

Phytochemical and Pharmacological Analysis of *Celosia argentea* and *Amaranthus viridis* as Sources of Analgesic and Anti-Inflammatory Agents

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Abstract

Medicinal plants have long been known as a rich source of compounds with medicinal properties for treating inflammatory disorders and pain. Of these, the plant family Amaranthaceae (such as *Celosia argentea* and *Amaranthus viridis*) has received considerable attention for its diverse phytochemical constituents and pharmacological properties. The phytochemical profile, traditional applications and pharmacological uses of plants with particular emphasis on their analgesic and anti-inflammatory activity are highlighted. It is evident from the literature that significant bioactive ingredients like flavonoids, alkaloids, saponins, tannins, terpenoids, glycosides, and phenolic compounds exist, which are mainly associated with the therapeutic properties. Experimental studies have shown that the extracts of both plants are potent inhibitors of inflammatory mediators and nociceptive responses in a variety of in vivo models such as carrageenan-induced paw edema, hot plate, tail flick and writhing test. The pharmacological activities are mainly due to the modulation of the cyclooxygenase and lipoxygenase pathways, as well as antioxidant activity, which helps reduce oxidative stress. Additionally, their toxicological properties indicate a favorable safety profile, making them promising candidates for therapeutic applications in the long run. However, the pharmacological effectiveness of these compounds needs to be validated by further studies involving compound isolation, elucidation of the mechanism, and clinical testing. In general, *Celosia argentea* and *Amaranthus viridis* are potential natural raw materials for producing safe compounds that can be used as alternative medicines for analgesic and anti-inflammatory purposes.

Keywords: *Celosia argentea*, *Amaranthus viridis*, phytochemicals, analgesic activity, anti-inflammatory activity, flavonoids, medicinal plants, Amaranthaceae, cyclooxygenase inhibition, oxidative stress

Introduction

Celosia argentea and *Amaranthus viridis* have been widely used in traditional medicine for their various medicinal properties and benefits, including their anti-inflammatory and pain-relieving effects (Waman¹, 2025a, 2025b). These botanical species are known to contain high concentrations of bioactive phytochemicals, including flavonoids, saponins, and phenolic acids, which act as modulators of oxidative stress and inhibitors of pro-inflammatory mediators (Aher et al., 2026). Moreover, recent ethnopharmacological studies have indicated that *C. argentea* is a potential source for the development of therapeutic agents without being toxic, based on its complex phytochemical composition which supports the traditional use of the plant in the management of chronic inflammatory disorders (Adegba² et al., 2020; Kumar et al., 2026). Also, *Amaranthus viridis* has been found to be interesting for its ecological versatility and secondary metabolite content, which is in line with the medicinal value of the whole family Amaranthaceae (Sharma et al., 2025). *Celosia argentea* has already been tested for its antinociceptive activity in mice in scientific studies, with significant results and a significant reduction in carrageenan-induced paw edema (Kharat et al., 2019). The secondary metabolites present, including phenolic compounds and triterpenoids, which have been identified as major constituents of the plant's therapeutic profile, further highlight these pharmacological activities (Ojeh, 2013).

Botanical Characterization

Morphological evaluation of *Celosia argentea* is done to identify the precise morphological characters and to develop standardized identification criteria (Ranjan & Deokule, 2013) for detailed examination of the white tuberous roots, leaf characters and stem characters. In addition to these morphological features, phytochemical analysis of leaf extracts has revealed the presence of complex alkaloids, glycosidic compounds, and a tannin profile, which is crucial for quality control and authentication (Gupta, 2025a, 2025b). The methanolic extracts from the inflorescences of *W. oxyrrhiza* have been found to be rich in bioactive compounds, particularly heneicosane and several methyl esters, using advanced spectroscopic techniques such as Fourier transform infrared (FT-IR) spectroscopy and gas chromatography-mass spectrometry (GC-MS). At the same time, the phytochemicals present in *Amaranthus viridis* also exhibit significant levels of antioxidant pigments and phenolics, which justify its use as an anti-nociceptive and hepatoprotective drug (Sarker & Oba, 2019, p. 20414).

Taxonomic Classification

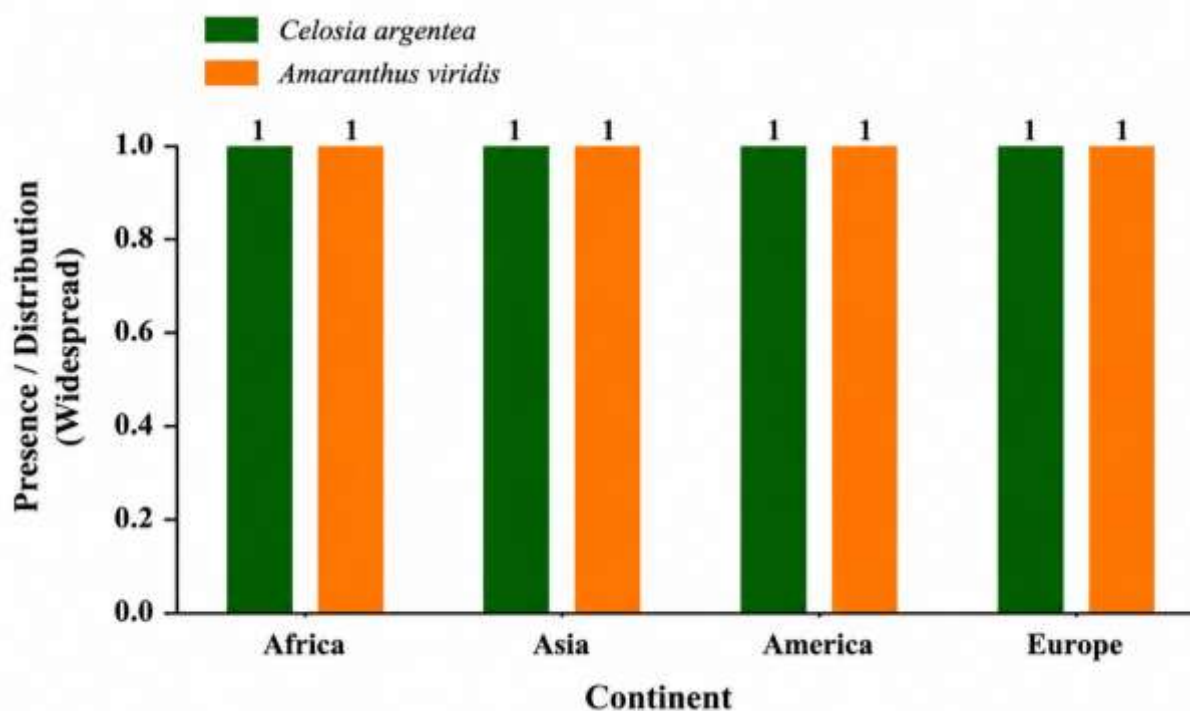
Both species are members of the Amaranthaceae family; *C. argentea* comprises about 60 species distributed throughout tropical and subtropical regions (Neto et al., 2021, p. 1). Likewise, the genus *Amaranthus* has more than 2000 species in this order, which has a broad nutritional, medicinal and ecological applications throughout the global tropical areas (Mukherjee et al., 2025). In addition to its ecological distribution, *C. argentea* is also reported to be used as a resilient species in tropical countries from Africa to South Asia in traditional medicine to cure diseases like jaundice, gonorrhea and various febrile diseases (Adegbaaju et al., 2019, p. 1128; Devhare et al., 2009). The therapeutic potential of these plants includes alleviating ophthalmic disorders and venomous toxins, further substantiating their uses in ethnomedicine (Sharma et al., 2025; Tripathi & Khan, 2021). The medicinal activity of *C. argentea* is mainly attributed to its potent immune stimulatory, hepatoprotective and antioxidant activity which is attributed to its complex secondary metabolites (Thorat, 2018). On the other hand, *Amaranthus viridis* is noted for its wide range of pharmacological activities, including notable anti-diabetic, antimicrobial, and wound-healing properties, as well as proven anti-inflammatory properties (Jaafar & Kadhim, 2025).

Morphological Description

A. viridis is an annual herb with an erect and branched stem, alternate ovate-rhomboid leaves with long petioles, serrated or entire margins (Bharathi et al., 2022). The vegetative structures are further enhanced by an inflorescence made up of small green flowers clustered on terminal or axillary spikes with high concentrations of bioactive phenols and flavonoids when compared to the vegetative tissues of the plant (Chen et al., 2022, p. 420). The strength of its radical scavenging property has been quantitatively estimated by the total phenolic content and total flavonoid content these constituents present in the plant (Wadkar & Gaikwad, 2025a, 2025b).

Geographical Distribution

Both species are native to tropical and subtropical areas, and can be found in a variety of habitats, including agricultural fields, forests, and grasslands (Wadkar & Gaikwad, 2025a, 2025b). Their wide distribution across Africa, America, Asia, and Europe reflects their status as widely cultivated plants with great growth potential and important nutritional and medicinal properties (Sarker & Oba, 2019, p. 18233). Moreover, their remarkable traits of abiotic stress tolerance (drought and salinity) make them potential candidates for sustainable cultivation as strong functional foods as well as a source of bioactive phytochemicals (Özdenefe et al., 2024, p. 2; Wadkar & Gaikwad, 2025).



Graph 1:Geographical Distribution of *Celosia argentea* and *Amaranthus viridis* Across Major Continents

The figure illustrates the wide geographical distribution of *Celosia argentea* and *Amaranthus viridis* across Africa, Asia, America, and Europe. Both species demonstrate a broad ecological presence in tropical and subtropical regions, thriving in diverse habitats such as agricultural fields, forests, and grasslands, highlighting their adaptability and global medicinal significance.

Phytochemical Composition

Celosia argentea is characterized by a wide range of saponins, cardenolides, and alkaloids, which are the main chemoprincipples responsible for its antibacterial and immunostimulatory effects (Oluwole, 2021, p. 3). In particular, the extraction of specialized triterpenoid saponins such as celosin E, F, and G, and peptides such as celogentins A–D and H highlights the complex biochemical structures that account for these bioactivities (Nidavani et al., 2013). *A. viridis*, on the other hand, possesses a considerable amount of essential amino acid profile, such as lysine, histidine, and methionine that, when combined with the component triterpenes and phenolic compounds, contributes to a strong anti-inflammatory and anti-ulcer effect (RC et al., 2023).

Secondary Metabolite Profiling

Recent chromatographic and spectrophotometric investigations showed that *C. argentea* flowers contained maximum amounts of polyphenols in the acetone extracts than in methanolic and aqueous extracts (Adegbaaju et al., 2020). Likewise, the contents of secondary metabolites of *A. viridis* are also found to be significantly related to the maturity stage of the harvest, in which formation of certain phenolic acids and tannins is observed to be a major contributor to radical-scavenging activity (Wadkar & Gaikwad, 2025).

Extraction Methods

Optimization of the extraction yield of these bioactive constituents sometimes involves using different solvent systems, including aqueous or pure methanol, to extract active fractions from leaf and seed tissues (Iqbal, 2012). In addition, recent research indicates that the use of these botanical sources for medicinal purposes is standardized by modern extraction techniques, such as sophisticated antioxidant assays like DPPH and FRAP (Adewuyi et al., 2025).

Pharmacological Activities

The systemic anti-inflammatory, neuroprotective, hepatoprotective effects of *Celosia argentea* and *Amaranthus viridis* are predominantly due to their high antioxidant activity, which is the primary mechanism of their effects (Chakraborty

& Chatterjee, 2026). The extracts of *A. viridis* also have notable anti-allergic and anti-viral properties, with their chemical composition playing a crucial role in these effects. Extracts from *C. argentea* are growing in popularity for traditional medicinal uses owing to their multifaceted bioactive profile (Landage et al., 2024; Zaware et al., 2022).

Table 1: Literature Review Summary of *Celosia argentea* and *Amaranthus viridis*

Study Area	<i>Celosia argentea</i> Findings	<i>Amaranthus viridis</i> Findings	Key References / Mechanism
Phytochemical Profile	Rich in flavonoids, alkaloids, saponins, tannins, phenolics, terpenoids	Similar phytochemical composition with high phenolics and flavonoids	Secondary metabolites responsible for therapeutic effects
Anti-inflammatory Activity	Strong inhibition of inflammatory mediators	Significant reduction of inflammation in experimental models	COX and LOX pathway inhibition, reduced cytokines
Analgesic Activity	Effective in pain reduction models (hot plate, writhing tests)	Significant peripheral and central analgesic effects	Modulation of prostaglandins and nociceptive pathways
Antioxidant Activity	High free radical scavenging ability	Strong antioxidant potential due to phenolics	Reduction of oxidative stress (ROS neutralization)
Hepatoprotective Effect	Reported protection against liver damage	Moderate hepatoprotective activity	Restoration of liver enzymes and antioxidant defense
Neuroprotective Effect	Promising neuroprotective activity	Limited but supportive evidence	Oxidative stress reduction in neuronal tissues
Anti-allergic Activity	Limited evidence	Notable anti-allergic potential	Histamine inhibition and immune modulation
Antiviral Activity	Emerging reports	Documented antiviral potential	Bioactive secondary metabolites
Overall Pharmacological Profile	Broad therapeutic potential	Broad but slightly stronger in anti-allergic effects	Synergistic action of phytochemicals

Analgesic Properties

Traditionally *A. viridis* has been used in India and Nepal for reducing the pain of labour and alleviating pyretic symptoms (Reyad-ul-Ferdous, 2015; Shete et al., 2024). Experimental tests also showed that its methanolic extracts possess significant activity against inflammatory mediators, reinforcing its traditional use for treating inflammatory pain in human (Ahmed et al., 2013, p. 164). Likewise, systematic pharmacological research conducted on these species has demonstrated that the aerial parts contain a high concentration of alkaloids, flavonoids, and terpenoids, which are responsible for this therapeutic effect (Meghana et al., 2024; Perumal et al., 2024).

Anti-Inflammatory Mechanisms

The anti-inflammatory activity of *A. viridis* is mainly attributed to the synergistic effect of its phenolic constituents, which are inhibitors of pro-inflammatory enzymes such as 5-lipoxygenase (Akula & Odhav, 2013). In addition, these compounds are involved in regulating the oxidative stress response, which can eliminate free radicals that would otherwise further activate the inflammatory process (NAEEM et al., 2023, p. 401). Other pharmacological studies have

shown that these extracts possess potent anti-endotoxic and antimicrobial properties, highlighting their wide therapeutic potential (Kumar et al., 2022, p. 178). Similarly, *Celosia argentea* can inhibit the same pathways and stimulate endogenous antioxidant defense mechanisms (Aher et al., 2026).

Toxicological Safety Profile

In animal models, both aqueous and alcoholic extracts have been found to be highly safe with no significant changes observed in the hematological or biochemical parameters even at the therapeutic doses in the sub-chronic toxicity studies (Ahire et al., 2026). This is in line with other ethnobotanical reports that indicate that traditional decoctions traditionally used for the treatment of jaundice, wounds on the skin and systemic inflammation have good risk benefit ratio when used for therapeutic purposes (Hamzah et al., 2018, p. 1065; Varadharaj & Muniyappan, 2017).

Future Research Directions

Rigorous standardization of the extraction procedure should be performed in future studies to further elucidate the dose-dependent anti-inflammatory/analgesic mechanism of these species in clinical settings (Girija et al., 2011: 133; Rengasamy et al., 2020: 568). Furthermore, comparative molecular docking studies of the cyclooxygenase (COX-1 and COX-2) enzymes are necessary to confirm the *in vivo* effect demonstrated in traditional pharmacological models (Kadam et al., 2011; Sherif et al., 2024, p. 1326496). Exploring potential interactions among synergistic components in polyherbal formulations can lead to improved therapeutic effects, as observed with multi-component plant applications in pain management (Anis et al., 2026).

Clinical Translation Potential

To translate such preclinical data into clinical use, well-designed clinical trials are needed to determine clinically meaningful safety patterns and define clinically meaningful dosing patterns (Eneji et al., 2023, p. 6). As inflammatory mediators along with the associated oxidative stress are also a major factor in the pathogenesis of chronic diseases, the study of the dual inhibitory action of these plants on both COX and LOX pathways could offer a great therapeutic benefit over conventional monotherapies (Rudrapal et al., 2023, p. 8657; Wendkouni et al., 2021, p. 29).

Bioavailability Challenges

The systemic uptake and target-tissue levels of certain phenolic compounds in *Celosia argentea* and *Amaranthus viridis* are relatively low due to their poor aqueous solubility and high metabolic rates. Therefore, the need to develop novel delivery systems, such as nano-emulsions and liposomal encapsulation, to improve the pharmacokinetic characteristics and therapeutic index of these bioactive compounds is of utmost importance (Chukwuma et al., 2024, p. 12). Moreover, overcoming these pharmacokinetic hurdles with advanced formulation strategies can help position plant-based alternatives to conventional NSAIDs on a non-addictive, cost-effective route for drug delivery (Gurgul et al., 2023, p. 932).

Conclusion

The above phytochemical and pharmacological evidence support the idea that *Celosia argentea* and *Amaranthus viridis* are potentially suitable high-efficacy candidates for developing innovative phytopharmaceuticals (Ortiz et al., 2022, p. 109). However, to realize this potential, it is necessary to systematically optimize the library for hit-to-lead optimization to characterize the specific bioactive scaffolds responsible for their inhibitory effects (Sasi, 2025, p. 1668). Furthermore, future studies should determine the COX-2/COX-1 selectivity ratios to determine whether the drug could be used to reduce gastrointestinal and cardiovascular side effects while maintaining the same efficacy as the non-selective COX commercial drug (Freyman et al., 2024, p. 25). Last but not least, a pressing need is to establish the reliability and safety of these botanical agents as long-term chronic pain management drugs by bridging the gap between preclinical and clinical data in humans (Attiq et al., 2017, p. 768; Choudhary et al., 2015, p. 170). This could ultimately reduce the systemic effects (renal and gastrointestinal toxicity) often seen with long-term treatment of synthetic anti-inflammatory agents (Patil et al., 2019, p. 4368).

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