Citrus Maturity and Packinghouse Procedures

Introduction

Florida grows about a quarter of the world's commercial citrus crop. All of this huge volume, 252.1 million 1-3/5 bu. boxes (10.3 million m. tons) in 1976-77, is produced for only one purpose, to make money for everyone involved in growing, harvesting, packing, processing, shipping and marketing it. The sole source of that income is the cash register in the retail outlet. This course emphasizes fruit qualities and many of the procedures which are essential links in returning a fair share of the money paid for fruit to the growers, packers, canners, pickers, laborers, truck drivers, etc., who make up the Florida citrus industry and all of whom depend for their livelihood upon how the fruit gets from the grove to the consumer. This, then, is the subject of FRC 4612 (FC 437).

Roughly 85% of the oranges, grapefruit, tangerines, temples, tangelos, etc., harvested in the state are processed. The remainder are shipped as fresh fruit or consumed locally. Thus, the grower has now, as he has had for some decades, viable alternative outlets for his fruit. (Florida's fresh fruit shipments amount to about 90% of California's exclusive of lemons, and their proportion of processed oranges is only 36.5%.) Fruit of any sort is of little value to a commercial grower unless he can get them harvested and delivered in sound, wholesome condition to the consumer. The grower has directly or indirectly a vital interest in the changes which take place in the fruit as they develop to a mature, edible state and in the factors influencing these changes. His initial concern is to have the proper scion variety on the proper rootstock in the proper location; his later concern is to produce the best possible quality and quantity of fruit on that rootstock-scion variety combination. Production of the crop is only part of the picture, particularly in the case of citrus where peak quality is attained at the time of harvest. Slow or inept handling later can obliterate or seriously impair quality to the point the fruit is unfit for human

Introduction (cont.)

consumption. Many people say all of this can be forgotten if the fruit is to be processed. Not so, for processed products, especially frozen concentrate and chilled juice, must be made from high quality fruit and handled properly if they are to be palatable. Furthermore, the grower who has only a single outlet for his fruit is at the mercy of the buyer, as the producers of a wide range of other crops have found to their dismay.

The present gigantic citrus industry in Florida with numerous varieties available for fresh consumption or processing into a multitude of frozen, chilled or canned products (Table 1) did not emerge overnight. The continually expanding body of knowledge regarding the chemical and physical components of the fruits, their modifiers, harvesting and handling practices and compliance with legal and market requirements is also based on decades of experience and research. It is not the purpose here to dwell upon the historical background of the citrus industry but rather to point out some of the highlights summarized in Table 2. At least 4 or 5 events of major consequence and numerous minor ones were instrumental in shaping its course. First of all, citrus was carried along on the voyages and explorations of Columbus, Ponce de Leon and de Soto in the late 1400's and early 1500's. Permanent plantings of sweet, sour and bittersweet oranges, lemons and West Indian lime were established at St. Augustine in 1565-1575. Citrus, unlike so many other plants, introduced from far away countries, thrived in Florida's congenial climate and indeed became naturalized in many areas of the state long before it became a commercial crop. The next major event, which marked the beginning of the modern industry, was the development of the 1-3/5 bu. standard box by E. Bean in 1875. The third one was the 1894-95 freezes and the subsequent move southward of the industry in ensuing decades as railroads and highways were built, since the move was into a vast area throughout which the industry could expand for many years. The fourth one, which has played and will continue to play a dominant role, was the perfection in 1943 of a frozen orange concentrate comparable in quality to fresh juice. The latest one was the introduction of chilled juice in 1955-56, a product which has grown by leaps and bounds in the

last 10-15 years. Among other forces influencing the growth of the industry have been the evolution of maturity standards culminating in the Florida Citrus Code of 1949 and later amendments, the gradual development of packinghouses and canneries, marketing agreements and standards for grades, and the myriad rules and regulations of federal and state agencies concerned with food quality, protection of the environment and the like.

An outline of citrus fruit characters, quality modifiers and legal and consumer factors is presented in Table 3. The starting point is the tree consisting of a scion variety ('Hamlin' orange, 'Marsh' grapefruit, etc.) budded on a rootstock (rough lemon, sour orange, etc.). The season of growth ranges from 8 to 15-18 months depending upon the variety, during which time the intrinsic external, internal and miscellaneous fruit characters develop. The expression of these characters depends first upon preharvest modifiers while the fruit remain on the tree. Citrus fruit in common with other produce are <u>living</u> organisms throughout their life cycle. They differ from other familiar fruits like apples, pears, bananas, avocados or mangos in their failure to accumulate starch. Development of sugars and other qualities occurs only while a citrus fruit remains on the tree. The respiration rate also remains low and constant at any given temperature (barring stresses) unlike the pronounced changes characteristic of climacteric fruits (Figure 1). The objective of postharvest modifiers is to minimize deterioration in fruit qualities from the moment they are harvested until consumed. Fruit shipped in interstate or intrastate commerce are subject to standards for maturity and grades and numerous rules and regulations to ensure only sound, wholesome produce reaches the market. The sole source of income is the cash register in the retail outlet, hence consumer factors of appearance, palatability and keeping quality are vitally important. This table and graph thus provide an overview of fruit characters and the principal factors affecting them.

A glossary of terms, whose understanding are indispensable to an understanding of the course content, and a conversion table for U.S. and metric measures are given in Tables 4 and 5, respectively.

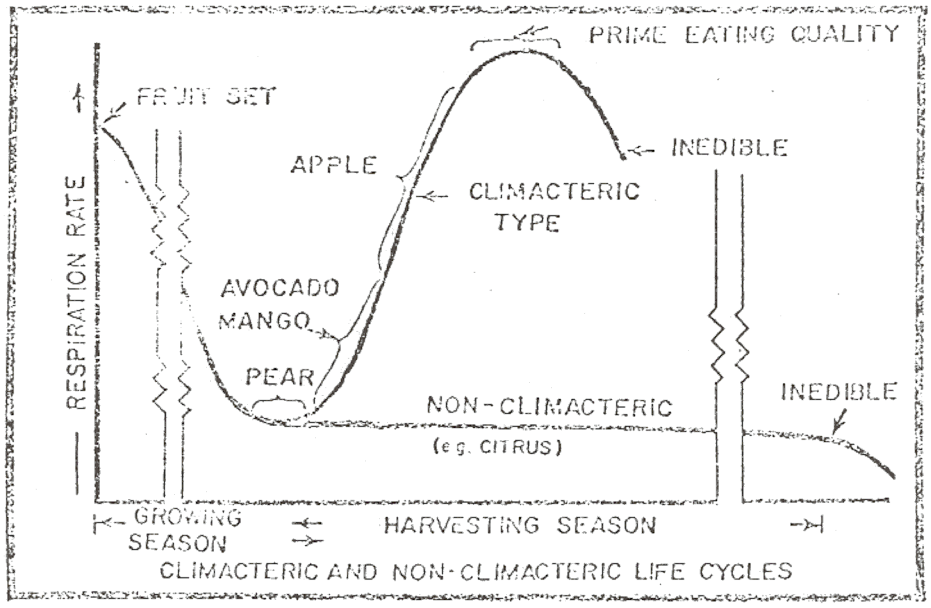

Figure 1. The key to postharvest handling (From Grierson, 1973).

Table 1. Area and disposition of Florida citrus, 1976-77 season.

Citrus groves (860,000 acres=348,000 ha.)

Commercial Varieties	Fresh Fruit 1000 1-3/5 bu. boxes (m. tons)	Processed Fruit
Oranges:		
Early (Hamlin, Parson Brown)	3,095.7 (126,304)	
Early-midseason (Navels)	1,447.4 (59,054)	111,488.0 (4,548,710)
Midseason (Pineapple)	904.7 (36,912)	
Late (Valencia)	2,285.0 (93,228)	69,115.3 (2,819,904)
Grapefruit:		
White seeded (Duncan)	31.0 (1,196)	8,650.4 (333,905)
Pink seeded (Foster)	7.9 (305)	386.5 (14,919)
White seedless (Marsh)	9,312.0 (359,443)	20,096.5 (775,725)
Pink and red seedless (Thompson, Ruby, Burgundy)	6,118.2 (236,163)	5,975.0 (230,635)
Specialty fruits:		
Temple	991.2 (40,441)	
Tangerines (Dancy, Robinson)	2,222.0 (9,576.8)	983.3 (42,380)
Honey tangerine (=Murcott)	290.7 (11,861)	1,006.7 (41,074)
Tangelos (Orlando, Nova)	2,118.3 (84,427)	2,505.3 (102,216)
K-Early	421.2 (17,185)	137.9 (5,262)
Acid citrus:		
Lemons (principally Bearss)	122.1 (3,116)	784.2 (31,996)
Limes (Tahiti)	650.1 (16,578)	

Table 2. History of citrus fruit handling.

Stage I. 1492-1875--Introduction

1492 - early 1500's: Citrus brought to New World--Columbus, Ponce de Leon, de Soto.
1565 - 1575: Permanent plantings established at St. Augustine--sweet orange, sour orange, bitter-sweet orange, lemon (including rough), (West Indian) lime.
1776: First shipment of oranges from Anastasia Island to England.
1823: Grapefruit introduced (Don Philippe, Safety Harbor).
1835, 1870's: Introduction of navel orange, (lost in 1835 and later freezes).
1840's - 1850's: Introduction of tangerines from Asia to Louisiana thence to Florida.
1870's: Introduction of Valencia orange.
1800's: Domestic shipments of oranges by boat or railroad in barrels and various boxes.

Stage II. 1875-1910--Modern Industry: Early phase

1875: Development of the standard citrus box by E. Bean; first systematic grading and sizing of oranges to fit 2 cu. ft. = 1-3/5 bu. box.
1880's: First shipments of grapefruit.
1894: Production about 5 million boxes at time of 1894-95 freezes.
1875 - 1910: Early packinghouse operations--washing (dry or wet), drying (sun), grading (removal of cuts and plugs, sorting of bright and rusty fruit), sizing (eye, slotted boards, diverging boards, rope), packing (individually wrapped fruit in standard nailed box with bulge); shipment by boat or rail.

Stage III. 1910-1945--Modern Industry: Middle phase

Evolution of Citrus Laws:

1911. Immature Fruit Law: Illegal to ship raw, immature fruit.
1913. Maturity Law: Season Sept. 1 to Nov. 15; 12-fruit sample; maximum 1.30% crystalline citric acid for oranges, 1.75% for grapefruit or half color.
1915. U.S. Bureau of Chemistry (USDA): Total soluble solids to total (titratable) acid (anhydrous citric acid) ratio 8-1 for oranges and 7-1 for grapefruit (interstate shipments).
1925. Maturity Law: First comprehensive standards for oranges and grapefruit, with sliding ratio (minimum according to total soluble solids); registration of packing-houses; inspection fees.
1927. Arsenic Law: Ban on use of arsenic on bearing citrus; lifted 1929-1930 for Mediterranean fruit fly campaign, reimposed 1931.
1933. Maturity Law: Minimum juice requirement for grapefruit (plus solids and ratio), minimum solids, ratio and color break for oranges. Permanent injunction by Judge H.C. Petteway against enforcement of arsenic law on grapefruit.

Table 2. (cont.)

1935. Maturity Law: Higher standards. Color Add Law: Legal on oranges, higher maturity standards. Creation of Florida Citrus Commission. Advertising Tax. Bond and License Law. Registration of field boxes.
1937. Federal Agricultural Marketing Agreement Act: Enabling act for marketing Agreements.
1939. Citrus Marketing Agreement (Order 905, originally 933). U.S. standards for Persian (Tahiti) Limes (revised 1952, 1957).
1941. Creation of Indian River Citrus Area. U.S. standards for citrus fruits: sweet oranges, grapefruit and mandarins, except tangerines. U.S. standards for tangerines (revised 1948, 1955, 1960, 1967, 1968). U.S. standards for lemons (revised 1959, 1961, 1964).
945. Maturity Law: Minor changes.

Research on Seasonal Changes of Citrus in Florida:

1913. Collison: Oranges and grapefruit, 500 tests over one season.
1935 on. Harding and associates: Oranges, grapefruit, tangerines; tests over 3 or 4 seasons.

Development of Packinghouses:

1915. Ramsey's research on benefits of precooling plus refrigeration at 40°F in transit for oranges; emphasis on careful handling.
1920. First degreening rooms, using kerosene fumes.
1923. Denny's discovery that ethylene was active ingredient in kerosene fumes.
1925. Borax first postharvest fungicide for control of stem-end rot.
1920-1945. Introduction of ruffleboard (longitudinal) washer, drier-polisher, slab wax, hot wax, grading belts, roller grading tables, longitudinal belt-and-roll sizers, transverse brushes (to replace longitudinal brushes), wirebound (Bruce) boxes, mesh (cloth, paper) bags, fiberboard cartons; refrigerator (ice bunker) cars, trucks for shipments; heavier loading (to 1000 instead of 400 to 600 boxes) of rail cars (during war).

Development of Canneries:

1915. Bottled grapefruit juice.
1920. First frozen citrus concentrate (not marketable).
1921. First grapefruit sections (glass containers, later cans).
1923. Canned grapefruit juice.
1924. Canned orange juice; hot pack concentrate (mainly grapefruit).
1924-1925. Citrus pulp dried for animal feed.
1930-1931. First marketing of frozen citrus juice (mainly grapefruit.
1935. First low temperature vacuum hot pack concentrate.

Table 2 (cont.)

1935-1936. Orange-grapefruit juice blends marketed; 212,000 boxes of oranges processed.
1943. First marketable frozen concentrated orange juice.
1944-1945. 14,243,000 boxes of oranges processed.

Stage V. 1945 to present--Modern Industry: Mature phase

Citrus Laws:

1949. Florida Citrus Code (Consolidation of existing statutes and changes into a single chapter-601; Indian River Citrus Area and registration of field boxes excluded): Higher maturity requirements for all fruits, including Temples; mandatory year around inspection of fruit to packinghouses and canneries; arsenic legal only on (bearing) grapefruit; legislative recognition of necessity for higher maturity standards and strict enforcement in public interest.
1951, 1953. Separate maturity requirements for seeded, white seedless and pink and red seedless grapefruit.
1955. Tangelo Act; increased juice requirements for grapefruit early in season.
1957. Revision of grapefruit juice requirements; changes in powers and composition of Florida Citrus Commission; recognition that maturity requirements are minimum quality standards; limes dropped from Citrus Code; changes in maturity test procedures.
1959. Revision of grapefruit maturity requirements; changes in powers of Florida Citrus Commission; Murcott maturity requirements established.
1961. Changes in Florida Citrus Commission powers; Citrus Stabilization Act (repealed 1963); color add under permit legal for Temples; changes in bonds for citrus fruit dealers (amounts increased); truck marking law; revision of fruit theft law; revision of grapefruit maturity requirements.
1963, 1965. Changes in Florida Citrus Commission Powers.
1967. Revision of grapefruit juice requirements; changes in Florida Citrus Commission powers; Orange Stabilization Act (lapsed in 1969).
1969. Changes in Florida Citrus Commission Powers.
1970, 1971. Changes in Florida Citrus Commission Powers; revision of definitions for tangerines and hybrid citrus; deletion of hybrids (Temples, tangelos, Murcotts) from Citrus Laws with maturity requirements established by Florida Citrus Commission Regulations; changes in maturity test procedures.
1975. Change of Florida Citrus Commission Regulations to Official Rules (Standard system statewide).

Table 2. (cont.

Marketing Agreements:

Order 905. Handling of oranges, grapefruit, tangerines and tangelos grown in Florida: 1939, amended 1946, 1947, 1957, 1965, 1966 and 1969.

Order 912. Grapefruit grown in the Indian River District in Florida: 1969.

Order 913. Grapefruit grown in the Interior District in Florida: 1969.

Order 914. Oranges grown in the Interior District in Florida: 1970 (dead).

U.S. Standards for Grades:

1946. Agricultural Marketing Act (enabling act for establishment of U.S. standards for grades of fresh and processed citrus).

Florida oranges and tangelos: 1947, 1955, 1960, 1961, 1965, 1967, 1968.
Florida grapefruit: 1947, 1952, 1960, 1961, 1967, 1968.
Florida tangerines: 1960, 1967, 1968.
Frozen concentrated orange juice: 1964, 1966, 1968.
Pasteurized orange juice (chilled juice): 1967, 1968, 1969.
Dehydrated orange juice: 1956, 1957, 1968.
Canned orange juice: 1964, 1966, 1968, 1969.
Concentrated orange juice for manufacturing: 1957, 1964.
Frozen concentrated grapefruit juice: 1956, 1957, 1968.
Frozen concentrated blended grapefruit juice and orange juice: 1951, 1957, 1958.
Dehydrated grapefruit juice: 1956, 1957, 1968.
Canned grapefruit: 1959, 1970.
Concentrated grapefruit juice for manufacturing: 1957.
Concentrated lemon juice for manufacturing: 1957.
Canned lemon juice: 1962.
Frozen concentrate for limeade: 1956, 1957, 1968.

Development of Packinghouses:

1945-1960: Bulk handling systems, solvent-type waxes, central belt-and-roll sizers, transverse sizers, perforated belt sizers, plastic bags, bag filling machines, carton fillers, pallet boxes, fungicidal waxes, Dowicide A-hexamine fungicide.

1960 to date: Two-stage packinghouse, ground-level packinghouse, pallet-box harvesting, plastic mesh bags, pallet-box degreening rooms (batch and continuous flow).

Development of Canneries:

1945-1946. 226,000 gallons (8,550 hl.) frozen concentrated orange juice (FCOJ).

1948-1949. 116,000 gallons (4,390 hl.) frozen concentrated grapefruit juice (FCGJ).

Table 2. (cont.)

1950–1951.	30,758,000 gallons (1,164,190 hl.) FCOJ; 2,530,000 gallons (95,760 hl.) processed COJ.
1955–1956.	70 million gallons (2,649,500 hl.) FCOJ; 2.5 million gallons (94,760 hl.) processed FCGJ; chilled juice first put on market.
1965–1966.	57,317,000 boxes (2,338,535 m. tons) for FCOJ (70.83 million gallons=2,680,915 hl.); 3,966,000 boxes (161,810 m. tons) for FCGJ (3,971,000 gallons= 150,302 hl.).
1970–1971.	103,521,000 boxes (4,223,660 m. tons) for FCOJ (125,174,000 gallons=4,737,835 hl.); 6,729,000 boxes (259,740 m. tons) for FCGJ (6,876,000 gallons= 260,255 hl.); 19,772,000 boxes (806,700 m. tons) for chilled juice; 2,348,000 boxes (90,635 m. tons) for chilled grapefruit juice; 7,668,000 boxes (312,855 m. tons) for single-strength OJ; 14,573,000 boxes (569,465 m. tons) for single-strength GJ; 2,333,000 boxes (90,055 m. tons) for grapefruit sections; 1,091,000 boxes (42,115 m. tons) for chilled grapefruit sections and salad.
1976–1977.	147,772,000 boxes (6,029,100 m. tons) for FCOJ (158,035,000 gallons=5,981,625 hl.); 27,250,000 boxes (1,111,800 m. tons) for chilled OJ (124,578,000 gallons=4,715,280 hl., 43.5% of which was from reconstituted FCOJ, 54,107,000 gallons=2,047,950 hl.) that is only 18.4% as many boxes but 78.4% as many gallons (actually about 30%, considering FCOJ gallons are concentrate); 7,429,000 boxes (303,100 m. tons) for single-strength OJ; 13,013,000 boxes (502,300 m. tons) for FCGJ (11,258,000 gallons=426,115 hl.); 4,331,000 boxes (167,175 m. tons) for chilled GJ (17,852,000 gallons=675,700 hl., 42% of which was from reconstituted FCGJ, 7,492,000 gallons= 283,570 hl.); 14,360,000 boxes (554,295 m. tons) for single-strength GJ.

Table 3. Outline of citrus fruit characters, modifiers of quality and legal and consumer factors.

Scion variety/Rootstock

Fruit Characters: External	Internal	Miscellaneous
	Juice	Size
	Total soluble solids (TSS)	Form
	Total acid (TA)	Weight
	Solids:acid ratio	Firmness
	Active acidity (pH)	Age
	Vitamin C	Decay
	Volatiles	
	Seeds, rag	

Quality Modifiers:	Preharvest	Postharvest
	Rootstocks	Respiration:
	Climate	Ethylene (endogenous)
	Soil	Ethylene (exogenous)
	Mineral nutrition	= degreening
	Sprays	Harvesting
	Water relations	Packinghouse handling
	Pruning	Refrigeration
	Tree age	Disorders and their
	Position on tree	control:
		Pathological
		Physiological

Legal Factors	Consumer Factors
Standards:	Appearance
Maturity	Palatability
Grade	Keeping quality
Rules and Regulations:	
CAC	
FCC (DOC)	
EPA	
etc.	

Table 4. Glossary[a]

Bin: container used for hauling citrus fruit from the grove to packing-house or cannery; square or rectangular (sometimes cylindrical) shallow metal, wooden or plastic boxes, usually stacked several on top of each other for transportation.

Box: 3 types of boxes have legal status in the Florida citrus industry.

a. Field box: 2.23 bu. (78.66 liters) capacity.

b. Pallet box: 10 box capacity (282 liters; 408 kg of oranges) or marked as such if larger; wooden or plastic with solid sides, slotted bottom and runners beneath, usually 32 inches (80 cm) high and 44 inches (119 cm) square.

c. Standard box: 1-3/5 bushels (56.4 liters); legal weights are 90 lb (40.8 kg) for oranges, 'Temples', tangelos, 85 lb (38.6 kg) for grapefruit and 95 lb (43.1 kg) for tangerines.

d. Standard shipping box: 4/5 bushel (28.2 liters).

British Thermal Unit (BTU): the quantity of heat required to heat 1 pound of water 1°F (actually from 59° to 60°F).

Brix: (synonymous with total soluble solids, which see).

Bulk bin: rectangular bin with sloping bottom and zigzag arrangement of baffles supporting ciderpress cloth, for temporary storage or degreening of oranges at a packinghouse; usual capacity is 100 to 150 boxes.

Climacteric fruit: one which contains starch or other energy sources and shows a characteristic rise in respiration indicative of ripening, during which period starches, etc., are converted to sugars.

Color-add: application of a dye (currently FDA Citrus Red No. 2) solution to the surface of oranges, 'Temple' or tangelos.

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[a]Additional terms will be defined in discussion of specific topics.

'able 4. (cont.)

Color break: the natural change in color of citrus fruit (excludes sunburn, insect damage, etc.) whereby the chlorophylls disappear and carotenoid pigments become evident.

Conduction: movement of thermal energy by transfer from one molecule to another, as in a solid or liquid.

Convection: movement of thermal energy by active motion of molecules in a medium (gas, liquid or solid; may be natural from differences in temperatures or forced as when molecules are moved with a fan or pump

Crop year: August 1 to July 31.

Degreening: the acceleration of the natural process whereby chlorophylls disappear and carotenoid pigments become evident, with the use of ethylene (1-5ppm), heat (85°F=29.4°C), high humidity (90-95% + relative humidity), and continuous air circulation and ventilation.

Discoloration: properly refers to light brown colored lesions on citrus fruit caused by rust mites but may also include light colored windscars, scattered speck-type melanose and the like.

Edibility: the stage of development when a citrus fruit may be eaten

Grade: an arbitrary classification of fruit (or vegetable) according to stipulated limits of their characteristics or qualities.

Heat: Thermal energy measured as BTU's or calories.

a. Field: the quantity of thermal energy removed in cooling or heating an object from one temperature to another, being the product of the temperature difference, mass (weight) and heat capacity (specific heat).

b. Latent: thermal energy released when a change of state occurs, as from liquid to solid (heat of fusion), solid to liquid (heat of liquefaction=heat of fusion), liquid to gas (heat of vaporization) or gas to liquid (heat of condensation=heat of vaporization) under standard conditions of pressure and volume.

Table 4. (cont.)

Respiration: thermal energy released in connection with metabolic processes (e.g., conversion of sugars to carbon dioxide and water) of plants or animals; usually expressed as BTU's per mass per unit time or the metric equivalent.

d. Sensible: thermal energy, including both field heat and heat of respiration, removed in cooling an object from one temperature to another. (Note that calculations involving sensible heat have a time-dependent component, heat of respiration.)

e Specific heat: the amount of thermal energy (BTU or cal.) required to change the temperature of a unit mass 1°.

Humidity: water vapor in the air.

a. Absolute (specific): the measure of the mass (weight) of water in a given mass of dry air (at standard barometric pressure).

b. Dewpoint: the temperature to which moist air must be lowered (at a constant pressure) to initiate condensation.

Relative: the ratio between the quantity of water vapor present and the maximum possible <u>at that temperature and barometric pressure</u> (disregarding corrections for partial pressure and percent saturation); normally expressed as a percentage.

d Vapor pressure: the partial pressure of water vapor in any dry air + water vapor combination at a given barometric pressure (or rather, corrected to a standard barometric pressure; e.g., that at sea level would be used in calculations in Florida). There is a direct correlation with absolute (specific) humidity (at a given barometric pressure) regardless of temperature. The quantity of water vapor that can exist in a given space (i.e., the vapor pressure or absolute humidity) is directly dependent, however, upon temperature.

'able 4. (cont.)

Maturity: the stage of development of a fruit such that it will ripen to an edible state. (Applies strictly to climacteric-type fruit, since no such stage is discernible in citrus.)

Maturity standard: an arbitrary legal limitation of some fruit factor such as juice content, total soluble solids, soluble solids:acid ratio, etc.

Mechanical reefer car, truck: Rail car or semi-trailer equipped with mechanical refrigeration facilities for keeping produce cool in transit.

Non-climacteric fruit: those like citrus which do not contain starch or other energy-rich constituents capable of being converted into sugars during the course of the ripening process. These fruit have neither a well-defined stage of maturity nor of ripening, hence they exhibit under normal circumstances a rather low rate of respiration throughout the later period of their lifetime.

Palatability: literally, the taste of a fruit, important contributing factors being sugars, sugar:acid ratio and volatiles at the time of consumption.

Pounds-solids: the product of pounds of juice x percentage total soluble solids, usually expressed on a per box basis.

Precooling: the rapid cooling of fruit prior to transportation.

Prorate: a shipment quota for some time period based upon a packing-house's relative share of the total shipments for the previous month or season.

Reefer: a rail car equipped with ice bunkers, fans and vents for refrigerating produce en route to market; now replaced by mechanical refrigerator cars and trucks.

Refrigeration: a general term for any type of cooling.

Ripening: the stage of development of a fruit when it becomes soft and edible; applicable strictly to climacteric-type fruit in which the process is preceded or accompanied by a rapid rise in rate of respiration.

Table 4. (cont.)

Season of growth: the period from fruit set to August for early and midseason varieties and to December to February for late varieties.

Season of maturity (edibility): the period from September to November or December for early, December to February for midseason and February to May or June for late varieties.

Seedless fruit: commercially, those with 0 to 6 seeds.

Specific gravity: the density of an object compared to that of a standard material such as water or air. (Solids or liquids are compared to water = 1.0.)

Spot picking: Selective removal of fruit from a tree on the basis of size, maturity or color.

Standards for grades: arbitrary ranges for color, firmness, form, discoloration and blemishes for a given classification (grade).

Thermal conductivity: heat per unit time per unit area per degree temperature gradient per unit thickness.

Thermal diffusivity: the heat passing through a unit area per unit time divided by the product of specific heat, density and temperature gradient (i.e., thermal diffusivity is the rate of heat movement whereas thermal conductivity is the quantity of heat).

Total soluble solids (° Brix): sugars, etc., in juice, measured as % pure sucrose (degrees Brix = % pure sucrose).

Total (titratable) acid: acids in juice titrated to the phenolphthalein endpoint with standard alkali and reported as % anhydrous citric acid.

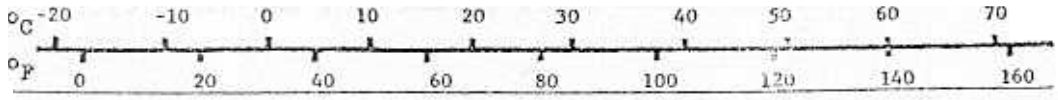
Tree storage: the practice of holding fruit on the tree beyond the normal harvest period.

Table 5. CONVERSIONS: U.S. & METRIC MEASURES

U.S. Units*		Metric Equivalents	Conversion Factors Metric to U.S.
Length or Thickness			
1 mile	=	1.6093 kilometers (km)	X 0.6214
1 yard	=	0.9144 meters (m)	X 1.0936
1 foot (ft)	=	0.3048 "	X 3.2808
1 inch (in)	=	2.5400 centimeters (cm)	X 0.3937
1 mil (1/1000 in)	=	0.0254 millimeters (mm)	X 39.3700
Area			
1 square inch (in^2)	=	6.4516 square centimeters (cm^2)	X 0.1550
1 square yard (yd^2)	=	0.8361 square meters (m^2)	X 1.1960
1 acre	=	0.4047 hectares (ha)	X 2.4710
1 section ($mile^2$)	=	258.988 "	X 0.0039
Volume or Capacity			
1 pint	=	0.4732 liters (ℓ)	X 2.1133
1 gallon (gal)	=	3.7853 "	X 0.2642
1 bushel (bu)	=	35.2381 "	X 0.0284
1 acre-inch	=	102.7938 cubic meters (m^3)	X 0.0097
1 Fla. field box (4,800 cu ins)	=	0.7866 hectoliters ($h\ell$)	X 1.2713
1 Fla. citrus carton (4/5 bu)	=	0.2922 "	X 3.5436
Weight			
1 ounce (oz)	=	28.3495 grams (g)	X 0.0353
1 pound (lb)	=	0.4536 kilograms (kg)	X 2.2046
1 hundredweight (cwt)	=	45.3592 "	X 0.0220
1 ton	=	0.9072 metric tonnes	X 1.1022
Rate or Yield			
1 grain/pound (gr/lb)	=	0.1429 grams/kilogram (g/kg)	X 7.0000
1 pound/acre (lb/acre)	=	1.1208 kilogram/hectare (kg/ha)	X 0.8922
1 ton/acre	=	2.2417 metric tonnes/hectare	X 0.4461
1 gallon/acre (gal/acre)	=	9.346 liters/hectare (ℓ/ha)	X 0.1070
1 Fla. field box/acre	=	1.9437 hectoliters/hectare ($h\ell$/ha)	X 0.5162
1 bushel/acre (bu/acre)	=	0.8705 " "	X 1.1488
1 pound/100 gallons (lb/100 gal)	=	1.1983 grams/liter (g/ℓ)	X 0.8345
1 cubic foot/minute (ft^3/min)	=	0.4720 liters/second (ℓ/sec)	X 2.1186
Energy, Light, & Pressure			
1 horsepower (HP)	=	0.7457 kilowatts (kw)	X 1.3410
1 foot candle (ft-cp)	=	10.7639 lux	X 0.0929
1 pound/square inch (psi)	=	70.3069 grams/cm^2	X 0.0142
1 British Thermal Unit (BTU)	=	0.2530 kilogram calories (kg-cal)	X 3.9526

Temperature

Fahrenheit = $\frac{(C \times 9)}{5} + 32$ Celsius (Centigrade) = $\frac{(F - 32) \times 5}{9}$



*Note that these are United States measures which often differ from British, eg., the ton hundredweight, bushel, gallon, etc.

(From Proc. Florida State Hort. Soc. 90, 1977.)

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