Contents list available http://www.kinnaird.edu.pk/

Journal of Natural and Applied Sciences Pakistan

Journal homepage: http://jnasp.kinnaird.edu.pk/

GARCINIA INDICA (THOUARS) CHOISY: ITS ETHNOBOTANICAL KNOWLEDGE, PHYTOCHEMICAL STUDIES, PHARMACOLOGICAL ASPECTS, FUTURE PROSPECTS.

Siddhartha Rajendra Maurya*[1]Ayeshabi Saeed Haji [1], Dr. Nisha Shah[1]
[1]Department of Life Sciences, University of Mumbai, Vidya Nagari, Kalina,

Article Info

*Corresponding Author
Email: siddharthmaurya321@gmail.com.

Abstract

Kokum (*Garcinia indica*), member of Clusiaceae family, is an ancient fruit that is often consumed in India's western ghats as sharbat. Kokum is a fruit tree that has culinary, medical, and nutraceutical use. Kokum has a long history in Ayurvedic medicine, where it has been used to treat wounds, dermatitis, diarrhoea, dysentery, ear infections, and digestive problems. Benzophenones, bioflavonoids, xanthones, and anthocyanin pigments are the most common secondary metabolites found in different regions of the species. The fruit rind has a high concentration of benzophenone garcinol, which has been linked to a variety of possible bioactivities, including antioxidant and cytotoxic properties. The primary red pigments in the fruit rind were identified as cyanidin-3-glucoside and cyanidin-3-sambubioside. The aim of this review article provides information mainly on various pharmacological activities like anti-bacterial, anti-helminthic, anti-inflammatory, antacid, anti-ulcer, cardio protective, UV protection, anti-hyperglycemic, protective effect against Parkinson disease, treatment for newly acquired or recently active traumatic disease, anti-cancer, anti-hyaluronidase and elastase, anti-obesity, anti-arthritic. Oil is extracted from kokum seeds. That oil is known as kokum butter, and it is utilized in curries, cosmetics, pharmaceuticals, and expensive confectionary recipes in other nations. Garcinia indica fruit extract has the potential to be utilized for biogenic generation of AgNPs with antibacterial and antioxidant properties that might be utilized in commercial biomedical applications."

Keywords

Garcinia Indica, Ethnobotanical Knowledge, Phytochemical Studies, Siddhartha Rajendra Maurya

1. Introduction

Throughout history, humans have depended on nature for basic necessities such as medicines, shelter, food, fragrances, clothing, flavours, fertilisers, and modes of transportation. Even today, plants are not only necessary in health care, but they are also the best source of safe future medicines. As a result, the fight against diseases must continue unabated. Traditional plant medicines retain a significant position in modern-day drug industries due to minor side effects and the synergistic action of compound combinations (Dar, Shahnawaz, & Qazi, 2017). The use of medicinal plants as medicine is the earliest kind of medical therapy known to humans, and it has been utilised throughout history in all societies. This indigenous knowledge, passed down from generation to generation in various parts of the world, has significantly contributed to the development of traditional medical systems while also providing a scientific basis for their traditional uses through the exploration of various biologically active natural products. Clusiaceae is a family of medicinal plants that includes roughly 50 genera and 600 species. It has been widely utilised in ethnomedicine to treat a variety of illness conditions, including wounds, ulcers, dysentery, cancer, inflammation, and infection (Lim, Lee, Lee, & Choi, 2021). The knowledge of plant-based remedies progressively evolved and was passed down, creating the groundwork for various systems of traditional medicine across the world. Herbal medicine is still an important aspect of various societies' medical systems (Kunle *et al.*, 2012).

Garcinia indica Choisy, also known as Kokum (Sutar, Mane, & Ghosh, 2012). Kokum is a prominent indigenous tree spice crop that grows in evergreen and semi-evergreen woods as well as in home gardens (Swami, Thakor, & Patil, 2014). It is mostly found in the western peninsular coastal areas of Maharashtra, Goa, Karnataka, and Kerala, as well as sections of Eastern India in the states of West Bengal, Assam, and the Northeastern Hill region, but it is now found growing in other parts of peninsular India. The tree bears fruit every year throughout the summer season, from March to May (Chate, Kakade, & Neeha,2019).

Table 1: Description of plant kingdom

Kingdom	**Plantae**
Subkingdom	Viridaeplantae
Division	Magnoliophyta
Subdivision	Angiospermeae
Class	Magnoliopsida
Subclass	Dilleniidae
Order	Malpighiales
Family	Clusiaceae
Subfamily	Garcinieae
Tribe	Garcinia
Genus	Garcinieae
Species	*Garcinia indica* Choisy

Figure 1: *Garcinia indica*

Figure 2: *Garcinia indica* leaves

1.1. Vernacular names (parle & dhamija, 2013)

English: Brindonia tallow, Goa-butter, Indian berry, Kokam, Red mango

Gujarati: Kokan

Hindi: Bhirand, Kokam, Kokam, Ratambi.

Kannada: Murgala, Punarpuli Konkani: Birondd, Birondi, Ratambi

Malayalam: Kokkam, Punampuli

Marathi: Bhirand, Kokam, Kokambi, Amsol, Katambi, Ratamba Punjabi: Kokam

Sanskrit: Vrikshamla, Amlabija, Amlashaka, Chukraphala, Raktapuraka

Tamil: Murgal Telugu: Puranapuli

French: Brindonnier

German: Cocum, Kokam

Italian: Cocum

Japanese: Garushinia indica

Spanish: Cocum

Tibetan: Da tri ga, Da tri gi.

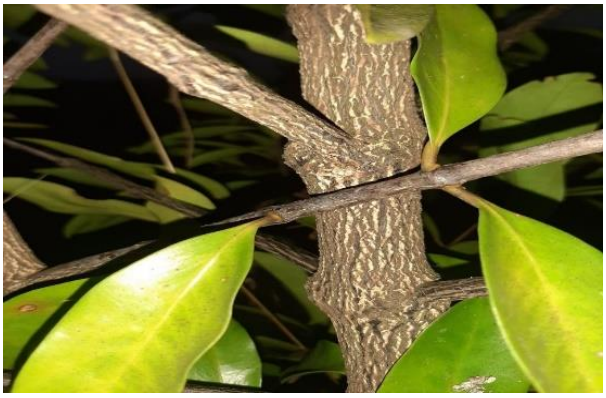

Figure 3: *Garcinia indica* bark

2. Botanical Description

The kokum tree grows to a height of 10 to 15 metres. This thin tree's dark green leaves, drooping branches, and pyramidal form make it seem quite beautiful in a woodland or garden. The leaves are simple and opposite, about 10 cm × 5 cm in size, glabrous above and paler underside, and are crimson when young and dark green when old. The flowers are tiny and unisexual, with male and female blossoms on the same tree. The calyx consists of four free sepals, while the corolla consists of four free petals. Male flowers have ten to twenty stamens. The female flowers feature an ovary with 4 to 8 chambers

and a lobed and sessile stigma (Chandran, 1996). The bark is generally grey to brown, having yellow or white inner bark on occasion. The stem and twigs exude yellow, white exudates called 'Gamboge.' Gamboge is a sticky resin that is hardened and present in immature fruit rind and leaves, as well as stem bark. Most Garcinia species have oblong seeds, with the exception of plano-convex *Garcinia indica*, with a smooth fruit surface and pulpy aril (Shameer, Rameshkumar, & Mohanan, 2016).

3. Ethnobotanical knowledge

Kokum has a long history of usage in traditional medicine, particularly in Indian Ayurveda (Ranveer & Sahoo, 2017).

3.1 Fruit and Fruit Rinds

Kokum fruits are round or oval in shape and vary in colour from yellow to purple. The fruits are used to make juice, which is used as a coolant, and the dried rinds are used as a condiment (Murthy, Dandin, Dalawai, Park, & Paek, 2018). Herbal remedies prepared from kokum rinds are used to treat inflammatory conditions, rheumatic aches, and gastrointestinal issues. The fruit has antihelmintic and cardiotonic properties. Kokum agal (Juice) and squash prepared from the rind are used to treat piles, haemorrhoids, colic difficulties, ulcers, inflammations, treat wounds, dermatitis, diarrhoea, dysentery, ear infection, and other ailments. It is also used to aid digestion and to avoid excessive or excessive sweating (Ranveer & Sahoo, 2017). Kokum is a natural antacid, and the combination of rind, yoghurt, and salt is said to treat gastrointestinal ulcers and a burning feeling (Ranveer & Sahoo, 2017). Commercially, kokum rinds are used to make concentrated syrups, which, when diluted properly, produce ready-to-drink chilled health beverages, especially during the off-season. The rinds are often used to make wine in the Goan community. Dried rinds are powdered and sold as an acidulant in traditional curries (Nayak, Rastogi, & Raghavarao, 2010). *Garcinia indica*, often known as Kokam, is a high-antioxidant plant that is popular as a summer drink. The aqueous extract of this species' fruits is often used to alleviate anxiety. The fruits are soaked in sugar syrup to prepare amrutkokum, a drink used to treat sunstroke (Pradhan, Manohara, Suresh, & Nayak, 2020).

3.2 Leaves

The leaves and fruits are widely recognised for their sour and astringent flavour, as well as their thermogenic, constipating, and digestive properties (Pradhan, Manohara, Suresh, & Nayak, 2020).

3.3 Seeds

Kokum butter extracted from the seeds is in high demand in the confectionery, pharmaceutical, and cosmetic sectors. Kokum butter possesses fatty acid and triacylglycerol compositions, tolerance to milk fat, and solidification qualities comparable to cocoa butter, and it is used as a substitute for cocoa butter in the making of chocolates. In addition, studies have shown that kokum butter, when combined with cocoa butter, boosts the heat-resistance quality of cocoa butter and chocolate, hence avoiding heat-induced softening and loss of consistency in chocolates (Reddy & Prabhakar, 1994). Kokum butter is beneficial in the treatment of dysentery, diarrhoea, phthisis pulmonalis, and scorbutic disorders. The application of kokum butter on the

skin is known to have wound healing properties and to be beneficial in the treatment of ulcerations, fissures of the lips, hands, chapped skin, and inflammatory sores (Ranveer & Sahoo, 2017). Kokum butter is also used in the manufacture of soaps and candles (Nayak, Rastogi, & Raghavarao, 2010). The seed butter is used as a cure for dysentery and mucous diarrhoea. Piles, stomach illnesses, oral ailments, and worm infestations are treated with the root, bark, fruit, and seed oil. It can be used as an infusion or directly applied to skin disorders such as rashes caused by allergies. Kokum butter is an emollient that may be used to treat burns, scalds, and chaffed skin (Pradhan, Manohara, Suresh, & Nayak, 2020).

4. Phytochemical Properties

Phytochemicals are biologically active, naturally occurring chemical compounds found in plants, which provide health benefits for humans as medicinal ingredients and nutrients. Phytochemicals are physiologically active, naturally occurring chemical substances found in plants that offer human health advantages as medicinal ingredients and nutrients. Phytochemicals have traditionally been classed as either primary or secondary metabolites based on their involvement in plant metabolism. The common sugars, amino acids, proteins, purines and pyrimidines of nucleic acids, and chlorophylls are examples of primary metabolites. Secondary metabolites are the residual plant compounds, which include alkaloids, terpenes, flavonoids, lignans, plant steroids, curcumines, saponins, phenolics, and glucosides (Koche, Shirsat, & Kawale, 2016). Classically, the phytochemicals have been classified as primary or secondary metabolites, depending on their role in plant metabolism. Primary metabolites include the common sugars, amino acids, proteins, purines and pyrimidines of nucleic acids, chlorophylls etc. Secondary metabolites are the remaining plant chemicals such as alkaloids, terpenes, flavonoids, lignans, plant steroids, curcumines, saponins, phenolics and glucosides. *Garcinia indica*, which is easily available in India, contains a variety of chemical substances, the most notable of which are polyisoprenylated benzophenone derivatives such as Garcinol and isogarcinol, which is the structural isomer of Garcinol. Garcinol is a yellow fat-soluble pigment, whereas isogarcinol is colourless (Kavitha, Krishnamoorthy, & Dhanalakshmi, 2021).

4.1 Fruit

In addition, the fruit includes hydroxycitric acid lactones, citric acid, and oxalic acid. It also has a higher concentration of malic acid, as well as trace levels of tartaric and citric acids, which give the fruit a delightful tangy flavour. Fruit composition of *Garcinia indica* has a high concentration of active chemicals such as garcinol, xanthochymol, isoxanthochymol, and hydroxy citric acid. Flavonoids, benzophenones, xanthones, lactones, and phenolic acids are examples. Garcinol, hydroxycitric acid, citric acid, acetic acid, malic acid, and ascorbic acid are all found in the fruits.

Table 2: Active constituents of different parts of *Garcinia indica* (Ananthakrishnan & Rameshkumar, 2016)

Parts	Chemical found
Leaves	D-Leucine isogarcinol, xanthochymol, isoxanthochymol, HCA and HCA lactone, Cambogic acid, mangostin, garcinol, fukugicide, GB-1, GB-2, and amentoflavone
Fruit and Fruit rinds	i HCA, HCA lactone JGarcinol, isogarcinol, citric acid, oxalic acid, xanthochymol, isoxanthochymol, anthocyanin, glucose, xylose, cyanidin-3-glucoside, cyanidin-3-sambubioside, and deoxyisogarcinol.
Bark	Euxanthone (1,7-dihydroxy xanthone), volkensiflavone, and morelloflavone Xanthochymol, isoxanthochymol, and camboginol
Seed	Isoxanthochymol, camboginol, palmitic acid, stearic acid, oleic acid, and linoleic acid

Garcinol $C_{38}H_{50}O_6$, a polyisoprenylated benzophenone, isogarcinol, and camboginol are the main components of kokum rind. Garcinol's main components are macurin, mangostin, isogarcinol, gambogic acid, clusianone, oblongifolin (A, B, C), and guttiferone (I, J, K, M, N). The pH of the Kokum fruit ranges from 1.5 to 2.0, naturally imparting the greater acidity. The primary components of ripe Kokum fruit rind are hydroxyacetic acid and hydroxycitric acid. It also includes 2.4% pigment in the form of a 4:1 combination of two anthocyanins, cyanidin-3-sambubioside and cyanidin3-glucoside. Fresh rind of Kokum contains 80% moisture, 2% protein, 2.8% tannin, 5% pectin, 14% crude fibre, 4.1% total sugars, 1.4% fat, 2.4% pigment, 22% hydroxycitric acid, and 0.06% ascorbic acid, according to studies. Per 100g of kokum leaves, there is Lleucine, 75% moisture, protein 2.3g, fat 0.5g, fibre 1.24g, carbs 17.2g, iron 15.14mg, calcium 250mg, ascorbic acid 10mg, and oxalic acid 18.10mg. Minor amounts of hydroxycitric acid, lactone, and citric acid may be found in the leaves and rinds (Kavitha, Krishnamoorthy, & Dhanalakshmi, 2021).

4.2 Seeds

Glycerides of stearic acid (55%), oleic acid (40%), palmitic acid (3%), linoleic acid (1.5%), hydroxyl capric acid (10%), and myristic acid (0.5%) are abundant in kokum seeds. Kokum seed contains around 25% edible fat, which is frequently referred to as Kokum butter. It is usually extracted by crushing the seeds, boiling them in water, and then extracting the fat from the top, or by churning the seeds in water or solvent extraction. The yellowish crude kokum butter is utilised as a ghee adulterant or edible fat. High-quality hydrogenated fats are equal to white-colored refined Kokum butter. Free fatty acids make up up to 7.2% of total Kokum butter. It is used in the cosmetic industry to make lotions, creams, lip balms, and soaps. Because of its relatively high melting point, Kokum butter is one of the most stable exotic butters that does not require refrigeration. Many investigations corroborate the existence of chemical ingredients and their

significance in illness prevention (Kavitha, Krishnamoorthy, & Dhanalakshmi, 2021).

4.3 Leaves

Per 100g, kokum leaves include L-leucine, 75% hydration, 2.3g protein, 0.5g fat, 1.24g fibre, 17.2g carbs, iron 15.14mg, calcium 250mg, ascorbic acid 10mg, and oxalic acid 18.10mg. Minor amounts of hydroxycitric acid, lactone, and citric acid may be found in the leaves and rinds (Jagtap, Bhise, & Prakya, 2015)

5. Traditional knowledge

G. indica has several applications and is widely used by the local populace. *Garcinia indica* dried fruit rind imparts a sweet-tangy flavour to food and is frequently used as a flavouring addition in culinary preparations as a substitute for tamarind. The fruits are occasionally used as a substitute for grapes in winemaking. The fruit's peel has also been used as a pink and purple food colouring agent. Kokum drinks made from *Garcinia indica* fruits, which is provided as a welcoming drink in Goa throughout the warm months. Konkani people from Goa and Maharashtra make bhirindi saar, a soup prepared with kokum juice, and kokum kadi, a drink made with kokum juice and coconut milk that is used as an after-meal drink to relieve gastrointestinal disorders. Every Konkan family has dried fruit rinds and syrup on hand as a reserve. Another important product generated from *G. indica* seeds is kokum butter, which is used in cosmetics such as lip balms, lotions, and soaps. Kokum has been used in herbal therapies for centuries to cure inflammatory disorders, dermatitis, digestive problems, rheumatic symptoms, and to prevent excessive sweating. Antihelmintic and cardiotonic effects are found in fruits. The juice of kokum rind is used to cure piles, colic, dysentery, and diarrhoea. Fruit rind decoction has long been used to treat diabetes Kokum butter has traditionally been used to cure wounds and cracks in the hands, as well as to moisturise and restore skin suppleness. The leaves of *G. indica* are used to treat skin ulcers, dyspepsia, and hyperplasia (Ananthakrishnan & Rameshkumar, 2016). *G. indica* has a wide range of applications and is popular among the local inhabitants The dried fruit rind of kokum imparts a sweet-tangy flavour to food and is often utilised as a flavouring component in culinary recipes in place of tamrind. The fruits are sometimes used in winemaking as a replacement for grapes. Kokum butter is used in a variety of cosmetics, including lip balms, lotions, and soaps (Dhaka & Mittal, 2021). Kokum has been used in herbal therapies for diarrhoea, inflammatory disorders, dermatitis, digestive problems, rheumatic symptoms, and to prevent excessive sweating. Antihelmintic and cardiotonic effects are found in fruits. Fruit rind decoction has long been used to treat diabetes. Kokum butter has long been used to treat wounds and cracks in the hands, as well as to restore skin suppleness and as a moisturizer. Kokum fat is used in confectionery preparation. Because of its soothing and therapeutic effects, kokum rind can be used to treat skin diseases and wounds. Kokum fruit extracts relieve gastric disorders such as flatulence, acidity, indigestion, and constipation. It also has antihelmintic effects and acts as a desire stimulator. In Ayurvedic medicine, kokum infusions are used to treat diarrhoea, piles, and infections.

Kokum strengthens the cardiovascular system and stabilises liver function. Fruit contains hydroxycitric acid, which inhibits lipogenesis and decreases cholesterol levels, so aiding in weight reduction. Powdered kokum rind is used to prevent nutritional loss and dehydration. Improves appetite and digestion, alleviates constipation, purifies the blood and fights infections, regulates the cardiovascular system, and alleviates burning sensations throughout the body. The rind of kokum fruit has antiulcer and anticancer properties. Kokum oil and paste are used to treat skin conditions and promote wound healing (Dhaka & Mittal, 2021).

6. Pharmacological activities

Table 3: Pharmacological activities of different parts of *Garcinia indica*

Leaves	Anti-dysentery, antacid, anti-diarrheal, anti-piles, anti-colic, anti-hyperplasia (Desai, Sharma, Kashyap, Choudhary, & Kaur, 2022), Thermogenic, Digestive (Ranveer & Sahoo, 2017).
Fruit and fruit rind	Antacid, anti-diarrheal, anti-piles, anti-colic, anti-hyperplasia (Desai, Sharma, Kashyap, Choudhary, & Kaur, 2022). Anti-inflammatory, Anti-helminthic, Cardio protective, anti-ulcer, protection against dermatitis, Ear infection, anti-allergic (Ranveer & Sahoo, 2017).
Seed	Wound healing, demulcent (Desai, Sharma, Kashyap, Choudhary, & Kaur, 2022), protects bone, anti -inflammation (Ranveer & Sahoo, 2017).
Bark	Astringent (Desai, Sharma, Kashyap, Choudhary, & Kaur, 2022).

6.1 Anti-bacterial activity

The antibacterial activity of *G. indica* was examined using the Agar Well Diffusion technique against several bacterial strains such as *Micrococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Micrococcus luteus*, *Salmonella typhimurium*, and *Bacillus megaterium*. Water, methanol, ethanol, and acetone were used to extract *G. indica* fruit at concentrations of 30 µl, 50 µl, and 100 µl for each extract. In the case of 30 µl volume, ethanolic extract illustrated (ZOI=10 mm); methanolic extract proven (ZOI=9 mm); acetone extract evidenced (ZOI=9 mm); ethanolic extract demonstrated (ZOI=5 mm); ethanolic extract verified (ZOI=6 mm); and methanolic extract indicated (ZOI=9 mm) against *M. aureus*, *M. luteus*, *B. megaterium.* In the case of 50 µl volume, ethanolic extract verified (ZOI=13 mm); water, ethanolic, and methanolic extracts proven (ZOI=10 mm); methanolic and acetone extracts demonstrated (ZOI=10 mm); water extract demonstrated (ZOI=11 mm); water extract demonstrated (ZOI=16.5 mm), and methanolic extract demonstrated (ZOI=10 mm) against *M. aureus* In the case of 100 µl volume, ethanolic extract demonstrated (ZOI=18 mm); water and acetone extracts demonstrated (ZOI=15 mm); ethanolic extract demonstrated (ZOI=15 mm); water extract demonstrated (ZOI=20 mm); and methanolic extract demonstrated (ZOI=16 mm) against *M. aureus*, *M. luteus*, *B. megaterium*, *E. coli*, *S.*

typhimurium (Sutar, Mane, & Ghosh, 2012). Research demonstrated that the stem bark crude, flavonone, flavone, and proauthocyanin fraction extracts exhibited antibacterial activity. The crude extract had high antibacterial action against *Staphylococcus aureus*, partial antibacterial activity against *Escherichia coli*, and medium antibacterial activity against *Salmonella typhi*. The flavononylflavone fraction had high antibacterial activity against *Staphylococcus aureus*, negligible activity against *Escherichia coli*, and mild activity against *Salmonella typhi*. Proauthocyanin has minor action against *Staphylococcus aureus*, partial activity against *E. coli*, and medium activity against *Salmonella typhi* (Lakshmi, Kumar, Dennis, & Kumar, 2011). Garcinia fruit rind aqueous extract shown antibacterial efficacy against *Escherichia coli, Bacillus subtilis, Enterobacter aerogenes*, and *Staphylococcus aureus* at minimum inhibitory values of 0.5 mg/ml, 5 mg/ml, 5 mg/ml, and 50 mg/l, respectively. The lowest inhibitory concentration against *Candida albicans* and *Penicillium* sp. was 50 mg/ml (Varalakshmi *et al.,* 2010).

6.2 Anthelmintics Activity

Helminthiasis is one of the primary causes of output losses, particularly in developing nations. Though there are chemical and managerial methods to control the disease, rising resistance of helminthes to anthelmintics has led to the quest for novel medicinal sources for the creation of anthelmintics. *Garcinia indica* crude extract was made from petroleum ether, ethyl acetate, methanol, and water to see if the plant had this action. The extract at 50 mg/ml concentration demonstrated the quickest time for paralysis and death of the worms that were treated with the extracts. Even though there was antihelminthic action, the active component responsible for it is unknown and has to be isolated and identified (Swapna *et al.,* 2012).

6.3 Anti-inflammatory activities

Inflammation is the body's response to damage in order to prevent the spread of infectious organisms and to destroy dead cells and tissues. It happens in four stages, with the severity or extent of the injury determining the degree of the injury. Anthocyanins and polyphones, which are found in the fruit rinds of *Garcinia indica*, have previously been shown to have anti-inflammatory effect. So, a study was conducted, and it was discovered that *Garcinia indica* extract at 400 mg/kg and 800 mg/kg concentrations substantially prevented paw edoema in carrageenan-induced hind paw edoema in rats. The same dose also reduced exudate development and granuloma formation in rats with cotton pellet induced granuloma. It was also discovered that *Garcinia indica* extract at the same concentration reduced the elevation of ALT, AST, ALP, SGOT, and SGPT levels, which are elevated during inflammation, implying that *Garcinia indica* is a good anti-inflammatory agent, either because of its anti-oxidant activity or because lysosomal membrane stabilisation inhibits inflammatory response (Panda *et al.,* 2013).

6.4 Antacid Activity

Acid production in the stomach causes a burning feeling in the neck and heart area in diseases such as gastritis, peptic ulceration, and gastro-oesophageal reflux disease. The stomach mucosal lining usually

maintains a balance between the variables that cause peptic ulcer disease and the defence system. This equilibrium is achieved by mucosal defence augmentation, acid secretion decreases and neutralisation, increased antioxidant levels in the stomach, promotion of gastric mucin formation, and prevention of *H. pylori* development, one of the causal reasons. *Garcinia indica* fruit rind extract has been used to treat acidity since ancient times. Based on this knowledge, a study was conducted that demonstrated that an aqueous extract of the fruit rind of *Garcinia indica* at doses of 400 mg/kg and 800 mg/kg exhibited significant and consistent acid neutralisation when compared to standard sodium bicarbonate and greater than water in an artificial stomach model (Vandana & Prashant, 2013).

6.5 Anti-ulcer

Agent Phytochemicals found in *Garcinia indica* have been shown to have pharmacological activities, hence it was chosen for research to assess its anti-ulcer efficacy. Ulceration affects a vast number of individuals worldwide, and the underlying causes are stress, smoking, alcohol intake, dietary inadequacies, and research into NSAIDs. *Garcinia indica* fruit rind water and ethanol extract were shown to have strong anti-ulcer effects in research. In rats, gastric lesion was produced with HCl or ethanol, whereas ulcer genesis was generated with indomethacin. Aqueous *Garcinia indica* fruit rind extracts reduced mortality by 52.94% in the former rats and 36.80% in the later rats. Ethanolic extracts reduced mortality by 34.45% in the former rats and by 61.62% in the later animals. The molecule responsible for this effect is unknown and must be isolated and tested pharmacologically (Deore *et al.*, 2011).

6.6 Cardioprotective Activity

This effect is caused by a molecule. Myocardial infarction is the primary cause of mortality in both sexes, resulting in diminished blood flow to the heart muscles, namely the myocardium, leading to ischemia, or myocardial muscle death. Because of the numerous adverse effects of synthetic medications, WHO has suggested that herbal drugs be used instead. *Garcinia indica* fruit rinds were used to test cardiac preventive effects due to its phyto-constituents and established traditional medicinal usage. Research found that *Garcinia indica* extract at doses of 250 mg/kg by weight and 500 mg/kg by weight reduced the activities of biochemical parameters such as LDH, AST, ALT, CK-MB, and CPK when compared to isoprenaline hydrochloride induced cardiotoxicity in rats and control rats. Similarly, the examination of membrane bound enzymes, i.e., ATPase, revealed a decrease in Ca2+ ATPase and Mg2+ATPase activity and a substantial increase in Na+ K+ ATPase activity at the same dose. When compared to the control and isoprenaline-treated groups. The cardio protective action of *Garcinia indica* may be attributed to its membrane stabilizing characteristics as well as its capacity to suppress the generation of free radicals. The precise mechanism is yet unknown (Kumar *et al.,* 2013).

6.7 UV Protection

Activity increasing pollution levels have resulted in ozone layer depletion, raising the danger of exposure to damaging UV radiations. Exposure to these

damaging UV rays causes acute, chronic, and delayed reactions, making skin care products necessary. Sunblockers including physical blockers, such as ZnO and TiO_2, have been found to have a whitening effect. Chemical blockers are unstable in the presence of physical agents, whereas organic blockers have a limited range of protection. As a result, the search for a broad-spectrum sun-blocker has led to the investigation of *Garcinia indica* fruit extracts and kokum butter extract. Fruit extracts were made with acidified methanol, ethanol, and ethyl acetate, whereas kokum butter extracts were made with ethyl acetate. A spectrophotometric analysis of the UV protection activities of both the fruit rinds and the kokum butter found that the ethyl acetate fraction of the fruit rinds exhibited good UV-A and UV-B absorbance at a concentration of 0.4 mg/ml. In the UVA area, kokum butter had lower UV absorption than in the UVB zone. Additionally, SPF was evaluated by making several sunscreen formulas. The sunscreen formulation had a Sun Protection Factor (SPF) of 2.02 at 105% ethyl acetate concentration, which was fairly good. Because the findings of these extracts outperformed TiO_2, which was used as a benchmark, it shows that this might be a suitable and effective choice for sunscreen goods (Dike & Deodhar, 2015).

6.8 Anti-hyperglycemic Agent

Diabetes is a chronic disease characterised by excessive blood glucose levels or, depending on the type of diabetes, inadequate insulin. The rinds of kokum are used to cure diabetes. Kokum restores the number of erythrocytes, an intracellular antioxidant, and studies have shown that it is effective in lowering the chance of developing secondary problems; this reflects the potential properties of kokum in treating both hyperglycemia and other complications (Waghmare, Shukla, & Kaur, 2019). Diabetes mellitus is rapidly increasing in the human population, which will eventually lead to a diabetes epidemic. This is a disorder characterised by insulin deficiency or resistance. Despite significant progress in diabetes management, disease-related complications continue to rise. *Garcinia indica* has long been recognized as an antioxidant and free radical scavenger. These are the characteristics that distinguish this plant as an antihyperglycemic agent. The blood glucose level was shown to be considerably lower following administration of 400mg/kg of aqueous whole fruit extract to euglycemic and streptozotocin (STZ) induced hyperglycemic Wistar rats of either sex in a study (Khatib & Patil, 2011). The primary cause of type 2 diabetes is oxidative stress, which is regulated by the thiol Glutathione (GSH). GSH deficiency causes a variety of consequences, including neurodegeneration, myocardial infarction, and other cardiovascular disorders. Another study discovered that aqueous extracts of *Garcinia indica* fruit dramatically improved body weight, lowered blood glucose levels, and boosted erythrocyte GSH levels in streptozotocin-induced type 2 diabetic rats (Kirana & Srinivasan, 2010).

6.9 Protective Effect against Parkinson's Disease

Parkinson's is a neurodegenerative disorder characterized by tremor, rigidity, bradykinesia, and postural instability. *Garcinia indica* is known for its

antioxidant and anti-inflammatory properties. Reports also suggest antispasmodic properties of the extracts. Due to these known properties the methanolic extract of the *Garcinia indica* fruit rind (GIM) was tested for the protective effect in dopaminergic neuronal loss induced by 6-hydroxydopamine (6-OHDA) in a rat model of Parkinson's disease. In the treatment of the 6-OHDA rat model with GIM extracts of various concentrations it was found that it had a neuroprotective effect against 6- OHDA in various behavioral models' biochemical models. When compared to the 6-OHDA group, the behavioural model revealed that increasing the dose of GIM (100, 200, and 400 mg/kg) resulted in a dose-dependent decrease in the number of rotations, increased the number of steps, decreased the initiation time, restored postural balance, and decreased disengage time. In contrast, the biochemical model demonstrated a decrease in striatum dopamine (DA) and its metabolites 3,4-dihydroxyphenylacetic acid (DOPAC) and homovanillic acid (HVA) compared to an increase in the 6-OHDA models. Though the study found a strong neuroprotective impact, the specific mechanism is yet unknown (Antala *et al.,* 2012).

6.10 Treatment for Newly Acquired or Recently Reactivated Traumatic Memories

Because of the various research conducted to clarify its mechanism, our understanding of the cellular and molecular mechanisms underpinning the consolidation and reconsolidation of traumatic fear memories has improved in recent years. The modulation of chromatin structure and function has been discovered to be one of the processes involved in consolidation and reconsolidation. The activity of histone acetyltransferase (HAT) has been linked to hippocampus dependent memory. The increase in H3 acetylation in the lateral amygdala, which is a storage site for fear memories, has been linked to improvements in long-term memory, possibly through playing a role in the consolidation and reconsolidation of traumatic fear memories. Garcinol, a naturally occurring chemical derived from the rind of *Garcinia indica*, is a HAT inhibitor. This has been proven to disrupt HAT, hence affecting long-term memory. Furthermore, when garcinol was delivered systemically or intra-laterally, it interfered with consolidation and reconsolidation, as well as the related neuronal plasticity in the lateral amygdala. HAT acetylation of H3 was shown to be impaired by local infusion in the lateral amygdala (Maddox, Watts, Doyère, & Schafe, 2013).

6.11 Human breast cancer cells

A study was conducted to determine the carcinogenic effect of cyclin D3, which is known to be implicated in nicotine-induced breast tumorgenesis, as well as the involvement of Nicotinic Acetylcholine Receptor (nAchR) binding in cyclin D3 regulation. Cyclin D3 was shown to be highly expressed in breast cancer cells when compared to normal surrounding cells. Furthermore, increased 9nAChR expression led in cyclin D3 induction, whereas decreased 9nAChR expression resulted in decreased cyclin D3 levels. The study also shown that 1M Garcinol isolated from the fruits of *Garcinia indica* suppressed cell growth by

downregulating 9-AChR and cyclin D3. Thus, Garcinol inhibits human breast cancer cell growth (Chen *et al.*, 2011).

6.12 Prostate and pancreatic cancer cells

Garcinol, a poly isoprenylated benzophenone isolated from the rind of the *Garcinia indica* fruit, shows strong antioxidant effects. The same component is known to have anticancer capabilities, causing cancer cells to die. Research found that garcinol decreased cell proliferation in all cell lines examined while inducing apoptosis in a dose-dependent manner. Because garcinol suppressed constitutive levels of NF-beta B activity, which was compatible with downregulation of NF-beta B-regulated genes, the mechanism by which this occurs was discovered to be downregulation of NF-kappa B signalling (Ahmad *et al.*, 2011). In another study, garcinol was tested against the human pancreatic cell lines BxPC-3 and Panc-1, and it was discovered that it decreased cell growth and promoted apoptosis in the same way as previously indicated, namely by regulating NF-kappa B signalling. As a result, it is involved in prostate and pancreatic cancer. Another study found that garcinol from *Garcinia indica* and curcumin from *Curcuma longa* had a synergistic impact, increasing bioactivity and lowering the dosage needed, which is greater when delivered separately (Parasramka & Gupta, 2012). A unique investigation was conducted to investigate the mechanism of action by which garcinol displays anticancer activity, which demonstrated that it inhibits total and phosphorylated STAT-3 signalling. It was also shown to limit cell invasion by decreasing IL-6-induced STAT-3 phosphorylation and urokinase-type plasminogen activator, vascular endothelial growth factor, and matrix metalloproteinase-9 synthesis (Ahmad *et al.*, 2012).

6.13 Anti-Hyaluronidase, Anti-Elastase Activity

The elasticity of the skin decreases with age owing to the enzyme elastase, which causes drooping, and hyaluronic acid in the skin also declines, causing the skin to become dry and wrinkled. As a result, matrix metallo proteins must be conserved by inhibiting the action of matrix metallo proteinases. Certain plant extracts have been shown to be powerful antioxidants. Because of the presence of phenolic group, garcinol and cambogiol found in the fruit rinds of *Garcinia indica* have been reported to be strong antioxidants. In addition to the fact that G. indica preparations can help you live longer, we separated crude Methanolic Extract (ME) into Ethyl Acetate and Water Fraction (WF), and those fractions were examined for anti-hyaluronidase and anti-elastase activity (Sahasrabud & Deodhar, 2010).

6.14 Antiobesity effects

In rats employing a cholesterol-induced hyperlipidemic paradigm, methanolic extract of kokum dried fruit demonstrated excellent anti-hyperlipidemic action. The utilization Kokum helps in reduction of appetite and inhibits lipogenesis and conrols body weight due to the presence of hydroxycitric acid. It has been observed that there is a considerable drop in total cholesterol, triglycerides, LDL-C, VLDL-C levels, and an increase in HDL-C levels. In-vitro investigations show that treating rats' adipocytes with cyaniding 3-glucoside increases adipocytokine production and

up-regulation of adipocyte specific gene expression without activating PPAR. Furthermore, in vivo investigations revealed an increase in adiponectin gene expression in white adipose tissue (Yamaguchi *et al.,* 2000).

6.15 Anti-arthritic effect

Arthritis is a widespread condition that may be classified into several forms, the most frequent of which are rheumatoid arthritis, osteoarthritis, psoriatic arthritis, and inflammatory arthritis. Although it is routinely used to treat many forms of anti-inflammatory arthritis, it has been linked to major adverse effects such as stomach haemorrhage and an increased risk of other cardiovascular issues. As a result, it is critical to investigate effective and safe anti-arthritic medication candidates derived from natural materials (Lim, Lee, Lee, & Choi, 2021). GEF's anti-arthritic properties in rheumatoid arthritis were investigated. G. indica extract (9 gm) was adsorbed onto silica and loaded. GEF's anti-arthritic properties in rheumatoid arthritis were investigated. G. indica extract (9 gm) was adsorbed onto silica and loaded. Following that, fractions were prepared using a stepwise gradient elution method with n-hexane-ethyl acetate, including a fraction (800 mg) with the highest concentration of garcinol. With a single injection of 0.1 mL of Complete Freund's Adjuvant, a rat model of adjuvant arthritis (AA) was created (CFA). The rats were split into four groups of six each: Group 1 (normal control); Group 2 (disease control with CFA alone); Group 3 (positive control with diclofenac sodium at 10 mg/kg); Group 4 (treated with GEF at 10 mg/kg). The volume of the left hind paw of rats was measured using an electronic transfusion metre on days 0, 1, 5, 12, 16, and 21 to analyse the main lesions. The volume of the right hind evaluates the effects of the treatment medications to identify the severity of the secondary lesions. Also measured was the paw. Furthermore, to assess the degree of AA, the rats' ears, nose, tail, forepaws, and rear paws were visually evaluated for inflammatory lesions, and arthritis severity was assessed based on redness, swelling, and the presence of nodules. The CFA-treated group developed primary arthritis in the left hind paw, and a substantial amount of swelling was detected and sustained for 21 days (p 0.0001) (Lim, Lee, Lee, & Choi, 2021). When contrasted to the disease control group, GEF treatment dramatically reduced paw edoema from days 5 to 21, similar to the positive control group. The GEF-treated group, on the other hand, experienced a reduction in edoema of the right hind paw, although this was not statistically significant. When compared to the control group, CFA-treated rats had a significant increase in the arthritis index, which peaked at 5 days and then gradually decreased. When compared to the disease control animal group, the animals treated with 10 mg/mL GEF, and diclofenac had a substantially lower arthritis index (p 0.01). CFA treatment significantly decreased stair climbing activity in all rats from days 5 to 21 compared to the control group, suggesting hyperalgesia induction (p 0.0001). However, the GEF and diclofenac group had considerably higher ratings on days 12 and 16, which were maintained until day 21. Furthermore, the motility score, which had been lowered by CFA treatment, gradually and significantly recovered in

the GEF-treated group from days 16 to 21. This study found that GEF had anti-arthritic efficacy in a CFA-induced arthritis animal model (Lim, Lee, Lee, & Choi, 2021).

6.16 Cytotoxic effect

The methanol extract of the fruit rinds of *Garcinia indica* showed significant cytotoxicity against three human cancer cell lines- breast (MCF-7), liver (WRL-68) and colon (Colo-320-DM). The methanol extract was fractionated into hexane-, chloroform- and ethyl acetate-soluble fractions. The quantification of xantho- chymol and isoxanthochymol in the above extracts' methanol, hexane, chloroform and ethyl acetate of the fruit rinds of *Garcinia indica* was achieved with the LC-MS/MS method using MRM transitions already developed (Kumar, Chattopadhyay, Darokar, Garg, & Khanuja, 2007). The synthesis and production of silver nanoparticles (AgNPs) have recently received more interest since it is a valuable metal utilised all over the world. Plant extract is being studied on a big scale among biological agents because it eliminates the substantial microbiological labour necessary for cell culture. The plant extract's biomolecules and metabolites work as both reducing and capping agents, avoiding the need for specific compounds as reducing and capping agents. Few plants with high phenolic content are thought to be ideal for bio reduction and avoiding agglomeration by stabilising nanoparticles. *Garcinia indica* Choissy, commonly known as Kokum is one of such medicinally important underexploited, fruit bearing tree species whose fruits are potential source of hydroxy citric acid (HCA) and other biomedically important phytochemicals. Kokum is phytochemically rich tree species whose fruit has been reported with high content of HCA and secondary metabolites like xanthones, benzophenones, flavonoids, biflavonoids and triterpenoids biogenic AgNPs (20 g/L) antibacterial activity both alone and in conjunction with the commonly used antibiotic Tetracyclin (10 g/L). The bactericidal activity of AgNPs alone and in combination with Tetracyclin is shown in Table 1. AgNPs at a concentration of 20 g/L clearly inhibited the growth of tested *E. coli*, *B. subtilis*, *S. aureus*, and *P. aeruginosa*, with a definite zone of inhibition in the 12-15 mm range. In our study, the combined effect of AgNPs and Tetracyclin was shown to be additive, extending the zone of inhibition from 14 to 30 mm against *E. coli*, 12 to 15 mm against *B. subtilis*, 15 to 22 mm against *S. aureus*, and 12 to 18 mm against *P. aeruginosa.* This synergistic activity of AgNPs with Tetracyclin clearly revealed that biogenic AgNPs might be employed in medicine formulation to minimise the dose of and reliance on antibiotics for the treatment of bacterial infections. It was discovered that biogenic AgNPs had increased H_2O_2 radical scavenging and DPPH activities, followed by lower power and NO radical scavenging activity. These findings suggested that biogenic AgNPs generated using Kokum fruit extract might be employed in the formulation of antioxidants (Sangaonkar & Pawar, 2018).

7. Potential Applications

Kokum Beverages- Kokum extract contains around 4% sugars and may be fermented to make a high-quality red wine. With the addition of sugar, kokum extract may be transformed into a variety of health

drinks and squash-like goods. In the summer, crimson syrup made from ripe fruit with the addition of sugar to kokum rinds may be preserved in the house for producing cold health beverages. Because of the high sugar content, the syrup will have a shelf life of 6-8 months. Another famous kokum beverage is 'solkhadi,' which is created by combining kokum extract with jaggrey and coconut milk. It can be offered with meals as a digestive drink (Nayak, Rastogi, & Raghavarao, 2010). Kokum Butter- Kokum seed contains 23-26% edible oil, which may be produced by boiling kokum seed. The top layer's oil may be separated and referred to as kokum butter. It is cream in colour and remains solid at room temperature. Kokum butter is said to be used in a variety of chocolates and confectionery recipes (Nayak, Rastogi, & Raghavarao, 2010). Dehydrated Kokum- Kokum powder is made by drying kokum pieces in a drier and then crushing them. The powder has been sieved and 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 many other food preparation (Nayak *et al.*, 2010). Cosmetic Industry- Aside from culinary applications, kokum has a variety of non-food applications. According to reports, kokum pigments have the ability to absorb UV rays. This feature might be used in the cosmetic sector to make sunscreen creams and pastes. PH Indicators Based on Kokum Pigments as the pH rises over 5.0, the color of the kokum pigment shifts from red to blue/violet. This characteristic was used to create pH indicators (Kamat, 2005). Because of its emollient properties, kokum is a natural moisturizer that keeps skin supple and velvety smooth. It is also beneficial in the treatment of very dry skin, ulceration, and fissures of the lips, hands, and feet, among other things (Swami, Thakor, & Patil, 2014). Kokum Agal (Salted juice)- It is a salty juice made from the Kokum fruit. The salt is applied, followed by the four levels of varying pulp concentrations. i.e. (14,16,18, &20%). The mixture was then mixed every day for seven days. After seven days, the entire combination was filtered through a 1mm stainless steel sieve, and the juice was placed in a pasteurized bottle (Waghmare, Shukla, & Kaur, 2019). Kokum Syrup (Amrit Kokum)- This product is made from fresh ripe kokum rind and cane sugar in a 1:2 ratios. After packing in a glass container, the mixture should be maintained in sunlight for 8 days with constant stirring. The mixture is then strained through muslin cloth and placed in a jar. If necessary, a preservative such as sodium benzoate is applied. This product must be diluted with water 5 to 6 times before use (Waghmare *et al.*, 2019).

8. Conclusion

The article highlights the traditional, pharmacological and commercial importance of *Garcinia indica* tree belonging to Clusiaceae family is native to India. Traditionally it has been a multiutility plant. Various parts of the plant have been used for variety of application. Flowers, fruits and fruit rinds, seed, bark, root and leaves have been used for medicinal and dietary applications. A variety of phytochemicals have been isolated from various extracts of different parts of the plant. kokum possesses diverse health benefits and that the phytochemicals garcinol, isogarcinol, cyanidin-3-

glucoside and hydroxycitric acid are useful in various medical conditions. According to studies, kokum and its extract may protect against and even treat a variety of diseases, including anti-bacterial, anti-helminthic, anti-inflammatory, antacid, anti-ulcer, cardio protective, UV protection, anti-hyperglycemic, protective effect against Parkinson disease, treatment for newly acquired or recently active traumatic disease, anti-cancer, anti-hyaluronidase and elastase, anti-obesity, anti-arthritic. Various products obtained from the plant are utilized on local level. The biochemistry of active chemical constituents present in the *Garcinia indica* is an emerging field of research. Kokum and its derivatives, such as dried rind powder, sarbat, solkadhi, agal, amsul, and seed butter, are high in various high-value chemicals with possible physiological benefits.

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