

Ethnobotanical, Phytochemical and Pharmacological Importance of Selected Members of Euphorbiaceae: A Review

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ABSTRACT

The family Euphorbiaceae is recognized as one of the most diverse groups of flowering plants and includes many species of medicinal, ecological, and economic importance. Plants belonging to this family are mainly distributed in tropical and subtropical regions, where they have long been used in traditional healthcare systems for managing respiratory disorders, digestive problems, liver diseases, skin infections, inflammatory conditions, and microbial illnesses. This review examines five representative species: *Euphorbia hirta*, *Ricinus communis*, *Acalypha indica*, *Croton bonplandianus*, and *Phyllanthus amarus*. These species were selected because of their ethnomedicinal value, rich phytochemical composition, therapeutic promise, and environmental adaptability. Published literature was carefully evaluated to summarize their taxonomy, morphology, traditional applications, chemical constituents, biological activities, and future research opportunities. Major compounds reported from these plants include flavonoids, alkaloids, tannins, lignans, terpenoids, fatty acids, and phenolic substances, many of which are linked with antioxidant, antimicrobial, anti-inflammatory, hepatoprotective, antidiabetic, wound-healing, bronchodilatory, and antiviral properties. Among the selected plants, *Phyllanthus amarus* shows notable promise for liver protection, whereas *Ricinus communis* remains highly significant for pharmaceutical and industrial uses. *Euphorbia hirta* and *Acalypha indica* continue to be valued as traditional medicinal herbs, while *Croton bonplandianus* has gained attention for its emerging pharmacological and ecological roles. Although these plants are widely used in folk medicine, several still require better standardization, toxicity assessment, and clinical validation. The review emphasizes the need to combine traditional botanical knowledge with modern phytochemical and pharmacological approaches for the development of evidence-based herbal medicines and sustainable biological resources. Further scientific investigation of these Euphorbiaceae species may support future drug discovery and strengthen plant-based healthcare systems.

Keywords: Euphorbiaceae, medicinal plants, phytochemistry, pharmacology, ethnobotany, herbal medicine, biodiversity.

1. INTRODUCTION

Medicinal plants continue to play a central role in healthcare systems worldwide. In many developing countries, a substantial proportion of the population still relies on herbal medicines for primary healthcare and day-to-day treatment of common illnesses. The World Health Organization has repeatedly acknowledged the importance of traditional medicine in improving healthcare accessibility, affordability, and cultural acceptability (WHO, 2013; WHO, 2019). Moreover, numerous modern drugs have originated directly or indirectly from plant-derived bioactive compounds, highlighting the continuing pharmaceutical significance of botanical resources. Well-known examples include aspirin, quinine, artemisinin, vincristine, and paclitaxel, all of which demonstrate the medicinal relevance of higher plants in drug discovery (Newman & Cragg, 2020; Wink, 2015).

Among angiosperm families, Euphorbiaceae is particularly significant because of its remarkable species diversity, broad ecological adaptability, and chemically rich members. The family comprises nearly 300 genera and more than 7,000 species distributed predominantly in tropical and subtropical regions, although some species extend into temperate habitats (Webster, 1994; APG IV, 2016). Members of the family include annual herbs, perennial shrubs, succulents, climbers, and latex-bearing trees. Several economically important crops and ornamental plants belong to this family, including cassava (*Manihot esculenta*), rubber tree (*Hevea brasiliensis*), castor (*Ricinus communis*), jatropha (*Jatropha curcas*), and poinsettia (*Euphorbia pulcherrima*) (Ross, 2003; Esser, 2012).

The medicinal value of Euphorbiaceae has been recognized since ancient times and is well documented in traditional healing systems across Asia, Africa, and Latin America. Various species are employed in Ayurveda, Siddha, Unani, African folk medicine, Traditional Chinese Medicine, and indigenous ethnomedical practices.

Traditionally, these plants have been used in the management of asthma, cough, diarrhea, dysentery, fever, jaundice, skin diseases, helminthic infections, urinary disorders, wounds, and inflammatory conditions (Khare, 2007; De Padua et al., 1999; Jain, 1991). Latex-bearing species are also frequently used externally for warts, cuts, ringworm, and musculoskeletal pain in many rural communities (Schmelzer & Gurib-Fakim, 2008).

Recent scientific investigations have validated several traditional claims through phytochemical screening, in vitro assays, animal models, and preliminary clinical observations. Many Euphorbiaceae members have shown antioxidant, antimicrobial, anti-inflammatory, antidiabetic, hepatoprotective, analgesic, anticancer, antiviral, and wound-healing properties (Amtaghri et al., 2022; Goyal et al., 2024; Kumar et al., 2010; Salehi et al., 2019). These activities are largely attributed to the presence of diverse secondary metabolites such as flavonoids, diterpenes, triterpenes, tannins, lignans, alkaloids, coumarins, fatty acids, and polyphenolic compounds (Wink, 2015; Seigler, 1994). However, despite promising pharmacological potential, many useful species remain underexplored because they are often considered weeds, roadside flora, or non-commercial plants.

The present review focuses on five selected members of Euphorbiaceae: *Euphorbia hirta*, *Ricinus communis*, *Acalypha indica*, *Croton bonplandianus*, and *Phyllanthus amarus*. These species were chosen because they collectively represent medicinal herbs, industrially relevant taxa, invasive or resilient wild species, and plants with strong ethnopharmacological importance. Existing literature was critically assessed to summarize their taxonomy, morphology, traditional uses, phytochemical composition, pharmacological properties, toxicological concerns, and future applications in evidence-based herbal medicine (Patel et al., 2011; Cavalcante et al., 2020; Kirtikar & Basu, 2006).

Available evidence indicates that these plants contain numerous biologically active compounds associated with broad therapeutic actions. Reported constituents include quercetin, rutin, gallic acid, ellagic acid, phyllanthin, hypophyllanthin, ricinoleic acid, terpenoids, sterols, and condensed tannins. These metabolites are linked with antimicrobial, antioxidant, anti-inflammatory, hepatoprotective, bronchodilatory, antidiabetic, antiviral, gastroprotective, and wound-healing effects (Kumar et al., 2010; Wink, 2015; Newman & Cragg, 2020). Some species have also demonstrated immunomodulatory and cytotoxic potential, suggesting relevance in future cancer and chronic disease research (Atanasov et al., 2021).

Therefore, the selected members of Euphorbiaceae continue to offer valuable opportunities for future phytopharmaceutical development, nutraceutical innovation, biodiversity-based livelihoods, and sustainable plant-based healthcare systems. Further multidisciplinary research involving phytochemistry, molecular pharmacology, toxicity profiling, cultivation practices, and controlled clinical trials is necessary to transform traditional knowledge into safe and standardized therapeutic products (WHO, 2019; Atanasov et al., 2021).

2. METHODOLOGY OF LITERATURE COLLECTION AND REVIEW STRATEGY

The present review was prepared through a systematic survey of available scientific and ethnobotanical literature concerning selected medicinal members of the Euphorbiaceae family. Information was collected from major academic databases including PubMed, Scopus, Web of Science, Google Scholar, ScienceDirect, SpringerLink, and Wiley Online Library. Additional information was obtained from classical medicinal plant books, floras, WHO reports, pharmacopoeias, and government publications.

The literature search covered publications using combinations of keywords such as *Euphorbiaceae medicinal plants*, *Euphorbia hirta pharmacology*, *Ricinus communis uses*, *Acalypha indica phytochemistry*, *Croton bonplandianus antioxidant*, *Phyllanthus amarus hepatoprotective*, *traditional medicine Euphorbiaceae*, and *plant secondary metabolites*.

Only peer-reviewed articles, review papers, ethnomedicinal reports, taxonomic references, and experimentally validated pharmacological studies were prioritized. Duplicate studies, non-scientific web sources, and unsupported anecdotal claims were excluded wherever possible.

The selected five species—*Euphorbia hirta*, *Ricinus communis*, *Acalypha indica*, *Croton bonplandianus*, and *Phyllanthus amarus*—were chosen based on the following criteria:

1. Traditional medicinal importance
2. Availability of phytochemical or pharmacological evidence
3. Ecological or economic relevance

4. Representation of herbs, shrubs, and utility plants within Euphorbiaceae
5. Future potential for phytopharmaceutical development

Collected information was critically organised under taxonomy, morphology, ethnomedicinal uses, phytochemistry, pharmacological activities, toxicity concerns, and prospects.

(Patel et al., 2011; Cavalcante et al., 2020).

3. REVIEW OF SELECTED SPECIES

3.1 *Euphorbia hirta*

Euphorbia hirta L. is one of the most widely recognized medicinal herbs of the family Euphorbiaceae and has long been valued in traditional systems of medicine throughout Asia, Africa, and tropical America. The species is commonly distributed in open grasslands, roadsides, cultivated lands, waste places, garden edges, and other disturbed habitats where soil moisture and sunlight are adequate. Because of its rapid growth and prolific seed production, it is often regarded as a ruderal weed; however, ethnobotanical evidence shows that this ordinary herb possesses considerable medicinal importance (Kumar et al., 2010; Webster, 1994). In India, the plant is popularly known as Dudhi, Dudhika, or Asthma weed, while in many English-speaking countries it is referred to as snakeweed or garden spurge (Khare, 2007; Kirtikar & Basu, 2006).

Taxonomically, *Euphorbia hirta* belongs to Kingdom Plantae, Order Malpighiales, Family Euphorbiaceae, Genus *Euphorbia*, and Species *hirta*. It is an annual herb usually reaching 15–60 cm in height, though growth may vary depending on soil fertility and climatic conditions (Webster, 1994; Esser, 2012). The stem is slender, cylindrical, often reddish or purplish, and covered with fine yellowish hairs. Branches spread close to the ground or become ascending in crowded habitats. Leaves are opposite, oblong to elliptic, asymmetrical at the base, serrated along the margins, and frequently marked with a dark purple spot in the center. Like many members of Euphorbiaceae, the plant exudes milky white latex when injured. The flowers are minute and arranged in compact cyathia at leaf axils. Fruits are small trilobed capsules containing tiny brown seeds that disperse easily, aiding colonization of disturbed soils (Ross, 2003; Patel et al., 2011).

The ecological adaptability of *E. hirta* contributes to its broad geographical distribution. It thrives in tropical and subtropical climates and is naturalized across India, Sri Lanka, Bangladesh, Southeast Asia, Africa, South America, and parts of Australia (De Padua et al., 1999). The species prefers sandy loam or well-drained soils but can tolerate nutrient-poor urban habitats. Its ability to survive seasonal drought, trampling, and repeated disturbance makes it common in human-modified environments. Although often removed as a weed, this resilience has also made it a readily available medicinal resource for rural communities with limited access to formal healthcare (Jain, 1991; Schmelzer & Gurib-Fakim, 2008).

The most famous traditional use of *Euphorbia hirta* is in respiratory disorders, which explains the common name “asthma weed.” In Ayurveda, Siddha, and folk medicine, aerial parts of the plant are prepared as decoction, infusion, or juice to relieve bronchial asthma, wheezing, persistent cough, hay fever, and upper respiratory congestion. Traditional healers frequently recommend warm leaf decoctions with honey for chronic cough and catarrh. In some African medicinal systems, the plant is smoked or inhaled in controlled forms to ease bronchospasm (Khare, 2007; Kumar et al., 2010; Schmelzer & Gurib-Fakim, 2008). Experimental findings suggest that this traditional use may be linked to smooth muscle relaxant and bronchodilatory effects of certain phytochemicals present in the herb (Attah et al., 2013; Salehi et al., 2019).

Phytochemical studies indicate that *Euphorbia hirta* contains a diverse range of secondary metabolites. Reported constituents include flavonoids such as quercetin, quercitrin, rutin, kaempferol, and myricitrin; tannins; triterpenoids; phytosterols including β -sitosterol; polyphenols; alkanes; and small quantities of essential oils (Kumar et al., 2010; Wink, 2015). Gallic acid, caffeic acid, and chlorogenic acid have also been reported in extracts. These compounds are well known for antioxidant, membrane-protective, anti-inflammatory, and antimicrobial actions. Latex fractions may contain diterpenoid constituents typical of several *Euphorbia* species, though their concentrations vary geographically (Seigler, 1994; Esser, 2012).

Antioxidant activity is among the most consistently reported biological properties of *E. hirta*. Methanolic and aqueous extracts have shown free radical scavenging ability in DPPH, FRAP, and nitric oxide inhibition assays. These effects are generally attributed to flavonoids and phenolic acids capable of neutralizing reactive oxygen species and reducing oxidative stress. Since oxidative damage is linked with inflammation, diabetes,

cardiovascular disorders, and aging, such antioxidant potential supports wider therapeutic interest in the plant (Salehi et al., 2019; Goyal et al., 2024).

Anti-inflammatory activity has also been demonstrated in several preclinical models. Extracts of *E. hirta* have reduced edema, inflammatory mediator release, and pain responses in laboratory studies. Proposed mechanisms include inhibition of cyclooxygenase pathways, modulation of cytokines, and stabilization of cellular membranes. These findings correlate with the traditional use of the herb in painful swellings, wounds, hemorrhoids, and inflammatory skin conditions (Attah et al., 2013; Atanasov et al., 2021).

Antimicrobial potential of the plant has been examined against both bacterial and fungal pathogens. Extracts have shown inhibitory activity against *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, and certain dermatophytic fungi under laboratory conditions. Though activity varies with extraction solvent and concentration, these observations lend support to ethnomedical uses in infected wounds, diarrhea, and fungal skin diseases (Kumar et al., 2010; Goyal et al., 2024). Some studies also report mild antiviral potential, although further validation is needed.

From a pharmaceutical perspective, *Euphorbia hirta* offers significant future potential. Standardized extracts rich in flavonoids could be explored for respiratory wellness products, topical antimicrobial formulations, antioxidant nutraceuticals, or adjunct therapies for inflammatory disorders. Sustainable harvesting is feasible because the species grows rapidly and abundantly. Nevertheless, future development requires botanical authentication, toxicity profiling, dosage standardization, and controlled clinical studies to validate efficacy and safety (Atanasov et al., 2021; Newman & Cragg, 2020).

In summary, *Euphorbia hirta* is far more than a common roadside weed. It is a pharmacologically promising herb with longstanding traditional use in asthma, cough, diarrhea, skin infections, and wound care. Its rich content of flavonoids, tannins, sterols, and phenolic compounds supports antioxidant, antimicrobial, anti-inflammatory, and bronchodilatory activities. Continued scientific evaluation may transform this easily available medicinal plant into a valuable component of future evidence-based phytotherapy (Kumar et al., 2010; Khare, 2007; Wink, 2015).

3.2 *Ricinus communis*

Ricinus communis L., commonly known as castor plant or castor bean, is one of the most economically important members of the family Euphorbiaceae. Unlike many medicinal herbs in the family, this species has achieved global significance because of its industrial oil, pharmaceutical applications, and wide ecological adaptability. The plant is cultivated in tropical, subtropical, and warm temperate regions, while it also grows as a naturalized shrub in wastelands, roadsides, abandoned fields, and riverbanks. Although often associated with agriculture and industry, *R. communis* also has a long history of medicinal use in traditional healing systems of Asia, Africa, and the Mediterranean region (Duke, 2002; Ross, 2003).

Taxonomically, *Ricinus communis* belongs to Kingdom Plantae, Order Malpighiales, Family Euphorbiaceae, Genus *Ricinus*, and Species *communis*. The genus *Ricinus* is monotypic, meaning it contains only this single species, though many cultivated varieties exist based on seed size, oil yield, pigmentation, and growth habit (Webster, 1994; Esser, 2012). The species is believed to have originated in northeastern Africa or the Indian subcontinent and was domesticated thousands of years ago. Archaeological evidence indicates that castor seeds were used in ancient Egypt for lamp fuel and medicinal purposes (Duke, 2002; Prakash & Gupta, 2005).

Morphologically, *Ricinus communis* is a fast-growing perennial shrub or small tree that may reach 2–5 m under cultivation and even taller in favorable climates. In tropical areas it may survive for several years, while in cooler climates it is often grown as an annual. The stem is hollow, glabrous, and green, reddish, or purplish depending on cultivar. Leaves are large, alternate, glossy, and palmately lobed with 5–11 pointed segments, giving the plant an ornamental appearance. The petioles are long and sturdy, and foliage may vary from bright green to bronze-red. Flowers are monoecious, borne in terminal inflorescences, with female flowers usually above male flowers. Fruits are globose, trilocular, and often covered with soft spines. Each capsule contains three smooth, mottled, oil-rich seeds known as castor beans (Ross, 2003; Kirtikar & Basu, 2006).

The species is cultivated extensively in India, Brazil, China, Ethiopia, and several African countries for commercial seed production. India remains one of the leading producers and exporters of castor oil in the world. The crop performs well in semi-arid climates and can tolerate drought better than many oilseed plants because of its deep root system. It grows in a wide range of soils but yields best in well-drained loamy soils with moderate fertility (Prakash & Gupta, 2005; FAO, 2020). Its adaptability has made it important for marginal lands and dryland agriculture.

The extraordinary economic importance of *Ricinus communis* is primarily due to castor oil extracted from seeds. Castor oil is unique among vegetable oils because it contains a very high proportion of ricinoleic acid, a hydroxylated fatty acid rarely found in significant quantities elsewhere. This unusual chemistry gives the oil high viscosity, lubricity, and stability under extreme temperatures, making it valuable for industrial applications (Prakash & Gupta, 2005; Ogunniyi, 2006). Castor oil is widely used in lubricants, hydraulic fluids, brake fluids, paints, coatings, plastics, nylon production, surfactants, biodiesel, printing inks, cosmetics, and specialty chemicals. It is also employed in textile finishing and leather processing industries (Mutlu & Meier, 2010).

Scientific investigations have reported antimicrobial activity in extracts of leaves, roots, and seed cake. Experimental studies have shown inhibitory effects against bacteria such as *Staphylococcus aureus*, *Escherichia coli*, and certain fungal pathogens. These findings provide some support for traditional external use in skin infections and wound care, though activity varies depending on extraction method and concentration (Duke, 2002; Goyal et al., 2024).

Anti-inflammatory and analgesic activities of *R. communis* have also been documented in preclinical studies. Leaf extracts and topical oil preparations have demonstrated reduction in edema, pain responses, and inflammatory markers in laboratory models. Ricinoleic acid itself has been investigated for anti-inflammatory actions through modulation of prostaglandin pathways and nociceptive signaling. Such effects may explain folk uses in arthritis, muscular pain, mastitis, and local swelling (Vieira et al., 2000; Atanasov et al., 2021).

Wound-healing potential is another promising area of research. Castor oil has emollient and occlusive properties that help maintain moisture and protect damaged skin. Some studies suggest enhanced epithelialization and improved healing in minor wounds when appropriately formulated topical preparations are used. Traditional medicine frequently combines castor oil with herbal powders or waxes in skin applications (Ross, 2003; Khare, 2007).

Modern pharmaceutical and cosmetic industries continue to utilize castor oil extensively. It serves as a vehicle in ointments, creams, capsules, lipsticks, soaps, shampoos, and emulsions. Hydrogenated castor oil is used in tablets and cosmetics, while polyethylene glycol derivatives of castor oil are employed as solubilizers in drug formulations. Some injectable medicines use modified castor oil derivatives as excipients (Rowe et al., 2009). This versatility has sustained commercial demand for castor products worldwide.

Despite these benefits, toxicology remains critically important. Ricin is among the most potent naturally occurring toxins and acts by inhibiting protein synthesis within cells. Ingestion of raw castor seeds can cause severe vomiting, abdominal pain, diarrhea, dehydration, organ damage, and potentially death depending on dose and age of the individual. Children are particularly vulnerable. Even a small number of chewed seeds may be dangerous. Therefore, raw seeds should never be used medicinally or consumed casually (Prakash & Gupta, 2005; WHO, 2019). Proper industrial processing removes toxic proteins from purified castor oil, making pharmaceutical-grade oil safe when used correctly.

Environmental and agricultural considerations also deserve mention. Castor is valued as a non-edible industrial oilseed crop that does not directly compete with edible oils. It can be grown in dry regions and contributes to rural income generation. Seed cake remaining after oil extraction, once detoxified, has potential as organic manure because of its nitrogen-rich content (Mutlu & Meier, 2010). However, care is necessary due to residual toxins in untreated cake.

Future prospects for *Ricinus communis* include improved cultivars with higher oil yield, reduced toxin content, and enhanced drought tolerance. Ricinoleic acid continues to attract interest for biodegradable plastics, green lubricants, specialty polymers, and sustainable chemistry. In medicine, controlled research on anti-inflammatory and wound-healing applications of castor derivatives may lead to new formulations (Newman & Cragg, 2020).

In conclusion, *Ricinus communis* is a multifunctional plant of exceptional industrial and medicinal value. Its seeds provide castor oil, one of the world's most distinctive plant oils, widely used in pharmaceuticals, cosmetics, lubricants, and specialty chemicals. Traditional uses of leaves, roots, and oil for pain, inflammation, and skin disorders are supported by emerging pharmacological evidence. Nevertheless, the presence of ricin in raw seeds makes unprocessed seed use hazardous. With appropriate processing and scientific validation, *R. communis* remains an important species linking traditional medicine, modern industry, and sustainable bioeconomy (Duke, 2002; Prakash & Gupta, 2005; Ross, 2003).

3.3 *Acalypha indica*

Acalypha indica L. is an important medicinal herb of the family Euphorbiaceae that has been widely used in traditional healing systems across South Asia, Southeast Asia, Africa, and parts of the tropical world. Although it commonly grows as a ruderal weed in waste lands and village surroundings, the species possesses substantial ethnomedicinal value and has long been recognized in indigenous healthcare traditions. The plant is frequently encountered near human settlements, along roadsides, field margins, compost-rich soils, cattle sheds, and moist disturbed habitats where organic matter is abundant. Because of its abundance and easy accessibility, *A. indica* has served as a low-cost herbal remedy for many rural communities (Khare, 2007; Kirtikar & Basu, 2006).

Taxonomically, *Acalypha indica* belongs to Kingdom Plantae, Order Malpighiales, Family Euphorbiaceae, Genus *Acalypha*, and Species *indica*. The genus *Acalypha* includes several hundred species distributed in tropical and subtropical regions, but *A. indica* remains one of the most medicinally significant members. It is believed to be native to tropical Asia, though now naturalized in many warm regions of Africa and the Americas (Webster, 1994; Esser, 2012).

Morphologically, *Acalypha indica* is an erect annual herb usually ranging from 30–75 cm in height, though luxuriant growth may exceed this under favorable conditions. The stem is green, soft, angular, and branched. Leaves are alternate, ovate to rhomboid, long-petioled, and distinctly serrated along the margins. The leaf surface is generally smooth or sparsely hairy with prominent venation. Inflorescences are elongated axillary spikes bearing small green unisexual flowers. Male flowers are usually found toward the upper portions, while female flowers occur below. Fruits are tiny capsules containing minute seeds that disperse readily, enabling rapid colonization of fertile disturbed soils (Khare, 2007; Ross, 2003).

Ecologically, *A. indica* thrives in moist waste places, village compounds, drainage margins, garden soils, and agricultural boundaries. It prefers nitrogen-rich soils with moderate moisture and sunlight. Because it germinates quickly after rainfall and grows vigorously in disturbed environments, it is often classified as a common weed. However, from an ethnobotanical perspective, this abundance is advantageous because it ensures reliable local availability for medicinal use. Many households harvest fresh plants directly from nearby surroundings when needed for cough, skin eruptions, or intestinal complaints (Jain, 1991; Schmelzer & Gurib-Fakim, 2008).

One of the most widely known traditional uses of *Acalypha indica* is in respiratory disorders. In Ayurveda, Siddha, and folk medicine, fresh leaf juice, decoction, or powdered herb is administered as an expectorant in cough, bronchitis, wheezing, pneumonia, and chest congestion. The plant is believed to help liquefy mucus, promote expectoration, and reduce irritation of the respiratory tract. In southern India, leaf preparations mixed with honey are commonly used in persistent cough, especially among children and elderly persons under traditional supervision (Khare, 2007; Singh & Singh, 2016).

Antioxidant activity is one of the most frequently reported biological properties of *A. indica*. Methanolic, ethanolic, and aqueous extracts have shown free radical scavenging effects in DPPH, nitric oxide, and ferric reducing assays. Such activity is generally attributed to flavonoids and polyphenols capable of neutralizing reactive oxygen species. Since oxidative stress contributes to inflammation, aging, and chronic metabolic disorders, this antioxidant profile enhances the medicinal relevance of the species (Salehi et al., 2019; Goyal et al., 2024).

Antimicrobial studies have shown promising effects against several pathogenic microorganisms. Extracts of *Acalypha indica* have demonstrated inhibitory activity against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Candida albicans*, and selected dermatophytic fungi. Although potency varies with extraction solvent and test conditions, these findings support traditional external use in eczema, scabies, wounds, and fungal skin infections (Suresh & Nagarajan, 2009; Goyal et al., 2024).

Anthelmintic activity is particularly noteworthy because of the long-standing folk use of the plant against worms. Experimental studies using model helminths have reported paralysis and death of worms exposed to plant extracts, suggesting biologically active compounds capable of affecting parasite neuromuscular systems or metabolism. These observations validate ethnomedical applications in intestinal worm infestations, though controlled human studies remain limited (Singh & Singh, 2016; Atanasov et al., 2021).

Anti-inflammatory potential has also been reported in preliminary laboratory investigations. Extracts of *A. indica* have reduced edema, inflammatory mediator release, and pain responses in experimental models. Such effects may be linked to flavonoids, saponins, and phenolics that influence prostaglandin pathways and cytokine activity. This correlates with traditional uses in inflammatory skin diseases, painful swellings, and irritated respiratory conditions (Suresh & Nagarajan, 2009; Wink, 2015).

Some studies have suggested additional pharmacological actions including hepatoprotective, antidiabetic, and cytoprotective potential, though evidence remains preliminary. These areas warrant more rigorous phytochemical

isolation studies, mechanistic evaluation, and clinical validation before therapeutic claims can be confirmed (Amtaghri et al., 2022; Newman & Cragg, 2020).

Future pharmaceutical prospects include development of herbal expectorant syrups, topical antimicrobial creams, antioxidant extracts, and antihelminthic formulations derived from standardized plant fractions. Sustainable cultivation is feasible because the species grows rapidly and reproduces easily. Biotechnological approaches may further help identify elite chemotypes rich in desirable bioactive compounds (Atanasov et al., 2021; Newman & Cragg, 2020).

In conclusion, *Acalypha indica* is much more than a common weed of moist waste places. It is a medicinally valuable herb with longstanding use as an expectorant, antihelminthic, and topical remedy for skin disorders. Its phytochemical richness, coupled with demonstrated antioxidant, antimicrobial, anti-inflammatory, and anti-parasitic properties, makes it a promising species for future phytotherapeutic development. Continued research may help transform this neglected wild herb into a useful component of sustainable community healthcare systems (Khare, 2007; Singh & Singh, 2016; Suresh & Nagarajan, 2009).

3.4 *Croton bonplandianus*

Croton bonplandianus Baill. is a fast-growing herbaceous plant belonging to the family Euphorbiaceae. It is widely distributed in tropical and subtropical regions and is commonly observed in disturbed habitats such as agricultural fields, roadsides, wastelands, railway embankments, and degraded ecosystems. Because of its rapid growth and adaptability to harsh environmental conditions, the species is often considered a common weed; however, it plays an important ecological role in soil stabilization and early-stage ecological succession (Singh et al., 2017; Webster, 1994).

Taxonomically, *Croton bonplandianus* belongs to Kingdom Plantae, Order Malpighiales, Family Euphorbiaceae, Genus *Croton*, and Species *bonplandianus*. The genus *Croton* is one of the largest within the Euphorbiaceae family, comprising over 1,200 species that are widely distributed across tropical and subtropical regions of the world. Many *Croton* species are known for their medicinal properties and aromatic resins, although *C. bonplandianus* itself remains comparatively less studied than other members of the genus (Esser, 2012; Salatino et al., 2007).

Morphologically, *Croton bonplandianus* is an erect, branched annual herb that typically grows between 30–90 cm in height. The stem is greenish to reddish, slender, and slightly pubescent. Leaves are simple, alternate, narrow-lanceolate to linear-lanceolate, and often possess a slightly serrated margin. The leaf surface may be covered with fine hairs, which help reduce water loss in dry environments. Inflorescences are terminal or axillary spikes bearing small unisexual flowers. Fruits are trilocular capsules containing small seeds that facilitate efficient dispersal in disturbed habitats (Singh et al., 2017; Ross, 2003).

Phytochemical investigations of *C. bonplandianus* have revealed the presence of several classes of secondary metabolites, including alkaloids, flavonoids, tannins, terpenoids, saponins, and phenolic compounds. These constituents are commonly associated with antioxidant, antimicrobial, anti-inflammatory, and cytotoxic activities. Although the phytochemical profile is not as extensively characterized as that of other medicinal plants in the Euphorbiaceae family, preliminary screening suggests the presence of biologically active compounds with therapeutic potential (Wink, 2015; Salehi et al., 2019).

Antioxidant activity has been reported in leaf and stem extracts of *C. bonplandianus*, where significant free radical scavenging ability was observed in standard in vitro assays such as DPPH and nitric oxide inhibition. These effects are generally attributed to phenolic compounds and flavonoids, which are known to neutralize reactive oxygen species and reduce oxidative stress. Since oxidative stress is linked to chronic diseases such as diabetes, cardiovascular disorders, and neurodegeneration, these findings suggest potential health relevance (Goyal et al., 2024; Wink, 2015).

Antimicrobial properties have also been documented in preliminary studies. Extracts of the plant have shown inhibitory activity against selected Gram-positive and Gram-negative bacteria, as well as certain fungal strains. These antimicrobial effects support traditional applications in wound healing and treatment of minor infections. However, the potency and spectrum of activity vary depending on extraction method and concentration, indicating the need for further standardized pharmacological evaluation (Singh et al., 2017; Amtaghri et al., 2022).

Cytotoxic activity has been observed in some experimental studies, suggesting that certain phytochemicals present in the plant may exhibit anti-proliferative effects against specific cell lines. This has generated interest in its potential as a source of anticancer compounds. However, these findings remain preliminary and require further

in-depth mechanistic studies and in vivo validation before any therapeutic conclusions can be drawn (Atanasov et al., 2021; Newman & Cragg, 2020).

Despite these promising biological properties, scientific literature on *Croton bonplandianus* remains relatively limited compared to other medicinal plants in the Euphorbiaceae family. Most available studies are preliminary and focus on basic phytochemical screening and general bioactivity assays. Comprehensive pharmacological, toxicological, and clinical studies are still lacking, which limits its current acceptance in formal phytotherapy systems (Singh et al., 2017; Salehi et al., 2019).

From an ecological perspective, the species plays a significant role in habitat restoration and soil recovery processes. Its ability to rapidly colonize degraded landscapes makes it valuable in natural regeneration and ecological succession. By stabilizing soil and improving microhabitat conditions, it facilitates the establishment of more complex plant communities over time. This ecological function is particularly important in tropical regions experiencing land degradation due to human activities (Jain, 1991; Schmelzer & Gurib-Fakim, 2008).

In conclusion, *Croton bonplandianus* is an ecologically important pioneer species with emerging medicinal relevance. Although traditionally used for fever, inflammation, wounds, and digestive disorders, scientific validation of its pharmacological properties is still in early stages. Preliminary evidence indicates antioxidant, antimicrobial, and cytotoxic potential, but further research is necessary to fully explore its therapeutic value. Its dual significance in ecological restoration and potential phytopharmaceutical development makes it a promising but underexplored member of the Euphorbiaceae family (Singh et al., 2017; Wink, 2015; Goyal et al., 2024).

3.5 *Phyllanthus amarus*

Phyllanthus amarus Schumach. & Thonn. is a small, erect annual herb belonging to the family Euphorbiaceae. It is widely distributed across tropical and subtropical regions of Asia, Africa, and South America, where it commonly appears during the rainy season in moist soils, wastelands, cultivated fields, gardens, and road margins. Due to its rapid growth cycle and widespread availability, the species is frequently encountered in rural and semi-urban environments and has long been incorporated into traditional healing systems (Patel et al., 2011; Webster, 1994).

Taxonomically, *Phyllanthus amarus* belongs to Kingdom Plantae, Order Malpighiales, Family Euphorbiaceae, Genus *Phyllanthus*, and Species *amarus*. The genus *Phyllanthus* is large and diverse, comprising more than 700 species, many of which are known for medicinal properties. Within this genus, *P. amarus* is one of the most extensively studied species due to its significant pharmacological relevance, particularly in liver-related disorders (Esser, 2012; Khare, 2007).

Morphologically, *P. amarus* is a delicate herb usually growing between 20–60 cm in height. The stem is slender, green, and glabrous, with numerous small branchlets arranged in a distichous (two-ranked) pattern that gives the appearance of compound leaves. True leaves are small, simple, oblong, and closely arranged along the branchlets. Flowers are minute, greenish, and unisexual, located in the axils of leaf-like structures. Fruits are small capsules containing tiny seeds that facilitate rapid propagation, especially in moist tropical conditions (Patel et al., 2011; Ross, 2003).

Ecologically, *P. amarus* thrives in warm and humid climates and is commonly seen during and after monsoon seasons. It grows well in disturbed soils, agricultural fields, gardens, and waste areas. Its ability to complete its life cycle quickly allows it to persist in seasonal environments. Although often considered a weed, its ecological adaptability ensures consistent availability for traditional medicinal use in many regions (Jain, 1991; Schmelzer & Gurib-Fakim, 2008).

Antiviral activity has also been widely investigated, particularly against hepatitis B virus. Some studies suggest that extracts of *P. amarus* may inhibit viral replication and reduce viral load, although results vary depending on extract type and experimental model. This has made the species a major focus in herbal drug development for liver infections, although clinical validation is still ongoing (Patel et al., 2011; Atanasov et al., 2021).

Nephroprotective effects have been reported in experimental models of kidney injury. The plant has shown protective activity against drug-induced and toxin-induced renal damage, possibly due to antioxidant and anti-inflammatory mechanisms. Its traditional use in kidney stones is also supported by evidence suggesting reduced crystal formation and improved renal function markers in experimental studies (Sharma et al., 2019; Salehi et al., 2019).

Antidiabetic activity has been observed in both in vitro and in vivo studies. Extracts of *P. amarus* have demonstrated blood glucose-lowering effects, improved insulin sensitivity, and protective effects on pancreatic tissue. These effects may be linked to flavonoids and phenolic compounds that modulate glucose metabolism and oxidative stress pathways (Goyal et al., 2024; Wink, 2015).

Anti-inflammatory and antioxidant properties further enhance the medicinal value of the plant. By scavenging free radicals and reducing inflammatory mediators, *P. amarus* may contribute to the management of chronic inflammatory diseases. These properties also support its hepatoprotective and nephroprotective roles (Salehi et al., 2019; Newman & Cragg, 2020).

Despite strong pharmacological evidence, standardization and clinical validation remain essential challenges. Variability in phytochemical content due to geography, season, and extraction method affects consistency of results. Additionally, long-term safety studies and controlled clinical trials are still limited, which restricts full integration into modern pharmacotherapy (WHO, 2019; Atanasov et al., 2021).

From a pharmaceutical perspective, *Phyllanthus amarus* is considered one of the most promising medicinal plants in the Euphorbiaceae family. Its well-documented hepatoprotective and antiviral activities, combined with a rich phytochemical profile, make it a strong candidate for phytopharmaceutical development. Standardized extracts or isolated compounds such as phyllanthin and hypophyllanthin could potentially be developed into therapeutic agents for liver diseases, kidney disorders, and metabolic conditions (Patel et al., 2011; Sharma et al., 2019).

In conclusion, *Phyllanthus amarus* is a highly valuable medicinal herb with strong traditional and scientific support, particularly in the management of hepatic and urinary disorders. Its rich phytochemistry, broad pharmacological activities, and increasing scientific validation position it as one of the most promising candidates for future plant-based drug development. Continued research focusing on clinical trials, safety profiling, and standardized formulations will be crucial for its integration into modern healthcare systems (Khare, 2007; Patel et al., 2011; Goyal et al., 2024).

4. COMPARATIVE PHARMACOLOGICAL IMPORTANCE

The five selected members of the Euphorbiaceae family—*Euphorbia hirta*, *Ricinus communis*, *Acalypha indica*, *Croton bonplandianus*, and *Phyllanthus amarus*—collectively represent a wide spectrum of pharmacological, ethnomedicinal, and ecological significance. Although they belong to the same botanical family, each species exhibits distinct therapeutic priorities shaped by its phytochemical profile, traditional usage pattern, and ecological adaptation. This diversity highlights the Euphorbiaceae family as a rich reservoir of bioactive compounds with potential applications in modern drug discovery and community healthcare systems (Patel et al., 2011; Wink, 2015; Goyal et al., 2024).

From a comparative perspective, these plants can be grouped according to their dominant pharmacological roles: respiratory therapy (*E. hirta*), industrial and laxative applications (*R. communis*), antimicrobial and anthelmintic uses (*A. indica*), ecological-antioxidant contribution (*C. bonplandianus*), and hepatoprotective-antiviral action (*P. amarus*). This functional classification demonstrates how members of a single plant family can serve multiple health and industrial sectors simultaneously (Khare, 2007; Salehi et al., 2019).

Table 4.1 Comparative ethnomedicinal and pharmacological profile of selected Euphorbiaceae species

Species	Habit	Main Traditional Uses	Major Reported Compounds	Key Activities
<i>Euphorbia hirta</i>	Annual herb	Asthma, diarrhea, wounds	Flavonoids, tannins, triterpenes	Bronchodilatory, antimicrobial
<i>Ricinus communis</i>	Shrub / small tree	Laxative, inflammation	Ricinoleic acid, alkaloids	Anti-inflammatory, industrial oil

<i>Acalypha indica</i>	Annual herb	Cough, worms, eczema	Alkaloids, saponins, phenolics	Antimicrobial, antihelminthic
<i>Croton bonplandianus</i>	Herb	Fever, wounds	Flavonoids, terpenoids	Antioxidant, antibacterial
<i>Phyllanthus amarus</i>	Annual herb	Jaundice, kidney stones	Phyllanthin, lignans, tannins	Hepatoprotective, antiviral

Respiratory and anti-inflammatory importance

Among the selected species, *Euphorbia hirta* stands out as the most prominent respiratory remedy. Its traditional use in asthma, bronchitis, and cough is supported by bronchodilatory and smooth muscle relaxant effects observed in experimental studies. The presence of flavonoids and triterpenoids is believed to contribute to its anti-inflammatory and antispasmodic properties, which help reduce airway constriction (Attah et al., 2013; Kumar et al., 2010).

Similarly, *Acalypha indica* is widely used in respiratory conditions such as cough and bronchitis, although its mechanism is less extensively studied compared to *E. hirta*. The combined expectorant, antimicrobial, and anti-inflammatory actions make these two species particularly relevant in traditional respiratory care systems (Singh & Singh, 2016; Suresh & Nagarajan, 2009).

Industrial and pharmacological duality of *Ricinus communis*

Ricinus communis differs significantly from the other species due to its strong industrial relevance. Castor oil, rich in ricinoleic acid, is one of the most valuable plant-derived oils used globally in pharmaceuticals, lubricants, cosmetics, and biodiesel production. This industrial importance is complemented by its medicinal role as a stimulant laxative and topical anti-inflammatory agent (Prakash & Gupta, 2005; Ogguniyi, 2006).

However, its pharmacological value is counterbalanced by toxicity concerns due to ricin, a highly potent ribosome-inactivating protein. This dual nature—therapeutic oil versus toxic seed content—makes *R. communis* a unique case within medicinal plant research, emphasizing the importance of processing and dosage control (Wink, 2015; WHO, 2019).

Antimicrobial and anthelmintic significance

Acalypha indica demonstrates strong antimicrobial and antihelminthic potential, making it particularly important in rural healthcare systems where parasitic infections and skin diseases are common. Its broad-spectrum antimicrobial activity supports its traditional use in treating wounds, eczema, scabies, and intestinal worms. The presence of flavonoids, tannins, and saponins contributes significantly to these effects (Khare, 2007; Suresh & Nagarajan, 2009).

Similarly, *Croton bonplandianus* shows moderate antimicrobial and antioxidant activity, although its pharmacological research is still relatively limited. Its traditional use in fever and wound healing is partially supported by early phytochemical screening, suggesting cytotoxic and antibacterial potential (Singh et al., 2017; Wink, 2015).

Hepatoprotective dominance of *Phyllanthus amarus*

Among all five species, *Phyllanthus amarus* exhibits the strongest and most well-documented hepatoprotective and antiviral properties. It is widely recognized in Ayurveda for treating jaundice, hepatitis, and liver dysfunction. Scientific validation has confirmed its protective effects against chemical-induced liver damage and its potential activity against hepatitis B virus (Patel et al., 2011; Sharma et al., 2019).

Its phytochemical richness—particularly lignans such as phyllanthin and hypophyllanthin, along with ellagitannins—provides a strong biochemical basis for its pharmacological actions. This positions *P. amarus* as one of the most promising candidates for phytopharmaceutical development within the Euphorbiaceae family (Atanasov et al., 2021; Newman & Cragg, 2020).

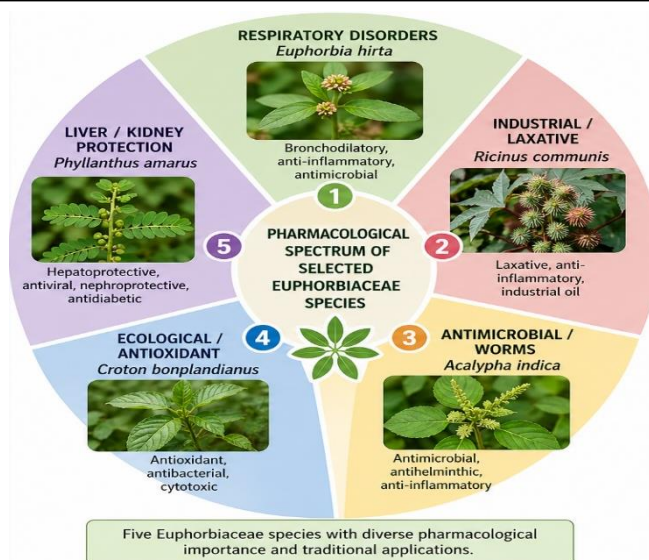


Figure 1.
Spectrum of Reviewed

Pharmacological
Species

Ecological and secondary pharmacological roles

While medicinal importance dominates most species in this review, *Croton bonplandianus* provides an additional ecological dimension. Its role as a pioneer species in disturbed habitats contributes to soil stabilization, erosion control, and ecological succession. Such ecological services indirectly support medicinal plant sustainability by maintaining biodiversity and soil health (Jain, 1991; Schmelzer & Gurib-Fakim, 2008).

Additionally, the antioxidant properties of *C. bonplandianus* align with its environmental resilience, as oxidative stress tolerance is often linked to survival in harsh conditions. This highlights an interesting connection between ecological adaptability and phytochemical defense mechanisms (Salehi et al., 2019).

Integrated comparative insight

Overall, the comparative analysis demonstrates that Euphorbiaceae species exhibit complementary pharmacological roles rather than overlapping functions. Respiratory relief (*E. hirta*), industrial and laxative utility (*R. communis*), antimicrobial defense (*A. indica*), ecological restoration (*C. bonplandianus*), and hepatoprotection (*P. amarus*) collectively cover a wide therapeutic spectrum.

Despite differences, a common pattern emerges: the presence of flavonoids, phenolics, terpenoids, and alkaloids across all species, which underpins their antioxidant, anti-inflammatory, and antimicrobial activities. This shared phytochemical foundation supports the idea that Euphorbiaceae represents a chemically convergent family with high pharmacological versatility (Wink, 2015; Goyal et al., 2024).

Table 4.2. Comparative Toxicity and Commercial Potential

Species	Main Toxicity Concern	Safety Level	Commercial Potential
<i>Euphorbia hirta</i>	Latex irritation	Moderate	Herbal respiratory products
<i>Ricinus communis</i>	Ricin toxin in seeds	Low if processed	Very high
<i>Acalypha indica</i>	Excess dose may irritate gut	Moderate	Herbal antimicrobial products
<i>Croton bonplandianus</i>	Limited toxicity data	Unknown	Moderate
<i>Phyllanthus amarus</i>	Generally safe in normal dose	High	Very high

Conclusion of comparative section

The comparative evaluation of these five species emphasizes the pharmacological richness and therapeutic diversity of the Euphorbiaceae family. While each plant has a distinct primary application, their combined properties highlight significant potential for integrated phytotherapy development. Further pharmacological

standardization, toxicity profiling, and clinical validation are required to translate this traditional knowledge into evidence-based medical applications (Patel et al., 2011; WHO, 2019; Atanasov et al., 2021).

5. TOXICITY AND SAFETY CONCERNS

Medicinal plants are often perceived as naturally safe; however, this assumption is not always correct. Like synthetic drugs, herbal medicines may produce adverse effects when consumed in excessive quantities, used for prolonged periods, or prepared improperly. Several members of the Euphorbiaceae family contain potent bioactive constituents that require careful dosage regulation and scientific assessment before therapeutic use. Therefore, safety evaluation remains an essential aspect of phytomedicine development.

Euphorbia hirta, though widely used for respiratory and gastrointestinal disorders, produces a characteristic milky latex that may irritate sensitive skin and mucous membranes. Excessive oral intake may also lead to stomach discomfort or mild gastrointestinal disturbance. Individuals with latex sensitivity should use the plant cautiously.

Ricinus communis presents the most serious toxicological concern among the reviewed species. Its raw seeds contain ricin, an extremely poisonous protein capable of causing vomiting, dehydration, organ injury, and potentially fatal poisoning. Consequently, raw seeds should never be consumed. Only properly processed and purified castor oil is considered suitable for medicinal use under recommended conditions.

Acalypha indica is generally employed in traditional medicine for cough, skin diseases, and worm infestations, yet high doses of crude extracts may induce nausea, abdominal irritation, or loose motions. Traditional preparations should therefore follow established dosage practices.

For *Croton bonplandianus*, available toxicological information remains limited. Since detailed safety studies are lacking, medicinal use should be approached conservatively until further pharmacological and toxicological data become available.

Among the reviewed plants, *Phyllanthus amarus* is regarded as comparatively safer in moderate doses. Nevertheless, prolonged unsupervised use may influence blood glucose levels or interact with concurrent medications.

Overall, standardization of extracts, controlled dosing, quality assurance, and clinical monitoring are necessary to ensure the safe integration of these medicinal plants into healthcare systems (WHO, 2019).

6. FUTURE PROSPECTS AND RESEARCH DIRECTIONS

The medicinal plants reviewed in this study possess considerable promise for future healthcare applications, yet their full therapeutic value can only be realized through systematic scientific advancement. Although many traditional claims are supported by preliminary pharmacological evidence, most investigations remain limited to laboratory experiments and animal models. Therefore, multidisciplinary research is essential to transform these botanical resources into reliable modern therapeutics.

One of the most important future priorities is the isolation and characterization of novel bioactive compounds. Advanced chromatographic, spectroscopic, and metabolomic techniques can help identify previously unknown molecules responsible for antimicrobial, hepatoprotective, anti-inflammatory, and antioxidant effects. Such discoveries may provide lead compounds for new drug development.

Clinical validation is equally necessary. Many Euphorbiaceae species demonstrate promising biological activities in vitro, but carefully designed human clinical trials are required to confirm efficacy, safety, dosage range, and long-term effects. Without clinical evidence, traditional applications cannot be fully integrated into evidence-based medicine.

Another significant direction involves the preparation of standardized herbal formulations. Capsules, syrups, creams, ointments, and tablets containing fixed concentrations of active constituents can improve consistency, therapeutic reliability, and patient acceptance. Standardization also helps reduce variability caused by geography, harvesting season, or processing methods.

Emerging technologies such as nanotechnology offer additional opportunities. Nanoencapsulation of plant extracts may enhance bioavailability, improve stability, allow controlled drug release, and reduce toxicity. Such approaches could substantially increase the medicinal effectiveness of plant-derived compounds.

Sustainable cultivation and conservation strategies are also essential as demand for herbal raw materials increases. Organized farming, seed banking, and habitat protection can prevent overexploitation of wild populations.

Artificial intelligence and machine learning may accelerate phytopharmaceutical discovery by predicting molecular targets and therapeutic pathways of Euphorbiaceae phytochemicals. In addition, selected species may be developed into functional foods or nutraceutical supplements after proper safety assessment. These combined approaches indicate a highly promising future for Euphorbiaceae-based medicine.

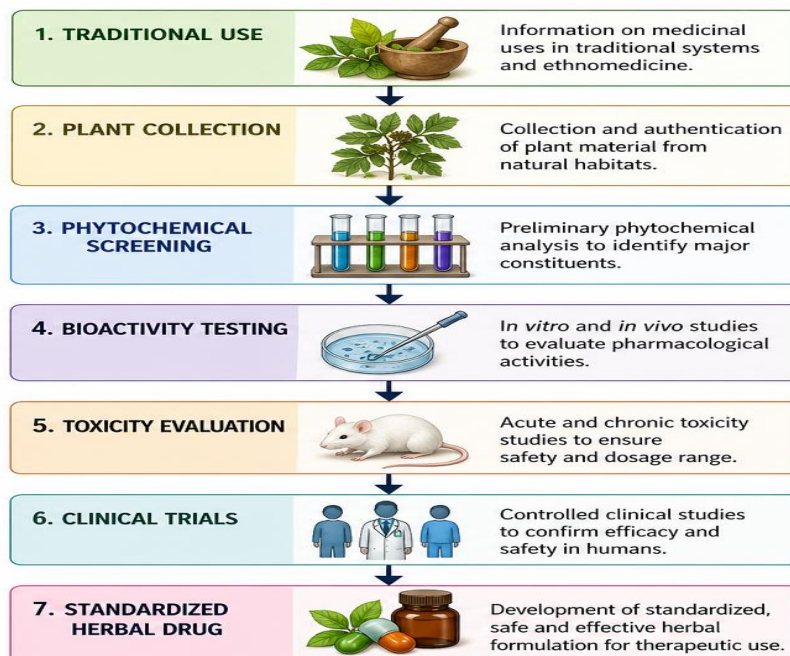


Figure 2. Workflow for Future Drug Development

7. CONCLUSION

The five selected species of the Euphorbiaceae family collectively exhibit substantial medicinal, ecological, and economic importance, highlighting the broad therapeutic potential of this diverse plant group. Each species contributes unique biological value based on its traditional applications and experimentally reported pharmacological activities. *Phyllanthus amarus* appears especially promising for future hepatoprotective and antiviral drug development due to its strong ethnomedicinal reputation and growing scientific support. *Ricinus communis* remains the most commercially significant species because of the extensive industrial and pharmaceutical applications of castor oil. *Euphorbia hirta* continues to be valued in traditional respiratory care, particularly for asthma, cough, and bronchial disorders. *Acalypha indica* offers inexpensive and accessible antimicrobial as well as antihelminthic potential for community healthcare systems. Meanwhile, *Croton bonplandianus* represents an ecologically resilient and comparatively underexplored species with emerging antioxidant and medicinal relevance.

Despite these promising attributes, many of the reviewed plants still require deeper phytochemical investigation, mechanism-based pharmacological studies, toxicological screening, and controlled clinical trials (Webster, 1994; Patel et al., 2011). Scientific standardization is necessary to ensure safety, efficacy, and consistency of herbal preparations. Sustainable harvesting and cultivation practices are equally important to conserve natural populations while meeting increasing medicinal demand.

Overall, the reviewed Euphorbiaceae species provide a valuable bridge between traditional knowledge and modern therapeutic innovation. With continued interdisciplinary research and responsible utilization, these plants may contribute significantly to future phytopharmaceutical development, biodiversity-based healthcare systems, and affordable global medicine.

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