

OXALIDACEAE FAMILY: AN INTEGRATIVE REVIEW OF BOTANICAL DIVERSITY, PHARMACOGNOSTIC FEATURES, PHYTOCHEMICAL CONSTITUENTS AND AYURVEDIC–ETHNOMEDICINAL SIGNIFICANCE

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ABSTRACT

Background: Oxalidaceae R.Br. is a distinctive flowering-plant family placed in the order Oxalidales. Current Plants of the World Online (POWO) treatment recognizes five accepted genera—Averrhoa L., Biophytum DC., Daphnia Korth., Oxalis L. and Sarcotheca Blume—and approximately 570 species, with Oxalis representing the largest genus. Members occur mainly in tropical and subtropical regions and include plants of nutritional, ornamental, ecological and medicinal importance.^[1,2]

Objective: This review integrates botanical characteristics, pharmacognostic significance, ethnomedicinal and Ayurvedic relevance, phytochemical composition, pharmacological evidence and toxicological considerations of selected medicinally important members of Oxalidaceae.

Materials and Methods: A narrative literature review was prepared from the literature contained in the original manuscript and supplemented with current taxonomic

information from Kew Plants of the World Online and peer-reviewed literature indexed in PubMed. Particular attention was given to Oxalis corniculata L., Biophytum sensitivum DC.,

Averrhoa carambola L. and Averrhoa bilimbi L. The evidence was interpreted according to the level of experimental or clinical support available. **Results:** The family is characterized by alternate leaves that are often compound, actinomorphic bisexual flowers, usually five sepals and five petals, ten stamens arranged in two whorls, a superior ovary and generally capsular fruits.^[1] Selected medicinally investigated species contain flavonoids, phenolic compounds, biflavonoids, tannins, terpenoids, polysaccharides and organic acids. Experimental studies report antioxidant, anti-inflammatory, antimicrobial, antidiabetic, wound-healing, immunomodulatory and anticancer activities for selected taxa, but most evidence remains preclinical.^[3–6] Averrhoa carambola is of particular safety interest because oxalate and caramboxin have been associated with renal and neurological toxicity.^[8–10] **Conclusion:** Oxalidaceae represents a valuable reservoir of medicinal and nutritionally important plants. Future research should emphasize botanical authentication, pharmacognostic standardization, chemical fingerprinting, mechanism-based investigations, pharmacokinetics, toxicity assessment, herb–drug interaction studies and well-designed clinical trials. Integration of classical Ayurvedic Dravyaguna knowledge with modern pharmacognosy and pharmacology may support scientifically rigorous evaluation of medicinal species.

KEYWORDS: Oxalidaceae; Oxalis corniculata; Biophytum sensitivum; Averrhoa carambola; Dravyaguna; pharmacognosy; phytochemistry; ethnomedicine; pharmacological activity; medicinal plants.

1. INTRODUCTION

Medicinal plants have historically contributed to traditional healthcare and continue to provide leads for pharmaceutical, nutraceutical and phytochemical research. Modern pharmacognosy and phytochemistry provide complementary approaches for botanical authentication, quality control, chemical characterization and evaluation of biological activity.

Oxalidaceae R.Br. is an accepted family of Oxalidales. Current Kew treatment recognizes five genera and approximately 570 species, with Oxalis comprising approximately 500 species.^[1] Members range from annual or perennial herbs to shrubs, climbers and small trees. Their diversity, together with the traditional use of several species, makes the family relevant to pharmacognosy and natural-product research.

Among Indian medicinal plants, *Oxalis corniculata* and *Biophytum sensitivum* are particularly relevant to Dravyaguna and ethnomedicine. *B. sensitivum* has been described in the literature under traditional names including Viparita Lajjalu/Vipareetalajjalu and has been investigated for antioxidant, anti-inflammatory, immunomodulatory, antidiabetic, wound-healing and anticancer activities.^[3,4] *O. corniculata* has also been investigated for antioxidant, antimicrobial, anti-inflammatory, antidiabetic and wound-healing potential.^[5,6]

Averrhoa carambola illustrates the importance of evaluating therapeutic and nutritional potential together with safety. Although multiple biological activities have been reported, star-fruit consumption has been associated with acute kidney injury and neurological toxicity, particularly in susceptible individuals.^[8–10]

2. MATERIALS AND METHODS

The manuscript was prepared as a narrative review. Literature was identified from peer-reviewed publications indexed in PubMed and from authoritative taxonomic resources, particularly Kew Plants of the World Online. The principal concepts used for literature identification were Oxalidaceae, *Oxalis corniculata*, *Biophytum sensitivum*, *Averrhoa carambola*, *Averrhoa bilimbi*, phytochemistry, pharmacognosy, ethnomedicine, pharmacology and toxicity. Current botanical nomenclature and family-level classification were cross-checked against POWO and the Angiosperm Phylogeny Group framework.^[1,2]

The evidence was synthesized narratively rather than quantitatively. Traditional uses were distinguished from experimental pharmacological evidence, and experimental findings were not interpreted as proof of clinical efficacy. Species-specific safety information was considered separately from general family-level claims.

3. Taxonomic Position of Oxalidaceae

Oxalidaceae belongs to the order Oxalidales. Current Kew treatment recognizes five accepted genera: *Averrhoa*, *Biophytum*, *Dapania*, *Oxalis* and *Sarcotheca*.^[1] APG IV places Oxalidaceae within Oxalidales.^[2]

Rank	Classification
Kingdom	Plantae
Major group	Angiosperms
Order	Oxalidales
Family	Oxalidaceae R.Br.
Accepted genera	<i>Averrhoa</i> , <i>Biophytum</i> , <i>Dapania</i> , <i>Oxalis</i> , <i>Sarcotheca</i>
Largest genus	<i>Oxalis</i> (ca. 500 species)

4. Botanical Description of the Family

4.1 Habit

Members may occur as annual herbs, perennial herbs, shrubs, climbers or small trees.

4.2 Root

Roots may be fibrous, fleshy or modified for storage, depending on the taxon.

4.3 Stem

Stems may be erect, ascending, prostrate, creeping, branched or reduced.

4.4 Leaves

Leaves are generally alternate and may be trifoliate, pinnately compound, palmately compound or, in some taxa, unifoliate. Leaflets are frequently articulated; trifoliate leaves are particularly characteristic of many *Oxalis* species.^[1]

4.5 Inflorescence

Inflorescences may be umbellate, cymose, thyrsoid-paniculate, spicate or capitate.

4.6 Flower

Flowers are generally bisexual, actinomorphic, hypogynous and pentamerous. The calyx generally consists of five persistent sepals and the corolla of five petals.^[1]

4.7 Androecium

Ten stamens are usually arranged in two whorls; the outer whorl is positioned opposite the petals.^[1]

4.8 Gynoecium

The ovary is superior and generally consists of five carpels. Axile placentation and heterostyly occur in the family.^[1]

4.9 Fruit

The fruit is generally a capsule. In some taxa, seeds possess a fleshy aril and may exhibit explosive dispersal.^[1]

5. Diagnostic Characters of Oxalidaceae.

Character	Diagnostic feature
Habit	Herbs, shrubs, climbers or small trees
Leaves	Alternate; commonly compound or unifoliate

Leaflets	Frequently articulated
Flowers	Bisexual, actinomorphic
Sepals	Usually 5
Petals	Usually 5
Stamens	10, in two whorls
Ovary	Superior
Carpels	Usually 5
Placentation	Axile
Fruit	Usually a capsule
Seeds	Sometimes arillate

6. Important Genera of Oxalidaceae

The family contains five accepted genera.^[1] *Oxalis* is the largest genus, followed by smaller genera with distinct geographic and morphological distributions. Among these, *Oxalis*, *Biophytum* and *Averrhoa* have received substantial medicinal or nutritional attention.

- *Oxalis* L.: the largest genus; includes *O. corniculata*, *O. acetosella*, *O. triangularis* and *O. pes-caprae*.
- *Biophytum* DC.: includes *B. sensitivum* and other herbaceous taxa with sensitive leaves.
- *Averrhoa* L.: includes economically important fruit trees such as *A. carambola* and *A. bilimbi*.
- *Dapania* Korth.: an accepted genus of the family.
- *Sarcotheca* Blume: an accepted genus of the family.

7. *Oxalis corniculata* L.

7.1 Botanical profile

Oxalis corniculata is a small herb with creeping or decumbent stems and trifoliate leaves. It is widely distributed in warm-temperate and tropical regions, including India.^[5,6]

7.2 Ethnomedicinal significance

Traditional literature describes the use of *O. corniculata* in inflammatory conditions, gastrointestinal complaints, skin disorders, infections and fever. These uses represent traditional or ethnomedical evidence and should not be equated with established clinical efficacy.^[5]

7.3 Phytochemistry

Reviews report diverse constituents including flavonoids, alkaloids, terpenoids, tannins, saponins, steroids, phenolic compounds, polysaccharides and organic acids. Recent literature

particularly highlights flavonoids, polysaccharides and organic acids in relation to the antioxidant and biological profile of the species.^[5,6]

7.4 Pharmacological evidence

Experimental studies and reviews describe antioxidant, antimicrobial, anti-inflammatory, antidiabetic, wound-healing and anticancer potential. However, the available evidence remains predominantly preclinical, and further standardized studies and clinical evaluation are required.^[5,6]

8. *Biophytum sensitivum* DC.

8.1 Botanical significance

Biophytum sensitivum is a small annual herb with characteristic sensitive leaves. It occurs in tropical regions of Africa and Asia, including India and Nepal.^[3,4]

8.2 Ayurvedic relevance

The species is described in the literature under Sanskrit names including Vipareetalajjalu/Viparita Lajjalu and is relevant to Indian traditional medicine and Dravyaguna teaching.^[3,4] Classical Ayurvedic attributes should, however, be cited directly from authoritative Ayurvedic texts when used in a formal scholarly article rather than inferred from modern pharmacological findings.

8.3 Traditional applications

Published reviews describe traditional use in inflammation, arthritis, wounds, burns, gastrointestinal complaints, cough, asthma, diabetes, urinary complaints and menstrual disorders.^[3,4] These reports should be interpreted as traditional-use evidence.

8.4 Phytochemistry

Important reported constituents include the biflavonoids amentoflavone and cupressuflavone, isoorientin and polysaccharide fractions, including BP100 III.^[3,4]

8.5 Pharmacological evidence

Experimental literature reports antioxidant, anti-inflammatory, immunomodulatory, antidiabetic, anticancer, chemoprotective, wound-healing, cardioprotective, radioprotective and antiangiogenic activities. These findings are predominantly from laboratory and animal studies and therefore require appropriate caution when translated to human therapeutic claims.^[3,4]

9. Genus *Averrhoa*

The genus *Averrhoa* includes economically important tropical fruit trees. Two important species discussed in medicinal and nutritional literature are *Averrhoa carambola* L. and *Averrhoa bilimbi* L.^[8,9]

10. *Averrhoa carambola* L.

10.1 Botanical and nutritional importance

Averrhoa carambola, commonly known as star fruit or carambola, is widely cultivated in tropical and subtropical regions, including India and Southeast Asia. It is valued as a food and has also been used traditionally in several medical systems.^[8,9]

10.2 Phytochemistry

A review reported approximately 132 compounds from *A. carambola*, with flavonoids, benzoquinones and glycosides among important chemical groups.^[8]

10.3 Pharmacological evidence

Experimental studies have reported antioxidant, antihyperglycemic, anti-obesity, antihyperlipidemic, anti-inflammatory, hepatoprotective, cardioprotective, antihypertensive, neuroprotective and antitumor activities.^[8] Most evidence is experimental, and clinical efficacy remains insufficiently established.

10.4 Toxicological importance

Star fruit requires particular safety consideration because it contains oxalic acid/oxalate and caramboxin. Oxalate can contribute to renal injury through calcium oxalate deposition, while caramboxin has been implicated in excitatory neurological toxicity, including confusion and seizures.^[9,10] A systematic review of reported cases found renal and neurological toxicity particularly among patients with chronic kidney disease, while acute kidney injury has also been described in people without previously recognized renal disease.^[10]

11. *Averrhoa bilimbi* L.

Averrhoa bilimbi is another tropical fruit-bearing species. Its acidic fruits are used as food and in traditional practices. Experimental research has examined antioxidant, antimicrobial, antidiabetic and anti-inflammatory potential; however, compared with *A. carambola*, the clinical pharmacology and safety evidence remains limited. Species-specific research and standardized studies are needed before therapeutic claims can be made.

12. Phytochemical Diversity of Oxalidaceae

Phytochemical group	Representative significance
Flavonoids	Antioxidant and anti-inflammatory potential
Biflavonoids	Amentoflavone and cupressuflavone reported particularly in <i>B. sensitivum</i>
Phenolic compounds	Radical-scavenging potential
Phenolic acids	Antioxidant activity
Tannins	Astringent and antimicrobial potential
Terpenoids	Diverse biological activities
Alkaloids	Species-dependent pharmacological activity
Polysaccharides	Immunomodulatory/antioxidant potential
Organic acids	Particularly relevant to <i>Oxalis</i>
Glycosides	Diverse biological roles
Oxalates	Nutritional and toxicological significance

Chemical composition can vary with species, plant part, geographical origin, developmental stage, environmental conditions and extraction method. Consequently, biological activity should not be generalized across the family solely on the basis of plant name.

13. Pharmacognostic Significance

13.1 Macroscopic evaluation

Authentication should include colour, odour, taste where appropriate, size, shape, surface, texture and fracture characteristics. These parameters should be recorded for the specific species and plant part under investigation.

13.2 Microscopic evaluation

Microscopic evaluation may include epidermal cells, stomata, trichomes, vascular bundles, fibres, parenchyma, crystals and secretory structures. Diagnostic characters should be established from authenticated material and compared with pharmacopoeial or validated botanical standards.

13.3 Powder microscopy

Powder microscopy may reveal epidermal fragments, vessels, fibres, starch grains, calcium oxalate crystals, sclerenchymatous elements and characteristic tissue fragments. Such features are useful for detecting substitution or adulteration when supported by validated reference standards.

14. Quality Standardization

- Organoleptic parameters: colour, odour, taste and texture.

- Physicochemical parameters: foreign matter, moisture content/loss on drying, total ash, acid-insoluble ash, water-soluble extractive, alcohol-soluble extractive and pH.
- Phytochemical parameters: preliminary phytochemical screening, total phenolic content, total flavonoid content, HPTLC fingerprinting and, where appropriate, HPLC or LC–MS profiling.
- Contaminant analysis: microbial load, heavy metals, pesticide residues and aflatoxins where applicable.

These parameters should be selected according to the species, plant part, intended use and applicable pharmacopoeial or regulatory standards rather than applied identically to every member of the family.

15. Pharmacological Evidence

Species	Major reported activities	Evidence level
<i>O. corniculata</i>	Antioxidant, antimicrobial, anti-inflammatory, antidiabetic, wound-healing and anticancer potential	Mainly preclinical ^[5,6]
<i>B. sensitivum</i>	Antioxidant, anti-inflammatory, immunomodulatory, antidiabetic, wound-healing and anticancer potential	Mainly preclinical ^[3,4]
<i>A. carambola</i>	Antioxidant, antihyperglycemic, anti-inflammatory, antihyperlipidemic, hepatoprotective and cardioprotective potential	Mainly experimental ^[8,9]
<i>A. bilimbi</i>	Antioxidant, antimicrobial, metabolic and anti-inflammatory potential	Experimental; limited clinical evidence

16. Antioxidant Activity

Oxidative stress contributes to multiple pathological processes. Phenolic and flavonoid constituents reported from selected Oxalidaceae species may contribute to antioxidant effects through radical scavenging, metal chelation and modulation of endogenous antioxidant pathways. *O. corniculata* has been specifically reviewed as a potential natural antioxidant source.^[6] These mechanisms remain species- and extract-dependent.

17. Anti-inflammatory and Antimicrobial Activities

Anti-inflammatory activity has been reported particularly for *B. sensitivum* and *O. corniculata*. Proposed mechanisms include modulation of inflammatory mediators, nitric

oxide production and oxidative stress, but mechanistic conclusions should remain linked to the individual experimental model.^[3–6]

Extracts from several Oxalidaceae plants have shown antimicrobial activity against selected microorganisms. Results can vary according to plant part, solvent, concentration, extraction method and microbial strain. Standardized minimum inhibitory concentration studies are therefore necessary for meaningful comparisons.

18. Antidiabetic Potential

Experimental studies have reported antidiabetic activity for selected species. Proposed mechanisms include antioxidant protection, inhibition of carbohydrate-digesting enzymes and modulation of glucose metabolism. However, the evidence is predominantly preclinical, and standardized human studies are needed before therapeutic efficacy can be established.^[3–6,8]

19. Wound-Healing Potential

Wound-healing activity has been reported particularly for *B. sensitivum* and *O. corniculata* in experimental studies.^[3–6] A plausible framework involves reduction of oxidative injury, modulation of inflammation and support of tissue repair; however, these mechanisms should be treated as hypotheses unless directly demonstrated in standardized mechanistic studies.

20. Anticancer Potential

Several Oxalidaceae species have demonstrated antiproliferative or anticancer effects in experimental models. Proposed mechanisms include apoptosis induction, cell-cycle modulation, oxidative-stress modulation and effects on angiogenesis or cell migration. *B. sensitivum* has received attention because of experimental work on amentoflavone and related constituents.^[3,4] These findings do not establish clinical anticancer efficacy.

21. Ayurvedic and Dravyaguna Perspective

Oxalidaceae provides an opportunity to integrate classical Ayurvedic drug knowledge with modern botanical and pharmacognostic methods. *B. sensitivum*, traditionally associated with Vipareetalajjalu/Viparita Lajjalu in the literature, is particularly relevant for Dravyaguna teaching and research.^[3,4]

For formal Ayurvedic research, Rasa, Guna, Virya, Vipaka, Karma and Prayoga should be documented directly from authoritative primary Ayurvedic texts and clearly distinguished

from modern pharmacological interpretations. Modern biological activity should not be used retrospectively to assign classical Ayurvedic properties.

22. Integration of Dravyaguna and Modern Pharmacology

A scientifically useful framework is: classical identification → botanical authentication → pharmacognostic evaluation → phytochemical profiling → pharmacological screening → mechanism-based investigation → toxicological evaluation → clinical validation. This approach can be applied particularly to medicinally important taxa such as *B. sensitivum* and *O. corniculata*.

23. Safety and Toxicology

Safety assessment should be an integral part of medicinal-plant research. Within the family, *A. carambola* has the clearest clinically documented safety concern. Star-fruit toxicity can involve oxalate-associated renal injury and caramboxin-associated neurological toxicity.^[9,10] The risk is especially important in individuals with renal impairment, although toxicity has also been reported without previously recognized kidney disease.^[10]

Accordingly, pharmacological potential should always be interpreted together with species-specific toxicological evidence. Long-term toxicity, dose-response relationships, pharmacokinetics and herb–drug interactions require further study for many Oxalidaceae taxa.

24. Research Gaps

- Insufficient reporting of voucher specimens, botanical authentication, geographical origin and harvesting season in some pharmacological studies.
- Large variation in extraction solvents, plant parts, concentrations and experimental models, limiting direct comparison between studies.
- Limited clinical evidence for most medicinally investigated Oxalidaceae species.
- Insufficient pharmacokinetic information on absorption, distribution, metabolism, elimination and bioavailability.
- Need for species-specific toxicity, long-term safety and herb–drug interaction studies.
- Need for validated chemical markers and standardized extracts.
- Need for authenticated plant material and reproducible pharmacognostic standards.

25. DISCUSSION

Oxalidaceae represents an important intersection between botanical diversity, traditional medicine and natural-product research. Current taxonomic resources recognize five genera and approximately 570 species, while *Oxalis* accounts for approximately 500 species.^[1] The pharmacological literature, however, is concentrated around a relatively small number of taxa, particularly *O. corniculata*, *B. sensitivum* and *A. carambola*.^[3–10]

O. corniculata demonstrates the research value of a widely distributed medicinal herb with a diverse phytochemical profile and multiple experimental activities.^[5,6] *B. sensitivum* is particularly relevant to Ayurvedic and ethnomedicinal research because of its traditional identity, sensitive-leaf morphology and reported constituents such as amentoflavone, cupressuflavone and isoorientin.^[3,4] *A. carambola* demonstrates why pharmacological evaluation must be accompanied by rigorous safety assessment, given the documented renal and neurological toxicity of star-fruit ingestion.^[9,10]

Future studies should move beyond nonspecific extract screening toward authenticated botanical material, standardized extracts, validated chemical markers, mechanism-based experiments, pharmacokinetic assessment, toxicology and carefully designed clinical trials. A systematic review of individual medicinal species could further strengthen evidence synthesis through protocol registration, duplicate screening, risk-of-bias assessment and, where appropriate, quantitative meta-analysis.

26. CONCLUSION

Oxalidaceae is a diverse family containing nutritionally, ethnomedicinally and scientifically important plants. Its botanical characteristics provide useful diagnostic features for family-level identification, while selected species possess significant pharmacognostic and phytochemical interest. *O. corniculata*, *B. sensitivum*, *A. carambola* and *A. bilimbi* have received varying degrees of pharmacological and ethnomedicinal attention.

Flavonoids, phenolics, biflavonoids, polysaccharides, terpenoids, tannins and organic acids represent important phytochemical groups reported from selected members. Experimental studies indicate antioxidant, anti-inflammatory, antimicrobial, antidiabetic, wound-healing, immunomodulatory and anticancer potential; nevertheless, most evidence remains preclinical.^[3–8] The toxicological profile of *A. carambola* further emphasizes the need to integrate safety assessment into medicinal-plant research.^[9,10]

From an Ayurvedic and Dravyaguna perspective, the family provides an opportunity to connect classical plant knowledge with modern botanical authentication, pharmacognosy, phytochemistry, pharmacology and evidence-based medicine. Future research should progress from authenticated botanical material and standardized phytochemical profiles to mechanism-based pharmacology, rigorous toxicology and clinical validation.

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