***Chapter 9***

# Phytochemicals and bioactivities of *Garcinia indica* (Thouars) Choisy- A review

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**Abstract**

*Garcinia indica* is well known as a fruit tree of culinary, pharmaceutical, nutraceutical and industrial significance in south India, especially in the Konkan region. The fruit juice is much appreciated as a health drink while the dried fruit rind is used as a spice and condiment. The fat extracted from *G. indica* seeds is known as *kokum butter* and is used in foods, cosmetics and medicines. Stearic acid and oleic acid are the major fatty acids in kokum butter, while the fruit rind contains hydroxy citric acid, the much valued anti-obesity agent. The major class of secondary metabolites reported from different parts of the species are benzophenones, biflavonoids, xanthones and anthocyanin pigments. The fruit rind is a rich source of the benzophenone garcinol, attributed with potential bioactivities, especially antioxidant and cytotoxic. Cyanidin-3-glucoside and cyanidin-3-sambubioside were identified as the major red pigments in the fruit rind. The present review gives an overview of the phytochemical and pharmacological aspects of *G. indica*.

**Keywords:** *Garcinia indica,* Kokum, Anthocyanins, Garcinol, Isogarcinol

## Introduction

*Garcinia indica* (Thouars) Choisy (Family: Clusiaceae) is one of the important indigenous *Garcinia* species grown in the Western Ghats of India. *Garcinia indica* (Kokum) is a slender, tropical evergreen tree that grows up to 15 m height. The branches are drooping, leaves ovate or oblong lanceolate, dark green above and pale beneath, stem bark thin lined, with pale yellow coloured exudates, and fruits globose or round, purple coloured when ripe, about 4 cm in diameter with 5-8 seeds. Flowering was observed during November-February and fruiting season was during April-June (Singh, 1993). *G. indica* is generally known as 'kokum tree', 'wild mangosteen' or 'goa butter tree' (Watt, 1890; Baliga *et al*., 2011).The species is well known for its food, medicinal and commercial values. The National Medicinal Plant Board (NMPB) has identified *G. indica* as an important plant for promotion and development. The present chapter gives a review on the distribution, traditional uses, pharmacological activities and phytochemical constituents of *G. indica*.

**Figure 1.***Garcinia indica* twig and fruits

**1. Distribution and conservation status**

*Garcinia indica* is widely distributed along the Western Ghats of India and also found in the forests of Assam, Meghalaya and West Bengal. In the Western Ghats, the tree is mainly found along the costal belt of Konkan region of Ratnagiri district of Maharashtra, Goa, Uttara Kannada, Udupi and Dakshina Kannada Districts of Karnataka and Kasaragod area of Kerala. It thrives well below an altitude of 800m and at coastal areas (Braganza *et al.*, 2012; Nayak *et al.*, 2010). A wide diversity has been observed for kokum trees in the Western Ghats due to the dioecious nature and cross pollination (Swami *et al.*, 2014; Joseph and Murthy, 2015). The study conducted on 268 accessions of *G. indica* from different parts of the State of Goa, showed that the sugar level varied from 1.9 to 22.4$^{o}$Brix, while the total acid in fresh fruit rind was in the range 1.2 to 11.2 % (Braganza *et al*., 2012). *G. indica* is under vulnerable status as categorised by IUCN. Western Ghats Kokum Foundation (WGKF) is an organisation which promotes cultivation and works on conservation of *G. indica* in India.

**2. Traditional uses of *Garcinia indica***

*G. indica* has got multifarious uses and finds various applications among the local population. The dried fruit rind of *G. indica* impart a sweet-tangy taste to food and is widely used as flavouring agent in food preparations as substitute for tamarind (Anonymous. 1956**;** Jayaprakasha and Sakariah, 2002). The fruits are also used as a substitute for grapes in wine making (Baliga *et al*., 2011). The fruit rind has also been utilized as a pink and purple food colouring agent (Kaur *et al*., 2012). Kokum drinks, made from the fruits of *G. indica*, served as a welcome drink in Goa during summer seasons. Konkani people of Goa and Maharashtra make *bhirindi saar*, a soup using kokum juice and also *kokum kadi* by mixing kokum juice and coconut milk, both used as after-meal drink to relieve any gastric problems (Menezes, 2001). Dried fruit rinds and syrup can be found as reserve in every house hold of Konkan region. Kokum butter is another important product obtained from the seeds of *G. indica*,

which is an important ingredient in cosmetic products like lip balms, lotions and soaps (Baliga *et al*., 2011).

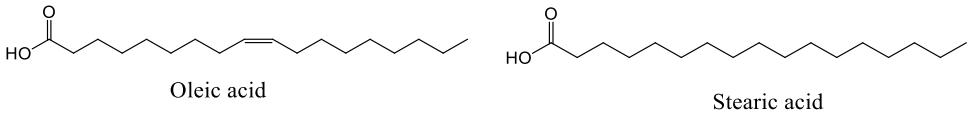
Traditionally, kokum is used in herbal medicines to treat diarrhoea, inflammatory ailments, dermatitis, bowel problems, rheumatic pains and to prevent hyper perspiration. Fruits are used as antihelmintic and cardiotonic. Kokum juice from the rind is used against piles, colic problems, dysentery and diarrhoea (Baliga *et al*., 2011; Watt, 1890). Decoction of fruit rinds are traditionally used against diabetes. Kokum butter is used traditionally to heal wounds, fissures in hands and is supposed to restore elasticity of skin and used as a moisturiser (Jeyarani and Reddy, 1999; Padhye *et al.*, 2009). Leaves of *G. indica* are used to treat skin ulcers, dyspepsia and hyperplasia.

**3. Value added products from *Garcinia indica* fruits**

With an estimated annual production of 10,200 tonnes of fruits (yield is 8.5 t/ha), the species is important for several industrial sectors such as nutraceutical, food supplementary, beverage and cosmetics (Braganza *et al.*, 2012; Swami *et al.,* 2014).. Several consumer products such as Kokum syrup, Kokum Agal (Kokum juice concentrate), Kokum sarbat*,* Kokum solkdhi, Kokum amsul (dried salted rind), Kokum butter and Kokum beverages are available in the market based on kokum fruits, rinds and kokum fat. Rinds are dried and stored, which can be used to prepare reconstitutable drinks during off season (Baliga *et al.*, 2011). It is also marketed as a spice in the local markets of Goa. Fresh rinds are added during wine making process, which gives the wine a pinkish appearance and a tingling taste. Kokum butter, because of its fatty acid content is used in soap and face creams (Padhye *et al.*, 2009). Kokum butter can be used as an ingredient in chocolate and due to the relatively high melting point (mp. 39 to 43°C), kokum butter prevents the chocolate from melting and can be used for preparing heat resistant chocolates (Maheshwari and Reddy, 2005; Jeyarani and Reddy, 1999). Kokum butter is sold as egg shaped lumps, used as edible fat and as a substitute of ghee in Goa.

**3. Phytochemistry of *Garcinia indica***

The seed kernels of *G. indica* contains hard and brittle fat (mp. 39 to 43°C) up to 45 % yield, which is commercially known as 'kokum butter'. Kokum butter contains about 30% of fat content. Extensive studies have been carried out on the fatty acid composition of kokum butter and kokum fat was found to be rich in stearic acid ($C_{17}H_{35}COOH$) and oleic acid ($C_{17}H_{33}COOH$) (Krishnamurthy *et al*., 1982, Jeyarani and Reddy, 1999). Quantitative analysis of kokum butter revealed that in addition to fatty acids, it contains glycerides such as oleodistearin and stearodiolein (Lipp and Anklam, 1998). Seed oil is a source of palmitic acid, stearic acid, oleic acid and linoleic acid. Reports show that seed oil of *G. indica*, because of high content of fatty acid methyl esters, can be used as biofuel or can be mixed with other fuels to enhance its efficiency (Hosamani *et al.*, 2009).




Oleic acid Stearic acid

**Figure 2.** Structures of stearic acid and oleic acid

The fruit juice of *G. indica* is very acidic with a pH 1.5 to 2.0 and contains large amounts of acids. Major portion of organic acids in kokum is hydroxycitric acid (HCA) (1, 2 dihydroxypropane-1, 2, 3-tricarboxylic acid). Rinds contain about 20-30% of (-)-HCA on dry basis (Swami *et al*., 2014). HCA is an anti-obesity agent, attributed with reduced food intake, increased energy expenditure, suppression of fatty acid synthesis and an enhancement of glycogen synthesis in liver (Jena *et al*., 2002). Among the different *Garcinia* fruits, *G. gummi-gutta* possesses the highest HCA content, followed by *G. indica*. However, in a recent study, Pandey *et al* (2015) reported that among the 11 *Garcinia* species leaves analysed, HCA content was highest in *G. indica* leaves, 120mg/g leaf methanol extract, while in *G. gummi-gutta*, the HCA content was 95 mg/g. The total acid content (HCA and HCA lactone) was however higher in *G. gummi-gutta* leaves (308mg/g), compared to *G. indica* leaves (276 mg/g). Besides HCA, kokum juice contains malic acid, citric acid and tartaric acid (Parthasarathy *et al*., 2012).

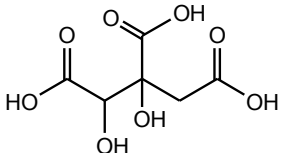



**Figure 3.** Structure of hydroxycitric acid

**Table 1**. Phytochemicals reported from *Garcinia indica*

| Plant part | Compound | References |
|---|---|---|
| Leaves | D- Leucine | Cotterill and Scheinmann1977 |
| | isogarcinol, xanthochymol, isoxanthochymol, | Chattopadhyay *et al.,*2006; Kumar *et al*., 2013 |
| | HCA and HCA lactone | Jayaprakasha and Sakariah2002 |
| | Cambogic acid, mangostin, garcinol, fukugicide, GB-1, GB- 2 and amentoflavone | Pandey *et al.,*2015 |
| Fruits and fruit rinds | (-) HCA, HCA lactone | Cotterill and Scheinmann1977; Jayaprakasha and Sakariah 2002; Padhye *et al.,* 2009 |
| | Garcinol, isogarcinol, citric acid, oxalic acid, xanthochymol, isoxanthochymol | Yamaguchi *et al*., 2000; Chattopadhyay *et al.,*2006; Padhye *et al*., 2009; Nayak *et al*., 2010; Kaur *et al*., 2012; Kumar *et al*., 2013; Bhagwat *et al*., 2014 |
| | Anthocyanin, glucose, xylose, cyanidin-3-glucoside, cyanidin-3-sambubioside and 14-deoxyisogarcinol. | Nayak *et al*., 2010 |
| | Polyprenylated acylphloroglucinol derivative | Kaur *et al*., 2012 |
| Bark | Euxanthone (1,7-dihydroxy xanthone), volkensiflavone and morelloflavone | Cotterill and Scheinmann1977 |
| | Xanthochymol, isoxanthochymol and camboginol | Chattopadhyay *et al.,*2006; Kumar *et al*., 2009 |
| Seed pericarps and Seed oil | Isoxanthochymol, camboginol, palmitic acid, stearic acid, oleic acid and linoleic acid | Kumar *et al*., 2009; Hosamani *et al*., 2009 |

The major secondary metabolites reported from *G. indica* are polyisoprenylated benzophenones, xanthones and biflavonoids. Garcinol (camboginol), isogarcinol (xanthochymol) and isoxanthochymol are the major benzophenone derivatives isolated from *G. indica* fruits, dry rinds and leaves (Yamaguchi *et al*., 2000; Kumar *et al*, 2009; Kumar *et al*., 2013; Kaur *et al*., 2012, Chattopadhyay *et al.,* 2006; Pandey *et al.,*2015). Garcinol is

crystallized out as yellow needles (1.5%) from the hexane extract of the fruit rind, while its isomeric form isogarcinol is colourless. A simple reverse-phase high-performance liquid chromatography-electrospray ionization mass spectrometric method (ESI-MS) for the identification and quantification of the two isomeric benzophenones, isoxanthochymol and camboginol in the extracts of the stem bark, seeds and seed pericarps of *Garcinia indica* have been reported by Kumar *et al.* (2009). Two new compounds, 14-deoxyisogarcinol and a polyprenylated acylphloroglucinol derivative were isolated from *G. indica* fruits by Kaur *et al*., (2012). Xanthones and biflavanoids were also detected from *G. indica* (Cotterill and Scheinmann, 1977). An extensive LC-MS study on methanol extracts of *G. indica* leaves led to the identification of multiclass bioactive constituents belonging to organic acids, phenolic acids, flavonoids, biflavonoids, xanthones, benzophenones and terpenoids (Pandey *et al*., 2015).

The fruit rind of G. *indica* has been utilized as a pink and purple food coloring agent and the rind contains 2 to 3 % of water soluble red colour pigments. The major colouring compounds are the anthocyanin pigments cyanidin-3-glucoside and cyanidin-3-sambubioside which are usually present in the ratio of 4:1 (Nayak *et al.,* 2010).The variation in colour shades of kokum fruits can be attributed to the variation in substitution of hydroxyl and methoxyl groups to the anthocyanin structural skeletons. Anthocyanins are the major antioxidant constituents in *G. indica* and the 3' and 4'-OH in B-ring determine radical scavenging capacity with a saturated 2, 3- double bond. Major phytochemicals isolated from *G. indica* and their structures are given in **Table 1 and Figure 1.**

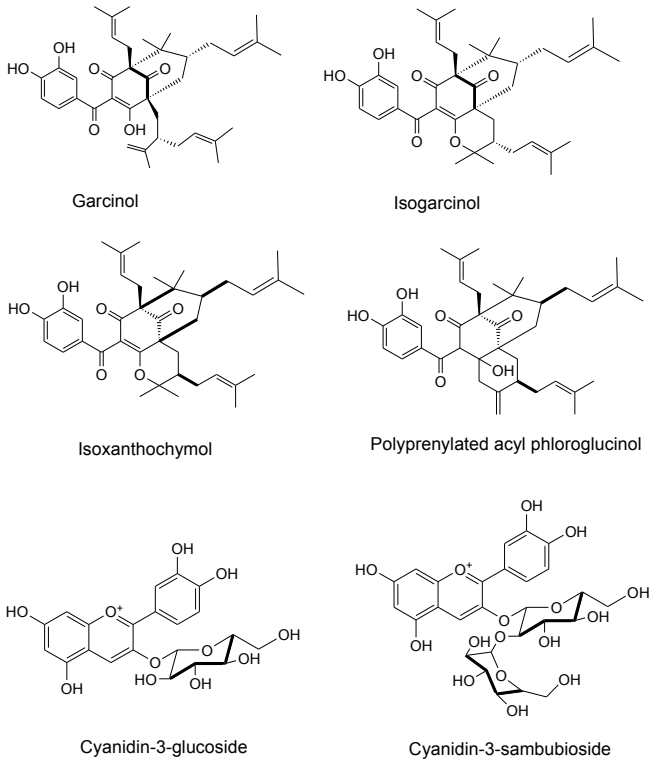



**Figure 1**. Characteristic compounds reported from *Garcinia indica*

**4. Bioactivites of *Garcinia indica***

Extracts as well as compounds isolated from *G. indica* have been studied extensively for various bioactivities like antioxidant, antibacterial, antifungal, antiobesity, antidiabetic, gastroprotective and anticancer activities. The pharmacological studies validated the traditional uses of the plant in various ailments. Benzophenones, anthocyanins and organic acids are the major bioactive constituents reported in *G. indica*.

Among the different bioactivities reported, antioxidant properties are perhaps the most important activity for *G. indica* (Krishnamurthy and Sampathu 1988**;** Mishra *et al*., 2006). Choloroform extracts of *G. indica* fruit rinds exhibited excellent antioxidant activities in β-carotene-linoleate and DPPH assays (Tamilselvi *et al.*, 2003). Aqueous extracts of *G. indica* fruits available in markets acts as very good antioxidants as evident from their DPPH and lipid peroxidation assays. Aqueous extracts of kokum inhibit ascorbate-$Fe^{2+}$ induced lipid peroxidation in rat liver mitochondrial fractions (Mishra *et al*, 2006). Organic acids like citric acid and malic acid from *G. indica* also acts as good antioxidants (Swami *et al*, 2014). A recent study on *G. indica* bark exudates showed its total phenol and xanthone content as 53.43 g/100g and 32.42 g/100g respectively, revealing it as a potential source of antioxidants (Parthasarathy and Nandakishore, 2016).

Kokum rind extracts showed antifungal effects against *Candida albicans, Penicillium* sp. and *Aspergillus flavus*. Also the extract showed inhibitory activity against '3T3' mouse fibroblasts (Mishra *et al*, 2006; Varalakshmi *et al.*, 2010; Tamilselvi *et al.*, 2003). Aqueous and methanol extracts of *G. indica* leaves and fruit rinds showed antibacterial activity against *Salmonella* sp (Pasha *et al.*, 2009). Methanol extracts of kokum fruits acted as an effective neuroprotective agent for striatal dopaminergic neurons in 6-OHDA lesioned rat model of Parkinsons disease (Antala *et al.*, 2012). Aqueous fruit rind extract of the kokum exhibited antidiabetic activity in streptozotocin-induced hyperglycemic rats (Kirana and Srinivasan, 2010). However, lyophilized aqueous-methanol extracts in water of *G. indica* fruit rinds showed a dose dependant genotoxicity in mice (Das *et al.,* 2016).

The major anthocyanin in *G. indica* fruits, cyanidin-3-glucoside decreased the number of non-malignant and malignant skin tumours in the two staged skin carcinogenesis and also caused a dose-dependent inhibitory effect on the migration and invasion of metastatic A549 human lung carcinoma cells (Ding *et al*., 2006, Chen *et al*., 2006). It was found effective in blocking accumulation of intracellular ROS and neurofilament protein expression and was effective against bipolar disorder by reducing ethanol-mediated activation of GSK3β. (Chen *et al.*, 2009). The biological activities of garcinol, the major polyisoprenylated benzophenone isolated from *G. indica* and (-) hydroxy citric acid, the major acid in *G. indica* fruits were dealt in detail in Chapter 10.

**Conclusions**

Recently, *Garcinia* species have received considerable attention worldwide from scientific as well as industrial sectors and several novel structures, bioactivities and potential utilities have been reported. In USA alone, mangosteen containing beverages had a turnover of more than $200 million in 2008. Kokum can be considered as a functional food that provide in addition to nutritional components, other physiological benefits as well. The consumption of high value products of kokum have increased tremendously due to the awareness of the potential health benefits associated with the diverse bioactive constituents in the plant. The review also

highlights the potential for developing *G. indica* as an economic crop to derive value added products with scientific validation.

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