



## Plant Profile, Phytochemistry and Pharmacology of *Garcinia indica*: A Review

Ramachandran HD\*

Department of Biochemistry, Bangalore University, Bangalore, Karnataka, India.

\*Corresponding author's E-mail: [drramac5@gmail.com](mailto:drramac5@gmail.com)

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### ABSTRACT

More than half of the world's population relies on traditional medicine for immediate as well as long term relief from disorders and diseases, and a major role played in traditional medicine is by plant extracts with their active constituents. Various plants have been identified to possess medicinal properties in various parts namely, leaves, fruits, seeds, bark and roots. Among them, *Garcinia indica*, a small to moderate size plant belonging to the Clusiaceae family or Guttiferae, according to the old classification, has approximately 1350 species. Plant parts such as leaves, fruit and seed have been reported for possessing anticancer, antiulcer, antioxidative, antiglycation and antitumor activity. Screening of fruits and seeds has shown the presence of Garcinol, anthocyanins and hydroxycitric acid. The present review focuses on details of geographical distribution, physiochemical parameters, phytoconstituents and pharmacological properties of *Garcinia indica* reported so far.

**Keywords:** Anticancer, Antiulcer, Antioxidative, anti-glycation activity, *Garcinia indica*.

### INTRODUCTION

Plant derived medicines are considered to be first line of defence in maintaining health and combating diseases and even today plant source is principal source of new drug of therapeutic property.<sup>1</sup> Approximately 72000 plant species were estimated for having medicinal properties of which India has more than 3000 plant species having medicinal values.<sup>2</sup> Ayurveda the "Science of life", defines the concept of positive health as metabolically well balanced human beings. For most indigenous system listed medicinal plants such as siddha, Ayurveda, Unani and allopathy which *Garcinia indica* is one of the traditional medicinally imported deciduous plants available all over India. The fruit has been reported to be rich in polysaccharide. The ripe fruit of *Garcinia indica* has been shown to possess adhesive property in our laboratory (unpublished). Unani system of drug medicine uses plant as antibacterial, antiviral and antitumor.<sup>3</sup> Polyherbal formulations, are extensively used by the masses in India for the treatment of common antitumor activity anticancer, anti inflammatory, antimicrobial & antiulcer activity.<sup>4-8</sup>

### Geographical distribution

Kokum (*Garcinia indica*) is also known by different English names such as wild mangosteen or red mango. In India, it is known by names such as Bindin, Biran, Bhirand, Bhinda, Katambi, Punarpuli, Ratamba or Amsool.<sup>9</sup> *Garcinia indica* belongs to the botanical family of Clusiaceae or according to the old classification it belongs to the family of Guttiferae which has approximately 1350 species. Clusiaceae is further divided into five sub-families, one of which is Clusioideae. Sub-family Clusioideae has two tribes Clusieae and Garcicieae and Garcicieae has two genera namely *Garcinia* and *Mammea*. The genus

*Garcinia* contains 200 species out of which over 20 are found in India.<sup>10</sup> Kokum is an evergreen tree predominantly grown in the tropical humid rainforests of Western Ghats in South India up to an elevation of around 800 meters.

### Morphology of *Garcinia Indica*

It is also called Kokum butter tree, brindonia tallow tree or mangosteen oil tree. The tree grows up to 10-18 meters with drooping branches.<sup>10</sup> It flowers from November to February with fruits ripening from April to May. After 15 years, a properly cared single plant yields about 30 to 50 kg of fruit.<sup>10</sup> The ripe Kokum fruit is red or dark purple colored containing 3-8 large seeds. The fruit is spherical, 2.5 to 3.0 cm in diameter. Seeds are usually connected to the rind by tissue and embedded in a red acidic pulp. High content of malic acid and little amounts of tartaric and citric acids give pleasant tart test to the fruit.<sup>10</sup> At present, India produces 10,200 metric tons of Kokum with productivity of 8.5 tons/ha.

Because of the sweetish acidic test and its typical flavor, Kokum is used as an acidulant in different curries like traditional fish curries. Different products like dried ripe Kokum rind (Amsul), Kokum syrup are made from the fruit and rind. The normal shelf life of fresh fruit is about 5 days at room temperature. Kokum fruits have longer shelf life at low temperatures. Traditionally, the fruit rinds are sun dried to reduce water activity and increase shelf-life. The fresh fruits are cut into halves and the seed is removed before sun drying for about 6-8 days. The product obtained after sun drying is commercially called Amsul and can be stored for several months. The dried rind is also used to make a peculiar soup and cold drinks in summer. The dried rind is extracted with water to make syrup which is sweetened to make a cold drink. In



some parts of India, rinds are spiced and sweetened with jaggery for feasts.<sup>10</sup> Aqueous Kokum extract also has 4% sugar which can be fermented to make excellent quality wine. Dried kokum rind pieces are powdered, sieved and stored in airtight containers. Powder is used in coconut and fish curries as an acidulant.<sup>11</sup> Kokum seed is a good source of fat called Kokum butter. It is used in chocolate and confectionary industry. Sometimes it is also used in surfactant and ointment industries.

### Nutritional profile of Kokum

Kokum fruit is naturally very acidic with a pH between 1.5 to 2.0 and contains large amounts of acid. Environmental conditions cause some variation in composition of fruit. Table 1 gives the proximate composition of fruit on fresh weight basis.

**Table 1:** Proximate composition of Kokum<sup>21</sup>

Nutrient	Amount (g/100g fresh weight)
Moisture	80.0
Protein	(N × 6.25%) 1.0
Total ash	2.6
Tannins	1.7
Pectin	0.9
Total sugars	4.1
Crude fat	1.4
Organic acid	5.9
Anthocyanins	2.4

**Table 2:** Fatty acid composition of Kokum butter<sup>10</sup>

Description	Value (%)
<b>Fatty acid composition (%)</b>	
Palmitic acid	2.5
Stearic acid	56.4
Olein	39.4
Linolein	1.7
<b>Glycerides composition (%)</b>	
Tristearin	1.5
Oleodistearin	68
Oleopalmitostearin	8
Palmitodiolein	20
Triolein	2

### Fat composition of Kokum

Kokum seed contains about 25% edible fat commonly known as Kokum butter. It is extracted mostly by crushing seeds, boiling them in water and removing fat from top or by churning the seeds in water. Sometimes it is also separated by solvent extraction. It is used as edible fat or adulterant of ghee. Crude Kokum butter is yellowish, while when refined, it is white in color. Refined Kokum butter is comparable with high quality hydrogenated fats. Fatty acid composition of Kokum butter is given in Table

2. Free fatty acids are present up to 7.2% of total Kokum butter.<sup>10</sup> The fatty acid composition is as follows: oleic, 40-50%; palmitic, 5-8%; linoleic, 2-4% and stearic, 40-50%. The physical, chemical and microbiological properties of Kokum are given in tables 3, 4 and 5, respectively.

**Table 3:** Physical properties of Kokum<sup>10</sup>

Parameter	Limits
Appearance	Light pinkish white colour
Odor	Characteristic odor of Kokum
Taste	Acidic
Colour (Lovibond 5-1/4 scale)	Max. 7.0 Red
Specific Gravity	0.898 to 0.914
Slip Melting Point	34 - 40 deg C
Moisture & Volatile Matter	0.5% Max.

**Table 4:** Chemical properties of Kokum<sup>10</sup>

Parameter	Limits	AOCS Method
Free Fatty Acid as Oleic	0.5 % max	Ca 5a-40
Peroxide value (meq / kg)	4.0 Max	Ja 8-87
Iodine Value	34 – 40	Cd 1c-85
Saponification Value	187 – 193	TI 1a-64
Unsaponifiable Matter	1.2% Max	Ca 6a-40
<b>Fatty Acid Composition in %:</b>	(Only for Major Components)	
Palmitic C16:0	2 – 8	
Margar C17:0	0 – 5	
Stearic C18:0	50 – 65	
Oleic C18:1	30 – 44	
Linoleic C18:2	0 – 8	
Aracid C20:0	0 – 5	

**Table 5:** Microbiological properties of Kokum<sup>10</sup>

Micro-organism	Maximum	Q.C. Method
Aerobic Plate Count	1000 cfu per gm	AOAC 990.12
Yeast & Mold	50 cfu / gm	BAM 19.01-19.03
Total Coli forms	Negative	AOAC 991.14
E. Coli	Negative	AOAC 991.14
Salmonella	Negative	BAM 7.01-7.17
C.P.Staphylococcus	Negative	BAM 14.01 – 14

### Nutraceuticals properties of Kokum

Kokum contains two major active compounds having nutraceuticals properties namely garcinol and hydroxy citric acid. Both of these compounds are present in the rinds of Kokum. They play beneficial role in human health since they have anti-cancer and anti-obesity properties.



## Garcinol

Garcinol is a yellow colored, fat soluble pigment found in the rinds of Kokum at level of 2-3%. In fact all *Garcinia* species have some amount of garcinol.<sup>13, 14</sup> Garcinol can be separated from the fruit rinds by ethanol or hexane extraction.<sup>9,13</sup>

### Chemistry of garcinol

Garcinol is a polyisoprenylated benzophenone derivative and contains phenolic hydroxyl groups. This makes it active antioxidant. It is also called as camboginol, a triisoprenylated chalcone. It has  $\beta$ -diketone moiety and thus resembles a known antioxidant namely curcumin.<sup>15</sup> Molecular weight of Garcinol is 602 ( $C_{38}H_{50}O_6$ ) and its melting point is 122°C.<sup>11</sup> It is crystallized out from hexane extract of the fruit rind. The absorption spectral data and molecular formula indicate relation to isomeric xanthochymol and in terms of optical rotation to cambogin. The 1, 3-diketonesystem is enolisable since presence of two isomeric trimethyl ethers. The UV spectrum of garcinol shows that 1, 3-diketone system is conjugated to the 3, 4-dihydroxybenzoylmoiety. The IR spectrum of trimethyl ethers shows there is presence of saturated carbonyl group and two  $\alpha$ ,  $\beta$ -unsaturated carbonyl groups. Some features of the garcinol molecule indicate it can be derivable from Maclurin (2, 4, 6, 3', 4'-pentahydroxybenzophenone) and five isoprenyl units.<sup>9</sup> The general structure of garcinol is shown in Figure 2.

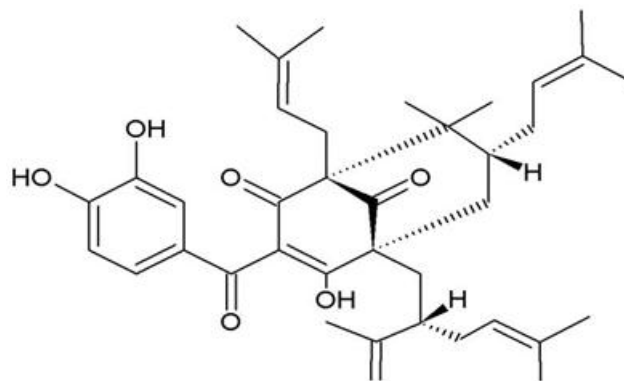


**Figure 1:** (a) Kokum Rinds (b) Rinds with seeds (c) Whole fruit with variation in color

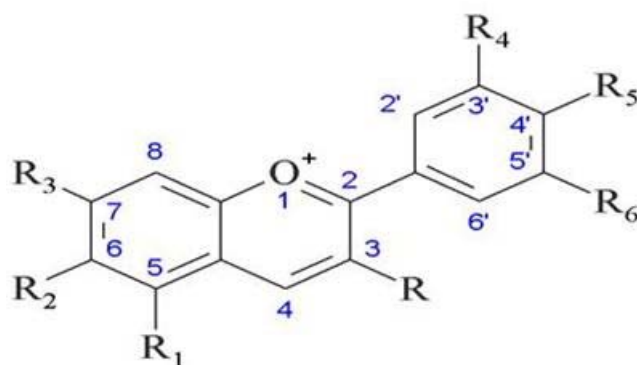
### Nutraceuticals properties of garcinol

Garcinol has been studied for its anti-cancer, anti-ulcer, anti-oxidative and antiglycation activity.<sup>11</sup> The antioxidant activity of Kokum syrup, aqueous and boiled extract has been measured by various techniques such as ORAC, FRAP, ABTS etc. and it is shown that these preparations have very good antioxidant potential due to presence of garcinol and anthocyanins.<sup>16</sup>

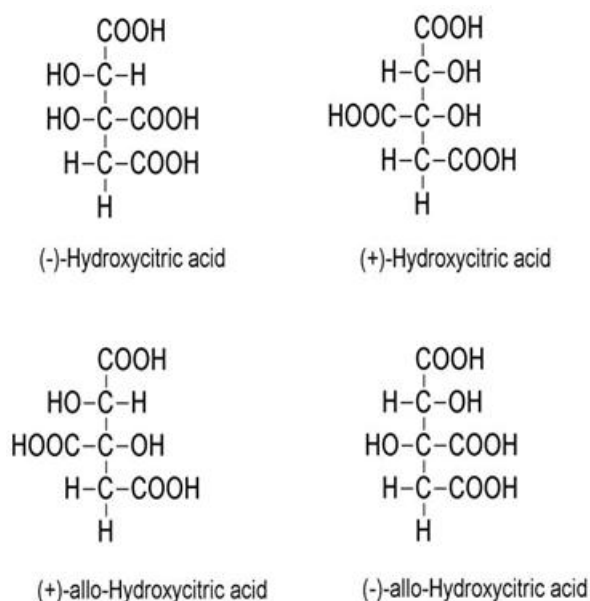
Garcinol also showed antimicrobial activity against *Staphylococcus aureus* which was comparable to traditional antibiotic Vancomycin.<sup>17,18</sup> Yoshida and co-workers reported garcinol fortified diet decreases the incidence of tongue neoplasm's and pre-neoplasms.<sup>19</sup> It also induces apoptosis through the activation of caspases and thus works as antitumor agent.<sup>15</sup> There are numerous reported mechanisms through which garcinol acts as antioxidant, anti-inflammatory or anti-cancer agent as explained above.



**Figure 2:** Structure of garcinol<sup>12</sup>



**Figure 3:** General structure of anthocyanin pigment<sup>23</sup>



**Figure 4:** Stereoisomers of hydroxycitric acid<sup>30</sup>

## Anthocyanins

The two major anthocyanin pigments found in Kokum are characterized as cyanidin-3-glucoside and cyanidin-3-sambubioside. They have been identified by thin layer chromatography as well as HPLC, mass and NMR spectroscopy.<sup>20</sup> Anthocyanins constitute approximately 2.4% of the total fruit biomass. These pigments can scavenge free radicals and are water soluble. They can be extracted from the fruit rind by hydraulic press using 1% acidified water as a solvent.<sup>21</sup> The monomeric anthocyanins in Kokum can be measured using pH differential method.<sup>22</sup>

### Chemistry of anthocyanins

Anthocyanins are a group of important compounds which are part of flavonoids. They are responsible for red and purple colours in fruits. Chemically, anthocyanins are based on a C-15 skeleton with a chromane ring having a second aromatic ring B in position 2 (C6-C3-C6). Usually one or more sugar molecules are attached to different hydroxylase positions of basic structure. Substituted glycosides or salts of phenyl-2-benzopyrylium (anthocyanins) are anthocyanins.<sup>23</sup> Basic structure of anthocyanin is shown in Figure 3 where different R could be -H, -OH or -OCH<sub>3</sub>. Figure 3 also shows the most accepted nomenclature.<sup>23</sup> This basic structure of anthocyanin pigment is responsible for a number of different color compounds produced by chemical combination with glycosides and acyl groups. The most common sugar groups occurring in nature are glucose, rhamnose, xylose, galactose, arabinose and fructose while common acyl groups are cinnamic, caffeic, ferulic, p-hydroxy benzoic, sinapic, malonic, acetic, succinic, malic and oxalic. Substitution of hydroxyl and methoxyl groups has influence on different shades of colors of anthocyanins. Increase in the number of hydroxyl groups gives more bluish shade while increase in methoxyl groups increases redness. Depending upon the number and position of hydroxyl and/or methoxyl groups there are total 17 anthocyanidins of which 6 are the most common ones, namely cyanidin, delphinidin, pelargonidin, malvidin, peonidin, petunidin. Cyanidins have hydroxyl groups attached at 3, 5, 7, 3' and 4' position. It gives magenta and crimson shades.<sup>23</sup> Cyanidin-3-glucoside found in Kokum has hydroxyl groups attached at the corresponding positions and glycosidic linkage at position 3. The other major pigment cyanidin-3-sambubioside is similar in structure and has disaccharide sambubiose attached instead of glucose.

### Nutraceuticals potential of anthocyanins

Anthocyanins have been shown to possess strong antioxidant activity. Given their wide distribution in nature, daily intake of anthocyanins is 25 to 215 mg/person depending upon gender and age.<sup>23</sup> Anthocyanins prevent ascorbic acid oxidation, scavenge free radicals, show inhibitory effects against oxidative enzymes and reduce the risk of cancer and heart

diseases.<sup>24</sup> The 3' and 4' -OH in B-ring determine radical scavenging capacity with a saturated 2, 3-double bond. Different glycosylation and hydroxylation positions determine their potential as an antioxidant.<sup>25</sup> With increase in hydroxyl groups in B ring, antioxidant activity increases when present as glycosides. Corresponding aglycones have weaker activities.<sup>26</sup> Fernandez *et al.* showed antioxidant properties of anthocyanins with DPPH, FRAP and oxygen consumption assays.<sup>27</sup> They showed radical scavenging activity and reducing capacity increased with the number of hydroxyl groups present in B-ring. 3' and 4' -OH groups are important in preventing ascorbic acid oxidation by anthocyanins-metal chelation.<sup>28</sup> Anthocyanins also have effect on lipid peroxidation. They are better agents against lipid peroxidation than  $\alpha$ -tocopherol. Anthocyanins also have scavenging properties against -OH and O<sup>2</sup>·. Bioflavonoids such as leucoanthocyanidins, catechins, flavonols, along with anthocyanins such as cyanidin-3-glucoside have shown activity to improve permeability and strength of capillaries, to accelerate the ethanol metabolism and to reduce inflammations and edematous reactions.<sup>23</sup>

### Hydroxy citric acid

Hydroxy citric acid (HCA) is a major acid found in Kokum. HCA is also found in other *Garcinia* species such as *G. cambogia*, *G. atrovirdis*.<sup>29</sup> Kokum can contain up to 23% of HCA on dry basis. The major part is found in leaves and rinds as HCA and some quantity is present as HCA lactone. HCA which is also called as *Garcinia* acid can be separated from rinds by thermal as well as athermal methods. HCA has been separated as sodium salt by combination of aqueous NaOH and methanol extraction and then neutralizing with HCl. Acetone is used to obtain pure crystals of HCA. HCA has also been separated by athermal method in which HCA is extracted with deionized water and then concentrated by osmotic membrane distillation with hydrophobic polypropylene membrane. This method being non thermal avoids degradation of HCA and also HCA lactone formation.<sup>11</sup>

### Chemistry of HCA

HCA has hydroxyl groups at the second and third carbon atom. HCA has two asymmetric carbons and thus two pairs of diastereoisomers. Out of the four, (-)-hydroxy citric acid is found in *Garcinia* species. Free HCA is readily converted to HCA lactone while evaporation or concentration. Structures of HCA and its isomers are shown in Figure 4.

There are two corresponding lactones for each pair namely, (-)-hydroxy citric acid lactone and (+)-allo-hydroxy citric acid lactone. Since HCA is unstable in its free form, it is commercially available as a calcium salt. Potassium hydroxy citrate is also formed by KOH treatment of HCA.<sup>30</sup>



### Regulatory effects of HCA

(-)-HCA has inhibitory effect on ATP-citrate lyase (ATP-citrate oxaloacetate lyase, EC 4.1.3.8). This enzyme plays influential role in fatty acid synthesis from carbohydrates. It catalyzes cleavage of citrate to acetyl-CoA and oxaloacetate. The ultimate source of carbon for fatty acids is acetyl-CoA and acetyl-CoA is an important molecule in formation of fats from carbohydrates. Thus by limiting the availability of acetyl-CoA, (-)-HCA plays important role in regulating fatty acid synthesis. The knowledge of powerful inhibition of ATP-citrate lyase by HCA helps in the study of citrate cleavage reaction.<sup>30</sup>

HCA, in some cases, has been observed to stimulate fatty acid synthesis. HCA inhibits lipogenesis only when cytoplasmic acetyl-CoA is produced by citrate cleavage enzyme otherwise if the alternate source of acetyl-CoA is available, for example, acetate, it will activate fatty acid synthesis.<sup>30</sup> Since HCA regulates the ATP-citrate lyase enzyme and thus citrate cleavage reaction it acts as an anti-obesity agent. Due to its regulatory effect it is also known as weight controlling agent.

HCA can be used to increase activity of carnitine palmitoyl transferase (CPT 1). CPT 1 is a rate limiting factor in fat burning and thus weight loss. HCA limits production of acetyl-CoA which in turn reduces production of malonyl-CoA. Malonyl-CoA has inhibitory effect on CPT1. Thus by reducing malonyl-CoA formation HCA works as a weight reducing agent. But since malonyl-CoA is also important in transmitting insulin signal in the cells, HCA may have adverse effect on insulin sensitivity.<sup>30</sup>

### Effects of extrusion on nutritional quality

To study effects of processing on Kokum and its active components, rice flour was chosen as a base for extrusion processing. Kokum fruit powder was mixed with rice flour before extrusion and different properties of extrudates were studied. Since rice is white in color it provided good base to study the red color of extrudates. Due to high temperature and shear inside the extruder, food components can undergo molecular changes including chemical reactions and physical transformations such as starch gelatinization and fragmentation, protein denaturation, flavor degradation, lipid oxidation and caramalization. These changes result in textural, color, flavor and nutritional developments.

### Background

The backbone of Indian tradition system of medication is herbal source, Ayurveda the oldest traditional medicinal system that is based on plant medicines and treatments. *Garcinia indica*, commonly known as Kokum, is a tropical fruit native to India.

The rinds of fruit are rich source of red anthocyanin pigments which are characterized as cyanidin-3-glucoside and cyanidin-3-sambubioside. The fruit juice is strongly acidic (pH is 1.87) due to the presence of hydroxy citric acid, an organic acid known for its weight-suppressing

action. Recently a new, yellow, fat soluble pigment called garcinol has been separated from the fruit rinds. Garcinol is a polyphenolic compound known to possess antioxidant activity. Presence of bioactive compounds in the fruit promotes its use as a colorant and antioxidant in a food product.

### Applications

The detailed plant information and its uses against various ailments might be further useful for references and related research work based on traditional Indian system of medication. The present review could help to lead the discovery of various new plant based drugs and treatment of various disorders and diseases.

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#### Corresponding Author's Biography: Dr. H D Ramachandran



Dr. H D Ramachandran, *M.Sc., Ph.D., FSPR.*, Associate Professor in the Department of Biochemistry, Bangalore University has completed his Master's and Doctoral degrees in Biochemistry from University of Mysore and Central Food Technological Research Institute (CFTRI), Mysore, respectively. He has received grants from various agencies like UGC, DST, DAE- BRNS, DBT for various projects. The areas of research undertaken in his laboratory include lipid biochemistry, oxidative stress and phytochemicals as antioxidants, nanobiotechnology.