

The Encyclopedia of Fruit & Nuts

Edited by

Jules Janick

*Department of Horticulture and Landscape Architecture
Purdue University
West Lafayette, Indiana, USA*

and

Robert E. Paull

*Department of Tropical Plant and Soil Sciences
University of Hawai'i at Manoa
Honolulu, Hawai'i, USA*



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Asimina triloba pawpaw

The North American pawpaw, *Asimina triloba* (L.) Dunal, grows wild as an understorey tree or thicket-shrub in mesic hardwood forests ranging from northern Florida to southern Ontario (Canada) and as far west as eastern Nebraska. Fruit (100–1000 g) may be borne singly or in clusters, are highly nutritious, have a strong aroma and a unique flavour that resembles a combination of banana, mango and pineapple. This oblong-shaped fruit has both fresh market and processing potential.

Pawpaws have a well-established place in folklore and American history. The traditional American folk song, ‘Way down, yonder in the pawpaw patch’ was quite popular at one time and autumn hunting for pawpaw in the woods is a cherished tradition for many rural families in the eastern USA. The first report of pawpaw dates back to 1541 when followers of the Spanish explorer Hernando de Soto found Native Americans growing and eating pawpaws in the valley of the Mississippi. The Native Americans used the bark of pawpaw trees to make fishing nets. Daniel Boone and Mark Twain were reported to have been pawpaw fans. Lewis and Clark, the explorers who between 1804 and 1806 successfully crossed America from St Louis to the mouth of the Columbia River, recorded in their journal (18 September 1806) how pawpaws helped save them from starvation. Several American towns, townships, creeks and rivers were named after the pawpaw during the 19th century. Interest in pawpaw as a fruit crop was evident in the early 1900s, however, the rapid perishability of the fruit is likely to have decreased interest in pawpaw. Interest in pawpaw did grow in the years between 1950 and 1985. Recently, there has been developing interest in pawpaw as a gourmet food.

World production

Although pawpaw has great potential for commercial production, orchard plantings remain limited. Currently, most pawpaw fruit for sale are collected from wild stands in the forest. However, in a number of states in the USA small private orchards, usually less than 1 ha in size, have been planted. There are also pawpaw plantings in Italy, China, Israel, Japan, Romania, Belgium and Portugal. In the USA, pawpaw fruit and products are mainly sold at farmers' markets, directly to restaurants and via entrepreneurs on the Internet. However, at present the grower base is insufficient to establish a commercial processing industry.

Uses and nutritional composition

Pulp from fruit can be eaten fresh or processed. The flavour of the fruit can intensify as it over-ripens, as with banana, resulting in pulp that is excellent for use in cooking. The seeds and skin are generally not eaten. Local delicacies made from fruit pulp include ice cream, compote, jam, pies, custards and wine. The pawpaw fruit has a high nutritional value (Table A.37). Pawpaw and banana are similar in dietary fibre content and overall nutritive composition. The highly perishable nature of the fruit can limit the available supply.

Botany

TAXONOMY AND NOMENCLATURE The pawpaw, *A. triloba*, is a member of the mostly tropical custard apple family, *Annonaceae*, which is the largest primitive family of flowering plants. This family includes several delicious tropical fruit such as the custard apple (*Annona reticulata* L.), cherimoya (*Annona cherimola* Mill.), sweetsop or sugar apple (*Annona squamosa* L.), atemoya (*A. squamosa* × *A. cherimola*) and soursop (*Annona muricata* L.). The genus *Asimina* is the only temperate-zone representative of the tropical *Annonaceae*, and includes nine species, most of which are native to the extreme south-eastern regions of Florida and Georgia. The North American native pawpaw (*A. triloba*) produces the largest fruit, has the most northerly and largest native range and the greatest commercial potential of the *Asimina* genus. Pawpaw is also a common name for papaya (*Carica papaya*), a tropical fruit in the family *Caricaceae*. The two fruits are genetically unrelated, but some pawpaws do have a papaya-like flavour.

DESCRIPTION Pawpaw is a moderately small, deciduous tree or shrub that flourishes in the deep, rich fertile soils of river-bottom lands of the forest understory. Trees may attain 5–10 m in height and are usually found in patches, due to root suckering. In sunny locations, trees typically assume a pyramidal habit, with a straight trunk and lush, dark green, long, drooping leaves (Fig. A.7 E). Leaves occur alternately, are obovate-oblong in shape, glabrous, with a cuneate base, acute midrib, and may be 15–30 cm long and 10–15 cm wide. Vegetative and flower buds occur at different nodes on the stem, the flower buds being basipetal. Vegetative buds are narrow and pointed, and the flower buds are round and covered with a dark-brown pubescence.

The dark maroon-coloured flowers of the pawpaw are hypogynous and strongly protogynous. Flowers are pendant or

Table A.37. Nutritional composition of pawpaw^a per 100 g (Source: Peterson *et al.*, 1982; Jones and Layne, 1997).

Proximal analysis	g
Food energy (kcal)	80
Protein	1.2
Total fat	1.2
Carbohydrate	18.8
Dietary fibre	2.6
Vitamins	mg
Vitamin A RE ^b	8.6
Vitamin A IU ^c	87
Vitamin C	18.3
Thiamine	0.01
Riboflavin	0.09
Niacin	1.1
Minerals	mg
Potassium	345
Calcium	63
Phosphorus	47
Magnesium	113
Iron	7
Zinc	0.9
Copper	0.5
Manganese	2.6
Essential amino acids	mg
Histidine	21
Isoleucine	70
Leucine	81
Lysine	60
Methionine	15
Cystine	4
Phenylalanine	51
Tyrosine	25
Threonine	46
Tryptophan	9
Valine	58

^a Pawpaw analysis was done on pulp with skin, although the skin is not considered edible. Probably much of the dietary fibre, and possibly some of the fat, would be thrown away with the skin.

^b RE, Retinol equivalents – these units are used in the Recommended Dietary Allowances table (National Research Council, 1989).

^c IU, International units.

nodding, with sturdy pubescent peduncles up to 4 cm long (Fig. A.7 B). The mature flowers have an outer and inner whorl of three, maroon-coloured, three-lobed petals reaching up to 5 cm in diameter (Fig. A.7 A). The inner petals are smaller and fleshier, with a nectary band at the base. The flower has a fetid aroma. Flowers have a globular androecium and a gynoecium usually composed of three to seven carpels resulting in three to seven fruited clusters; up to nine-fruited clusters have been noted (Fig. A.7 C). Flowers emerge before leaves in spring (about April in Kentucky). Pawpaw blossoms occur singly on the previous year's wood.

Pawpaw's custard apple-like fruit are berries. The fruit have an oblong shape, green skin, a pleasant but strong aroma when

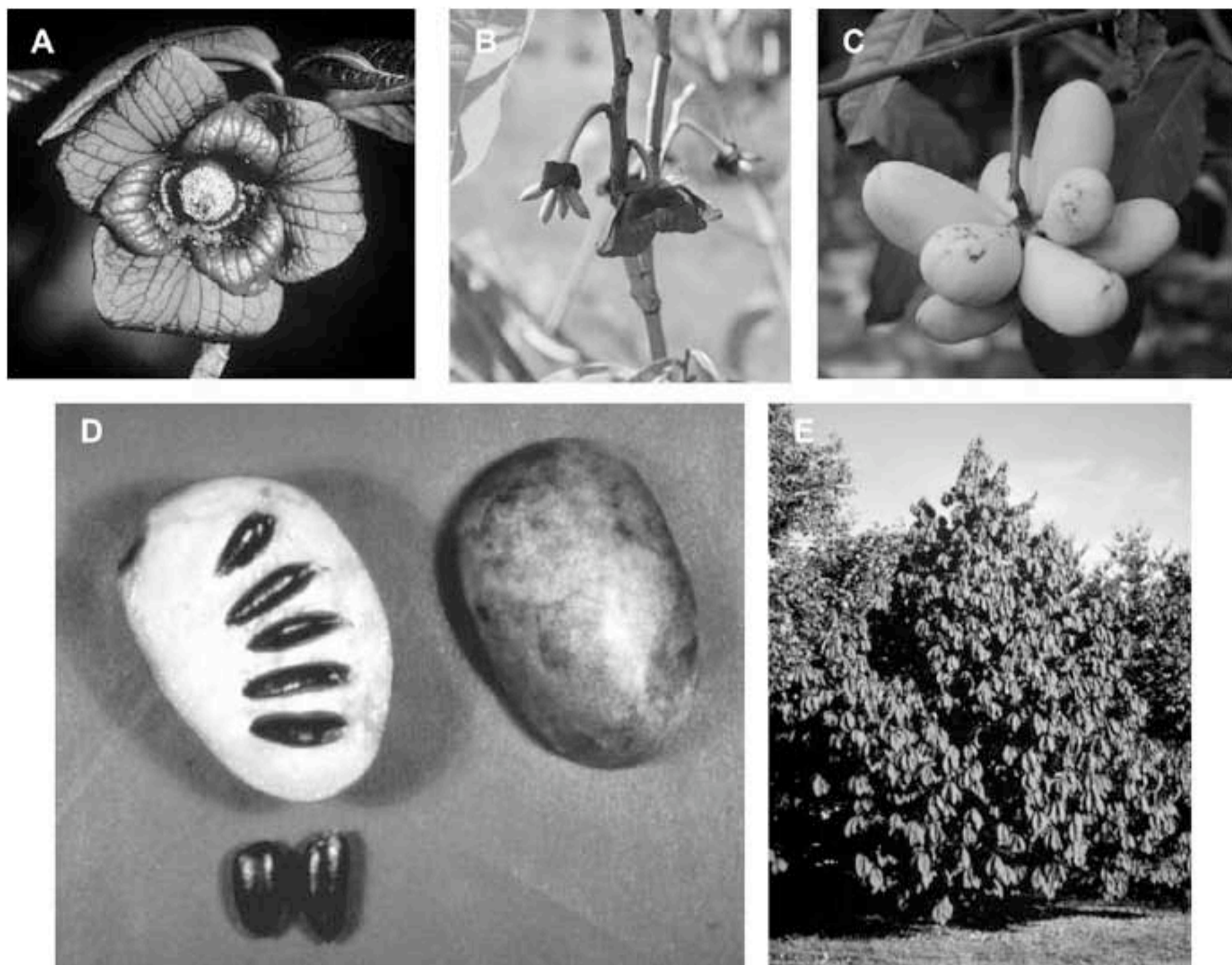


Fig. A.7. (A) Mature flower with an outer and inner whorl of three maroon-coloured, three-lobed petals; (B) a mature pawpaw flower and developing cluster from an earlier flower; (C) pawpaw cluster with ripe fruit; (D) a fruit cut open lengthwise and seeds removed; and (E) a pawpaw tree showing natural pyramidal growth habit in a full sun exposure.

ripe, and intense flavour (Fig. A.7 C, D). However, flavour varies among cultivars, with some fruit displaying complex flavour profiles. Fruit from poor quality pawpaw genotypes can have a mushy texture, lack sweetness and have an overly rich flavour with turpentine or bittersweet aftertaste; many wild pawpaws have poor eating quality. Fruit from superior genotypes have a firm texture, a delicate blend of flavours, are rich but not cloying, and have no bitter aftertaste. The flavour of a pawpaw fruit can intensify when it over-ripens, as with banana, resulting in pulp that is excellent for use in cooking. The fruit are oblong-cylindrical, typically 3–15 cm long, 3–10 cm wide and weigh from 100 to 1000 g. They may be borne singly or in clusters which resemble the ‘hands’ of a banana plant. In the fruit, there are two rows of seeds (12–20 seeds) that are brown and bean shaped and that may be up to 3 cm long. The seeds and skin of the fruit are generally not eaten. The endosperm of the seeds contain alkaloids that are emetic and if chewed may impair mammalian digestion. Pawpaw fruit allergies have been reported in some people.

REPRODUCTIVE BIOLOGY Flowers are strongly protogynous and are predominantly self-incompatible, although the pawpaw cultivar ‘Sunflower’ may be self-fruitful. Pollination is by flies (Diptera) and beetles (Nitidulidae), and possibly other nocturnal insects. Seedlings normally begin to flower upon reaching about 1.8 m in height, but may not set fruit; cropping is achieved at 5–8 years of age. Grafted pawpaw trees often flower within 3 years of planting, but often fail to set fruit at that time. This may be due to inadequate pollination or inadequate canopy to support fruit development. Grafted trees usually begin reliable fruit production at 5–6 years of age.

For an individual tree, the bloom and pollination period may last from 3 to 4 weeks. There is also cultivar variation for bloom date that may be related to chilling hour requirement. As a result, harvest for an individual tree may be extended over a 3–4 week period. Thus, multiple harvests are necessary depending on fruit ripeness. Each fruit cluster develops from an individual flower, and fruit within a cluster develop and

often ripen at different times (Fig. A.7 C). In cultivation, pawpaw yields per tree are often low. Yields for mature grafted trees in the seventh year can average between 2.0 and 6.5 kg/tree, depending on the cultivar. The tropical *Annonaceae* relatives of the pawpaw, such as cherimoya, sweetsop (sugar apple), soursop and atemoya also have low yields, due to low rates of natural pollination. Pawpaws in the wild often have poor fruit set due to low light levels in the understory and pollinator limitation. Pawpaws in the wild often produce many root suckers that could potentially result in large clonal patches contributing to poor fruit set because of self-incompatibility. Fruit set can be improved by hand cross-pollination and it is likely this could be used to improve yields.

FRUIT GROWTH AND DEVELOPMENT Fruit increase in size during the course of spring and summer, ripening in late summer or early autumn. Pawpaw fruit ripening is characterized by an increase in soluble solids concentration (up to 20%), flesh softening, increased volatile production and, in some genotypes, a decline in green colour intensity of the skin. Within 3 days after harvest, ethylene and respiratory climacteric peaks are clearly evident as pawpaw fruit rapidly soften. A common practice to determine maturity is to touch each fruit to determine if it is ready to harvest; ripe softening pawpaw fruit yield to slight pressure, as ripe peaches do, and can be picked easily with a gentle tug. Thus, fruit are harvested when they have already begun ripening and have lost some firmness.

Horticulture

PROPAGATION The pawpaw produces a relatively large, flat seed with a dark brown fibrous seedcoat. Seed can be collected from fruit when the flesh is soft or over-ripe. Pawpaw has moderately recalcitrant seed that does not tolerate desiccation, and it only has a relatively short period of viability at room temperature. As little as 5 days under open-air conditions can reduce the moisture content of pawpaw seeds to 5% and result in total loss of viability. Pawpaw seed requires stratification for optimal germination. Pawpaw seeds must be stored moist at chilling temperature (5°C) to overcome embryo dormancy. Seed can be stored in moist peat moss in ziplock bags for 2–3 years at 5°C and maintain a high germination percentage. Storing pawpaw seed in a freezer (-15°C) will kill the embryo and make the seed not viable.

Stratified seed can be sown in a well-aerated potting substrate with a high sphagnum peat moss component (> 75% by volume), cation exchange capacity and water-holding capacity. Tall containers should be used to accommodate the developing taproot of seedlings. Because pawpaw has a coarse fibrous root system that is quite fragile, most commercial nurseries propagate pawpaw in containers rather than in a nursery bed. Although some commercial nurseries sell bare-root trees grown in nursery beds, we do not recommend this practice. Transplant shock is common with bare-root trees and field establishment is usually poor. Young pawpaw seedlings are sensitive to excessive ultraviolet (UV) light and can be damaged under full sun conditions. If growing seedlings outside, the plants should be kept in moderate shade their first year (we use 55% shade cloth) for maximum growth of the

plant. Seedlings will grow well in whitewashed or even unshaded greenhouses. Plants in their second year of growth outside do not require shading and will grow nicely in full sun provided water is not limiting.

Chip-budding and whip-and-tongue grafting are the two most reliable means to clonally propagate pawpaw. Winter collected, dormant budwood should have its chilling requirement fulfilled. Chip budding and grafting are most successful when the seedling rootstock is at least 0.5 cm diameter and actively growing. Bud take exceeding 90% can be obtained. Clonal propagation of pawpaw by other methods such as root cuttings or softwood cuttings has been unsuccessful. Clonal propagation of pawpaw by tissue culture has been attempted using various explant sources of different physiological ages. The primary limitation in tissue culture is the inability of explants to form roots.

ROOTSTOCKS Currently, pawpaw cultivars with superior fruit characteristics are propagated by grafting and budding onto seedling rootstocks. No clonal rootstocks are available for pawpaw.

TRAINING AND PRUNING Present recommendations for pawpaw plantings are 2.4 m within rows and 3.7–4.6 m between rows. Row orientation should be north–south if possible. Shading of pawpaw in the field the first year is recommended and can be accomplished by installing translucent double-walled polyethylene ‘tree-tubes’ around each tree, securing them with bamboo stakes. However, trees taller than 45 cm at planting do not require shading. During warm summer temperatures (> 35°C), the tubes should be removed from the trees, otherwise foliage within tubes can become heat-stressed and desiccated. Weed control is important to limit competition and improve establishment, but there are no herbicides currently recommended for use on pawpaw. Mulching with straw or other organic material can be used to limit weed growth in the tree row. When natural rainfall is inadequate, supplemental irrigation can substantially improve tree survival rates.

Most pawpaw genotypes naturally develop a strong central leader. The growth habit is similar to that of ‘Bradford’ pear, a popular ornamental tree in the USA. Trees should not be headed at planting and no pruning is required in the first year. Branches can often develop narrow crotch angles in relation to the trunk. Training to more horizontal scaffold limbs increases scaffold strength and reduces limb breakage that may occur under heavy crops or during ice storms. Pruning is conducted in late winter–early spring and consists of removing low branches to a height 60–90 cm on the trunk.

THINNING Pawpaw fruit set can often be low, but some growers do practise hand thinning of fruit to increase fruit size.

FERTILIZATION Fertilization requirements have not been determined for bearing pawpaw trees. However, trees provided with water-soluble fertilizer (20N-8.6P-16.6K) plus soluble trace elements once in May, June and July during active growth have achieved 30–45 cm of shoot extension each year in Kentucky. Excellent growth has been achieved with

granular ammonium nitrate fertilizer (34N-0P-0K) broadcast under pawpaw trees in early spring at 30–60 g N/tree applied before budbreak.

DISEASES AND PESTS Pawpaws have few disease problems; however, leaves can exhibit leaf spot, principally a complex of *Mycocentrospora aiminae*, *Rhopaloconidium asiminae* Ellis and Morg. and *Phyllosticta asiminae* Ellis and Kellerm. At orchards in Oregon (outside pawpaw's native range), vascular wilt-like symptoms have been observed in the spring after pawpaw trees have leafed out. The pawpaw peduncle borer (*Talponia plummeriana* Busck) is a small moth whose 5 mm-long larva burrows into the fleshy tissues of the flower causing the flower to wither and drop. The zebra swallowtail butterfly (*Eurytides marcellus*), whose larvae feed exclusively on young pawpaw foliage, will damage leaves, but this damage has been negligible in plantings. The larvae of a leafroller (*Choristoneura parallela* Robinson) may also damage flowers and leaves. Deer will not generally eat the leaves or twigs, but they will eat fruit that has dropped on the ground. Occasionally, male deer will rub their antlers on young trees, scraping off bark and occasionally breaking off branches. Japanese beetles (*Popillia japonica* Newman) occasionally feed on young foliage and can damage pawpaw trees.

Biologically active compounds known as annonaceous acetogenins have been extracted from pawpaw twigs and have potential as human medications and botanical pesticides. About 250 of these compounds have been isolated and characterized. Three of these compounds, bullatacin, bulletin and bullanin have high potencies against human cancer cells *in vitro*. Dr Jerry McLaughlin of Nature's Sunshine Products (Spanish Fork, Utah) has developed a commercial head-lice-removal shampoo from pawpaw. Botanically derived pesticides that are environmentally compatible and biologically degradable may also be obtained from pawpaw because the annonaceous acetogenins are toxic to several economically important insect species.

HANDLING AND POSTHARVEST STORAGE Pawpaw fruit soften rapidly at room temperature after harvest. At room temperature, very soft ripe fruit have a shelf life of 2–3 days while those fruit that are just beginning to soften have a shelf life of 5–7 days. Fruit that have just begun to soften can be stored for 1 month at 4°C with little change in fruit firmness and they will ripen normally when returned to room temperature. Hard immature fruit will not ripen, even if treated with ethephon. Because fruit are non-uniform in size and shape, packaging that minimizes bruising during shipping needs to be developed.

MAIN CULTIVARS AND BREEDING Efforts to domesticate the pawpaw began early in the 20th century. In 1916, a contest to find the best pawpaw was sponsored by the American Genetics Association. This contest generated much interest and the sponsors thought that with time and 'intelligent breeding' commercial quality varieties could be developed and an industry begun. However, an industry did not develop. Pawpaw enthusiasts noted that the rapid perishability of pawpaw fruit was the major factor inhibiting commercialization.

Beginning in the 20th century, elite pawpaw selections from the wild were assembled in extensive collections by various enthusiasts and scientists, including Benjamin Buckman (Farmington Illinois, c. 1900–1920), George Zimmerman (Linglestown, Pennsylvania, 1918–1941), and Orland White (Blandly Experimental Farm, Boyce, Virginia, 1926–1955). From about 1900–1960, at least 56 clones of pawpaw were selected and named. Fewer than 20 of these selections remain, with many being lost from cultivation through neglect, abandonment of collections, and loss of records necessary for identification. Since 1960, additional pawpaw cultivars have been selected from the wild or developed as a result of breeding efforts of hobbyists. More than 40 clones are currently available (Table A.38). From 1995 to 1999, Kentucky State University (KSU) and the PawPaw Foundation (PPF) established a Pawpaw Regional Variety Trial (PRVT) with 28

Table A.38. Commercially available pawpaw cultivars (Source: descriptions derived from Jones and Layne, 1997; Jones *et al.*, 1998; and unpublished data of K. Pomper)^a.

Cultivar	Description ^b
'Adam's Secret'	From Pennsylvania, large fruit, few seeds, skin remains green when ripe
'Blue Ridge'	Selected in Kentucky by Johnny Johnson; has white-fleshed fruit
'Collins'	Selected in Georgia
'Convis'	Selected from Corwin Davis orchard. Large-size fruit, yellow flesh; ripens first week of October in Michigan
'Davis'	Selected from the wild in Michigan by Corwin Davis in 1959. Introduced in 1961 from Bellevue, Michigan. Medium-size fruit, up to 12 cm long; green skin; yellow flesh; large seed; ripens first week of October in Michigan; keeps well in cold storage.
'Duckworth A'	Low-chill cultivar selected in San Mateo, Florida by Eric Duckworth, seedling of Louisiana native parent; tree with pyramidal shape
'Duckworth B'	Low-chill cultivar selected in San Mateo, Florida by Eric Duckworth, seedling of Louisiana native parent; grows no larger than a shrub
'Estil'	Selected by Nettie Estil in Frankfort, Kentucky. Large fruit, smooth-textured flesh
'Ford Amend'	Selected from wild seedling of unknown parentage by Ford Amend around 1950. Introduced from Portland, Oregon. Medium-size fruit and earlier than 'Sunflower'; ripens late September in Oregon; greenish-yellow skin; orange flesh
'G-2'	Selected from G.A. Zimmerman seed by John W. McKay, College Park, Maryland, in 1942
'Glaser'	Selected by P. Glaser of Evansville, Indiana. Medium-size fruit
'IXL'	Hybrid of 'Overleese' and 'Davis'; large fruit, yellow flesh; ripens second week of October in Michigan
'Jack's Jumbo'	Selected in California from Corwin Davis seed; large fruit

Cultivar	Description ^a
'Kirsten'	Hybrid seedling of 'Taytwo' × 'Overleese'; selected by Tom Mansell, Aliquippa, Pennsylvania
'LA Native'	From LA, blooms late in Tennessee, small fruit, somewhat frost hardy
'Little Rosie'	Selected by P. Glaser of Evansville, Indiana. Has small fruit. Reported to be an excellent pollinator
'Lynn's Favorite'	Selected from Corwin Davis orchard. Yellow fleshed, large fruit; ripens second week of October in Michigan
'M-1'	Selected from 'G-2' seed by John W. McKay, College Park, Maryland, in 1948
'Mango'	Selected from the wild in Tifton, Georgia, by Major C. Collins in 1970. Vigorous growth
'Mary Foos Johnson'	Selected from the wild in Kansas by Milo Gibson. Seedling donated to North Willamette Experimental Station, Aurora, Oregon, by Mary Foos Johnson. Large fruit; yellow skin; butter-coloured flesh; few seeds; ripens first week of October in Michigan
'Mason/WLW'	Selected from the wild in Mason, Ohio, by Ernest J. Downing in 1938
'Middletown'	Selected from the wild in Middletown, Ohio, by Ernest J. Downing in 1915. Small-size fruit
'Mitchell'	Selected from the wild in Jefferson Co., Illinois, by Joseph W. Hickman in 1979. Medium-size fruit, slightly yellow skin, golden flesh, few seeds
'NC-1'	Hybrid seedling of 'Davis' × 'Overleese'; selected by R. Douglas Campbell, Ontario, Canada, in 1976. Large fruit; few seeds; yellow skin and flesh; thin skin; early ripening, 15 September in Ontario and early September in Kentucky
'Overleese'	Selected from the wild in Rushville, Indiana, by W.B. Ward in 1950. Large fruit; few seeds; bears in clusters of three to five; ripens first week of October in Michigan and early September in Kentucky
'PA-Golden 1'	Selected as seedling from seed originating from George Slate collection by John Gordon, Amherst, New York. Early cropping. Medium-size fruit, yellow skin, golden flesh; matures late August in Kentucky and mid-September in New York
'PA-Golden 2'	Selected as seedling from seed originating from George Slate collection by John Gordon, Amherst, New York. Fruit: yellow skin, golden flesh; matures mid-September in New York
'PA-Golden 3'	Selected as seedling from seed originating from George Slate collection by John Gordon, Amherst, New York. Fruit: yellow skin, golden flesh; matures mid-September in New York
'PA-Golden 4'	Selected as seedling from seed originating from George Slate collection by John Gordon, Amherst, New York. Fruit: yellow skin, golden flesh; matures mid-September in New York
'Prolific'	Selected by Corwin Davis, Bellevue, Michigan, in mid-1980s. Large fruit; yellow flesh; ripens first week of October in Michigan
'Rebecca's Gold'	Selected from Corwin Davis seed, Bellevue, Michigan, by J.M. Riley in 1974. Medium-size fruit; kidney-shaped; yellow flesh
'Ruby Keenan'	Medium-size fruit with excellent flavour
'SAA-Overleese'	Selected from 'Overleese' seed by John Gordon, Amherst, New York, in 1982. Large fruit; rounded shape; green skin; yellow flesh; few seeds; matures in mid-October in New York
'SAA-Zimmerman'	Selected as seedling from seed originating from G.A. Zimmerman collection by John Gordon, Amherst, New York, in 1982. Large fruit; yellow skin and flesh; few seeds
'Silver Creek'	Selected from the wild in Millstedt, Illinois, by K. Schubert. Medium-size fruit
'Sue'	Selected in southern Indiana. Medium-size fruit, yellow flesh, skin yellow when ripe
'unflower'	Selected from the wild in Chanute, Kansas, by Milo Gibson in 1970. Tree reported to be self-fertile. Large fruit; yellow skin; butter-coloured flesh; few seeds; ripens early to mid-September in Kentucky and the first week of October in Michigan
'Sunglo'	Yellow skin, yellow flesh, large fruit that ripens first week of October in Michigan
'Sweet Alice'	Selected from the wild in West Virginia by Homer Jacobs of the Holden Arboretum, Mentor, Ohio, in 1934
'Taylor'	Selected from the wild in Eaton Rapids, Michigan, by Corwin Davis in 1968. Small fruit; bears up to seven fruit in a cluster; green skin; yellow flesh; ripens first week of October in Michigan
'Taytwo'	Selected from the wild in Eaton Rapids, Michigan, by Corwin Davis in 1968. Sometimes spelled 'Taytoo'. Small fruit; light-green skin; yellow flesh; ripens first week of October in Michigan
'Tollgate'	Yellow fleshed, large fruit that ripens first week of October in Michigan
'Wells'	Selected from the wild in Salem, Indiana, by David Wells in 1990. Small- to medium-size fruit; green skin; orange flesh. Ripens mid- to late September in Kentucky
'White'	Selected in Kentucky by Johnny Johnson; has white-fleshed fruit
'Wilson'	Selected from the wild on Black Mountain, Harlan Co., Kentucky, by John V. Creech in 1985. Small fruit; yellow skin; golden flesh
'Zimmerman'	Selected in New York from G.A. Zimmerman seed by George Slate

^aDescriptions come from a wide variety of sources and most of the cultivars have not been compared for performance side by side at one geographic site.

^bFruit size categories of small, medium and large are < 100 g, 100–150 g and > 150 g, respectively.

clones at 13 sites across the USA. Cultivars being tested include 'Middletown', 'Mitchell', 'NC-1', 'Overleese', 'PA-Golden 1', 'Rappahannock', 'Shenandoah', 'Sunflower', 'Susquehanna', 'Taylor', 'Taytwo', 'Wells' and 'Wilson'. The other 15 clones were selections from the PPF breeding effort. Tree survival, trunk cross-sectional area, fruit size and taste, flesh-to-seed ratio, resistance to pests and diseases, and overall productivity on a year-to-year basis are among the attributes being evaluated. The pawpaw cultivars 'PA-Golden 1', 'Overleese', 'NC-1', 'Sunflower', 'Shenandoah' and 'Susquehanna' have performed well in Kentucky, have excellent fruit size and flavour, and are recommended for planting in the south-eastern USA. Complete results from the PRVT and additional regional recommendations will be available in a few years.

Kirk W. Pomper and Desmond R. Layne

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Rollinia mucosa biriba

Biriba tree, *Rollinia mucosa* (Jacq.) Baill. (*Annonaceae*), is considered to have been cultivated in pre-Columbian times and is now widely grown throughout the Amazon region. It is also found in north-eastern Brazil, the Antilles and other parts of the Caribbean. The fruit is appropriate for the fresh fruit market, with prices varying according to size. The species is an excellent alternative to diversify fruit gardens and to supply the demand motivated mainly by originality of the native fruit. Moreover it is an important genetic resource for its natural genetic variability, which can be used in domestication studies, for selection of superior genotypes or as a source of genes for related species.

The species is most commonly known as biriba. Other names include biribazeiro, biriba-de-pernambuco or fruta-de-condessa (Brazil); anon (Peru); chirimoya (Ecuador); mulato (Colombia); sinon (Venezuela); anona babosa or zambo (Mexico); cachiman morveusc, cachiman coehon or cachiman montagne (Guadalupe); cachiman or anon cimamon (Puerto Rico); anonillo (Panama); candongo or anona (Dominican Republic); and wild sugar apple (English).

World production and yield

In Central Amazon, the fruit is sold per unit at open markets or by street vendors. The species is not commercially exploited, even considering its value as a food source and for income for small farmers. It is most often found in home gardens or urban yards and small farms. Fifteen-year-old trees can produce over 150 fruit/year (Souza *et al.*, 1997). During the first three harvests of trees evaluated at EMBRAPA Western Amazon Experimental Station, State of Amazon, the average production reported was about 45 fruit/tree, with a range from 35 to 55 (Souza, 1998).

Uses and nutritional composition

Biriba has become a popular fruit due to its delicate flavour, pulp yield and fruit size which is enough for one individual.