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A comprehensive review on phytochemistry, health benefits, and therapeutic potential of *Elaeocarpus angustifolius* Blume

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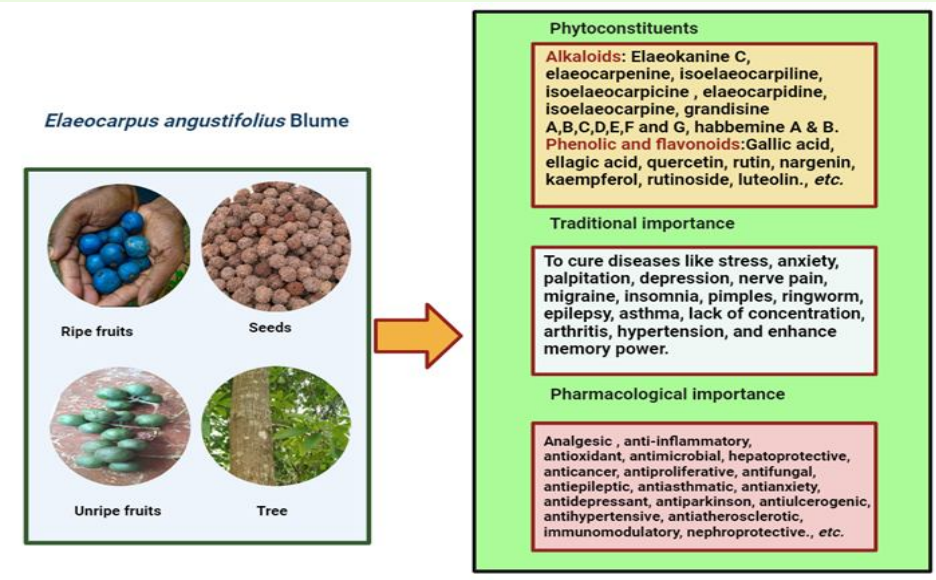
Abstract

Elaeocarpus angustifolius Blume (*E. angustifolius*), is a tropical evergreen plant, primarily found in India, Malaysia, Indonesia, Myanmar, Nepal, Australia, Thailand, and the Pacific Islands. It exhibits immense ethnobotanical and pharmacological characteristics. Despite its broad ancient usage, there is still a research gap in the comprehensive examination and collection of available evidence on its medicinal value. Throughout ancient times, Ayurveda has employed various parts of this plant to address a range of health issues, including mental illness, anxiety, stress, depression, epilepsy, nerve pain, migraine, palpitations, asthma, poor concentration, arthritis, hypertension, and liver disorders. In addition, it can be used to treat leprosy, hysteria, coma, leucorrhoea, and other skin conditions like pimples, ringworm, *etc*. This review provides valuable insights that could inform future research directions, drug discovery efforts, and the integration of rudraksha into complementary medicine practices. This study collected literature published on the phytochemistry and pharmacology of *E. angustifolius* before November 2023. Scientific literature in English from databases such as Science Direct, Wiley, Springer, Frontiers, PubMed, and Google scholar. Chemical structures found in *E. angustifolius* were depicted using ChemDraw (version 12.0.2), following an extensive search in PubChem databases. To identify pertinent articles and materials, the search was conducted using keywords like "*Elaeocarpus angustifolius*," "Rudraksha," "*Elaeocarpus granitrus*," "*Elaeocarpus sphaericus* pharmacology and bioactive compounds," and other phrases of a similar kind. Furthermore, the possible mechanism of action underlying the pharmacological potential has been explored. Nevertheless, clinical studies are required to ascertain the efficacy of *E. angustifolius* in treating human diseases.



1. Introduction

Medicinal plants are exploited for their ethnomedicinal advantages and have been utilized in various populations for the biosynthesis of numerous pharmacological agents. Plant-based medicines have grown in popularity because they are highly affordable, accessible, readily available, more effective, and have a lower toxicity profile than

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synthetic drugs. The advantages derived from plants are from their diverse primary and secondary metabolic activities. Primary metabolites involve crucial components necessary for plant growth, synthesized consistently throughout their life cycle. Secondary metabolites primarily function to shield the plant from biotic and abiotic stresses, generally posing less toxicity towards human responses (Arif *et al.,* 2022; Shruthi *et al.,* 2023). Ethnomedicines sourced from medicinal plants are believed to be safer alternatives and have demonstrated efficacy in treating various ailments (Maroti *et al.,* 2022). Approximately, 80% of the world's population relies on plant extracts for primary healthcare, with nearly 90% of prescriptions in traditional medicine systems being derived from plant-based drugs (Bhuvaneswari *et al.,* 2021). Exploring traditional medicine presents an engaging and challenging pursuit for ethnobotanists (Santhosha *et al.,* 2023). This review centres on one such plant that has been utilised for therapeutic purposes in the Ayurveda system of medicine.

E. angustifolius, commonly referred to as rudraksha, is a medicinal plant renowned for its ethnomedicinal applications, varied pharmacological health benefits, and its significance to mankind. The term *Elaeocarpus* originates from two Greek words, where "Elaeo" signifies olive, and "carpus" indicates fruit. As a result, *Elaeocarpus* produces fruits that are similar to olives. It is a large, eternal tree, that produces rudraksha beads and is popularly known as the rudraksha tree in India (Manu *et al.,* 2013). It is regarded as the most well-known tree with both spiritual and therapeutic benefits. A rudraksha bead emerges from the blue-coloured pulp of this plant when the pulp is removed and these beads have a hard and bumpy texture, alienated into segments by ridges at the top and bottom. Those ridges are called rudraksha's faces. It is believed that the rudraksha seed possesses electromagnetic properties that drive out negative energy (Aryal *et al.,* 2021). *E. angustifolius* has been traditionally used in the Ayurveda system of medicine to address various ailments like anxiety, epilepsy, depression, asthma, neuralgias, arthritis, hypertension, and liver disorders. Additionally, it is used to treat leprosy, hysteria, comas, leucorrhoea, and skin conditions (Kumari *et al.,* 2018). These seeds have potential health benefits, but additional research is necessary to identify their mechanism and then determine its effectiveness. This paper reviews the current literature on *E. angustifolius* concentrating on its phytochemistry, ethnobotany, and pharmacological properties. The comprehensive health benefits of *E. angustifolius* seeds are shown in Figure 1.

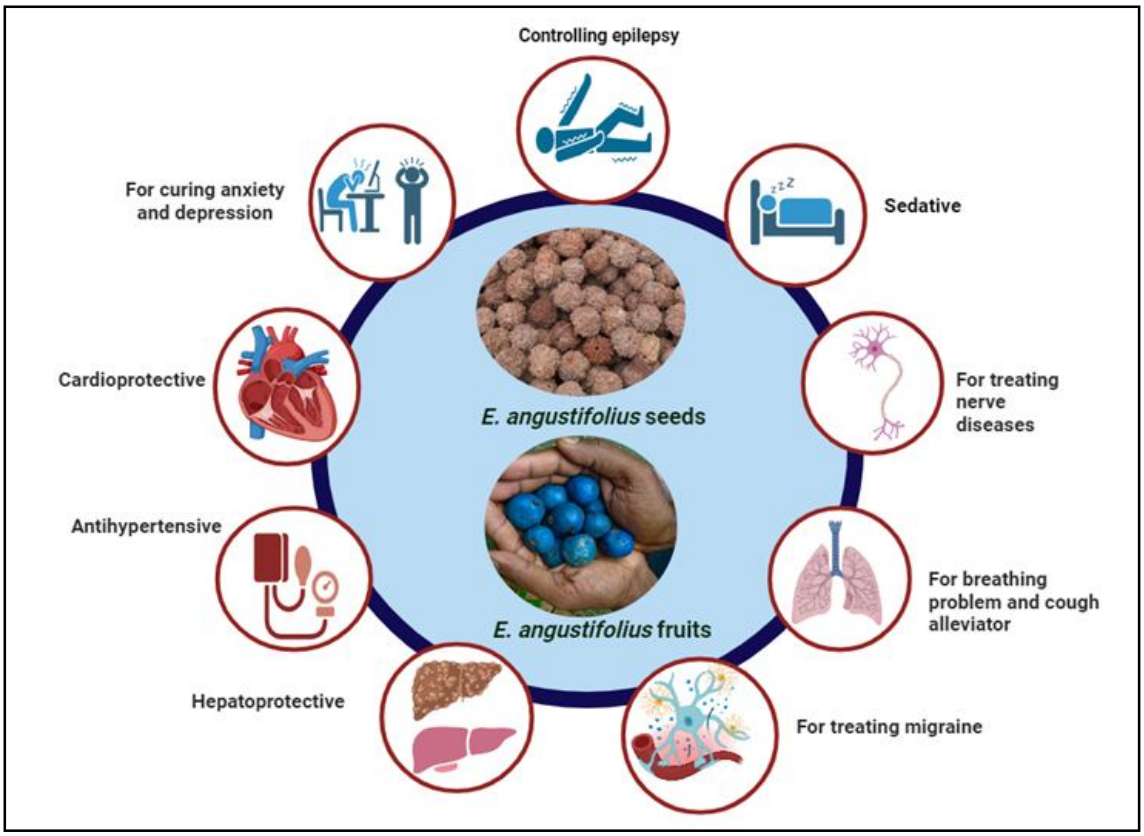


Figure 1: Comprehensive health benefits of *E. angustifolius*.

1.1 Botanical description of the plant

E. angustifolius is a tall evergreen tree belonging to the Elaeocarpaceae family, may grow to a height of 14.6-29.2 meters with a trunk diameter of up to 1.23 meters. The stem is cylindrical and has a coarse texture, featuring bark that is greyish-white in colour (Kumari *et al.,* 2018). The leaves measure 10-15 cm in length and 6-8 cm in width. They are simple, smooth, oblong-lanceolate, with a mostly smooth or irregularly crenated margin and are shiny green, pointed or acuminate at the tip, slightly bitter, and lack any distinct smell (Arivu *et al.,* 2017). The flowers exhibit a white or yellow hue, commonly blooming in April and May. Clusters of tightly packed flower stems typically arise from the junctions of fallen leaves (Hardainiyan *et al.,* 2015) The fruits, which are small and either round or oval, have a sour

taste, particularly in the pulp. While they are initially green, as they ripen, they change to blue, violet, and finally brown or grey (Kumari *et al.,* 2018). The ripe fruit presents a plump appearance and houses a blue seed inside. The term "Rudraksha" pertains to the innermost part of the bead found within the seed. The seeds are brown, five-segmented, stony, very hard, spherical, obovoid, or oval in shape, vary in size, and have longitudinal grooves and tubercles. The seed coats consist of multi-layered stone cells followed by thin-walled parenchymatic cells containing a reddish-brown pigment. The endosperm comprises oval to polygonal parenchymatic cells with calcium oxalate rosette crystals and oil globules, while the embryo is composed of parenchymatous cells containing oil globules (The Ayurvedic Pharmacopoeia of India, 2004). Each seed exhibits varying numbers of perpendicular lines on its surface, defining its 'Mukhs' or faces, ranging from 1 to 24 (Rashmi *et al.,* 2014). The morphology of *E. angustifolius* is shown in Figure 2.

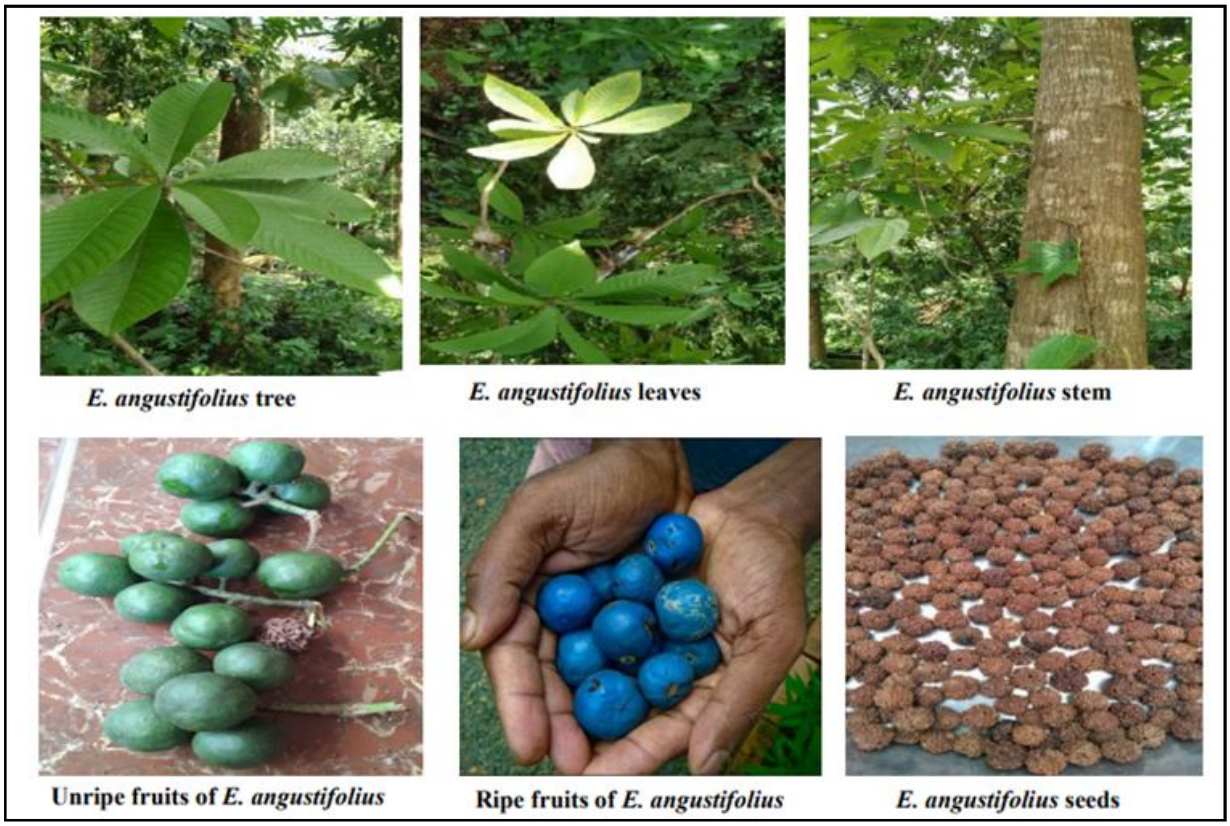


Figure 2: Morphology of *E. angustifolius*.

1.2 Geographical distribution of plant

E. angustifolius is a perennial tree indigenous to tropical and subtropical regions, thriving at elevations up to 2,000 meters above sea level. The species is found in the Himalayan foothills of Nepal, Southeast Asia, Indonesia, Hawaii, Guam, Hawaii, and Guinea, as well as in Australia (Gaurav Kumar *et al.,* 2014; Kumari *et al.,* 2018). Within the *Elaeocarpus* genus, which comprises 552 known species, Asia alone harbours 120 species, and 25 species occur in India. *E. angustifolius* trees are primarily found in the Himalayan region of India. They can also be found in the states of Uttarakhand (Haridwar, Garhwal), Uttar Pradesh, Bihar, West Bengal (Darjeeling), Assam, Arunachal Pradesh, Nagaland, Manipur, Meghalaya, Madhya Pradesh, and Maharashtra. In South India, they are found in Telangana, Andhra Pradesh, Karnataka, Kerala, Mysore, and Tamil Nadu (Kumari *et al.,* 2018).

1.3 Conservation status in India

Approximately 120 *Elaeocarpus* species are distributed across diverse regions in Asia, encompassing countries like Nepal, Bhutan, Sikkim, Tibet, Java, Indonesia, and the Himalayan foothills. Among these, 25 species are identified in various Indian states, including Uttar Pradesh, Maharashtra, Bihar, Madhya Pradesh, Assam, Arunachal Pradesh, and Meghalaya. The *E. angustifolius* tree is sporadically found in Assam, with more prevalence in places like Charaideu, Digboi, Margherita, Dibrugarh, Jorhat, and Golaghat. In Arunachal Pradesh, it is common along the foothills of all districts except Tawang and upper Subansiri. However, the rudraksha production in Arunachal Pradesh has significantly decreased due to factors like excessive extraction of forest resources, large-scale disturbances to forest ecosystems, urbanization, construction activities (hydroelectric dams, buildings and roads), encroachment on forest lands for agriculture expansion, logging, mining operations, and shifting cultivation (Rashmi *et al.,* 2014).

1.4 Composition of *E. angustifolius* seed

Several research papers have explored the chemical composition of *E. angustifolius*, revealing the presence of diverse gases and phytochemicals. According to Dubey *et al.* (2018), *E. angustifolius* contains 50.03% Carbon, 30.53% Oxygen, 17.89% Hydrogen, and 0.95% Nitrogen. Similarly, Das (2017) identified tannins, flavonoids,

steroids, saponins, and cardiac glycosides in three different extracts of *E. angustifolius* ethanolic, methanolic, and aqueous. Water extraction yielded carbohydrates, tannins, and proteins, while ethanol ether extraction revealed proteins, alkaloids, carbohydrates, tannins, and flavonoids. Additionally, Dubey *et al.* (2018) noted the presence of phytosterols and fixed oil fats when *E. angustifolius* was extracted with petroleum ether. The chemical composition of *E. angustifolius* seed is shown in Figure 3.

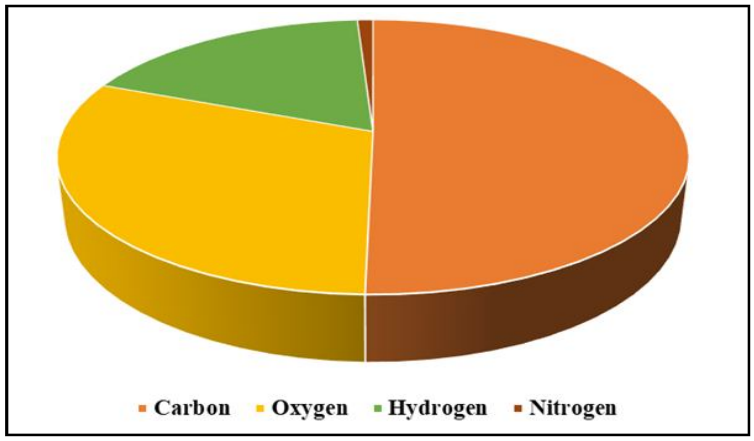


Figure 3: Chemical composition of *E. angustifolius* seed.

1.4.1 Types of rudraksha beads

Rudraksha beads are classified according to the number of "mukhi's," or surface clefts and furrows. Rudraksha beads with 1 to 38 "mukhi's," are mentioned in literature, although those with 1 to 14 "mukhi's," are usually highlighted. The most prevalent form of rudraksha is the five-faceted or "Punch "mukhi," while higher mukhi beads are rare. As seen in Table 1, every bead has a unique effect correlated with its number of mukhi's. Traditional scriptures assign specific value and importance to different mukhi seeds based on the number or type of faces each seed possesses.

Table 1: Types of rudraksha beads and their pharmacological uses (Krishna *et al.*, 2019; Arivu *et al.*, 2017; Hardainiyan *et al.*, 2015)

Types of rudraksha beads	Pharmacological uses
Single faced	Persistent asthma, cardiac issues, anxious tendencies, tuberculosis, a history of stroke, paralysis, skeletal discomfort, and headaches.
Double faced	Erectile dysfunction, kidney malfunction, stress, anxiety, difficulty concentrating, depression, pessimistic thoughts, vision issues, mental turmoil, hysteria, and gastrointestinal disorders.
Three faced	Several conditions include mental impairment, depression, schizophrenia, irregular menstrual cycles, stress, high blood pressure problems, mood swings, fever, debility, and jaundice.
Four faced	Circulatory issues, cough and brain-related ailments, asthma, memory lapses, and respiratory obstruction concerns.
Five faced	Hypertension, cardiac issues, stress, cognitive impairment, obesity, anger control, diabetes, haemorrhoids, neurotic conditions, and issues related to maladjustment.
Six faced	Seizures and issues related to women's reproductive health.
Seven faced	Conditions such as asthma, pharynx inflammation, impotence, foot-related ailments, respiratory issues, and mental disorientation.
Eight faced	Abdominal pain, tension, skin ailments, and uneasiness.
Nine faced	Functions as an enigmatic remedy for addressing uncommon illnesses.
Ten faced	Imbalance in hormonal levels within the body, mental insecurity, and pertussis.
Eleven faced	Physical discomfort, pain in the back, persistent alcohol abuse, and liver ailments.
Twelve faced	Conditions affecting the bones, such as rickets, osteoporosis, mental impairment, and anxiety.
Thirteen faced	Muscular dystrophy.
Fourteen faced	Conditions associated with the brain and various other illnesses.
Fifteen faced	Dermatological issues, repeated pregnancy loss, and stillbirth. Considered a boon for women facing difficulties in conceiving, and in such instances, both partners wearing it are believed to enhance fertility.
Sixteen faced	Hansen's disease, pulmonary tuberculosis, and respiratory ailments.
Seventeen faced	Memory lapses and disturbances in bodily functions.

Eighteen faced	Balancing of the mind and a decline in power.
Nineteen faced	Blood irregularities and issues related to the spine.
Twenty faced	Consumed as a remedy for issues related to eyesight and snake bites.
Twenty-one faced	Possesses inherent healing properties and is capable of eliminating various diseases.
Trijuti/tribhagi	Disorders affecting both the internal and external aspects of the body.
Gauri shanker	Disorders related to sexuality and behaviour.
Garbh gauri	Issues related to Gynaecological disorders.
Ganesh rudraksha	Issues related to the female reproductive system.

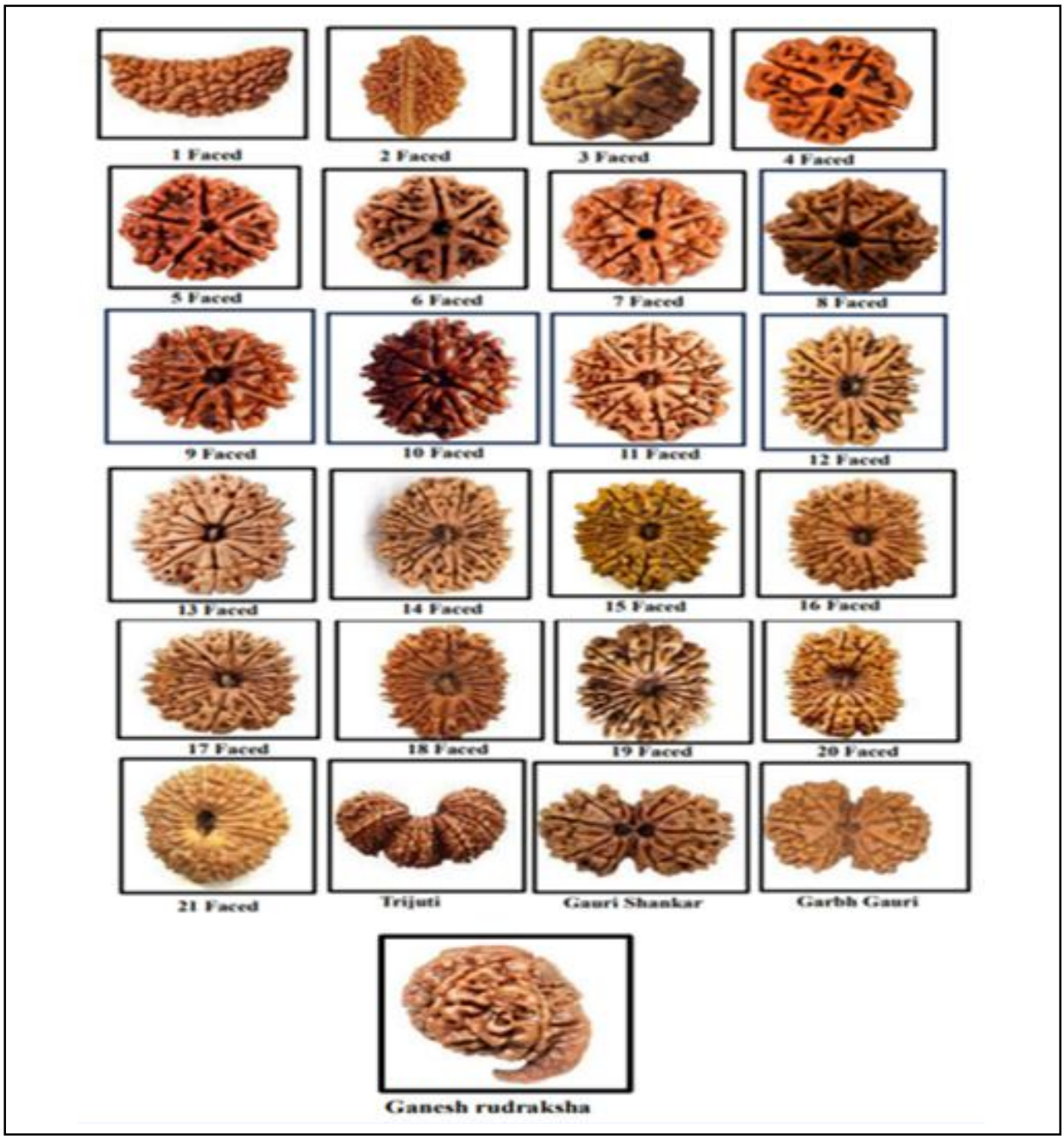


Figure 4: Photographs illustrating different types of rudraksha beads (Sharma *et al.*, 2023; Gholse *et al.*, 2017).

1.4.2 Scientific method for testing *E. angustifolius* seeds

To address the rising demand for rudraksha beads, manufacturers are now producing uncommon varieties like the single-faced rudraksha (Ek mukhi rudraksha). Rudraksha beads are also crafted using materials such as bhadraksha, areca nut, nutmeg, or tulsi. This has led to significant confusion regarding authentic rudraksha. Unfortunately, the market has seen instances of fraudulent practices, with fake rudraksha being sold. As a result, some buyers lack confidence in the current rudraksha market (Kumar *et al*., 2021; Swami *et al.,* 2010).

Table 2: Various tests conducted on *E. angustifolius* seeds along with a brief description of each test method

Tests	Description
Cut test	Despite its reliability, the seed spoils permanently when used in this test. If a seed is incised in a straight line, it will be segmented into a similar number of sections and lines present.
Properties test	The test aims to evaluate if the seeds display properties akin to inductance, capacitance, electromagnetic resonance, and electric conduction.
Eye test	Even though fake or artificial *E. angustifolius* facets appear identical to the real ones, they cannot be made as real as those found on real *E. angustifolius* facets. On the bead, there is a partition, like in the Natural Grove. Using a magnifying glass (Lens), one can closely examine these deep linings (facets) and easily distinguish real *E. angustifolius* seeds.
Copper coin test	The *E. angustifolius* bead, when placed between two copper coins, is generally believed to rotate clockwise or anticlockwise. *E. angustifolius* beads exhibit this phenomenon due to their physical and magnetic characteristics.
Water test.	Scarce and precious *E. angustifolius* beads, like Gauri shankar rudraksha and trijuti rudraksha, are synthetically produced by joining two or more beads using adhesive. When a synthetic artificial *E. angustifolius* bead is kept in boiling water for some time, it will emerge with a razor-sharp band at its joint.
X-ray	By using this technique, it is possible to examine the inner structure of the seeds without endangering them. Up to nine Mukhi, X-ray testing on the bead was straightforward, but after the number reaches ten Mukhi or higher, the internal seeds line may overlap, making the results less accurate.
CT imaging	*E. angustifolius* can also be identified via CT scanning, but this procedure is more expensive than X-ray. Compared to an X-ray, it produces significantly more precise results.

1.5 Medical and scientific significance of *E. angustifolius*

E. angustifolius beads possess both medicinal and spiritual healing properties, attributed to their electromagnetic characteristics. Viewing the entire human body, particularly the nervous system, as a sophisticated bioelectronic circuit, various reflex actions such as heart pumping, generate electric impulses, collectively known as bioelectricity. The optimal functioning of the body's senses relies on the smooth flow of this bioelectric current. In moments of stress or maladjustment, this intricate electronic circuit in the body and mind experiences disruption, causing discomfort and hindering effective work. *E. angustifolius* beads function as a stabilizing anchor due to their inherent electric and magnetic fields. The electrical characteristics of *E. angustifolius* beads can be broadly classified in Table 3.

Table 3: Various properties of *E. angustifolius* beads accompanied by detailed explanations of their characteristics and benefits (Swami *et al.*, 2010)

Tests	Description
Resistance	Each facet (mukhi) of Rudraksha beads possesses a distinct resistance factor measured in ohms. They impede the flow of bioelectric impulses in the body, generating specific currents in amperes. These impulses trigger the production of positive brain chemicals, fostering a sense of positivity. This, in turn, enhances the individual's confidence, self-control, and energy levels.
Dielectric property	Rudraksha beads stabilize bioelectric currents and preserve electrical energy by functioning as dielectrics. This characteristic is helpful in controlling disorders such as hyperactivity and heart palpitations, returning overall activity to a normal level during times of increased physical exertion and stress.
Inductance	Rudraksha beads have enduring magnetic properties, emitting inductive vibrations measured in Henry units (Volt seconds/Ampere). This unique feature allows individuals to experience a sense of well-being.
Magnetic property	Rudraksha beads have dynamic polarity, parabolic properties, and diamagnetic characteristics. By eliminating artery and vein blocks, they improve blood circulation, which results in a sudden rejuvenation, contributing to healing and the alleviation of illness.

2. Bioactive compounds from *E. angustifolius*

The primary bioactive compounds of *E. angustifolius* include alkaloids, phenolic and flavonoid compounds.

2.1 *E. angustifolius* alkaloid

The alkaloids obtained from the leaves and branches of *E. angustifolius* comprise (±)-3-oxoisoelaeocarpine (1) and (±)-elaeocarpine N-oxide, elaeocarpidine, (±)-elaeo-carpine, and (±)-isoelaeocarpine, (-)-isoelaeocarpiline, (±)-8,9-Dehydroelaeocarpine, (±)-9-epielaeocarpine Cis-N-oxide trifluoroacetate, and (±)-elaeocarpine trifluoroacetate. Identification of these structures involved a combination of IR, UV, MS, and NMR techniques, as well as chemical correlation (Zhou *et al.,* 2011; Hong *et al.,* 2019). In *E. angustifolius* seeds, Elaeokanine C, elaeocarpenine, isoelaeocarpiline,

isoelaeocarpicine, elaeocarpidine, isoelaeocarpine grandisine A, B, C, D, E, F, and G, habbemine A and B were detected using liquid chromatography-mass spectrometry (Primiani *et al.,* 2022).

The *E. angustifolius* seeds contain the indolizidine type of alkaloids that have a strong affinity for delta opioid receptors (DORs) which are useful in treating a variety of CNS and DOR-related diseases. Using DOR as a target is proving beneficial for the discovery of new pain therapies or analgesics, antidepressants, antianxiety drugs, and anticonvulsants (Quirion *et al.,* 2020; Primiani *et al.,* 2022). The alkaloids from *E. angustifolius* have potent inhibitory effects on cholinesterase enzyme which plays an important role in nerve transmissions and central nervous system function.

The neurotransmitter acetylcholine is hydrolysed by acetylcholinesterase and butyrylcholinesterase, which are key regulators of cholinergic neurotransmission (Hong *et al.,* 2019). Alzheimer's disease results from disruption of cholinergic transmission, which can be treated with cholinesterase inhibitors.

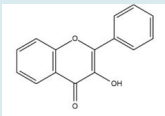
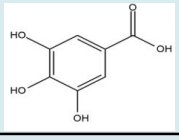
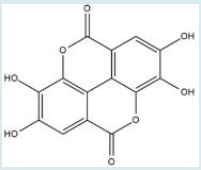
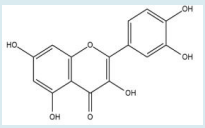
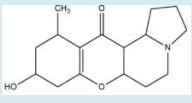
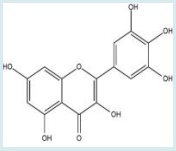
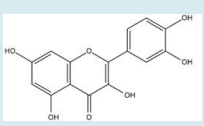
2.2 Phenolic and flavonoid compounds from *E. angustifolius*

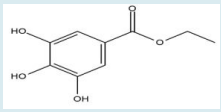
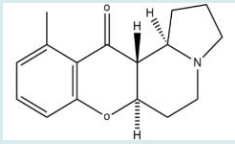
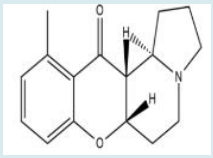
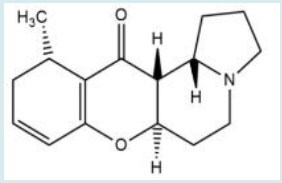
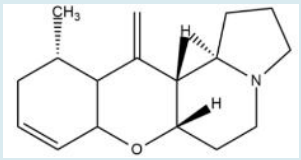
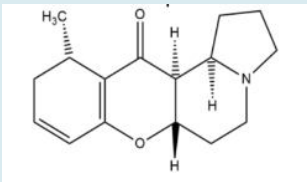
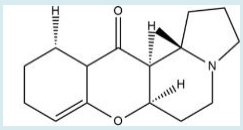
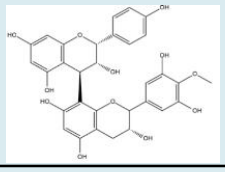
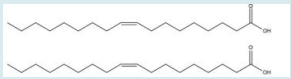
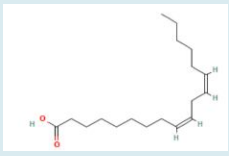
The phenolic and flavonoid compounds identified by LCMS in *E. angustifolius* seeds include gallic acid, ellagic acid, quercetin, rutin, nargenin, kaempferol, rutinoside, luteolin., *etc.* (Primiani *et al.,* 2021). Methanolic leaf extract of *E. angustifolius* contains a high phenolic compound. The extract values for gallic acid and quercetin are the dry weight contains 37.5 milligrams of gallic acid equivalent per gram and 53.3 milligrams of quercetin equivalent per gram (Primiani *et al.,* 2021; Deepika *et al.,* 2018). Phenolic and flavonoid compounds derived from *E. angustifolius* offer numerous pharmacological advantages, including antioxidant, anticandida, antimicrobial, and antianxiety properties (Singh *et al.,* 2013).

2.3 Other bioactive compounds of *E. angustifolius*

The other bioactive compounds determined by LCMS in *E. angustifolius* seeds include terpenoids like Elaeocarpucin A, B, C, D, E, F, G, cucurbitacin D, F, tannin like geraniin, catechin, steroids like alpha-tocopherol, fatty acids like folic, palmitic, stearic and myristic acids (Primiani *et al.,* 2021; Shukla *et al.,*1993).

Table 4: Bioactive compounds of *E. angustifolius* and their pharmacological activities (Tripathy *et al.*, 2023)

Bioactive compounds of *E. angustifolius*	Structure	Pharmacological activities	References
Flavonol		Anti-cancer, cardioprotective, neuroprotective, anti-inflammatory, antioxidant, hepatoprotective.	Sharma *et al.*, 2018
Gallic acid		Allergic inflammation, neuroprotective, antioxidant, rheumatoid arthritis, pelvic inflammation and gastroenteritis, obesity, pneumonia and hepatitis.	Bai *et al.*, 2021
Ellagic acid		Antioxidant, neuroprotective, anti-inflammatory, anticancer, antidiabetic, antihyperlipidemic, hepatoprotective.	Rios *et al.,* 2018
Quercetin		Antioxidant, anti-inflammatory, anticancer, antiviral, antimalarial, antihypertensive, neuroprotective, hepatoprotective and cardioprotective properties.	Mahmud *et al.*, 2023
Rudrakine		Antihypertensive, antidepressant, anti-inflammatory, central analgesic activity, antioxidant, antimicrobial, antimalarial, cytotoxic, anxiolytic, and bronchial asthma.	Garg *et al.*, 2013
Myricetin		Antioxidant, anti-inflammatory, anticancer, antidiabetic, antimalarial, neuroprotective and cardioprotective.	Bordoloi *et al.*, 2017 Ray *et al.*, 1979
Kaempferol		Neuroprotective and antioxidant.	Yuan *et al.*, 2021

Ethyl gallate		Antioxidant, anticancer, UV protective.	Bai *et al*., 2021
Elaeocarpine		Conditions affecting the mind, seizures, headaches, allergic reactions, neurological disorders, diabetes, asthma, cancer and various other circulatory issues.	Singh *et al*., 2015
Isoelaeocarpine		Convulsions, anticancer, antidiabetic, asthma and anti-inflammatory.	Hong *et al*., 2019
Alloelaeocarpiline		Antidepressant, anti-inflammatory, central analgesic activity, antioxidant, ant-imicrobial, cytotoxic, anxiolytic and bronchial asthma.	Hong *et al*., 2019
Epielaeocarpiline		Antioxidants fight against microbes, antimalarial, cytotoxic, anxiolytic, and bronchial asthma.	Katavic *et al*., 2006
Epialloelaeocarpiline		Cytotoxic, anxiolytic, anti-hypertensive, antidepressant, anti-inflammatory, anti-cancer, antioxidant, antimicrobial and antimalarial.	Katavic *et al*., 2006
Isoelaeocarpiline		Antihypertensive, antidepressant, anti-inflammatory, central analgesic activity, antioxidant, antimicrobial, antimalarial, cytotoxic, anxiolytic and bronchial asthma.	Katavic *et al*., 2007
Proanthocyanidins		Antioxidant, anti-inflammatory, and anticancer suppress the activity of α-glucosidase and α-amylase.	Rue *et al*., 2018
Oleic acid		Antihypertensive lowers cholesterol, antidiabetic, memory enhancer, ulcerative colitis, emollient and anticancer.	Mirgorodskaya *et al*., 2023
Palmitic acid		Food additives, emollients, surfactants and cosmetics.	Carta *et al*., 2017
Linoleic acid		Possessing protective effects on the cardiovascular system, anticancer properties, neuroprotective qualities, prevention of osteoporosis, anti-inflammatory actions and antioxidative benefits.	Kim *et al*., 2014

3. The significance of rudraksha in Ayurveda

Rudraksha has been utilized widely in Ayurvedic medicine and is extensively documented in herbal preparation literature for its preventive and therapeutic attributes. People who live in areas where *E. angustifolius* trees grow use bark, leaves, and the outer shell of the beads to treat a variety of illnesses, such as headaches, fevers, skin diseases, mental disorders, and wound healing. In the Indian Materia Medica, rudraksha is listed as a medicinal substance that helps balance the vata, pitta, and kapha doshas without the need for allopathic drugs and their possible adverse effects. Rudraksha, with its subtle electromagnetic properties influencing the mind, has been found to contribute to the cure of various diseases. The University of Mumbai's research has demonstrated the benefits of rudraksha for conditions related to the nervous system, memory, and cardiovascular disorders.

The acidic properties of rudraksha help to balance the vata and kapha energies, which helps to relieve headaches and mental ailments. Testimonials from locals living in places rich in rudraksha attest to its effectiveness in controlling blood pressure and mental illnesses. Ancient epics confirm rudraksha's efficacy in addressing various illnesses (Ashraf *et al*., 2019).

3.1 Uses of rudraksha in Ayurveda

i. **Strengthening body constitutions:** Rudraksha is believed to strengthen the body constitution when worn on various body parts.

ii. **Blood purification:** It is suggested that rudraksha can be used to treat blood impurities and enhance overall blood quality.

iii. **Antibacterial properties:** Rudraksha is said to have antibacterial properties and can be used for treating burns, marks, coughs, and breathing problems.

iv. **Control of epilepsy:** The soft tissue of rudraksha ripened fruit, bark, or bead is used to make a powder for controlling epilepsy.

v. **Blood pressure and heart diseases:** Rudraksha is recommended for treating hypertension and CVS diseases.

vi. **Skincare use:** Rudraksha can enhance the skin's radiance and contribute to a charming facial appearance.

vii. **Tongue cracks and loss of taste:** Using a decoction of rudraksha for gargling is considered effective in alleviating sensations of heaviness, tongue cracks, and tastelessness.

viii. **Improving memory power:** Rudraksha, when taken with milk, is thought to help improve memory power.

ix. **Fertility:** A combination of rudraksha and sarpakshi is suggested to aid in conception when taken during the menstrual period.

x. **Brain diseases:** Rudraksha is believed to be useful in treating various brain diseases, including brain fever.

xi. **Burns and pox marks:** The five-faced rudraksha is mentioned for treating burn or pox marks on the face.

xii. **Liver problems, jaundice, and stomach ache:** Rudraksha is recommended for treating stomach pain, liver problems, jaundice, and related issues.

xiii. **Piles:** The text suggests rudraksha for treating piles.

xiv. **Insect bites/poisonous effects:** Rudraksha paste, when applied with lemon juice, is suggested for treating poisonous effects caused by insect bites (Jain *et al*., 2014).

The information provided above is based on traditional beliefs about the benefits of rudraksha, and it is crucial to approach such remedies with caution and consult with healthcare professionals for modern medical advice (Jain *et al*., 2014).

4. Pharmacological benefits of *E. angustifolius*

E. angustifolius has shown a wide range of pharmacological effects and has been found effective against specific biological targets after extensive screening of various plant extracts.

Table 5: Scientific research/pharmacological activities reported for *E. angustifolius*

Pharmacological activity	Plant parts	Extracts	Model/organism /cell lines	Outcomes	References
Antioxidant activity	Leaves	Methanolic	Total flavonoid content $AlCl_3$ colourimetric method, total phenolic content folin-ciocalteau method and antioxidant capacity DPPH method.	The study findings showed total phenolic content (TPC) and total flavonoid content (TFC) in the extract, measuring 37.5 mg gallic acid equivalents/g of dry weight and 53.3 mg quercetin equivalents/g of dry weight respectively, the DPPH assay revealed significant high percentage inhibition, indicating robust antioxidant activity, with an IC_{50} value of 477.125 µg/ml.	Deepika *et al*., 2018
	Leaves	Methanolic and ethyl acetate fraction	Membrane-stabilizing activity hypotonic solution induced haemolysis and antioxidant activity DPPH method.	The findings of the study indicated that the fractions from the extract exhibited the highest membrane-stabilizing activity (66.65 ± 3.22% and 90.28 ± 1.03%) and antioxidant activity (90.28 ± 1.03 and 89.25 ± 0.88) respectively.	Kumar *et al*., 2017

	Leaves	Ethanolic	Total antioxidant capacity, hydroxyl radical scavenging, metal chelating, reducing power, ABTS radical scavenging activities.	At a concentration of 500 µg/ml, the extract demonstrated maximum iron chelating activity (76.70%), ABTS radical scavenging activity (55.77%), and minimal hydroxyl radical scavenging activity (13.43%). Furthermore, the total antioxidant capacity at this concentration was identified as 24.18 mg ascorbic acid equivalents. These results underscore the significant antioxidant capability derived from the phenolic and flavonoid compounds found in the leaves.	Kumar *et al*., 2008
Antioxidants and antimicrobial activities	Leaves	Methanolic	DPPH scavenging assay, the antibiotic susceptibility test and well diffusion assay.	The extract exhibited an antioxidant activity of 98.01 g/ml. It demons trated inhibitory effects on both gram-positive and gram-negative bacteria, signifying its anti-bacterial properties.	Koirala *et al*., 2021
Wound healing property	Leaves	Ethanolic	Excision wounds in rat model (16 days).	The findings indicated that an ointment containing the ethanolic leaf extract exhibits wound-healing capabilities and significantly diminishes wound diameter.	Dogiparthi, *et al*., 2022
Analgesic and anti-inflammatory	Leaves	Methanolic and aqueous extract	Induction of inflammation in the paw using carrageenan in rats and evaluation of the tail-flick response in mice.	The findings demonstrated noteworthy analgesic and anti-inflammatory activity for both extracts at doses of 100 mg/kg b. wt and 200 mg/kg b. wt, amounting to 46.21% and 41.66%, respectively.	Nain, *et al*., 2012
Hepatoprotective activity	Leaves	Aqueous extract of mixed fatty acid	CCl_4 induced hepatotoxicity in rats.	The results indicated a significant restoration by the extracts in the increased serum enzymatic levels of SGPT, SGOT, ALP, SOD, total bilirubin, and catalase. This suggests the hepatoprotective effect of the extracts.	Anusha, *et al*., 2014
Antimicrobial and antiproliferative/ anticancer properties	Leaves	Aqueous and methanolic silver nano conjugate	Antibacterial activity diffusion assay and biofilm assay, antifungal activity disc diffusion assay, antiproliferative activity yeast (*saccharomyces cerevisiae*) model and anticancer activity MTT assay.	The silver nanoconjugates demonstrated notable antibacterial effectiveness against pneumonia, *Pseudomonas, Staphylococcus aureus, Escherichia coli, Klebsiella aeroginosa,* and *Bacillus cereus*. Additionally, they exhibited antifungal activity against *Penicillium notatum, Aspergillus niger, Aspergillus flavus,* and *Trichothecium roseum*. In antiproliferative studies, nanoconjugates affect cell division and viability in rapidly proliferating yeast cells at concentrations as low as 0.50 mg/mL. According to the MTT assay findings, it is probable that these nanoconjugates have anticancer properties, with an IC_{50} value of 361.49 µg against the MCF-7 breast cancer cell line, comparable to the camptothecin (positive control).	Mahajanakatti *et al*., 2022

Analgesic activity	Leaves	Ethanolic and methanolic	Acetic acid induced writhing	The results revealed that both extracts, at a dose of 400 mg/kg body weight, exhibited the highest percentage of analgesic potency, comparable to the mefenamic acid dose at 500 mg/kg body weight.	Kiromah, *et al*., 2021
	Fruits	Petroleum ether, benzene, chloroform, acetone and ethanol	Hotwire tail flick response technique.	The results revealed that all the extracts of *Elaeocarpus sphaericus* showed significant analgesic activity at a dose of 200mg/kg.	Singh *et al*., 2000
Antibacterial activity	Fruits		Antibacterial activity disc diffusion and plate dilution methods.	The study findings indicated robust antibacterial effectiveness of the acetone extract fraction against 10 species. The ethanolic extract demonstrated activity against *Plesiomonas shigelloides, Shigella flexneri*i, and *Sh. Sonneii*, while the benzene extract exhibited activity against *Salmonella typhimurium* and *Morganella morganii*.	Singh *et al*., 1999
Anti-fungal activity	Dried fruits	Chloroform and ethanolic	*In vitro* antifungal activity the disk diffusion assay and broth dilution test.	Based on the results of the study, chloroform and ethanolic extracts showed maximum antifungal activity against *Candida albican* and moderate inhibition against *Aspergillus niger*.	Singh *et al*., 2010
Anti-asthmatic activity	Fruits	Petroleum ether, benzene, chloroform, acetone and ethanol	*In vitro* rat mesenteric mast cell.	All extracts exhibited notable mast-cell stabilizing activity within a lower dose range, providing evidence for the efficacy of *Elaeocarpus ganitrus* in addressing bronchial asthma.	Singh *et al*., 2000
	Fruits		Bronchospasm induced by acetylcholine and histamine aerosols.	The extracts (200 mg/kg, i.p.) significantly reduced bronchospasm induced by histamine and acetylcholine aerosol in guinea pigs.	Singh *et al*., 2000
Antiulcerogenic activity	Fruits		Aspirin induced ulcer.	Study results showed significant ulcer index reductions for all extracts (200 mg/kg, p.o.).	Singh *et al*., 2000
Immunomodulatory and nephroprotective activity	Seeds	Ethanolic	Gentamicin induced nephrotoxicity.	The findings demonstrated the immunomodulatory and nephroprotective effects of the ethanolic extract derived from *Elaeocarpus ganitrus* seeds.	Kakaji *et al*., 2014
Antiparkinsonian activity	Dried fruits	Ethanolic	Haloperidol induced parkinson's disease rota rod and catalepsy bar tests.	At doses of 200 and 400 mg/kg, p.o., the extract notably prolonged retention time in the rota rod test and reduced the latency period in the catalepsy bar test.	Bagewadi H.G. *et al*., 2015
	Dried fruits	Ethanolic	MPTP induced motor and non motor impairments.	As per the findings, administering the extract at doses of 200 and 400 mg/kg, p.o., increased hanging time during the hanging wire test. Additionally, it led to an increase in the number of entries and time spent in the open arm, a decrease in the number of entries and time spent in the closed arm of the elevated plus maze (EPM), and a	

				reduction in the number of vacuous chewing movements (VCMs) compared to the MPTP treated group.	
Anxiolytic effects	Fruits	Methanolic	Elevated plus maze.	In the study, the administration of the extract at a dose of 200 mg/kg led to an increase in the percentage of time spent in the open arms and a decrease in the percentage of time spent in the closed arms of the elevated plus maze.	Shah *et al*., 2010
Antihypertensive effect	Seeds	Aqueous	Renal artery occluded hypertensive rats.	In this study, extracts were administered at doses of 25, 50, and 100 mg /kg, i.v. significantly reduced elevated blood pressure in animals. This suggests that the extract has antihypertensive activity through its action on renin-angiotensin.	Sakat *et al*., 2009
Antiatherosclerotic activity	Seeds	Ethanolic	Diet induced hyperlipidaemic rabbits.	In rabbits fed with cholesterol, the extract demonstrated a dose dependent correction of the altered lipid profile at doses of 250 mg/kg and 500 mg/kg.	Jain *et al*., 2017
***In vitro* and *in vivo* immunomodulatory effects**	Seeds	Methanolic	*In vitro* isolated murine peritoneal macrophages and *In vivo* phagocytic activity by carbon clearance assay.	The analysis of the extract indicated a noteworthy elevation in the release of nitric oxide (at concentrations of 416, 104, and 52 µg/ml), superoxide (at concentrations of 416, and 208 µg/ml), and lysosomal enzymes (at concentrations of 208, 104 µg/ml). *In vivo* studies, 100 and 200 mg/kg doses exhibited a significant increase in the phagocytic index.	Hule *et al*., 2010
***In vitro* thrombolytic activity**	Bark	Aqueous, methanolic, and chloroform	Clot lysis method.	The findings revealed that the aqueous, methanolic, and chloroform extracts demonstrated clot lysis percentages of 59.1%, 48.2%, and 62.1%, respectively. These values were statistically significant in comparison to the positive control, streptokinase, which exhibited a clot lysis percentage of 71.7%.	Marisetti *et al*., 2016

5. Conclusion

The current review provides a comprehensive overview of the primary bioactive compounds found in *Elaeocarpus*, with a particular emphasis on alkaloids, phenolic compounds, and flavonoids. Findings from these studies indicate that *E. angustifolius* exhibits significant pharmacological activities, including antioxidant, antimicrobial, analgesic, anti-inflammatory, anxiolytic, immunomodulatory, nephroprotective, hepatoprotective, antiatherosclerotic, wound healing, antiproliferative, antiulcerogenic, antiasthmatic and antiparkinsonian activities. The main areas of pharmacological impact identified include delta-opioid receptor (DOR)-related diseases. Future research in Elaeocarpus is recommended to be collaborative and focused on standardized extractions tailored to specific therapeutic purposes.

Overall, this review highlights the potential of *E. angustifolius*, as a valuable source of bioactive compounds with diverse pharmacological activities. Further exploration and understanding of its therapeutic potential can pave the way for the development of novel treatments for various health conditions.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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