The Chinese Tallow Tree

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Tallow tree's potential:

- Grows on land unsuited for row crop agriculture
- Seeds can produce more than 20 times the oil/ac as soybeans
- Has few insect or disease pests
- Perennial that can conserve soil/water
- Can be harvested within 3-5 yrs

The Tallow tree is a fast growing species that produces abundant quantities of seed rich in lipids suitable for the production of biodiesel and other uses.

Because of its high seed yields, this perennial crop has legitimate potential to supply the biodiesel industry with critical feedstock at low-cost.

Tallow trees readily adapt to soils too infertile, wet or saline for profitable agriculture and therefore commercial production will not compete with food crops for limited land resources.

Duke (1998) states that in managed systems, CTT is capable of producing seed yields of 14,000 kg/ha (12,500 lbs/ac) containing 2,600 kg oil (~300 gal) and 2,800 kg tallow (~180 gal). Scheld et al (1980, 1984) reported yields of 4,000 to 10,000 kg/ha, and cite estimates of 1050 gal/ac per year as a sustained energy yield.

Observations in Louisiana confirm that exceptional naturalized trees growing in favorable environments are also capable of astonishing yields. A moderate sized tree covering 34 sq. yards produced 68 lbs of seed (Breitenbeck 2009). Some older trees have produced more than a 100 lbs of seed.

Nomenclature

The Chinese tallow has many common names in the US and other countries. In the southern US, it is called chicken tree, popcorn tree, candleberry tree, vegetable tallow, white waxberry and Florida aspen. In French, it is boiré (to drink). In Spanish, árbol del sebo. In its native land of China, it is called wu bai (black cypress, or blackbird tree).

The USDA has recently reclassified this species as *Triadica sebifera* (L.) Small. The previous classification as *Sapium sebiferum* (L.) Roxb. is still widely used, though USDA botanists have reserved the genus *Sapium* exclusively for plants of the neotropical Americas. In Asia, *Sapium sebiferum* is used. Earlier species names include *Croton sebiferum* L, *Excoecaria sebifera* Müll. Arg, and *Stillingia sebifera* (L.) Michx. The kernel oil has retained the name 'Stillingia oil' as a remnant of its previous classification.

Classification	
Division:	**Magnoliphyta**
Class:	**Magnoliopsida**
Order:	**Malpighiales**
Family:	**Euphorbiaceae**
Subfamily:	**Euphobioideae**
Tribe:	**Hippomaneae**
Subtribe:	**Hippomaninae**
Genus:	***Triadiaca***
Species:	***T. sebifera***

Identification

glands

Leaves: Margins are entire (smooth). Petiole is at least half as long as the leaf blade. Blade shape varies from orbiculate (circular) to deltoid, 2.5-7 cm wide with a pointed apex (acute to acuminate). Base is often acute (as shown here), usually with a pair of glands at the petiole apex. The lower blade surface is pale to distinctly whitish-farinose (dusty-looking). Secondary veins are distinct, with the lowermost pair forming the basal leaf margin.

Bark: greyish brown with fissures

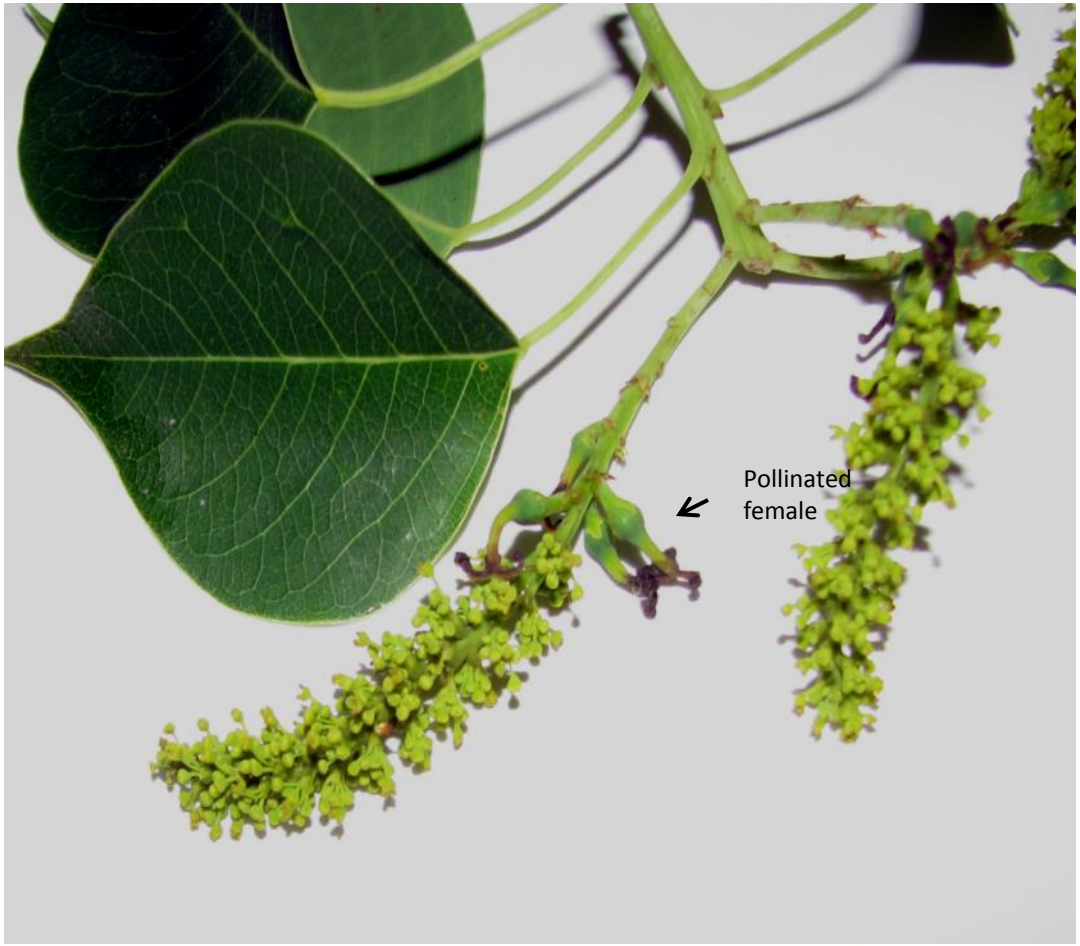
Trunk: often divided and twisted. Heights as great as 60 ft are reported, though most trees are less than 30 ft tall.

Flower buds develop in early spring (early April and May in southern Louisiana) at the terminal bud of fruiting branches. Fruiting branches emerge earlier in the season from leaf buds on year-old branches, and less commonly from older wood. Both male and female flowers are born on an ament, or catkin.

Branches emerging later in the season often attempt to flower, but these flowers fail to pollinate or the catkin is abscised before it matures. Small catkins have been observed as late as September, but only those occurring in Spring successfully set fruit.

As these photos show, most trees form a single catkin at the axil of a fruiting branch.

While a single catkin per branch is most common, some trees produce predominately two, three, or as many as six catkins per branch. Whether multiple catkins result in higher seed yield potentials is not known.



Young
female
flowers

Mature
pollen

The female flowers are located at the base of the catkin. Generally each catkin will support 6-12 female flowers, though as many as 21 have been observed. Female flowers mature rapidly and are usually pollinated before the tree's male pollen matures.

The dependence on pollen from nearby trees no doubt contributes to the wide range in genetic traits displayed by this tree.

Fruits are usually three-lobed, three-valved capsules. As the capsules mature, their color changes from green to dark brown. Until maturity, the developing tallow layer is a hydrated gel too soft to allow threshing and sieving. Upon maturity, the capsule walls fall away and three seeds are exposed. The tallow covering hardens upon exposure to air to provide a protective covering that resists wetting. Seeds persist on the tree for extended periods. The tallow layer is involved in retention of the seed on the tree.

As the fruit approach maturity, cutting fruiting branches from the tree will cause immature fruit to rapidly mature and open. Fruit on branches blown down in early Oct by a hurricane all matured and opened, but contained less lipids than those left to ripen on the tree.

Seed matures in the late fall (Oct.-Nov.). The mature seed contains 32%-39% lipids suitable for conversion to biodiesel or other petroleum substitutes.

The energy in a single seed can be easily demonstrated by holding a dry seed in a pair of forceps and igniting with a flame. It burns slowly at first, then bursts into an intense flame that burns for a minute or more.

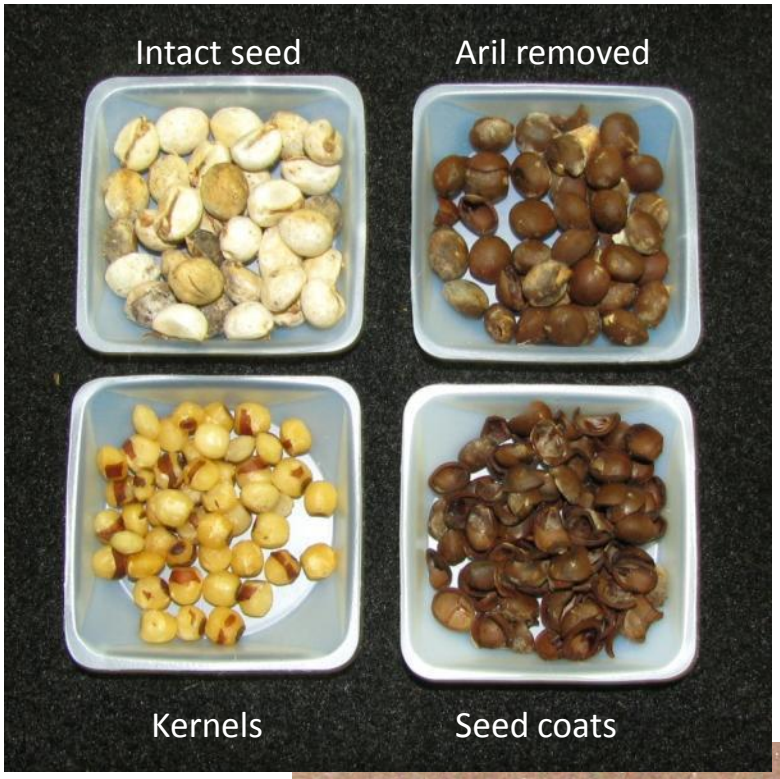
Seed from previous season

Blackening

Seeds can persist on the tree for a year or more, though seed retention varies greatly among ecotypes. Some trees will retain seed until after the next year's crop matures.

The rate of seed blackening is dependent on rainfall, microenvironment and genetics. The seeds of some trees remain white after hanging several months while others begin to blacken shortly after exposure.

Fungi (Cercospora sp., others) cause the white aril to turn black with time. The rate of blacking is influenced by moisture and genetics. This blackening appears to result from decomposition of hemicelluloses and does not significantly affect lipids.



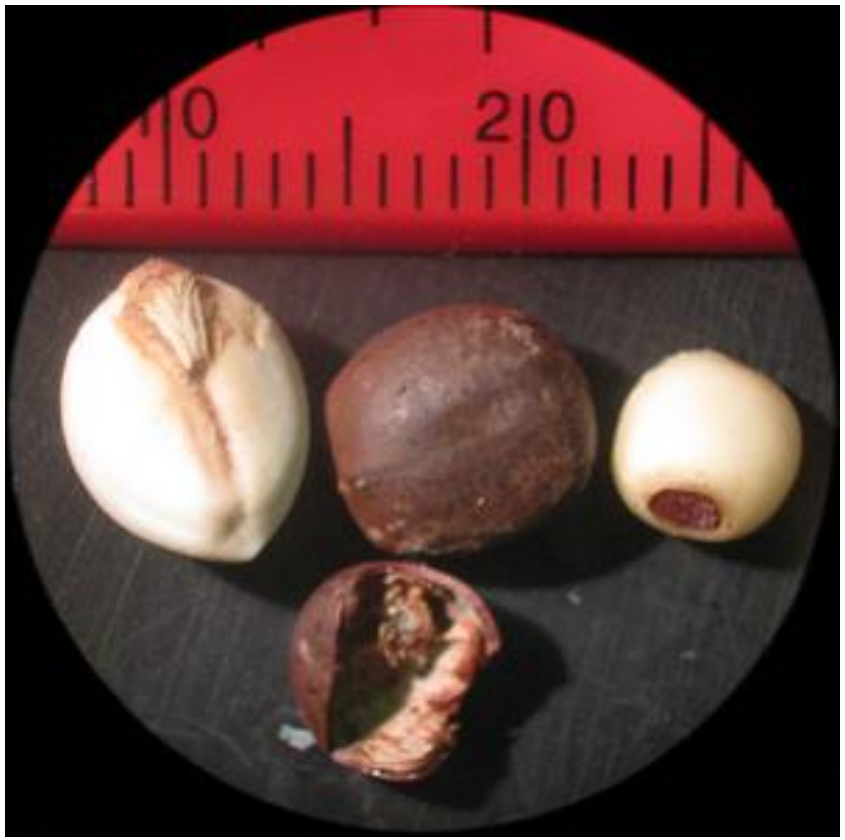
The seed contains two oil-bearing components: a waxy aril (or sacrotesta) commonly called the ‘tallow layer’, and the kernel or germ. These components are separated by a hard seedcoat.

The lipids in the tallow layer are similar in composition to cocoa butter. It is non-toxic and is sometimes used in the production of chocolate candy.

The kernel oil contains a higher percentage of unsaturatured fatty acids, predominately 18:1. The high protein kernel meal contains a mild toxin reducing its value as food or feed.

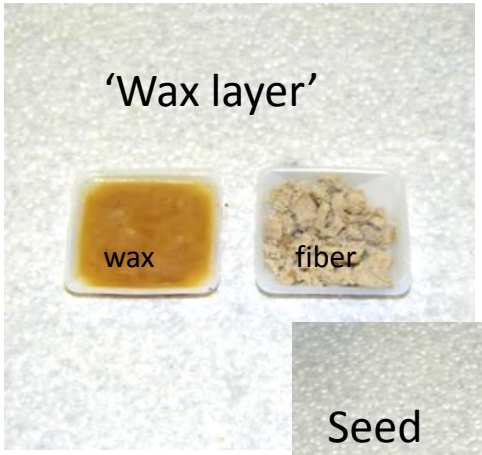
Tallow Tree Seed Components

- 27-33% Aril (tallow)
  - 55-80% fats
- 29-35% Kernel
  - 53-64% fats
- 36-41% Seed coat



Harvested seed can be efficiently separated into ‘wax layer’ and ‘seed’ by a proprietary process for subsequent lipid extraction.

Solvent extraction of the wax layer results in about 75% lipids and 25% fibrous material. Preliminary work suggests this fiber is primarily a hemicelluose of pentose sugars, possibly xylan.



Tallow Layer Triglycerides

- 64% oleodipalmitin
- 13% stearodipalmitin
- 8% tripalmitin
- 8% oleopalmitostearin
- Others

Composition varies among ecotypes

Kernel Oil

The kernel oil (stillingia oil) is considered a drying oil, that is, it will polymerize (harden) when exposed to air. It can be used as a wood finish and as a paint additive.

The iodine value ranges from 158 to 196, varying among ecotypes. The predominant fatty acid is 18:1 (oleic acid) with lesser amounts of 18:0 (stearic acid) and 18:2 (linoleic acid). The kernels of some trees contain 18:3 (linolenic acid).

In Asia, the kernel oil has been widely used to manufacture ink as well as lamp oil. Its value as a premium feedstock for biodiesel production is gaining recognition.

Tallow Tree Wood

Tallow tree wood dries to a light chestnut color. The wood contains high lignin and is very hard when dried. The end grain can be polished to a high finish. In China, tallow tree wood is used to make traditional printing blocks as well as for furniture and cabinetry.

In the US, the wood has been considered for use in chipboard manufacture, but the twisted trunks of the tree limit loading on log trucks to such a degree that commercial harvesting for wood is unlikely.

Sir, London, Oct. 7, 1772

In my last I acquainted you with the Change of Ministry in the American Department, as then expected. It has since taken place: and from the Character of Lord Dartmouth we may hope there will be no more of those arbitrary Proceedings in America that disgrac'd the late Administration.

Inclos'd I send you a small Quantity of Upland Rice from Cochin China. It grows on dry Ground, not requiring to be overflow'd like the common Rice. I hope it will grow with you, and that it may be useful to your Country, as you already are acquainted with the manufacturing of the Article. Mr. Ellis, who imported the Seed, tells me it has been carefully & well preserved on the Voyage; and requests me to send a small quantity to Mr. Jonathan Bryant. If he be in your Province, as I think he is, please to give him some out of your Box. I send also a few seeds of the Chinese Tallow Tree, which I believe will grow & thrive with you. 'Tis a most useful Plant.

With great Respect, I am, Sir
Your most obd^t^ humble Servant

B. Franklin.

Noble W^m^. Jones Esq.

The first record of the tallow tree's introduction to the US is a letter from Benjamin Franklin to Noble W. Jones, a member of the original group of colonists to settle in Georgia.

'Tis a most useful Plant' may refer to the seed's extensive use in China to produce candles, soap, lamp oil and cooking fuel. The kernel oil was a principal ingredient in China ink. When boiled with a mordant, the leaves and bark produced a black dye used for dying silk.

The tree was widely planted along banks and rice levees for erosion control in ancient China. The seed meal remaining after extracting the oil was a principal source of fertilizer in rice paddies.

US Distribution

Source: USDA
http://plants.usda.gov/java/profile?symbol=TRSE6

The tallow tree is found throughout the humid South. While it can be found in semi-humid environments especially along stream banks, it flourishes on wet soils in areas of high rainfall. Tallow trees are commonly seen growing in ditches and canals that are flooded most of the year.

Tallow trees are somewhat tolerant of freezing temperatures, but they are not found where severe winters occur. While the tree has been reported as far south as South Florida, it thrives in areas where the average annual minimum temperature ranges from 5 to 25 ^{o}F (hardiness zones 7b to 9a)

Until recently, tallow trees were widely planted as ornamentals in the Southeast because of their rapid growth and fall color.

But they can quickly escape and invade other areas. This shows a dense stand of naturalized trees in SW Louisiana, an area containing one of the highest populations of naturalized tallow trees in the US. Commercial production of tallow tree seed in this area poses little environmental threat as the tree is already widespread.

Tallow trees are excellent honey plants. Flowers occur in early spring when sources of pollen and nectar are in short supply.

The honey derived from tallow trees has a slight ‘twang.’ Some prefer their honey to have no taste but ‘sweet’, whereas others prefer the stronger taste of many local honeys. One honey producer in Louisiana includes a small amount of tallow tree honey to give his brand its characteristic cajun taste.

A persistent rumor claims that beekeepers played a key role in the “naturalization” of this tree in SE Texas and SW Louisiana.

Invasiveness

Once established in an area, tallow trees can rapidly spread by seed dispersal and from suckers originating from roots of nearby trees.

Areas most at risk of colonization are poorly maintained pastures, clear cut forests and abandoned farmland.

Tallow tree seedlings are controlled by cutting in their first season. Pastures that are mowed once a year seldom have a problem. Once the tree is established, cutting causes numerous shoots to arise from the roots of the damaged tree to form a dense stand.

In China, tallow trees are used extensively to protect banks of waterways from erosion. They tolerate flooding far better than drought. In southern Louisiana, tallow trees compete with black willow and other species along ditches, streams and bayous.

The seeds float for variable times. It will take several weeks for all the seed in this beaker to imbibe sufficient water to sink. In Nature, prolonged floating results in the dispersal of seed considerable distances.

Toxicity

During periods of vegetative growth, the sap of the tallow tree is mildly toxic and can irritate sensitive tissues such as lips and eyes. Cattle and horses will not browse the leaves though some claim goats prefer young tallow trees. Tallow trees make quick and reliable shade in pastures. The unpalatable nature of young trees may be an advantage in commercial plantings as fields can be managed as pastures as trees mature.

After leaf fall, the mature seeds are browsed by livestock, birds and wildlife. The non-toxic waxy layer is digested, but the thick seedcoat protects the embryo until it is excreted—another important vector for dispersal.

Pests

Tallow trees have few insects pests, possibly because of sap components. An occasional plant bug or 'sharpshooter' (*Homalodisca vitripennis* (Germar) is found feeding on young stems. Occasionally light damage from chewing insects is observed.

The gossamer web coating the tallow tree trunk in the picture on the lower right is caused by psocids, commonly called bark or book lice. This infestation caused no lasting damage to the tree and the web disappeared after a few storms.

No significant fungal or bacterial infestations have been observed in naturalized tallow trees. The most common disorder is a cupping and deformation of usually young leaves. The cause is under investigation.

Wind Tolerance

This tallow tree suffered damage in the path of Hurricane Gustav in 2008. Similar to pecan trees, tallow tree limbs are brittle and tend to snap in high winds.

Along the coast, the main trunks of some young trees snapped during the 2008 hurricanes. By next spring, numerous suckers had arisen from the roots of the damaged trees, providing erosion protection against the next hurricane season.

Drought Tolerance

Tallow trees prefer wet environments and are susceptible to drought. In one study, a severe drought early in the season caused flowers to abscise. While additional flowers were produced later in the season, these failed to produce fruit.

Once capsules appear, seed production appears to be less affected by mild summer drought. However, severe drought causes leaves to die and occasionally large branches of mature trees are abscised. The ability to irrigate during drought merits consideration in the commercial production of oilseed.

Cold Tolerance

Tallow trees withstand freezing winter temperatures and may require ‘chill hours’ for seed production.

Late frosts pose a significant hazard. Flowering begins in early April and a severe frost after flowering results in the death of existing blooms. The photo at the lower right shows the effects of a late frost. New catkins emerged at the base of the damaged catkin, but these replacement flowers failed to set many fruit and yield was substantially reduced.

The likelihoods of late frost and early spring drought may prove the principal environmental constraints in determining the practicality of commercial tallow tree oilseed production.

Few naturalized trees produce significant amounts of seed. Shading greatly reduces seed production, but even where adequate light, nutrients and water are available most naturalized trees do not produce seed or only a few.

Occasionally, a tree displaying seed loads with commercial potential is found and tagged for clonal propagation.

Criteria for Selection of Elite Trees

- Yield
- Oil/tallow content
- Oil/tallow composition
- Flowering
- Maturity date
- Uniformity of maturity
- Seed retention
- Seed size

- Precociousness
- Germination rates
- Growth rate
- Growth pattern

Variations among naturalized trees

A growing collection of ‘elite’ trees among the naturalized population is being characterized to identify trees with the most suitable traits for production of biodiesel feedstock.

Uniformity of growth, seed size, maturity date, etc. are essential for efficient mechanical harvesting of trees.

Trait	Range
Yield/tree (>15 ft)	0 to 68 lbs
% aril	24% to 35%
% kernel	28% to 37%
% seed coat	34% to 44%
% lipids in aril	59% to 80%
% lipids in kernel	14% to 24%
Individual seed weight	97 to 185 mg
Avg bushel wt.	31.6 to 43.3 lbs
1st Flowering date	Feb 10 March 30
Maturity	9/21 thru 11/15
Number of catkins per branch	1 to 6
Seeds per capsule	2 to 4
Seed germination	0% to 85%

These photos illustrate the differences in growth and flowering two years after transplanting randomly selected 1-yr saplings into a similar environment. Only one of the 18 trees shows promise for commercial production. The tree on the right produced 7.4 lbs of seed. The tree on the left represents average growth in the study and failed to produce seed.

Clonal Propagation

Because tallow trees are heavily cross pollinated by a genetically diverse population, propagation from seed results in a diverse population unsuited for mechanical harvesting.

Vegetative cuttings often produce shoots, but fail to produce adequate roots and so eventually die.

Grafting and micropropagation are the most promising methods of clonal propagation. Because of the vast number of ‘elite’ trees needed to significantly impact the demand for biodiesel feedstocks, micro-propagation techniques are receiving greater emphasis.

Establishing commercial plantings with clones of elite parents ensures that trees will be highly productive, possess the optimal oil composition, and express uniform traits needed from mechanical harvesting.

A number of ecotypes in our collection have been selected for precociousness in addition to their other favorable traits. While most trees do not bear fruit for 5 years or more, these trees begin to bear fruit in their second or third season. It may prove profitable to harvest these trees in the second or third year after transplanting 1-2 yr old saplings.