PANAMA NATURE FRESH

QUALITY STANDARDS

SPECIFICATIONS FOR CITRUS (PNFPL0004)

Citrus Fruits

I. Taxonomy, major cultivars.

The genus *Citrus* belongs to the Rutaceae family, sub-family *Aurantoideae.* This family contains many edible species, some distantly related such as White Sapote (*Casimiroa edulis* Llave & Lex.) and Wampee (*Clausena lansium* Skeels.). While *Citrus* is by far the most important genus, two other genera contain commercially important species:

1. *Fortunella spp.* (Kumquats). Originally classified with citrus, then moved to its own genus, named after Robert Fortune, who introduced kumquats to Europe. Evergreen shrubs or small trees (8-15 ft), these plants are native to southern China, but can be grown around the world into subtropical areas. Unlike citrus fruits, the peel of the fruit is edible, although tart/spicy. Fruit are eaten-out-of-hand, and often used as a decoration in gift packs of citrus fruits for holiday trade. Kumquats are grown commercially in China and Japan. They are exceptionally high in calcium, potassium, Vitamins A and C, like most citrus fruits. They are unusual fruits in that the peel is sweeter than the pulp. Four major cultivars are given species status by some taxonomists:

a. *F. margarita* Swing. - 'Nagami'. Also called Oval or Long Kumquat. This is the most popular cultivar in the US. Oblong fruits (1 3/4 inch long) contain 4-5 segments and 2-5 seeds; thin, yellow-orange peel.

b. *F. hindsii* Swing. - 'Hong Kong', or 'Hong Kong Wild'. Fruit used in east Asia, grown only as an ornamental (thorny shrub). Fruit is orange/scarlet when ripe, 3-4 segments, many plump seeds.

c. *F. japonica* Swing. - 'Marumi' (syn. *Citrus madurensis* Lour.). Also called round kumquat. Thin, golden-yellow peel surrounds aromatic and spicy 4-7 segmented pulp. More cold hardy than 'Nagami', can be grown in coastal Georgia & N. Florida.

d. *F. crassifolia* Swing. - 'Meiwa', or Large Round Kumquat. Possibly a hybrid between 'Nagami' and 'Marumi'. Round fruit, thick orange-yellow peel, sweet pulp in 7 segments, often seedless or few seeds. Trees are dwarf and nearly spineless. Rarely found in the US, but extensively grown in China.

2. *Poncirus trifoliata* L. Raf. (monotypic; the trifoliate orange). Important as a rootstock for citrus, especially in Japan; also used as a *%* parent in production of citrange rootstocks. It has a deciduous habit in cooler areas, and can tolerate more freezing than any other citrus or related species; grown as far north as Philadelphia in botanic gardens. It is native to northern China. Used as a dense, thorny hedge to ward-off intruders/wild animals since ancient times. Used as an ornamental in some areas of Europe, Eastern US.

There is considerable debate over the number of species within *Citrus*. Some “lumpers” argue that all citrus fruits belong to one large species as they are freely graft and cross-compatible for the most part. On the other extreme, there are taxonomists that give almost each cultivar a species name, which is clearly in error. Biochemical evidence (R.W. Scora, 1988. Proc. 6th Int’l. Citrus Congress) suggests that there are probably four “basic” species of citrus fruits:

1. *C. halimii* Stone - Native to southern Thailand and west Malaysia, this may have been the possible progenitor species for *Poncirus* and *Fortunella*.

2. *C. medica* L. (the citron). The citron is used mainly for its peel, which is candied. It can also be used in place of lemons in cooking, and may be the progenitor species for all acid citrus (lemons and lime-like fruits).

3. *C. reticulata* Blanco. The mandarin; This may be the ancestral form of all oranges and tangerines, or may be the progeny of a now extinct ancestor. It is more fully described below.

4. *C. maxima* (Burm.) Merril (syn. *C. grandis*) - the pummelo or shaddock. This is probably the progenitor of the pummelo and grapefruit.

The literature on citrus usually recognizes each economically important type as a species, yielding the following:

A. *C. limon* (the lemons, including rough lemons). Includes the lemons of commerce, such as 'Lisbon' (oval to round, less pronounced stylar end) and 'Eureka' (oval, pronounced stylar end bulge). The 'Meyer' is considered to be a lemon hybrid of unknown percentage. The rough lemon was widely used as a rootstock in Florida and Arizona until it was discovered as being susceptible to citrus blight; *C. jambhiri* Tanaka is used to denote this “species”. *C. limonia* or the 'Rangpur' lime is also used as a rootstock.

Lemon hybrids include: “Lemonange” (lemon × sweet orange), “Lemonimes” (lemon × limes), “Lemandarins” (lemon × mandarin), and “Eremolemon” (*Eremocitrus* × lemon).

B. *C. aurantifolia* (limes and lime-like fruits). The two main cultivars include the 'Key' (syn. ‘Mexican’), and 'Tahiti' (syn. ‘Persian’). The latter is sometimes given species status as *C. latifolia* (Tanaka) or *Citrus x tahiti* (C. Campbell). *C. macrophylla* is a lime-like fruit which has become an important rootstock for lemons in California and Florida. Limes hybrids include: “Lemonimes” (lime × lemon), and “Limequats” (lime × kumquat). Two other groups of “limes” are given the names *C. limetta* (the limettas or sweet limes/lemons) and *C. limettioides* (Palestine sweet lime - an important rootstock).

C. *C. aurantium* (the sour orange). This is allied with limes by some, but is a very important rootstock and ornamental. Since it often appears in the literature, it is convenient to keep this species name. Cultivars and variants include: Bittersweet, Oklawaha, Vermillion Globe, Paraguay, Trabut, var. *myrtifolia* (Myrtle), Bergamot, daidai (Japanese), Leaf of Chinnoto, and *C. taiwanica* Tanaka. Sour orange X trifoliate orange hybrids are called “citradias”.

D. *C. sinensis* (the sweet oranges). This is a widely accepted name for this group, containing 4 groups of cultivars:

a. Common or round oranges. Mostly used for juice or fresh market. Cultivarsinclude ‘Valencia’, ‘Hamlin’, ‘Parson Brown’, and ‘Pineapple’.
b. Blood oranges. Increasing in importance in the US, these red-juiced variantscontain anthocyanin in the peel and juice. ‘Torocco’ and ‘Moro’ are the major cultivars.
c. Navel oranges. This group is unique in that cultivars have a secondary ovaryembedded within the usual ovary, giving a small fruitlet at the stylar end of the fruit at maturity; a fruit-within-a-fruit. ‘Washington’ is a major cultivar, but there are dozens.
d. Acidless oranges. An odd group of oranges without acid, yielding insipidlysweet flavor. Used mostly in the Mediterranean region.

The term “orange” is used rather loosely, sometimes for fruits that look like oranges but are not C. sinensis. Examples include: 'Temple' and ‘Page’ oranges (tangerine hybrids), Satsuma orange (a cold hardy variant of tangerine), and Trifoliate orange (*Poncirus trifoliata*). Sweet orange hybrids include: Citranges (sweet orange × trifoliate orange), Citrangors (sweet orange × citrange), Citrangequats (citrange × kumquat), Citrangeremos (citrange × *Eremocitrus*).

E. *C. reticulata* (mandarin, satsuma, or tangerine). As stated above, this is probably a “real” species. Due to the success of breeding with these types (as they are often monoembryonic), many cultivars and hybrids have been produced or formed naturally, some erroneously given species status. Common cultivars include: 'Dancy', Clementine' or 'Algerian', 'Owari' (a satsuma), ‘Cleopatra' (common mandarin rootstock). I prefer to use *C. reticulata* for all tangerines, but other species names sometimes given in the literature include: *X Citrofortunella mitis* (Calamondin), *C. unshiu* (Satsuma), and *C. deliciosa* (Willowleaf mandarin).

Tangerine hybrids may be more important economically than pure tangerines. The most important hybrids are tangelos (tangerine x grapefruit), tangors (tangerine x orange), and tangtangelos (tangerine x tangelo). Popular cultivars include: 'Orlando' tangelo, 'Minneola' tangelo, 'Page' orange (actually a tangtangelo), 'Robinson' tangerine (a tangtangelo). "Ugli" fruit from Jamaica is probably a chance seedling from a natural cross between *reticulata* and *paradisi*; it is now marketed under the more politically correct name “Unique” fruit.

F. *C. grandis or C. maxima* (the pummelo or shaddock). This species originates from southeast Asia where it is as common as grapefruit is in the US. It is much larger and thicker-peeled than grapefruit, but poorer in flavor.

G. *C. paradisi* (the grapefruit). This is a relatively recent species (since 1700's) of unknown origin. It probably derives from Caribbean 'Forbidden Fruit', and was introduced to Florida from there. Cultivars include: 'Duncan', 'Marsh', 'Red-blush', and 'Thompson' (syn. 'Pink Marsh'). Hybrids include the tangelos and citrumelos; the latter are used as rootstocks.

II. Origin, History of Cultivation.

The center of diversity for *Citrus* ranges from northeastern India eastward through the Malay archipelago and south to Australia. Sweet oranges probably arose in India, the trifoliate orange and mandarin in China, and acid citrus types from Malaysia. Oranges and pummelos were mentioned in Chinese literature in 2400 BC, and later in Sanskrit writings (800 BC) lemons were mentioned. Theophrastus, the Father of Botany, gave a taxonomic description of the citron in 310 BC, classifying it with apple as *Malus medica* or *Malus persicum*. At the time of Christ and shortly thereafter, the term “citrus” arose as a

mispronunciation of the Greek word for cedar cones, “Kedros”. Alternatively, “citrus” may have arose through a condensation of “*Callistris*”, the name for the sandalwood tree.

At this time, citrus fruits were spread throughout Asia, North Africa, and Europe along trade routes. The dissemination was carried out by many cultures, indicating widespread appeal of the fruits at this time. From the first centuries BC to medieval times, orangeries and citrus “groves” were established in Europe, and cultivation became more sophisticated. Columbus, Ponce de Leon, and Juan de Grijavla carried various citrus fruits to the new world in the late 1400's early 1500's. Citrus culture proliferated in Florida in the late 1700's, when the first commercial shipments were made. Right about this time, citrus was introduced to California, although it was much later that commercial production began in the west. With the advent of large-scale irrigation projects in the 1940's, citrus culture increased greatly in western states. In Florida, citrus acreage peaked in the 1970's at about 1 million acres, but has declined since then due to freezes and Foreign competition. Today, Citrus is grown in Florida, California, Arizona, and to a limited extent in Texas and Louisiana.

III. Folklore, medicinal/toxic properties, alternative usage.

In addition to various food products from pulp, citrus peels are candied, fed to livestock, used to scent perfumes and soap products, and limonene oils from the peel have an insecticidal property recently discovered. Seeds are used to derive a cooking oil, and oils for plastics and soaps. Flowers and foliage are used in perfume manufacture. Nectar is converted to honey by bees, and is a profitable industry itself.

A. Limonene oils - in peel and leaves may cause contact dermatitis. These are also "photosensitizing compounds", meaning that one may get a sunburn rash if juice gets on skin while exposed to UV light. (agent = furocoumarin?). B. Citromellal - volatile oil, has mutagenic properties.

C. Chewing and sucking "quids" - of various tribal peoples; contain lime juice and other alkaloids. May actually cause cancer. Lime juice causes release of alkaloids from other materials.

D. Cancer therapy - Two citrus relatives being studied for cancer therapy drugs:

Acronychia baueri (Australia) - Acronycine
Fagara macrophylla (Nigeria) - 8-methoxy-dihydronitidine.

E. Hesperidin (syn. citrin, vitamin P) - a bioflavonoid, up to 8% in dried peel. Strong vasopressor agent (reduces blood pressure). Also in rose hips and black currants, which oddly enough, are used for vitamin C sources like citrus.

F. Sweeteners -

1. Naringin (flavonoid) - in grapefruit, has 1000x the sweetness of sugar. Said to be along-lasting sweetness that is slow to develop - aftertaste like licorice or menthol.
2. Neohesperidin (dihydrochalcone) - flavonoid in *C. grandis*.

G. Volatile oils - in *Clausena anisata*, anise-scented leaves are used to repel mosquitos in tropical Africa. In many species these oils are used to scent creams, shampoos, etc.

H. Oral -

1. *Aegle marmelos* - twigs used as chew sticks in Africa.
2. Sweet orange - peel used in Panama for toothache relief. Also, leaf decoctions ofsour orange used as mouthwash or gargle for sore throat.
3. Toothache tree - (*Zanthoxylum hirsuta*). Native to Texas, leaves can be crushed and applied to gums for relief.

I. General -

1. Sour orange - Said to be good for headache, fever, dysentery, ophthalmia, oralinfections, vermifuge, vomiting.

2. *Clausena anisata* - Stems used in Africa for evacuant, headache, liniment, respiration, ailments.

3. Anti-diarrheal agent - rind of *Aegle marmelos* and other edible citrus may control diarrhea.

4. Citrus pectin reduced cholesterol 30%, aortal plaque 85%, and narrowing ofcoronary arteries by 88% in animals feeding studies.

J. Myth/folklore - Because the orange tree bears flowers and fruits at the same time, it was used in fertility rituals and weddings - the white flower symbolized virginity, and the fruits symbolized fertility. The citron is used in certain religious ceremonies by Hebrews. The word "orange" is said to have derived from the Spanish word naranja; English-speaking folks applied the indefinite article to the spanish word to give "a naranja" which was corrupted to "an orange".

The term “golden apples” arose from the myth of Hercules and the golden apples. The Hesperides were Mediterranean islands, where the giant Atlas lived, and were a haven for the golden apples (probably quinces, not citron). This is because the Gods were fearful of the golden apples being stolen. Hercules managed to obtain some of the golden apples as one of his 12 tasks, despite Atlas' attempt to trick him into holding up the sky. Later Perseus visited the Hesperides to obtain some golden apples, and succeeded by turning

Atlas to stone using the head of Medusa; the Atlas Mountains of northern Africa now hold up the sky, fortunately.

There is also the myth of the Grecian Maiden Atlanta, "who was as fleet of foot as she was beautiful". To obtain her hand in marriage, her suitor had to beat her in a foot race; if he lost, he was beheaded. Hippomenes, an apparently slow but sly individual, obtained some golden apples, and during the race rolled them at her feet as she passed. She stopped to pick them up and Hippomenes scooted to the finish line the victor.

K. Bael Fruit (*Aegle marmelos* Correa) - Hard-shelled fruit, used for medicinal purposes ranging from laxative, diuretic, treatment of hemorrhoids, diarrhea and dysentery (unripe fruit), purgative. Has antibiotic activity in fruits, leaves, and roots.

L. Wampee (*Clausena lansium* Skeels). - Small, peel-able fruit of southeast Asia; eaten out-of-hand or made into jams, desserts, pies, etc. Vietnamese remedy for bronchitis.

IV. Production.

Oranges

A. World (1999 FAO) - **57,915** (1000's MT).

1. Brazil - 19,399	6. India - 2,000
2. US A - 8,968	7. Italy - 1,921
3. Mexico - 3,538	8. Iran - 1,749
4. S pain - 2,500	9. Egypt - 1,525
5. China - 2,258	10. Pakistan - 1,410

B. United States (1997 USDA) - **12,380 (1000s** MT) , **value = 1.96 billion $**.

1. Florida (76%)	600,000 - 700,000 acres
2. California (23%)	188,000 acres
3. Arizona (<1%)	. 30,000 acres
4. Texas (<1%)	?

Fresh Exports, 1996: 5-6% of production
Fresh Imports, 1996: <1% of production

Juice exports, 1997: 147 million gallons as concentrate.

Price per lb - $0.06

Grapefruit

A. World (1999 FAO) - **4,910 (1000s** MT)

1. US A - 2,315	6. Mexico - 180
2. Cuba - 420	7. S outh Africa - 123
3. Israel - 335	8. India - 92
4. China - 254	9. Turkey - 65

5. Argentina - 210 10. S udan - 64

B. United States (1997 USDA) - **2,478 (1000s MT) value = $225-275 million**

1. Florida (80%)
2. California (12%)
3. Texas (8%)
4. Arizona (1%)

Fresh Exports, 1997: 18-20% of production
Fresh Imports, 1997: <1% of production

Juice exports, 1997: 21 million gallons as concentrate

Price per lb - $0.05

Tangerines & hybrids

A. World (1999 FAO) - **15,899 (1000s MT).**

1. China - 5,874 6. Thailand - 630
2. S pain - 1,750 7. Pakistan - 522
3. J apan - 1,176 8. Korea - 512
4. Iran - 726 9. Italy - 504
5. Brazil -680 10. US A - 484

B. United States (1997 USDA) - **483,500 MT**, **value = 120-150 million $**.

1. Florida (67%) - Tangelos = Tangerines > Temples

2. California (28%) - Mostly tangerines, but Sunkist now marketing 'Minneola' andother hybrids. (8,600 acres- increased >10% in last 3 years).

3. Arizona (4-8%) - All Tangerines (increasing acreage slightly and diversifying)

Fresh exports, 1997: 3% of production
Fresh imports, 1997: <1% of production

Price per lb - $0.12; prices 2-3 fold higher for tangerines than tangelos or temples in general, but this may be misleading for certain cultivars.

Lemons & Limes

A. World - (1999 FAO) **9,374 (1000s MT)**. Note: lemons and limes, as we know them in the US, are not distinguished by the FAO. Thus, the following data are totals of lemon- and lime-like fruits. In Mediterranean climates (like Spain, Italy, and California),

production of lemons dominates; in tropical and subtropical regions (like Mexico, Brazil, and Florida) lime production dominates.

1. Mexico - 1,159
2. Argentina - 1050
3. India - 1,000
4. Iran - 891
5. US A - 741
6. S pain - 700
7. Italy - 610
8. Brazil - 470
9. Egypt - 300
10. Turkey - 360

B. United States (1997 USDA)- **849,800 MT of lemons**, **value = $240-300 million**; **13,090 MT of limes, value = $ 3.2 million.**

1. California (88%) lemons only.

2. Arizona (12%) lemons only.

3. Florida - limes only. Devastated by hurricane Andrew in 1992, production dropped from 1 to 1.5 million boxes per year to 320,000 boxes in 1998. Value was also only a fraction of pre-hurricane values, because demand apparently decreased following the hurricane also.

Price per lb - $0.12-15 for lemons, $0.07-0.16 for limes

	Exports	Imports	(% of US production)
Lemons	15-20%	1-2%	
Limes	25-30%	>1000%	

V. Botanical description.

Plant: Small, spreading, evergreen trees or tall shrubs. Stems often armed with long thorns, particularly in limes or in all types when young. Current season's shoots are angular, green like the leaves. Older wood has thin, dark grey bark. Leaves are unifoliate (sometimes termed compound unifoliate to indicate the loss of lateral leaflets over time), relatively thick, ovate with acute to obtuse tips, having entire or crenulate margins and a petiole wing of various width, depending on species (grapefruit = large, tangerine = small). Leaves contain characteristic citrus oils in glands ("pellucid dots") which makes them fragrant when crushed.

Flower: *Fragrant* flowers are solitary or in short cymes, borne axillary on current flush of growth (then termed "leafy bloom"), and also without leaves from the previous flush of growth (then termed "bouquet bloom"). Usually perfect, rarely staminate by pistil abortion. Normally 5 petals and sepals; petals linear, sometimes curved lengthwise, white, waxy, and thick; sepals fused at base to form a small cup. A globular, green ovary subtends a

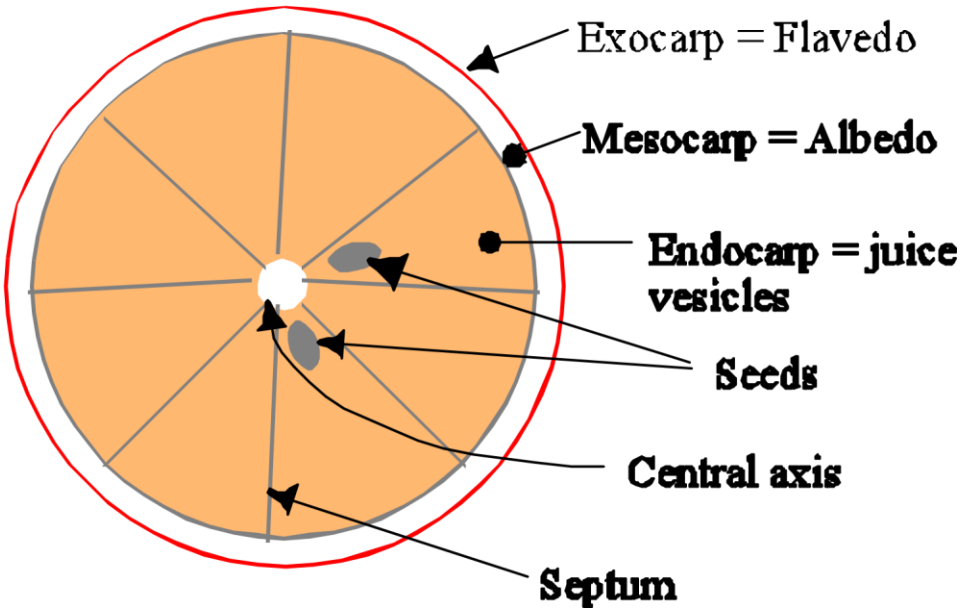
thin straight style which terminates in a pronounced, donut-shaped stigma. Ovary with 1014 locules in most commercial cultivars, each with potentially 4-8 seeds; axile placentation. Ovary, superior, subtended by raised nectary disc.

Pollination: Most cultivars are self-fruitful through self-pollination, and some are parthenocarpic, setting and maturing commercial crops of seedless fruit without fertilization (but not necessarily without pollination). Examples of parthenocarpic cultivars are 'Marsh' grapefruit, 'Tahiti' or Persian lime, 'Hamlin' sweet orange. 'Marsh' and 'Hamlin' also develop seeds. Fruit size is related to seed # in all cultivars.

Pollinizers are necessary for some tangerine (hybrid) cultivars. 'Robinson', 'Nova', and 'Page' (all tangtangelos) require pollination for adequate fruit set.

Fruit: A hesperidium. The endocarp (edible portion) is divided into 10-14 sections, separated by thin septa, each containing up to 8 seeds, but usually only one seed/segment. Placentation is axile. Each segment is composed of juice vesicles ("pulp"), with long stalks attached to the outer wall, containing juice. The mesocarp is the white tissue usually adherent to the outer surface of the endocarp, except for mandarins; it is also called the albedo. The exocarp, or flavedo, is the thin, pigmented outer portion of the rind, with numerous oil glands.

The seeds contain both nucellar (maternal) and multiple embryos, except in some tangerines where only 1 zygotic embryo forms. Nucellar embryony and polyembryony are characteristics exploited by nurserymen, but impede breeding efforts, since germination often exceeds 100% in seed lots, yet variation in seedling progeny is non-existent since most seedlings are clones of the maternal parent.



VI. General culture

A. Soils and Climate.

Soils: Citrus is adapted to a wide variety of soil types and conditions. Trees are grown on almost pure sand in central Florida, to organic muck along the Indian River, to loamy, heavy soils in southern California. Citrus is more tolerant of high or low pH and salinity than most other tree crops, tolerating several times the soluble salt levels of Rosaceous tree crops.

Climate:

Citrus fruit obtains highest internal quality in subtropical humid climates. However, with irrigation, it also grows well in Mediterranean climates, like California, achieving the best external quality. In the tropics, citrus accumulates less sugar and acid, and the peel usually remains green; also, bloom is not synchronized, so several stages of maturity are present on the tree at any given time, causing some immature fruit to be harvested.

Cold hardiness is the major limiting factor for citrus production in subtropical areas.

Fruit are killed by 30 minutes @ 26-28EF; larger fruit are more cold tolerant due to greater thermal mass. Fruit freeze from the stem end to the button, and mildly frozen fruit can be salvaged for juice.

Leaves and stems are killed by a few minutes at 20-28 EF, depending on stage of acclimation, species, and age of tissue.

Hardiness increases in the following order: Citron < limes & lemons < grapefruit & pummelo < sweet oranges < tangerines & hybrids < sour orange < satsuma < kumquats < citranges < trifoliate orange.

Citrus has no chilling requirement, and does not attain a truly dormant state, but becomes quiescent at temperatures below . 55 EF.

Flowering is induced following emergence from quiescence, and sometimes by drought in tropical species like limes.

Fruit quality and climate: Internal and external quality of citrus differs in humid subtropical and Mediterranean climates. Heat and humidity are the main environmental factors controlling quality.

1. Peel thickness, texture - Peels become thicker and have more “pebbly” or roughtexture in Mediterranean climates than more humid climates.

2. Peel color - is higher in Mediterranean climates than warmer areas due to cool winters and greater day/night temperature fluctuations.

3. Juice content - is higher in humid climates.

4. Sugar and acid content - Acid content is higher and sugar content generallylower in Mediterranean climates than areas with warm temps during ripening. Acids do not accumulate as much in areas with warm nights, like Florida; hence the solids:acid ratio is higher in Florida, and fruit is said to be richer in flavor, because flavor results from a balance of sugar and acids.

5. Fruit size - may be larger in humid climates, although this parameter is morestrongly influenced by fruit set and seed #/fruit.

6. Rate of maturation - is faster in hot, desert areas of California and Arizona thanin cool, coastal areas.

The above influences are the reason why juice oranges are grown in Florida (poor external quality, good internal quality), and fresh oranges are grown in California (excellent external quality, fair internal quality). Also, lemons are limited to CA and AZ due to better peel color and acid development, whereas limes are grown in Florida since they are marketed green and obtain higher juice content.

B. Propagation. Although citrus seedlings will produce fruit identical to the parent tree, due to nucellar embryony, trees are generally T-budded onto various rootstocks to avoid the long juvenile period for seedlings. Budding can be performed during most of the year, when pencil-sized, round budsticks are available, and bark slips on rootstocks. C. Rootstocks.

Citrus was grown from seed until the mid-1800s, due to ease of propagation from seed and trueness of type. *Phytophthora* foot rot appeared in the Azores in 1842 and later in other parts of the world, which stimulated a search for resistant stocks. Sour orange arose as the predominant stock for sweet orange worldwide, but in S America, S Africa, Australia, and California, trees were declining due to tristeza, which nearly wiped out industries in Brazil and Argentina. Rangpur lime (*C. limonia*) and citranges began replacing sour orange, and are popular worldwide today.

Common stocks:

1. Sour orange (*C. aurantium* L.). Highly used worldwide, except in areas with tristeza. Produces a tree with moderate to high vigor, size, and yield. Imparts excellent

fruit quality characteristics to both sweet orange and grapefruit, although harvest may be delayed due to higher acid content. Complete resistance to *Phytophthora* foot rot and high quality make this stock useful for grapefruit on the Indian River. Imparts cold hardiness to the scion. Not used for juice oranges since higher yield of lbs-solids per acre can be obtained with more vigorous stocks.

2. Rough Lemon (*C. jambhiri* Lush.). This stock enabled the movement of the Florida industry onto the deep, excessively drained sands of the "Ridge" after the 1890's freezes. Hence, it imparts drought tolerance, high vigor and yield, even though the tree itself is low in vigor, but poor internal quality. Fruit size is generally higher than for other stocks. Intolerant of *Phytophthora* and nematodes, and imparts poor cold hardiness to scions. Used for grapefruit, oranges, and lemons where yield and not quality are important; a good stock for juice oranges. Not being produced in Florida anymore due to susceptibility to citrus blight or young tree decline, a serious disease of unknown etiology.

3. Rangpur lime (*C. limonia* Osb.). Actually not a lime but probably descended from rough lemon and sour orange parentage. Very similar to rough lemon in many characteristics, but generally better fruit quality and more tolerant of high pH and salt. Mostly used in Sao Paulo, Brazil for juice orange production.

4. Citranges (*P. trifoliata x C. sinensis*). 'Carrizo', and 'Troyer', are the most common; 'Rusk' and 'Morton' no longer used, except ‘Rusk’ for dwarfing (by 15-20%) specimens. Crosses were made after the 1895 freeze to produce cold-hardy scions, but fruit quality was poor and they were used as stocks instead. Excellent stocks in general; good cold hardiness and vigor, good fruit quality and yield. Susceptible to blight, exocortis, poor tolerance of salt and high pH. Excellent nursery characteristics. Used as a replacement for Rough Lemon in Florida, for oranges in California, unpopular but increasing in use outside the US.

5. Cleopatra mandarin (*C. reshni* Hort. ex Tan.). The major rootstock for tangerines and hybrids, due to excellent fruit quality. Also tolerant of tristeza, exocortis, xyloporosis, Phytophthora, salt, cold, and high pH. Two major faults preclude use for grapefruit and processing oranges: 1) trees are slow to come into bearing, and Cleo is very slow in the nursery, 2) fruit size is small.

6. Trifoliate orange (*P. trifoliata* (L.) Raf.). More important as a parent of hybrid stocks, it is used in Japan for satsumas due to cold hardiness, and to a limited extent in Argentina. Two misconceptions prevail about this stock: trees are very cold hardy with proper acclimation, but cold tender in areas with warm winters; dwarfing was a result mostly of exocortis infection, and drought stress on sandy soils since trees are relatively shallow rooted. 'Flying Dragon' is a trifoliate mutant with serpentine stems, curved thorns, small leaves, and contorted habit; can be useful in pot culture since it truly dwarfs trees. Fruit yield and quality are very good. Trees are intolerant of high pH.

7. Citrumelos (*P. trifoliata x C. paradisi*). 'Swingle' is the only important selection. Tolerance includes citrus nematode, *Phytophthora,* and viruses including tristeza. High pH is a problem as for all trifoliate hybrids. Production declined in Florida in the early 1980s due to supposed susceptibility to citrus canker; however, this was probably overrated and more a function of vigor than species. Performance with oranges, grapefruit and lemons has been very good to date.

D. Planting design, Pruning, Training.

1. Design. Citrus has been traditionally grown in rectangular arrangements which eventually become tall hedgerows. Spacings are typically 20 x 25 for grapefruit and vigorous trees, 15 x 20 for oranges and tangerines, and 12-15 x 18-20 for limes and smaller cultivars.

2. Pruning and Training. Citrus has a naturally sympodial growth habit, forming a large bush (18-20 ft tall) if left unpruned. Very little training is done; young trees are headed at . 30 inches to induce branching, and stripped of trunk sprouts and suckers and de-fruited for the first 2-3 yr. At maturity, trees are hedged and topped to form hedges about 12 ft tall and wide with automated equipment. Almost no hand pruning is done. Equipment is expensive, but growers can contract this service by specialists. Typically, hedging and topping is done every other year.

E. Backyard considerations. Citrus trees make excellent containerized plants for the patio or deck; kumquats, ‘Meyer’ lemon, and calamondin are ornamental and do very well. They must be brought indoors or covered if temperatures drop below 25°F. Of course, trifoliate orange is hardy throughout the southeast, and the ‘Flying Dragon’ cultivar makes a good rock garden or specimen tree with its striking serpentine stems. In coastal Georgia, I have successfully fruited ‘Owari’ satsuma, ‘Changsha’ tangerine, ‘Sinton’ and ‘Thomasville’ citrangequat, and a few others outdoors with temperatures as low as 17°F.

VII. Harvest, post-harvest.

A. Maturity. The best indices of maturity for citrus are EBrix, acid content, and the Brix/acid ratio. External color is a function of climate more than ripeness, and is a poor indicator of maturity. Legal maturity standards are enforced in major citrus regions. For limes, juice content must be at least 42% to market; diameter must be at least 1 7/8" also.

Brix . sugar content (measured with hydrometer or hand refractometer); increases during maturation:

Oranges - 7-14%
Grapefruit - 10-12%
Tangerines - 16-17%

Lemons/limes - <10% (Brix not a factor for these fruits)

Acid; (measured by titration with NaOH (Phenolphthalein) indicator); decreases with maturation:

Oranges - 1.5 - 0.5%
Grapefruit - 2.0 - 1.0 %
Tangerines - 2.3 - 0.6%
Lemons/limes - 6.0%

Ratio; "sliding scale"; ratio can be lower for early season fruit; increases as season progresses. Minimum ratio is 8:1.

External quality: Blemishes caused by 1) wind scar, 2) melanose, 3) rust mites. An example:

US Fancy #1 = <10% blemishes, any cause.
US # 1 = <20% blemishes.
US # 1 bronze = <33% blemished by rust mite. [Florida only] US # 1 russet = <33% blemished by any cause. US # 2 = >33% blemished; culls in Florida.

B. Harvest Method. Citrus is hand harvested, whether processed or marketed fresh.Mechanical harvesters have been attempted but have not been successful to date. Tangerines and some fresh oranges must be clipped, not pulled from the tree, to prevent plugging the peel.

C. Handling and Packing. Citrus can be handled fairly roughly from tree to packinghousesince fruit are tough and resilient, with the exception of tangerines. Fruit are dumped from picking bags into 900 lb bulk bins, which are moved by forklift onto trucks.

For fresh fruit, packing line operations include (in order) dumping, culling, washing, brushing, waxing, drying, grading (human), sizing, and boxing.

For processed fruit, growers are paid for lbs-solids or sugar, based on analysis. Fruits are culled for rots and splits, then fruit is washed prior to crushing. Juice is separated from pulp, and pooled into lots of various colors and sugar levels; some mixing is done to produce uniform product. Juice is then evaporated to 44-48 EBrix for frozen concentrate, or canned as single-strength juice. The peels and rag are sold as livestock feed supplement.

D. Storage. Citrus is a non-climacteric fruit, and may be stored for fairly long periods at lowtemperatures. Chilling injury is common in grapefruit and other acid citrus when stored at 10-15 EC, and rare in oranges and mandarins at this temp. Brown pitting and

staining of the rind occur, sometimes with a watery breakdown of peel and pulp. Several pathogenic rots, including the common green mold (*Penicillium spp*.) can occur post-harvest.

A unique aspect of citrus is the ability to store fruit on the tree; since fruit are nonclimacteric, they ripen slowly, will not soften or abscise for periods up to several months, as with grapefruit in California. This allows growers to pick over an extended period of time, choosing prices at their highest. The danger of course is potential freeze damage, or loss due to diseases.

VIII. Contribution to diet, food uses.

Food Value Per 100 g of Edible Portion		
SWEET ORANGE		
	Juice	%RDA
Calories	44	1.6
Moisture	88 g	---
Protein	0.75 g	1.3
Fat	0.2 g	---
Carbohydrates	10.3 g	---
Fiber	0.1 g	---
Ash	0.4 g	---
Calcium	10 mg	1.2
Phosphorus	17 mg	2.1
Iron	0.25 mg	2.5
Sodium	1 mg	---
Potassium	199 mg	4.2
Vitamin A	200 I.U.	4
Thiamine	0.09 mg	6.4
Riboflavin	0.03 mg	1.9
Niacin	0.4 mg	2.2

Vitamin C	49 mg	109