Maximizing Fresh Fruit & Vegetable Quality

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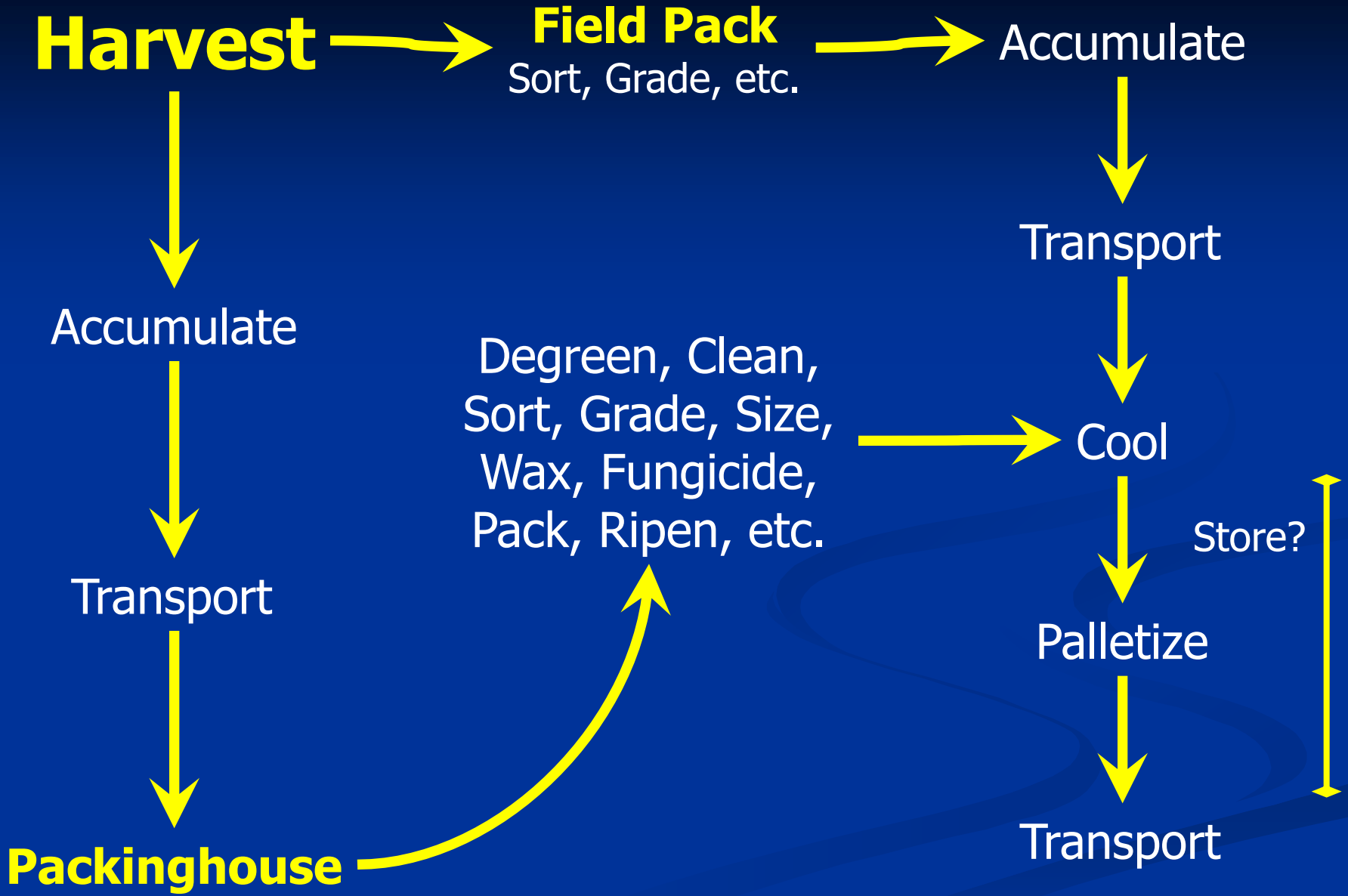

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Preharvest Factors Affecting Harvest & Quality

- Preharvest Factors
  - **Genetics**
    - Tree size – e.g. dwarf vs. full sized.
    - Uniformity of crop – e.g. harvest one time or spot pick / harvest multiple times.
    - Ease of separating product from plant – e.g. maturity, abscission zone formation, etc.
    - Product location on the tree – e.g. inner vs. outer canopy.

Preharvest Factors (continued)

- **Weather Conditions**
  - Rainfall.
    - Too much: increased decay, blue albedo, zebra skin, diluted sugars, etc.
    - Not enough: poor size, wilting, increased plugging, concentrated sugars, etc.
  - Dew on the crop.
    - E.g. oil spotting.

http://alexjonesphoto.com/recent/archive/rainycitrus.jpg

Preharvest Factors (continued)

- **Weather Conditions** (continued)
  - Temperature.
    - E.g. chilling or high temperature injury, color change, shape (sheepnose), etc.
  - Wind.
    - E.g. wind scarring, sand damage, spread of dirt & spores.

Preharvest Factors (continued)

- **Weather Condi**
  - Light.
    - E.g. effects on photosynthesis & temperature.

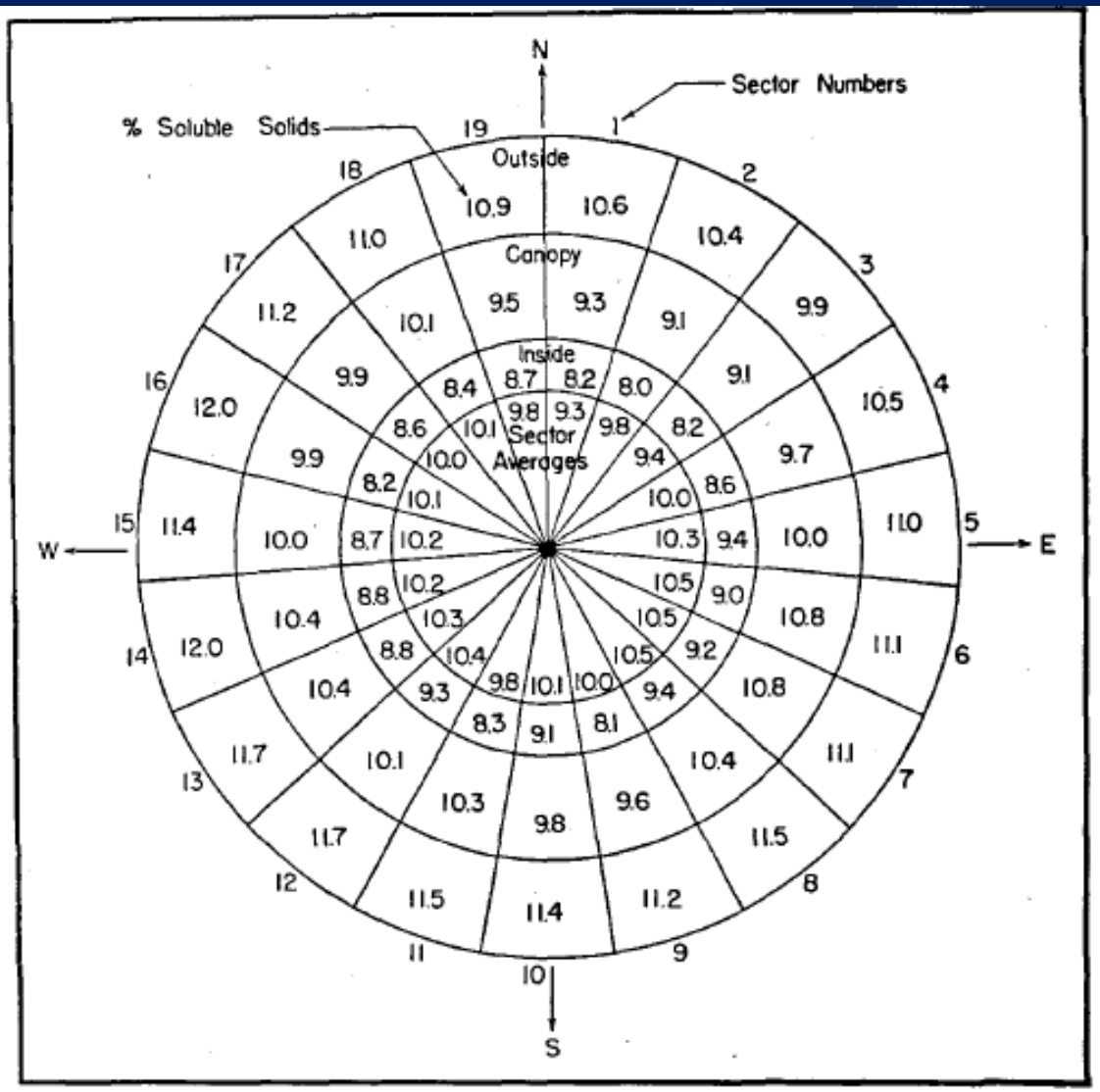


FIG. 2. Effect of direction of exposure and amount of shading on per cent soluble solids content of Valencia oranges.

Preharvest Factors (continued)

- **Weather Conditions** (continued)
  - Light.
    - E.g. effects on photosynthesis & temperature.

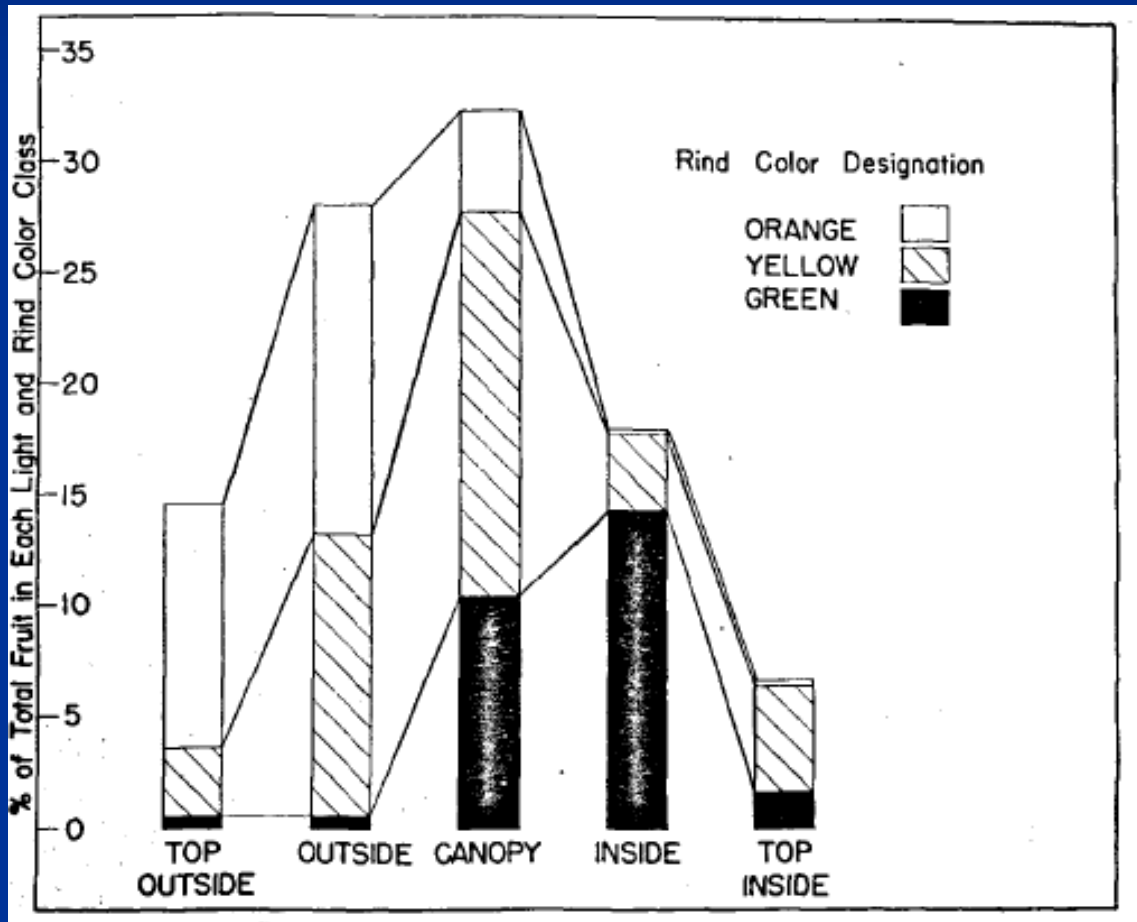


FIG. 4. Color of the rind of Valencia oranges affected by the amount of shading. The length of the bar indicates the percentage of total fruit represented in each light class.

Time of Day

- **Temperature**.
  - High temperatures increase cooling demand. Possible use of night harvesting.
  - Chilling susceptibility may change throughout the day.
- **Dew on the crop.** (e.g. oil spotting in citrus)
- **Food supply within product** (e.g. photosynthate reserves in flowers).

Preharvest Factors (continued)

- **Cultural Practices**
  - Use of chemicals – e.g.:
    - Ethylene releasing chemicals (Ethephon), Abscission inhibitors, pesticides.
  - Irrigation
  - Nutrition
  - Pruning
  - Planting densities
  - Cover crops/ plastic mulches
    - Can affect crop maturity, color, insect damage, etc.

When to Harvest?

- Are minimum maturity standards met?
- Harvest time is usually a compromise between:
  - Maximum quality

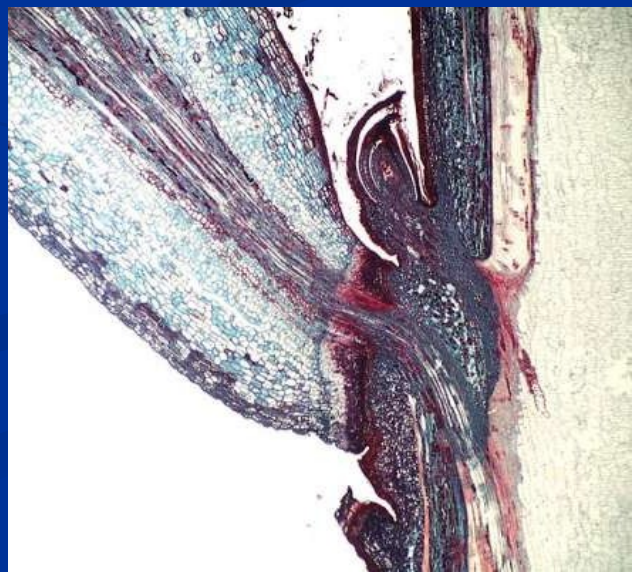
    and
  - The commodity's ability to survive the marketing chain

When to Harvest?

- Economics
  - Is there a market for the crop? If not,
    - Can the crop be harvest & stored until there is a market?
    - Leave the crop unharvested?
- Supplies, labor, packing & storage facilities, etc. available to harvest & process the crop?

Harvesting

- Fruit often are can naturally detach from a plant through the formation of an abscission zone.
  - May accelerate or delay abscission by the use of growth regulators e.g.:
    - Ethephon (ethylene)
    - Ethylene inhibitors (e.g. Retain=AVG)
- Most vegetables usually do not have an abscission zone.



From: http://botit.botany.wisc.edu/

Harvesting

- Often the most traumatic time of a commodity's life.
  - Detachment from "food" and water.
  - Force required to remove the commodity.
    - Fingernail marks, finger pressure.
  - Drops/impacts onto branches, harvesting bags, buckets, bins, trailers, other fruit etc.
  - Vibrations during transport on dirt/rough roads.

Field vs. Packinghouse Packing

- Field Packing (e.g. strawberries, head lettuce, grapes)
  - Less material to transport and dispose.
  - Fewer handling steps => less mechanical damage.
  - Smaller initial start-up cost.
  - Requires large machinery in the field (soil compaction, trampled product, etc.).

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Field vs. Packinghouse Packing

- Field Packing (continued)
  - More dependent on weather.
  - Requires skilled labor.
  - Product in containers are more difficult to cool.
  - Less control over quality.
  - Cannot apply many postharvest treatments (e.g. waxes, fungicides, etc.).

The Harvesting Process

- **Identify** mature product for harvest using maturity/quality standards.
  - E.g. color, size, shape, firmness, lack of defects, etc.

The Harvesting Process

- **Detach** the product from the plant.
  - pull, cut, twist, shake, etc.
- **Collect** into picking bags, buckets, etc.

The Harvesting Process

- **Accumulate** product in field boxes, bins, trailers, etc.

The Harvesting Process

- **Transport** product away from field to processing/packing facility.
  - Minimize time between harvest & transport.

Minimizing Injury

- **Careful handling** of all produce containers.
- Use **bubble plastic liners and top pads** in field bins.
- **Minimize distance** of forklift movement of field bins to loading point.
- **Grade farm roads** and **restrict travel speed** of transport vehicles relative to road quality.
- Use **good (i.e., "air") suspension systems** on all trucks and **reduce tire pressure**.
- **Keep all packing equipment clean** to avoid abrasive surfaces.

Physical Damage

- Causes the greatest amount of loss to fresh horticultural products.
- Affects (among other things):
  - Respiration, ethylene production, ripening, and other metabolic processes.
  - Pathogen growth and ability to invade tissue.
  - Tissue discoloration.

Photo courtesy of Steve Sargent

Types of Mechanical Injury

- *Bruises*
  - *Impact: Drops*
  - *Compression: Excessive weight*
- *Cuts, Punctures, Abrasion*

Figures courtesy of Steve Sargent

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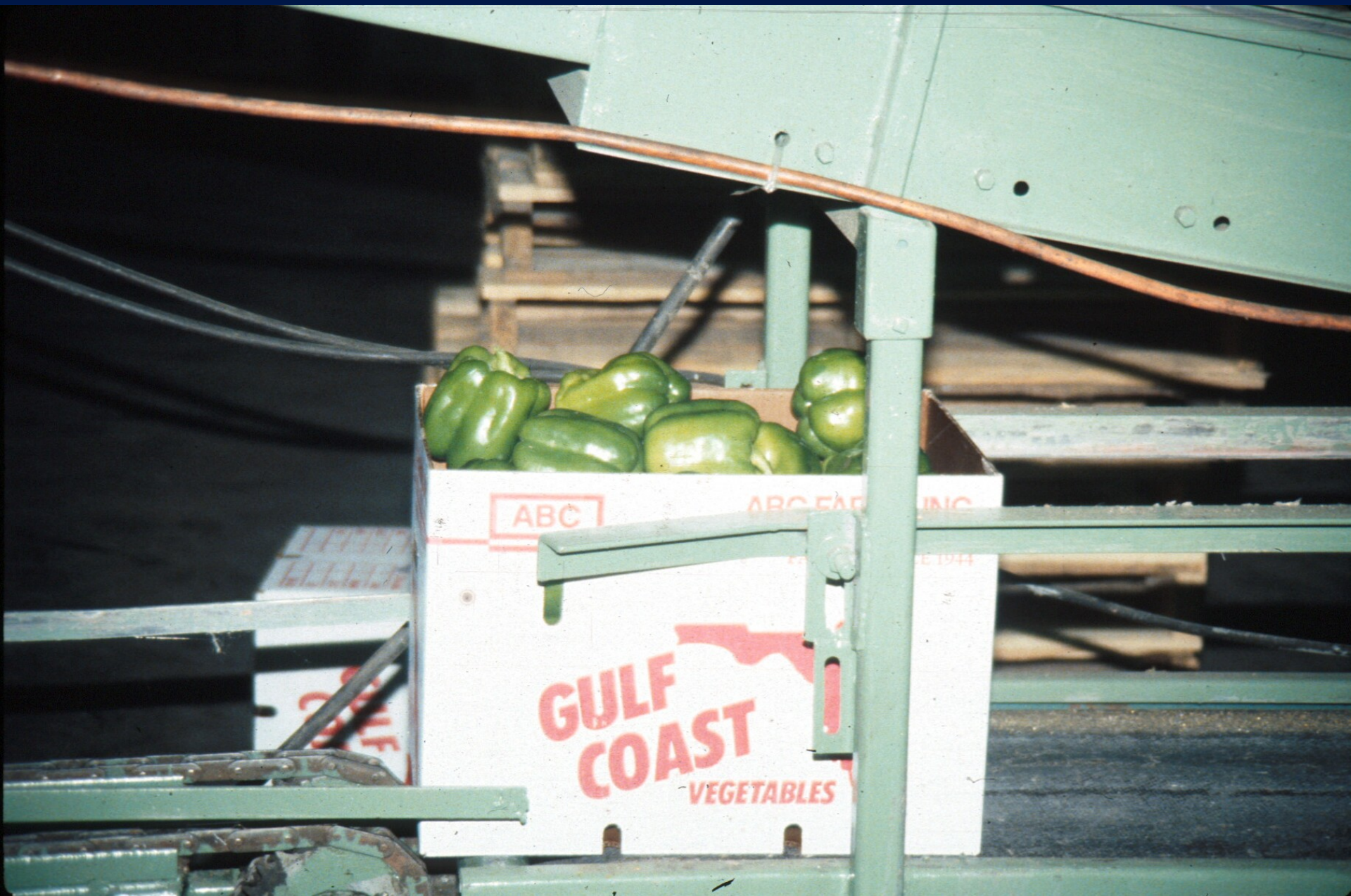

Pathology (decay)

- Fungi, bacteria and viruses.
- Preharvest (latent) and postharvest infections.
- Most postharvest infections are a result of rupturing the epidermis of the commodity.

Minimizing Decay

- Importance
  - Commodity Losses
    - Commodities with visible decay are often discarded (especially in wealthy societies).
  - Quality Losses
    - Spores on fruit (e.g. green Penicillium), mold on floral parts, etc.
    - Off-flavors in un-infected parts of a fruit.
    - Accelerated ethylene production, ripening, aging, physiological disorders, etc.

Minimizing Decay

- Importance (continued)
  - Food Safety
    - Mycotoxins (e.g. Aspergillus flavus infection of nuts and dried fruits => aflatoxin).
    - Human pathogens (e.g. E. coli 0157:H7, Salmonella, Listeria, etc.) – Discussed earlier.

Minimizing Decay

- Commodities are Very Resistant to Infection!
  - Out of millions of microorganisms on the surface of produce representing >100,000 different species of fungi,
    - Almost all are unsuccessful at penetrating and infecting tissue.
    - Less than 100 species (10%) are responsible for most postharvest decay.

Commodity Resistance to Decay

- Structural Factors
- Existing Biochemical Defenses
- Physiological & Biochemical Responses

Commodity Decay Resistance

- Structural Factors
  - First line of defense = cutinized epidermis.
    - Few fungi produce enzymes that can break down cutin.
  - Suberin – more common in underground parts, woody stems & wound healing.
  - The above compounds also restrict water movement => inhibits spore germination.

Commodity Decay Resistance

- Existing Biochemical Defenses – If the first line of defense if broken (e.g. windscar, wounding, etc.).
  - Plant tissues already contain many compounds that restrict fungal growth. Examples:
    - Phenolics
    - Alkaloids
    - Acidic pH

Commodity Decay Resistance

- Physiological & Biochemical Responses:
  - Plants respond to attacks (or wounds) by forming scar tissue containing suberin.
    - Restricts water loss and repairs the barrier to pathogen entry.
  - Plants respond to attacks by producing compounds toxic to fungi = phytoalexins.
    - Many phytoalexins are phenolic compounds.

Breakdown in Defense

- Most postharvest infections arise from ruptures of the epidermis (juice release).
  - Fungal spores will only germinate under high humidities or in the presence of free water. Rupturing the epidermis provides water to germinate.
  - Rupturing the epidermis releases sugars to "feed" spore germination and development.
  - Rupturing the epidermis allows fungi entry into tissue flesh.

Getting Through Defenses

- Invasion through stomates, lenticels and other natural openings.
- Some fungi have the capability to penetrate epidermal cells directly (e.g. anthracnose).
- Latent infections – fungi penetrate tissue earlier in development but was inactivated (walled off) but not killed. Continued development resumes as natural defenses break down. E.g. Anthracnose.
  - Difficult to control because infections can occur over a long period of time and the fungi are protected within tissue from postharvest fungicides.

Decay Control Measures
Preharvest decay control

- Prevent latent infections and spore load (inoculum) on fruit coming in from the field.
  - Field sanitation – remove dead/diseased plant parts and wood (e.g., leaf litter, rotting fruit, dead branches, etc.).
  - Chemical applications. Know the biology of the fungi to maximize spray effectiveness.

Decay Control Measures
Postharvest decay control

- Sanitation
  - Clean & disinfect bins, trucks, equipment, packinghouse areas, storage rooms, etc.
  - Use sanitizers (e.g. chlorine) in all recirculated water systems (dump tanks, hydrocoolers, etc.) to reduce pathogen populations.

Environmental Effects

- Relative Humidity
  - High humidity or free water induces spore germination.
- Temperature
  - In general, lower temperatures = slower growth.
  - Some fungi grow relatively well at low temperatures.
    - E.g. blue mold (Pencillum italicum) worse during cold storage.
  - Some fungi are killed at low temperatures.
  - High temperatures can also inhibit fungal growth.
  - Storage of chilling sensitive commodities at chilling temperatures = increased decay.
  - Heat treatments (e.g. hot water dips) can kill pathogens without damaging the commodity.

Decay Control Measures
Postharvest decay control

- Atmospheric Compositions.
  - Low oxygen and/or high carbon dioxide concentrations can reduce fungal growth.
    - E.g. use of high (15%) CO_2 for strawberries.
    - The real question is how well a particular commodity can tolerate these atmospheres without injury.

Decay Control Measures
Postharvest decay control

- Chemical Treatments.
  - In general, treatment during spore germination and early development is most effective. Before spore germination and after establishment within tissue = very difficult to control.
  - Fumigation – effective for packed commodities.
    - E.g. Methyl bromide, Sulfur dioxide (grapes) and Carbon monoxide (CO)
  - Water Applications (sprays, dips, etc.). – Most commonly used methods.

Decay Control Measures
Postharvest decay control

- Radiation
  - Used mostly for insect quarantine treatments.
  - In general, radiation levels high enough to kill fungi, also damage commodity tissue.
- Growth Regulators
  - E.g. use of 2,4-D to maintain button vitality, use of GA to maintain citrus peel puncture resistance.
- Barriers
  - E.g. fruit wraps, coatings (incl. those with fungicides) help prevent decay organisms from "nesting" (spreading to adjacent fruit).

Maximum Residue Limits

- Maximum Residue Limits (MRLs)
  - Also referred to as Import Tolerances.
  - MRLs are the **maximum residues of specific chemicals (often pesticides) allowed on food**.
    - In the U.S., they are set based on the maximum residues that could be expected if the product was used to the maximum allowable labeled rate.
    - MRLs vary by country & can become a barrier to trade.
  - Expressed as mg of residue/kg product (=ppm).

MRLs Vary by Country

- Growers produce fruits and vegetables for both domestic and export markets.
- CODEX was an attempt to harmonize MRLs for international trade.
  - However, many countries have now developed their own MRL standards.
- Since each country usually sets its own residue tolerances:
  - **Following U.S. label rates may still result in MRL violations for different export markets.**

http://mrldatabase.com/

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Welcome to the International Maximum Residue Level Database

Terms of Use

Users are advised that international regulations and permissible Maximum Residue Levels (MRL) frequently change. Although this International MRL Database is updated frequently, the information in it may not be completely up-to-date or error free. Additionally, commodity nomenclature and residue definitions vary between countries, and country policies regarding deferral to international standards are not always transparent. This database is intended to be an initial reference source only, and users must verify any information obtained from it with knowledgeable parties in the market of interest prior to the sale or shipment of any products. The developers of this database are not liable for any damages, in whole or in part, caused by or arising in any way from user's use of the database.

Please Review the Following Important Information

I. Three rules of the International MRL Database should be noted:

1. Only those chemicals that have a permanently established EPA tolerance are included.
2. Foreign market MRLs are included only when an EPA tolerance is in place for the same commodity.

   *** There is one exception to Rule 2: Some foreign markets set MRLs for crop groupings rather than for individual commodities (e.g. for citrus but not oranges). In those cases, the MRL database includes the tolerances set for the crop grouping, even if EPA has not set a tolerance for the crop group. These crop group MRLs will be shown for the individual commodities that are members of the crop group. A pop-up note will indicate that the commodity is part of a crop group and that the MRL is set for the group and not the individual commodity.*

3. Sometimes US EPA sets tolerances for crop groups rather than for individual commodities (e.g. for stone fruit but not for peaches). These crop group MRLs will be shown for the individual commodities that are members of the crop group. A pop-up note will indicate that the commodity is part of a crop group and that the MRL is set for the group and not the individual commodity.

II. Information about types of MRLs not listed in database.

The MRL Database exclusively reflects maximum residue levels (MRL) that have been established on a permanent basis under domestic US legislation according to the US Code of Federal Regulation (CFR).

The following types of MRLs are **not** included in the database:

- US import tolerances explicitly noted in the CFR
- Tolerances for indirect residues
- Tolerances explicitly noted in the CFR as lacking a current US registration

For further clarification, please consult the US Code of Federal Regulations - Title 40, Part 180 for pesticide tolerances and Title 21, Part 556 for veterinary drug tolerances.

☐ **I Accept and Understand These Terms**

Enter

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Pesticide MRL Database

Pesticide Directions:

1. **Select a Blue Commodity Type Tab - Plant Product Commodities, Animal Product Commodities, or All Commodities.**
2. **Select Commodities, Pesticides, and Markets to Include in Database Search.**

Plants Product Commodities | Animals Product Commodities | All Commodities

Please specify the commodities, pesticides, and markets per page below.

Commodities | Pesticides | Markets

Select a Commodity Below - *or* - Search For a Commodity go

Select All | Deselect All

- Acerola
- Allspice
- Amaranth, leafy
- Ambarella
- Angelica, dry
- Angelica, stem and leaves
- Anise, seed
- Anise, star
- Annatto, seed
- Apple
- Apricot
- Apricot, Japanese
- Aronia berry
- Arracacha, root
- Arrowroot, tuber
- Artichoke, Chinese, tuber
- Artichoke, globe
- Artichoke, Jerusalem, tuber
- Arugula
- Asparagus
- Atemoya
- Avocado
- Azarole
- Balm, leaves
- Balm, leaves, dry
- Balsam apple
- Balsam pear
- Fennel, leaves
- Fennel, leaves, dry
- Fennel, seed
- Fenugreek, seed
- Fig
- Flaxseed/Linseed
- Fritillaria, bulb
- Fritillaria, leaves
- Garden huckleberry
- Garlic, bulb
- Garlic, great headed, bulb
- Garlic, serpent, bulb
- Gherkin, West Indian
- Ginger, root
- Ginger, white, flowers
- Ginseng, root
- Goji berry
- Gold of pleasure
- Gooseberry
- Gourd, buffalo, seed
- Gourd, edible (bottle)
- Grains of paradise
- Grape, table
- Grape, wine
- Grapefruit
- Grapefruit, Japanese summer
- Groundcherry
- Parsley, turnip-rooted
- Parsnip, root
- Parsnip, tops
- Partridgeberry
- Passion fruit
- Pawpaw
- Pea, blackeyed, succulent
- Pea, dry (blackeyed)
- Pea, dry (crowder)
- Pea, dry (dwarf)
- Pea, dry (English)
- Pea, dry (field)
- Pea, dry (garden)
- Pea, dry (green)
- Pea, dry (pigeon)
- Pea, dry (snow)
- Pea, dry (southern)
- Pea, dry (sugar snap)
- Pea, dwarf, succulent
- Pea, English, succulent
- Pea, field, succulent
- Pea, garden, succulent
- Pea, green, succulent
- Pea, pigeon, succulent
- Pea, snow, succulent
- Pea, southern, succulent
- Pea, sugar snap, succulent

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Commodities | Pesticides | Markets

Select a Pesticide Below - or - Search For a Pesticide go

Select All Deselect All

- 1,3-Dichloropropene
- 1-Naphthaleneacetamide
- 1-Naphthaleneacetic acid
- 2, 6-Diisopropylnaphthalene (2, 6-DIPN)
- 2,4-D
- 2,4-DB
- Abamectin
- Acephate
- Acequinocyl
- Acetamiprid
- Acetochlor
- Acibenzolar-S-methyl
- Acifluorfen
- Alachlor
- Aldicarb
- Alpha-Cypermethrin
- Ametoctradin
- Ametryn
- Amicarbazone
- Aminopyralid
- Amitraz
- Asulam
- Atrazine
- Aviglycine
- Azinphos-methyl
- Azoxystrobin
- Benfluralin
- Benoxacor
- Etofenprox
- Etoxazole
- Etridiazole
- Famoxadone
- Fenamidone
- Fenarimol
- Fenbuconazole
- Fenbutatin-oxide
- Fenhexamid
- Fenoxaprop-Ethyl
- Fenpropathrin
- Fenpyroximate
- Fentin hydroxide
- Ferbam
- Fipronil
- Flazasulfuron
- Flonicamid
- Florasulam
- Fluazifop-P-butyl
- Fluazinam
- Flubendiamide
- Flucarbazone-sodium
- Fludioxonil
- Flufenacet
- Flufenoxuron
- Flufenpyr-ethyl
- Flumetsulam
- Flumiclorac-pentyl
- Oxamyl
- Oxydemeton-methyl
- Oxyfluorfen
- Oxytetracycline
- Paraquat dichloride
- Pendimethalin
- Penflufen
- Penoxsulam
- Pentachloronitrobenzene
- Penthiopyrad
- Permethrin
- Phenmedipham
- Phorate
- Phosmet
- Phosphine
- Picloram
- Picoxystrobin
- Pinoxaden
- Piperonyl Butoxide
- Pirimiphos-methyl
- Prallethrin
- Primisulfuron-methyl
- Procymidone
- Profenofos
- Prohexadione calcium
- Prometryn
- Propachlor
- Propamocarb hydrochloride

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Please specify the commodities, pesticides, and markets per page below.

Commodities | Pesticides | Markets

Select a Market Below - or - Search For a Market go

Select All | Deselect All

- United States
- Codex
- European Union
- Albania
- Algeria
- Angola
- Antigua and Barbuda
- Argentina
- Australia
- Bahamas
- Bahrain
- Bangladesh
- Barbados
- Belgium
- Bermuda
- Brazil
- Canada
- Cayman Islands
- Chile
- China
- Colombia
- Costa Rica
- Cuba
- Denmark
- Dominican Republic
- Ecuador
- Egypt
- France
- French Pacific Islands
- French West Indies
- Germany
- Greece
- Guatemala
- Gulf Cooperation Council
- Haiti
- Honduras
- Hong Kong
- Iceland
- India
- Indonesia
- Ireland
- Israel
- Italy
- Jamaica
- Japan
- Jordan
- Kenya
- Korea
- Kuwait
- Lebanon
- Malaysia
- Mexico
- Morocco
- Netherlands
- New Zealand
- Nicaragua
- Norway
- Oman
- Pakistan
- Panama
- Peru
- Philippines
- Poland
- Portugal
- Qatar
- Russia
- Saudi Arabia
- Singapore
- South Africa
- Spain
- Sri Lanka
- St. Lucia
- Sweden
- Switzerland
- Taiwan
- Thailand
- Trinidad and Tobago
- Tunisia
- Turkey
- United Arab Emirates
- United Kingdom

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Pesticide MRL Database

The query has returned 1 result

Current Page Current Page

Make sure your brower's pop-up blockers are turned off to print or download excel results.

Legend

- MRL values in *Red Italics* are more restrictive than US
- All numeric values listed are in parts per million (ppm), unless otherwise noted
- --- (dashes) indicate that no specific MRL for the commodity or relevant crop group is established. A default MRL may apply for countries that have default MRLs (see Default MRLs section below). Additionally, inadvertent or extraneous MRLs are not included in the database; and the database does not indicate substances that are banned in a country or exempt from requiring an MRL.
- ! indicates there is a note to scroll over with your mouse.
- Cod (Codex), EU (European Union), US (United States) and EXP (exporting market) indicate the source of the MRL for countries which defer to other markets' MRL regulations.
- Section 18, Time-Limited, or Regional: indicates that the US MRL is a temporary Section 18, Time-Limited Tolerance, or Regional Tolerance.

Default MRLs

These countries have a default MRL which may be applicable if a specific MRL is not established. However, default MRL regulations vary by country. Before assuming a default MRL applies, the country's specific regulations governing the default MRLs should be consulted. Country MRL regulations are summarized in market information pages located at the "Market Information" link on the toolbar at the top of this page.

European Union: 0.01 ppm | Argentina: 0.01 | Canada: 0.1 ppm | Iceland: 0.01 | Japan: 0.01 ppm | Malaysia: 0.01 ppm | New Zealand: 0.1 ppm | Norway: 0.01 | South Africa: 0.01 ppm

Grapefruit - Pyrimethanil

Show Legend

US !	Cod !	EU !	Can !	Jpn !	Kor !	Tai !
10	{7}	10	10	15	{1}	{7}

Buyer Requirements

- Even more confusing can be individual buyer residue tolerances that are more restrictive that country MRLs.
  - These include food processors.
- Such tolerances are not widely distributed, but must be obtained through communication directly with the buyer.
  - **Close and frequent communication with buyers is essential.**

Thank you!

See the UF Postharvest Information Website for more information

http://irrec.ifas.ufl.edu/postharvest/

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