Grades and Grade Lowering Defects of Citrus Fruits

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INTRODUCTION

There are no universal grade standards for citrus fruits, nor will there ever be any. Misunderstandings often arise when fruit from widely disparate growing areas are shipped to the same marketing area. What is a grade lowering defect in one district may be totally acceptable in another. What is a perfect No. 1 Grade fruit by one set of standards may be quite illegal on the basis of internal quality on the standards of another district. To cite the abstract from a paper at a recent International Citrus Symposium [1]

> "Abstract. Grades and quality standards for citrus are sharply conditioned by climate in the growing areas. All efforts to arrive at uniform international standards have failed. Such universal standards will never be achieved because climate overrides culture. In general, areas with Mediterranean-type climates (low rainfall, cool winters, high sunlight) tend to produce fruit with beautiful exteriors but modest internal quality. Subtropical areas (high rainfall, warm winter nights) tend to produce fruit

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[1] I will deposit with the Instituto Agronomico Mediterraneo de Zaragoza a loose-leaf notebook containing copies of many of the references cited here.

with poor color and much exterior blemish but excellent internal quality. Each area has developed standards which capitalize on its advantages and minimize its disadvantages to as great an extent as the market will allow. Production areas with Mediterranean-type climates have adopted standards emphasizing high color and freedom from external blemish while minimizing internal quality factors. Standards for subtropical growing areas necessarily minimize external grade factors while setting very high internal standards. Buyer reliance on appearance gives a real advantage to fruit from arid cool-night areas but subtropical areas have considerable advantages in both quality and yield of processed products. Since the U.S. citrus areas includes both extremes of climate, U.S. grades and standards are discussed in detail together with examples from other areas. The need for worldwide standardization of terminology and quality testing methods is emphasized" (Grierson and Ting 1978)

The same authors summarized (and simplified) the effects of climate on citrus fruit quality in the following figure.

(See Figure 10, p. 68)

A growing district with a comparatively arid climate and consistently low night temperatures will inevitable need to capitalize on the 'consumer appeal" of good external color. A consistently warm, humid district will seek to minimize color as a grade standard, while capitalizing on high juice yield and sugar content.

is well illustrated by the differences between grades and standards for California and Florida oranges. The federal U.S. Department of Agriculture sets different standards for external factors for fruit from the two states. The standard for U.S. No. 1 Grade for California oranges allows so little exterior blemish that only the most exceptional crop of Florida oranges could be packed under such a grade. But California state law stipulates a minimum ratio of sugar to acid[2] that would be illegal in Florida and relaxes that minimum level if the fruit is highly colored (California Food and Agricultural Code, 1975). Because of humid growing conditions and high winds soon after fruit set, U.S. No. 1 Grade for Florida oranges allows color and defects that would not be tolerated for California oranges. However, Florida state law (Wardowski _et al_. 1979) stipulates very high standards for juice content, for °Brix ("soluble solids" which approximates to suga content) and for ratio of °Brix to acid on a complicated scale related to °Brix and to the time of year. Even with such high (and rigidly enforced) internal standards Florida oranges usually sell for much less than the more handsome oranges from California

VARIETIES (CULTIVARS)

<u>Seedy, Seedless, Sparsely Seeded</u>

few citrus fruits are 100% seedless. It is exceedingly rare to find a seed in a 'Persian' 'Tahiti') lime or a navel orange. But

[2]Within Europe this ratio of °Brix, "soluble solids," etc. to percentage acid is commonly referred to as index of maturity

convention allows that most supposedly "seedless' varieties such as 'Valencia Late' orange or 'Marsh Seedless' grapefruit can have up to 5 or 6 seeds. In the course of correspondence relating to the 1974 revision of ISO standards for citrus fruits (ISO 1974), L. Ginsburg of South Africa proposed the use of the term "sparsely seeded" for such varieties. This would be most realistic.

Varietal Characteristics

Unlike such fruits as the apple (for which some experts can distinguish scores of varieties solely by external appearance) citrus varieties are often indistinguishable by external appearance alone, often being characterized by such factors as seediness, season of bearing, etc. Moreover, characteristics of a given variety can vary so widely with growing district as to be scarcely recognizable.

Hodgson (1967) lists 164 varieties of oranges and yet probably not more than 10 or 12 are of major importance in world marketing. In this lecture, therefore, I will cover only some of the principal varieties of citrus, with emphasis on those that I know best.

Oranges

'Valencia'- This is probably the most widely grown orange, especially in warmer climates where it is harvested in late spring to early summer, as in Florida. In California, it crops from early to late summer. Fruit is oblong to round, well colored at early maturity but with a strong tendency to regreen later. Seedless to sparsely seeded. Sugar content exceptionally high.

'Navel'- Characterized by a rudimentary second fruit (navel) embedded at the blossom end and almost perfect seedlessness. Medium size, approximately spherical. Color usually good. Flavor usually aromatic but less sweet than Valencia. Two major cultivars are 'Washington Navel' (particularly in California) and the 'Bahianinha' of Brazil.

'Shamouti'- The characteristic orange of the Eastern Mediterranean, particularly Israel. Fruit oval, short radial furrows at the stem end Skin thick, color good. Flavor fragrant to sweet.

'Hamlin'- A very early variety. Round to oblate, smooth thin skin. Very few seeds. Juicy, but tending to be so low in acid that it is often harvested well before optimum maturity. The main early orange of Florida and Brazil.

'Pineapple'- A mid-season variety that typically crops between 'Hamlin' and 'Valencia.' Thick rind, very seedy, round to obavate. Excellent color. Flavor good (someone supposedly thought it reminiscent of pineapples). Very subject to peel injury which limits carrying quality.

'Pera'- This Valencia-type variety is the major export orange from Brazil. Medium-size to small. Very few seeds. Medium-thin, lightly pebbled rind, pale orange in color. Late in season, ships well. It has been compared to the Spanish 'Berna.'

'Blood Oranges'- (Fr. Sanguine, Sp. Sanguigna, It. Sanguinella). These oranges have various varieties varying from those with lightly pigmented flesh to some (such as 'Sanguinella') that are deeply pigmented both inside and outside. The red to reddish-purple color is due to anthocyanin pigments instead of the carotenoid pigments common to citrus fruits. They are all Mediterranean varieties that most North American consumers have never seen.

Grapefruit

'Duncan'- This old, whitefleshed Florida variety is the highest quality grapefruit of all. However, it is disappearing from the fresh fruit trade because of its many seeds. It has excellent keeping quality, excellent flavor and unusually high Vitamin C content. Because of mixed budwood used in propagation of older grapefruit groves, it occasionally turns up in supposedly seedless shipments.

'White Marsh Seedless'- The first of the seedless grapefruit Shape and appearance vary widely with time of bloom and the rootstock used. Fruit from an early bloom on trees on Sour Orange rootstock can be very flat (oblate) in shape and very thin skinned. Seeds are usually

than five. Because of high heat requirements, this variety (and the red fleshed grapefruit also) are largely limited to growing areas with warm winters

Red-fleshed grapefruit. Since the first pink-fleshed mutation appeared in Florida in 1907, there have been a series pf selections

increasingly deep flesh color. Quality is never as good as 'Duncan', but the public will pay consistently higher prices for a combination of seedlessness and red flesh color. 'Ruby Red' has been largely planted in Texas and is now increasingly planted in Florida. As the season progresses (and grapefruit can have an eight-month harvesting season) the flesh color tends to fade from deep red to a very pale pink. Because of this, several varieties such as 'Burgundy' and 'Star Ruby have been selected for persistence of flesh color.

Tangerines and Hybrids

'Clementine'- The most important early mandarin-type of the Mediterranean area but little known elsewhere. It is small to medium size, good orange color, slightly pebbled skin. Flavor sweet, sub-acid and aromatic. Shape oblate, sometimes slightly necked at the stem end. Seedless when grown in the absence of pollinator varieties but can be seedy if grown in mixed blocks. (This is true of many of these specialty varieties.)

'Dancy'- The standard Florida tangerine. Fruit is medium size, oblate ahape but often strongly necked. Skin smooth but tends to puff when past optimum maturity. Color deep red-orange. Seedy with open core. Flavor rich but tending to high acid

'Temple'- A reputed tangor (tangerine x orange). Fruit large, flattened at the blossom end. Color deep orange. Seedy. Flavor very aromatic, high in both acid and sugar. For best quality, it is limited to warmer areas such as Florida

'Ortanique'- Another "reputed tangor" from Jamaica. Fruit large.

thin. Color yellowish orange. Seedy. Flavor excellent. Properly handled it has good shipping quality.

'Ellendale'- This Australian mandarin is remarkable for its excel-

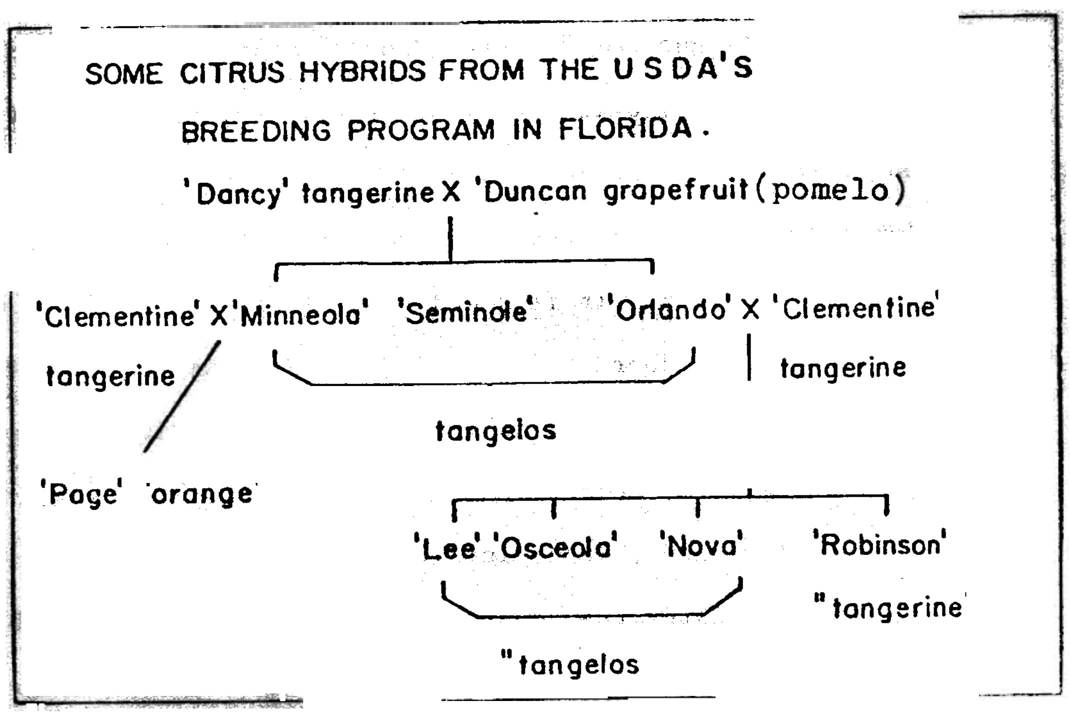
shipping quality. It is a medium to large fruit. Good orange color. Rind thin, adhering but peelable. Seedless to seedy depending on whether grown adjacent to pollinators. Flesh bright orange color, juicy, pleasantly sub-acid.

'Murcott'- ('Honey Tangerine'). Another reputed tangor (from Florida). It is later than most mandarin-types. Shape is oblate, rind color a poor yellowish orange, very subject to wind scarring. Flesh color deep orange. Moderately seedy. Despite its poor color, this variety is gaining in popularity because of its high sugar content (usually so high they will sink in water).

'Minneola'- A tangelo (= tangerine x grapefruit; from "pomelo", the old name for grapefruit). Deep reddish-orange color, few seeds, excellent flavor. This is a very short season fruit with an unfortunate shape. A very pronounced "neck" at the stem-end makes it very susceptible to mechanical damage and so difficult to ship.

'Orlando'- Another tangelo, earlier than "minneola' with a flattish (oblate) to round shape making it much easier to handle. Light orange color. Thin rind, few seeds. Flavor light, but pleasant

Other mandarin-type hybrids. There are many of these intentional hybrids such as 'Robinson' and 'Nova' from Florida; 'Kinnow' and 'Wilking' from California; and natural hybrids such as the 'Ugli' from Jamaica. Most need to be handled with extreme care if they are to move in international commerce.



Lemons

will attempt no more than to distinguish between the true lemons (Citrus limon (L) Burm.f) such as 'Lisbon,' 'Eureka,' 'Bearss, 'Villafranca' and 'Berna', and the 'Meyer' lemon which is a prolificly bearing hybrid of unknown parentage from China. The last's juice is practically indistinguishable from juice of true lemons. However, the peel oil has a quite different flavor, thereby limiting its usefulness

Limes

'Tahiti' or 'Persian' limes (Citrus latifolia Tan.). The origin of these limes was certainly neither Tahiti nor Persia! They are large-fruited, green in color, almost perfectly seedless, very juicy, but extremely vulnerable to "Stylar End Breakdown, a form of handling damage for which see below. Very susceptible to chilling injury if handled below 10°C.

'West Indian,' Mexican' or 'Key' limes (Citrus aurantifolia Swing.). This is the typical lime of the Caribbean area. Fruit are much smaller than the 'Tahiti' lime. Seedy and tend to turn yellow with advancing maturity. Juice and oil are indistinguishable from the 'Tahiti' type. They are very much easier to ship and store, being less vulnerable to both chilling injury and handling damage.

NON-PARASITIC DEFECTS ORIGINATING IN THE GROVE (ORCHARD)

Nutritional

Nitrogen deficiency. This does not show as a symptom on the fruit— except that fruit is very small and not much of it.

Copper deficiency (so-called "ammoniation"). Horrid dark brown pustules on the peel. The name "ammoniation" came from the fact that increasing nitrogen in the absence of adequate copper brought out this defect.

Baron deficiency. Gummy deposits within thick lumps in the peel Symptoms are identical with those of arsenic toxicity. (Arsenic is used as a post-bloom spray to decrease acidity of grapefruit).

Magnesium deficiency. This causes characteristic leaf symptoms. On the fruit an abnormally early disappearance of green color is the only symptom and that is really only distinguishable on the tree.

Potassium deficiency. On most varieties this affects the fruit only in terms of having a very thin smooth peel and abnormally advanced color development. When coarse, thick peels are a problem, growers sometimes drastically cut back on potassium, which can get them into trouble with peel pitting, particularly with the 'Pineapple' variety of orange (Grierson 1965).

Phosphorus deficiency. Phosphorus deficiency, which is uncommon in most citrus areas, causes abnormally thick skins and hollow cores in varieties in which this is not usual. It is almost impossible to detect in the market place since various other conditions can cause such symptoms

Creasing is characterized by narrow sunken furrows in the rind of oranges and 'Temples under which the albedo (white portion of the peel) is entirely or partially absent. It seems to be in some way related to nutrition, particularly the balance between nitrogen and potassium but no clear cut control has ever been demonstrated. In susceptible crops, it tends to get worse with increasing maturity. "Creased" fruit are very subject to mechanical damage, the creases tending to split open under modest mechanical pressure.

Spray Burns

No detailed dissertation is possible since spray materials are constantly changing and any possible injuries vary sharply with variety and climate. Some characteristic injuries seem worth describing.

"DN" injury used to be quite common when the dinitro compounds were used for mite control at grove temperatures above 30°C. The injury took the form of discrete, sharply defined sunken lesions. In Florida we have long been using chlorobenzilate instead of "DN" and experienced no injury But the U.S. Environmental Protection Agency is considering banning chlorobenzilate (and almost everything else!).

Oil blotch can occur on oranges, 'Temples,' and tangerines if are sprayed with a mix containing oil when they are between 2 and 4 cm in diameter. Once larger than that, the hazard passes. Oil blotch lesions are irregular in shape, pale brown and corky in texture.

Star melanose is a form of copper injury. f very small melanose lesions (ca. 1 mm) are already present, a copper spray can cause them to develop into angular "stars" that are corky in texture

Sulphur burn can occur on the side of the fruit exposed to the when sulphur containing sprays are used in very hot weather. The lesion is dark brown, irregular, raised, but that side of the fruit may flatten as the fruit grows.

Weather

Freeze injury. Citrus fruit can be frozen on the tree and apparently survive. If the injury is drastic enough to cause the fruit to evolve considerable amounts of ethylene, a standard stress symptom, the fruit will fall. Otherwise it persists and looks deceptively sound. Intact membranes are essential if a fruit is to shrivel. Freeze damage ruptures membranes and so freeze damaged fruit never shrivel. The standard symptom is a drying out of the flesh, characteristically at the stem end (Wardowski and Grierson 1972). In the introduction I mentioned that internal standards tend to be low when external appearance is good. Freeze damage is an excellent example. For California standards (California Food and Agricultural Code, 1975) for No. 1 Grade, freeze damage is judged on a center cut on which 20% of the area exposed can show drying. Florida's

No. 1 Grade allows no more than a total volume equal to a quarter-inch (6.35 mm) slice off the top of the flesh of the fruit. What standards for freeze damage are elsewhere I do not know, but these possibly illustrate the extremes possible.

Windscar. This injury usually occurs in the first four to six weeks after fruit set. In some areas of Florida, South Africa, Australia and elsewhere, strong winds in this period can brush the small (5 to 10 mm) fruit against adjacent leaves causing tiny lesions that expand as the fruit grows. Since such lesions occur before the wax and cutin layer over the peel is developed, in humid growing districts they often become infected with melanose and, sometimes, scab.

Hail. Hail can cause injuries on growing fruit that would inevitably result in decay of harvested fruit. Such lesions result in healed characteristic scars.

Zebra skin of tangerines (in which the peel over each segment turns black) is caused by a sudden reversal of drought stress. If tangerine trees are allowed to get too dry and then are watered by rain or irrigation, within about three days the peel cells can become so turgid that the fruit cannot be handled. It can be avoided by delaying picking for about one week. (Grierson *et al.* 1965)

Physiological

Rind staining of navels. When navel oranges are held on the tree until very mature, the cuticular wax becomes very soft and routine handling can result in ugly brown stains. In California this is now routinely prevented by the use of gibberellin sprays to delay peel senescence.

Stem-end rind breakdown. With susceptible fruit, this is caused by drying conditions between picking and waxing but shows up several days after packing. Susceptibility is apparently determined by nutrition since it is usually most pronounced when nitrogen fertilization is high and potassium low, but there are undoubtedly other factors involved (Grierson 1965). This does not seem to be a problem in very arid growing areas

Sloughing. A peculiarity of red-fleshed grapefruit. If picked too early, the peel may collapse in an unpleasant soft brown condition that will slough off when handled (Grierson and Patrick, 1956). Once a problem in Florida, it has been virtually eliminated by raising juice requirement for early grapefruit (Wardowski *et al.* 1979) thus eliminating picking in the brief susceptible period at the beginning of the season

Chimeras. Many types of fruits (particularly apples and citrus) exhibit sectional mutations in which one segment of the fruit is markedly different. This is particularly striking in citrus fruits which may show a segment that is markedly different; an orange segment on a yellow fruit, a section immune to such blemishes as rust mite, etc Usually these are eliminated at the grade table but those that slip through sometimes alarm consumers unnecessarily. This is just one of nature's many oddities

PARASITIC DEFECTS ORIGINATING IN THE GROVE (ORCHARD)

Insects & mites

Rustmites. (*Phyllocoptruta oleivora* Ashmead). This tiny (ca. 0.08 mm) but industrious mite, may need to puncture a single epidermal cell 20 times to destroy it. But when enough rust mites have punctured enough epidermal cells, the fruit can finish up somewhere between brown and purple with a russetted surface. Since rust mites avoid direct sunlight fruit outside the leafy canopy will characteristically have an undamaged area that had been exposed to direct sunlight.

Mealybug (Planococcus citri Risso). The mealy bug itself is not apt to persist on the fruit, but it is a copious producer of "honeydew" with subsequent sooty mold.

Purple scale (Lepidosaphes beckii Newm). Often persistent on the fruit. Purple to dark brown. About 2 mm long.

Red scale (Chrysomphalus aonidum L.). Often persistent on the fruit. Circular about 2 mm diameter. Dark outer edge with paler red center. Tends to cause persistence of green [just the reverse, degreened spots] in the peel.

Chaff scale (Parlotoria pergandii Comst.). Small, almost transparent and often missed during the growing period. Causes very pronounced persistent green color in the peel, even long after scales have been killed or washed off.

Fruit flies. The most widely feared is the Mediterranean fruit fly (Ceratitis capitata Wied.) but there are others such as the Caribbean fruit fly (Anastrepha suspense Loew) and the Mexican fruit fly (Anastrepha ludens Loew). For all of them the female oviposits in the fruit and the eggs hatch into larvae (wrigglers) that grow in the flesh of the fruit. Such fruit inevitably rot. Larvae crawl out of the fruit when ready to pupate.

Leprosis ("nail head rust") looks like a fungus disease. Round discrete lesions ("nail heads") disfigure the fruit and tend to be surrounded by a pale yellow "halo." It is caused by either of two species of false spidermite; Brevipalpus australis Tucker in South America and Tenuipalpus pseudocuneatus Blanchard in North America. (I have not heard of it elsewhere). It is fortunately uncommon being easily controlled with grove sprays of various forms of sulphur. If the current fad for "organic" cultural methods continues, it may well again become important.

FUNGI

Fungi Causing Surface Blemishes

Sooty mold (Capnodium citri Berk. & Desm.). This is purely epiphytic, growing in the exudate of certain insects such as white flies and mealy bugs. Sooty mold washes easily off smooth textured fruit but can be

'Dancy' tangerines.

Sooty blotch (Gloeodes pomigena (Schw.) Colby) is not as dark nor as abundant as sooty mold. But it does not need insect exudate to grow in and the fungus mycelium penetrates between the wax platelets of the :uticle making it very much more difficult to wash off. t will bleach with chlorine, but it is far better to control it in the grove.

varying from pinpoint lesions to great "mud cake" or "tear stain" areas. The same fungus causes one form of stem-end rot.

Anthracnose (Colletotrichum gloeosporioides Penz. is a weak pathogen that usually causes skin lesions or sometimes a fruit rot of over-mature or otherwise weakened fruit. It is, however, the primary decay organism of the newly released 'Robinson' hybrid tangerine and so should be watched for with other new hybrids. On such varieties it causes initial ilvery areas, typically at the stem end. These soon darken and develop

Elsinoe Fawcettii Bit. & Jenk.) causes raised whitish "[illegible] on peel of susceptible varieties such as grapefruit, lemons, 'Temple' and sour orange. Sweet orange is very resistant, as are some minor types of citrus such as citron, Key lime, etc.

Pitting of grapefruit, small scattered pits on the peel that are not usually apparent until the fruit degreens. This has fairly recently been to be another manifestation of the "Greasy Spot" fungus Mycosphaerella citri. Characteristic persistent green rings are usual around the small peel lesions.

Fungi Causing Fruit Rots

Green mold (Penicillium digitatum Sacc.) is the most ubiquitous of all citrus decay organisms. The airborne spores have to enter through a wound of some kind. Sporulation on a decayed fruit can be so heavy as to cause 'soilage" of the rest of the fruit in the same container. It s not a "nesting" fungus.

Blue mold (Penicillium italicum Wehmer) is a curiously localized mold being, for example, troublesome in some Mediterranean areas and ir California, but rare in Florida. It is a "nesting" type fungus. i.e. enzymes from a rotting fruit can dissolve the cuticle of an adjacent fruit thereby spreading the mold from fruit to fruit even when there is no prior peel lesion

Stem-end rot is caused by either of two major pathogens, Phomopsis citri Faw. that also causes melanose and Diplodia natalensis Pole-Evans which causes one form of root rot. Both these rots are transmitted by water-borne spores which typically are transmitted to the very small developing fruit in the several weeks after petal fall and germinate to form a mat of latent mycelium under the button (calyx). Because of the manner of transmission, these stem-end rots are unusual in arid growing

The Diplodia form is sharply stimulated by ethylene degreening which is one reason why Florida degreening recommendations stipulate the use of no more than 5 parts per million (ppm) of ethylene. Note that in some districts Alternaria rot is also referred to as "stem-end rot."

Alternaria rot ("Black rot," Alternaria citri Ellis & Pierce) is primarily a storage rot. The fungus is widely disseminated in most citrus growing regions. Occasionally,it infects fruits while on the tree in which case it enters through the stylar end, either at the navel of navel oranges or through a microscopic opening left when the fruit sheds the style (stalk-like portion between the stigma and the ovary) without complete closing of the wound. This form of "Black rot" is almost entirely limited to early orange varieties. Mercifully, Alternaria being a strong ethylene former, the fruit usually develop brilliant

and fall before they can be picked. Commercially, "Black rot" is much more of a problem on storage fruit. In this form it normally enters through the stem end and takes 8 to 12 weeks to develop. It is particu-

troublesome on lemons that are picked in the winter months and stored

the hot weather when lemons are in greatest demand and on 'Valencia' oranges stored at the end of the season for out-of-season sale. One of the first indications of "Black rot" is the presence of occasional brilliantly colored fruit, another manifestation of the production of endogenous ethylene.

Sour rot (Geotrichum candidum (Lk.) Carmichael). This slow-developing, rather inconspicuous decay is becoming of increasing importance in world-wide commerce. First because it is a soil-borne organism and as fruit picking degenerates in almost all districts, more and more fruit come in contact with the ground or with dirty picking containers. The second problem is that Sour rot is almost totally immune to any legally acceptable fungicides

Brown rot (Phytophthora citrophthora (Sm. & Sm.) Leonian and P. parasitica Dastur). Both species of Phytophthora are usually more troublesome due to causing severe forms of root rots of citrus trees than as postharvest decays. These are soil-borne organisms that are occasionally severe on fruit borne near the ground when heavy rains have splashed soil onto the "skirts" of the tree. (A fairly recent severe case in Florida was traced to over-head irrigation with water from a drainage ditch). The decay looks somewhat like Phomopsis or Diplodia stem-end rot but does not necessarily originate at the stem-end, is firmer in texture and has a distinctive odor

Bacteria

Canker. There is only one bacterial disease that could be considered of importance on citrus fruits, but it is the most feared citrus disease of all, canker (Xanthomonas citri Hasse). It is classically the threat from Japan since it is endemic there and, under their climatological conditions, the types of citrus that they grow there (Unshiu "oranges really more a mandarin type, Natsudaidai, etc.) are tolerant of this bacterium. Sweet oranges (Citrus sinensis (L) Osbeck) are susceptible and grapefruit (C. paradisi Macf.) are so susceptible that the trees can be destroyed in two or three seasons. There are almost always outbreaks in South America and so infected fruit might appear from that area. A fruit can be affected without visible lesions. But severely infected ruit will have small (2-4 mm) raised corky pustules, brown in color with typical craters in the center of each one. Any appearance of canker in a citrus growing district is cause for alarm

HARVESTING RELATED PROBLEMS

Immaturity

Maturity rules vary widely from area to area and in some citrus growing areas are practically non-existent. Fruit should be, at least, palatable at time of picking. Citrus fruits, being non-climacteric, do not improve in quality after picking. (Lemons are an interesting exception since they get juicier, thinner skinned and develop an attractive "characteristic yellow color while curing in storage).

Oleocellosis

The name means literally "killing cells with oil" which is a fair description. The contents of the oil cells within the peel are toxic to the surrounding tissue. When turgid (as in early morning picking) the oil cells are very prominent, and easily broken. The oil is then extruded kills the surrounding epidermal tissue which sinks, darkens and becomes susceptible to invasion by fungi. Probably most of the fruit that decay n commercial marketing do so because, at the moment of leaving the tree, a careless picker broke oil cells causing oleocellosis. Lemons and navel oranges are particularly susceptible to oleocellosis

Blossom-end Clearing

This is a peculiarity of heavy, thin-skinned seedless grapefruit If dropped on their blossom ends, internal cells can be ruptured in a cone-shaped area around the blossom end. These tissues become water-logged and decay soon follows. Although often denied, this is purely a problem of rough harvesting.

Stylar-end Breakdown of Limes

This is another often-proclaimed "mystery." It has long since ceased to be a mystery (Grierson *et al.* 1971, Davenport and Campbell, 1977). f a 'Tahiti' lime is handled roughly enough to break an internal juice vesicle, the juice released is toxic to the albedo cells and from there on this "mysterious" disease progresses. The larger sizes tend to be particularly vulnerable.

Stem-end Rind Breakdown (S.E.R.B.

This was mentioned above under "physiological problems." It is also a harvesting problem. Even susceptible oranges will not develop S.E.R.B if they are protected from sun and wind, handled without delay, and kept under humid conditions between picking and waxing.

Mechanical Injury

A cut or deep scratch is obviously a mechanical injury, but it is amazing how many minor mechanical injuries are persistently regarded as "mysteries. Tiny scratches no deeper than the flavedo (the colored layer of the peel), sand scratches, etc. can heal if not allowed to dry out and often develop a conspicuous reddish color (Ismail and Brown, 1975).

PACKINGHOUSE, STORAGE & TRANSIT

Surprisingly little damage is usually done on the packinghouse machinery. Most of what is blamed on packinghouse handling has usually been initiated in the harvesting operation.

"Ethylene burn"

There isn't any such thing! Peel lesions appearing after ethylene degreening can inevitably be traced to poor handling at harvest and/or too low humidity during degreening. (Most of our Florida degreening rooms now have electronic humidity control systems to hold humidity at 95-98%). Twenty-seven years ago I published a paper relating a peel injury of ples' to the concentration of ethylene used in degreening. Very much later it was found that no such effect occurred if humidity is held at the levels now routinely used in Florida.

Brush Burn

Excessive polishing of fruit results in only temporary improvement in appearance and can result in disastrous peel injury of tender mandarins, navel oranges, etc

Fruit Distortion

Next to sloppy picking, there is probably more postharvest damage blameable on fruit buyers than on anything else. The constant demand for "a good full pack" results in too much fruit being forced into the container. Such fruit distorts during transit during the course of which cells broken during the process of distortion dry out. resulting in hollow spaces within the fruit. A very interesting study with Florida grapefruit showed that the degree of care during picking was sharply correlated with the later resistance of the fruit to such distortion. Six degrees of care were used (from very gentle to very rough), six times throughout the season. With each increase in roughness of handling the later resistance of the fruit to mechanical distortion decreased (Riverc et al. 1979).

Chilling Injury

The susceptibility to chilling injury varies with species, growing district and even time of year. In general, limes are extremely susceptible to peel injury if shipped or stored at or below 10°C. Grapefruit vary in susceptibility according to time of year, growth status of the tree at time of picking and time between picking and cold storage. (For Florida grapefruit, we have found that grapefruit that have been allowed to lose about 2.5 to 3% of their weight prior to cold storage are curiously resistant to chilling injury). When grapefruit are in a susceptible condition, the use of the fungicide diphenyl increases the susceptibility to chilling injury. Lemons are particularly susceptible when still green (as they usually are at picking).

Fungicide Burn

The fungicide sodium o-phenylphenol (SOPP, Dowicide A, Dow-hex) must be used within rather narrow pH limits, (11.5-12.0). (McCornack et al 1979). If the pH is allowed to drop, a bright red peel injury may result

EDB "Burn"

Citrus districts with fruit fly infestations are often required to fumigate fruit to be shipped to certain districts. The common fumigant is ethylene dibromide (EDB). If fruit is fumigated and then promptly washed, waxed and packed, injury very seldom results. When packed fruit is fumigated, a reddish-brown peel injury may result. This almost always results after the actual fumigation and is attributable to EDB that lingers in the packaging material (particularly corrugated fibreboard). At the end of the fumigation period the chamber should be blown out and then the fruit promptly removed to as well ventilated conditions as possible.

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Table 7 Total soluble solids, total acid, solids-acid ratio and juice content of individual Duncan grapefruit (Long et al.

Fruit Size	1955[a] Average	1955[a] Range	1957[b] Average	1957[b] Range
		Total soluble solids (%)		
96	11.4	8.2-14.9	11.5	8.6-14.7
80	11.6	8.2-14.2	11.4	8.7-13.9
70	11.4	8.6-14.8	11.1	8.4-13.2
64	11.1	8.7-14.4	10.9	8.5-13.5
54	10.9	8.2-13.9	10.2	8.1-13.0
46	10.7	8.3-13.4	10.5	8.5-13.2
		Total acid (%)		
96	1.11	0.47-2.09	1.18	0.67-1.75
80	1.10	.48-2.16	1.17	.80-1.60
70	1.03	.41-1.88	1.20	.71-1.91
64	.99	.49-1.97	1.19	.67-1.55
54	.80	.36-1.74	1.11	.79-1.48
46	.85	.40-1.65	1.12	.69-1.44
		Solids:acid ratio		
96	11.3	6.0-22.1	9.8	7.3-13.5
80	11.3	6.0-20.4	9.7	6.3-13.2
70	12.0	6.6-24.2	9.2	4.8-13.1
64	12.3	6.8-21.2	9.2	6.6-13.2
54	13.1	6.7-25.2	9.3	7.2-11.6
46	13.8	7.1-26.4	9.3	7.0-14.1
		Juice content (ml per fruit)		
96	214	139-288	225	163-330
80	234	154-311	241	186-316
70	261	180-352	267	218-374
64	288	214-386	308	229-395
54	325	184-426	346	254-524
46	376	254-534	425	302-588

[a] Averages of 150 fruit.

[b] Averages of 50 fruit

Table 8 . Total soluble solids, total acid, solids-acid ratio and juice content of individual Marsh grapefruit 1953-54, 1954-55, 1956-57 and 1957-58 (Long et al. 1959).

Fruit size	Fall harvest[a]		Spring harvest[b]	
	Average	Range	Average	Range
		Total soluble solids (%)		
96	9.6	7.7-11.7	10.0	7.1-12.7
80	9.5	7.7-12.2	9.8	6.8-12.9
70	9.5	7.2-11.5	9.7	6.6-15.1
64	9.3	7.8-11.5	9.7	6.7-13.6
54	9.2	7.6-11.2	9.4	6.0-13.1
46	8.9	7.3-10.9	9.3	6.0-13.1
		Total acid (%)		
96	1.21	0.64-1.76	1.04	0.58-1.89
80	1.19	.69-1.61	1.02	.51-1.72
70	1.20	.74-1.66	.97	.45-1.72
64	1.15	.75-1.63	.98	.49-1.74
54	1.12	.67-1.60	.93	.45-1.60
46	1.07	.66-1.62	.90	.33-1.51
		Solids:acid ratio		
96	7.9	5.9-13.4	9.6	6.0-16.2
80	8.0	5.9-12.5	9.6	6.3-18.9
70	7.9	6.0-12.4	10.0	6.8-21.0
64	8.1	6.2-11.2	9.9	6.1-20.9
54	8.2	5.9-12.4	10.1	5.8-20.6
46	8.3	6.0-11.7	10.3	7.0-25.7
		Juice (ml per fruit)		
	1954-55	1956-57		1957-58
	March-May	October	Mar.-May	Sept., Oct.
96	227	175	215	200
80	259	196	241	226
70	280	212	262	246
64	294	235	288	271
54	342	251	321	299
46	385	291	357	340

[a] 10 samples
[b] 16 samples

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Fruit Characters (cont.)

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