Cacao *Theobroma cacao* "Food of the Gods"



About 1500 BC in lowlands of Gulf of Mexico in todays Mexico appeared the Olmec civilization. By 1000 BC their word "kakawa" was written which is the sound we use "cacao". By that time people had moved the tree over 1800 miles from its origin in the Amazon river basin.

Its now thought that earliest use of cacao was a fermented drink made from the mucilage surrounding the seed. This jug dated around 1400 B.C. had traces of two alkaloids in cacao pulp – theobromine and caffeine. Its designed to pour a drink. Later jugs were for creating foam from the crushed, fermented seed.



Maya prepared drink from cocoa beans called "xocolatl", Aztecs -"cacahuatl"; the Mexican Indian word "chocolate" comes from a combination of the words "choco" ("foam") and "atl" ("water") (early chocolate was only consumed in beverage form). Cups with theobromine residues dating to 1000 A.D. found New Mexico, Thus indicating a lack of concern for "food miles" as the dried seed was carried by people from at least 1500 miles away.





Understory 6-8 m tall some 12-14 m tree of rainforest, native to Amazonian Peru.

Leaves simple, 12-60 cm long by 4-20 cm wide. Two distinct branch types: verticals called chupon, its leaves spiral around the stem. It eventually forms a special bud- the jorquette which the produces multiple lateral branches called fan branches. Leaves on fan branches are opposite sides of the stem.



Flowers are produced on 'pads' formerly leaf scars on trunk and main branches. Fruit is a fleshy 'pod' 10-30 cm long, containing 30-60 2-4 cm long by 1-2 cm wide seeds covered with white mucilage.







Pollination via midges, less than 1 % set. Some trees can self-pollinate. Pod cut length to show seed in mucilage.



3 historical subspecies:

Criollo deeply furrowed pods, best flavor, low yield found in Central America/Caribbean

Forastero - less furrowed pods, high yield but lower quality found in upper and lower Amazon basin.Trinitario - hybrids of criollo and lower Amazon



Today we know that pod color -green ripening to yellow and red ripening to orange- and pod shape have little bearing on quality due to cross pollination and evaluation in the past 50 years.

Modern classification system Recent exploration has found distinct populations of cacao in the Amazon. This coupled with the use of genetic markers permits enables us to determine the percentage genetic contribution of these populations in a tree. Contamana, Guiana, Iquitos, Criollo, Purus, Amelonado, Nacional, Curaray, Maranon, and Nanay are the names of the 10 populations. No doubt this system will expand but it will be confusing for sometime.

Cacao does not grow true from seed- its does not normally selfpollinate; therefore several methods are used to get uniform trees. Propagation can be by seed from grafted sibling trees that cross pollinate, grafting buds or branches on to seedlings, rooted cuttings, even tissue culture.



Seedlings



Cuttings



Ready to plant



or grafting with buds or short scions.







Patch bud graft

Several spacings are used in Hawaii. Fertilizer, irrigation and windbreaks are used to substitute for shade.





1.3 x1.3 x 2.5 m, this double row system is common in HI but likely will change to a wider spacing in the future
I will evaluate 3 x 3 m spacing without shade in a statewide variety experiment.

Pruning is to train tree to single chupons, stopping at second jorquette and to remove diseased limbs.





Pest and Fungal Diseases



Frosty Pod





Witches Broom

Black Pod

Japanese Rose beetle is a serious establishment problem in Hawaii

Harvesting

By hand year-round, higher after end of rainy season (Feb to May on Oahu and in Kona), and in August to November in East Hawaii. Note clippers (left) and long handled, curved knives (rt) are used to cut pods (fruit) from trunks and branch. Pulling pods tears the bark and reduces flowering at the damaged area.



On-farm processing Open pod near upper third with curved blade, machete, or mallet- don't cut seed to prevent spoilage. Only ungerminated seeds are



Only ungerminated seeds are removed by hand and pulled from placenta.

Mucilage covered seeds are placed in wooden boxes or barrels, even plastic pails, 'ice chests' all 50 cm deep, with drain holes.





Holes drain the mucilage.

Fermentation is necessary to develop the chocolate flavor precursors and to remove the mucilage which easily absorbs water making it difficult to dry the seed. Essentially this is fast compost that includes a brief germination and turning the mass several times to increase uniformity. A succession of 3 microorganisms yeast, lactic acid then acetic acid forming bacteria are involved. These are introduced from the air, workers hands, and fermentation boxes. After 5-8 days it is complete.



Germinated seed is discarded as microorganisms invade when the root tip dies and falls off, leaving a hole in seed coat.

Seeds can be cut to monitor fermentation. A well fermented seed will show cracks, juiciness, and a darken ring on edge of seed.



Fresh seed showing white embryo

Well fermented seed

Well fermented seed after drying



Seeds inoculated with baking yeast (0.1 g/kg) to prevent mold, seed held in container (incubator, box with light bulb) over water at 35C 3d, then at 45C for 3d, dried at 35C.



1 qt plastic cans inverted over smaller can to collect mucilage.

Mold in ferment gone bad.





Modular acrylic system of tubes

Drying

Drying is essential to stop the fermentation, and to safely store and transport the seed



Small open solar dryer with hinged roof for rain.



Hoop house with open ends for ventilation covered with translucent film. Dry seeds, left in seed coat (shell) right without shell, it is fragile.

World Production 2009 4.1 M Mt

As dried cocoa beans

- Cote d' Ivoire 1.2 M Mt
- Indonesia 0.8 M Mt
- Ghana 0.66 M Mt

As ground cocoa beans for cocoa mass, cocoa cake, cocoa butter

- Netherland 0.44M Mt
- USA 0.41M Mt

• Cote d' Ivoire 0.28M Mt Chocolate consumption 2008

- 1 Germany 11.4 kg/person
- 2 Switzerland 10.8 kg/person
- 3 United Kingdom 10.3/person
- 14 US 5.1 kg/person

60% of chocolate sold in Europe and US, 20% of world population

History of cacao in Hawaii 1850 to 1905

1850 Hillebrand introduced cacao into Honolulu (Foster Botanical Garden)
1890's Crick and Hitchcock start plantings in Hilo, East Hawaii island
1905 Hawaii Experiment Static (TAUD) mode 2 conclusion



1905 Hawaii Experiment Station (predecessor to CTAHR) made 3 acre planting near Hilo

1914 to 1918 - World War I

Disrupted shipping raised world cocoa prices 1917 HI legislature asks, Hawaii Experiment Station says:

- Target yield of 600 lbs/acre/ yr of dried seed
- Make cocoa or chocolate to compete with low cost producer countries
- Locate farms near sea level, in moist, sheltered areas of Hilo, Puna, Hana

Post World War I

Cocoa prices dropped after the war. Interest waned in Hawaii. Plantings were abandoned. Research ceased. CTAHR's Dean commented in 1956: We know it knows in Hilo, Kona, and Hana plus no major diseases here. Someone needs grow 10 acres for 10 years and we'll know if its profitable.

1986 to 1992

Jim Walsh and Hawaii Cocoa caused renewed interest from his imported plantings in east Hawaii. Several international chocolate companies were potential partners.



Grafting in the bud garden

Lahaina, Maui site

Manager's Field, E. Hawaii

1989

CTAHR releases a bulletin under its **Economic fact** Sheet series on Cacao citing of the world cacao facts and mentions the Hershey - Hawaii Cocoa venture. **CTAHR MS student** thesis discusses determining cacao sites using a GIS.



Early 1990s

Dr. Clarence Hodge Farm in Kona, 1992





Today owned by Bob and Pam Cooper as the Original Hawaiian Chocolate Factory

Dole plants 18 acre farm in Waialua in 1996.

2000's Oszustowicz forms Hawaii Gold Cacao Tree in east Hawaii planning to build a factory-but fails. Small growers begin planting on all islands Dole abandons in 2000 and rejuvenates its Oahu cacao farm in 2005.





- CTAHR/UHM, USDA, and HARC begin work on cacao genetics
- Hawaii Tropical Fruit Growers organizes a cacao group. First Hawaii Cacao Symposium June 2005.
- CTAHR's Bittenbender applies for grant from Hawaii Dept of Ag for Hawaii State-wide Cacao Trail. Evaluate 10 'varieties' in locations (cooperating farms) to determine best location - variety combination based on chocolate expert evaluation. Goal is to create the world of chocolate in the islands.

Field planting of 10 selections begins in late 2009.

What will Hawaii do?

Farmers have started on Kauai, Oahu (largest in state is the 19 acre Waialua Chocolate farm), west and east Hawaii.OHCF is vertically integrated, tree to retail product.

A larger factory to produce cocoa liquor, cocoa butter and chocolate is needed.

Nibs are being sold as are limited amounts of chocolate. Manufacturing a finished product provides more marketing options than selling dried seed.









Making Chocolate at home ?

Roasting - 100 to 150C, until cracking sound stops, or strong aroma of 'brownies baking' up to 60 min,



Crushing and winnowing - produces "nibs" (seed pieces) and shell (seed coat), using a hop crusher (or rolling pin). A hair dryer or fan blows away the shell pieces, leaving the nibs.



If producing cocoa powder and cocoa butter use a press to squeeze the nibs so the cocoa butter (oil) flows out. If producing chocolate grind nibs to produce cocoa liquor this is the first stage of sensory evaluation.

Next is conching mixing & refining- cocoa liquor, sugar, cocoa butter, lecithin (a natural phosolipid that works as an emulsifier) and frequently vanilla are added. This process may take several hours to days. Stone or metal rollers reduce the particle size of the cocoa and sugar so the chocolate will not feel gritty in our mouth.

We conch for 16 to 48 hrs.



Recipe for 65% cacao chocolate: 55% cocoa liquor 10% cocoa butter 35% sugar 0.3% lecithin





Next is tempering which raises the melting point of the chocolate and increase hardness- the 'snap' you hear when broken. When the cocoa butter solidifies (freezes) it forms different types of crystals. The goal is to cool the chocolate to produce all the crystal types then warm to melt all except the highest melting temperature crystal (type 4) is formed around 93 F/ 33 C). Then allow to cool, the type 4 crystal starts a chain reaction to produce only itself. The uniformity of the crystal pattern makes it hard. Take 1/3 of the liquid chocolate and stir in cool place until the chocolate is 'chunky', then return it to the warm remainder and thoroughly mix. Last is pouring the chocolate into molds or simply onto a marble slab or silicon pad.





What in chocolate is good for you? Polyphenols (flavanols specifically epicatechin) improve blood flow, reduces blood pressure. Polyphenols are in the cocoa fraction of the seed, not in cocoa butter. So higher in dark chocolate and least in milk chocolate. Cocoa butter is about 60% saturated fat- mostly stearic acid and about 40% unsaturated fat, mostly oleic acid. 900 calories per 100g or 260 calories / OZ.