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Morphological and Phytopharmacological Evaluation of Indian *Artabotrys* Species: A Review

Review Article

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Abstract

Artabotrys R.Br. (*Arta-* = to suspend; *-botrys* = a bunch of grapes) is one of the largest genera in the family Annonaceae (the custard-apple family). The palaeotropical genus *Artabotrys* comprises approximately 110 species of woody climbers characterized by persistent inflorescence hooks and is distributed mainly throughout tropical and subtropical regions, particularly tropical Africa and Southeast Asia. In India, the genus is represented by 10 species: *A. burmanicus*, *A. caudatus*, *A. hexapetalus*, *A. manoranjanii*, *A. nicobarensis*, *A. sahyadricus*, *A. sericeus*, *A. speciosus*, *A. suaveolens* and *A. zeylanicus*. Species of *Artabotrys* are rich in diverse phytochemicals, including alkaloids, flavonoids, saponins, phenolic compounds, tannins and glycosides, which contribute to their broad spectrum of biological activities. Traditionally, *Artabotrys* species have been used in the treatment of cancer, skin diseases, diabetes, headaches and several other ailments. Pharmacological investigations have demonstrated such as antimicrobial, anthelmintic, anticancer, anti-inflammatory, antioxidant, antileishmanial, mosquito repellent and antifertility activities. In addition, certain species exhibit uterine stimulant, muscle relaxant and cardiac stimulant properties. The present review provides a comprehensive account of the morphology, phytochemistry, traditional uses and pharmacological properties of the genus *Artabotrys*, with particular emphasis on the Indian species. The novelty of this review lies in integrating the currently available information on Indian *Artabotrys* species into a single comprehensive resource, encompassing taxonomy, ethnobotany, phytochemistry, pharmacology and their potential for drug discovery. In conclusion, *Artabotrys* species and their bioactive metabolites possess considerable medicinal and socio-economic significance. Further phytochemical, pharmacological, toxicological and clinical investigations are required to validate their therapeutic efficacy, facilitate the discovery of novel drug candidates and promote the sustainable utilization and conservation of these valuable plant resources.

Keywords: *Artabotrys*; Morphology; Phytochemicals and Pharmacological Analysis

Introduction

India is a major source of medicinal plants, with two of the world's 18 plant biodiversity hotspots located in India: The Eastern Himalayas and the Western Ghats. Surprisingly, India ranks seventh among the 16 super diverse countries, with 70% of the world's species occurring collectively. India's natural resources are exorbitant, accounting for a rich flora of endemic plant species consisting of 5725 angiosperms, 10 gymnosperms, 193 pteridophytes, 678 bryophytes, 260 liverworts, 466 lichen characteristic features are shown in chens, 3500 fungi and 1924 algae [1]. Plants have been always an integral part of the ancient Indian Culture, China and Egypt as medicine and their importance even dates back to the Neanderthal period. These medicines initially took the form of crude drugs such as tinctures, teas, poultices, powder and other herbal formulations [2]. According to the World Health

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Organization (WHO), approximately 80% of the people in developing countries still rely on traditional medicines for their primary health care needs [3] and a significant portion of conventional medicine involves the use of plant extracts or their therapeutic ingredients [4].

Artabotrys is one of the most significant genera of Annonaceae, a pantropical family of flowering plants consisting of over 2430 species. *Artabotrys*, a genus with over 100 species discovered in the tropical forests of Africa, Madagascar, Asia, New Guinea and Australia, belongs to the Xylopieae tribe of the Annonoideae subfamily [5]. Artabotrys is represented by nine species in India [6]. It inhabits tropical rain forests and seasonally dry forests and is distributed mainly in tropical Africa and Asia [7]. *Artabotrys* is characterized by hooked peduncles and inflorescence axes, as well as constricted inner petals over the reproductive organ. Kebler (1993) [8], Chen *et al*., (2018) [9] and Chen and Eiadthong (2020) [10] describe biovulate carpels with basal placentation and sessile to stipitate monocarps. *Artabotrys* species commonly climb by means of hooked. Peduncles and inflorescence axes, but can also appear as straggling shrubs [11]. Some Annonaceae species have thorns, which are typically found on the lower part of the plant [12].

Table 1: Morphological characters of common Indian species of *Artabotrys*.

Plant species	*Artabotrys hexapetalus*	*Atabotrys zeylanicus*	*Artabotrys Savoulens*	*Artabotrys caudatus*	*Artabotrys burmanicus*	*Artabotrys sahyadricus*	*Artabotrys sericeus*	*Artabotrys speciosus*	*Artabotrys nicobarianus*	*Artabotrys manoranjanii*
Habit	Liana or Scadent shrub to 8-10 m tall.	Woody scadent climbing shrubs.	Scadent shrub	Woody climber or scadent shrub	Climber	Woody climber/ half scandent shrub	Woody liana, 20–25 m tall	Climbing shrubs	Scandent shrub. Bark dark brown.	Shrubby Climber
Leaf	Lenticellate dark green, dark-brown when dry, lanceolate/ oblanceolate 5-25 cm, 2.5-10 cm.	Simple, alternate, exstipulate, oblong, 13-18 × 5-7 cm	Lanceolate or oblong, 8- 15 cm, abaxially pale, adaxially glossy	Dark green, ovate/oblong lanceolate,10. 16 - 15.24 cm, both surface is glabrous and glossy.	Pubscent, chartaceo us,11- 18cm × 4.5 - 6 cm, oblanceolate	Simple, alternate leaves, the lamina is oblong to elliptic-lanceolate, leathery and glabrous on both surfaces.	Thick-coriaceous, drying grey above with brown midrib, glabrous; blade oblong-elliptic, 9–10 × 3.5–4 cm, glossy; reticulate	Simple, alternate, oblong to oblong-lanceolate, acuteat base, 9-16.5 x 2-7.5 cm glabrous; petioles *ca* 5 mm long, thickened.	Simple, alternate, elliptic, 10-14 x 4-5.5 cm across, coriaceous, dark green, shining glabrous	Simple, spirally arranged, florescent green, very thin at young and dark green and thick at mature, elliptic lanceolate/ oblong, 8-15× 4- 6 cm.
Inflorescence	Glabrous or sparsely pubscent.	Solitary	Peduncle hooked	Axillary	Terminal or axillary peduncle hooked	Solitary or occasionally in small cluster peduncle	Hooks, flattened, sparsely pubescent, Lenticellate,	Recurved hooked peduncles;	Hooked peduncles,	Single flower at curvature of peduncle
Flower	1-4 Flowered, peduncle 2, flower bud broadly ovoid, banana like fragrant; sepal green, ovate to triangular; petals 6, green to bright yellow; carpel 5-30, ovary ovate-oblong.	Fragrant, sepal petals 6 in 2 rows, sub equal or outer petals slightly longer and wider than the inner petals, outer whorl fleshy, stamen many; carpel 4- many, 2 ovule per carpel	Greenish yellow, fragrant; sepal ovate, reflexed, apexacute; petals 2-4 cm, pubescent	1-2flowered; peduncle hooked, petiole short, greenish yellow, ripe apple or jackfruit like fragrant; sepals3; petals 6; numerous stamen; carpel many, pyriform	Petal pale green to yellow, flatly ovate, petal 3 rhombic, Stamens 100, light yellow; carpel 29	greenish-yellow to yellow coloration, 6 petals arranged in two whorls, numerous stamens, several free carpels	1–4 flowered, shorter flowering pedicels and thickness of petals *in vivo* the petal apex is acute, the outer petal blades are ovate and the inner petal blades are oblong-elliptic.	Sepals 3, ovate, 4-6 x 1.5-2mm, pubescent outside, glabrous inside. Petals 6 (3+3), yellow; outer petals narrowly, concave at base, linear upwards to obtuse apex carpels few ca 1.5 mm long, mixed with straight hairs; styles articulate,	Sepals 3, ovate, apex acute, brown tomentose outside, about 4 mm long. Petals 6, dissimilar, ovate, apex acute or pointed, outer petals clawed, linear lanceolate, tomentose grey. Carpels few.	Sepal 3, broadly ovate, 5- 6× 5- 6 mm, petals 6 (3+3), greenish to marble white, thick and more fleshy, stamen ca 100,bright pinkish, 2 mm long, carpel ca 14, ovoid,4-5 mm, prominent stigma

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Fruit	Monocarp yellow, ellipsoid to obovoid.	Apocarpous, berried and ovoid	Monocarp 6- 10, green, obo void	Monocarp, yellow, oblong	Monocarp 8-12	Aggregate of monocarp	Monocarps 8–12 per fruit, sub obovoid to globose.	Monocarps *ca* 2-3 cm long,	Apocarpous many, sub sessile, berried and ovoid	Monocarp not seen
Seed	2 seeded, Pale / dark brown, transversely grooved	2 seeds rarely 1 per monocarp, brown, finely wrinkled.	Oblong, deeply grooved on one side.	2 seeded	2 seeded	1 Seeded, smooth, hard, dark brown in colour	2 seeded	2 seeded ellipsoids	2 seed rarely 1 per monocarp, aril absent	2 seeded
Distribution	Southern India, Sri Lanka	Karnataka, Kerala, Tamil Nadu (Western Ghats), Maharashtra, Sri Lanka	Great Nicobar Island	North-east India, Malwa, Bangladesh.	Kanchana buri, North east India, Western Thailand	Kerala (Western Ghats)	Tamilnadu (Southern Western Ghats)	Andaman Island	Great Nicobar Island	North Andaman Island (Saddle Peak National Park)
Soil type	Alluvial, red soil	Red soil, Laterite	Laterite, Alluvial	Black soil	Alluvial soil	Red soil, black soil	Lateritic and red-sand soil	Alluvial, Laterite	Alluvial, Laterite	Sandy/ clayey loam soil
Habitat	Tropical evergreen	Tropical evergreen and semi evergreen forests	Tropical evergreen	Tropical evergreen	Wet Tropical biomes	Dry deciduous forests	Tropical semi evergreen forests	Inland evergreen forests	Tropical evergreen dense forests	Ever green

Table 2: Enthanomedicinal uses *Artabotrys* species.

Plant species	Plant Part Used	Ethnomedicinal Uses
Artabotrys hexapetalus	Leaves	Treatment of itching
Artabotrys hexapetalus	Flower	Treatment of bad breath, biliousness, bladder diseases, blood and heart diseases, headache, itching, leukoderma, sweating, thirst and vomiting
Artabotrys caudatus	Roots and leaves	Treatment of fever, diarrhea and pain relief.
Artabotrys suaveolens	Roots	Treatment of gastrointestinal disorders
Artabotrys suaveolens	Leaves	Treatment of fever
Artabotrys speciosus	Leaves and Bark	Traditionally used for minor ailments.
Artabotrys hexapetalus	Fruits	Treatment of topical fungal infection
Artabotrys zeylanicus	Flower	Treatment of vomiting (decoction)
Artabotrys burmanicus	Leaves	Antifertility, muscle relaxant
Artabotrys burmanicus	Bark	Wound healing

Methodology

A systematic literature search was carried out using major scientific databases, including Google Scholar, PubMed, Scopus and Web of Science. Relevant publications were identified using keywords such as *Artabotrys*, traditional uses, phytochemistry and pharmacology. The reference lists of selected articles were also screened to obtain additional relevant studies.

Plant Description

Artabotrys (Arta-: to hang; -botrys: a cluster of grapes) is among the largest genera within the custard-apple family, Annonaceae [13]. The genus *Artabotrys*, which is found in paleotropical regions, includes approximately 110 species of woody climbing plants known for their persistent inflorescence hooks [10], primarily located in tropical and subtropical areas of the world [14], with a particular abundance in tropical Africa and Eastern Asia [15]. This genus has various traditional applications, such as the treatment of cholera, malaria and additional health conditions [16]. The chemical compounds found in these plants include alkaloids [17], volatile oils [13], cyclohexenes [18], phenylpropanoids [19] quinones, flavonoids [20] and sesquiterpenes [21]

Systematic position (Bentham and Hooker)

Class : Dicots

Subclass : Polypetalae

Series : Thalamiflorae

Order : Ranales

Family : Annonaceae

Genus : *Artabotrys*

Morphological Characters

The leaves are simple, alternate and possessing petioles [22] or opposite [23], having a leathery texture [24], smooth or becoming smooth [25], shiny [26]. Accessory buds located in the leaf axils on orthotropic shoots can develop into vegetative plagiotropic shoots, produce thorns particularly in shady environments or form sympodial inflorescences, with each sympodial unit ending in a hook [27]. The flowers possess both male and female reproductive structures [25]

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Table 3: Chemical Constituents of *Artabotrys* species.

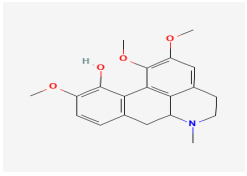
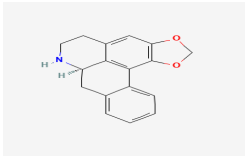
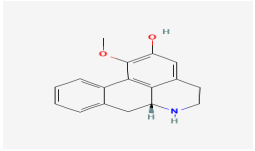
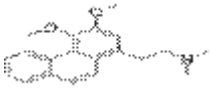
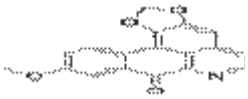
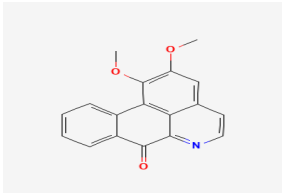
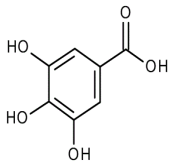
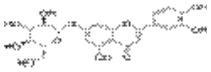
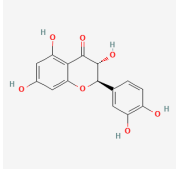
Compound	Structure	Plant species
N-methylcoclaurine		*Artabotrys hexapetalus*
Artabotrine		*Artabotrys zeylanicus Artabotrys hexapetalus*
Anonaine		*Artabotrys hexapetalus* *Artabotrys zeylanicus*
Asimilobine		*Artabotrys hexapetalus*
Atherospermidine		*Artabotrys zeylanicus*
Lanuginosine		*Artabotrys zeylanicus*
Lysicamine		*Artabotrys zeylanicus*
Gallic acid		*Artabotrys hexapetalus*
Cynaroside		*Artabotrys hexapetalus*
Taxifolin		*Artabotrys hexapetalus*

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Table 4: Pharmacological properties of *Artabotrys* species.

Extract/ Compound	Plant species	Plant part	Pharmacological property
Methanol extract	*A. hexapetalus*	Leaves	Remarkable inhibition against *Bacillus megaterium Enterococcus faecalis*, *Lactobacillus casei*, *Staphylococcus aureus*, *Streptococcus entericus, Streptococcus mutans, Escherichia coli, Pseudomonas aeruginosa*, *Salmonella typhi* and *Xanthomonas campestris*, with zones of inhibition ranging from 11 mm to 18 mm
Water extract	*A. hexapetalus*	Flower	Strong antibacterial activity against *Staphylococcus aureus* ATCC 29737, *Escherichia coli* ATCC 10536, *Pseudomonas aeruginosa* ATCC 27853 and *Salmonella typhi* ATCC 14028, with zones of inhibition ranging from 17 ± 0.11 mm to 19 ± 0.03 mm
8-Methoxyouregidione Ouregidione Oxocrebanine	*A. zeylanicus*	Stem bark	Preferential toxicity towards DNA repair-deficient RS 321N and RS 322YK (RAD 52Y) strains of *Saccharomyces cerevisiae*
Artabotrine	*A. zeylanicus*	Stem bark	Strong inhibitory effect on both camptothecin resistance and wild-type P388 leukemia cell lines with respective GI50 values of 1.12 μM and 1.59 μM
Petroleum ether extract	*A. hexapetalus*	Leaves	High anti-implantation activity (72%) at a dose of 250 mg/kg on days 1-7 post-coitum in female albino rat

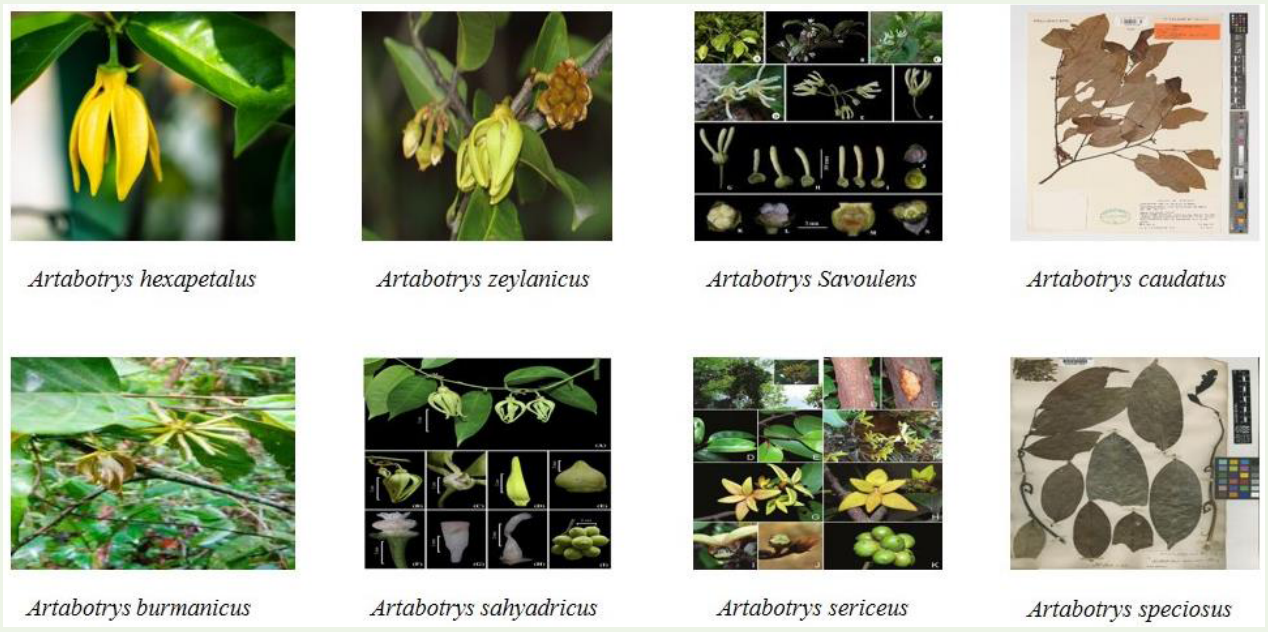

Figure 1: The different species of *Artabotrys*.

and can be either white or yellow [24], functioning as hermaphrodites [22] with a strong fragrance [28]. They may appear alone or in small clusters [29] and are supported by woody, typically thick [26] and almost always distinctly hooked peduncles, which are frequently found opposite to the leaves or adjacent to lateral branches [25]. The three sepals may either be partially fused at the base [30] or completely separate [23] and arranged valvately [22] the six petals are arranged in a valvate manner [26], consisting of two whorls, each containing three petals [31], which are roughly equal in size, distinct from one another, concave at the base [25] and overlap above the stamens and carpels [32]. The stamens are numerous [5], tightly grouped [30], have a quadrate oblong or cuneate shape [29] and feature a truncate, expanded connective apex [23]. The carpels are also numerous [33], have an oblong or oval shape [26] and contain two basal ovules within the ovary [10]. The fruits are made up of cylindrical or ellipsoid monocarps that are indehiscent [22], primarily sessile [23] and have one or two seeds [25]. The seeds are oblong [22], erect [34], collateral [10] and lacking an aril [35]. These characteristic features are shown in (Table 1).

Ethnomedicinal and non-medicinal uses

Traditional medicine has constantly depended on medicinal plants as its basis for functioning. India has a bizarre nature of old medical systems. These conventional drug systems prioritize safety,

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efficacy and quality, leading to a desire to preserve their conventional practices [36]. The fragrant flowers of *A. hexapetalus* are tonic and stimulating. The fruits and bark are useful for fever, diarrhoea, infections of the skin, sores, ulcers, inflammation, cough, asthma and bronchitis. The leaves extracts exhibit antibacterial, antifertility and antifungal activities [37]. In Assam, the pulp of ripened fruits is used to treat fungal illnesses in domestic animals, while Malay tribes make use of a leaf decoction to treat cholera. Aromatherapy uses the volatile oil from flowers in the Unani system of healing. Flowers are utilized as tonics and stimulants in the Ayurveda and Siddha medicinal systems. Flowers are used as flavouring in tea. South India; Sri Lanka used in perfumery to produce essential oils. In Salem, Tamil Nadu, Southern India, it is used to prepare stimulating tea-like beverages [38]. The pleasant odour of the flower is often employed in the production of perfumes [39]. In Java, Indonesia, Philippines, Southern China and India, the entire plant is used as an attractive plant and screen planting in big gardens. Malaria and scrofula are treated with traditional Chinese medicine [40]. *Artabotrys* species have been traditionally used to treat a range of medical conditions, including scrofula [41], malaria [42] and cholera [43]. *Artabotrys* species are used as folk medicines in many countries to treat a wide range of ailments. The most commonly used plant parts in local populations include roots, leaves, stems, flowers and fruits. Prior to delivery, the majority of plant treatments are made as decoctions and infusions from specific plant parts or combinations of plant parts or species. The utilization of numerous plant species in the formulation of remedies may be related to their synergistic effects during disease therapy [44]. Ethnomedicinal and non-medicinal uses are shown in (Table 2).

Phytochemical Constituents

More than 200 chemical constituents have been found and isolated from the *Artabotrys* genus, including 67 terpenoids [45], 68 alkaloids [46], 28 phenolic compounds [47] and 40 additional related chemicals [48]. Aporphinoids make up the majority of the alkaloids found in *Artabotrys* species, with anonaine [49], asimilobine [50], norstephalagine [51] and atherospermidine [41] being the most commonly isolated chemicals. Flavonoids are the most common type of phenolic chemical found in *Artabotrys* species, with catechin being the most abundant [52]. Modern chromatography and spectroscopy techniques, such as HPLC (High Performance Liquid Chromatography), UPLC (Ultra Performance Liquid Chromatography), NMR (Nuclear Magnetic Resonance) and MS (Mass Spectroscopy), have greatly aided in the isolation and determination of natural products [53].

Alkaloids

Artabotrys plants are likely to contain a high concentration of alkaloidal compounds. *Artabotrys* alkaloids are classified into many categories, the most common being aporphines, which have over fifty isolates. Aporphines are identified in seventeen *Artabotrys* plants. *Artabotrys* aporphines are found in both monomeric and dimeric forms. Anonaine, artabotrine, asimilobine, atherospermidine, liriodenine, nornuciferine and norstephalagine were commonly identified. As a representative example, annonine was discovered in *A. hexapetalus* stem and *A. zeylanicus* stem bark. Chromatographic separation of the acidic methanol extract of *A. hexapetalus* stem led in the identification of two new benzylisoquinolines hexapetalines and a known analogue (+)-reticuline [54].

Terpenoids and sterols

Terpenoid types: sesqueterpenoids were the second most abundant chemical class in *Artabotrys* plants [55]. *A. hexapetalus* contains a derivative of the sesqueterpenoid. *A. hexapetalus* was a source of novel sesqueterpenoids. Artaboterpenoid A and its two enantiomers (-)- artaboterpenoid B and (+)- artaboterpenoid B were isolated. The alcoholic extract of *A. hexapetalus* root along with seven new pairs of enantiomers (±) - yinzhaosus E-K and two analogs yinzhaosus L-M, were isolated and identified [56].

Sterols were discovered as the second chemical class in the isolation process of *Artabotrys* extract. *Artabotrys* plants frequently produce β-sitosterol and stigmasterol, two well-known sterols. *A. hexapetalus* contains β-sitosteryl-3-O-β-D glucoside, a glycoside derivative [57].

Flavanoids and Polyoxygenated Compound

Flavanoids are a chemical class of naturally occurring metabolites with antioxidant characteristics that are thought to have a favourable effect on the cellular signalling system. *Artabotrys* plants are also said to contain some common chemicals. Over twenty flavonoids have been purified to date. They comprised flavones, flavan, flavanone and pterocarpan [58]. *Artabotrys* flavones are given in either free or glycosylated form. *Artabotrys* glycones are mostly composed of glucose, galactopyranose, apiose, arabinose and rhamnose [41]. The chromatographic isolation of *A. hexapetalus* leaf extract yielded two new flavone glycosides, arapetalosides A-B, along with five recognized analogs [20].

Fatty Acids

Tetrahydrofuran-4-methylidene-3-ol and (+)-tulipalin B were discovered for the first time in the genus *Artabotrys*, and they came from *A. uncinatus* stems and *A. hexapetalus* aerial parts, respectively. Acetogenins are a well-known class of bioactive polyketides from the Annonaceae family. Currently, *Artabotrys* plants have given four novel acetogenins [59]. Three novel compounds, artapetalins A-C, were successfully precipitated from the methylene chloride (CH_2Cl_2) extract of *A. hexapetalus* aerial portion using a gradient chromatography column [19].

Pharmacological Values

The current pharmacological study on *Artabotrys* plants has resulted in a variety of biological studies. Various biomedical categories have been investigated to date, however cytotoxic and antibacterial actions were shown to be the most abundant in assays using *Artabotrys* plant materials. The key pharmacological values such as cytotoxic activity, antimicrobial activity, antioxidative activity, antidiabetic activity, antiviral activity, antiplasmodial activity, hepatoprotective activity and more were shown in (Table 4).

Research gap and future perspectives:

- Several Indian *Artabotrys* species remain unexplored phytochemically.
- Nutritional studies are extremely limited.
- Pharmacological validation is lacking for many species.
- Toxicity and safety studies are scarce.

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- Tissue culture and conservation studies are insufficient.
- Genomic and metabolomics investigation are largely absent.
- Clinical validation of traditional uses is lacking.

Summary

Artabotrys plants are commonly known in traditional medicine systems to treat various ailments such as cholera, vomiting, malaria, headache etc. Around 10 species, including *Artabotrys hexapetalus*, *Artabotrys zeylanicus, Artabotrys burmanicus, Artabotrys caudatus, Artabotrys nicobarensis, Artabotrys speciosus, Artabotrys manoranjanni, Artabotrys sahyadricus, Artabotrys sericeus* and *Artabotrys suaveolens*. So far, over two hundred thirty secondary metabolites have been extracted and their structures clarified from *Artabotrys species*. The metabolites discovered were found to encompass various chemical classes, with the major categories including alkaloids (78 compounds), terpenoids (44 compounds), flavonoids (22 compounds), polyoxygenated compounds (19 compounds) and fatty acids (16 compounds), along with several minor components. These findings highlight the considerable medicinal and socio-economic importance of the genus. The compiled evidence demonstrates that the certain species, particularly *Artabotrys hexapetalus,* have been investigated extensively, most Indian species remain poorly explored. Information on their phytochemical constitutions, nutritional composition, biological activity, toxicity, tissue culture potential and conservation status is limited or unavailable for several taxa. Addressing these knowledge gaps through phytochemical investigations, pharmacological validation, toxicological evaluation, metabolomic studies, molecular approaches, tissue culture techniques and conservation programs is essential to fully realize the medicinal and economic potential of these species.

The novelty of this review lies in its integration of the most up-to-date information on all Indian *Artabotrys* species into a single comprehensive resource. By combining taxonomic revisions with ethnobotanical, phytochemical, pharmacological, tissue culture and conservation data, this review provides a holistic understanding of the genus in the Indian context. Furthermore, by identifying existing research gaps and outlining priority areas for future investigation, it offers a valuable reference for botanists, phytochemists, pharmacologists, natural products researchers and conservation biologists. This review is expected to serve as a scientific foundation for future research, sustainable utilization, conservation planning and the discovery of novel bioactive compounds from Indian *Artabotrys* species.

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