Pineapple

Ananas comosus


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The pineapple is the leading edible member of the family Bromeliaceae which embraces about 2,000 species, mostly epiphytic and many strikingly ornamental. Now known botanically as Ananas comosus Merr. (syns. A. sativus Schult. f., Ananassa sativa Lindl., Bromelia ananas L., B. comosa L.), the fruit has acquired few vernacular names. It is widely called pina by Spanish-speaking people, abacaxi in the Portuguese tongue, ananas by the Dutch and French and the people of former French and Dutch colonies; nanas in southern Asia and the East Indes. In China, it is po-lo-mah; sometimes in Jamaica, sweet pine; in Guatemala often merely "pine".
Description

The pineapple plant is a terrestrial herb 2 1/2 to 5 ft (.75-1.5 m) high with a spread of 3 to 4 ft (.9-1.2 m); a very short, stout stem and a rosette of waxy, straplike leaves, long-pointed, 20 to 72 in (50-180cm) long; usually needle tipped and generally bearing sharp, upcurved spines on the margins. The leaves may be all green or variously striped with red, yellow or ivory down the middle or near the margins. At blooming time, the stem elongates and enlarges near the apex and puts forth a head of small purple or red flowers, each accompanied by a single red, yellowish or green bract. The stem continues to grow and acquires at its apex a compact tuft of stiff, short leaves called the "crown" or "top". Occasionally a plant may bear 2 or 3 heads, or as many as 12 fused together, instead of the normal one.

As individual fruits develop from the flowers they join together forming a cone shaped, compound, juicy, fleshy fruit to 12 in (30 cm) or more in height, with the stem serving as the fibrous but fairly succulent core. The tough, waxy rind, made up of hexagonal units, may be dark-green, yellow, orange-yellow or reddish when the fruit is ripe. The flesh ranges from nearly white to yellow. If the flowers are pollinated, small, hard seeds may be present, but generally one finds only traces of undeveloped seeds. Since hummingbirds are the principal pollinators, these birds are prohibited in Hawaii to avoid the development of undesired seeds. Offshoots, called "slips", emerge from the stem around the base of the fruit and shoots grow in the axils of the leaves. Suckers (aerial suckers) are shoots arising from the base of the plant at ground level; those proceeding later from the stolons beneath the soil are called basal suckers or "ratoons".

Origin and Distribution

Native to southern Brazil and Paraguay (perhaps especially the Parana-Paraguay River) area where wild relatives occur, the pineapple was apparently domesticated by the Indians and carried by them up through South and Central America to Mexico and the West Indies long before the arrival of Europeans. Christopher Columbus and his shipmates saw the pineapple for the first time on the island of Guadeloupe in 1493 and then again in Panama in 1502. Caribbean Indians placed pineapples or pineapple crowns outside the entrances to their dwellings as symbols of friendship and hospitality. Europeans adopted the motif and the fruit was represented in carvings over doorways in Spain, England, and later in New England for many years. The plant has become naturalized in Costa Rica, Guatemala, Honduras and Trinidad but the fruits of wild plants are hardly edible.

Spaniards introduced the pineapple into the Philippines and may have taken it to Hawaii and Guam early in the 16th Century. The first sizeable plantation 5 acres (2 ha)—was established in Oahu in 1885. Portuguese traders are said to have taken seeds to India from the Moluccas in 1548, and they also introduced the pineapple to the east and west coasts of Africa. The plant was growing in China in 1594 and in South Africa about 1655. It reached Europe in 1650 and fruits were being produced in Holland in 1686 but trials in England were not successful until 1712. Greenhouse culture
flourished in England and France in the late 1700's. Captain Cook planted pineapples on the Society Islands, Friendly Islands and elsewhere in the South Pacific in 1777. Lutheran missionaries in Brisbane, Australia, imported plants from India in 1838. A commercial industry took form in 1924 and a modern canning plant was erected about 1946. The first plantings in Israel were made in 1938 when 200 plants were brought from South Africa. In 1939, 1350 plants were imported from the East Indies and Australia. but the climate is not a favorable one for this crop.

Over the past 100 years, the pineapple has become one of the leading commercial fruit crops of the tropics. In 1952-53, world production was close to 1,500,000 tons and reportedly nearly doubled during the next decade. Major producing areas are Hawaii, Brazil, Malaysia, Taiwan, Mexico, the Philippines, South Africa and Puerto Rico. By 1968, the total crop had risen to 3,600,000 tons, of which only 100,000 tons were shipped fresh (mainly from Mexico, Brazil and Puerto Rico) and 925,000 tons were processed. In the period 1961-66, imports of fresh pineapples into Europe rose by 70%. Soon many new markets were opening. In 1973, the total crop was estimated at 4,000,000 tons with 2.2 million tons processed. The increased worldwide demand for canned fruit has greatly stimulated plantings in Africa and Latin America. For years, Hawaii supplied 70% of the world's canned pineapple and 85% of canned pineapple juice, but labor costs have shifted a large segment of the industry from Hawaii to the Philippines. Because production costs in Hawaii (which are 50% labor) have increased 25% or more, Dole has transferred 75% of its operation to the Philippines, where, in 1983, it employed 10,000 laborers on about 25,000, mostly rented, acres (10,117 ha).

Pineapples were first canned in Malaya by a retired sailor in 1888 and exporting from Singapore soon followed. By 1900, shipments reached a half million cases. The industry alternately grew and declined, and then ceased entirely for 3 1/2 years during World War II. The Malaysian Pineapple Industry Board was established in 1959. Thereafter there has been steady progress. The pineapple, was a very minor crop in Thailand until 1966 when the first large cannery was built. Others followed. Since then processing and exporting have risen rapidly. In 1977-78 many farmers switched from sugarcane to pineapple. Of the annual production of 1 1/2 million tons, 1/8 is canned as fruit or Juice.

South Africa produces 2.7 million cartons of canned pineapple yearly and exports 2.4 million. In addition, 31,000 tons of fresh pineapple are sold on the domestic market and 500,000 cartons exported yearly. As in many areas, pineapple culture existed on a small scale on the Ivory Coast until post WW II when cultural efforts were stepped up. By 1950, annual production amounted to 1800 tons. By 1972, it had risen to 200,000 tons for shipment, fresh or canned, to western Europe. Cameroun's annual production is about 6,000 tons.

In the Azores, pineapples have been grown in green-houses for many years for export mainly to Portugal and Madeira. They are of luxury quality, carefully tended and blemish free, graded for uniform size and well padded in each box for shipment.

As of 1971, the ten leading exporters of fresh pineapples were (in descending order): Taiwan (39,621 tons), Puerto Rico, Hawaii, Ivory Coast, Brazil, Guinea, Mexico, South Africa, Philippines and Martinique (5,000 tons). The ten leading exporters of processed pineapples were (in descending order): Hawaii, Philippines, Taiwan, South Africa, Malaysia (Singapore), Ivory Coast, Australia, Ryukyu, Mexico, Thailand (10,500,000 tons).
In Puerto Rico, the pineapple is the leading fruit crop, 95% produced, processed and marketed by the Puerto Rico Land Authority. The 1980 crop was 42,493 tons having a farm value of 6.8 million dollars.

For 250 years, pineapples have been grown in the Bahama Islands. At one time plantings on Eleuthera, Cat Island and Long Island totaled about 12,000 acres. The pineapple was a pioneer crop along the east coast of Florida and or, the Keys. In 1860 fields were established on Plantation Key and Merritt's Island. And in 1876 planting material from the Keys was set out all along the central Florida east coast. Shipping to the North began in 1879. In 1910 there were 5000 to 10,000 acres stretching as far north as Ft. Pierce. There were more than a dozen families raising pineapples on Elliott's Key where an average crop was 50,000 to 75,000 dozen fruits, mostly sent by schooner to New York. When the industry was flourishing, Florida shipped to New York, Philadelphia and Baltimore one million crates of pineapples a year from the sandy ridge along the Indian River. It was believed in those days that the pineapple benefitted by closeness to salt water.

Wood-lath sheds roofed with palmetto fronds, Spanish moss or tobacco cloth were constructed to provide shade which promoted vigorous plant growth and high fruit quality. Wood-burning ovens were scattered through the sheds for frost protection in winter. Small, open boxcars operating on steam or horsepower ran on wooden rails the length of the shed to transport loads of fruit to the packing station. In open fields, plants were sheltered by palmetto fronds from mid-December to mid-March. 'Smooth Cayenne' had to be grown in sheds. It was not successful in the open. One early planter on Eden Island moved his farm to the mainland because bears ate the ripe fruits. With the coming of the railroad in 1894, pineapple growing expanded. The 1908-09 crop was 1,110,547 crates. Then Cuban competition for U.S. markets caused prices to fall and many Florida growers gave up. The ridge pineapple fields began to fail as the humus was exhausted by cultivation. Fertilization was steadily raising the pH too high for the pineapple. World War I brought on a shortage of fertilizer, then several freezes in 1917 and 1918 devastated the industry.

In the early 1930's, the United Fruit Company supplied slips for a new field at White City but the pressure of coastal development soon reduced this to a small patch. Shortly after World War II, a plantation of 'Natal Queen' and 'Eleuthera' was established in North Miami but, after a few years, the operation was shifted inland to Sebring, in Highlands County, Central Florida, where it still produces on a small scale.

Varieties

In international trade, the numerous pineapple cultivars are grouped in four main classes: 'Smooth Cayenne', 'Red Spanish', 'Queen', and 'Abacaxi', despite much variation in the types within each class.

'Smooth Cayenne' or 'Cayenne', 'Cayena Lisa' in Spanish (often known in India, Sri Lanka, Malaysia and Thailand as 'Sarawak' or 'Kew') was selected and cultivated by Indians in Venezuela long ago and introduced from Cayenne (French Guyana) in 1820. From there it reached the Royal Botanical Gardens, Kew, England, where it was improved and distributed to Jamaica and Queensland, Australia. Because of the plants near freedom from spines except for the needle at the leaf tip and the size-4 to 10 lbs (1.8 4.5 kg)-cylindrical form, shallow eyes, orange rind, yellow flesh, low fiber, juiciness and rich mildly acid flavor, it has become of greatest importance worldwide
even though it is subject to disease and does not ship well. Mainly, it is prized for canning, having sufficient fiber for firm slices and cubes as well as excellent flavor.

It was the introduction of this cultivar into the Philippines from Hawaii in 1912 that upgraded the Philippine industry from the casual growing of the semi-wild type which was often seedy. There are several clones of 'Smooth Cayenne' in Hawaii which have been selected for resistance to mealybug wilt. It is the leading cultivar in Taiwan. In 1975, the Queensland Department of Primary Industries, after 20 years of breeding and testing, released a dual purpose cultivar named the 'Queensland Cayenne'. South Africa's Pineapple Research Station, East London, after 20 years of selecting and testing of 'Smooth Cayenne' clones, has chosen 4 as superior especially for the canning industry.

'Hilo' is a variant of 'Smooth Cayenne' selected in Hawaii in 1960. The plant is more compact, the fruit is smaller, more cylindrical; produces no slips but numerous suckers. It may be the same as the 'Cayenne Lisse' strain grown in Martinique and on the Ivory Coast, the fruit of which weighs from 2 to 3 3/4 lbs (1-1 1/2 kg) and has a very small crown.

'St. Michael', another strain of 'Smooth Cayenne' is the famous product of the Azores. The fruit weighs 5 to 6 lbs (2.25-2.75 kg), has a very small crown, a small core, is sweet with low acidity, and some regard it as insipid when fully ripe.

'Giant Kew', well-known in India, bears a large fruit averaging 6 lbs (2.75 kg), often up to 10 lbs (4.5 kg) and occasionally up to 22 lbs (10 kg). The core is large and its extraction results in too large a hole in canned slices.

'Charlotte Rothschild', second to 'Giant Kew' in size in India, tapers toward the crown, is orange-yellow when ripe, aromatic, very juicy. The crop comes in early. 'Baron Rothschild', a Cayenne strain, grown in Guinea, has a smaller fruit 1 3/4 to 5 lbs (0.8-2 kg) in weight, marketed fresh.

'Perolera' (also called 'Tachirense', 'Capachera', 'Motilona', and 'Lebrija') is a 'Smooth Cayenne' type ranking second to 'Red Spanish' in importance in Venezuela. It has long been grown in Colombia. The plant is entirely smooth with no spine at the leaftip. The fruit is yellow, large-7 to 9 lbs (3-4 kg) and cylindrical.

'Bumanguesa', of Venezuela and Colombia, is probably a mutation of 'Perolera'. The fruit is red or purple externally, cylindrical with square ends, shallow eyes, deep-yellow flesh, very slender core but has slips around the crown and too many basal slips to suit modern commercial requirements.

'Monte Lirio', of Mexico and Central America, also has smooth leaves with no terminal spine. The fruit is rounded, white-fleshed, with good aroma and flavor. Costa Rica exports fresh to Europe.

Other variants of 'Smooth Cayenne' include the 'Esmeralda' grown in Mexico and formerly in Florida for fresh, local markets; 'Typhone', of Taiwan; 'Cayenne Guadeloupe', of Guadeloupe, which is more disease resistant than 'Smooth Cayenne'; and 'Smooth Guatemalan' end 'Palin' grown in Guatemala; also 'Piamba da Marquita' of Colombia. Some who have made efforts to classify pineapple strains have proposed grouping all smooth-leaved types under the collective name 'Maipure'. In Amazonas, Venezuela, this name is given to a large plant with smooth leaves stained with red. The fruit has 170 to 190 eyes.
Philipps Platts, a leading pineapple authority, experimented with 60 to 70 cultivars in Florida but 'Red Spanish' proved most dependable. Despite the spininess of the plant, it still is the most popular among growers in the West Indies, Venezuela and Mexico. 'Red Spanish' constitutes 85% of all commercial planting in Puerto Rico and 75% of the production for the fresh fruit market. It is only fair for canning. The fruit is more or less round, orange-red externally, with deep eyes, and ranges from 3 to 6 lbs (1.36-2.7 kg). The flesh is pale-yellow, fibrous, with a large core, aromatic and flavorful. The fruit is hard when mature, breaks off easily and cleanly at the base in harvesting, and stands handling and transport well. It is highly resistant to fruit rot though subject to gummosis.

Two vigorous hybrids of 'Smooth Cayenne' and 'Red Spanish' were developed at the Agricultural Experiment Station of the University of Puerto Rico and released in 1970—'P.R. 1-56' and the slightly larger 'P.R. 1 67', both with good resistance to gummosis and mealybug wilt and of excellent fruit quality. 'P.R. 1 67' averages 5 3/4 lbs (2.5 kg), gives a high yield—32 tons per acre (79 tons/ha). The fruit is sweeter yet with more acidity than 'Red Spanish', less fibrous and good for marketing fresh and for canned juice. It was introduced into Venezuela about 1979 and is grown in the State of Lara.

'Cabezona' ('Bull Head', or 'Pina de ague') is a prominent variant (a natural tetraploid) of 'Red Spanish' long grown in Puerto Rico in the semiarid region of Lajas, to which it is well suited; also in El Salvador. The plant is large, over 3 ft (1 m) high; the leaves are gray-green. The fruit is conical but not as tall as that of 'Valera'; averages 4 to 6 lbs (1.8-2.75 kg) and may reach 18 lbs (8 kg) or more. It is orange-yellow at maturity, has few fibers and sweet-acid flesh. The stem is large and extends up into the base of the fruit and if the fruit is broken off when harvested it leaves a cavity. Consequently, it must be cut with a machete and later trimmed flush with the base in the packing house. It is marketed fresh only. It is resistant to gummosis. Platts reported that it gave a low yield and was disease prone in Florida. There are small plantings in the States of Trujillo and Monagas, Venezuela. It has been cultivated frequently in the Philippines.

'Valera' ('Negrita', or 'Andina'), is an old cultivar originating in Puerto Rico; it is grown in the States of Lara, Merida and Trujillo in Venezuela. It is a small to medium plant with long, narrow, spiny, purple green leaves. The fruit is conical cylindrical, weighing 3 1/2 to 5 1/2 lbs (1.5-2.5 kg); is purple outside with white flesh.
'Valera Amarilla' is a 'Red Spanish' strain grown in the States of Lara and Trujillo in Venezuela. The fruit is broad cylindrical and tall with a large crown; weighs 4 1/2 to 9 lbs (2-4 kg); is yellow externally with very deep eyes, about 72 to 88 in number. The flesh is pale-yellow and very sweet in flavor.

'Valera Roja', grown in Lara, Trujillo and Merida, Venezuela, is a small-to-medium plant with cylindrical fruit 1 1/2 to 2.2 lbs (0.6-1 kg) in weight, reddish externally, with 100 eyes. It has pale-yellow flesh.

'Castilla' is a 'Red Spanish' strain grown in Colombia and El Salvador.

'Cumanesa', supposedly a selection of 'Red Spanish', grown mainly in the State of Sucre, Venezuela, is a medium-sized plant, very spiny, producing an oblong fruit with a large crown. It is orange-yellow externally; weighs 2 to 3 3/4 lbs (0.9-1.70 kg). and has yellowish-white flesh.

'Morada', believed to be a variant of 'Red Spanish', is one of the less important cultivars of Colombia and the State of Monagas, Venezuela. The plant is large, with long, narrow, purple-red leaves. The fruit is broad-cylindrical, purple-red externally, with white flesh.

'Monte Oscuro' ('Pilon'), is a large plant with broad, sawtoothed, spiny-edged leaves. The fruit is barrel-shaped, large, weighing 6.6 lbs (3 kg); has 160-180 medium-deep eyes; is yellow outside with deep-yellow, fibrous flesh. It is grown among Mauritia palms in the State of Monagas, Venezuela.

'Abacaxi' (also called 'White Abacaxi of Pernambuco', 'Pernambuco', 'Eleuthera', and 'English') is well known in Brazil, the Bahamas and Florida. The plant is spiny and disease-resistant. Leaves are bluish-green with red-purple tinge in the bud. The numerous suckers need thinning out. The fruit weighs 2.2 to ll lbs (1-5 kg), is tall and straight-sided; sunburns even when erect. It is very fragrant. The flesh is white or very pale yellowish, of rich, sweet flavor, succulent and juicy with only a narrow vestige of a core. This is rated by many as the most delicious pineapple. It is too tender for commercial handling, and the yield is low. The fruit can be harvested without a knife; breaks off easily for marketing fresh.

'Sugarloaf' (also called 'Pan de Azucar') is closely related to 'Abacaxi', and much appreciated in Central and South America, Puerto Rico, Cuba and the Philippines. The leaves of the plants and crowns pull out easily and this fact gave rise to the unreliable theory that pineapple ripeness is indicated by the looseness of the leaves. The fruit is more or less conical, sometimes round; not colorful; weighs 1 1/2 to 3 lbs (0.68-1.36 kg). Flesh is white to yellow, very sweet, juicy. This cultivar is too tender for shipping.

Among several strains of 'Sugarloaf' are 'Papelon', and 'Black Jamaica', and probably also 'Montufar' ('Sugar Slice' of Guatemala). The latter fruit is green, conical, weighs 2 to 5 1/2 lbs (0.8 2.5 kg); has yellow, very juicy, flesh, sweet yet a little acid. This pineapple also is too tender to ship. There are a number of tropical American cultivars not categorized as to groups, and among them are:
'Brecheche', grown to a limited extent in southern Venezuela, is a small fruit with small, spineless crown. Average weight is 1 1/2 to 2.2 lbs (0.7-1 kg). The fruit is yellow externally. Flesh is yellow, with little fiber, small core, very fragrant, very juicy.

'Caicara', grown to a small extent in the State of Bolivar, Venezuela, is a large fruit weighing 4 to 5 1/2 lbs (1.8-2.5 kg), with a large, spiny crown. It is cylindrical conical with deep eyes; yellow externally with white flesh, a little fiber, very juicy, with large core.

'Chocona' and 'Sante Clara' are cultivars that have been introduced into Trinidad.

'Congo Red' is a plant with bright-red, long-lasting flowers. The fruit bends over and cracks in hot, dry weather. It weighs up to 5 lbs (2.25 kg), is waxy, with yellow flesh of good flavor.

'Panare', named after the tribe of Indians that has grown it for a long time, is commercially grown to a small extent in the State of Bolivar, Venezuela. The plant is of medium size with long, spiny leaves. The fruit is bottle-shaped, small, 1 to 1 1/2 lbs (0.45-0.70 kg), with small crown; ovate, with deep eyes; orange externally with deep-yellow flesh; slightly fragrant, with little fiber and small core.

'Santa Marta' of Colombia, is subject to cracking of the core in hot, dry weather.

In Peru, farmers still grow the old common 'Criolla' because it can be sold fresh and is not easily damaged in shipment. But modern pineapple production in that country depends on the 'Smooth Cayenne' for canning.

Minor cultivars in Colombia include: 'Amarilla de Cambao', 'Amarilla de Tocaima', 'Blanca Chocoana', 'Blanca del Atrato', 'Blanca de Valle del Cauca', 'Cimarrona', 'Espanola de Santander', 'Hartona', 'Jamaiquena' and 'Manzana'.

'Cacho de Venado' is grown to a small extent in Monagas and Sucre, and 'Injerta' in Trujillo, Venezuela.

'Pearl', 'Itaparica', 'Paulista', and 'Maranhao' (or 'Amarella') are spoken of in Brazil; 'Azucaron' in El Salvador; 'Roja' in Mexico. It remains to be determined if some of these names are merely synonyms for cultivars already referred to.

'Mauritius' (also known as 'European Pine', 'Malacca Queen', 'Red Ceylon' and 'Red Malacca') is one of the 2 leading pineapple cultivars in Malaya; also important in India and Ceylon. The leaves are dark green with broad red central stripe and red spines on the margins. The fruit is small, 3 to 5 lbs (1.36-2.25 kg), yellow externally; has a thin core and very sweet flesh. It is sold fresh and utilized for juice.

'Singapore Red' (Also called 'Red Jamaica', 'Singapore Spanish', 'Singapore Queen', 'Singapore Common') is second to 'Mauritius' in popularity. The leaves are usually all-green but sometimes have a reddish stripe near the margins; they are rarely spiny except at the tips. The fruits, cylindrical, reddish, with deep eyes, are small—3 1/2 to 5 lbs (1.6-2.25 kg)—with slender core, fibrous, golden-yellow flesh; insipid raw but valued for canning. The plant is disease and pest-resistant.
The related 'Green Selangor' (also called 'Selangor Green', 'Green Spanish', and 'Selassie') of Malaysia has all-green leaves prickly only at the tips. The flesh is golden-yellow, often with white dots. This cultivar is grown for canning.

'Queen' (also called 'Common Rough' in Australia) is the leading cultivar in South Africa, Queensland and the Philippines. The plant is dwarf, compact, more cold-resistant and more disease-resistant than 'Smooth Cayenne'. It matures its fruit early but suckers freely and needs thinning, and the yield is low. The fruit is conical, deep-yellow, with deep eyes; weighs 1 to 2 1/2 lbs (0.45-1.13 kg); is less fibrous than 'Smooth Cayenne', but more fragrant; it is juicy, of fine flavor with a small, tender core. It is sold fresh and keeps well. It is only fair for canning because of its shape which makes for much waste.

'Natal Queen' of South Africa, also grown in El Salvador, produces many suckers. The fruit weighs 1 1/2 to 2 lbs (0.75-0.9 kg).

'MacGregor', a variant of 'Nasal Queen' selected in South Africa and grown also in Queensland, is a spreading, more vigorous plant with broad leaves and large suckers produced less freely. The fruit is cylindrical, medium to large, with firm flesh and flavor resembling 'Queen'.

'James Queen' (formerly 'Z') is a mutation of 'Nasal Queen' that originated in South Africa. It has larger fruit with square shoulders.

'Ripley' or 'Ripley Queen', grown in Queensland, is a dwarf, compact plant with crimson tinge on leaves; takes 22 weeks from flowering to fruit maturity; is an irregular bearer. The fruit weighs 3 to 6 lbs (1.36-2.7 kg); is pale-copper externally; flesh is pale-yellow, non-fibrous, very sweet and rich. In Florida this cultivar tends to produce suckers without fruiting.

'Alexandria', a selection of 'Ripley Queen' in Queensland, is more vigorous with large suckers and fruit. The fruit is conical, tender, with 'Ripley Queen' flavor.

'Egyptian Queen' was introduced into Florida in 1870. It was popular at first, later abandoned. The fruit weighs 2 to 4 lbs (0.9-1.8 kg).

'Kallara Local' is a little-known cultivar in India. Minor strains in Thailand are 'Pattavia', 'Calcutta', 'Sri Racha', 'Intorachit' and 'Chantabun'.

In the evaluation of pineapples, the crown can be an asset or a liability. Small crowns detract from the decorative appearance of the fruit; large crowns are more attractive but hamper packing and constitute too great a proportion of inedible material from the standpoint of the purchaser.

Climate

The pineapple is a tropical or near tropical plant limited (except in greenhouses) to low elevations between 30°N and 25°S. A temperature range of 65°-95°F (18.33-45°C) is most favorable, though the plant can tolerate cool nights for short periods. Prolonged cold retards growth, delays maturity and causes the fruit to be more acid. Altitude has an important effect on the flavor of the fruit. In Hawaii, the 'Smooth Cayenne' is cultivated from sea level up to 2,000 ft (600 m). At higher elevations the fruit is too acid. In Kenya, pineapples grown at 4500 ft (1371 m) are too sweet for
canning; between 4500 and 5700 ft (1371-1738 m) the flavor is most suitable for canning; above 5700 ft (1738 m) the flavor is undesirably acid. Pineapples are grown from sea level to 7545 ft (2300 m) in Ecuador but those in the highlands are not as sweet as those of Guayaquil.

Ideally, rainfall would be about 45 in (1,143 mm), half in the spring and half in the fall; though the pineapple is drought tolerant and will produce fruit under yearly precipitation rates ranging from 25 to 150 in (650-3,800 mm), depending on cultivar and location and degree of atmospheric humidity. The latter should range between 70 and 80 degrees.

Soil

The best soil for pineapple culture is a well-drained, sandy loam with a high content of organic matter and it should be friable for a depth of at least 2 ft (60 cm), and pH should be within a range of 4.5 to 6.5. Soils that are not sufficiently acid are treated with sulfur to achieve the desired level. If excess manganese prevents response to sulfur or iron, as in Hawaii, the plants require regular spraying with very weak sulfate or iron. The plant cannot stand waterlogging and if there is an impervious subsoil, drainage must be improved. Pure sand, red loam, clay loam and gravelly soils usually need organic enrichment. Filter presscake from sugar mills, worked into clay soils in Puerto Rico, greatly enhances plant vigor, fruit yield, number of slips and suckers.

Propagation

Crows (or "tops"), slips (called nlbs or robbers in New South Wales), suckers and ratoons have all been commonly utilized for vegetative multiplication of the pineapple. To a lesser degree, some growers have used "stumps", that is, mother plant suckers that have already fruited. Seeds are desired only in breeding programs and are usually the result of hand pollination. The seeds are hard and slow to germinate. Treatment with sulfuric acid achieves germination in 10 days, but higher rates of germination (75-90 % ) and more vigorous growth of seedlings results from planting untreated seeds under intermittent mist.

The seedlings are planted when 15-18 months old and will bear fruit 16-30 months later. Vegetatively propagated plants fruit in 15-22 months.

In Queensland, tops and slips from the summer crop of 'Smooth Cayenne' are stored upside down, close together, in semi-shade, for planting in the fall. Some producers salvage the crowns from the largest grades of fruits going through the processing factory to be assured of high quality planting material.

South African experiments with 'Smooth Cayenne' have shown medium-size slips to be the best planting material. Next in order of yield were large crowns, medium-size suckers, medium-size crowns and large suckers. Medium and large suckers, however, fruited earlier. Trimming of basal leaves increased yields. Workers in Johore, Malaya, report, without specifying cultivar, that large crowns give highest yield and more slips, followed by small crowns, big slips, small slips, large and small suckers in descending order.
With the 'Red Spanish' in Puerto Rico, the utilization of large slips for planting in the first quarter of the year, medium slips during the next six months, and small slips in the final quarter, provides fruits of the maximum size over an extended period of harvest. Storage of slips until optimum planting time prevents premature bloom and diminished fruit size.

The 'Red Spanish' reaches shipping-green stage (one week before coloring begins) in Puerto Rico 150 days after natural blooming.

In South Africa the 'Queen' is grown mainly from stumps, secondly from suckers. The stumps which have fruited are detached from the mother plant as soon as possible to avoid their developing suckers of their own. In comparison with suckers, the stumps are consistently heavier in yield after the 4th crop. When suckers are used, those of medium size, approximately 18 in (45 cm) long, planted shallow and upright, yield best.

In the past, growers preferred plants that supplied abundant basal slips for planting, not recognizing the fact that such plants gave smaller fruits than those without slips or suckers. Also, breeders aim toward elimination of slips to facilitate harvesting. Because of the increased demand for planting material, a new method of mass propagation received wide attention in 1960. During the harvest, plants that have borne single-crowned, superior fruits without basal slips are selected and marked. Following harvest, these plants are cut close to the ground, the leaves are stripped off and the stems—usually 1 to 2 ft (30-60 cm) long and 3 to 4 in (7.5-10 cm) thick—are sliced lengthwise into 4 triangular strips. The strips are disinfected and placed 4 in (10 cm) apart, with exterior side upward, in beds of sterilized soil, semi-shaded and sprinkler-irrigated. Shoots emerge in 3 to 5 weeks and are large enough to transplant to the nursery in 6 to 8 weeks. 'Smooth Cayenne' yields an average of 3 shoots per slice. 'Red Spanish' and 'Natal Queen', 4 per slice.

This use of the stem is a major improvement over the former practice of allowing it to develop suckers high up after the fruit is harvested. If such suckers bear fruit in situ they are not strong enough to support it and collapse. They are better removed for planting, but repeated removal of suckers weakens the mother plant.

In Sri Lanka, the shortage of planting material inspired experiments at first utilizing stem cross-sections 1 in (2.5 cm) thick—15 to 24 from each stem. These sprouted in 4 weeks but plant growth was slow and fruiting was delayed for 30 months. Most of the cuttings developed a single sprout, some as many as 5, others, none at all. Accordingly, this technique was abandoned in favor of a system developed for purposes of reproducing a selected strain in Hawaii. Stems are cut into segments bearing 3 to 5 whorls of leaves. The leaves are trimmed to 4 to 5 in (10-12.5 cm) and the disinfected cuttings set upright in beds until each gives rise to one strong plantlet which is then transferred to the nursery.

The butts, or bases, of mother plants, with leaves intact, are laid end to end in furrows in nurseries and covered with 2 to 3 in (5-7.5 cm) of soil. Sprouting occurs in 6 to 8 weeks. The butts give an average of 6 suckers each, though some have put forth up to 25. A one-acre (0.4 ha) nursery of 25,000 butts, therefore, yields between 100,000 and 200,000 suckers.
The Pineapple Research Institute in Hawaii has also employed axillary buds at the base of crowns. Each crown segment may develop 20 plantlets. This method has been adopted in Sri Lanka for perpetuating superior strains but not for commercial cultivation because the resulting plants require 24 months or more to fruit.

In India, because of low production of slips and suckers in 'Smooth Cayenne', crown cuttings (15-16 per crown) have been adopted for propagation with 95% success, and this method is considered more economical than the utilization of butts.

Vegetative propagation does not assure facsimile reproduction of pineapple cultivars, as many mutations and distinct clones have occurred in spite of it.

**Culture**

The land should be well prepared at the outset because the pineapple is shallow-rooted and easily damaged by post-planting cultivation. Fumigation of the soil contributes to high quality and high yields.

**Planting:** In small plots or on very steep slopes, planting is done manually using the traditional short-handled narrow-bladed hoe, the handle of which, 12 in (30 cm) long, is used to measure the distance between plants. Crowns are set firmly at a depth of 2 in (5 cm); slips and suckers at 3 1/2 to 4 in (9 10 cm). Butts, after trimming and drying for several days, are laid end-to-end in furrows and covered with 4 in (10 cm) of soil.

Double-rowing has been standard practice for many years, the plantlets set 10 to 12 in (25 30 cm) apart and staggered, not opposite, in the common rows, and with 2 ft (60 cm) between the two rows. An alley 3, 5 1/2 or 6 ft (.9, 1.6 or 1.8 m) wide is maintained between the pairs, allowing for plant populations of 17,400, 15,800 or 14,500 per acre (42,700, 37,920 or 33,800 per ha) respectively. Close spacing gives highest total crop weight—e.g., 18,000 plants/acre = 28.8 tons (43,200 plants/ha = 69.12 tons). However, various trials have shown that overcrowding has a negative effect, reducing fruit size and elongating the form undesirably, and it reduces the number of slips and suckers per plant. Density trials with 'P.R. 1-67' in Puerto Rico demonstrated that 21,360 plants per acre (51,265/ha) yielded 35.8 tons/acre (86 tons/ha) in the main crop and 18.9 tons/acre (45.43 tons/ha) in the ratoon crop, but only one slip per plant for replanting. Excessively wide spacing tends to induce multiple crowns in 'Smooth Cayenne' in Hawaii and in 'Red Spanish' in Puerto Rico.

Some plantings are mulched with bagasse. In large operations, asphalt-treated paper, or black plastic mulch is regarded as essential. It retards weeds, retains warmth in cool seasons, reduces loss of soil moisture, and can be laid by machines during the sterilization and pre-fertilization procedures. Mulch necessitates removal of basal leaves of crowns, slips and suckers and the use of a tool to punch a hole at the pre-marked planting site for the insertion of each plantlet. The mulch is usually rolled onto rounded beds 3 1/4 ft (1 m) wide.

**Mechanical planting:** Research on the potential of machines to replace the hard labor of planting pineapples was begun in Hawaii in 1945. A homemade device was first employed in Queensland in 1953. Early semi-mechanical planters were self propelled platforms with driver and two men who made the holes in the mulch and set the plants in place. With a 2-row planter, 3 men can set 7,000 plants per hour of operation. Frequent stops are necessary to reload with planting material. With
improved equipment, mechanical planting has become standard practice in large plantations everywhere. The most sophisticated machines have attachments which concurrently apply premixed fertilizer and lay a broad center strip of mulch, set the plantlets along each edge, and place a narrow strip along the outer sides. The only manual operation, apart from driving, is feeding of the plantlets to the planting unit. With this system, up to 50,000 plants have been set out per day.

**Fertilization:** Nitrogen is essential to the increase of fruit size and total yield. Fertilizer trials in Kenya show that a total of 420 lbs N/acre (471.7 kg/ha) in 4 equal applications during the first year is beneficial, whereas no advantage is apparent from added potassium and, phosphorus. Puerto Rican studies have indicated that maximum yields are achieved by urea sprays supplying 147 lbs N/acre (151 kg/ha). In Queensland, total yield of mother plants and ratoons was increased 8% by urea spraying. Normal rate of application is 3 1/2 gals (13.3 liters) per 1,000 plants. On acid Bayamon sandy clay in Puerto Rico, addition of magnesium to the fertilizer mix or applying it as a spray (300 lbs magnesium sulfate per acre—327 kg/ha) increased yield by 3 tons/acre (7 tons/ ha). On sloping, stony clay loam high in potassium, Queensland growers obtained high yields of 'Smooth Cayenne' from side dressings of NPK mixture 5 times a year. On poor soils, nitrogen and potassium levels of the plants may become low toward the end of the crop season. This must be anticipated early and suitable adjustments made in the application of nutrients. Potassium uptake is minimal after soil temperatures drop below 68°F (20°C). On fine sandy loam in Puerto Rico, the cultivar 'P.R. 1-67' performed best with 13-3-12 fertilizer applied at the rate of 1.5 tons/acre (3.74 tons/ha). In this expertmeet, 13,403 plants/acre (32,167/ha) produced 9,882 fruits/acre (23,717/ha), weighing 31.28 tons/acre (75 tons/ha). In Venezuela, 6,250 medium-size fruits per acre (15,000 fruits/ha) is considered a very good crop.

Fruit weight has been considerably increased by the addition of magnesium. In Puerto Rican trials, magnesium treatment resulted in 54% more total weight providing an average of 2.7 more tons/acre (64.8 tons/ha) than in control plots. Fruit size and total yield have been enhanced by applying chelated iron with nitrogen; also, where chlorosis is conspicuous, by accompanying nitrogen with foliar sprays of 0.10% iron and manganese.

Some growers thin out suckers and slips to promote stronger growth of those that remain.

**Irrigation:** Irrigation is desirable only in dry seasons and should not exceed 1 in (2.5 cm) semi-monthly.

**Weed Control:** Manual weeding in pineapple fields is difficult and expensive. It requires protective clothing and tends to induce soil erosion. Coir dust has been used as mulch in Sri Lanka to discourage weeds but it has a deleterious effect on the crop, delaying or preventing flowering. The use of paper or plastic mulch and timely application of approved herbicides are the best means of preventing weed competition with the pineapple crop.

**Flower Induction:** Pineapple flowering may be delayed or uneven, and it is highly desirable to attain uniform maturity and also to control the time of harvest in order to avoid overproduction in the peak periods. In 1874 in the Azores it was accidentally discovered that smoke would bring pineapple plants into bloom in 6 weeks. The realization that ethylene was the active ingredient in the smoke led to the development of other methods.
As far back as 1936, compressed acetylene gas, or a spray of calcium carbide solution (which generates acetylene) were employed to expedite uniform blooming. Some growers have merely deposited calcium carbide in the crown of each plant to be dissolved by rain. A more advanced method is the use of the hormone, \textit{a}-naphthaleneacetic acid (ANA) or \textit{B} naphylacetic acid (BNA) which induce formation of ethylene. In recent years, \textit{B}-hydroxyethyl hydrazine (BOH) came into use. Treatment is given when the plants are 6 months old, 3 months before natural flowering time. The plants should have reached the 30 leaf stage at this age.

Spraying of a water solution of ANA on the developing fruit has increased fruit size in 'Smooth Cayenne' in Hawaii and Queensland. In West Malaysia, spraying 'Singapore Spanish' 6 weeks after flowering with Planofix, an ANA-based trade product, delayed fruit maturity, increased fruit size, weight and acidity. Similar results have been seen after hormone treatment of 'Cayenne Lisse' on the Ivory Coast.

Trials with 'Sugarloaf' in Ghana showed calcium carbide and BOH equally effective on 42-to 46-week-old plants, and Ethrel performed best on 35-to 38-week-old plants. 'Sugarloaf' seems to respond 10 days earlier than 'Red Spanish'.

Ethrel, or the more recently developed Ethephon, applied at the first sign of fruit ripening in a field will cause all the fruit to ripen simultaneously. It brings the ratoons into fruit quickly. There is a great saving in harvesting costs because it reduces the need for successive pickings.

Plants treated with naphthaleneacetic acid produce long, cylindrical, pointed fruits, maturing over an extended period of time, ripening first at the base while the apex is still unripe. Ethylene treatment results in a square shouldered, shorter fruit maturing over a shorter period and ripening more uniformly.

In Puerto Rico, treatment in 'Cabezona' can be done to induce flowering at any time of the year.

**Pests**

Nematodes (\textit{Rotylenchulus}, \textit{Meloidogyne}, \textit{Pratylenchus}, \textit{Ditylenchus}, \textit{Helicotylenchus}, and other genera) cause stunting and degeneration in pineapple plants unless soil is fumigated. In Queensland, nematicides have increased yields by 22-40%. Crop rotation has been found effective in Puerto Rico. Turning the field over to Pangola grass (\textit{Digitaria decumbens} Stent.) or green foxtail grass (\textit{Setaria viridis} Beauv.) for 3 years suppresses nematode populations and benefits the soil but may not be practicable unless spare land is available for pineapple culture in the interim.

Mealybugs (\textit{Pseudococcus brevipes} and \textit{P. neobrevipes}) attack leaf bases and cause wilt. The leaves turn orange-brown and wither due to root rot. Prevention requires spraying and dusting to control the fire ants (\textit{Solenopsis} spp. ) which carry the mealybugs from diseased to healthy plants. Control is difficult because there are many weeds and other local plants acting as mealybug hosts. Some success was achieved in Florida in combatting mealybugs with the parasitic wasp, \textit{Hambletonia pseudococcia}a Comp., though the general use of insecticides limits the activity of the wasp.

The pineapple mite, or so-called red spider (\textit{Dolichote-tranychus} (or \textit{Stigmacus}) floridanus (Banks) also attacks leaf bases and is troublesome during prolonged droughts, heavily infesting the slips. The pineapple red scale (\textit{Diaspis bromeliae}) has been a minor pest in Florida. Since 1942 this scale
has spread to many pineapple districts in southeastern Queensland, with occasional serious infestations. Natural predators afford about 40% control. The palmetto beetle (*Rhynchophorus cruentatus*), which feeds on palm logs, enters the bud and lays eggs in young fruits and the fruit stalk.

The sap beetle (*Carpophilus humeralis*) is one of the main enemies of pineapple fruits in Puerto Rico, Hawaii and Malaysia and is especially attracted to fruits affected by gummosis. Populations have been diminished by sanitary procedures and growing of cultivars resistant to gummosis, and chemical control is being evaluated.

In Brazil, larvae of the large moth, *Castnia licus*, and of the butterfly, *Thecla basilides*, damage the fruit. The latter is a problem in other parts of tropical America also and in Trinidad.

Cutworms eat holes in the base of the immature fruit. Fruit fly larvae do not pupate in 'Smooth Cayenne' but new hybrids lack resistance and may require treatment.

In New South Wales, poison baits are employed to combat fruit damage by crows, rats and mice. Rats may eat the base of the stem and destroy ratoons and suckers. Rabbits in winter eat the leaves as high as they can reach.

**Diseases**

In Queensland, top rot and root rot are caused by the soil fungi *Phytophthora cinnamomi* and *P. nicotianae* var. *parasitica* which are most prevalent in prolonged wet weather in autumn and winter. Improved drainage helps reduce the risk and monthly spraying with fungicide gives good control. *P. cinnamomi* may also cause rot in green fruit on ratoons. These diseases are largely prevented by the use of paper or plastic mulch on raised beds.

Base rot is caused by the fungus *Ceratocystis paradoxa*, especially where drainage is poor. The imperfect form (conidial state) of this fungus, known as *Thielaviopsis paradoxa*, causes butt rot in planting material, also soft rot or breakdown of fruits during shipment and storage. If 1/4-ripe 'Red Spanish' fruits are kept at temperatures between 44.6° and 46.4°F (7°-8°C) while in transit, soft rot will not develop.

*Fusarium* spp. in the soil are the source of wilt. Black heart is a physiological disorder not visible externally, usually occurring in winter particularly in locations where air flow is inadequate. Highest incidence in West Africa has been reported in midsummer. It begins as "endogenous brown spot" at the base of the fruitless close to the core. Later, affected areas merge. It has been attributed to chilling or low light intensity from dense planting or cloudiness. It can be controlled by one-day heat treatment at 90° to 100°F (32°-38°C) before or after refrigerated storage. In 1974, the microorganism *Erwinia chrysanthemi* was identified in Malaya as the cause of bacterial heart rot and fruit collapse.

Yellow spot virus on leaves is transmitted by *Thrips tabaci* Lind. Black speck and water blister are mentioned among other problems of the pineapple.
A condition called Crookneck is caused by zinc deficiency. It occurs mainly in plants 12-15 months old but is also frequent in suckers. The heart leaves become curled and twisted, waxy, brittle, and light yellowish-green. Sometimes the plant bends over and grows in a nearly horizontal position. Small yellow spots appear near the edges of the leaves and eventually merge and form blisters. Later, these areas become grayish or brownish and sunken. Treatment is usually a 1% solution of zinc sulfate. Many growers use a combined spray of 10% urea, 2% iron sulfate and 1% zinc sulfate. If burning occurs, the proportion of urea should be changed to 5%. Excessive use of urea for this or any other purpose can lead to leaf tip dieback and yellowing of older leaves due to the biuret content in urea.

Copper deficiency is evident in concave leaves with dead tips and waxiness without bloom on the underside.

Sunburn or sunscald develops when fruits fall over and expose one side to the sun, though 'Abacaxi' may sunburn even when erect. Affected fruits soon rot and become infested with pests. They must be cut as soon as noticed and safely disposed of where they will not contaminate other fruits. Dry grass, straw, excelsior or brown paper sleeves may be placed over fruits maturing in the summer to prevent sunburn.

**Harvesting**

It is difficult to judge when the pineapple is ready to be harvested. The grower must depend a great deal on experience. Size and color change alone are not fully reliable indicators. Conversion of starch into sugars takes place rapidly in just a few days before full maturity. In general, for the fresh fruit market, the summer crop is harvested when the eye shows a light pale green color. At this season, sugar content and volatile flavors develop early and steadily over several weeks. The winter crop is about 30 days slower to mature, and the fruits are picked when there is a slight yellowing around the base. Even then, winter fruit tends to be more acid and have a lower sugar level than summer fruit, and the harvest period is short. Fruits for canning are allowed to attain a more advanced stage. But overripe fruits are deficient in flavor and highly perishable.

Maturity studies conducted with 'Giant Kew' in India showed that highest quality is attained when the fruit is harvested at a specific gravity of 0.98-1.02, total soluble solids of 13.8-17%, or total soluble solids/acid ratio of 20.83-27.24 with development of external yellow color. Some people judge ripeness and quality by snapping a finger against the side of the fruit. A good, ripe fruit has a dull, solid sound; immaturity and poor quality are indicated by a hollow thud.

In manual harvesting, one man cuts off or breaks off the fruits (depending on the cultivar) and tosses them to a truck or passes them to 2 other workers with baskets who convey them to boxes in which they are arranged with the stems upward for the removal of bracts and application of a 3% solution of benzoic acid on the cut stem of all fruits not intended for immediate processing. The harvested fruits must be protected from rain and dew. If moist, they must be dried before packing. All defective fruits are sorted out for use in processing.

If the work is semi-mechanized, the harvesters decrown and trim the fruits and place them on a 30-ft conveyor boom which extends across the rows and carries the fruits to a bin on a forklift which loads it onto a truck or trailer. Some conveyors take the fruits directly into the canning factory from the field. In most regions of the world, pineapples are commonly marketed with crowns intact, but
there is a growing practice of removing the crowns for planting. For the fresh fruit market, a short section of stem is customarily left on to protect the base of the fruit from bruising during shipment.

Total mechanical harvesting is achieved by 2 hydraulically operated conveyors with fingers on the top conveyor to snap off the fruit, the lower conveyor carrying it away to the decrowners. After the fruit has been conveyed away, the workers go through the field to collect the crowns (where they have been left on the tops of the plants) and place them on the conveyors for a trip to the bins which are then fork lifted and the crowns dumped into a planting machine.

**Life of plantation**

In Florida, 'Abakka' fields were maintained for 2, 3, or 4 crops. Some plantings of 'Red Spanish' were prolonged for 25-26 years. In current practice, after the harvesting of the first crop, workers trim off all but 2 ratoons which will bear fruit in 15-18 months. Perhaps there may be a second or third ratoon crop. Then the field is cleared to minimize carryover of pests and diseases. The method will vary with the interest in or practicality of making use of by products. In Malaya, fields have been cleared by cutting the plants, leaving them to dry for 12-16 weeks, then piling and burning. Spraying with kerosene or diesel fuel makes burning possible in 9 weeks. Spraying with Paraquat allows burning in 3 weeks but does not destroy the stumps which take 3-5 months to completely decay while new plants are set out between them.

Field practices will differ if pineapples are interplanted with other crops. In Malaya, pineapples have been extensively grown in young rubber plantations. In India and Sri Lanka the pineapple is often a catchcrop among coconuts. Venezuelan farmers may interplant with citrus trees or avocados.

**Storage**

Cold storage at a temperature of 40°F (4.44°C) and lower causes chilling injury and breakdown in pineapples. At 44.6-46.4°F (7-8°C) and above, 80-90% relative humidity and adequate air circulation, normal ripening progresses during and after storage. At best, pineapples may be stored for no more than 4-6 weeks. There is a possibility that storage life might be prolonged by dipping the fruits in a wax emulsion containing a suitable fungicide. Irradiation extends the shelf life of half-ripe pineapples by about one week.

**Food Uses**

In Puerto Rico and elsewhere in the Caribbean, Spaniards found the people soaking pineapple slices in salted water before eating, a practice seldom heard of today.

Field ripe fruits are best for eating fresh, and it is only necessary to remove the crown, rind, eyes and core. In Panama, very small pineapples are cut from the plant with a few inches of stem to serve as a handle, the rind is removed except at the base, and the flesh is eaten out-of-hand like corn on the cob. The flesh of larger fruits is cut up in various ways and eaten fresh, as dessert, in salads, compotes and otherwise, or cooked in pies, cakes, puddings, or as a garnish on ham, or made into sauces or preserves. Malayans utilize the pineapple in curries and various meat dishes. In the Philippines, the fermented pulp is made into a popular sweetmeat called *nata de pina*. The pineapple does not lend itself well to freezing, as it tends to develop off flavors.
Canned pineapple is consumed throughout the world. The highest grade is the skinned, cored fruit sliced crosswise and packed in sirup. Undersize or overripe fruits are cut into "spears", chunks or cubes. Surplus pineapple juice used to be discarded after extraction of bromelain (q.v.). Today there is a growing demand for it as a beverage. Crushed pineapple, juice, nectar, concentrate, marmalade and other preserves are commercially prepared from the flesh remaining attached to the skin after the cutting and trimming of the central cylinder. All residual parts cores, skin and fruit ends are crushed and given a first pressing for juice to be canned as such or prepared as sirup used to fill the cans of fruit, or is utilized in confectionery and beverages, or converted into powdered pineapple extract which has various roles in the food industry. Chlorophyll from the skin and ends imparts a greenish hue that must be eliminated and the juice must be used within 20 hours as it deteriorates quickly. A second pressing yields "skin juice" which can be made into vinegar or mixed with molasses for fermentation and distillation of alcohol.

In Africa, young, tender shoots are eaten in salads. The terminal bud or "cabbage" and the inflorescences are eaten raw or cooked. Young shoots, called "hijos de pina" are sold on vegetable markets in Guatemala.

Food Value Per 100 g of Edible Portion*

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<tr>
<td>Moisture</td>
<td>81.3-91.2 g</td>
<td>Ether Extract</td>
<td>0.03 0.29 g</td>
<td>Crude Fiber</td>
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<tr>
<td>Nitrogen</td>
<td>0.038-0.098 g</td>
<td>Ash</td>
<td>0.21-0.49 g</td>
<td>Calcium</td>
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<tr>
<td>Phosphorus</td>
<td>6.6-11.9 mg</td>
<td>Iron</td>
<td>0.27-1.05 mg</td>
<td>Carotene</td>
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<tr>
<td>Thiamine</td>
<td>0.048 0.138 mg</td>
<td>Riboflavin</td>
<td>0.011-0.04 mg</td>
<td>Niacin</td>
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<tr>
<td>Ascorbic Acid</td>
<td>27.0-165.2 mg</td>
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*Analyses of ripe pineapple made in Central America.

Sugar/acid ratio and ascorbic acid content vary considerably with the cultivar. The sugar content may change from 4% to 15% during the final 2 weeks before full ripening.
Toxicity

When unripe, the pineapple is not only inedible but poisonous, irritating the throat and acting as a drastic purgative.

Excessive consumption of pineapple cores has caused the formation of fiber balls (bezoars) in the digestive tract.

Other Uses

**Bromelain:** The proteolytic enzyme, bromelain, or bromelin, was formerly derived from pineapple juice; now it is gained from the mature plant stems salvaged when fields are being cleared. The yield from 368 lbs (167 kg) of stern juice is 8 lbs (3.6 kg) of bromelain. The enzyme is used like papain from papaya for tenderizing meat and chill proofing beer; is added to gelatin to increase its solubility for drinking; has been used for stabilizing latex paints and in the leather-tanning process. In modern therapy, it is employed as a digestive and for its anti-inflammatory action after surgery, and to reduce swellings in cases of physical injuries; also in the treatment of various other complaints.

**Fiber:** Pineapple leaves yield a strong, white, silky fiber which was extracted by Filipinos before 1591. Certain cultivars are grown especially for fiber production and their young fruits are removed to give the plant maximum vitality. The 'Perolera' is an ideal cultivar for fiber extraction because its leaves are long, wide and rigid. Chinese people in Kwantung Province and on the island of Hainan weave the fiber into coarse textiles resembling grass cloth. It was long ago used for thread in Malacca and Borneo. In India the thread is prized by shoemakers and it was formerly used in the Celebes. In West Africa it has been used for stringing jewels and also made into capes and caps worn by tribal chiefs. The people of Guam hand-twist the fiber for making fine casting nets. They also employ the fiber for wrapping or sewing cigars. Pina cloth made on the island of Panay in the Philippines and in Taiwan is highly esteemed. In Taiwan they also make a coarse cloth for farmers' underwear.

The outer, long leaves are preferred. In the manual process, they are first decorticated by beating and rasping and stripping, and then left to ret in water to which chemicals may be added to accelerate the activity of the microorganisms which digest the unwanted tissue and separate the fibers. Retting time has been reduced from 5 days to 26 hours. The rested material is washed clean, dried in the sun and combed. In mechanical processing, the same machine can be used that extracts the fiber from sisal. Estimating 10 leaves to the lb (22 per kg), 22,000 leaves would constitute one ton and would yield 50-60 lbs (22-27 kg) of fiber.

**Juice:** Pineapple juice has been employed for cleaning machete and knife blades and, with sand, for scrubbing boat decks.

**Animal Feed:** Pineapple crowns are sometimes fed to horses if not needed for planting. Final pineapple waste from the processing factories may be dehydrated as "bran" and fed to cattle, pigs and chickens. "Bran" is also made from the stumps after bromelain extraction. Expendable plants from old fields can be processed as silage for maintaining cattle when other feed is scarce. The silage is low in protein and high in fiber and is best mixed with urea, molasses and water to improve its nutritional value.
In 1982, public concern in Hawaii was aroused by the detection of heptachlor (a carcinogen) in the milk from cows fed "green chop" leaves from pineapple plants that had been sprayed with the chemical to control the ants that distribute mealybugs. There is supposed to be a one year lapse to allow the heptachlor to become more dilute before sprayed plants are utilized for feed.

**Folk Medicine:** Pineapple juice is taken as a diuretic and to expedite labor, also as a gargle in cases of sore throat and as an antidote for seasickness. The flesh of very young (toxic) fruits is deliberately ingested to achieve abortion (a little with honey on 3 successive mornings); also to expel intestinal worms; and as a drastic treatment for venereal diseases. In Africa the dried, powdered root is a remedy for edema. The crushed rind is applied on fractures and the rind decoction with rosemary is applied on hemorrhoids. Indians in Panama use the leaf juice as a purgative, emmenagogue and vermifuge.

**Ornamental Value**

The pineapple fruit with crown intact is often used as a decoration and there are variegated forms of the plant universally grown for their showiness indoors or out. Since 1963, thousands of potted, ethylene treated pineapple plants with fruits have been shipped annually from southern Florida to northern cities as indoor ornamentals.

Last updated: 8/20/2011 by ch

Ref.: [http://www.hort.purdue.edu/newcrop/morton/pineapple.html](http://www.hort.purdue.edu/newcrop/morton/pineapple.html)