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REVIEW ARTICLE

Unveiling insights into the ethnopharmacology, phytochemistry, and pharmacological properties of *Garcinia xanthochymus* L.: a systematic review

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Abstract

The objective of this work was to compile information on the phytochemical profile, traditional uses, and pharmacological properties of *Garcinia xanthochymus*. A literature review was conducted, including published books, journals, and papers. Databases such as Google Scholar, Science Direct, Scopus, PubMed, ProQuest, and others were used to gather information. Chem Sketch 5.0 was used to sketch the chemical structures of phytoconstituents. The fruits of *Garcinia xanthochymus* are traditionally used as an anthelmintic, appetite stimulant, and cardiotonic. Phytochemical analysis revealed the presence of polyprenylated benzophenone derivatives such as xanthochymol and isoxanthymol, flavones and xanthones, and other phytochemicals in the bark, leaves, roots, twigs, and seeds. These phytochemicals contribute to the plant's pharmacological activity. This review provides up-to-date data on the phytochemical profile, traditional uses, and pharmacological properties of *Garcinia xanthochymus*. The information gathered from this study can be useful for further research on this plant and its potential therapeutic applications.

Keywords: *Garcinia xanthochymus*; Phytochemical Constituents; Ethnopharmacology; Therapeutic Activity

1. Introduction

For treating various ailments, researchers of the recent decade have mainly focused on natural sources of medicine. Often, plant-based chemicals are employed as lead compounds in the investigation and development of novel medications, as they have several benefits over synthetic products. This review mainly focuses on a single plant species widely available in Southeast Asia known as *G. xanthochymus*, which is from the genus of Garcinia and the Clusiaceae family (Payamalle et al., 2017; Gupta et al., 2018). The native place of this plant species is Southeast Asia, apart from which it is also available in Africa and Australia. The northeastern part of India is the hub of medicinal plants. Therefore, this plant species is found in Manipur and Assam. In the state of Manipur, India, the species is known as Heirangkhoi locally, Heirangoi, or Heiranggoi (Sharma et al., 2012). *G. xanthochymus* is traditionally, used as a medicine for treating diarrhea, nausea, vomiting, dysentery, anthelmintic, cardiotonic, and as a tonic to improve appetite in different parts of South East Asia (Victorsinge, 2008; Rai and Appaiah, 2014). Researchers found phytochemicals such as benzophenones, flavonoids, and xanthones during scientific studies. The phytochemicals present in *G. xanthochymus* exhibit a wide range of antimicrobial, antioxidant, and anti-inflammatory properties (Fu et al., 2012). This tropical plant yields fresh edible fruits which are used to make vinegar, beverages, and other products (Payamalle et al., 2017; Chen et al., 2017; Liu et al., 2016). Fabric dyes and watercolors are among the two major products that are being prepared from the fruit of G. xanthochymus (Gogoi et al., 2016). This review article has been written with the aim of highlighting the morphology, microscopy, phytochemical constituents, and different pharmacological activities of *G. xanthochymus*, which will definitely help researchers in the future to investigate the worth of the plant species medicinally and commercially.

2. Materials and methods

The literature search was methodically conducted across several databases, including Google Scholar, Science Direct, Scopus, PubMed, and ProQuest, to identify studies relevant to the ethnopharmacology, phytochemistry, and pharmacological properties of *Garcinia xanthochymus*. Keywords related to the plant's traditional uses, phytochemical constituents, and pharmacological activities were utilized. The search was limited to articles published in English, with no time restriction to encompass the breadth of available literature.

Articles were selected based on predefined inclusion criteria, peer-reviewed studies reporting on the traditional uses, phytochemical analysis, and pharmacological activity of *Garcinia xanthochymus*. Exclusion criteria were established to omit studies not directly related to the scope of this review, such as those not focusing on *Garcinia xanthochymus* or lacking primary data. editorials, and non-peer-reviewed literature were also excluded to ensure the inclusion of original research findings only.

Data were extracted systematically from each selected study, including information on the plant's traditional uses, identified phytochemicals, and documented pharmacological activities. The quality of included studies was assessed based on the clarity of methodological reporting, the comprehensiveness of phytochemical analysis, and the rigor of pharmacological testing.

The data extracted from the included studies were synthesized to provide a comprehensive overview of the ethnopharmacology, phytochemistry, and pharmacological potential of *Garcinia*

xanthochymus. The synthesis aimed to identify patterns, gaps, and inconsistencies in the literature, offering a basis for future research directions.

3. Description

Commonly known as gamboge and yellow mangosteen, G. xanthochymus, belongs to the family of Clusiaceae (Bagget et al., (a) 2005; Youn et al., 2017; Manohar et al., 2014). It is a Bushy, annual evergreen tree, 5-15m high, 40-130 cm in diameter, the bark is greyish brown; the trunk is erect, drooping cone-shaped branches; stems are solid, woody, rough, fibrous, polygonal, and produce whitish gummy latex (Gupta et al., 2018).

3.1. Taxonomic hierarchy

The detailed hierarchy is given in Table 1 (Sharma et al., 2012).

Table 1. Taxonomic hierarchy of *G. xanthochymus*.

Kingdom	Plantae
Subkingdom	Viridiplantae
Class	Magnoliopsida
Division	Tracheophyta
Family	Clusiaceae
Order	Malpighiales
Species	*G. xanthochymus*
Genus	*Garcinia L*

3.2. Morphological characteristic

Leaves of *G. xanthochymus* are linear to oblong-lanceolate, 20-35×6-12 cm, simple, exstipulate, opposite decussate, entire margin, apex-acuminate, coriaceous shinning, midvein robust petiole 1.5-2.5 cm base liguliform or V-shaped sharp wedge with clasping ends. It has Inflorescence corymbose cyme 4-10 flowers, arising from leafless axils; peduncle 6–12 mm; pedicel 1.2-1.7 cm; flower, 8-10×6-8 mm, ebracteolate, pentamerous, complete, bisexual, zygomorphic. It consists of five calyxes with connate at the base, two smaller sepals with bracteoles, imbricate rough, margin ciliated/pubescent, persistent beneath the larger three sepals. It consists of five corollas, polypetalous, orbicular concave shape, 1 cm across, greenish-white, imbricate, always in a concave shape in early and late floral stages; margin ciliated/pubescent (Parthasarathy and Nandakishore, 2014). Five staminal fascicles arranged in pentaheptaphalangeous form alternating with five beehive-like yellowish glands with polyadelphous five broad bundles (Victorsinge, 2008). Anthers are bithecus, adnate, introrse. It has superior gynoecium, pentacarpellary, syncarpous-pentalocular, one ovule per locule, placentation axile, style short or subsessile; five stigmatic lobes, oblong, pelted, separate entire, persistent. Fruits consist of thin exocarp with smooth, subglobose, pointed towards rudimentary stigmatic lobe and it became deep yellow when ripped, 2-4 seeds are present with an oblong shape, testa is brown and smooth (Prashanth et al., 2012) (Figure 1 and Figure 2).

Figure 1. Ripen fruit of *Garcinia xanthochymus*

3.3. Microscopic Characteristics

Transverse section of the leaf passing through the midrib region is dorsiventral in shape. The leaf is made up of a single, tiny layer with thin walls that are about rectangular in shape. Both the upper and bottom surfaces of the epidermis are smoothed with cuticle. Palisade is composed of compact, elongated cells that are arranged in a single layer under the upper epidermis. It possesses an intracellular space-filled, loosely organized 6-7 spongy mesophyll layer (Naveen and Krishnakumar, 2012). The presence of collenchyma has shown by the midrib, which is below the upper epidermis and above the lower epidermis. Phloem surrounded xylem which is arranged in an arc shape and large vascular bundle covered with pericyclic fibers. Paracytic stomata are present in the lower leaf, and few cystoliths are seen in the parenchyma region. The circular petiole TS has single-layered, wavy epidermal cells that are thickly coated in cuticle. A large area of the cortex is occupied by parenchymatous cells, and the metaxylem, protoxylem, and phloem that make up the bicollateral vascular bundle are arranged in a crescent shape in the petiole's center (Gogoi et al., 2016).

The transverse section of the stem is almost circular with a wavy outline. A thick cuticle-covered single-layered and thick-walled epidermis is seen. Collenchymatous hypodermis, is arranged in 5-6 layers with a wide cortex composed of parenchymatous cells with numerous secretary canals. Continuous, well-developed broad phloem around the xylem circumference and no distinguishable endodermis (Sharma et al., 2012). A layer of sclerenchyma elements is present on the outer boundary of the phloem. The xylem is in continuous ring form and consists of vessels such as radial rows, fibers, and parenchyma. Distinct medullary rays, a single seriated, collenchymatous pith occupied the central portion (Victorsinge, 2008).

Figure 2. Aerial parts of *Garcinia xanthochymus*

3.4. Phytochemical constituents

G. xanthochymus extract from various parts of the plant, such as bark, fruit, leaves, and others, were studied and found with several beneficial bioactive constituents (Baggett et al., (b) 2005; Konoshima et al., 1970). Isolation and identification of bioactive compounds have been performed by many means (Li et al., 2017; Chen et al., 2008). Some of the techniques involve column chromatography, Partition Chromatography, Thin Layer Chromatography, Ultraviolet-Visible Spectroscopy, High-Performance Liquid Chromatography, High-Performance Centrifugal High-Speed Counter Current Centrifugal Chromatography, as well as Nuclear Magnetic Resonance, Infrared Spectroscopy, and Mass Spectroscopy. The maximum of phytochemicals extracted and isolated from the bark, fruit, leaves, and twigs of the *G. xanthochymus* is given in Figure 3, Figure 4 and Figure 5, respectively (Zhong et al., 2007; Bheemaiah and Kushalappa, 2019). Isolation of five new xanthone from bark, including garcinenone A, B, C, D, and E, and their structural elucidation was done through 2D-NMR, and four compounds such as Jacareubin 1,4,6-trihydroxy-5-methoxy-7-(3-methyl-2-butenyl) xanthone, subeliptenone B, and symphoxanthone were isolated from bark extract of *G. xanthochymus* for the first time (Zhong et

al., 2009). Flavonoids and benzophenones are commonly isolated from *G. xanthochymus* fruits. Two bioactive benzophenones, namely guttiferone H and gambogenone, were isolated from fruits (Bagget et al., (a) 2005). The column chromatographic technique was one of the most commonly adopted methods for isolating compounds from this plant. Seed oil is composed of nine major fatty acids: myristic acid, palmitic acid, stearic acid, palmitoleic acid, oleic acid, linoleic acid, linolenic acid, arachidic acid, and behenic acid were also identified (Manohar et al., 2014).

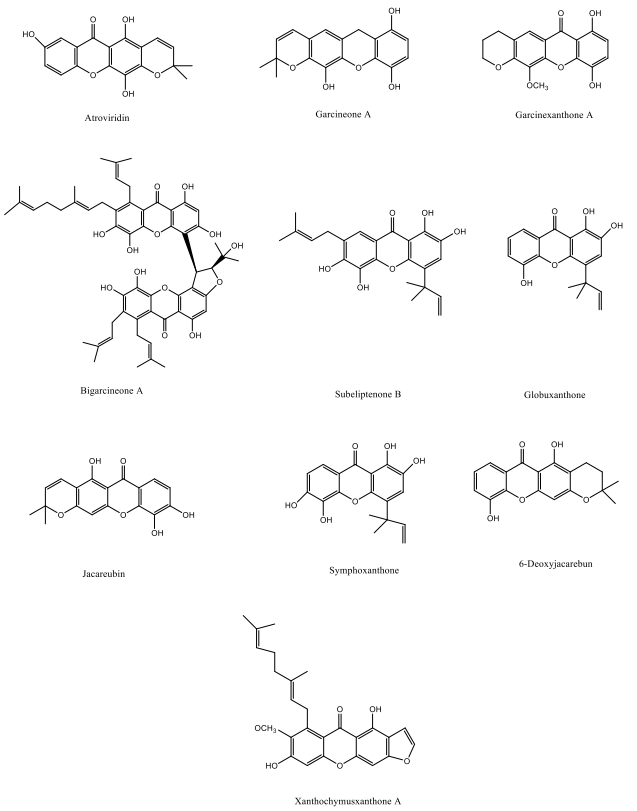

Figure 3. Phytocompounds present in *Garcinia xanthochymus* bark (Zhong et al., 2007; Nguyen et al., 2017; Han et al., 2007).

4. Pharmacological activity of *G. xanthochymus*

4.1. Antioxidant activity

Antioxidant activity has been exhibited by the extract obtained from *G. xanthochymus* due to the presence of polyphenols like flavonoids and xanthones, which is very beneficial for humans as free radicals' generation is inhibited, which is the primary reason for oxidative stress and may cause life-threatening diseases like cardiovascular diseases, cancer, hypertension, etc (Rai and Appaiah, 2014; Chen et al., 2017). Assay involving free radical scavenging technique with the help of l,l-diphenyl-2-picrylhydracyl (DPPH) used mainly during the antioxidant in-vitro studies as it is simple, accurate, and consumes less time (Prasanth et al., 2012). The radical scavenging assay is carried out by measuring the DPPH absorbance with an ultraviolet spectrophotometer and calculating the sample's IC50. DPPH is converted into DPPH-H(diphenylhydrazine) molecule when free radicals are scavenged and neutralized by DPPH by transferring an electron (Liu et al., 2015). This is the core mechanism of the assay method. In UV visual spectroscopy, antioxidant activity is inversely proportional to the DPPH absorbance value, which means the antioxidant activity of the sample will increase with decreased DPPH absorbance value, In contrast, the IC50 value shows that half of the sample compound's maximum inhibitory response is needed to produce the antioxidant activity. Ascorbic acid as a reference standard is compared with the samples of the test compound (Gogoi et al., 2015). Antioxidant activity is also exhibited by the secondary metabolites produced from the bark of *G. xanthochymus*. High antioxidant activity was observed in the studies due to the presence of a large number of polyphenols. When experimented with DPPH, xanthones such as jacareubin, garcinenone A, bigarcinenone A, alloathyriol, subeliptenone B, and flavanoids such as fukugiside, volkensiflavone etc. exhibited excellent antioxidant activity. Aside from that, benzophenones separated, and the oil of *G. xanthochymus* seeds has additionally shown good cancer prevention activity (Manohar et al., 2014). This finding might be valuable to the researchers for contributing to a profoundly successful pharmacological compound with the least side effects (Chen et al., 2010) (Table 2).

4.2. Hypoglycemic activity

Diabetes, which is caused due to metabolic disorders, is interrelated with the day-to-day lifestyle and food habits of individuals, characterized by hyperglycemia, and this disease has emerged as a global disease.

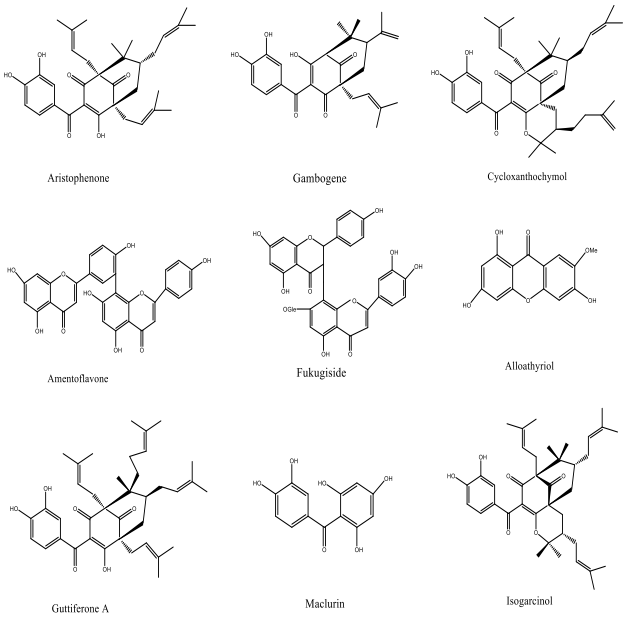

Figure 4. Phytocompounds present in *Garcinia xanthochymus* fruit (Chen et al., 2017; Scott et al., 2005; Manohar et al., 2014).

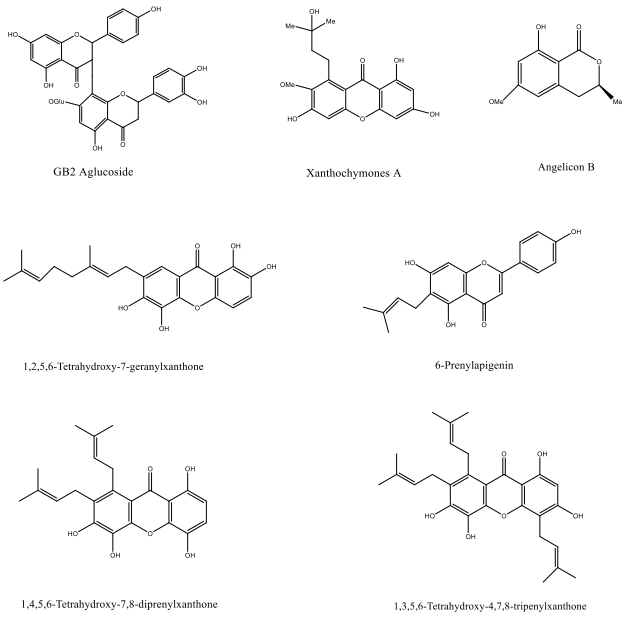

Figure 5. Phytocompounds present in *Garcinia xanthochymus* leaves (Bheemaiah et al., 2019; Hassana et al., 2018).

Diabetes is classified into two types: type 1 diabetes and type 2 diabetes. Type 1 diabetes occurs as a result of impairment of the pancreas, making it unable to secrete insulin due to an autoimmune disorder. Glucose uptake into the cells from the bloodstream is done by insulin using the Insulin receptor substrate. Due to the binding of the α subunit of the insulin receptor or tyrosine kinase to glucose, the β subunit gets autophosphorylated. Protein kinase gets activated due to phosphorylation which converts Guanosinediphosphate to Guanosine triphosphate, triggering the translocation of glucose transporter 4 into the cell

Table 2. Phytoconstituents and Pharmacological activities of *G. xanthochymus*

Phytochemical constituents	Experimental Model	Pharmacological activities	References
Xanthones: Alloathyriol Bigarcinenone A Bigarcinenone B Garcinenone A Garcinenone B Garcinenone C Garcinenone D Garcinenone E Garcinexanthone F Jacareubin Subeliptenone B Symphoxanthone 1,4,6-trihydroxy-5-methoxy-7-(3-methyl-2-butenyl) xanthone 1,5,6-trihydroxy-7-(3-methyl-2-butenyl)-8-(3-hydroxy- 3-methylbutyl)–furano(2′,3′:3,4) xanthone 1,5,6-Trihydroxy-7-(3- methyl-2-butenyl)-8-(3-hydroxy-3-methylbutyl)–6′,6′-dimethylpyrano (2′,3′ 3,4) xanthone 1,5,6-trihydroxy-7-(3-methyl-2-butenyl)-8- (3-hydroxy-3-methylbutyl)–5′-(1-hydroxy-1-methyl-ethyl)-4′,5′ dihydrofurano (2′,3′:3,4) xanthone 1,2,5,4′-tetrahydroxy-4-(1,1 dimethylallyl)- 5′-(2 hydroxypropan-2-yl)-4′,5′-dihydrofurano-(2′,3′:6,7) xanthone 1,3,5,6-tetrahydroxy-7 geranylxanthone 1,4- Dihydroxy-6′,6′ dimethylpyrano (2′,3′:5,6) xanthone, **Flavanoids:** Fukugetin, Fukugiside, Volkensiflavone and 3,8′′-biapigenin **Benzophenones:** Aristophenone A Cycloxanthochymol, Gambogenone Guttiferone E Guttiferone H Isoxanthochymol Xanthochymol	DPPH radical scavenging activity	Tt Antioxidant activity	(Bagget et al., (a) 2005; Zhon et al., 2009; Chen et al., 2011; Zhong et al., 2008)
Garciniaxanthone E, Isogarciniaxanthone E, 1,4,5,6-tetrahydroxy-7,8-di(3-methyl-2-enyl) xanthone, 12b-hydroxy-des-Dgarcigerrin A 1,2,6-trihydroxy-5-methoxy-7-(3-methylbut-2-enyl) xanthone 1,2,6-trihydroxy-5-methoxy-7- (3-methylbut-2-enyl) xanthone 1,4,5,6-Tetrahydroxy-7,8-di(3-methylbut-2-enyl) xanthone 12b-hydroxy-des-D-garcigerrin A	NGF-potentiating activity by inducing neurite outgrowth from PC12D cells in pheochromocytoma cell line	Nerve growth factor (NGF)-potentiating activity	(Chanmahasathien et al., 2003; Vieira and Kijjoa, 2005; Joseph et al., 2016)
12b-hydroxy-des-D-garcigerin A, 1,2,5,6-tetrahydroxy-4-(1,1-dimethyl-2-propenyl)-7-(3-methyl-2-butenyl) xanthone and 1,5,6-trihydroxy-7,8-di(3-methyl-2-butenyl)- 6′,6′-dimethylpyrano (2′,3′:3,4) xanthone Subelliptenone F, GB2a glucoside, GB2a Fukugetin	Enzyme inhibitory assays such as α-amylase and α-glucosidase	Anti-diabetic activity	(Nguyen et al., 2017; Li et al., 2015; Li et al., 2017; Chen et al., 2016)
Xanthochymol Aristophenone A Alloathyriol Amentoflavone 3,8″-biapigenin Cycloxanthochymol Guttiferone E Fukugetin Isoxanthochymol Fukugiside Volkensiflavone Guttiferone H 1,4,5,6-tetrahydroxy-7-prenylxanthone 1,4,6-trihydroxy-5-methoxy-7-prenylxanthone 1,2,5,6-tetrahydroxy-7-geranylxanthone 6-prenylapigenin 1,4,5,6-tetrahydroxy-7,8-diprenylxanthone 1,3,5,6-tetrahydroxy-4,7,8-triprenylxanthone Garciniaxanthone E	MCF7 (hormone-dependant breast carcinoma), A549 (lung carcinoma) and HCT116 (colon carcinoma) cell lines.	Cytotoxic effect	(Han et al., 2007; Protiva et al., 2008; Acuña et al., 2009).
Xanthochymones A Xanthochymones B Xanthochymones C Garcinexanthones A 1,4,6-trihydroxy-5-methoxy-7-prenylxanthone Volkensiflavone Morelloflavone Angelicoin B Xanthochymol	Dilution assay to measure the Minimum Inhibitory Concentration (MIC) against gram-negative and gram-positive bacteria	Antimicrobial activity	(Manohar et al., 2014; Trisuwan et al., 2014).
6-monoacetate-β-mangostin, 6-O-methyl β-mangostin, 6-O-benzyl β-mangostin, 6-O-hexyl β-mangostin, 6-O-sec-butylβ-mangostin 6-O-isobutyl β-mangostin,	LPS-induced RAW cell 264.7 using Griess assay	Anti-inflammatory activity	(Karunakaran et al., 2018)

membrane, causing glucose uptake (Payamalle et al., 2017). Various researchers have conducted antidiabetic studies on different parts of the *G. xanthochymus*, which showed stimulation in the uptake of glucose by derivatives of xanthones such as tetrahydroxy-4-(1,1-dimethyl-2-propenyl)-7-(3-methyl-2-butenyl) xanthone and 12b-hydroxy-des-D-garcigerin A (Nguyen et al., 2017). Enzymes responsible for carbohydrate digestion, such as α-glucosidase and α-amylase are inhibited by Subelliptenone and fukugetin, causing a decrease in the glucose level in the blood as a result of the decreased conversion of carbohydrates into glucose (Li, 2014). To build up the most reasonable medication with the least side effects, researchers need to concentrate on different studies identified with antidiabetic activity (Table 2).

4.3. Nerve growth factor (NGF)-potentiating activity

The nervous system of the body is essential in transmitting impulses across the body via the neurons. This defect in the transmission of impulses leads to several neurodegenerative disorders that can include Parkinsonism, Alzheimer's disease, Huntington's disease, dementia or loss of memory, etc. Several study data revealed that the extract of G. xanthochymus has Nerve

Growth Factor (NGF) potentiating activity. Using a phase-contrast microscope, the researchers' study revealed that the methanolic extract of this wood significantly increased NGF-mediated neurite growth from PC12D cells (Jing et al., 2017). Garciniaxanthone E, isogarciniaxanthone E, 1,4,5,6-tetrahydroxy-7,8-di(3-methyl-2-enyl) xanthone, 12b-hydroxy-des-Dgarcigerrin A, and 1,2,6-trihydroxy-5-methoxy-7-(3-methylbut-2-enyl) xanthone are the possible phytochemicals associated with this activity. Additionally, data from another study indicates that the NGF action is amplified at higher concentrations of 1,2,6-trihydroxy-5-methoxy-7- (3-methylbut-2-enyl) xanthone; however, high concentrations of certain compounds, including 1,4,5,6-Tetrahydroxy-7,8-di(3-methylbut-2-enyl) xanthone and 12b-hydroxy-des-D-garcigerrin A, demonstrated toxicity (Chanmahasathien et al., 2003) (Table 2).

4.4. Anticancer activity

The search for a potent anticancer drug of plant origin is still of greater interest, and several studies are still going on. Several studies are still related to the finding of a lead compound with minimal side effects for the complete cure of this disease (Protiva et al., 2008). Many study data revealed that the extract of G. xanthochymus has the tendency to induce apoptosis, and it can induce cell arrest at the G1 phase of the cell cycle, thereby limiting protein synthesis (Ji et al., 2012). The precise mechanism is still unknown, but it may have to do with the mTOR cell survival pathway being inhibited and the ERS response being activated. The phytochemicals from this species believed to be having anticancer potentials are xanthochymol, aristophenone A, alloathyriol, amentoflavone, 3,8″-biapigenin, cyclo-xanthochymol, guttiferone-E, fukugetin, iso-xanthochymol, fukugiside, volkensiflavone, and guttiferone. Moreover, certain other compounds extracted from the twigs of this plant are found to exhibit cytotoxicity against cell lines of breast cancer and lung adenocarcinoma (Hamidon et al., 2016). The activity is thought to be exhibited by 1,4,5,6 tetrahydroxy-7-prenylxanthone, 1,4,6-trihydroxy-5-methoxy-7-prenylxanthone, 1,2,5,6-tetrahydroxy-7-geranylxanthone, 6-prenylapigenin, 1,4,5,6-tetrahydroxy-7,8-diprenylxanthone,1,3,5,6-tetrahydroxy-4,7,8 triprenylxanthone and garciniaxanthone E (Han et al., 2007) (Table 2).

4.5. Antimicrobial activity

In another study, the antimicrobial activity potential of the extract of G. xanthochymus was accessed (Manohar et al., 2014; Jackson et al., 2015). The oil extracted from the seed of this plant was found to have the potential to resist the growth of some Gram-ve bacteria like *E. coli* and Gram +ve microbes such as *B. subtilis* and *S. aureus*. Moreover, the fruit was subjected to extraction, and this showed potential against gram-positive bacteria such as *S. mutans, S. pyrogens, S.faecalis, and S.aureus,* and a few gram-negative strains like (*V.cholera, E.coli, S. flexnerii, S. typhimurium, P. aeruginosa* and a fungus-like *C. parapsilosis*. Additionally, a number of phytochemical components that were also extracted from *G. xanthochymus* twigs show notable antibacterial activity. These include xanthochymones A, B, and C; garcinexanthones A; 1,4,6-trihydroxy-5-methoxy-7-prenylxanthone; volkensiflavone; morelloflavone; and angelicoin B. One of the bioactive compounds identified from this species is xanthochymol, which also demonstrated antimicrobial activity against Methicillin-Resistant Staphylococcus aureus (MRSA) which was nearly on par with vancomycin-resistant strains. While some other studies for estimating the activity used the dilution assay method to estimate the Minimum Inhibitory Concentration (MIC), most antimicrobial studies use the disc diffusion method to visualize the zone of inhibition. The bioactive component of the extract provides the primary antimicrobial action, while the dose determines the potency of inhibition: the higher the concentration of the extract added, the lower the MIC value and the higher the compound's zone of inhibition against microbes. (Table 2).

5. Conclusion

The herbal source is the backbone of the Indian traditional medicinal system. *G. xanthochymus* belongs to the family of Clusiaceae. In this review the ethnopharmacology of the plant was thoroughly investigated where information about various traditional use of the plant was discovered including anthelmintic, cardiotonic and treatment of diarrhea, dysentery etc. The investigation revealed that the plant is rich in various phytoconstituents, predominantly featuring the xanthone scaffold. Moreover, an in-depth examination of the plant's pharmacological activities provided insights into its therapeutic potential, including hypoglycemic, anticancer, antimicrobial, antioxidant, and NGF (Nerve Growth Factor) potentiating activities. Detailed information about the plant and its medicinal uses could help us in finding a plant-based lead molecule. Despite the fact that a great number of studies on the functions of molecules derived from Garcinia species have been published, there are still plenty of functions and thorough interactions that need to be researched. It is necessary to perform validation on both the results and the reports through research on the human population in order to comprehend the possibility of improving health and the possibility of developing new drug discoveries. G. xanthochymus seeds can produce up to 17% oil. The fruit juice can be used in the dye industry. The gum and resin obtained from the plants can be used for different industrial purposes. More research has to be done to figure out how to improve the quality of fruit products, and then the findings need to be applied on an industrial scale so that businesses can satisfy customers on a global scale. Therefore, expanding both the production and consumption of underused fruits may make a substantial contribution to the improvement of health, as well as the creation of revenue and ecological sustainability.

Conflict of Interest

The authors declare that there is no conflict of interest, financial or otherwise.

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Author's contributions

Nongmaithem Randhoni Chanu conceptualized the review, wrote the initial draft, and supervised the project. Kunal Bhattacharya assisted in the literature search and manuscript revision. Dibyajyoti Das contributed to the ethnopharmacology section and data analysis. Saikat Sen provided expertise in pharmacological properties and critical revisions. Satyendra Deka contributed to the literature survey. All authors read and approved the final manuscript.

Conflict of interests

The authors declare that they have no conflict of interest.

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