https://burro.ai/robots/

Autonomous Field Transport Platforms

- Tortuga AgTech
- https://www.tortugaagtech.com/

Summary: To be effective, consider…

- Crop suitability for mechanical harvest
- Available systems & reliability
- Changes necessary in field layout
- Labor availability
- Cost/benefit analysis