Camellia sinensis (L.) Kuntze Theaceae Tea

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

Uses

Dried and cured leaves widely used for a beverage, which has a stimulant effect due to caffeine. Used for this purpose in China for nearly 3,000 years. Chasei is a tea extract; powdered tea (Teu-cha) a ceremonial tea. Green tea is made from leaves steamed and dried, while black tea leaves are withered, rolled, fermented and dried. Steam distillation of black tea yields an essential oil. Tea extract is used as a flavor in alcoholic beverages, frozen dairy desserts, candy, baked goods, gelatins, and puddings (Leung, 1980). Air-dry tea seed yields a clear golden-yellow oil resembling sasanqua oil, but the seed cake, containing saponin, is not suitable for fodder. Refined teaseed oil, made by removing the free fatty acids with caustic soda, then bleaching the oil with Fuller's earth and a sprinkling of bone black, makes an oil suitable for use in manufacture of sanctuary or signal oil for burning purposes, and in all respects is considered a favorable substitute for rapeseed, olive, or lard oils. The oil is different from cottonseed, corn, or sesame oils in that it is a non-drying oil and is not subject to oxidation changes, thus making it very suitable for use in the textile industry; it remains liquid below -18deg.C. Tea is a potential source of food colors (black, green, orange, yellow, etc.).

Folk Medicine

The infusion, once recommended in China as a cancer cure, contains some tannin, suspected of being carcinogenic. Chinese regard tea as antitoxic, diuretic, expectorant, stimulant, and stomachic (Leung, 1980). Tea, considered astringent, stimulant, and acts as a nervine or nerve sedative, frequently relieving headaches. It may also cause unpleasant nerve and digestive disturbances. The infusion is also recommended for neuralgic headaches. According to Leung, tea is reportedly effective in clinical treatment of amebic dysentery, bacterial dysentery, gastroenteritis, and hepatitis. It has also been reported to have antiatherosclerotic effects and vitamin P activity (Leung, 1980). Teabags have been poulticed onto baggy or tired eyes, compressed onto headache, or used to bathe sunburn. Duke and Wain (1981) report that the plant has a folk reputation as analgesic, antidotal, astringent, cardiotonic, carminative, CNS-stimulant, demulcent, deobstruent, digestive, diuretic, expectorant, lactagogue, narcotic, nervine, refrigerant, stimulant, and stomachic; used for bruises, burns, cancer, cold, dogbite, dropsy, dysentery, epilepsy, eruptions, fever, headache, hemoptysis, hemorrhage, malaria, ophthalmia, smallpox, sores, toxemia, tumors, and wounds (Duke and Wain, 1981).

Chemistry

Fresh leaves from Assam contain 22.2% polyphenols, 17.2% protein, 4.3% caffeine, 27.0% crude fiber, 0.5% starch, 3.5% reducing sugars, 6.5% pectins, 2.0% ether extract and 5.6% ash. Per 100 g, the leaf is reported to contain 293 calories, 8.0 g H_2O, 24.5 g protein, 2.8 g fat, 58.8 g total carbohydrate, 8.7 g fiber, 5.9 g ash, 327 mg Ca, 313 mg P, 24.3 mg Fe, 50 mg Na, 2700 ug beta-carotene equivalent, 0.07 mg thiamine, 0.8 mg riboflavin, 7.6 mg niacin, and 9 mg ascorbic acid. Another report tallies 300 calories, 8.0 g H_2O, 28.3 g protein, 4.8 g fat, 53.6 g total carbohydrate, 9.6 g fiber, 5.6 g ash, 245 mg Ca, 415 mg P, 18.9 mg Fe, 60 mg Na, 8400 ug beta-carotene equivalent, 0.38 mg thiamine, 1.24 mg riboflavin, 4.6 mg niacin, and 230 mg ascorbic acid. Yet another gives 299 calories, 8.1 g H_2O, 24.1 g protein, 3.5 g fat, 59.0 g total carbohydrate, 9.7 g fiber, 5.3 g ash, 320 mg Ca, 185 mg P, 31.6 mg Fe, 8400 ug beta-carotene equivalent, 0.07 mg thiamine, 0.79 mg riboflavin, 7.3 mg niacin, and 85 mg ascorbic acid (Duke and Atchley, 1984). Leaves also contain carotene, riboflavin, nicotinic acid, pantothenic acid and ascorbic acid. Caffeine and tannin are among the more active constituents (C.S.I.R., 1948-1976). Ascorbic acid, present in the fresh leaf, is destroyed in making black tea. Malic and oxatic acids occur, along with kaempferol, quercitrin, theophylline, theobromine, xanthine, hypoxanthine, adenine, gums, dextrins, and inositol. Chief components of the

volatile oil (0.007-0.014% fresh weight of leaves) is hexenal, hexenol, and lower aldehydes, butyraldehyde, isobuteraldehyde, isovaleraldehyde, as well as n-hexyl, benzyl and phenylethyl alcohols, phenols, cresol, hexoic acid, n-octyl alcohol, geraniol, linalool, acetophenone, benzyl alcohol, and citral. Does this mean that the leaves contain more dangerous substances than herb tea? More properly it only indicates that Camellia has been more intensively studied than most herb teas. Certain constituents, especially catechin, epigallocatechin, and epigallocatechin gallate are said to have antitoxidative properties (Leung, 1980). October 1, 1979, caffeine was trading at ca $9 per kilo, theobromine at about $10 and theophylline at about $12.

Toxicity

According to Tyler, there is evidence indicating that the condensed catechin tannin of tea is linked to high rates of esophageal cancer in some areas where tea is heavily consumed. This effect apparently may be overcome by adding milk which binds the tannin preventing its deleterious effects. GRAS ([[section]]182.20). Tyler (1982) produces a chart comparing various caffeine sources to which I have added rounded figures from Palotti (Industric Alimentaire 16:) (1977).

Cup (6 oz.) expresso coffee: 310mg
Cup (6 oz.) boiled coffee: 100mg
Cup (6 oz.) instant-coffee: 65mg
Cup (6 oz.) tea: 10-50mg
Cup (6 oz.) cocoa: 13mg
Can (6 oz.) cola: 25mg
Can (6 oz.) coca cola: 20mg
Cup (6 oz.) mate: 25-50mg
Can (6 oz.) pepsi cola: 10mg
Tablet Caffeine: 100-200mg
Table (800 mg) Zoom (Paullinia cupana): 60mg

In humans, caffeine, 1,3,7-trimethylxanthine, is demethylated into three primary metabolites: theophylline, theobromine, and paraxanthine. Since the early part of the 20th century, theophylline has been used in therapeutics for bronchodilation, for acute ventricular failure, and for long-term control of bronchial asthma. At 100 mg/kg theophylline is fetotoxic to rats, but no teratogenic abnormalities were noted. In therapeutics, theobromine has been used as a diuretic, as cardiac stimulant, and for dilation of arteries. But at 100 mg, theobromine is fetotoxic and teratogen (Collins, FDA By-lines No. 2, April 1981). Leung reports a fatal dose in man at 10,000 mg, with 1,000 mg or more capable of inducing headache, nausea, insomnia, restlessness, excitement, mild delirium, muscle tremor, tachycardia, and extrasystoles. Leung also adds "caffeine has been reported to have many other activities including mutagenic, teratogenic, and carcinogenic activities; ...to cause temporary increase in intraocular pressure, to have calming effects on hyperkinetic children ...to cause chronic recurring headache...

Description

Small evergreen tree to 16 m tall, usually pruned back to shrubs in cultivation, with strong taproot giving rise to a surface mat of feeders with endotrophic mycorrhizae; leaves alternate, exstipulate, lanceolate to obovate, up to 30 (usually 4-15) cm long, 2-5 (7-12) cm broad, pubescent, sometimes becoming glabrous, serrate, acute or acuminate; flowers 1-3, in axillary or subterminal cymes, deflexed, 2-5 cm broad, aromatic, white or pinkish, actinomorphic, sepals and petals 5-7, pedicels 5-15 mm long; stamens numerous; ovary 3-5-carpellate, each carpel 4-6-ovulate; capsules depressed-globose, brownish, lobate, to 2 cm broad, valvate, with 1-3 subglobose seeds in each lobe; approximately 500 seeds per kg. Fl. Oct.-Dec. in Japan.

Germplasm

Reported from the China-Japan, Hindustani Centers of Diversity, tea or cvs thereof is reported to tolerate drought, frost, low pH, peat, shade, and slope. Because of the long cultivation of tea, many cultivars have been developed, based on flavor of the tea-producing substances, size, of leaves and adaptability to climatic conditions. Named teas often depend on where they originate, the color as tea or the combinations of tea so blended. Pekoe, Orange Pekoe and Flowery Pekoe indicate partly the fineness of leaf in each. Black teas which have undergone fermentation or a chemical process, include Hyson, Young Hyson, Gunpowder and Imperial. Oolong Tea, a favorite in North America, comes from Taiwan. Green teas come mainly from China, India and Sri Lanka. Sri Lanka and Indian teas include: Quality Djarling, Golden Djarling, Assam Tea and Ceylon Flowery. Sri Lanka teas are usually blacker than Indian teas. Chinense teas are grouped as red, green, yellow, red brick and green brick; each group is subdivided into 4 grades: rough, tender, old and new. Yellow tea is Mandarin Tea, a very fine tea. Surplus tea is finely powdered, steamed and pressed into hard bricks, tablets or balls for easier transportation, known as Compressed Tea, and may be either green or black. Black Brick is usually 20 x 30 cm; Green Brick, 15 x 30 cm. Tablets of Compressed Tea are employed in Manchuria, Mongolia and Siberia as money. Some of the Chinese Tea is shipped to Tibet and contains prunings and lower leaves; Tibet Bricks together with four dumplings and butter are used as soup. Botanical variations include: forma *rosea* with pink flowers and forma *macrophylla* with larger leaves and is usually the cultivated form. ($2n$ = 30, 45, 60)

Distribution

Native to Southeast Asia, from Sri Lanka and India to Assam and China, tea has been planted widely in tropical and subtropical areas. Near the Equator, it ranges up to nearly 2,000 m elevation.

Ecology

Ranging from Warm Temperate Dry to Wet through Tropical Very Dry to Moist Forest Life Zones, tea is reported to tolerate annual precipitation of 7 to 31 dm, annual temperature of 14 to 27°C, and pH of 4.5 to 7.3. Although evergreen, tea is intolerant of frost, and requires equable, humid, warm situations; some Chinese tea varieties can tolerate cooler climes. Thrives on tropical red earths and deep, well-drained, acid (pH 4.5-6.0) soils. Mean minimum temperatures should not fall below 13°C, nor maximum go above 30°C. An annual rainfall of 120 cm or more is desirable. Several months With less than 5 cm rainfall each are intolerable. Successful plantations have been established in southeast United States.

Cultivation

Tea is propagated either from seeds or by vegetative means. Seedbearing trees, selected for yield and quality, are cross-fertilized, and the progeny of seed sown in new seed orchards, spaced 300-350 trees/ha. Under better conditions, selected clones are propagated vegetatively. It requires 4-12 years to bear seed. Better seeds from seed orchards are planted in nursery or at stake, protected from sun and wind. At first, seedlings should be shaded. Seedlings 6-12 months old may be outplanted with a ball of earth, while much older seedlings can be planted bare-rooted, cutting the stem 10 cm from the ground mark. Single-internode cuttings, cut just above a node with an axillary bud, inserted in the soil at an angle so that the subtending leaf rests on the medium, take well. Hedge plantings in rows about 1.5 m apart spaced 60 cm apart in the row give better initial yields and may facilitate mechanical harvesting. Interplantings with shade trees is no longer recommended. In Assam, the 'bushes' are let grow for 3 years and pruned across the leaders and laterals at about 45 cm. Subquently they are top-pruned each year; or the entire plant is trimmed back to 15 cm when bush is 1-1.5 m tall. Assam teas give a linear response to nitrogen up to 140 kg/ha.

Harvesting

Terminal sprouts with 2-3 leaves are usually hand-plucked, 10 kg of green shoots (75-80% water) produce about 2.5 kg dried tea. Bushes are plucked every 7-15 days, depending on the development of the tender shoots. Leaves that are slow in development always make a better flavored product. Various techniques are used to produce black teas, usually during July and August when solar heat is most intense. Freshly picked leaves are spread very thinly and evenly on trays and placed in the sun until the leaves become very

flaccid, requiring 13 hours or more, depending on heat and humidity. Other types of black teas are made by withering the leaves, rolling them into a ball and allowing to ferment in a damp place for 3-6 hours, at which time the ball turns a yellowish copper color, with an agreeable fruity one. If this stage goes too far, the leaves become sour and unfit for tea. After fermenting, the ball is broken up and the leaves spread out on trays and dried in oven until leaves are brittle and have slight odor of tea. Tea is then stored in air-tight tin boxes or cans. As soon as harvested, leaves are steamed or heated to dry the natural sap and prevent oxidation to produce green tea. Still soft and pliable after the initial treatment, the leaves are then rolled and subjected to further firing. Thus dried, the leaves are sorted into various grades of *green tea*.

Yields and Economics

In Assam yields range from 1,200-2,250 kg/ha, but clonal tea yields in Sri Lanka have attained 6,700 kg/ha. World tea production, excluding Mainland China, for 1971 was approximately 1,092,000 metric tons. Some of the major producing countries include Pakistan, India, Kenya, Uganda and Argentina. World tea exports, including estimates for Mainland China, in 1970 were 635,000 tons, a 10% gain over the previous year's level of 574,000; South African exports totaled 101,000 tons, South American, 23,000 tons; Asian, 511,000 tons. London auction prices in 1970 for all teas averaged 49.7cents/lb, as compared to 44.1cents/lb in 1969; with an average price of $1.25/kg. Largest importers of tea are United Kingdom, totaling 254,564 tons in 1970, and the United States, approximately 150 million pounds in 1970. Sri Lanka remains the largest source of U.S. imports with 46.1 million pounds, followed by Indonesia, India, and Kenya.

Energy

There was a world low production yield figure of 300 kg/ha in South Korea, an international production yield of 861 kg/ha, and a world high production yield of 2,586 kg/ha in Bolivia (FAO, 1980a). Clonal tea yields as high as 6,700 have been reported (Sri Lanka), but this represents many pluckings. Only 25% of the harvest remains in dried tea, the 75% moisture having evaporated. Annual productivities in species of *Camellia* range from 6-16 MT/ha. Much of this would be pruned back annually to keep the shrubs at good plucking height. Tea yields of 1-4 MT/ha/yr of dry shoot tips are much less than those of other vegetative crops like grasslands or forests growing in similar conditions, partly because plucking restricts tea biomass production, but mainly because the harvest index of tea is small. In Kenya, plucked tea produced 36% less biomass/ha per year than unplucked tea and 64% less wood. Only 8.3% of the total annual biomass increment was harvested. This proportion might be increased by plucking older leaves, increasing the shoot:root ratio, and by lowering the plucking table so that less wood was produced. (Magambo and Cannell, 1981) Near Kericho, Kenya, tea yields only 1.0-2.5 MT/ha/yr at elevations over 2,000 m, rarely more than 4 MT at lower elevations. Still these are high. Tea's poor biomass productivity is due to plucking, which decreased annual production by 36%. Unplucked tea produced 26.3 MT/ha/yr which at 2,178 m altitude near the equator, may be as much as is produced by C3 grasslands, forests, or root crops. Of the 9.4 MT ."extra" dry matter produced by unplucked bushes, 64% (6 MT/ha) went to stems, 16% (1.5 MT) went to roots, and 20% (1.9 MT) went to leaves (Magambo and Cannell, 1981).

Biotic Factors

Tea flowers are largely, if not completely, self-sterile and require cross-pollination by insects to produce seed. Numerous fungi attack the tea plant, including the following: *Aglaospora aculeata, Amphitiarospora neothiosporoides, Armillaria mellea, Asterina camelliae, Auricularia polytricha, Beltrania indica, Botryodiplodia theobromae, Botryosphaeria microspora, B. ribis, B. theicola, Calonectria theae, Cephaleuros virescens, C. mycoidea, Cercospora theae, Colletotrichum camelliae, Corticium salmonicolor, C. solani, Cylindrocladium camelliae, C. parvum, Diatrype conferta, Didymosphaeria theae, Discosiella longiciliata, Elsinoe theae, Exobasidium vexans, Fomes lignosus, F. noxius, Fusarium oxysporum, Glomerella cingulata, Guignardia camelliae, Helicobasidium compactum, Hypocrella scutata, Hypoxylon michelianum, H. vestitum, Irpex destruens, Leptoporum lignosus, Leptosphaeria depressa, L. tornatospora, Macrophoma theae, M. theicola, Macrophomina phaseoli, Marasmius equicrinus, M. pulcher, M. scandens, Massaria theicola, Melanoconiella stellata, Mycosphaerella camelliae, M. ikedai, M. theae, Nectria lucida, Penicillium caryophilum, Pestalotia theae, P. guepini, Pestalotiopsis gigas, P. nattrassii, P. theae, Phaeosphaerella theae,*

Phoma camelliae, Phyllosticta erratica, Ph. theae, Pythium complectens, P. vexans, Rhizoctonia bataticola, Rosellina arcuata, R. bunodes, Sclerotium rolfsii, S. zeylanicum, Sphaerostilbe repens, Sporidesmium deightonii, S. tropicale, Stachylidium bicolor, Stilbella theae, Thyronectria pseudotrichia, Trichoderma viridi, Ustulina deusta and *U. zonata.* Bacteria known to attack tea include: *Agrobacterium tumefaciens, Erwinia theae* and *Pseudomonas theae.* The cause of oil-spot is undetermined. Many nematodes are known to infest tea also, including: *Anguillulina pratensis, Basirotyleptus archius, B. basiri, B. eximius, Criconema octangulare, Criconemella. rustica, Helicotylenchus erythrinae, Hemicriconemoides brachyurus, H. gaddi, H. kanayaensis, Hemicycliophora longicaudata, Longidorus utriculoides, Meloidogyne arenaria, M. brevicauda, M. camelliae, M. hapla, M. incognita, M. incognita acrita, M. javanica, Paratylenchus curvitatus, Pratylenchus coffeae, P. loosi, P. pratensis, Radopholus similes, Trichodorus monohystera, Xiphanema campinense, X. radicicola.*

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