Postharvest Biology and Technology of Citrus Fruits

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Thanks to Professor Irving Eaks, UCRiverside for providing some of the figures used in this presentation.

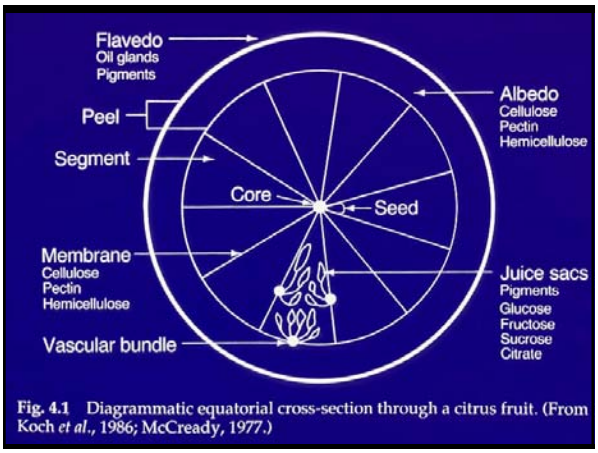
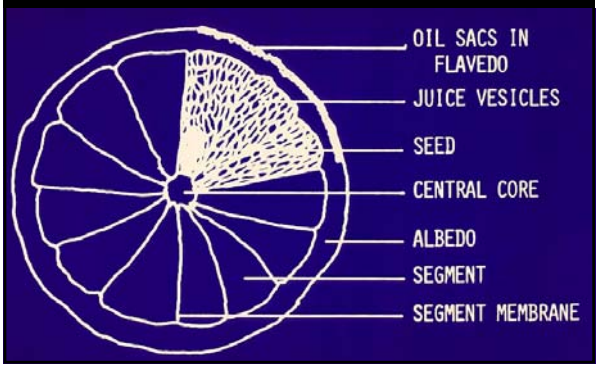


Fig. 4.1 Diagrammatic equatorial cross-section through a citrus fruit. (From Koch *et al.*, 1986; McCready, 1977.)

Citrus fruits have less internal air space (intercellular spaces) than most other fruits, which results in a higher gradients between internal and external gas concentrations .

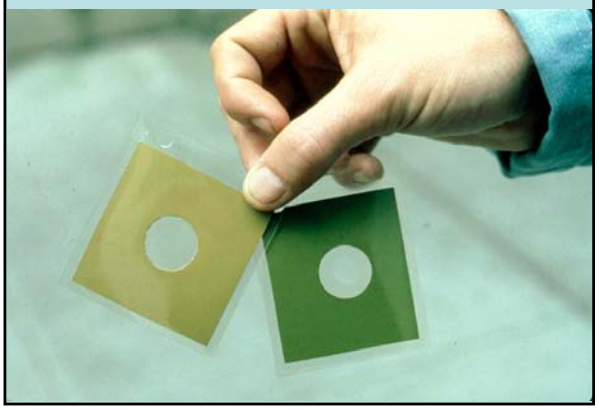


California Minimum Maturity Indices for Citrus Fruits

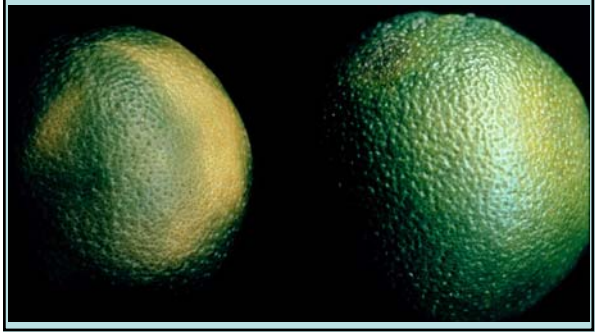
Fruit	Minimum maturity indices
Grapefruit	SS/A ratio of 5.5 or 6.0 (desert areas), 2/3 of fruit surface showing yellow color
Lemon	30% juice by volume
Orange	SS/A ratio of 8.0 (and orange color on 25% of the fruit surface) or 10.0 (and less intense orange color)
Tangerine	SS/A ratio of 6.5 and yellow, orange, or red color on 75% of the fruit surface

SS= soluble solids, A=acidity

Color Guides for Citrus Fruits



Minimum Yellow to Orange Color as a Maturity Index for Oranges Provided that the Soluble Solids/Acid Ratio is 8 or higher



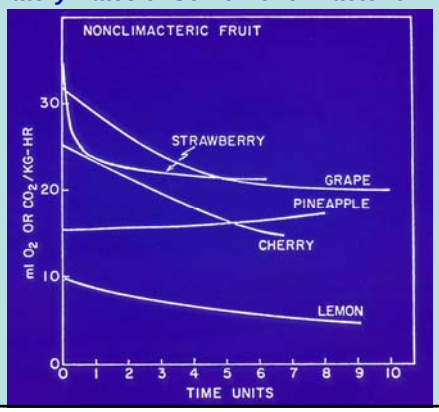
Hydrometer for Measuring Soluble Solids Content of Orange Juice

Relationship Between Sugar/Acid Ratio And Panelist's Response To The Question About Willingness To Buy Navel Oranges

Sampling Week	*% samples below sugar/acid ratio of 8*	*Number of responses*	
		Yes	*No*
11/14-18	*39*	*42*	*58*
11/28-12/2	*27*	*53*	*47*
12/12-16	*13*	*63*	*37*

Source: Ivans and Feree (1987)

Respiratory Rates of Some Nonclimacteric Fruits

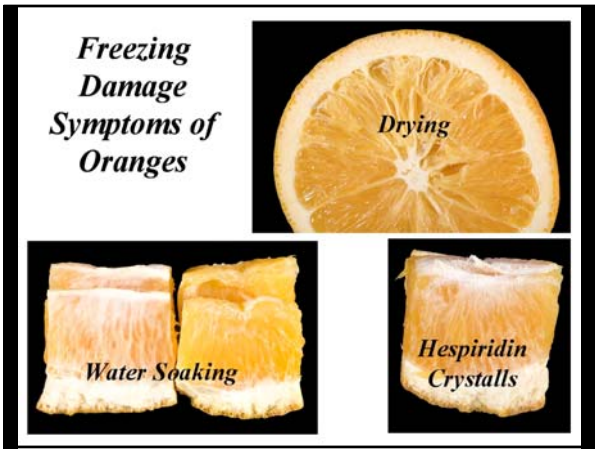


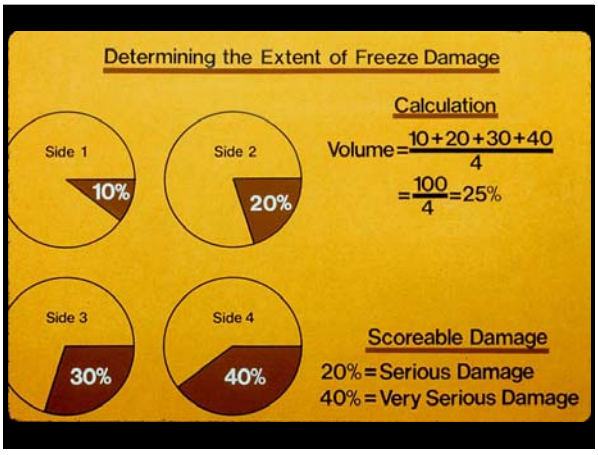
Respiration and Ethylene Production Rates

Citrus cultivars	Respiration rates ($mlCO_2kg^{-1}hr^{-1}$)		Ethylene production ($nlkg^{-1}hr^{-1}$)	
	5°C	20°C	5°C	20°C
[a]Navel oranges (Winters)	12.0 ± 2.8	44.2 ± 4.8	50 ± 20	70 ± 20
[a]Navel oranges (Winters)	8.1 ± 3.6	30.8 ± 6.8	150 ± 60	130 ± 80
[a]Navel oranges (Fresno)	6.7 ± 2.3	34.9 ± 5.0	90 ± 30	110 ± 60
[b]'Satsuma' mandarins	7.4 ± 1.6	25.1 ±11.7	40 ± 20	60 ± 30
[b]'Clemenules clementine' mandarins	7.3 ± 0.1	37.6 ± 2.7	30 ± 20	50 ± 10
'W. Murcott' mandarins	7.3 ± 2.1	34.7 ±11.6	30 ± 20	40 ± 20

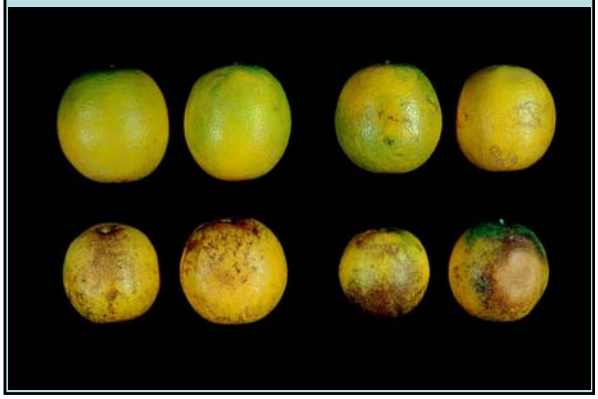
[a]Values are the mean of five replicates ± SD
[b]Valuse are the mean of three replicates ± SD

These respiration rates are about double those reported in USDA Handbook 66 (2-4 at 5ºC and 10-17 ml CO2/kg.hr at 20ºC) for mandarins and oranges.

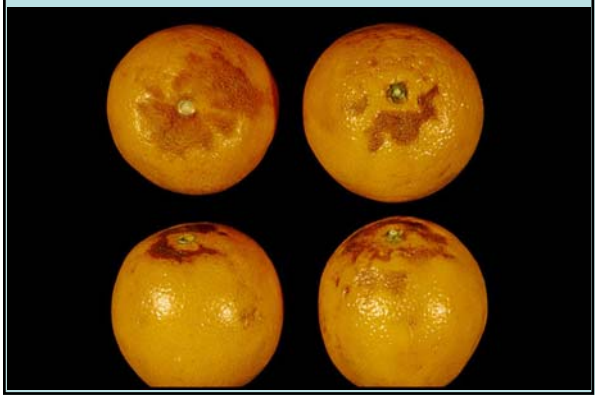




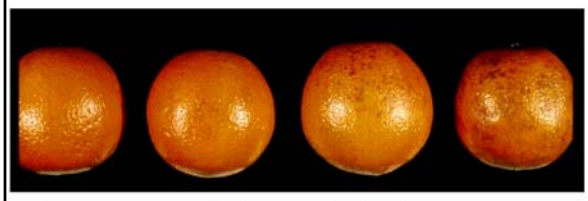
Skin Staining is a Preharvest Disorder



Rind Staining Following Skin Abrasions

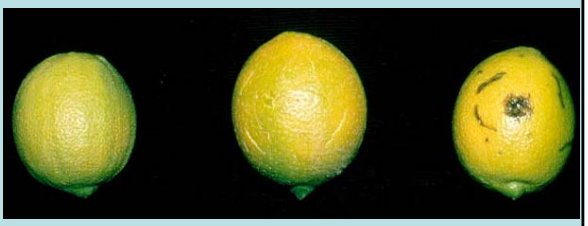


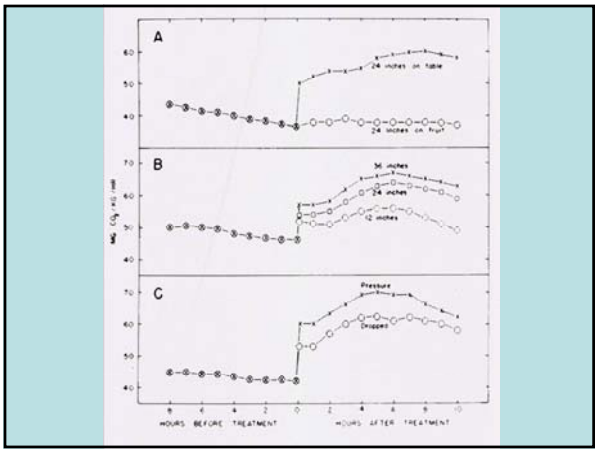
Surface Abrasions of Oranges



None Slight Moderate Severe

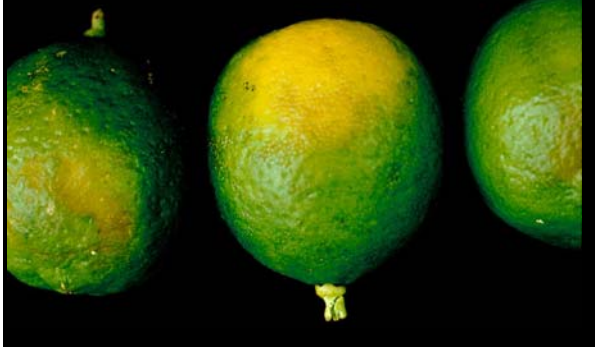
Detection of Wounds on Lemons

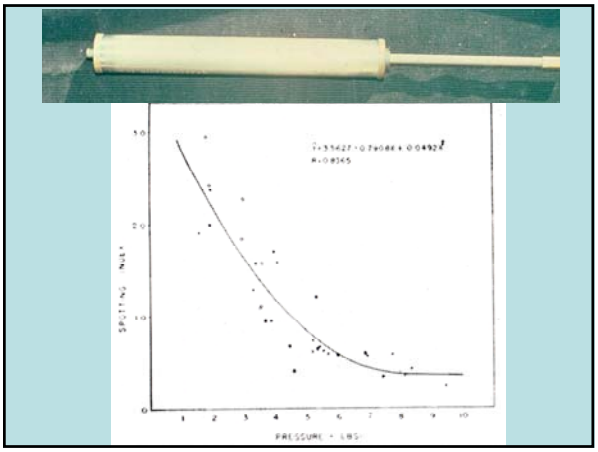




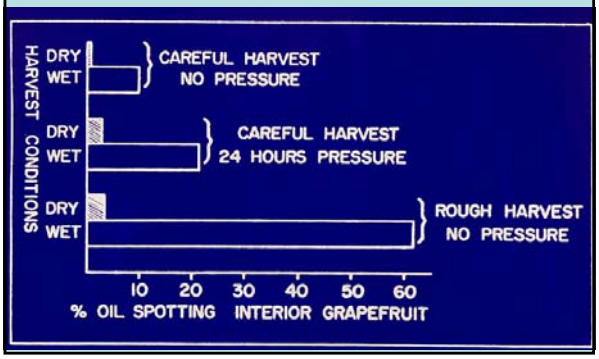
Oil Spotting on Lemons

Oil Spotting on Limes



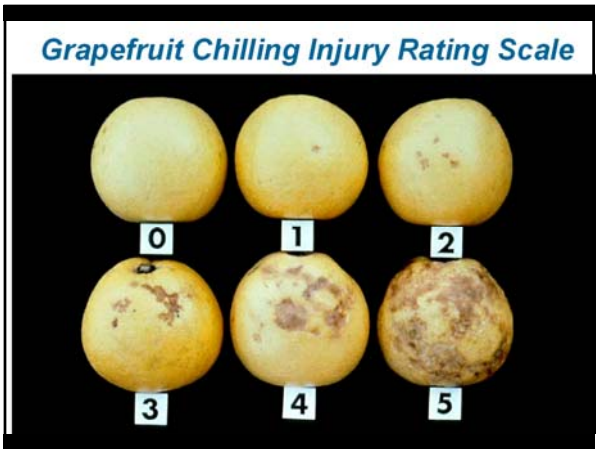


Preharvest Factors Affecting Susceptibility to Oil Spotting



Chilling Injury Symptoms on Citrus Fruits

Grapefruit Chilling Injury Rating Scale



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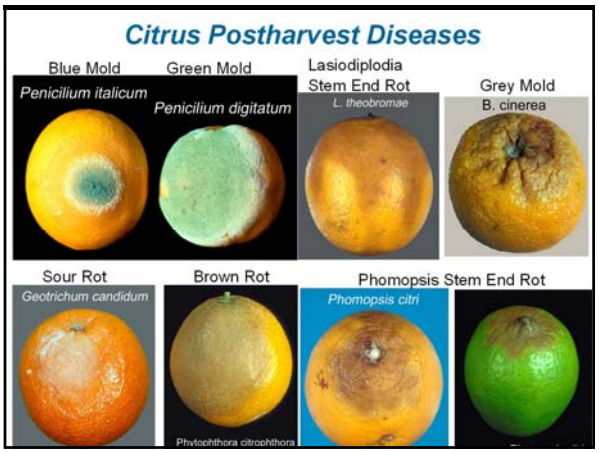
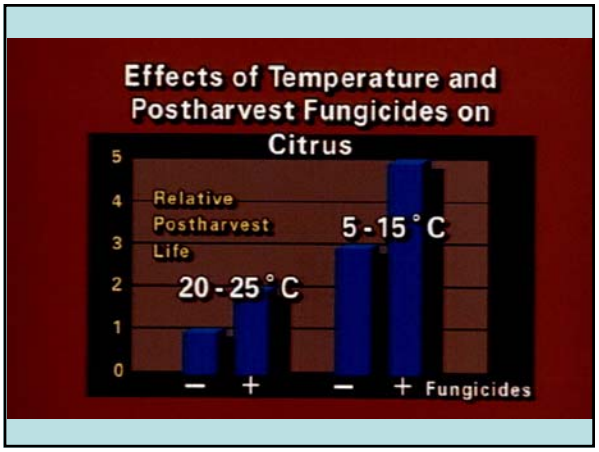


Strategies for postharvest decay control

- Preharvest practices
  - Reduce conducive environments for pathogen infection
  - Minimize the amount of pathogen that may infect the crop before harvest.
- Harvest practices
  - Harvest when fruit are physiologically mature, but still firm.
  - Avoid fruit injuries (hand-harvest, transport)
- Postharvest handling
  - Maintain healthy fruit physiology (a healthy fruit is better able to fight off pathogen attacks).
  - Minimize fruit injury (injuries are preferred entry points of pathogens)
  - Eliminate infected and injured fruit
- Postharvest treatments

From: Jim Adaskaveg



Alternatives For Citrus Decay Control

- ***New chemicals (e.g. Gauzatine, Prochloraz)***
- ***Controlled atmospheres (including carbon monoxide)***
- ***Ionizing radiation (1.5 to 2.0 KGy)***

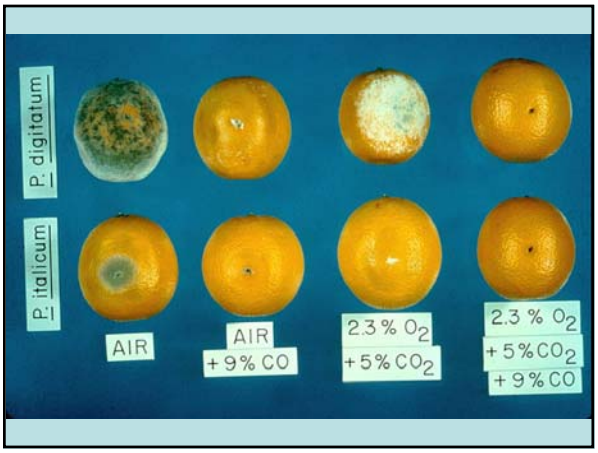
Current and future postharvest fungicides for decay control of citrus in the US

Phenols	Benzimidazoles	SI-imidazoles
Sodium ortho-phenyl phenate (SOPP)	**Thiabendazole** (TBZ)	**Imazalil**
1930s	1970s	1980s
Phenylpyrroles	**Strobilurins**	**Anilinopyrimidines**
Fludioxonil (Scholar)	**Azoxystrobin** (Abound)	**Pyrimethanil** (Penbotec)

Approximately simultaneous registration 2004/05

- Reduced risk fungicides

From: Jim Adaskaveg



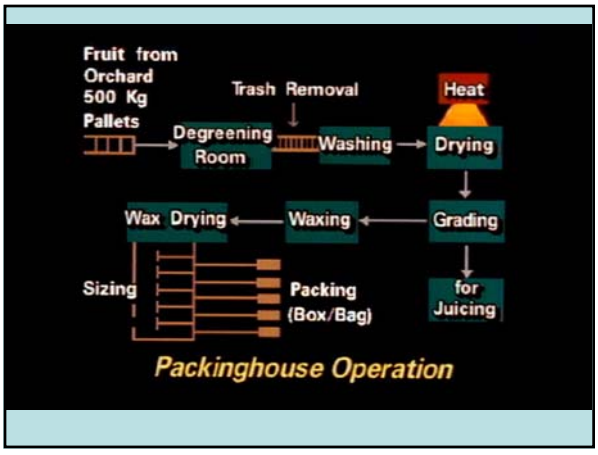
Alternatives For Citrus Decay Control

- Heat treatments
  (Dip in 44°C H_2O for 2-4 min.)
- Biological antagonists
  (e.g. *Trichoderma viride*)
- Breeding for resistance of fruits to decay

Harvesting Citrus Fruits

Clippers Used For Harvesting Citrus Fruits

Delivering Bins of Citrus Fruits to Packinghouse



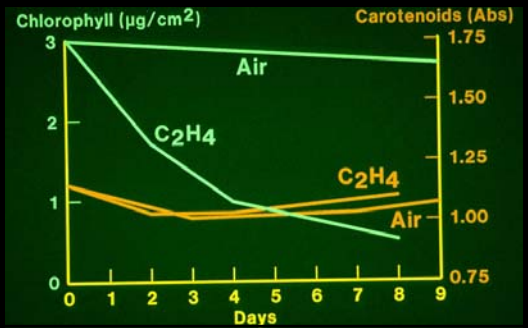
Citrus Degreening Rooms

Inside Citrus Degreening Rooms

Degreening Of Citrus Fruits -Recommended Conditions-

Temperature	20-25°C
Relative humidity	90-95%
Ethylene	5-10ppm
Air circulation	1 room vol/min
Ventilation	1-2 air changes/hr

During degreening, chlorophyll content (green color) decreases and allows the yellow and orange color (carotenoids) to become visible. Ethylene accelerates chlorophyll degradation.



Duration of degreening required depends on maturity stage (amount of chlorophyll) in the skin of citrus fruits

Citrus Packinghouse Operations

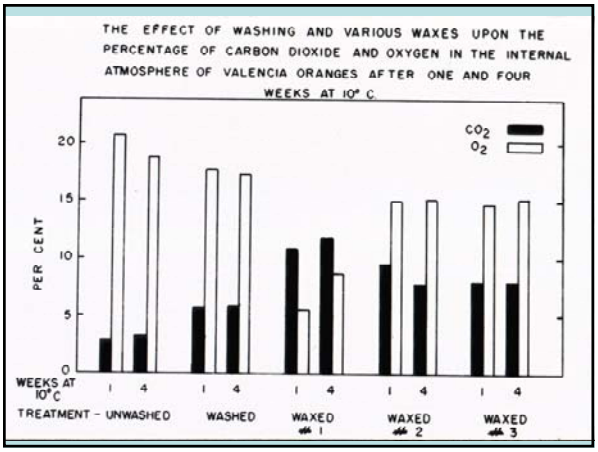
-Dumping-

Washing

Surface Drying

Waxing and Fungicide Application

Surface Drying



Stamping Individual Fruits

Volumetric Sizer

Machine Vision (Electronic) Sizer

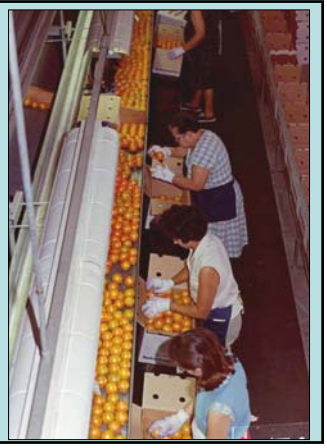
Enclosure Within Which Fruits are Sorted Under UV Light to Eliminate Defects

Sorting Into Quality Grades

Sorting By Quality

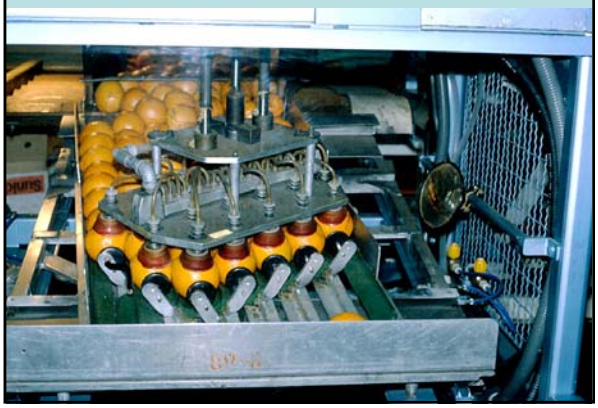
Fruit Destined For Juice Plant

Hand Packing Citrus Fruits

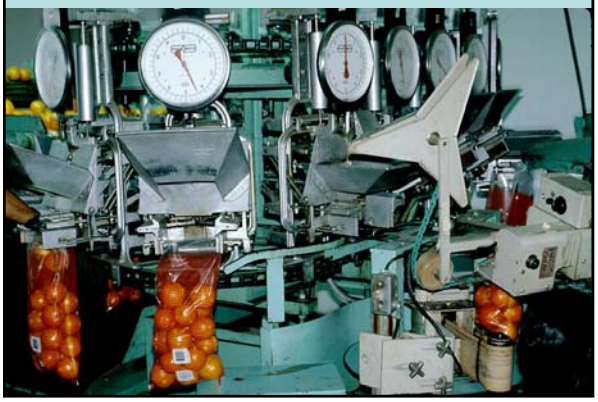


Pattern Packer -1

Pattern Packer -2



Packing Into Consumer Bags



Packed Boxes May Be Slightly Vibrated to Settle Fruits With the Box

Palletized Boxes In Storage Room