Morton, J. 1987. Avocado. p. 91–102. In: Fruits of warm climates. Julia F. Morton, Miami, FL.

Avocado

Persea americana

The avocado, unflatteringly known in the past as alligator pear, midshipman's butter, vegetable butter, or sometimes as butter pear, and called by Spanish-speaking people *aguacate*, *cura*, *cupandra*, or *palta*; in Portuguese, *abacate*; in French, *avocatier*; is the only important edible fruit of the laurel family, Lauraceae. It is botanically classified in three groups: A), *Persea americana* Mill. var. *americana* (P. *gratissima* Gaertn.), West Indian Avocado; B) *P. americana* Mill. var. *drymifolia* Blake (*P. drymifolia* Schlecht. & Cham.), the Mexican Avocado; C) *P. nubigena* var. *guatemalensis* L. Wms., the Guatemalan Avocado.

Description

The avocado tree may be erect, usually to 30 ft (9 m) but sometimes to 60 ft (18 m) or more, with a trunk 12 to 24 in (30-60 cm) in diameter, (greater in very old trees) or it may be short and spreading with branches beginning close to the ground. Almost evergreen, being shed briefly in dry seasons at blooming time, the leaves are alternate, dark-green and glossy on the upper surface, whitish on the underside; variable in shape (lanceolate, elliptic, oval, ovate or obovate), 3 to 16 in (7.5-40 cm) long. Those of the Mexican race are strongly anise-scented. Small, pale-green or yellow-green flowers are borne profusely in racemes near the branch tips. They lack petals but have 2 whorls of 3 perianth lobes, more or less pubescent, and 9 stamens with 2 basal orange nectar glands. The fruit, pear-shaped, often more or less necked, oval, or nearly round, may be 3 to 13 in (7.5-33 cm) long and up to 6 in (15 cm) wide. The skin may be yellow-green, deep-green or very dark-green, reddish-purple, or so dark a purple as to appear almost black, and is sometimes speckled with tiny yellow dots, it may be smooth or pebbled, glossy or dull, thin or leathery and up to 1/4 in (6 mm) thick, pliable or granular and brittle. In some fruits, immediately beneath the skin there is a thin layer of soft, bright-green flesh, but generally the flesh is entirely pale to rich-yellow, buttery and bland or nutlike in flavor. The single seed is oblate, round, conical or ovoid, 2 to 2 1\2 in (5-6.4 cm) long, hard and heavy, ivory in color but enclosed in two brown, thin, papery seedcoats often adhering to the flesh cavity, while the seed slips out readily. Some fruits are seedless because of lack of pollination or other factors.

Fig. 28: West Indian avocados (*Persea americana*). The fruit cut open is a 'Hall'.

Origin and Distribution

The avocado may have originated in southern Mexico but was cultivated from the Rio Grande to central Peru long before the arrival of Europeans. Thereafter, it was carried not only to the West Indies (where it was first reported in Jamaica in 1696), but to nearly all parts of the tropical and subtropical world with suitable environmental conditions. It was taken to the Philippines near the end of the 16th Century; to the Dutch East Indies by 1750 and Mauritius in 1780; was first brought to Singapore between 1830 and 1840 but has never become common in Malaya. It reached India in 1892 and is grown especially around Madras and Bangalore but has never become very popular because of the preference for sweet fruits. It was planted in Hawaii in 1825 and was common throughout the islands by 1910; it was introduced into Florida from Mexico by Dr. Henry Perrine in 1833 and into California, also from Mexico, in 1871. Vegetative propagation began in 1890 and stimulated the importation of budwood of various types, primarily to extend the season of fruiting. Some came from Hawaii in 1904 (S. P. I. Nos. 19377-19380).

Now the avocado is grown commercially not only in the United States and throughout tropical America and the larger islands of the Caribbean but in Polynesia, the Philippines, Australia, New Zealand, Madagascar, Mauritius, Madeira, the Canary Islands, Algeria, tropical Africa, South Africa, southern Spain and southern France, Sicily, Crete, Israel and Egypt.

Though the Spaniards took the avocado to Chile, probably early in the 17th Century and it was planted from the Peruvian border southward for over 1000 mi (1,600 km) actual commercial plantings were not established until California cultivars were introduced about 1930 into two areas within 100 mi (160 km) of Santiago where the industry is now centered.

The first trees were planted in Israel in 1908, but named cultivars ('Fuerte' and 'Dickinson') were not introduced until 1924. These aroused interest in the feasibility of the crop for the southern half of the coastal plain and the interior valleys, and development of the industry has steadily gone forward, except for a period in the 1960's when much planting stock was destroyed because of marketing problems. In 1979, Israel produced 33,000 tons (30,000 MT) and exported 28,600 tons (26,000 MT).

In just the last few years, New Zealand has launched a program to expand commercial production, especially in the Bay of Plenty area, with protection from wind and frost, with a view to becoming a major exporter of avocados.

California produced 265 million lbs (12,045 MT) in 1976; 486 million lbs (22,090 MT) in 1981. The Florida avocado potential is estimated at 150 million lbs (6,818 MT). Both states suffer fluctuations because of the impact of periodic freezes, droughts, high winds or other seasonal factors.

Presently, Mexico, with 150,000 acres (62,500 ha) is the leading producer—267,786 tons (243,000 MT); the Dominican Republic is second—144,362 tons (131,000 MT); U.S.A. (California and Florida combined) with 52,000 acres (21,666 ha), third—131,138 tons (119,000 MT); Brazil is fourth—128,934 tons (117,000 MT). Israel, with 16,000 acres (6,666 ha), is fifth; and South Africa sixth. Half of California's plantings are in San Diego County close to Mexico.

As an exporter, Mexico again leads, followed by California, Israel, South Africa and Florida, in that order. Nearly all of Brazil's crop is consumed domestically.

Varieties

WEST INDIAN race: Florida avocados were at first mainly of the summer fruiting West Indian race, but these had to compete commercially with similar fruits imported from Cuba, and growers sought other cultivars maturing at a later season. This led to the development of West Indian X Guatemalan hybrids. The cessation of trade with Cuba in the early 1960's brought about a shift back to summer cultivars in new groves to fill the gap. The majority of the avocados grown in the West Indies, Bahamas and Bermuda and the tropics of the Old World are still of the West Indian race. The skin is leathery, pliable, non-granular, and the flesh low in oil. The leaves are not aromatic. The following are the most prominent of early and more recent West Indian cultivars which have played an important role in the development of the avocado industry in Florida and elsewhere. New selections appear from time to time that may have special adaptability to certain locales or conditions.

'Butler' (a USDA selection in Florida; fruited in 1909, propagated from 1914 to 1918) pear shaped; medium-large; skin smooth; seed of medium size, tight in the cavity. Season: Aug.-Sept. No longer grown in Florida. Cultivated in Puerto Rico.

'Fuchs' ('Fuchsia') (seed of unknown origin planted in Homestead, Florida, in 1910; propagated commercially in 1926); pear shaped to oblong, sometimes with a neck; of medium size; skin smooth; flesh pale greenish-yellow; 4 to 6% oil; seed loose. Season: earlyJune-Aug.; a poor shipper. Tree not very productive in Florida; no longer popular in commercial groves.

'Maoz' (a seedling selected from a plot near Maoz, Israel); pear-shaped; of medium size; skin rough, leathery, violet-purple when ripe; flesh sweetish and very low in oil. Season: medium-late (Oct.). Tree is an alternate bearer but is fairly small, highly salt-tolerant; used in Israel as rootstock on either saline or calcareous soils.

'Pollock' (originated in Miami before 1896; commercially propagated in 1901); oblong to pear shaped; very large, up to 5 lbs (2.27 kg); skin smooth; flesh green near skin, contains 3 to 5% oil; seed large, frequently loose in cavity. Season: early July to Aug. or Oct. Shy-bearing and too large but of superior quality.

'Ruchle' (a seedling of Waldin planted at the Agricultural Research and Education Center, Homestead, in 1923; first propagated in 1946); pear-shaped; of medium size, 10 to 20 oz (280-560 g); flesh low in oil (2-5%). Season begins in July in Florida; Jan. in Queensland. Heavy bearer in Florida.

'Russell' (originated in Islamorada in Florida Keys); pearshaped at apex with long neck giving it a total length up to 13 in (32.5 cm); skin, smooth, glossy, thin, leathery; flesh of excellent quality; seed small. Season: Aug. and Sept. Tree bears well and is recommended for home gardens.

'Simmonds' (possibly from a seed of Pollock, first fruited in Miami in 1913; propagated commercially in 1921); oblongoval to pear-shaped; large; skin smooth, light green; flesh of good flavor, 3 to 6% oil; seed of medium size, usually tight. Season: mid-July to mid-Sept. Tree bears more regularly than Pollock but is less vigorous; sometimes sheds many of its fruits; no longer planted commercially in Florida.

'Trapp' (originated in Miami in 1894; propagated in 1901); round to pear-shaped; medium to large; skin smooth; flesh golden-yellow, green near skin, of excellent quality, 3 to 6% oil; seed large, loose in cavity. Season: medium-late (Sept. to Nov. or Dec.); a good shipper. Was prominent in Florida for 25 years despite tendency to overbloom and bear lightly some years; usually bore regularly and well.

'Waldin' (seed planted in Florida in 1909; propagated commercially in 1917); oblong to oval; medium to large; skin smooth; flesh pale to greenish-yellow, of good flavor, 5 to 10% oil; seed medium to large, tight. Season: fairly late (mid-Sept. through Oct.). Tree tends to overbear and die back; is hardy. Has been a leading commercial cultivar in central and southern Florida.

There are several Puerto Rican selections—'Alzamora', 'Avila', 'Faria', 'Garcia', 'Hernandez', 'St. Just'—and some cultivars of unknown ancestry: 'Amador', 'Galo', 'Gimenez', 'Torres', and 'Trujillo'.

GUATEMALAN race: (skin varies from thin to very thick and is granular or gritty). Among prominent early Florida and California cultivars were:

'Anaheim' (originated in California); oval to elliptical; large; skin glossy, rough, thick; flesh of fair to good flavor, up to 22% oil, but inferior to'Fuerte', 'Nabal' and 'Benik'; is best in Mar. and Apr. in Israel, July and Aug. in Queensland. Tree slender, erect, tall, cold-sensitive; bears regularly, up to 220 lbs (100 kg) annually in Israel. Considered of poor quality and subject to disease during ripening in Queensland.

'Benik' (introduced from Guatemala to California in 1917 and from California into Israel in 1934); pear-shaped; medium to large; skin rough, purple, medium-thick; flesh of good quality, 15 to 24% oil; seed nearly round, medium. Season: Apr. to Aug. in Calif.; Jan. to Mar. in Israel; July and Aug. in Queensland. The tree begins to bear late and yields only about 116 lbs (53 kg) per year. Color is not popular on the market. Not grown in Florida.

'Dickinson' (a California selection, first propagated in 1912); oval to obovate; small to medium; skin dark-purple with large maroon dots, rough, very thick, granular, brittle; flesh of good quality; seed small to medium, tight. Season: June-Oct. in California; Feb. and Mar. in Florida; Jan. and Feb. in Puerto Rico. Tree is a moderate but regular bearer. In Israel 'Dickinson' is described as round, small to large, very thick-skinned with very large seed; of poor quality, not worth growing. It is no longer grown in Florida or California.

'Edranol' (seedling planted at Vista, California in 1927; propagated in 1932), pear-shaped; of medium size; skin olivegreen, slightly rough, thin leathery; flesh of high quality and nutty flavor, 15 to 18% oil; seed small, tight. Season: Feb. to July at Vista; Apr. to Dec. at Santa Barbara; May and June in Queensland. Disease resistant. Rated as excellent. No longer planted in California but popular in Mexico.

'Hazzard' (seedling of 'Lyon'planted at Vista, California in 1928) pear-shaped; of medium size; skin rough, fairly thin; flesh of good quality, 15 to 34% oil; seed small. Season: Apr. to July in California, July and Aug. in Queensland where it is rated as excellent and free of external and internal diseases and discolorations in storage. The tree grows slowly, reaches only 12 to 15 ft (3.5-4.5 m), begins bearing early and is a dependable producer. Some fruits may crack if left on tree too long. More than 100 trees can be planted per acre (240 per ha).

'Itzamna' (budwood brought from Guatemala to Florida in 1916); oblong pear-shaped; medium large; skin rough; flesh yellow, 11% oil; seed small, tight. Season: very late (Mar. to May). May not bear well; little planted in Florida; a commercial cultivar in California and in Puerto Rico where it is a consistently heavy bearer.

'Linda' (budwood introduced into California from Guatemale in 1914; propagated in Florida in 1917); elliptical; very large; skin rough, dull-purple when ripe; flesh yellow, 10 to 14% oil; seed small, tight. Season: May to Oct. in California; late (Dec. to Feb.) in Florida. A good shipper but not popular in Florida because of size and color. Of some commercial importance in California. Tree low, spreading, vigorous and bears regularly.

'Lyon' (originated in California; propagated in 1911); broad-pear-shaped; beyond medium to large; skin somewhat rough to rough; bright-green with many small yellowish or red-brown dots; medium-thick, granular and brittle; flesh greenish near skin, of high quality; seed medium-small to medium, tight. Season: Apr. to Aug. in California. Tree comes into bearing early and bears heavily, so much so as to weaken the tree. Grown in Florida only from 1918 to 1922.

'Macarthur' (originated in 1922 at Monrovia, California); pear-shaped; large; skin thin, pliable; flesh has sweet, nutty but watery flavor, contains 13 to 16.7% oil; seed medium to large. Season: Aug. to Nov. in California; Aug. and Sept. in Queensland where it is rated as of poor quality. It is one of the 6 leading commercial cultivars in California, where it is very cold-hardy.

'Nabal'(budwood brought from Guatemala in 1917; propagated in California since 1927, in Florida from 1937; in Israel since 1934); nearly round; medium to large; skin nearly smooth, thick, granular; flesh of high quality, green near skin; 10 to 15 % oil in Florida, 18 to 22 % in Queensland; seed small, tight. Season: June to Sept. in California; Jan. and Feb. in Florida; Oct. and Nov. in Queensland. Tree bears well in central Florida; bears late and poorly in Israel averaging 68 lbs (31 kg) per year in alternate years. In Queensland, bears in alternate years very heavily, but is rated as of medium quality and disease-prone during prolonged ripening.

'Nimlioh' (USDA budwood brought from Guatemala in 1917; propagated commercially in 1921); elliptical; large; skin slightly rough; flesh thick; seed fairly small, tight. Season: late (Jan. and Feb.) in Florida; May to Aug. in California. Tree bears moderate crops on south coast of Puerto Rico. Abandoned in Florida in 1925 because tree found to be weak and not prolific.

'Panchoy' (a USDA introduction into Florida from Guatemala; fruited in 1919); pear-shaped to almost elliptical; medium to large; skin rough, very thick; seed of medium size, tight. Season: very late (Mar. to early Apr.) in Florida; Apr. to Aug. in California. Formerly a heavy bearer in Florida and still is on the south coast of Puerto Rico but subject to die-back. Has been commercially important in California and Hawaii.

'Pinkerton' (seedling, probably of 'Rincon', found on Pinkerton ranch in Ventura Co., California, in 1970; patented); early crop roundish; later, pear shaped with neck; of medium size, 8 to 14 oz (227-397 g); skin medium-leathery, pliable; flesh thick, up to 10% more than in 'Hass' or 'Fuerte'; smooth textured, of good flavor, high in oil, rated as of good quality but inferior to 'Hass' and 'Fuerte'; tends to darken in the latter part of the season; seed small, separates readily from the flesh with the coat adhering to the seed. Season: first crop, Oct. or Nov., 2nd crop, Dec. or Jan. Fruit ships well and has good shelf life, but the neck is a disadvantage on the fresh fruit market; accordingly, the late-season fruits are sent to processing plants. The tree is of low, spreading habit; bears early and heavily; is as cold-sensitive as 'Hass'. About 1200 acres (486 ha) in California in 1984.

'Reed' (originated about 1948 on Reed property in Carlsbad, California, as a seedling, possibly of a 'Anaheim' X 'Nabal' hybrid; patented in 1960; patent now expired); round; medium to large, 8 to 18 oz (227-510 g); skin slightly rough, medium-thick, pliable; flesh cream-colored with rich, faintly nutty flavor; doesn't darken when cut; rated as excellent quality; seed small to medium, tight; coat adheres to seed. Season:July to Oct. in California;

late Feb. to Apr. in New Zealand where it is one of the most promising cultivars. Tree erect, can be spaced 15 x 15 ft (4.6x4.6 m); bears early and regularly; about as cold-sensitive as 'Hass'. In 1984, about 1,000 acres (405 ha) in California.

'Schmidt' (budwood introduced into California in 1911; propagated in Florida in 1922); pear-shaped; medium to large; skin rough; flesh pale-yellow, 12 to 16% oil; seed of medium size, tight. Season: very late (Feb. and Mar.). The tree is a poor bearer and cold-sensitive and the fruit of poor keeping quality.

'Sharpless' (originated in California; propagated in 1913); slender-pear-shaped, sometimes with long neck; large to very large; skin slightly rough, greenish-purple to dark-purple with many yellowish dots, thick, granular; flesh of superior quality and flavor; seed small, tight. Very late (Oct. to Feb.) in California.

'Solano' (originated in California; propagated in 1912); obovate to oval; beyond medium to large; skin nearly smooth, bright-green with many yellowish dots, medium-thick, granular; flesh greenish near skin, of fair quality; seed small, tight. Season: Mar. to May in California; Oct. to mid Nov. or Dec. in Florida. A good bearer, but not grown in Florida for many years.

'Spinks' (originated in California; propagated in 1915); broad-obovate; very large; skin rough, dark-purple, thick, granular, brittle; flesh of very good quality and flavor; seed small, tight. Season: Aug. to Apr. in California. Formerly grown in central Florida.

'Taft' (originated in 1899 in California; propagated in 1912); broad pear-shaped; medium to very large; skin faintly rough, more so at base; many yellowish dots, thick, granular but somewhat pliable; flesh of excellent quality and flavor; seed of medium size, tight. Season: May to Dec. in California; Feb. and Mar. in Florida. Poor bearer in California; fair in Florida but cold-sensitive.

'Taylor' (seed of 'Royal' planted in Florida in 1908, propagated commercially in 1914); obovate to pear-shaped, occasionally with neck; small to medium size—12 to 18 oz (340510 g); skin rough, with many small yellow dots; fairly thin; flesh of excellent quality and flavor, 12 to 17% oil; seed of medium size, tight. Season: late (Dec. and Jan. or even to end of Mar.). The tree is cold-hardy but excessively tall and slender.

'Tonnage' (seed of 'Taylor' planted in Florida in 1916; propagated commercially in 1930); pear-shaped, medium large; skin dark green, rough, thick; flesh green near skin, rich in flavor, 8 to 15% oil; seed medium, fairly tight. Season: from mid-Oct. through Nov. in Florida; May to mid-Aug. inArgentine. Tree erect, fairly slender, requiring less distance between trees; is a heavy bearer. Cross pollinated by 'Lula' and 'Collieson' in Argentina.

'Wagner' (seed of 'Royal' planted in California in 1908; propagated in Florida in 1916); rounded to obovate; small to medium; skin slightly rough; flesh light yellow, 16 to 20% oil; seed large, tight. Season: Late (mid-Jan. to mid-Mar.). Tree lower-growing than 'Taylor', a heavy bearer, but fruit more subject to black spot than 'Taylor'. Not recommended in Florida.

'Wurtz' (originated in 1935 at Encinitas, California; cultivated in Queensland for only the past 12 or 13 years); pearshaped, small to medium; 8 to 12 oz (226-240 g); seed large. Season: May to Sept. in Calif.; late in Queensland. Tree is small and slow growing, bears moderately but regularly. More than 100 trees may be planted per acre (240 per ha).

GUATEMALAN X WEST INDIAN hybrids: Inasmuch as pure Guatemalan avocados proved not well adapted to Florida, Guatemaian X West Indian hybrids have come to be of utmost importance in the Florida avocado industry, representing more than half of the more than 20 major and minor commercial cultivars grown in this state today. Prominent cultivars past and present include:

'Bonita' (seed planted in Florida in 1925); obovate, slightly flattened on one side; of medium size; skin slightly rough; flesh contains 8 to 10% oil; seed of medium size. Season: late (Dec. and Jan.). Hardy in California.

'Booth 1' (seed planted in Florida in 1920); round-obovate; medium-large; skin almost smooth, medium thick, brittle; flesh pale, 8 to 12% oil; seed large and loose; Season: late (Dec. and Jan.). The tree is a heavy bearer but the fruit is of poor quality and the seed is too big.

'Booth 7' (seed planted in Florida in 1920; propagated commercially in 1935); round obovate; of medium size; skin slightly rough, thick, brittle; flesh contains 7 to 14% oil; seed of medium size, tight. Season: late (Dec. to mid-Jan.). The fruit is commercially popular and the tree is a good bearer.

'Booth 8' (seed planted in Florida in 1920); oblong-obovate; medium-large; skin slightly rough, fairly thick, brittle; flesh contains 6 to 12% oil; seed medium large, tight. Season: late (Nov. to mid-Dec.). Popular commercially and the tree is a heavy bearer.

'Chequette' (originated in Miami from seed planted in 1929; propagated in 1939); oval; large; skin glossy, smooth, slightly leathery; flesh of good quality, 13% oil; seed medium, tight. Season: Jan. to Mar. Tree bears heavily in alternate years.

'Collinson' (seed planted in Florida in 1915); broad-obovoid to elliptical; large; skin smooth; flesh of excellent flavor, 10 to 16% oil; seed of medium size, tight. Season: late (Nov. and Dec.). Tree doesn't produce pollen in Florida; is a heavy bearer in Puerto Rico when interplanted with other cultivars. The flesh is apt to blacken around the seed in cold storage Cold-sensitive and unfruitful in Israel.

'Fuchs-20' (a seedling of 'Fuchs' selected in Israel); ellipsoid; medium to large; skin smooth, speckled with yellowish lenticels when ripe; flesh flavor is excellent. Season: medium late (Oct.). Tree is vigorous but a poor bearer; seedlings vary in salt-tolerance but cuttings of resistant selections perform well in saline conditions.

'Grande' (brought to California in 1911 from Atlixco, Mexico); pear-shaped; large; skin rough, green to purplish; seed of medium size, tight. Season: late (Dec. and Jan. in Fla.; Apr. and May in Calif.). Grown in California and Puerto Rico. Tree is a heavy bearer around Mayaguez.

'Hall' (originated in Miami; of unknown parentage; fruited in 1937, propagated in 1938); pear-shaped; large: skin smooth, fairly thick; flesh deep-yellow, 12 to 16% oil; seed medium large, tight. Season: Nov. and Dec. Heavy bearer and coldhardy but subject to scab.

'Herman' (seed planted in Florida in 1935); obovate; skin smooth, fairly thin, flexible; flesh yellow, 10 to 14% oil; seed small. Season: fairly late (mid-Nov. to mid-Jan.). Tree a heavy bearer and hardy.

'Hickson'(seedling, fruited in Florida in 1932; propagated commercially in 1938); obovate; medium to small; skin slightly rough, thick, brittle; flesh of fair to good quality, 8 to 10% oil; seed small, tight. Season: late (Dec. and Jan.). Tree bears heavily every other year; is cold-sensitive.

'Simpson' (a sprout of 'Collinson'; fruited in Florida in 1925); obovate-elliptical; rather large; skin slightly rough and thick but not brittle; flesh pale, 10 to 14% oil; seed medium-large, tight. Season: late (mid Nov. and December). The tree is a good bearer.

'Winslowson' (seed of 'Winslow' planted in Miami in 1911; propagated commercially in 1921); round-oblate; large; skin smooth; flesh pale, 9 to 15% oil; seed of medium size, loose. Season: late (Oct. to Dec. in Fla.; Dec. and Jan. in Puerto Rico). This hybrid is closer to the West Indian race than the Guatemalan and therefore popular in Puerto Rico. Formerly commercial in Florida but abandoned because of loose seed, overblooming, tendency to shed crop, and tree and fruit are susceptible to anthracnose.

In 1963, Puerto Rican horticulturists reported on the performance of 25 selections from 100 studied in the previous 5 years. Four of the selections preceded the establishment of the collection at the Isabela Substation of the University of Puerto Rico. One of the objectives was to identify late maturing varieties with superior quality and yield. Of the leading 10, all are presumed to be Guatemalan X West Indian hybrids except one, 'Kanan No. 1', which is probably Guatemalan, and this and 'Melendez No. 2' are the only ones of alternate bearing habit. 'Gripina' Nos. 2, 5 and 12 were highly rated as, respectively, better than 'Nabal', one of the best commercial cultivars, and most attractive of all. 'Semil' Nos. 23, 31, 34, 42, 43, and 44 seemed equally desirable, with Nos. 34 and 42 noted as wind-resistant.

Puerto Rican breeders have now developed the following Guatemalan X West Indian hybrids: 'Adjuntas', 'Guatemala', 'Melendez 2', 'Gripina 45', and 'Semil 34' and 43, as late-maturing (Nov. to Mar.), having medium oil content, rich-yellow flesh, and tight seed in order to be able to stand handling and shipment.

MEXICAN race: (skin thin and tender, clings to the flesh; flesh of high oil content, up to 30%. The foliage has a pronounced anise-like odor; the tree is more cold resistant than those of the other races or hybrids, thriving near Puebla, Mexico, at 500 ft (1,800 m) above sea-level.

'Duke' (originated in California in 1912); elongated; rather small 5 1\2 to 7 oz (150 200 g); flesh of good quality, 14.5% oil. Season: Sept. to Nov. in Calif.; late July or mid Aug. to mid-Sept. in Israel. Tree is large, symmetrical and wind and cold-resistant, and also highly resistant to root rot, especially when grown from cuttings. It is a poor bearer in some areas of California; has borne 168 lbs (78 kg) annually from the 6th to the 15th year in Israel.

'Ganter' (originated in 1905 in California; introduced into Israel in 1943); small, about 5 1/2 oz (150 g); of good quality, 18% oil; seed small to medium, usually loose. Season: Oct. to Dec. in Calif.; second half of Sept. in Israel. Tree is small, yields no more than 44 lbs (20 kg) per year. Poor shipper.

'Gottfried' (seed of a seedling on Key Largo planted at USDA, Miami, in 1906; distributed in 1918); pear shaped; medium size; skin smooth, purple; flesh of excellent quality, 9 to 13% oil; seed medium. Season: Aug. to Oct. Tree prolific in California; a poor bearer in southern Florida and subject to anthracnose, but hardy and desirable for home gardens on west coast of Florida.

'Mexicola' (originated about 1910 at Pasadena, California; propagated about 1912); very small; skin black; flesh of excellent flavor; seed large. Season: Aug. to Oct. Grown only in home gardens in California. Bears early and regularly; very heat- and cold-resistant; much used as a parent in California breeding programs.

'Northrop' (seedling from C.P. Taft planted about 1900 near Tustin, California; propagated about 1911); small, 3 1/2 to 5 1/2 oz (100-150 g); skin nearly black; flesh of good quality, 26% oil; seed medium. Season: Oct. and Nov. in California; mid July to mid-Sept. in Florida; mid Sept. to mid Oct. in Israel. Fruit does not keep well; flavor disagreeable when overripe. Tree bears regularly but has lower yield than 'Duke'.

'Puebla' (considered pure Mexican but some suggest may be a Mexican X Guatemalan hybrid; was found in 1911 at Atlixco near where 'Fuchs' originated). Of medium size; skin smooth, purple; flesh of good flavor; oil content nearly 20%; seed medium to large. Season: Sept. and Oct. in Florida; early to mid-winter in cool regions of California. Tree does not set fruit regularly in California or Israel and therefore is seldom planted now. Has been recommended for home gardens in Central Florida because of hardiness.

'Zutano' (hybrid, originated in 1926 at Fallbrook, California; registered in 1932); pear shaped; medium-small, skin light green, very thin, leathery; flesh watery, 15 to 22% oil; seed medium. Season: Dec. and Jan. in California; Apr. and May in Queensland where it is considered of poor quality

delicate to handle, and prone to disease during ripening. Tree is a good bearer. Ranks among 6 leading commercial cultivars in California, being grown where it is too cold for 'Hass'.

GUATEMALAN X MEXICAN hybrids include:

'Bacon' Quality of flesh slightly better than 'Zutano'. Season: slightly later then 'Zutano'. Tends to be affected with end spot, an external blemish. This cultivar and 'Zutano' are the only 2 reasonably productive of 60 cultivars tried in Los Angeles and Orange Counties in California. In 1957, top working of all the others to these 2 cold hardy cultivars was strongly recommended. 'Bacon' is a good choice for tropical American highlands about 5,200 ft (160 m).

'Fuerte' (a natural hybrid originated at Atlixco, Mexico; introduced into California in 1911); pear shaped; small to medium or a little larger; skin slightly rough to rough, with many small yellow dots, thin, not adherent to flesh; flesh green near skin, 12 to 17% oil; seed small, tight. Season Jan. to Aug. in southern California; Dec. to Feb. in Israel; Apr. and May in Queensland, and New South Wales; mid-Aug. to Oct. in New Zealand. Tree is broad, very productive, but tends to bear biennially. Subject to scab and anthracnose in Florida. Formerly very popular in California (61 % of all avocados shipped); now second to 'Hass' because of a trend to summer instead of winter production and marketing that began in 1972. It is the leading cultivar in Chile where it bears more dependably than in California. It is a very erratic bearer in Israel. Represents 42% of all Australian plantings. Has long been the leading avocado on the European market.

'Hass' (seed planted at La Habra Heights, Calif.; registered in 1932); pear shaped to ovoid; of medium size; has a tendency to be undersized except in New Zealand; skin tough, leathery, dark-purple or nearly black when ripe; pebbled; fairly thin; flesh of good flavor, 18 to 22% oil, generally; up to 35% in Queensland; seed small. Season: begins in mid-Mar. in California; Nov. to Jan. in Queensland; mid-Nov. to Mar. in New Zealand; Aug. and Sept. in New South Wales. Formerly accounted for 20% of California avocados shipped; now is the leading cultivar (70% of the crop in 1984). Tree bears better then 'Nabal' in cool areas of California, but grows tall and requires topping. This is the leading cultivar in New Zealand, representing 50% of all commercial plantings; 25% in Queensland. It is second in importance to 'Fuerte' in Chile.

'Hayes' (a new hybrid in Hawaii, one parent being 'Hass'). Fruit resembles 'Hass' but is larger; skin is glossier, is pebbled, rough, thick and becomes brown-purple. Season: late (mid-Oct. to Dec. in New Zealand). Tree is erect with drooping branches and the fruit is largely sheltered by the foliage.

'Lula' (seed of 'Taft' planted in Miami in 1915); pearshaped, sometimes with neck; medium large; skin almost smooth; flesh pale-to greenish-yellow, 12 to 16% oil; seed large, tight. Season: medium-late (mid-Nov. and Dec.). Tree tall, bears early and heavily; cold resistant, successful in central and southern Florida where it was formerly the leading commercial cultivar. It is the principal cultivar in Martinique for exporting to France; represents 95% of the crop.

'Rincon' (originated at Carpinteria, California); pearshaped; small to medium; skin fairly thin, smooth, leathery; flesh buttery, contains 15 to 26.5% oil; fibers in flesh near base turn black when fruit is cut; seed of medium size. Season: Mar. and Apr. in Queensland, where it is rated as of poor quality. It is one of the 6 leading cultivars in California. Tree has a low spreading habit.

'Ryan' (perhaps seedling of 'amigo' found in 1927 at Whittier, California); pear-shaped; of medium size, 8 to 12 oz (226-340 g); skin medium-rough; flesh of fair quality; seed rather large. Season: May to Sept. in California; July to Oct. in Queensland. Tree large and bears regularly but not as heavily as 'Fuerte' or 'Hass' in Queensland. Important in Chile.

'Sharwil' (originated in Australia); similar to 'Fuerte' in shape but a little more oval; of medium size, skin rather rough, fairly thin; flesh rich in flavor, of high quality, 15 to 26% oil. Season: May and June in New South Wales and Queensland. Tree bears regularly but not heavily. Represents 18 to 20 % of all avocados in New South Wales and Queensland. Disease-free during ripening.

'Susan' (evaluated by California Avocado Society January 2, 1975; patented but patent has now expired); pear-shaped; of medium size, averaging 8 to 10 oz (227-283 g); skin light-green smooth, thin, peels well; flesh pale cream-color, of bland flavor; ripens unevenly with darkening spots; has slight tendency to turn dark when cut; not attractive; of only fair quality; seed large, loose; coat adheres to seed. Season: early fall; short. Tree of medium size; grown commercially only in the San Joaquin Valley because of its cold hardiness.

Many local and introduced cultivars representing all 3 races are being grown and evaluated at the experimental station at Minas Gerais, Brazil. A large collection is also maintained in Bahia. The U.S. Department of Agriculture has an international repository of 170 clones in Miami.

In general, small to medium-sized fruits are best for commercial production and especially for metropolitan markets. Large fruits are suitable for local use especially by large families. Smooth, thin or fairly thin, pliable, green skin is preferred by the consumer. The flesh should be virtually fiberless and of agreeable flavor and, for the dieter, of low oil content. The seed must be small and tight so as not to bruise the flesh during handling and shipping. The seed coats ought to adhere to the seed and not to the cavity. The fruit should ship well and stand cold storage. The tree should be of moderate height, slender enough to permit judiciously close planting without crowding. It should bear at an early age and regularly but not so heavily as to suffer die back, and, of course, should be disease-, insect-, and, in subtropical areas, cold-resistant. Cold-resistant cultivars stand cold-storage better than cold-sensitive cultivars.

Pollination

Many isolated avocado trees fail to fruit from lack of pollination. Commercial growers are careful to match Class A cultivars whose flowers will receive pollen in the morning with Class B cultivars that release pollen in the morning and every grower must be sure to include compatible pollinators in his grove. Bulletin 29 (1971) of the Ministry of Agriculture in Guatemala tabulates the flowering periods (varying from August to April) of 48 introduced and locally selected cultivars, and the hours of the day when each is receptive to or shedding pollen.

Climate

The West Indian race requires a tropical or near tropical (southern Florida) climate and high atmospheric humidity especially during flowering and fruitsetting. The Guatemalan race is somewhat hardier, having arisen in subtropical highlands of tropical America, and it is successful in coastal California. The Mexican race is the hardiest and the source of most of California avocados. It is not suited to southern Florida, Puerto Rico or other areas of similar climate. Temperatures as low as 25ºF (-4ºC) do it little harm. In areas of strong winds, wind-breaks are necessary. Wind reduces humidity, debydrates the flowers and interferes with pollination, and also causes many fruits to fall prematurely.

Soil

The avocado tree is remarkably versatile as to soil adaptability, doing well on such diverse types as red clay, sand, volcanic loam, lateritic soils, or limestone. In Puerto Rico, it has been found healthier on nearly neutral or slightly alkaline soils than on moderately or highly acid soils. The desirable pH level is generally considered to be between 6 and 7, but, in southern Florida, avocados are grown on limestone soils ranging from 7.2 to 8.3. Mexican and Guatemalan cultivars have shown chlorosis on calcareous soils in Israel. The tree's primary requirement is good drainage. It cannot stand excessive soil moisture or even temporary water-logging. Sites with underlying hardpan must be avoided. The water table should be at least 3 ft (.9 m)

below the surface. Salinity is prejudicial but certain cultivars (see 'Fuchs-20' and 'Maoz') have shown considerable salt-tolerance in Israel. Avocados grafted onto 'Fuch-20' rootstocks and irrigated with water containing 380 to 400 ppm C1 performed well in a commercial orchard. In the Rio Grande Valley of Texas, cultivars of the Mexican race must be grafted onto salt tolerant West Indian rootstocks.

Propagation

Normally, avocado seeds lose viability within a month. 'Lula' seeds can be stored up to 5 months if placed in non-perforated polyethylene bags and kept at 40ºF (4.4ºC), thus indicating that it may be possible to successfully store seeds of other cultivars ripening at different seasons for later simultaneous planting. Fresh seeds germinate in 4 to 6 weeks, and many people in metropolitan areas grow avocado trees as novelty house plants by piercing the seed partway through with toothpicks on both sides to hold it on the top of a tumbler with water just covering 1/2 in (1.25 cm) of the base. When roots and leaves are well formed (in 2 to 6 weeks), the plant is set in potting soil. Of course, it must be given adequate light and ventilation. In nurseries, seeds that have been in contact with the soil are disinfected with hot water. Experiments with gibberellic acid and cutting of both ends of the seed with a view to achieving more uniform germination have not produced encouraging results. Seedlings will begin to bear in 4 or 5 years and the avocado tree will continue to bear for 50 years or more. Some bearing trees have been judged to be more than 100 years old.

In Australia, seeds planted in early fall germinate in 4 to 6 weeks; if planted later, they may remain dormant all winter and germinate in early spring. Seedlings should be kept in partial shade and not overwatered. While many important selections have originated from seeds, vegetative propagation is essential to early fruiting and the perpetuation of desirable cultivars. However, seedlings are grown for rootstocks.

For many years, shield budding was commonly practiced in Florida, but this method requires considerable skill and experience and is not successful with all cultivars. Therefore, it was largely replaced by whip, side-, or cleft-grafting, all of which make a stronger union than budding.

In the past, seedlings were grafted when 18 to 36 in (45-90 cm) high. It is now considered far better to graft when 6 to 9 in (15-23 cm) high, making the graft 1 to 3 in (2.5-7.5 cm) above ground level. West Indian rootstocks are desirable for overcoming chlorosis in avocados in Israel.

Avocado cuttings are generally difficult to root. Cuttings of West Indian cultivars will generally root only if they are taken from the tops or side shoots of young seed rings. But etiolated cuttings (new shoots) from gibberellin treated hardwood and semi hardwood cuttings of 'Pollock' as well as 'Lula' have been rooted with 50-60% success and, when treated with IBA, 66-83% success under mist in Trinidad. Cuttings of 'Fuchs-20' have rooted under mist with 40 to 50 or even 70% in Israel. Cuttings of 'Maoz' have rooted at the rate of 60% by a special technique developed in California. An Israeli selection, 'G.A. 13' has given 70 to 90% success in rooting cuttings under mist for the purpose of utilizing them as rootstocks in saline and high lime situations. Air-layering is sometimes done to obtain uniform material uninfluenced by rootstock, for research on specific problems. Degree of success depends on the cultivar (those of the Mexican race rooting most quickly), and air-layering is best done in spring and early summer.

At times, mature avocado groves are top worked to change from an unsatisfactory cultivar, or one declining in popularity, to a more profitable one, or an assortment of cultivars for different markets. In 1957, 2,700 ";obsolete"; avocado trees in Ventura, California, were being grafted (top-worked) to mainly 'Hass', some to 'Bacon' and 'Rincon'. This procedure may involve thousands of trees in a given region. It is done in December and January in Florida.

Inasmuch as avocado roots are sensitive to transplanting, it is now considered advisable to raise planting material in plastic bags which can be slit and set in the field without disturbing the root system.

Spacing

Spacing is determined by the habit of the cultivar and the character of the soil. In light soil, 25 x 25 ft (7.5x7.5 m) may be sufficient. In deep, rich soil, the tree makes its maximum growth and a spacing of 30 or 35 ft (9.1 or 10.7 m) may be necessary. If trees are planted so close that they will ultimately touch each other, the branches will die back. Some growers plant 10 to 15 ft (3-4.5 m) apart initially and remove every other tree at 7 to 8 years of age. If the surplus trees are not bulldozed but just cut down leaving a stump, application of herbicide may be needed to prevent regrowth. Ammonium sulfamate has been proven effective. In modernized plantings, space between rows is necessary for mechanical operations.

Holes at least 2 ft (0. 6 m) deep and wide are prepared well in advance with enriched soil formed into a mound. After the young plant is put in place a mulch is beneficial, weeds should be controlled, and watering is necessary until the roots are well established. Generally small amounts of fertilizer are given every 2 months with the amount gradually increasing until fruiting begins. Bearing trees need, on the average, 3 to 4 lbs (1 1/2-2 kg) 3 times a year, beginning when the tree is making vegetative growth. No fertilizer should be given at blooming time; one must wait until the fruits are firmly set. Nitrogen has the greatest influence on tree growth, its resistance to cold temperatures, and on fruit size and yield. Fertilizer mixes vary greatly with the type of soil. Mineral deficiencies determined by leaf analysis, are usually remedied by foliar spraying. Magnesium deficiency was formerly a serious handicap to avocado growers in Florida and Kenya. In California, zinc deficiency has been corrected by applying zinc chelates or zinc sulfate to the soil instead of spraying the foliage.

Keeping the upper soil moist has been greatly facilitated by drip irrigation, which also may carry 80% of the fertilizer requirement.

Because some cultivars tend to grow too tall for practical purposes, commercial growers cut trees back to 16 or 18 ft (4.8-5.4 m), let them grow back to 30 ft (9.1 m) and top them again. But decapitation is not a perfect remedy because the tendency of the avocado tree is to grow a new top very quickly. Recently it has been found that the growth-inhibiting chemical, TIBA (triiodobenzoic acid) slows down terminal growth and encourages lateral shoots. A system of pruning to encourage lower branching is being tried on 'Lula' in Martinique.

Avocado branches frequently need propping to avoid breaking with the weight of the developing fruits.

Some growers find it profitable to interplant bananas until the avocado trees reach bearing age.

Maturity and Harvesting

Avocados will not ripen while they are still attached to the tree, apparently because of an inhibitor in the fruit stem. Homeowners usually consider the entire crop pickable when a few mature (full grown) fruits have fallen. This is not a dependable guide because the prolonged flowering of the avocado results in fruits in varying stages of development on the tree at the same time. The largest fruits, of course, should be picked first but the problem is to determine when the largest are full grown (perfectly mature for later perfect ripening). If picked when full grown and firm, avocados will ripen in 1 to 2 weeks at room temperature. If allowed to remain too long on the tree, the fruits may be blown down by wind and they will be bruised or broken by the fall.

Florida maturity standards for marketing have been determined by weight and time of year for each commercial cultivar so that immature fruits will not reach the market. Immature fruits do not ripen but become rubbery, shriveled and discolored. Most West Indian cultivars will ripen properly if picked when the specific gravity becomes 0. 96 or lower, but 'Waldin' is fully mature when the specific gravity is still above 0.98. Guatemalan and Guatemalan X West Indian cultivars generally are harvest-mature when the specific gravity is 0.98 or lower. In California, physiological maturity of 'Bacon', 'Fuerte,' 'Hass' and 'Zutano' has been determined by measurement of length, diameter and volume, but dry weight, correlating with oil content, is considered a better maturity index. California law has, since 1925, required a minimum of 8 % oil, but oil content varies greatly among cultivars

and also the climatic region where the fruit is grown. Some people complain that the 8% standard is too low for some cultivars. Maximum flavor of 'Fuerte' develops when the fruit is harvested at an oil content of 16%. Therefore, a minimum dry weight standard of 21 % has been recommended.

Formerly, avocados were detached by means of a forked stick and allowed to fall, but this causes much damage and loss. Nowadays harvesters usually use clippers for lowhanging fruits and for those higher up a long handled picking pole with a sharp ";V"; on the metal rim to cut the stem and a strong cloth bag to catch the fruit. Gloves are worn to avoid fingernail scratches on the fruit. In California, studies have been made of the effects of hand clipping (leaving stem on), hand snapping (which removes the stem), tree-shaking, and limb shaking (which removes the stem from some of the fruits). All methods are acceptable if the stem scar is waxed on stemless fruits to avoid weight loss before ripening at which time the stem detaches naturally. In Australia, some growers are using hydraulic lifts to facilitate hand-picking. A tractor fitted with a triple-decked picking platform has been adopted by some large growers in Chile. Efforts to develop dwarf avocado trees by means of sandwich interstocks from low growing types have been going on in California since 1964.

Avocados must be handled with care and are packed and padded in single or double-layer boxes or cartons for shipment. A special ";Bruce box";, holding 32 lbs (14.5 kg) is used for large fruit. The fruits may be held in position in molded trays.

Yield

It will be seen that the yield varies greatly with the cultivar, age of tree, the locale, weather and other conditions. The small tree, 'Ganter', has yielded 44 lbs (20 kg) annually; 'Nabal', 68 lbs (31 kg); 'Benik', 116 lbs (53 kg); 'Duke', 168 lbs (76 kg), and 'Anaheim', 220 lbs (100 kg). Close-planting in southern Florida provides yields averaging 11,000 lbs per acre (11,000 kg per ha) in young groves and nearly twice this amount is anticipated after the time has come to thin the planting by half.

Girdling has been tested in Florida, Australia and Israel as a means of increasing the yield of shy bearing but popular cultivars. It must be repeated every year to be fully effective. It may decrease the yield of normally fruitful cultivars.

Marketing

Inasmuch as the avocado, outside of Latin America, has been widely regarded as a luxury fruit, large scale marketing has been dependent on consumer education and advertising. Calavo Growers of California is an enterprising association of 2,600 avocado growers. The Mayflower Fruit Association, of which Blue Anchor is a member, packs over 60% of the avocados grown in the San Joaquin Valley. The California Avocado Commission spends millions of dollars in newspaper, magazine, television, radio and other publicity financed by grower assessments. The Florida Lime and Avocado Administrative Committees, together with the Florida Division of Marketing's Bureau of Market Expansion and Promotion, spend about 1/4 million dollars annually for advertising and publicity through the Press and by means of special marketing displays and distribution of recipes. The trademarks, ";Calavo"; and ";Flavocado"; (Florida Avocado Growers Exchange), are recognized nationally and internationally.

The 8% oil standard established in California kept Florida avocados out of the California market until a court decision in 1972 outlawed the discrimination against Florida fruits which average about half the oil content of California cultivars and are advocated by growers as having better flavor and fewer calories. Calavo Growers Cooperative of California now handles 57% of the local avocado crop and 33% of the Florida crop, selling directly to the retail markets. Combined Florida and California efforts have raised the rate of regular avocado consumption in the United States from 6% in the late 1960's to over 15% today. In California, the Avocado Marketing Research Information Center was created in 1983 to gather and report information on production, foreign and domestic shipments and other activities.

Israel makes substantial investments in developing European markets for avocados and has attained the position of principal exporter to Europe. France and the United Kingdom are the chief consumers.

Storage

Ripening of avocados may be hastened by exposure to an atmosphere of at least 10 ppm ethylene 25 to 49 hours after harvest. The avocado does not respond to earlier treatment. Changes in pectinesterase activity and pectin content are being studied to measure ripening of avocados in storage. Dipping in latex has retarded decay in avocados stored at room temperature.

Avocados ship well and are sent to overseas markets under refrigeration in surface vessels. The fruits are subject to chilling injury (dark-brown or gray discoloration of the mesocarp) in refrigerated storage and degree of susceptibility varies with the cultivar and stage at harvesting and length of time in storage. Most commercial cultivars can be held safely at temperatures between 40º and 55ºF (4.5º-12.8ºC) for at least two weeks. The best ripening temperature after removal from storage is 60ºF (15.5ºC).

Removal of ethylene from controlled atmospheric storage (2% oxygen, 10% carbon dioxide) prolongs the marketable life of avocados. Reducing atmospheric pressure to subatmospheric 60 mm Hg in the refrigerated storage unit at 42.8ºF (6ºC) retards ripening of avocados by reducing respiration and ethylene production. Removed after 70 days, fruits have ripened normally at atmospheric pressure and 57.2ºF (14ºC). Experimental calcium treatments have delayed ripening and reduced internal chilling injury in storage but make the fruit externally less attractive and are, therefore, considered commercially undesirable.

'Hass' fruits dipped in fungicide 24 hours after harvest and sealed in polyethylene bags containing an ethylene absorbent (potassium permanganate on vermiculite or on aluminum silicate), have been successfully stored for 40 or 50 days at 50ºF (10ºC). Waxed 'Fuerte' avocados stored for 2 weeks at 41ºF (5ºC) and ripened at 68ºF (20ºC) ripened only 1 day later than non-waxed; however, waxing does reduce weight loss.

In 1965, to overcome the problem of oversupply during the harvesting season and undersupply during the offseason, California adopted liquid-nitrogen freezing of peeled or unpeeled avocado halves, which can be thawed and served as the equivalent of fresh fruits in restaurants, on airplanes and in institutions.

Pests and Diseases

Avocados have no major insect enemies in Florida but migrating cedar waxwings feed on leaves, flowers and very young fruits and the fruits are commonly attacked by squirrels, rats and mice. The avocado red mite, *Oligonychus yothersi*; is the most common predator on the leaves in some groves and not in others. Red-banded thrips, *Selenothrips rubrocinctus*, the greenhouse thrips, *Heliothrips haemorrhoidalis*, and red-spider, *Tetranychus mytilaspidis*, may feed on avocado leaves and blemish the fruits from time to time. There are several scales also which may feed on foliage, especially the Florida wax scale, *Ceroplastes floridensis*, the pyriform, or soft white, scale, *Protopulvinaria pyriformis*, Dictyospermum scale, *Chrysomphalus dictyospermi*; and the black scale, *Saissetia oleae*. Among two dozen other minor pests in Florida are the citrus mealybug, *Pseudococcus citri* and avocado mealybug, *P. nipae*. Stinkbugs may prick the fruits leaving little dents in the skin coupled with gritty areas at the same locations inside.

In California, 2 lepidopterous pests, *Amorbia cuneana* and the omnivorous looper, *Sabulodes aegrotata*, when present in large numbers, cause severe defoliation and fruit-scarring. Biological control is being achieved by release of the egg parasite, *Trichogramma platneri*; which is now commercially available to growers. Since 1949, the orange tortrix (a leaf roller), *Argyrotaenia citrana*, has been increasing as a menace to the avocado in California,

the larvae feeding on twigs, terminal buds and foliage, flowers, and fruits. Since the pest requires shaded areas, it is best controlled by thinning out a close-planted grove or top-working to less susceptible cultivars.

The fruit-spotting bug, *Amblypelta nitida*, and banana spotting bug, *A. Iutescens*, are important pests requiring control in Queensland. The Mediterranean fruit fly is a major hazard in Israel, but very thick-skinned fruits such as 'Anaheim' are not attacked. The Queensland fruit fly, *Dacus tryoni*; seriously damages only Mexican cultivars or Guatemalan X Mexican hybrids in Australia. In 1971, a nematode survey in Bahia, Brazil, revealed 9 genera of known or suspected parasitic nematodes associated with avocado tree decline. Israeli avocado growers are seeking and testing means of biological control of the more serious of the 3 dozen insects and mites preying on the crop in that country. In Mexico, the avocado weevil, *Heilipus lauri*; tunnels into the seeds.

The major disease of avocados in South and Central America and some islands of the West Indies, in California, Hawaii, and various other areas, is root-rot caused by the fungus, *Phytophthora cinnamomi*, which is being combatted by the use of strict sanitary procedures and resistant rootstocks, especially 'Duke'. At the University of California, Riverside, over 750 seedlings and cuttings were being tested for root-rot resistance in 1976 and 1977 and the most promising tried out for grafting compatibility with commercial cultivars. Also, soil fumigation experiments with methyl bromide and newly developed chemicals were being carried forward. The disease has been so devastating in the high rainfall areas of New South Wales and Queensland that plantings have expanded into the semi-arid Murray Valley in the hope of avoiding it. In New Zealand, it is not a problem on deep, volcanic soils, but occurs on shallow, heavier soils. It was allegedly introduced into Chile with balled trees from California and vigorous measures are being taken to control it.

Mushroom root-rot from *Clitocybe tabescens* may occasionally occur. Cercospora spot (brown spots on the leaves and fruits), caused by the fungus, *Cercospora purpurea*, may cause cracks in affected areas of the skin and thus allow entrance of the anthracnose fungus, *Colletotrichum gloeosporioides*, which invades and spoils the flesh. *Glomerella cingulata* is an important source of anthracnose in Queensland. Some cultivars are subject to scab which is readily controlled by copper sprays.

More than 30 other pathogens are variously responsible for wood rot, collar rot, dieback, leafspot, stem-and rot of fruit, branch canker, and powdery mildew. Sunblotch viroid cripples young trees and damages fruits in California and Israel. So far, it is unknown in New Zealand. Stems of young trees may be affected by sunburm, and hot, dry winds cause tipburm of leaves. The avocado tree may show copper or zinc deficiency or tipburm from an excess of mineral salts.

Food Uses

Indians in tropical America break avocados in half, add salt and eat with tortillas and a cup of coffee—as a complete meal. In North America, avocados are primarily served as salad vegetables, merely halved and garnished with seasonings, lime juice, lemon juice, vinegar, mayonnaise or other dressings. Often the halves are stuffed with shrimp, crab or other seafood. Avocado flesh may be sliced or diced and combined with tomatoes, cocumbers or other vegetables and served as a salad. The seasoned flesh is sometimes used as a sandwich filling. Avocado, cream cheese and pineapple juice may be blended as a creamy dressing for fruit salads.

Mexican guacamole, a blend of the pureed flesh with lemon or lime juice, onion juice or powder, minced garlic, chili powder or Tabasco sauce, and salt and pepper has become a widely popular ";dip"; for crackers, potato chips or other snacks. The ingredients of guacamole may vary and some people add mayonnaise.

Because of its tannin content, the flesh becomes bitter if cooked. Diced avocado can be added to lemon-flavored gelatin after cooling and before it is set, and chunks of avocado may be added to hot foods such as soup, stew, chili or omelettes just before serving. In Guatemalan restaurants, a ripe avocado is placed on the table when a hot dish is served and the diner scoops out the flesh and adds it just before eating. For a ";gourmet"; breakfast, avocado halves are warmed in an oven at low heat, then topped with scrambled eggs and anchovies.

In Brazil, the avocado is regarded more as a true fruit than as a vegetable and is used mostly mashed in sherbet, ice cream, or milk shakes. Avocado flesh is added to heated ice cream mixes (such as boiled custard) only after they have cooled. If mashed by hand, the fork must be a silver one to avoid discoloring the avocado. A New Zealand recipe for avocado ice cream is a blend of avocado, lemon juice, orange juice, grated orange rind, milk, cream, sugar and salt, frozen, beaten until creamy, and frozen again.

Some Oriental people in Hawaii also prefer the avocado sweetened with sugar and they combine it with fruits such as pineapple, orange, grapefruit, dates, or banana.

In Java, avocado flesh is thoroughly mixed with strong black coffee, sweetened and eaten as a dessert.

Avocado slices have been pickled and marketed in glass jars. California began marketing frozen guacamole in 1951, and a frozen avocado whip, developed at the University of Miami, was launched in 1955. To help prevent enzymatic browning of these products, it is recommended that sodium bisulfite and/or ascorbic acid be mixed in before freezing.

Avocado Oil

Oil expressed from the flesh is rich in vitamins A, B, G and E. It has a digestibility coefficient of 93.8% but has remained too costly to be utilized extensively as salad oil. The amino acid content has been reported as: palmitic, 7.0; stearic, 1.0; oleic, 79.0; linoleic, 13.0.

The oil has excellent keeping quality. Samples kept in a laboratory in Los Angeles at 40ºF (4.4ºC) showed only slight rancidity after 12 years. There is much interest in the oil in Italy and France. The Institut Francais de Recherches Fruitieres Outre Mer has studied the yield of oil in 25 cultivars. Joint Italian/Venezuelan studies of 5 prominent cultivars indicated that the fatty acid composition and tryglyceride structure was not influenced by variety. The oil is used as hair-dressing and is employed in making facial creams, hand lotions and fine soap. It is said to filter out the tanning rays of the sun, is non-allergenic and is similar to lanolin in its penetrating and skinsoftening action. In Brazil, 30% of the avocado crop is processed for oil, 2\3 of which is utilized in soap, 1/3 in cosmetics. The pulp residue after oil extraction is usable as stockfeed.

Food Value Per 100 g of Edible Portion (Flesh)*

Moisture	65.7-87.7 g
Ether Extract	5.13-19.80 g
Fiber	1.0-2.1 g
Nitrogen	0.130-.382 g
Ash	0.46-1 68 g
Calcium	3.6-20.4 mg

Phosphorus	20.7-64.1 mg
Iron	0.38-1.28 mg
Carotene	0.025-.0475 mg
Thiamine	0.033-0.117 mg
Riboflavin	0.065-0.176 mg
Niacin	0.999-2.220 mg
Ascorbic Acid	4.5-21.3 mg

*Analyses of West Indian, Guatemalen and Mexican avocados marketed in Central America.

Browning of the flesh of freshly cut avocado fruits is caused by polyphenol oxidase isoenzymes. Avocado halves average only 136 to 150 calories.

The avocado has a high lipid content-from 5 to 25% depending on the cultivar. Among the saturated fatty acids, myristic level may be .1%, palmitic, 7.2, 14.1 or 22.1%; stearic, 0.2, 0.6 or 1.7%. Of the unsaturated fatty acids, palmitoleic may range from 5.5 to 11.0%; oleic may be 51.9, 70.7 or 80.97%, linoleic, 9.3, 11.2 or 14.3%. Non saponifiable represents 1.6 to 2.4%. Iodine number is 94.4. In feeding experiments which excluded animal fat, 16 patients were given 1/2 to 1 l/2 avocados per day. Total serum cholesterol and phospholipid values in the blood began to fall in one week. Body weight did not increase. Cholesterol values did not rise and 8 patients showed decreases in total serum cholesterol and phospholipids.

Amino acids of the pulp (N = 16 p. 100) are recorded as: arginine, 3.4; cystine, 0: histidine, 1.8; isoleucine, 3.4; leucine, 5.5; lysine, 4.3;methionine, 2.1; phenylalanine, 3.5; threonine, 2.9; tryptophan, 0; tyrosine, 2.3; valine, 4.6; aspartic acid, 22.6; glutamic acid, 12.3; alanine, 6.0; glycine, 4.0; proline, 3.9; serine, 4.1.

Toxicity

Unripe avocados are said to be toxic. Two resins derived from the skin of the fruit are toxic to guinea pigs by subcutaneous and peritoneal injection. Dopamine has been found in the leaves. The leaf oil contains methyl chavicol. Not all varieties are equally toxic. Rabbits fed on leaves of 'Fuerte' and 'Nabal' died within 24 hours. Those fed on leaves of 'Mexicola' showed no adverse reactions. Ingestion of avocado leaves and/or bark has caused mastitis in cattle, horses, rabbits and goats. Large doses have been fatal to goats. Craigmill *et al*. at Davis, California, have confirmed deleterious effects on lactating goats which were allowed to graze on leaves of 'Anaheim' avocado an hour each day for 2 days. Milk was curdled and not milkable, the animals ground their teeth, necks were swollen and they coughed, but the animals would still accept the leaves on the 4th day of the experiment. By the 10th day, all but one goat were on the road to recovery. All abnormal signs had disappeared 20 days later. In another test, leaves of a Guatemalan variety were stored for 2 weeks in plastic bags and then given to 2 Nubian goats in addition to regular feed over a period of 2 days. Both suffered mastitis for 48 hours. Avocado leaves in a pool have killed the fish. Canaries have died from eating the ripe fruit. The seeds, ground and mixed with cheese or cornmeal, have been used to poison rodents. However, tests in Hawaii did not show any ill effect on a mouse even at the rate of 1/4 oz (7 g) per each 2.2 lbs (1 kg) of body weight, though the mouse refused to eat the dried, grated seed material until it was blended with cornmeal. Avocado seed extracts injected into guinea pigs have caused only a few days of hyperexcitability and anorexia. At Davis, mice given 10 to 14 g of half-and-half normal ration and either fresh or dried avocado seed died in 2 or 3 days, though one mouse given 4 times the dose of the others survived for 2 weeks.

The seed contains 13.6% tannin, 13.25% starch. Amino acids in the seed oil are reported as: capric acid, 0.6; myristic, 1.7; X, 13.5; palmitic, 23.4; X, 10.4; stearic, 8.7; oleic, 15.1; linoleic, 24.1; linolenic, 2.5%. The dried seed contains 1.33% of a yellow wax containing sterol and organic acid. The seed and the roots contain an antibiotic which prevents bacterial spoilage of food. It is the subject of two United States patents.

The bark contains 3.5% of an essential oil which has an anise odor and is made up largely of methyl chavicol with a little anethole.

Other Uses

The seed yields a milky fluid with the odor and taste of almond. Because of its tannin content, it turns red on exposure, providing an indelible red-brown or blackish ink which was used to write many documents in the days of the Spanish Conquest. These are now preserved in the archives of Popayan. The ink has also been used to mark cotton and linen textiles.

In Guatemala, the bark is boiled with dyes to set the color.

Much avocado wood is available when groves are thinned out or tall trees are topped. The sapwood is cream-colored or beige; the heartwood is pale red-brown, mottled, and dotted with small drops of gummy red sap; fine-grained; light—40 lbs per cu ft—(560-640 kg/cu m); moderately soft but brittle; not durable; susceptible to drywood termites and fungi. The wood has been utilized for construction, boards and turnery. An Australian woodworker has reported that it is suitable for carving, resembles White Beech (*Eucalyptus kirtonii*); is easy to work, and dresses and polishes beautifully. He has made it into fancy jewel boxes. It probably requires careful seasoning. A Florida experimenter made bowls of it but they cracked.

Honeybees gather a moderate amount of pollen from avocado flowers. The nectar is abundant when the weather is favorable. When unmixed by that from other sources it produces a dark, thick honey favored by those who like buckwheat honey or sugarcane sirup.

Medicinal Uses: The fruit skin is antibiotic; is employed as a vermifuge and remedy for dysentery. The leaves are chewed as a remedy for pyorrhea. Leaf poultices are applied on wounds. Heated leaves are applied on the forehead to relieve neuralgia. The leaf juice has antibiotic activity. The aqueous extract of the leaves has a prolonged hypertensive effect. The leaf decoction is taken as a remedy for diarrhea, sore throat and hemorrhage; it allegedly stimulates and regulates menstruation. It is also drunk as a stomachic. In Cuba, a decoction of the new shoots is a cough remedy. If leaves, or shoots of the purple-skinned type, are boiled, the decoction serves as an abortifacient. Sometimes a piece of the seed is boiled with the leaves to make the decoction.

The seed is cut in pieces, roasted and pulverized and given to overcome diarrhea and dysentery. The powdered seed is believed to cure dandruff. A piece of the seed, or a bit of the decoction, put into a tooth cavity may relieve toothache. An ointment made of the pulverized seed is rubbed on the face as a rubefacient—to redden the cheeks. An oil extracted from the seed has been applied on skin eruptions.

Related Species

Persea schiedeana Nees, called *coyo*, *coyocte*, *chalte*, *chinini; chucte, chupte, cotyo*, *aguacate de monte, aguacaton*, wild pear, and *yas*, grows wild in mountain forests from southern Mexico to Panama at altitudes between 4,600 and 6,200 ft (1,400-1,900 m). The tree is usually from 50 to 65 ft (15-20 m) tall, occasionally to 165 ft (50 m). Young branches are densely brown-hairy. The leaves are deciduous, obovate to oval, often cordate at the base; 5 to 12 in (12.5-30 cm) long, 2 3/4 to 6 in (7-15 cm) wide, white-hairy on the underside. Downy flowers, borne in densely grayish-hairy panicles, are light greenish-yellow, the perianth and stamens turning red with age. The fruit, resembling that of the avocado and equally variable, is generally pear-shaped, weighing 8 to 14 oz (227-397 g), with thick, leathery, flexible skin. Variously described as brownish-white, light-brown, pale-green, greenish-

brown or dark-brown, the flesh is oily with a milky juice, few to many coarse fibers, but a very appealing, avocado-coconut flavor. The seed is very large. The cotyledons, unlike those of the avocado, are pink internally.

The tree is left standing when forests are cleared and is cultivated in Veracruz and on some farms in Guatemala. The fruits from the best of the wild and cultivated trees are marketed locally. The timber is used in construction and carpentry. This species was introduced into the USA from Guatemala and Honduras in 1948 as a wilt-resistant rootstock for the avocado. It is very sensitive to frost. In 1974 it was reported to be a poor bearer in Puerto Rico.

A more distant relative is *Beilschmiedia anay* Kosterm. (*Huielandia anay* Blake), called *anay, payta, escalalan* or *excalan*, which is native to moist, relatively low altitudes, 985 to 2,300 ft (300 to 700 m) in southern Mexico, Guatemala, Costa Rica and Colombia. Seeds were collected by Dr. Wilson Popenoe in 1917 and seedlings were set out in the Plant Introduction Garden of the U.S. Department of Agriculture, Miami.

The tree attains a height of 66 ft (20 m); the young branches are brown-hairy. Leathery leaves, broad-elliptic or broad-ovate, are 4 3/4 to 12 in (12-30 cm) long and 3 to 7 1/2 in (7.5-19 cm) wide, white-hairy only on the veins. The flowers (in December and January) are fragrant, greenish, in slender panicles to 5 in (13 cm) long. The fruit is ellipsoid-pyriform, 2 3/4 to 6 in (7-15 cm) long, with very thin, glossy, purplish-black skin and sparse green, oily flesh similar to that of the avocado in texture and flavor. The seed is obovoid, up to 2 3\4 in long, with thick, purplish-yellow, red spotted coat, and strong almond odor. In Guatemala, the fruit matures in August and September, falls while hard, and ripens in 2 or 3 days. Analyses in Guatemala show (per 100 g/flesh): moisture, 73.86 g; protein, 1.62-1.80 g; carbohydrates, 3.32-3.90 g; fat, 12.98-17.44 g; cellulose, 2.12 g; ash, 1.38 g.

Food Value Per 100 g of Edible Portion (*flesh*)*

Moisture	76.5-77.6 g
Ether Extract	5.55-7.59 g
Fiber	1.0-1.8 g
Nitrogen	0.191-0.204 g
Ash	0.72-0.91 g
Calcium	11.4-12.5mg
Phosphorus	35.5-36.2 mg
Iron	0.31-0.35 mg
Carotene	0.003-0.033 mg
Thiamine	0.048-0.070 mg
Riboflavin	0.067-0.089 mg
Niacin	0.598-0.718 mg
Ascorbic Acid	5.7-16.4mg

*Analyses by Munsell *et al*.

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