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Review of research on kokum, camboge and related species

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Abstract

Garcinia species are distributed throughout the tropics and have tremendous potential, both as spice and medicinal plants. Though there are more than 200 species in the genus, only 20 are found in India. The two species namely *Garcinia gummi-gutta* (L.) Rob. (camboge) and *G. indica* Choisy (kokum) are widely distributed in the Western Ghats and are very popular in South Indian cuisine. Recently *Garcinia* excited the scientific world for possessing properties that regulate obesity. Though commercially important, these species remained neglected and not much attention was given for their research and development. In this review, an attempt has been made to collect and compile the available information so that areas of interest could easily be identified for further investigation and research.

Key words: camboge, *Garcinia gummi-gutta*, *G. indica*, kokum.

Introduction

Garcinia species are distributed widely throughout the old world especially Asia and Africa. They comprise a large genus of evergreen trees, shrubs, lianes and herbs.

Garcinia belongs to the botanical family Clusiaceae and according to old botanical classification, *Garcinia* is placed within the family Guttiferae which includes about 1350 species. Some of the species in this family possess medicinal properties, whereas most of the plants are known for their oil glands or secretory canals or cavities, which contain yellow or brightly coloured resins. Guttiferae is further divided into 42 genera and five sub-families: Kielmeroideae, Hypericoideae, Calophylloideae, Moronbeioideae and Clusioideae. Of these, the subfamily Clusioideae consists of two tribes, Clusieae and Garcinieae and Garcinieae in turn has two genera namely *Garcinia* and *Mammea* (Muhammed *et al.* 1994).

The genus *Garcinia* includes 200 old world tropical species and out of these, over 20 are found in India. These include *Garcinia gummi-gutta*, *G. morella*, *G. livingstonei*, *G. mangostana*, *G. paniculata*, *G. pedunculata*, *G. atroviridis*, *G. indica*, *G. hombroniana*, *G. lanceaefolia*, *G. microstigma*, *G. dulcis*, *G. echinocarpa* etc. (Roberts 1984).

The typical features of *Garcinia* species include monopodial growth, an yellow exudate from stem, coriaceous or leathery textured leaves etc. (CSIR 1956). The present review deals with research in the genus *Garcinia* with special emphasis on *G. gummi-gutta* (camboge) and *G. indica* (kokum).

Botany of *Garcinia* species

Trees in this genus can be either dioecious or polygamous. In dioecious species, reproductive organs are unisexual. In the polygamous species, male, female and hermaphrodite flowers are found in the same plant. Male flowers in the *Garcinia* are noted for their distinctive pistilodes (Raven *et al.* 1986).

The flowers of *Garcinia* species may be solitary, fascicled and umbelled or panicled. Flowers usually have 4 to 5 sepals, which form the outer layer of the unopened flower bud. Four to five imbricate petals are generally present. In the male flowers, the stamens exist either free or joined to form a ring or lobular mass that surrounds a rudimentary ovary.

The anther filaments are short and thick; though sometimes two-lobed or four-lobed, anthers are straight/horse-shoe shaped with annular dehiscence. In the female flowers, the staminodes are free or joined together. The ovary consists of 2 to 12 cells with solitary ovules positioned at the inner angle of each cell. The female flower has a largely conspicuous but varied stigma, which is sub-sessile. The peltate leaf may be lobed, entirely smooth, or tubercled with wart like growths. The berry encapsulated by a tough rind, sits on top of the calyx. Most *Garcinia* berries contain several large seeds suspended in a pulpy interior (CSIR 1956; Roberts 1984).

Garcinia indica Choisy

Garcinia indica Choisy is synonymous with *Garcinia purpurea* and is known as *brindon* in Goa, *bhirind* or *ansul* in Marathi and Konkani, *Murugal* in Kannada and *Punampuli* in Malayalam (Sullivan *et al.* 1974). The tree is commonly known as kokum butter tree, mangosteen oil tree or brindonia tallow tree. Kokum is reported to be imported from Zanzibar to India (Williams 1949).

Distribution and climate

Kokum *(G. indica)* is an evergreen tree occurring upto an elevation of about 800 metres from sea level. It is abundant in Western India and is distributed throughout Konkan, Goa, North Kanara, the Western Ghats, South Kanara and in areas west of Bombay (Muhammed *et al.* 1994). According to Krishnamurthy *et al.* (1981) it is found in tropical rain forests of Western Ghats, North Malabar, Coorg and Wynad as well as in West Bengal and Assam.

Description, flowering and fruiting

The kokum tree reaches a height of about 10 to 15 metres. It has dark green and drooping foliage. Smaller than most of the species of the genus *Garcinia*, it is distinguised by oblong-lanceolate and glabrous leaves. The tree flowers in November - February and fruits ripen in April – May (CSIR 1956). The flowers, which can be axillary or terminal, exist in solitary form or as spreading fascicles. The scale like bracts are decidious or shed seasonally. The sepals are deccusiate, thick and fleshy. Four thick petals extend in length slightly beyond the sepals. Male flowers are characterised by numerous stamens and two celled anthers with exceedingly short filaments. Female flowers are either sessile or on short pedicels, bundled two or three together. Ovary is 4-8 celled with sessile stigma. The fruit is spherical but un-furrowed and purple, 2.5 to 3.0 cm in diameter and encases 5 to 8 seeds (Muhammed *et al.* 1994; Subash Chandra 1996).

Propagation

The conventional way of propagation is by seeds. As the crop is cross pollinated, the seedling progeny shows heterogeneity and thereby variability. In certain pockets of Konkan region, soft wood grafting as well as approach grafting are resorted to which favour early yield and high density planting (Subhash Chandra 1996). Tissue culture is also being attempted for micropropagation (Rao *et al.* 2000).

Processing

Freshly harvested fruits are reddish green in colour and turn into full red-purple colour in a day or two (Fig. 1a). The flesh of the fruit is juicy and has a sweetish acid taste. The normal

shelf-life of fresh fruit is about five days. The common method practised for preservation is sun drying. For this, the fresh fruits are cut into halves and the fleshy portion containing the seed is removed. The rind (skin) is then repeatedly soaked in the juice of the pulp during sun drying. The product obtained after sun drying is referred to as amsul or unsalted kokum in commerce. Salted kokum (agar) is also marketed; wherein common salt is used during soaking and drying of the rind. Lonavala kokum, Pakali kokum, Khane or edible kokum and Khoba kokum are some of the trade varieties (Sampathu & Krishnamurthy 1982).

The seeds yield a valuable, edible fat known in commerce as kokum butter. It is extracted mostly as a cottage industry by crushing the kernels, boiling the pulp in water and skimming off the fat from the top or churning the crushed pulp with water. Presently oil is obtained by solvent extraction also. The yield of oil (fat) is about 25%. Kokum butter sold in market consists of egg shaped lumps or cakes of light grey yellowish colour with a greasy texture and a bland oily taste. It is used mainly as an edible fat and sometimes as an adulterant of ghee. Refined and deodorised fat is white in colour and compares favourably with high class hydrogenated fats (Nadkarni 1954; CSIR 1956).

Kokum rind contains 2 to 3 percent anthocyanin pigments. It is a promising source of natural colourant for acid foods. Processing conditions have been standardised at CFTRI, Mysore for commercial scale extraction and purification of the pigment concentration. Preliminary studies have shown that cyanidin-3-sambubioside and cyanin-3-glucoside as the major pigments present in the ratio of 4:1. Food applications for kokum colour are in the area of processed fruit products, alcoholic and nonalcoholic beverages, preservatives and instant foods (Krishnamurthy *et al.* 1982).

Characteristics and composition of *G. indica* fat (kokum butter) (Jameisen *et al.* 1943) are as follows:

Character	Value
M.P.	39.5 - 40.0° C
Sap. equiv.	299.5
Iodine value	37.4
Unsapen matter %	1.4
Free fatty acids (% as oleic)	7.2
Component fatty acids (% by weight)	
Palmitic	2.5
Stearic	56.4
Arachidic	-
Olein	39.4
Linolein	1.7
Component glycerides (% by mol)	
Tristearin	1.5
Oleodistearin	68
Oleopalmitostearin	8
Palmitodiolein	20
Triolein	2

Chemical composition

The acid in kokum rind (dry) has been identified as hydroxycitric acid and is present to the extent of 15 percent. A new fat soluble pigment namely, garcinol has been isolated from the fruit rind. Chemical identity of this pigment has been established by chemical and spectral studies (Krishnamurthy *et al.* 1981).

The composition of fresh kokum rind is as follows (Sampathu & Krishnamurthy 1982):

Moisture (%)	80.00
Protein (Nx 6.25)%	1.92
Crude fibre (%)	14.28
Total ash (%)	2.57
Tannine (%)	2.85
Pectin (%)	5.71
Starch (%)	1.00
Crude fat (%) (Hexane extract)	10.00

Acid (as hydroxy citric acid)	22.80
Pigment (%)	2.40
Ascorbic acid (%)	0.06
Carbohydrates by difference (%)	35.00

(Values are expressed on moisture free basis)

Uses

The fruit has an agreeable flavour and a sweetish acid taste. Kokum has been traditionally used as an acidulant. It is used in the Konkan region, chiefly in the form of kokum as a garnish, to give an acid flavour to curries and also for preparing cooling syrups (CSIR 1956). For the traditional fish curry of the Konkan coast and Goa, kokum rind is a usual ingredient. The dried rind, strained in water, is boiled into a soup called solkadi. Spiced and sweetened with jaggery it is a must for marriage feasts and functions in Uttara Kannada District of Karnataka. It is considered to promote digestion. Wine red syrup, extracted from the rind of the ripe fruit with the help of sugar, is stored in the households of this region for making cool drinks in summer (CSIR 1956). The sweet pulpy cover of the seeds is eaten or made into curries. The fruit is also pickled (Subhash Chandra 1996).

Kokum butter is suitable for use as a confectionery butter. It is also suitable for making candle and soap. It possesses properties similar to piney tallow (from *Vateria indica*) and may be employed in the sizing of cotton yarn (Williams 1950; CSIR 1956; Muhammed *et al.* 1994).

The fruit of *G. indica* is anthelmintic and cardiotonic and useful for treatment of piles, dysentry, tumours, pains and heart complaints. A syrup from the fruit juice is given in bilious affections. The root is astringent (Krishnamurthy *et al.* 1981; Sampathu & Krishnamurthy 1982).

Kokum butter is considered nutritive, demulcent, astringent and emollient. It is suitable for ointments, suppositories and other pharmaceutical purposes. It is used for local application to ulcerations and fissures of lips, hands etc.The cake left after extraction of oil is used as a manure (CSIR 1956).

Kokum butter is used as a specific remedy for diarrhoea and dysentry. It is now being used in cosmetics and medicines known as Vrikshamla in Ayurveda. Various parts of the tree like root, bark and fruit and seed oil are used for treating piles, sprue and abdominal disorders (Subash Chandra 1996).

Garcinia gummi-gutta (L.) Rob.

The name *Garcinia gummi-gutta* (L.) Rob. was given by the French botanist, Desrousseaux. It is referred to in the vernacular as 'kudampuli' and is also known as Malabar tamarind.

Distribution and climate

G. gummi-gutta is found commonly in the evergreen forests of Western Ghats, from Konkan south to Travancore and in the shola forests of Nilgiris upto an altitude of 6000 feet. In Western Ghats of Kerala, 'kudampuli' grows at an altitude of 1300 to 2000 m above MSL. The best suited regions for its growth are those having high humidity and an altitude of 400-100 m (CSIR 1956; George 1998).

Description, flowering and fruiting

It is a small or medium sized tree with round crown and horizontal or drooping branches, leaves dark green and shining, elliptic obovate, 5 - 7cm long and 2.5 - 7.5 cm broad, fruits ovoid or spherical in shape, 5 cm in diameter, yellow or red when ripe, with 6 - 8 grooves (Fig. 1b); about 6 - 8 seeds, surrounded by a succulent aril (CSIR 1956).

Dioecious in nature, the productive bisexual trees outnumber the males (referred to as 'varangu' in vernacular) which are usually not retained once they exhibit their sexuality.

Every year, from February to April the trees put forth flowers. The flowers are pale yellow in colour, 10 to 40 flowers are seen as bunches in the male plants. These flowers fall off. In the female plants three or four flowers are seen in a bunch and the female/ bisexual flowers are bigger than male flowers. After flowering it takes almost three weeks for fruit set. It takes 120 to 135 days for the fruits to ripen. Ripening usually coincides with the June-July rains. The

Fig. 1. Fruits of a. *Garcinia indica* (kokum); b. *G. gummi-gutta* (camboge)

ripe fruits are orange yellow in colour and are ellipsoid or spherical in shape. The fruits vary in size weighing 50 g to 180 g and the fruit rind is grooved into 7 to 10 segments. Fruits abscise on ripening and are collected. Seeds are enclosed in a pulpy translucent aril which is often sweet and edible, but sometimes acrid. On pricking, the fruits exude a yellow resinous liquid which hardens slowly into a brown gummy mass (Nadkarni 1954; Raven *et al.* 1986; Muhammed *et al.* 1994).

Propagation

G. gummi-gutta can be propagated by seeds. But the plants propagated through seeds do not generally exhibit parental characteristics. The seedlings segregate into productive bisexual and unproductive male trees. Sex is revealed only after flowering for which the seedlings take 7-8 years. The unproductive trees are usually removed after they have exhibited their sex. To overcome this drawback softwood grafting is usually practised. Grafts come to flowering in 3 to 4 years of planting. Also this results in dwarf bushy trees favouring high density planting.

Grafting can be taken up at anytime of the year, if mist chamber facility is available. If not, June to October is suitable (Spices Board 2001). While selecting the rootstock, the best results are obtained on *G. gummi-gutta* although, other species like *G. tinctoria* and *G. mangostana* are also used. One year old seedlings of *Garcinia* are used for softwood grafting (Muthulakshmi & Sarah 1999). Planting of the grafts can be taken up at the onset of the first monsoon showers.

Recognising the commercial importance of *G. gummi-gutta*, research on tissue culture has been initiated very recently and the success is encouraging. Multiple shoot regeneration from axi-llary buds has been observed (Rao *et al.* 2000).

Chemical composition

The dried fruit rinds of *G. gummi-gutta* are hard and dark brown in colour. It is rich in acids (about 30 %), which comprises of tartaric acid 10.6%; reducing sugars (as glucose) 15.0%; and phosphoric acid (as calcium triphosphate) 1.52%. Of the total acids present, nearly 90% are non-volatile.

The principal acid in the fruit rinds of *G. gummi-gutta* and two other species were identified as (-) hydroxycitric acid based on chemical and spectroscopic studies and not citric acid (Lewis & Neelakandan 1965). By titration and measurement of conductivity the acid proved to be an alpha-hydroxy tribasic acid. Hydroxycitric acid (1, 2-dihydroxypropane-1, 2, 3-tricarboxylic acid) has two asymmetric centers(Fig. 2). Being a gamma-hydroxy acid, it cyclisizes readily to the corresponding lactose (Lewis & Neelakandan 1965).

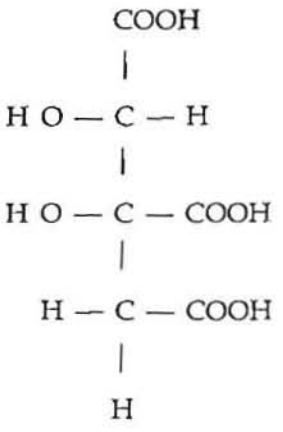

Fig. 2. Structure of hydroxy citric acid

Lowenstein (1971) found that (-) hydroxy citric acid (HCA) strongly inhibited fatty acid synthesis *in vivo* or in living systems. Sullivan *et al.* (1972) reported that fatty acid and cholesterol synthesis was blocked significantly in test animals which were given (-) HCA before. In another study Sullivan *et al.* (1974) noted that rats fed on (-) HCA tend to eat less than did the control animals. Sullivan & Triscari (1977) reported that (-) HCA lowered body fat level with no loss of body protein or lean mass in test animals that had been experimentally made obese.

Constituents like cambogin and camboginol were isolated from the latex of *G. gummi-gutta* tree and their structure was confirmed by UV, IR, and NMR studies (Rao & Sakariah 1988).

The seeds of *G. gummi-gutta* yield 31% of an edible fat, resembling kokum butter. The fat has a granular structure with the following constants: m.p. - 29.5°C, acid val. - 5.0; sap. val. - 203.5; acet. val. - nil; iod. val. - 52.5°; R.M. val. - 0.2; unsapon matter - 1.0% and titre - 51.2°. The fat is rich in oleic acid (Naidu 1917; CSIR 1956).

Processing

Different methods of processing like sun drying, smoke drying and oven drying are followed for camboge rind. The common method followed is that collected fruits are first split open length-wise. After removing the seeds they may be sun dried or smoke dried or alternatively smoke and sun dried. To ward off fungal infestation this may be given a coating with coconut oil and salt. Among the different drying methods the rind from smoke drying was found to be soft and flexible, shiny black in colour and with good shape retaining capacity and consumer appeal (Muthulakshmi *et al.* 2001).

Uses

Fruits are edible but too acidic to be eaten raw. They are valued for their dried rind which is used in Travancore - Cochin and Malabar regions, as a condiment for flavouring curries in place of tamarind or lime. The dried rind is used in fish curries for imparting the unique delicate flavour (Muthulakshmi & Sarah 1999). In Sri Lanka, the fruits are picked underripe, the thick pericarp cut into sections, dried in the sun and preserved for future use. The dried material is used along with salt in the curing of fish.

A decoction of the fruit rinds is given for rheumatism and bowel complaints. It is also employed in veterinary medicine as a rinse for diseases of mouth in cattle. The resin possesses purgative properties. (Rama Rao 1914; Chandrasena 1935; Kirtikar & Basu 1984). The extracts of *G. gummi-gutta* are said to activate digestion and are used in treatment of worms and parasites, tumors and dysentery.

HCA inhibits lipogenesis, lowers the production of cholesterol and fatty acids, increases the production of glycogen in the liver, suppresses appetite, increases the body's production of heat by activating the process of thermogenesis (Lowenstein 1971). It is found to be a potential dietary supplement for weight loss and appetite control. Several products of (-) HCA like Citrin, Citrimax, *Garcinia* spray, *Garcinia* puff etc. are available commercially in market (Muhammed *et al.* 1994). They are gaining popularity as drugs for weight loss (Dallas & Michael 1990).

The dried rind is also used for polishing gold and silver and as a substitute for acetic and formic acids in the coagulation of rubber latex.

The wood (3700 - 4625 kg m^{-3}) is grey and close grained. It is not durable, but the heartwood of old trees is reported to be distinctly hard and durable. The wood is used for posts, match boxes and splints (Rama Rao 1914; Gamble 1922; Lewis 1934; CSIR 1956).

Other species

Research on other species is very limited and the available information has been tabulated in Tables 1 and 2 (Parkinson 1972; Grieve 1979; Warrier *et al.* 1986; Asrina & Parkasi 1992; Singh & Johari 1992; Ambasta *et al.* 1994; Rema & Krishnamurthy 2000).

Conclusions

Therapeutically no spice has excited the scientific world as the species *Garcinia*. These trees possess great economic value as their fruits impart a special flavour and taste besides the medicinal properties.

Garcinia is able to tolerate fluctuating water tables and prolonged inundation. So it can be grown in low lying reclaimed lands where other perennial crops cannot be grown. It can be grown along the water and river belts also. This crop can withstand drought to a certain extent and does not require high doses of manures and fertilizers. The incidence of diseases and pests is also very meagre (Subash Chandra 1996).

Many gaps exist in *Garcinia* research due to lack of concerted efforts. There is an urgent need to intensify our research on these highly potential crops and the main thrust areas identified are as follows.

- Identification of trees for high yield, earliness, regularity in bearing and fruit quality.
- Commercialization of tissue culture protocol for the rapid multiplication of elite trees.
- Standardization of nutritional requirements and cultural practices.
- Mechanization of post harvest operations especially for hygeinic processing.
- Development of more value added products.
- Standardizing the storage conditions for increasing the shelf life of the product.
- Validation of medicinal uses to increase its utility in the medical field especially in maintaining health as a neutrceutical.

References

Ambasta S, Ramachandran K, Kashyapa & Chand R 1994 The Useful Plants of India. CSIR, New Delhi.

Asrina S C & Parkashi 1992 The Treatise of Indian Medicinal Plants. Vol II Publication and Information Directorate, New Delhi.

Chandrasena J P C 1935 The Chemistry & Pharmacology of Ceylon and Indian Medicinal Plants. Lucy Chandrasena, Colombo.

CSIR 1956 The Wealth of India - Raw Materials. Vol IV. (pp.101 - 103). New Delhi, India

Dallas C & Michael R 1990 The Diet and Health Benefits of HCA . Keats Publishing Inc, New York.

Gamble J S 1922 A Manual of Indian Timbers. Sampson, Low, Marstan & Co. Ltd., London.

George S T 1998 *Garcinia* –The neglected acid fruit of Kerala. Indian Cocoa, Arecanut and Spices Journal 11(3) : 100-101.

Grieve M 1979 A Modern Herbal. Lowe and Brylone Printers Ltd. Thefford, Norfolk.

Jameison G S 1943 Vegetable Fats and Oils (2nd edition). Reinhold Publishing Corp., New York.

Kirtikar K R & Basu B D 1984 Indian Medicinal Plants (Text 1). Lalit, Mohan Basu, Allahabad.

Krishnamurthy N, Lewis Y S & Ravindranath B 1981 On the structure of garcinol, isogarcinol and camboginol. Tetrahedron Letters 22(8) : 793.

Krishnamurthy N, Lewis Y S & Ravindranath B 1982 Chemical constituents of kokum fruit rind. Journal of Food Science and Technology 19 : 97-100.

Krishnamurthi Naidu G 1917 Commercial Guide to the Forest Economic Products of Mysore. Govt. Press, Bangalore.

Lewis F 1934 The Vegeteble Products of Ceylon. The Associated Newspapers of Ceylon Ltd., Colombo.

Lewis Y S & Neelakandan S 1965 (-)Hydroxy citric acid – the principal acid in the fruits of *Garcinia cambogia*. Phytochemistry 4 : 619.

Table 1. Habit and distribution of commercially important species of *Garcinia*

Scientific Name	Habit	Distribution
Garcinia andamanica King	Medium sized tree	Andaman islands
G. anomala Planc	A small erect tree	Khasla hilla
G. atroviridis Griff	A medium sized tree	North eastern districts of Assam
G. cornea L	Medium or tall ever green tree	Bengal
G. cowa Roxb	Tall or medium sized dioecious tree	Eastern parts of India mainly Assam, Bengal, Bihar, Orissa and Andaman Islands
G. dulcis(Roxb) Kurz	Medium sized ever green tree	Introduced into India from Malaysia
G. eugenifolia Wall	A small tree	Singapore
G. echinocarpa Thw	Tall tree	Tirunelveli forests, Sri Lanka
G. gumni gutta(L) Rob (*G. cambogia* (Gaertn) Desr)	Small or medium sized tree with rounded crown and horizontal or drooping branches	Western ghats upto 1800 ft, Maharasahtra, Goa, Karnataka, Kerala and Shola forests of Nilgiris
G. hanburyii Hook	Medium to tall tree	Ceylon, South India and Cambodia
G. harmandii Pierre	--	Cambodia
G. heterandra Wall	--	Pegu and Tenasserin
G. hombroniana Pierre	Small tree	Nicobar islands
G. indica Choisy	Slender evergreen tree with drooping branches	Western Ghats from Konkan to southwards in Mysore, Coorg and Wynad
G. kydia Roxb	--	Andaman Islands
G. lanceaefolia Roxb	A shrub or small tree	Assam and Khasi Hills upto 3000 feet
G. livingstonei T.Anders	A small tree with short branches	Introduced into India from East Africa.
G. mangostana L.	Small or medium sized evergreen tree	South India on the lower hills of the Nilgiris
G. microstigma Kurz	Small tree	Andaman Islands
G. morella Desr	Small or medium sized evergreen tree	Assam and Khasi Hills, Western Ghats upto an altitude of 3000 feet
G. paniculata Roxb	A medium or tall evergreen dioecious tree	Foot hills of Himalayas, Assam, Khasi Hills
G. pedunculata	A tall tree with short spreading branches	Assam upto an altitude 3000 feet and Manipur
G. speciosa Wall	A moderate sized ever green tree	Andaman Islands
G. spicata Hook(*G. ovalifolia* Hook.f.)	Medium sized or tall tree	Western Ghats from Konkan southwards
G. stipulata.T. Anders	A tall tree	Eastern Himalayas
G. succifolia Kurz	Medium ever green tree	South India
G. travancorica Beddome	Medium sized tree	Western Ghats
G. wightii T. Anders	--	Forests of South India
G. xanthochymus Hook (*G. tintoria* Wight)	A medium sized bushy evergreen tree	Lower hills of Eastern Himalayas, Western Ghats and Andaman Islands

Table 2. Uses of different species of *Garcinia*

Scientific name	Part used	Uses	Distinct/distinguishable characters
G. anomala Planc.	Stem	The tree yields a gum resin which is of inferior quality.	–
G. atroviridis Griff.	Fruit pericarp	Fruits are edible, fruit rind is stewed with sugar and eaten. Rind of under-ripe fruit is used as a substitute in place of tamarind in cooling. Also used as a fixative with alum in dyeing of silk.	Fruits are subglobose and orange yellow when ripe.
G. cornea L.	Fruit, gum, resin	Yields an inferior kind of gamboge which is used in medicine and are edible.	Fruits are dark purple and have a pleasant flavour.
G. cowa Roxb.	Fruit, leaf, bark	Fruits are edible but acidic. It is used for making jams and preserver. Leaves are used as vegetables. An yellow dye is also obtained from the bark. The tree yields an yellow resin which is used as a varnish for metalic surface	Fruits are depressed, globular yellow, or reddish. Leaves are broadly lanceolate, acute, thick and shining, flowers axillary or terminal and clustered.
G. dulcis (Roxb.) Kurz.	Fruit, seed, bark	Fruits are used for making jams and jellies. The seeds have medicinal properties and is used for dysentery and diarrhea and for external application. Bark is used for dyeing mats.	Fruits are globose or pyriform bright yellow or orange when ripe with orange pulp.
G. engenifolia Wall	Unknown	Tree yields gum resin.	–
G. echinocarpoi Thw.	Seed	Seeds yield an oil which is used for illuminating lamps and for soap and candle manufacture. Leaves and bark are used in dropsical affections and as vermifuge.	–
G. gummi gutta (L) Rob (*G. cambogia* (Gaertu) Desr.	Rind , leaf	The dried pericap is acidic and is used for flavouring curries. Seed yields an edible fat resembling kokum butter which is obtained from *G.indica*. Hydrocitric acid present in the fruit inhibits lipogenesis and is used as an antiobaesity agent. The tree yields an yellow resin which is used as a varnish. The resin has purgative properties. The decoction of the fruit rind is used against rheumatism and bowel complaints as it is a good vermifuge. The dried fruits are used in diarrhoea, dysentery and dyspepsia.	The fruit is yellow when ripe.

G. hanburyil Hook.	Gum resin	Gamboge is obtained from the stem. It is a source of Siam gamboge and is used as a pigment in lacquer varnishes and brass work. It is a powerful hydragogue and lowers blood pressure.	–
G. harmandii Piere	Not known	Medicinal use	
G. heterandra Wall	Gum resin	Gum resin is used as a medicine.	
G. hombroniana Pierre	Fruit, wood	The pulp of the rose red fruit is edible. Timber is used for building constructions and oars.	The fruit is rose red in colour. The tree resembles *G. mangostana.*
G. indica Choisy	Pericap, seed, leaf	Kokum is prepared by drying the outer rind by soaking in the juice of the pulp and sun drying. Kokum contains 10 percent malic acid and is used to garnish curries and for preparing cooling syrups. It is anthelmintic, astringent, demulcent and antiseptic. It is also reported to inhibit lipogenesis. An edible fat, kokum butter, is obtained from the seed.	Fruits are dark purple when ripe and are globose or spherical. Leaves ovate or oblong, lanceolate, broad , dark green above and pale beneath. The seeds of the fruits yield 23-26% on the weight of seeds and 44% on weight of kernels an edible fat called kokum butter.
G. lanceaefolia Roxb.	Fruit, leaf	The fruits are edible when ripe and leaves are used as vegetables.	The fruits are obovoid and bright orange yellow.
G. livingstonei T.Anders	Pericarp, pulp	The fleshy pericap and the coloured pulp are used for preparing fermented beverages.	–
G. mangostana L.	Fruit, bark	The fruit is edible and the entire fruit has medicinal properties. The rind is astringent and is used against dysentery, diarrhoea febrifuge and is effective against skin infections. An yellow resin which is similar to gamboge is obtained from the rind and it contains the bitter principle mangostin.	The fruits are borne near the tips of short branches, mostly on the outside of the trees. The rind is smooth, globose, reddish or purplish. The seeds are enclosed in a thick, snowwhite jelly like aril. Fruits are slightly flattened . It is considered to be the most delicious among tropical fruits. Referred to as queen of fruits.
G. micristigma Kurz.	Fruit, leaf	Fruits are edible when ripe and leaves are used as vegetable.	The fruits are depressed, globose and dark red.
G. morella Desr.	Stem, seed	It is the indigenous source of commercial gamboge used as a pigment and also for preparation of varnishes. The gamboge is astringent, tonic, aphrodisiac, antibacterial, vermifuge, amenorrhaea, anthelmintic and obortifacient. Seeds yield fat similar to kokum butter. Seeds have antibacterial properties.	Fruits are globose and of the size of a small plum. The seeds are slightly compressed and darkbrown.

G. paniculator Roxb.	Fruit	The pulpy aril of the highly flavoured fruit is edible.	Leaves are long and broad, shining, anuminate and fruits are globose. The plant has been recommended as a suitable rootstock for mangosteen.
G. pedunculata Roxb.	Pericap, wood	Fleshy pericarp, used in place of lime or lemon. Used as a fixative or as a mordent in saffron dye. The wood is used for planks, beams and for building purposes.	Leaves are obovate or oblanceolate, broad and leathery and fruits are yellow. It is one of the species of the genus with large fruits (7.5-12.0 cm diameter). Malic acid is the principal acid of the fruit pulp with fruits.
G. speciosa Wall	Wood, gum resin	The wood is used as bridge and house posts and also for making bows in Andaman islands. Tree yields an inferior gamboge. The wood is hard, heavy, reddish brown and close-grained.	The bark of the tree is dark greenish and peels off as flakes. Fruits are globose and bright red when ripe.
G. spicata Hook (*G. ovalifolia* Hook f.)	Wood, bark	Wood is a strong timber and a dye is obtained from the bark.	Leaves are ovate or lanceolate, fruits are globose, smooth and darkgreen. The Japanese dye stuff Fukuji is reported to be obtained from *G. speccata*. Garcinia a second colouring matter is reported to be present in the bark
G. stipilata T And.	Stem, fruit	The fruit is edible and the tree produces an inferior gum	—
G. succifolia kurz.	Wood, gumresin	Yields an inferior gamboge. The wood is used as timber.	—
G. travancorica Beddome.	All plant parts	Gum resin is obtained.	
G. wightic T. Anders.		The gamboge of this species is very soluble and yields a good pigment.	—
G. xanthochymus Hook (*G. tinctoria* wight)	Stem, fruit, seed, bark	The fruit is edible, when ripe and preserves and jams are prepared from the fruit. The fruit is also used as a substitute for tamarind. An inferior gamboge is obtained from the stem. The exudate from the bark and fruit is used as a dye.	The fruit is dark yellow in colour. Leaves are leathery and shining. The tree produces abundant fruits, sometimes twice a year.

Lowenstein J M 1971 Effect of (-) hydroxy citrate on fatty acid synthesis by rat liver *in vivo*. J. Bio. Chem. 246 : 629-632.

Muhammed M, Rosen R, McCarty M, Conte A, Patil D & Butrym E 1994 Citrin - A Revolutionary Herbal Approach to Weight Management. New Editions Publishing, Burlingame, CA.

Muthulakshmi P & Sarah T G 1999 Kodampuli: a multipurpose fruit tree. Indian Hort. 44(2) : 7-8.

Muthulaksmi P, Sarah T G & Lila Mathew K 2001 Quality parameters of Kodampuli rind under different drying conditions. Spice India 14(1) : 14-16.

Nadkarni A K 1954 Indian Materia Medica Vol. III. Popular Book Depot, Bombay.

Parkinson C E 1972 The Forest Flora of Andaman Islands. Bishen Singh & Mahendra Pal Singh, New Delhi.

Rama Rao M 1914 Flowering Plants of Travancore. Govt. Press, Trivandrum.

Rao R N & Sakariah K K 1988 Lipid lowering and antiobesity effect of hydroxy citric. J. Nutr. Res. 8 : 209-212.

Rao Y S, Mary Mathew K, Kuruvilla K M, Lakshmanan, R, Gilu Lizy George, Madhusoodanan, K.J. & Potty S N 2000 Practice and promise of tree spices tissue culture. In : Programme and Abstracts (pp. 40-41), PLACROSYM XIV, 12-15 December 2000, Hyderabad, India (Abstract).

Raven P, Evert R & Eichhorn S 1986 Biology of Plants, 4th Edn. Worth Publishers, New York.

Rema J & Krishnamoorthy B 2000 *Garcinia* species of economic importance - distribution and uses. Indian Spices 37 (1) : 20-23.

Roberts E 1984 Vegetable Materia Medica of India and Ceylon. Bishen Singh Mahendra Pal Singh, Dehra Dun, India

Sampathu S R & Krishnamurthy N 1982 Processing and utilization of kokum. Indian Cocoa, Arecanut and Spices Journal VI (2) : 12-14.

Singh W & Johri B M 1992 Dictionary of Economic Plants in India. ICAR, New Delhi. 287 pp.

Spices Board 2001 Camboge; Package of Practices. Cochin, Kerala. 8 pp.

Subash Chandra M D 1996 Nature watch - The kokum tree, Resource 1(1) : 86-89.

Sullivan A C, Hamiltan J G, Miller O N & Wheahkey V R 1972 Inhibition of lipogenesis in rat liver by (-) hydroxy citrate. Arch. Biophys. 150 : 183 - 190.

Sullivan A C & Triscari J 1977 Metabolic regulation as a control for lipid disorders. Influence of (-) hydroxy citrate on experimentally induced obesity in the rodent. Am. J. Clin. Nutr. 30 : 767-776.

Sullivan A C, Triscari J, Hamiltan J G & Miller O N, 1974 Effect of (-) hydroxy citrate upon the accumulation of lipid in the rat. Appetite Lipids 9 (2) : 129-234.

Williams R O 1949 Useful and Ornamental Plants of Zanzibar and Pemba Govt. Press, Zanzibar.

Williams K A 1950 Oils, Fats and Fatty foods J.A. Churchill Ltd, London. 336 pp.

Warrier P K, Nambiar V P K & Ramankutty C 1986 Indian Medicinal Plants Vol 3. Orient Longman Ltd. Madras.