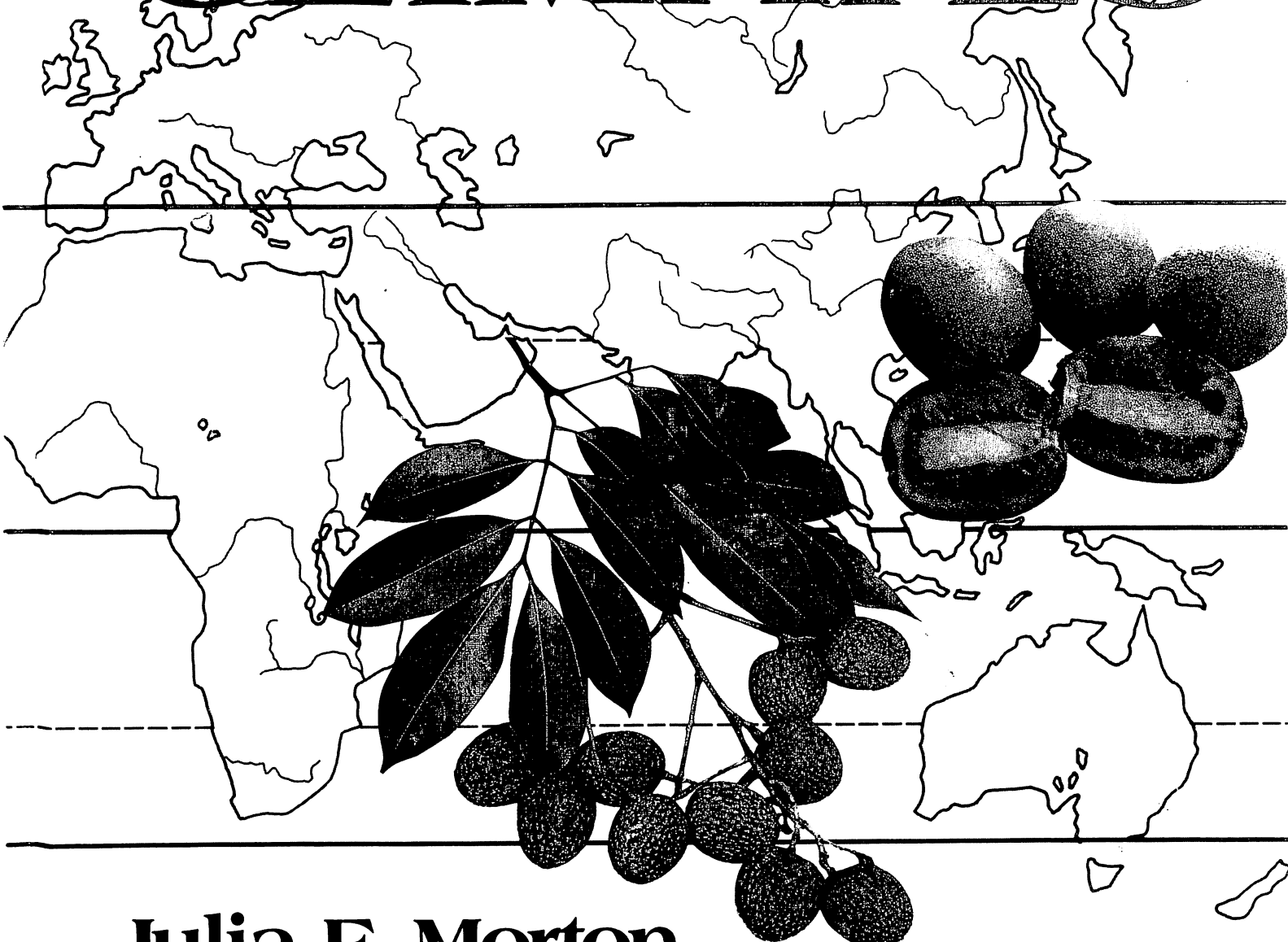


FRUITS OF WARM CLIMATES



Julia F. Morton

Grapefruit (Plate XVIII)

A relative newcomer to the citrus clan, the grapefruit was originally believed to be a spontaneous sport of the pummelo (q.v.). James MacFayden, in his *Flora of Jamaica*, in 1837, separated the grapefruit from the pummelo, giving it the botanical name, *Citrus paradisi* Macf. About 1948, citrus specialists began to suggest that the grapefruit was not a sport of the pummelo but an accidental hybrid between the pummelo and the orange. The botanical name has been altered to reflect this view, and it is now generally accepted as *Citrus X paradisi*.

When this new fruit was adopted into cultivation and the name grapefruit came into general circulation, American horticulturists viewed that title as so inappropriate that they endeavored to have it dropped in favor of "pomelo". However, it was difficult to avoid confusion with the pummelo, and the name grapefruit prevailed, and is in international use except in Spanish-speaking areas where the fruit is called *toronja*. In 1962, Florida Citrus Mutual proposed changing the name to something more appealing to consumers in order to stimulate greater sales. There were so many protests from the public against a name change that the idea was abandoned.

Description

The grapefruit tree reaches 15 to 20 ft (4.5-6 m) or even 45 ft (13.7 m) with age, has a rounded top of spreading branches; the trunk may exceed 6 in (15 cm) in diameter; that of a very old tree actually attained nearly 8 ft (2.4 m) in circumference. The twigs normally bear short, supple thorns. The evergreen leaves are ovate, 3 to 6 in (7.5-15 cm) long, and 1 3/4 to 3 in (4.5-7.5 cm) wide; dark-green above, lighter beneath, with minute, rounded teeth on the margins, and dotted with tiny oil glands; the petiole has broad, oblanceolate or obovate wings. The white, 4-petaled flowers, are 1 3/4 to 2 in (4.5-5 cm) across and borne singly or in clusters in the leaf axils. The fruit is nearly round or oblate to slightly pear-shaped, 4 to 6 in (10-15 cm) wide with smooth, finely dotted peel, up to 3/8 in (1 cm) thick, pale-lemon, sometimes blushed with pink, and aromatic outwardly; white, spongy and bitter inside. The center may be solid or semi-hollow. The pale-yellow, nearly whitish, or pink, or even deep-red pulp is in 11 to 14 segments with thin, membranous, somewhat bitter walls; very juicy, acid to sweet-acid in flavor when fully ripe. While some fruits are seedless or nearly so, there may be up to 90 white, elliptical, pointed seeds about 1/2 in (1.25 cm) in length. Unlike those of the pummelo, grapefruit seeds are usually polyembryonic. The number of fruits in a cluster varies greatly; a dozen is unusual but there have been as many as 20.

Origin and Distribution

The grapefruit was first described in 1750 by Griffith Hughes who called it the "forbidden fruit" of Barbados. In 1789, Patrick Browne reported it as growing in most parts of Jamaica and he referred to it as "forbidden fruit" or "smaller shaddock". In 1814, John Lunan, in *Hortus Jamaicensis*, mentions the "grapefruit" as a variety of the shaddock, but not as large; and, again, as "forbidden fruit", "a variety of the shaddock, but the fruit is much smaller, having a thin, tough, smooth, pale yellow rind". In 1824, DeTussac mentions the "forbidden fruit or smaller shaddock" of Jamaica as a variety of shaddock the size of an orange and borne in bunches. William C. Cooper, a citrus scientist (USDA, ARS, Orlando, Florida, to 1975), traveled widely observing all kinds of citrus fruits. In his book, *In Search of the Golden Apple*, he tells of the sweet orange and the grapefruit growing wild on several West Indian islands. He cites especially a fruit similar to grapefruit that is called *chadique* growing wild on the mountains of Haiti and marketed in Port-au-Prince. The leaves are like those of the grapefruit. He says that it was from the nearby Bahama Islands in 1823 that Count Odette Phillipe took grapefruit seeds to Safety Harbor near Tampa, Florida. When the seedlings fruited, their seeds were distributed around the neighborhood.

At first, the tree was grown only as a novelty in Florida and the fruit was little utilized. Even in Jamaica, the trees were often cut down. Mrs. Mary McDonald Carter of Eustis, Florida, was quoted in the *Farm and Livestock Record*, Jacksonville, in 1953, as relating that her father, John A. MacDonald, settled in Orange County in 1866. In 1870, he was attracted to a single grapefruit tree with clusters of lemon-colored fruits on the Drawdy property at Blackwater. He bought the entire crop of fruits, planted the seeds and established the first grapefruit nursery. The first grapefruit grove planted from this nursery by a man named Hill was sold in 1875 to George W. Bowen who developed it commercially. In 1881, MacDonald bought the Drawdy crop and once more raised seedlings for his nursery in Eustis. Early settlers began planting the tree and acquired a taste for the fruit. There was already a small demand in the North. New York imported 78,000 fruits from the West Indies in 1874. Florida started sending small shipments to markets in New York and Philadelphia between 1880 and 1885.

In 1898, Dr. David Fairchild was excited to learn of a grove of 2,000 grapefruit trees in the Kendall area south of Miami on the property of the Florida East Coast Railway. In 1904, he was amazed to see one tree in the door-

yard of the Kennedy ranch in southern Texas where he thought the climate too cold for it. He was told that the tree had been frozen to the ground but had recovered. He predicted that a citrus industry could not be established in that region of the country. In 1928, he photographed the same tree, which had been killed back several times in the interim, but was again in fruit. By 1910, grapefruit had become an important commercial crop in the Rio Grande Valley and, to a lesser extent, in Arizona and desert valleys of California. By 1940, the United States was exporting close to 11,000,000 cases of grapefruit juice and nearly one-half million cases of canned sections. Cultivation had reached commercial proportions in Jamaica and Trinidad and spread to Brazil, South America and Israel. In 1945/46, the United States (mainly Florida) produced a record of 2,285,000 tons of grapefruit. In 1967/68, this country accounted for 70% of the world crop despite a great decline in Texas production because of severe weather. Grapefruit was moving forward by leaps and bounds. Israel, in 1967, supplied only 11% of the world crop but, by 1970, her production had increased by 300%. In 1980, Florida exported just under 10 million boxes, making grapefruit this state's most valuable export crop. Japan is the main importer and has, at times, suspended shipments to determine the safety of fungicide residues or because of discovery of larvae of the Caribbean fruit fly. Great care is taken to maintain this important trade. Other countries which had entered the grapefruit industry were Mexico, Argentina, Cyprus, Morocco and some areas of South America which raise grapefruit for local markets. In Central America, the grapefruit is not much favored because of its acidity.

In the late 1960's and early 1970's, Mexico was rapidly expanding its grapefruit plantings, especially in the states of Tamaulipas and Veracruz, to save its citrus industry in view of the decline in market value of oranges and tangerines brought on by over-production. Furthermore, there were great advantages in the lower costs of producing grapefruit without irrigation and with good biological control of pests. Now Mexico exports large quantities of grapefruit to the United States and lesser amounts to Canada and Japan. Puerto Rico formerly exported grapefruit to the United States but is no longer able to compete in the trade and has only remnants of former plantations. Cuba has planted 370,000 acres (150,000 ha) of citrus, mostly grapefruit with expectations of exporting to the Soviet Union and eastern European countries. The grapefruit is grown only in a small way in the Orient where the pummelo is cultivated. In recent years, the grapefruit has become established in India in hot regions where the sweet orange and the mandarin are prone to sunburn.

Varieties

Named varieties of grapefruit appeared in the official list of the American Pomological Society in 1897, but pioneers had selected and named favorite clones for several years before that time. The following are among the most noteworthy of old and new cultivars:

'Duncan'—the original trees were virtually identical seedlings that grew in a grove owned by a man named Snedcor

near Safety Harbor, Florida. Propagation was first undertaken by A. L. Duncan of Dunedin in 1892. The fruit is round or slightly obovate; large, 3½ to 5 in (9–12.5 cm) wide; peel is very light yellow (usually called "white"), with large oil glands, medium-thick, highly aromatic; pulp is buff, in 12–14 segments with medium-tender membranous walls, very juicy, of fine flavor; seeds medium-large, 30–50. Early to mid-season. Tree is unusually cold-hardy. This was the leading cultivar for many years in Florida and Texas and was introduced into all the grapefruit-growing areas of the world. Today, in the United States, it has largely given way to cultivars with fewer seeds, but it is being grown commercially in India. Recent seed irradiation experiments have shown that a high percentage of seedless mutants results from exposure to 20–25 krad.

'Foster' ('Foster Pink Flesh')—Originated as a branch sport of a selection called 'Walters' in the Atwood Grove near Ellenton, Florida, discovered by M. B. Foster of Manatee in 1906, and propagated for sale by the Royal Palm Nurseries. Fruit is oblate to round; medium-large, averaging 3¾ in (9.5 cm) in width; peel light-yellow blushed with pink, smooth but with large, conspicuous oil glands; albedo pink; pulp light-buff, pinkish near the center; in 13 or 14 segments with pinkish walls, tender, juicy, of good quality despite seeds, up to 50 or even more, of medium size. Medium-early in season. Not very popular; grown to a limited extent in Florida, Texas, Arizona and India. In Texas, it is more colorful, the pulp being entirely pinkish in hue.

'Marsh' ('Marsh Seedless')—one of 3 seedling trees on the property of a Mrs. Rushing near Lakeland, Florida, purchased by William Hancock in 1862. Because the fruits of this tree were seedless, C. M. Marsh took budwood from it for nursery propagation and he bought young trees previously budded by others. He sold the budded offspring and, in time, the 'Marsh' was planted more than any other cultivar. The original tree was killed by cold in the winter of 1895–96. The fruit is oblate to round, medium in size, 3½ to 4¾ in (9–12 cm) wide; peel is light-yellow, very smooth, with medium-size oil glands, mildly aromatic; pulp is buff, in 12–14 segments with tender membranes, melting, extremely juicy and rich in flavor; seeds absent or 3–8, medium-sized. Medium to late in season and holds well on the tree. Keeps well after harvest. The leading grapefruit cultivar; grown in Florida, California, Texas, Arizona, South America, Australia, South Africa, Israel and India. A local selection, presumably of a seedling 'Marsh', in Surinam is known there as 'Hooghart'. The two are almost indistinguishable.

'Oroblanco'—a triploid from a grapefruit X pummelo cross made in 1958 by geneticists R. K. Soost and J. W. Cameron of the University of California, Riverside. Patent obtained in 1981 and assigned to the University of California Board of Regents. Fruit form and size similar to 'Marsh'; peel paler and thicker; pulp paler and has larger hollow in center; sections easily skinned; tender, juicy, non-bitter; has faintly astringent after-taste before full maturity or in cooler climates; seedless. Season early: December to April at Riverside; early November through February at Landcove. Tree is vigorous, large, hardy, can tolerate temperatures down to 30°F (-1.11°C); yields medium to heavy crops and may tend to alternate bearing. Seems better adapted to California's inland citrus locations than to desert sites. Has been grown experimentally on trifoliate orange, 'Troyer' citrange, citremon 1449, Brazilian sour orange, grapefruit, sweet orange, rough lemon and 'Red' rough lemon rootstocks. The two latter have adversely affected internal quality.

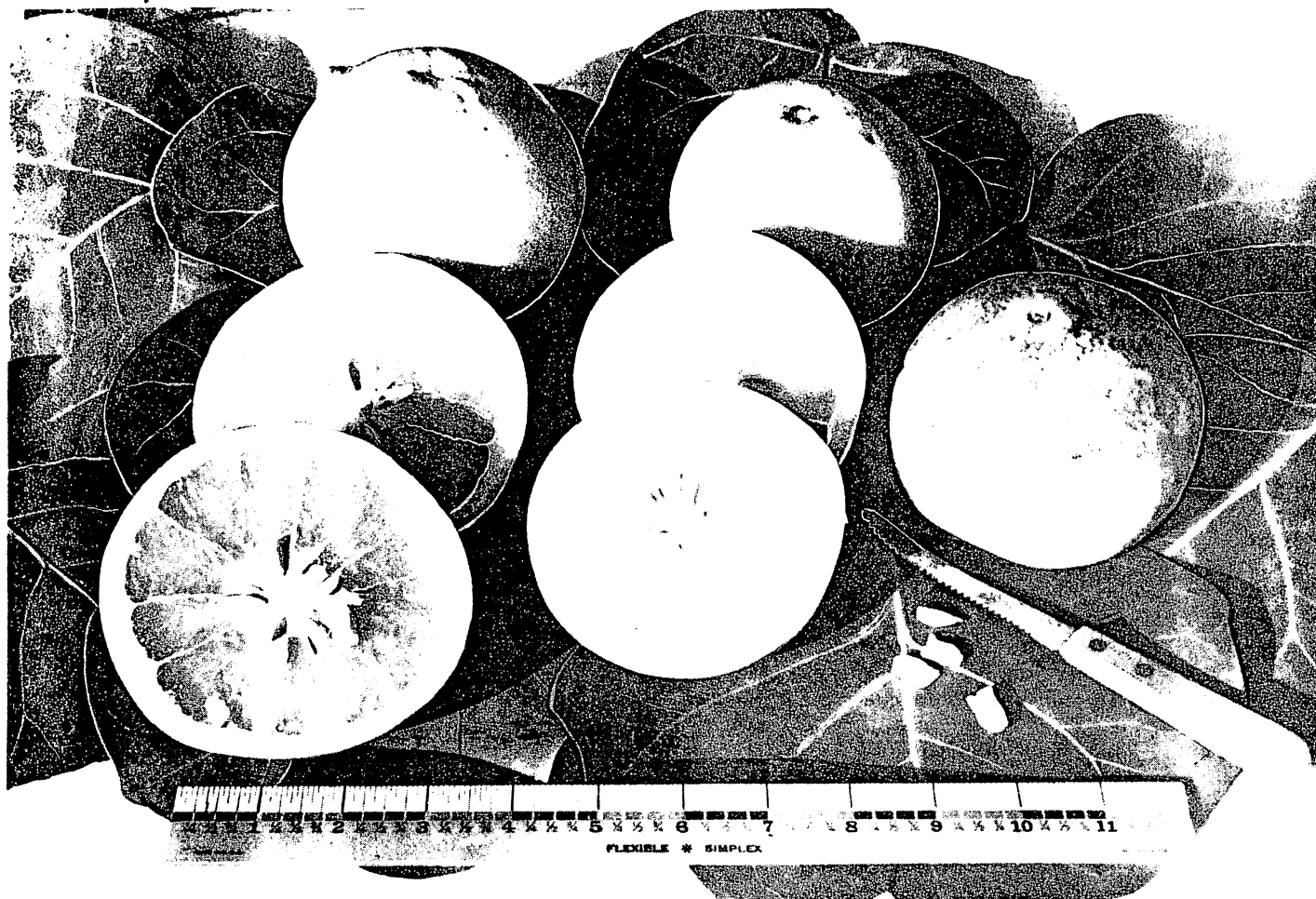


Fig. 39: Grapefruit (*Citrus paradisi*): pink (left); yellow (center); and russet (right). In: K. & J. Morton, *Fifty Tropical Fruits of Nassau*, 1946.

'Paradise Navel'—a selection from the 100-year-old Nicholson citrus grove near Winter Garden, Florida; propagated and patented by W.H. Nicholson, improved and released for distribution in 1976. Fruit is oblate, smaller than a typical grapefruit. Originally very seedy, but, by budding onto various rootstocks and transferring from one rootstock to another over a period of years, there eventually emerged one tree bearing fruit without seeds. Budwood from this tree has produced uniformity of seedlessness regardless of rootstock. The fruits have been sold to local customers but no scions nor trees were sold prior to 1976.

'Redblush' (including 'Ruby', 'Ruby Red', 'Shary Red', 'Curry Red', 'Fawcett Red', 'Red Radiance', and 'Webb' ['Webb's Redblush Seedless'])—originated as sports—lower branches—growing out of 'Thompson' trees which a Texas nursery had purchased from Glen St. Mary Nursery and sold to growers in the Rio Grande Valley, and which were frozen back in 1929. All are seedless and otherwise similar to 'Thompson' but display redder color. 'Redblush' grapefruits have been extensively planted in Florida in the past few decades though the juice is not suitable for canning as it tends to turn brown with age. By 1950, 75% of Florida's grapefruit crop was of the pink or red seedless type. Under the name, 'Ruby Red', a member of this group is a standard commercial cultivar in Texas. In 1958, budwood of 'Redblush' from California was acquired by the Regional Fruit Research Station at Abohar, India, was propagated on rough lemon, and the resulting trees

performed so well and showed such disease resistance that the cultivar was recommended for growing under irrigation in the arid regions of the Punjab and Haryana, where it averages 250 fruits annually per tree. Probably includable in this group is 'Burgundy'. Its peel is not blushed but the pulp is intense red throughout the season. 'Ray Ruby' and the similar if not identical 'Henderson' are branch sports propagated in Texas and introduced into Florida in the 1970's. The peel is redder than that of 'Ruby Red' and the pulp is red though not as intense as 'Star Ruby' throughout the season. Recently, budwood of 'Ray Ruby' has become available from the Florida Department of Agriculture's Bureau of Citrus Budwood Registration in Winter Haven. 'Ray Ruby' is expected to perform better than 'Star Ruby' on standard rootstocks.

'Star Ruby'—a lower branch mutation bearing red-blushed fruits, noticed on a 'Foster' tree at San Benito, Texas, in the mid 1930's. The tree had been frozen back nearly to the bud union the previous year. Budwood from the branch was propagated by C.E. Hudson as the 'Hudson Red' but, because of its coarse texture and high number of seeds (40-60), it was not adopted commercially. Seeds were irradiated at the Texas A & I Citrus Center, Weslaco, in 1959. The seedling from one of these treated seeds was named the 'Star Ruby' and introduced into cultivation in 1971 by Richard Hensz of Texas A & I University. Several thousand trees were planted in Texas. At least 65,000 budded trees were brought into Florida in 1971 by commercial interests without proper qualifications and permits

under the Division of Plant Industry. Investigation revealed a susceptibility to *Phytophthora* root rot and ringspot virus in Texas. The Florida State Agricultural Commissioner ordered the destruction of all unauthorized imported trees. About 25,000 were voluntarily destroyed by owners but the ruling was contested and the trees were placed under quarantine. Subsequently, ringspot virus was found on one of the imported trees which had already been used as a source of budwood. Infected trees from this source were found in a nursery and were destroyed together with all neighboring healthy trees. By April 1977, certified, disease-free budwood of 'Star Ruby' was made available and nearly 200,000 "budeyes" were released to growers. They were urged to make only limited plantings until more was known of this cultivar's fruiting habits. The tree tends to become more chlorotic than 'Ruby Red' when sunburned or affected by poor drainage, or high applications of herbicides and pesticides, and it is sensitive to adverse weather conditions.

'Star Ruby' has a yellow peel distinctly red-blushed and intensely red pulp and juice, 3 times more colorful than 'Ruby Red'. Though the color decreases with maturity, it is maintained throughout the season. The pulp is smooth and firmer than that of 'Ruby Red' and has a bit more sugar and acid. Furthermore, there may be no seeds or no more than nine. Some of the juice color is dissipated by heat in the pasteurization process but there is still enough for the product to be blended with white or pink grapefruit juice to provide more consumer appeal.

'Sweetie'—a grapefruit X pummelo hybrid released in 1984 by the Citrus Marketing Board in Israel, has all the features of a typical grapefruit but the flavor is sweet.

'Thompson' ('Pink Marsh')—In 1913, one branch of a 'Marsh' tree owned by W.R. Thompson, Oneco, Florida, bore pink-fleshed, seedless fruits. Propagation of budwood from the branch was undertaken by the Royal Palm Nurseries in 1924. A similar bud variation of the 'Marsh' had appeared around 1920 at Riverside, California. The fruit is oblate to round, of medium size, $2\frac{3}{4}$ to $3\frac{3}{4}$ in (7-9.5 cm) wide; peel is light-yellow, smooth, with small, inconspicuous oil glands, faintly aromatic; pulp is light- to deep-buff more or less flushed with pink, sometimes throughout, occasionally just near the center. There are 12 to 14 segments with abundant, colorless juice, and few seeds—usually 3 to 5. The color of the pulp is most intense in January and February. By late March and April it has faded to nearly amber.

'Triumph' (possibly the same as 'Royal' and 'Isle of Pines')—a seedling on the grounds of the Orange Grove Hotel in Tampa, Florida, propagated in 1884. The fruit is oblate to ellipsoid, slightly flattened at both ends; of medium size; peel light-yellow, very smooth, with oil glands of medium size; medium-thick; pulp pale, tender, juicy, only faintly bitter, the flavor having a touch of orange; the center is semi-hollow; of superior quality; 35-50 seeds. Medium-early in season, beginning in November. Grown only in dooryards in Florida, but has been widely distributed in citrus regions; does better than 'Marsh' in South Africa.

A grapefruit-like, triploid hybrid named 'Melogold' was developed by crossing a sweet pummelo with a seedy, white, tetraploid grapefruit in 1958. The fruit is larger than 'Marsh' grapefruit and its pummelo-like flavor is considered superior though it may have a trace of bitterness at the beginning and end of the season which extends from early November or December through February. 'Melogold' is grafted onto rough lemon and 'Troyer'

citrange rootstocks and is recommended for interior California, not in hot desert nor in humid coastal situations. Patent rights are held by the University of California and budwood is released only to licensed nurserymen.

Climate

The grapefruit prospers in a warm subtropical climate. Temperature differences affect the length of time from flowering to fruit maturity. At Riverside, California the period is 13 months; at warmer Brawley in the Imperial Valley of southern California, only 7 to 8 months. The fruit is lower in acidity in the Indian River region and areas of southern Florida, the lower Rio Grande Valley of Texas, and in the tropics than in cooler situations.

Humidity contributes to thinness of peel, while in arid climates the peel is thicker and rougher and, as might be expected, the juice content is lower. Low winter temperatures also result in thicker peel the following year and even affect the fruit shape.

Ideal rainfall for grapefruit is 36 to 44 in (91.4-111.7 cm) rather evenly distributed the year around.

Soil

The grapefruit is grown on a range of soil types. In the main growing area of Florida, the soil is mildly acid sand and applications of lime may be beneficial. On the east coast there are coquina shell deposits and, in the extreme southern part of the peninsula, there is little soil mixed with the prevailing oolitic limestone. Where the grapefruit is grown in California, Arizona and Texas, the soils are largely alkaline and frequent irrigation causes undesirable alkaline salts to rise to the surface. In Surinam, grapefruit is grown on clay. Successful grapefruit culture depends mainly on the choice of rootstock best adapted to each type of soil.

Salinity of the soil and in irrigation water retards water uptake by the root system and reduces yields.

Propagation

In the early years of grapefruit-growing, the customary citrus rootstocks were utilized: sour orange on heavy hammock and flatwoods soils, rough lemon on sand, though trees grafted on this stock were short-lived. In the early 1950's, sweet orange was being preferred over sour orange. In 1946, the United States Department of Agriculture, Texas A & M University, and Rio Farms, Inc., of Monte Alto, Texas, launched a cooperative program of testing grapefruit on different rootstocks. Of 13 different rootstocks utilized, 'Swingle citrumelo', 'Morton' and 'Troyer' citranges gave the best yield of large fruits. Rough lemon and 'Christian' trifoliolate orange reduced acidity. 'Swingle citrumelo' was never used extensively as a rootstock until 1974 when it was released to nurserymen and growers because of its tolerance of exocortis, xyloporosis, and tristeza and resistance to foot-rot and citrus nematode, and low uptake of salts, together with its ability to support heavy crops. It is now in third place after 'Troyer' citrange and sour orange.

In the past, 'Marsh' and 'Hooghart', the commercial grapefruits of Surinam, have been grown there on sour orange rootstock, but fear of tristeza inspired a rootstock testing program. Among the stocks tried, 'King' and 'Sunki' resulted in high yield and excellent quality in contrast to rough lemon and Rangpur lime. The two latter also showed susceptibility to *Phytophthora* root rot. 'Cleopatra' lowered the yield, and trifoliolate orange proved unsatisfactory in such a humid climate. In the Lower Rio Grande Valley of Texas, grapefruit trees on 'Swingle citrumelo' have grown very poorly on heavy clay as compared to those on sour orange.

Culture

In general, culture of grapefruit is similar to that of the orange, q.v., except that wider spacing is necessary.

Nutritional experiments with grapefruit have shown that excessive nitrogen results in malformed fruit, coarser texture and less juice. Lack of certain minor elements is evident in symptoms often mistaken for disease. The condition called exanthema is caused by copper deficiency; mottle leaf results from zinc deficiency.

Harvesting and Handling

In Florida, all commercial cultivars reach legal maturity in September or October if sprayed after blooming with lead arsenate to reduce acidity. Even after legal maturity the grapefruit can be "stored" on the tree for months, merely increasing in size, and extending the marketing season. The fruits can be harvested until near the end of May when they begin to fall and seeds start sprouting in the fruit. The only adverse effect of late harvesting is a corresponding reduction in the following year's crop. It has been found that spot-picking of the largest fruits partially counteracts this effect of late harvest. Fruit drop can be retarded by spraying with a combination of gibberellic acid and 2,4-D. Either of these agents or both together will reduce the germination of seeds. Germination may be inhibited for periods up to 11 weeks by cool storage at 50°F (10°C).

Grapefruits were formerly harvested by climbing the trees or using picking hooks which frequently damaged the fruit. Today, the fruits on low branches are picked by hand from the ground; higher fruits are usually harvested by workers on ladders who snap the stems or clip the fruits as required. California began utilizing a modified olive limb-shaker for harvesting grapefruit in 1972. The machines work in pairs to harvest opposite sides of each tree and the trees must be pruned to remove deadwood and to give access to 3-5 main limbs for shaking. Lower branches must be lopped off to leave a clear 2½ ft (75 cm) space for the catching frame. Mechanical harvesting causes some superficial injury. A team of 3 workers with one machine can harvest 150 to 188 field boxes—50 lbs (22.7 kg) when filled—per hour, as compared with 45 boxes per hour for 3 manual pickers. Stems are removed from the fruits before packing to avoid stem-damage.

Early in the season, when the fruits are mature but not fully colored, they are often degreened by exposure to

ethylene gas. The grapefruit is remarkable for its durability, but modern practices of applying fungicide to the harvested fruit are given credit for the great reduction in marketing losses. The cull rate in New York wholesale warehouses in 1983 was found to be 1.4% (mostly fungal), as compared with 13% estimated in 1960. Retail losses in 1983 were 3.5%, and only a small proportion were the result of physical injury.

Keeping Quality

The grapefruit keeps well at 65°F (18.33°C) or higher for a week or more and for 2 or 3 weeks in the fruit/vegetable compartment of the home refrigerator. The first sign of breakdown is dehydration and collapse of the stem-end. To retard moisture loss, fruits for marketing are washed and waxed as soon as possible after harvest. When kept in prolonged storage, the grapefruit is subject to chilling injury (peel pitting) at temperatures below 50°F (10°C). The degree of injury depends on several factors: the fruits on the outside of the tree are more susceptible than the fruits that have been sheltered by foliage. The use of preharvest growth regulators tends to reduce susceptibility, as does 100% relative humidity during storage. Preconditioning at 60.8°F (16°C) for 7 days before storing at 33.8°F (1°C) prevents injury. Lowering the temperature gradually after preconditioning is also beneficial, as is sealing the fruit in polyethylene shrink-film before refrigerating.

The banning of ethylene dibromide fumigation except for export has made it necessary to resort to cold treatment as an alternative measure against fruit fly infestation for shipment to Texas, Arizona and California. The United States Department of Agriculture now requires that imported citrus fruits be kept at 32°F (0°C) for 10 days or at 36°F (2.2°C) for 16 days after the fruit has been cooled down to the specified temperature. In Israel, investigators have found that waxing with a coating containing fungicide, and holding the packed fruit for 6 days at 62.6°F (17°C) before the cold treatment, gives good protection from chilling injury and decay in storage. Cold treatment costs 5 times as much as fumigation with ethylene dibromide. Methyl bromide has been tested and proposed as an effective fumigant.

Pests and Diseases

The grapefruit is subject to most of the same pests that attack the orange, including Caribbean and Mediterranean fruit flies. In addition to the cold treatment referred to above, irradiation has been studied as a method of disinfection, but has not been authorized for citrus fruit treatment. Exposure of early-season fruit to 60 and 90 krad causes scald and rind breakdown after 28 days of storage, and mainly pitting in midseason and late fruits. Minimal injury results from exposure to 7.5, 15, and 30 krad.

The following diseases have been reported for the grapefruit tree and its fruit by the Florida Division of Plant Industry: leaf spot (*Alternaria citri*, *Mycosphaerella horii*, *Phyllosticta hesperidearum*); algal leaf spot (*Cephaleuros*

virescens); greasy spot (*Cercospora citri-grisea*); tar spot (*C. gigantea*); anthracnose (*Colletotrichum gloeosporioides*); thread blight (*Corticium koleroga* and *C. stevensii*); gummosis (*Diaporthe citri*); dieback (*Diplodia natalensis*); heart rot (*Fomes applanatus*, *Ganoderma sessilis*, and *Xylaria polymorpha*); charcoal root rot (*Macrophoma phaseolina*); root rot (*Fusarium oxysporum*); sooty blotch (*Gloeodes pomigena*); flyspeck (*Leptothyrium pomi*); mushroom root rot (*Clitocybe tabescens*); foot rot (*Phytophthora megasperma*, *P. palmivora*, and *P. parasitica*); damping-off (*Rhizoctonia solani*); seedling blight (*Sclerotium rolfsii*); felt fungus, (*Septobasidium pseudo-pedi-cellatum*); branch knot (*Sphaeropsis tumefaciens*); leaves may be attacked by *Chaetothyricum hawaiiense*, and twigs by *Physalospora fusca*. Brown rot of fruit is caused by *Phytophthora citrophthora* and *P. terrestris*; stem-end rot, *Botryosphaeria ribis*; dry rot of fruit (*Nematospora coryli*); green mold (*Penicillium digitatum*); blue mold, (*P. italicum*); pink mold (*P. roseum*); scab (*Elsinoe fawcetti*).

The tree is highly susceptible to citrus canker and several viruses: crinkly leaf virus, psorosis, tristeza, xyloporosis, and infectious variegation. Mesophyll collapse is caused by extreme drought and dehydrating wind.

Food Uses

As a relatively new food, the grapefruit has made great advances in the past 75 years. In 1970, consumption of grapefruit was temporarily heightened by a widely promoted "grapefruit diet" plan claimed to achieve a loss of 10 lbs (4.5 kg) in 10 days and continuous gradual loss until the achievement of normal body weight. In 1983, the United States Department of Agriculture Marketing Service reported that, among fresh fruits and vegetables consumed in Metropolitan New York, grapefruit was exceeded only by potatoes, lettuce, oranges and apples.

Grapefruit is customarily a breakfast fruit, chilled, cut in half, the sections loosened from the peel and each other by a special curved knife, and the pulp spooned from the "half-shell". Some consumers sweeten it with white or brown sugar, or a bit of honey. Some add cinnamon, nutmeg or cloves. As an appetizer before dinner, grapefruit halves may be similarly sweetened, lightly broiled, and served hot, often topped with a maraschino cherry. The sections are commonly used in fruit cups or fruit salads, in gelatins or puddings and tarts. They are commercially canned in sirup. In Australia, grapefruit is commercially processed as marmalade. It may also be made into jelly.

The juice is marketed as a beverage fresh, canned, or dehydrated as powder, or concentrated and frozen. It can be made into an excellent vinegar or carefully fermented as wine.

Grapefruit peel is candied and is an important source of pectin for the preservation of other fruits. The peel oil, expressed or distilled, is commonly employed in soft-drink flavoring, after the removal of 50% of the monoterpenes. The main ingredient in the outer peel oil is nookatone. Extracted nookatone, added to grapefruit juice powder, enhances the flavor of the reconstituted

juice. Naringin, extracted from the inner peel (albedo), is used as a bitter in "tonic" beverages, bitter chocolate, ice cream and ices. It is chemically converted into a sweetener about 1,500 times sweeter than sugar. After the extraction of naringin, the albedo can be reprocessed to recover pectin.

Grapefruit seed oil is dark and exceedingly bitter but, bleached and refined, it is pale-yellow, bland, much like olive oil in flavor, and can be used similarly. Because it is an unsaturated fat, its production has greatly increased since 1960.

Food Value Per 100 g of Edible Portion*			
	Pulp (raw)	Juice (raw)	Peel (candied)**
Calories	34.4-46.4	37-42	316
Moisture	87.5-91.3 g	89.2-90.4 g	17.4 g
Protein	0.5-1.0 g	0.4-0.5 g	0.4 g
Fat	0.06-0.20 g	0.1 g	0.3 g
Carbohydrates	8.07-11.5 g	8.8-10.2 g	80.6 g
Fiber	0.14-0.77 g	trace	2.3 g
Ash	0.29-0.52 g	0.2-0.3 g	1.3 g
Calcium	9.2-32.0 mg	9.0 mg	
Phosphorus	15-47.9 mg	15.0 mg	
Iron	0.24-0.70 mg	0.2 mg	
Sodium	1.0 mg	1.0 mg	
Potassium	135 mg	162 mg	
Vitamin A			
(white)	10 I.U.	10. I.U.	
(pink/red)	440 I.U.	440 I.U.	
Thiamine	0.04-0.057 mg	0.04 mg	
Riboflavin	0.01-0.02 mg	0.02 mg	
Niacin	0.157-0.29 mg	0.2 mg	
Ascorbic Acid	36-49.8 mg	36-40 mg	
Tryptophan	2 mg		
Methionine	0-1 mg		
Lysine	12-14 mg		

* According to analyses made in California, Texas, Florida, Cuba and Central America.

**Peel Oil: 90% limonene; the volatile fraction (2-3%) consists mainly of oxygen compounds and sesquiterpenes; the waxy fraction (7-8%) consists of C₈ and C₁₀ aldehydes, plus geraniol, cadinene and small amounts of citral and dimethyl arthranilate, plus acid. Also present are 9 coumarins and 0.88% 22-dihydrostigmaterol. The dried pulp and seeds contain β-sitosterol-D-glucoside and β-sitosterol.

The glycoside 7 β-neohesperidosyl-4-(β-D-glucopyranosyl) naringenin occurs in the pulp segments. Feruloylputrescine is found in the juice and leaves. Mature grapefruit leaves contain the flavonoid, apigenin 7 β-rutinoside. Young leaves contain the 7 β-neohesperidoside and 7 β-rutinoside of naringenin.

Other Uses

Factory waste: The waste from grapefruit packing plants has long been converted into molasses for cattle.

Seed hulls: After oil extraction, the hulls can be used for soil conditioning, or, combined with the dried pulp,

as cattlefeed. A detoxification process must precede the feeding of this product to pigs or poultry.

Wood: Old grapefruit trees can be salvaged for their wood. The sapwood is pale-yellow or nearly white, the heartwood yellow to brownish, hard, fine-grained, and useful for domestic purposes. Mainly, pruned branches

and felled trees are cut up for firewood.

Medicinal Uses: An essence prepared from the flowers is taken to overcome insomnia, also as a stomachic, and cardiac tonic. The pulp is considered an effective aid in the treatment of urinary disorders. Leaf extractions have shown antibiotic activity.