

## PHARMACOLOGICAL PROFILE, PHYTOCHEMISTRY & APPLICATION OF *GARCINIA INDICA* FRUITS

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### ABSTRACT

*Garcinia indica* is a member of the Clusiaceae family and is a small to medium-sized plant. There are 200 different species of this tropical fruit, which is most frequently referred to as kokum. Fruits are green when unripe, becoming scarlet or dark purple as they ripen. Kokum is a fruit tree with uses in agriculture, medicine, nutraceuticals, and industry. As a long-used remedy for dermatitis, diarrhoea, dysentery, ear infections, and to aid in digestion, kokum has a long history in Ayurvedic medicine. Oil is extracted from kokum seeds. In other countries, this oil is known as kokum butter and is used in expensive confectionary dishes, cosmetics, and curries. According to chemical research, the rind includes anthocyanins such as cyanidin-3-glucoside and cyanidin-3-sambubioside as well as polyisoprenylated phenolics. It also contains protein, tannin, pectin, sugars, fat, Garcinol, and organic acids including (-)-hydroxycitric acid, hydroxycitric acid lactone, and citric acid. This review emphasises the most current developments in *G. indica*'s different pharmacological properties. According to these research, *G. indica* possesses both in vitro and in vivo properties that are anti-oxidant, anti-obesity, anti-arthritis, anti-inflammatory, antibacterial, hepatoprotective, cardioprotective, antidepressant, and anxiolytic. The purpose of this review is to describe the information that is currently available regarding traditional, medical, pharmaceutical, and bioactive uses for the kokum fruit. This information will help to generate interest in *Garcinia indica* and may be useful in the development of new formulations that have greater therapeutic and financial value.

**KEYWORDS:** *Garcinia indica*, phytochemicals, pharmacological activities, cardioprotective, anti-arthritis, anti-depressant.

### INTRODUCTION

The earliest kind of medical care known to humans is the use of medicinal plants as medicine, which has been practised throughout history in all civilizations. By examining various biologically active natural products, this indigenous knowledge that has been passed down from one generation to the next throughout the world has greatly influenced the development of traditional medical systems. It has also provided a scientific foundation for their traditional uses. For instance, around 26% of novel chemical entities between 1981 and 2014 were either derived from or natural products. They have the distinct benefit of having minimal toxicity and side effects when compared to chemical medications, which makes them particularly useful in the prevention and treatment of clinical disorders. The biggest genus is the dioecious *Garcinia*, which includes 600 species and 50 genera and is widely used in ethnomedicine to cure a range of ailments, including wounds, ulcers, diarrhoea, cancer,

inflammation, and infection.<sup>[1]</sup> *Garcinia indica*, a tropical fruit with a pleasant, tangy-sweet flavour and several health advantages, might be thought of as a wonder berry. Its dried rind is known as "kokum"<sup>[2]</sup> It belongs to the family Clusiaceae.<sup>[3]</sup> The *Garcinia indica* seed contains 23-26% oil, which is used to make chocolate, medications, and cosmetics and is solid at normal temperature.<sup>[4]</sup> It is an Indian spice that is used across the nation to make famous dishes like "solkadhi" and a variety of vegetarian and non-vegetarian "curry" preparations. Amrutkokum, a popular summertime nutritious soft drink to prevent sunburn, is made by steeping fruits in sugar syrup. Aqueous Kokum extract also contains 4 sugar, which when fermented, produces wine of exceptional quality. The chocolate and confectionery industries employ a fat called kokum butter, which is derived from kokum seed.<sup>[2]</sup> The cosmetics industry uses kokum butter, a great emollient, to make lotions, creams, lip balms, and soaps. It has one

of the most stable unusual butters that doesn't require refrigeration and a relatively high melting point. Kokum butter is extremely important in the beauty industry since it has been shown to be an effective moisturiser and in the healing of skin wounds.<sup>[3]</sup> It is taken from the Kokum seed and is intended to minimise skin cell degeneration and restore elasticity.<sup>[4]</sup> While the bark's decoction is used to cure paralysis, the plant's extract is utilised as an

appetiser in West Coast Indian speciality cuisine.<sup>[4]</sup> B-complex vitamins and minerals, such as potassium, manganese, and magnesium, are abundant in kokum and help regulate blood pressure and heart rate, protecting against stroke and coronary heart disease<sup>2</sup>. Traditional uses for kokum include the treatment of diarrhoea, inflammatory conditions, intestinal issues, rheumatic aches, and the prevention of excessive sweating.<sup>[5]</sup>

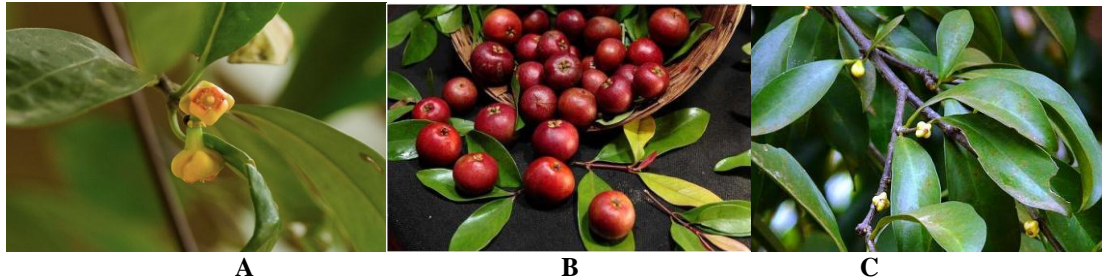


Fig. 01: A. Flowers of *Garcinia indica* B. Fruits of *Garcinia indica* C. Leaves of *Garcinia indica*.

The kokum fruit is known by several names in different parts of India, As shown in Table 01.

Table 01: Name of Kokum fruit.<sup>[6]</sup>

Language	Name
English	kokum, Goa butter tree, Kokum butter tree
Sanskrit	Vrikshamia, Vrikshamla, Amlabija, Raktavikshamla, Amlapura, Amlashaka Kokum
Hindi	Kokum
Bengali	Kokum
Tamil	Bhiranda, Murgal, Murgal-mala
Gujarati	Kokum
Oriya	Tintali
Tulu	Punarpuli
Malayalam	Kaattampi
Sinhala	Goraka
Kannada	Murgina, Punarpuli, Devana huli
Kokani	Bhirind
Marathi	Bheranda

#### Scientific classification<sup>[7]</sup>

Kingdom	Plantae
Class	Magnoliopsida
Division	Magnoliophyta
Order	Malpighiales
Family	Clusiaceae
Subfamily	Clusioideae
Genus	<i>Garcinia</i>
Species	<i>G. indica</i> Chois
Tribe	Garcinieae

#### History/Origin<sup>[8]</sup>

The Indians originally saw this lovely decorative fruit tree in Mumbai thousands of years ago, and they have since exploited it for a variety of purposes and desires. These people have traditionally valued kokum, and it has long been a part of Ayurvedic therapy. A member of India's Western Ghats, kokum has played a significant role in that nation's history for many years. While certain

kokum butter-based cosmetic items have started to appear on the global markets, the Southeast Asian subcontinent is still well known for its ability to identify kokum fruits.

#### Geographical distribution

An indigenous tree to India is the kokam. However, it is now growing in other parts of peninsular India. It is

primarily found in the western peninsular coastal regions and the nearby Western Ghats in the states of Maharashtra, Goa, Karnataka, and Kerala as well as portions of eastern India in the states of West Bengal, Assam, and the North Eastern Hill region. The tree produces fruit every year from March to May during the Kokum summer season.<sup>[9]</sup> It is a medium-sized to giant tropical evergreen tree. It is located at a height of around 800 metres above sea level. The tree is thin with sagging branches. It is an androdioecious tree that produces bisexual and male blooms on different plants.<sup>[2]</sup>

### Morphology of plant

The tree has drooping branches and may reach heights of 10–18 metres. It blooms from November to February, and from April to May, its fruits mature.<sup>[10]</sup> Kokum fruits range in shape from round to oblong or oval, measure 2.5 to 3.0 cm in diameter, have pointy points, and are capped by a stigma with a four-part stalk. When completely mature, kokum fruits turn from dark to light green in colour at first, to crimson red with a yellow undertone, and finally to dark violet or purple. The fruits can reach a lemon-sized size. A typical kokum tree produces hundreds of fruits, each of which weighs between 21 and 85 g. Three to eight big seeds may be found in a kokum fruit, which is coated in yellowish pulp that has a pleasant flavour.<sup>[9]</sup> A crimson, acidic pulp surrounds the seeds, which are often attached to the rind by tissue. The fruit has a nice tart flavour due to the high malic acid concentration and little quantities of tartaric and citric acids. India now produces 10,200 metric tonnes of kokum, with an output of 8.5 tonnes per hectare. because of its distinctive flavour and sweet-but-acidic taste. The fruit and rind are used to make a variety of goods, such as dried, ripe Kokum rind (Amsul) and Kokum syrup. Fresh fruit typically lasts for five days at room temperature.<sup>[10]</sup> Low temperatures extend the shelf life of kokum fruits, and rainfall between 2500 and 4000 mm is beneficial to the development of this tree. The kokum crops require laterite and alluvial soil. The best places to cultivate kokum are near coconut plantations and between areca nut and coconut plantations.<sup>[3]</sup> The fruit rinds are often sun dried to reduce water activity and lengthen shelf life.<sup>[11]</sup>

### Chemical Composition

Garcinol, a polyisoprenylated benzophenone, isogarcinol, and camboginol are the main components of kokum rind. The main oxidative byproducts of garcinol are garcim-1, garcim-2, and cambogin, as well as isogarcinol, gambogic acid, mangostin, clusianone, macurin, oblongifolin (A, B, and C), and guttiferone (I, J, K, M, and N)<sup>[12]</sup> Kokum fruit has a pH range of 1.5 to 2.0,<sup>[13]</sup> making it quite acidic by nature. Kokum fruit rind contains hydroxyacetic and hydroxycitric acids when it is mature. Additionally, it has 2.4% pigment, which is a 4:1 blend of the anthocyanins cyanidin-3-sambubioside and cyanidin-3-glucoside. According to studies, the fresh rind of kokum is 80 percent water, 2 percent protein, 2 percent tannin, 5 percent pectin, 14 percent crude fibre, 4

percent total sugars, 1 percent fat, 2 percent colour, 22 percent hydroxycitric acid, and 0.06% ascorbic acid. L-leucine, 75% moisture, 2.3g of protein, 0.5g of fat, 1.24g of fibre, 17.2g of carbs, 15.14 mg of iron, 250 mg of calcium, 10 mg of ascorbic acid, and 18.10 mg of oxalic acid are all claimed to be present in a 100g serving of kokum leaves.<sup>[14]</sup> In trace amounts, citric acid and hydroxycitric acid lactone are also found in leaves and rinds. Glycerides of stearic acid (55%) and other fatty acids, such as oleic acid (40%) and palmitic acid (3%), linoleic acid (1.5%), hydroxyl capric acid (10%), and myristic acid (0.5%), are abundant in kokum seeds. About 25% of the edible fat in kokum seeds, sometimes called kokum butter, is present.<sup>[15]</sup>

### Phytochemistry

GC-MS analysis is typically used to conduct phytochemical research.<sup>[16]</sup> According to research, kokum's peel contains the greatest quantity of anthocyanins (2.4 g/100 g of kokum fruit) when compared to any other natural source. The anthocyanins found in kokum are the main pigment there.<sup>[17]</sup> The outer rind contains iso garcinol and two poly iso prenylated phenolics garcinol. According to studies, the main organic acid in kokum leaves and the outer skin is hydroxycitric acid. This substance, which is present in the amounts of 4.1–4.6 and 10.3–12.7% in the leaves and fruits of kokum, is responsible for the fruit's and leaves pleasant flavour. The plant also includes lactone and hydroxyl citric acid in trace amounts.<sup>[18]</sup>

#### 1. Garcinol

Garcinol, a polyisoprenylated benzophenone derivative with a melting point of 122°C, is present in Kokum fruit at a rate of 1.5%<sup>[19]</sup>. Garcinol has a molecular weight of 602. It is also known as camboginol, a yellow, fat-soluble chalcone that has been triisoprenylated. Garcinol's UV spectrum reveals that the 3, 4-dihydroxybenzoyl molecule is linked to a 1, 3-diketone system. Trimethyl ethers' IR spectra reveal the existence of two, -unsaturated carbonyl groups as well as a saturated carbonyl group.<sup>[20]</sup> In an aqueous ethanol solution, garcinol demonstrated three times the weight-based DPPH (1,1 diphenyl-2-picrylhydrazyl) free scavenging activity of DL- $\alpha$ -tocopherol.<sup>[4,21]</sup> It is produced by crystallising the hexane extract of *Garcinia indica* fruit rinds. It was discovered to be a strong inhibitor of the histone acetyl transferase enzyme.

A possible anti-cancer agent is garcinol. Antibiotic, antioxidant, chelating, free radical scavenging, anti-ulcer, and anti-glycation properties have all been linked to it, according to reports.<sup>[22]</sup> By using several methods, including ORAC, FRAP, ABTS, and others to assess the antioxidant activity of Kokum syrup, aqueous, and boiling extract, it has been determined that these preparations have extremely excellent antioxidant potential because garcinol and anthocyanins are present.<sup>[23,24]</sup> The antibacterial activity of garcinol against *Staphylococcus aureus* was equivalent to that of the

conventional antibiotic Vancomycin. According to Yoshida and colleagues, a diet supplemented with garcinol lowers the frequency of tongue neoplasms and pre-neoplasms. Through the activation of caspases, it also promotes apoptosis and functions as an anticancer agent.<sup>[25]</sup> Fig. 02 depicts the overall structure of garcinol.

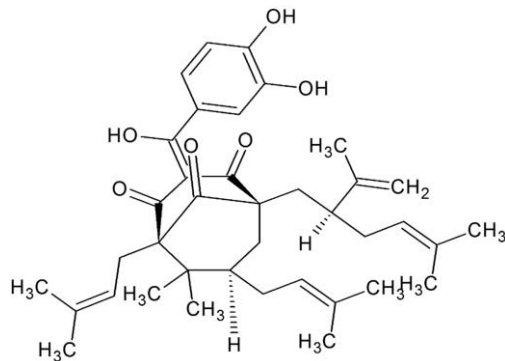


Fig. 02: Garcinol.

## 2. Anthocyanins

Red pigment makes around 2 to 3% of kokum. Kokum's anthocyanins are water soluble and have antioxidant properties. Cyanidin-3-glucoside and cyanidin-3-sambubioside, which are often found in a 4:1 ratio, are two main pigments that are characteristic of kokum. Through the use of acetic acid and thin layer chromatography, these two anthocyanins were initially discovered: 15:3:82.<sup>[15,26]</sup> is the ratio of HCl to water. 2.4% of the total fruit biomass is made up of anthocyanins. These pigments are water soluble and may scavenge free radicals. With the use of a hydraulic press and 1% acidified water as a solvent, they may be removed from the fruit rind.<sup>[27]</sup> The pH differential method may be used to determine the monomeric anthocyanins in kokum.<sup>[28]</sup> By chemically combining glycosides and acyl groups with the anthocyanidin pigment's fundamental structure, a variety of distinct colour compounds may be created.<sup>[14,29]</sup> Strong antioxidant activity has been shown in anthocyanins. Anthocyanins lower the risk of cancer and heart disease, stop the oxidation of ascorbic acid, scavenge free radicals, exhibit inhibitory actions against oxidative enzymes, and more.<sup>[15,30]</sup> With a saturated 2, 3-double bond, the 3' and 4' -OH in the B-ring dictate the capacity to scavenge radicals. Additionally, anthocyanins have an impact on lipid peroxidation. Compared to  $\alpha$ -tocopherol, they are more effective anti-lipid peroxidation agents.<sup>[31]</sup> Additionally, leucoanthocyanidins, catechins, flavonols, and other bioflavonoids including anthocyanins have scavenging abilities against  $\cdot\text{OH}$  and  $\cdot\text{O}_2$ .<sup>26,27</sup> Along with anthocyanins, compounds like cyanidin-3-glucoside have demonstrated activity to increase capillary permeability and strength, speed up the metabolism of ethanol, and minimise inflammatory and edematous reactions.<sup>[32]</sup> Fig. No. 3 depicts the anthocyanin's overall structure.

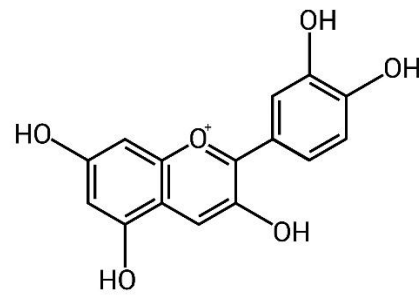


Fig. 03: Anthocyanin.

## 3. Hydroxy citric acid (HCA)

One of the main acids in kokum is hydroxy citric acid (HCA). On a dry basis, kokum can contain up to 23% HCA.<sup>[33]</sup> The majority is available as HCA in the leaves and rinds, while a little amount is present as HCA lactone.<sup>[34]</sup> HCA has been demonstrated to drastically cut body weight and reduced lipid buildup because it inhibits the creation of fat and cholesterol. It is also the only known anorectic substance present in edible foods that people eat naturally.<sup>[34,35,36]</sup> Garcinia acid, as it is often known, may be extracted from rinds using both thermal and non-thermal techniques. By combining aqueous NaOH and methanol extraction with HCl neutralization, HCA has been isolated as a sodium salt. To create pure HCA crystals, acetone is utilized. HCA has also been separated using a thermal process in which it is first extracted using deionized water and then concentrated using a hydrophobic polypropylene membrane during membrane distillation. Due to the non-thermal nature of this approach, HCA is not degraded or HCA lactones are not formed.<sup>[37,38,39]</sup> HCA functions as an anti-obesity drug by controlling the ATP-citrate lyase enzyme and, therefore, the citrate cleavage process. It is sometimes referred to as a weight-controlling agent because of its regulatory effect.<sup>[40,41]</sup> Fig. 04 depicts the overall organization of HCA.

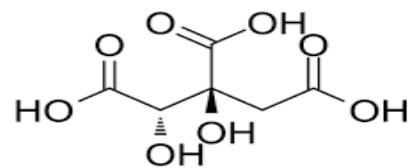


Fig. 04: Hydroxy citric acid.

## Pharmacological and Biological properties

**1. Antioxidant and Hepatoprotective activity-** Micronutrients known as antioxidants have become more important in recent years because of their capacity to inhibit free radicals or their effects. One of the desirable qualities of a dietary component is believed to be its antioxidant impact because of the new trends in nutrition towards the production of healthy meals in the form of "functional foods." Deore et al. investigated the antioxidant and hepatoprotective effects of aqueous and

ethanolic extracts of *Garcinia indica* Linn fruit rind on Wistar albino rat liver damage caused by carbon tetrachloride (1.5 ml/kg).<sup>[34,42]</sup> Biochemical markers such aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALKP), and serum bilirubin (SBRN) were used to assess the level of liver protection. While the biochemical indicators sulphoxide dismutase (SOD), glutathione (GSH), lipid peroxidation (LPO), and catalase (CAT) were used to assess the antioxidant effect. Gogoi et al. investigated the total phenolic content and free radical inhibition ability of methanolic fruit rind extract of *Garcinia indica* fruit rind.<sup>[43,44]</sup> Cold and hot aqueous extracts of kokum showed free radical scavenging action in addition to the concentrated syrup that is sold. Strong antioxidant activity equivalent to those of normal ascorbic acid were demonstrated by kokum fruit methanolic extract.<sup>[45,46]</sup>

**2. Antimicrobial and cytotoxic activity-** *Garcinia indica* has antimicrobial effects on certain microorganisms as well as cytotoxic effects on Balb/c 3T3 murine fibroblasts. The aqueous extract had minimum inhibitory values of 0.5 mg/ml against *Escherichia coli*, 5 mg/ml against *Bacillus subtilis* and *Enterobacter aerogenes*, and 50 mg/ml against *Staphylococcus aureus*. On cultivated 3T3 mouse fibroblasts, *Garcinia indica* fruit rind extract exhibited inhibitory effects. As the extract concentration increased, the concentration of cells dropped. Both antifungal and antibacterial properties are seen in the *Garcinia indica* extract.<sup>[47,48,49]</sup>

**3. Antifungal activity-** The primary infectious agents in plants, including post-harvest, are pathogenic fungi, which influence plant growth at various stages. There are many different fungal genera that affect fruit and vegetable quality in ways that affect aspect, nutritional value, organoleptic features, and shelf life. Additionally, since they produce mycotoxins or allergens, fungi are occasionally indirectly to blame for allergic or toxic illnesses in consumers.<sup>[50]</sup> Aqueous kokum rind extract has been shown by Varalakshmi and colleagues to have antifungal properties against *Candida albicans* and *penicillium sp.* Kokum rind extracts in chloroform inhibited *Aspergillus flavus* growth and aflatoxin production.<sup>[51]</sup>

**4. Anti-bacterial activity-** The active ingredient in kokum, garcinol, and its hexane and benzene extracts have strong antibacterial properties of their own. Additionally, it strengthened clarithromycin's anti-*H. Pylori* properties. *Salmonella typhi*, *salmonella paratyphi A*, and *Salmonella typhimurium* are harmful bacteria that can be inhibited by even kokum leaf extract. *Escherichia coli*, *Enterobacter aerogenes*, *Staphylococcus aureus*, and Kokum rind extract are said to have the lowest antibacterial efficacy against *Bacillus subtilis*. Garcinol, isogarcinol, and xanthochymol are phytoconstituents that have an inhibitory impact on the development of methicillin-resistant *S. aureus*.<sup>[46,48,52]</sup>

**5. Anti-inflammatory activity-** Acute inflammation is a defence mechanism that helps the body deal with infections, tissue damage, and immunological responses.

It is hardly surprising that kokum has been utilised in traditional medicine for inflammatory illnesses for many years. Using a carrageenan-induced paw edoema model, the anti-inflammatory activity of kokum rind aqueous and ethanolic extract was examined. Anthocyanins and phytopoly compounds, which are strong antioxidants and advantageous for their anti-inflammatory action, are active components found in *Garcinia indica* fruits. In an acute investigation, both extracts greatly reduced inflammation. Its anti-inflammatory action is further supported by a considerable decrease in the lysosomal enzymes acid phosphate and alkaline phosphate.<sup>[53]</sup>

**6. Anti-ulcer activity-** Aqueous and ethanolic extracts of the rind of *Garcinia indica* Linn fruit were shown to have ulcer-protective properties, according to Deore et al. Indomethacin-induced ulcerogenesis and HCl/ethanol-induced stomach lesions were examined for ulcer-protective efficacy in *Garcinia indica* Linn's aqueous and ethanol extracts. In the HCl/ethanol and indomethacin generated gastric lesion rat models, oral treatment of the aqueous and ethanol extracts of *Garcinia indica* fruit rind at the dose of 500 mg/kg caused a substantial ( $p < 0.001$ ) decrease in ulcer index.<sup>[54,55]</sup>

**7. Cardioprotective Activity-** Despite tremendous advances in diagnosis and treatment, CVD cause one-third of all yearly deaths worldwide. Additionally, because low- and middle-income nations have inadequate resources for health care and account for 80% of all cardiovascular-related fatalities, the effects of CVD are catastrophic. Studies conducted in vitro on bovine artery endothelial cells revealed that cyanidin-3-glucoside raised eNOS levels—an enzyme crucial for preserving blood pressure regulation and vascular integrity—and nitric oxide production simultaneously. Cyanidin-3-glucoside enhanced Src and ERK1/2 phosphorylation at the molecular level. Additionally, it improved the transcription factor Sp1's ability to bind to the GC box in the bovine artery endothelial cells proximal eNOS promoter. Together, these findings imply that cyanidin-3-glucoside boosted NO generation and stimulated eNOS expression, which may aid in treating endothelial dysfunction, regulating blood pressure, and maybe preventing atherosclerosis.<sup>[56,57]</sup>

**8. Anti Lipid peroxidation Activity-** A surplus of free radical's damages lipid membranes, impairs cell activity, and eventually kills cells. Therefore, preventing lipid peroxidation is crucial for the cell to operate at its best. According to Mishra's research, kokum extracts and syrup prevented ascorbate—Fe<sup>2+</sup>-induced lipid peroxidation in an in vitro rat liver experiment. The kokum syrup, cold aqueous extract, and hot aqueous extract all performed best. Contradictory findings have been made about the anti-lipid peroxidative abilities of garcinol. Additionally, lipid peroxidation caused by peroxynitrite in blood platelets and plasma is said to be effectively inhibited by garcinol.<sup>[42,58,59]</sup>

**9. Gastroprotective activity-** The multifactorial condition known as peptic ulcers affects a sizable portion of the world's population. According to studies, garcinol (40–200 mg/kg) oral dosing prevented rats from

developing stomach ulcers brought on by indomethacin. Garcinol had effects that were comparable to cetraxate-HCl when it was employed as a positive in decreasing water (23°C) immersion-induced stomach ulcers. Garcinol has also been proven to be effective against *H. Pylori*, the cause of stomach ulcers and cancer, in in vitro experiments, both by itself and in conjunction with clarithromycin. Together, these findings strongly support the value of garcinol in preventing the development of stomach ulcers and call for further study.<sup>[42]</sup>

**10. Anti-neoplastic activity-** Antineoplastic activity refers to actions taken to stop or impede the growth of a neoplasm (a tumour). Garcinol inhibited DNA damage by neutralising the hydroxyl radical and preventing the development of cancer. Additionally, both normal immortalised intestinal cells and neoplastic colon cancer cells were significantly inhibited in their ability to proliferate by garcinol and its derivatives, cambogin, garcim-1, and garcim-2. Through the activation of caspase-3 in cancerous cells, isogarcinol and xanthochymol cause apoptosis. Cyanidin-3-glucoside was predicted by in vivo research to reduce the number of benign and malignant skin tumours in mice using a skin carcinogenesis model. The cytotoxicity of the peroxy radical (AAPH) was reduced and Caco-2 colon cancer cells were protected against it by cyanidin-3-glucoside.<sup>[1,2]</sup>

**11. Anti-diabetic or Hypoglycaemic activity-** In both an acute and chronic research, the whole fruit extract of kokum dramatically reduced fasting blood glucose levels in streptozotocin-induced hyperglycemic rats. Its anti-hyperglycemic effect was revealed by the considerable improvement in oral glucose tolerance following acute administration of an aqueous extract at a dose of 400 mg/kg. These findings imply that kokum may be helpful in treating both hyperglycemia and other problems. Kokum also restored the levels of erythrocyte GSH, an intracellular antioxidant that has been shown to be effective in reducing the chance of developing secondary complications. According to studies using a bovine serum albumin/fructose system, garcinol isolated from the rind of *Garcinia indica* has significant glycation-inhibiting activity.<sup>[1,10]</sup>

**12. Neuroprotective activity-** Kokum fruit's anti-Parkinson's action in rats was demonstrated by the strong neuroprotective potential it displayed against 6-OHDA in methanolic extract. The expression of LPS-induced anti-inflammatory mediators was likewise decreased by garcinol. In astrocytes that had been treated with LPS, iNOS and COX-2 stopped the buildup of nitric oxide. Additionally, its anticholinesterase properties were discovered. Cyanidin-3-glucoside's capacity for neuroprotection is demonstrated by the way it inhibits neurite development and the production of neurofilament proteins.<sup>[24,60]</sup>

**13. Anti-ageing activity-** Different pigments found in the kokum plant are advantageous for skin care and useful in treating all skin diseases since they have the ability to absorb UV rays. For the treatment of skin,

Kokum shown activity against elastase and hyaluronidase. We separated crude methanolic extract (ME) from *G. indica* into ethyl acetate and water fractions (WF), and we tested those fractions for anti-hyaluronidase and anti-elastase activity.<sup>[2]</sup>

**14. Anti-obesity activity-** Using a cholesterol-induced hyperlipidemic paradigm, Darji and his colleagues found that the dried fruit of kokum's methanolic extract had exceptional antihyperlipidemic action in rats. Numerous studies have demonstrated that consuming the hydroxycitric found in kokum decreases hunger, prevents lipogenesis, and lowers body weight. Rat adipocytes treated with cyaniding 3-glucoside in in vitro experiments showed an increase in adipocytokine production and elevation of adipocyte specific gene expression without activation of PPAR. Additionally, adiponectin gene expression increased in the white adipose tissue according to in vivo investigations. Isogarcinol has also been demonstrated to have anti-obesity and lipase inhibitory properties.<sup>[33]</sup>

**15. Anthelmintic activity-** One of the main reasons for output losses, particularly in developing nations, is helminthiasis. To determine if the plant demonstrates such an action, Swapna et al employed crude extract of *Garcinia indica* made from petroleum ether, ethyl acetate, methanol, and water. The methanol extract at a dosage of 50 mg/ml demonstrated the quickest paralysis and death of the worms that were treated with the extracts out of these extracts. Even if there was anthelmintic action, the active ingredient in question has to be isolated and identified.<sup>[54]</sup>

## Uses

Despite being consumed in smaller amounts, many herbs and spices have a considerable positive impact on health since they are rich in antioxidants and other mineral components. Both medicinal and culinary applications for kokum are abundant. Magnesium, potassium, and manganese are minerals found in kokum that regulate blood pressure, heart rhythm, and provide protection from cardiac conditions. Flatulence, acidity, indigestion, and constipation are just a few of the health issues that are treated with this all-purpose kokum. Popularity as a cool, pleasant beverage.<sup>[8,14]</sup>

## Traditional Uses of Kokam

Table 02: Traditional uses of kokam.<sup>[2]</sup>

Pharmacological activity	Plant parts involved
Digestive	Fruit
Anti-dysentery	Fruit, Rind and leaves
Antacid	Fruit, Rind and leaves
Anti-diarrheal	Fruit, Rind and leaves
Anti-piles	Fruit, Rind and leaves
Anti-ulcer	Rind
Anti-colic	Rind and leaves
Anti-obesity (Fruit)	Fruit
Anthelmintic	Fruit
Anti-asthmatic	Fruit
Cardiotonic	Fruit
Hepatoprotective	Fruit
Anti-tumor	Fruit
Anti-hyperplasia	Leaves
Wound healing	Kokam butter
Analgesic	Rind and fruit
Anti-inflammatory	Rind
Anti-dermatitis Rind	Rind
Anti-perspirant	Rind
Astringent	Leaves, fruit and roots
Demulcent	Kokam butter

### Applications for kokum in the food and related sectors<sup>[61,62]</sup>

Kokum fruits have a four to five-day shelf life at room temperature, but if properly stored at 130°C and 86% relative humidity, they may last up to 28 days. Many foods and food compositions can benefit from the colour that comes from kokum. The section that follows discusses a few particular cases.

**Kokum Beverages:** A high-quality red wine may be made by fermenting kokum extract, which has around 4% sugars. With the addition of sugar, the kokum extract may be transformed into a variety of healthy drinks and squash-like goods. Kokum rinds and red syrup made from the ripe fruit may be kept in the house and used to make refreshing healthy beverages in the summer. The syrup is anticipated to have a shelf life of 6 to 8 months due to its high sugar content. Another well-known kokum beverage is called "solkhadi," which is produced by mixing kokum extract with jaggery and coconut milk. It can be provided with meals as a drink to aid with digestion.

**Dehydrated Kokum:** Kokum pieces are dried in a dryer, then ground to make kokum powder. After being sieved, the powder is kept in sealed containers. This product is used as an acidulant in many Indian recipes, including fish and coconut curries, as well as in several other food preparations.

**Kokum syrup:** Kokum fruit juice has a sweet and tangy flavour that many people enjoy. By removing the fruit pulp and seeds, the kokum rind is separated using the conventional process. In a container with a wide mouth,

combine sugar and kokum rind in an equal amount. For eight to ten days, this sugar and kokum combination might be left exposed to the sun. In this procedure, juice is extracted from kokum rind and combined with sugar. Juice and rind should be filtered using a cotton towel. Fill a clean glass bottle with this tidy Kokum Syrup. These full bottles were left in the sun for another 10 days without caps in order to preserve them for the long term.

**Kokum sarbat:** In a western ghat of India, kokum is frequently consumed in the form of sarbat. The kokum syrup is used to make it. Kokum syrup is diluted with water at a ratio of 1:5, along with salt and cumin powder.

**Kokum Butter:** By putting kokum seeds in boiling water, it is possible to extract the 23-26% edible oil that the kokum seed contains. When the oil in the top layer is separated, it is known as kokum butter. It is cream in colour and maintains its solid form at room temperature. There are rumours that kokum butter is used in a variety of chocolate and confectionery products. In addition to making various medicinal items, it may also be used to make soaps and candles.

**Kokam Aamsul:** Aamsul made from kokum fruit peel is known as kokum aamsul. For its sour flavour, aamsul is a great addition to curries and vegetarian recipes.

**Cosmetic Industry:** Kokum may be used in a variety of non-food applications in addition to its uses in the cosmetic industry. According to reports, kokum pigments have the ability to absorb UV rays. This feature may be used in the cosmetic sector to make sunblock pastes and creams.

**Kokum Pigments Based pH Indicators:** As the pH is raised over 5.0, the kokum pigment's hue shifts from red to blue/violet. The development of pH indicators made use of this characteristic. When compared to other artificial hues, kokum's limitations as a natural food colouring include higher vulnerability to oxygen, light, and high or low pH. Before utilising kokum in food preparation, certain restrictions should be considered and acknowledged.

## CONCLUSION

This analysis makes it abundantly evident that *G. indica* is a crucial herbal plant that makes a major contribution to the management of healthcare. A range of human ailments, including as mouth ulcers, digestive issues, diarrhoea, piles, obesity, asthma, etc., are treated using its components or the complete plant. The fruit of the *Garcinia indica* tree contains high concentrations of polyisoprenylated benzophenone derivatives, including the yellow, fat-soluble pigment garcinol and its colourless isomer isogarcinol. hydroxycitric acid (HCA), a component that is water soluble. Citric acid, oxalic acid, and hydroxycitric acid lactones are among the other substances present in the fruit. Ascorbic acid, malic acid, polyphenols, carbs, anthocyanin, and pigments. Numerous pharmacological activities, including antioxidant, anti-inflammatory, antidiabetic, toxic, anti-cancer, anti-microbial, anti-fungal, anti-ulcer, cardioprotective, and many more, were observed in the present revival through pharmacognosy, analytical study, and other means. People are starting to realise the significance of this magnificent plant during this pandemic crisis now that *G. Indica* is used in so many different ways.

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## Conflicts of interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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