REVIEW ARTICLE

Chaff-flower (*Achyranthes aspera*): Its pharmacology, disease curing, and therapeutic uses

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Abstract

Wound healing is a natural process; it often becomes sluggish and difficult when an infection occurs or when inflammation persists for an extended period. The demand for new treatments that can both prevent infection and promote tissue repair has grown in recent years due to the rise in antibiotic resistance. A well-known medicinal plant in traditional medicine, *Achyranthes aspera* has drawn interest in contemporary study due to its potential for wound healing and infection prevention. According to studies, its extracts may have antibacterial, antioxidant, and anti-inflammatory properties since they contain significant bioactive substances such as flavonoids, glycosides, alkaloids, and saponins. Laboratory tests have demonstrated enhanced cell motility, which is crucial for tissue regeneration, and efficacy against common wound-associated bacteria. In addition, topical treatment has been shown in animal tests to improve skin strength, shorten healing times, and increase wound contraction. Despite the encouraging early results, further systematic research, safety testing, and clinical trials are still required before normal medical use.

Key words: *Achyranthes aspera,* anti-inflammatory activity, infection control, phytochemicals, wound healing activity

INTRODUCTION

Inflammation, granulation tissue creation, re-epithelialization, collagen deposition, and remodelling are some of the overlapping processes that make up the intricate biological process of wound healing. Acute wounds frequently heal correctly, but many develop chronic or delayed healing as a result of oxidative stress, prolonged inflammation, microbial infection, and decreased cellular migration [Figure 1]. Because infected wounds not only heal slowly but also exhibit poor tissue strength, a higher chance of recurrence, and an increased likelihood of systemic spread, these consequences are clinically significant. Treatment options are further restricted by the developing issue of antibiotic resistance, which has raised interest in plant-derived medicines that can support tissue healing as well as infection control.

Apamarga or *Achyranthes aspera* Linn. (Amaranthaceae) is a widely distributed medicinal plant that has long been used to treat wounds and infectious diseases. According to current research, this plant has a variety of bioactive phytochemical groups, including flavonoids, alkaloids, glycosides, and saponins, which may all contribute to its pharmacological potential.[1] Methanolic extracts of *A. aspera* have demonstrated significant antioxidant activity and bactericidal effects against Gram-positive and Gram-negative organisms associated with wound infections, including *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Escherichia coli*, and *Staphylococcus aureus*.[1] *A. aspera* may encourage cellular movement necessary for re-epithelialization and wound closure, as evidenced by reports of increased Vero cell motility in addition to antibacterial action.[1]

The biological significance of these results is reinforced by *in vivo* investigations. Topical ointments made with methanol leaf extract (2.5–10% w/w) greatly enhanced wound contraction, decreased epithelialization time, and boosted

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Received: 21-02-2026
Revised: 23-03-2026
Accepted: 31-03-2026

Figure 1: Photomicrograph of the floral parts of *Achyranthes aspera*

breaking strength in rat excision and incision wound models, suggesting both quicker closure and better tissue quality.[2] Similar results have been documented in experimental burn wounds, where a 5% methanol leaf ointment enhanced pro-healing biochemical markers, including hydroxyproline and total protein, as well as wound contraction and antioxidant defenses such as superoxide dismutase, catalase, and Vitamin C.[3] This burn model's histological findings confirmed structural improvement in the healing tissue by showing fibroblast proliferation, collagen deposition, and epidermal development.[3] Furthermore, alterations in the expression of Matrix Metalloproteinase-2 (MMP-2) and Matrix Metalloproteinase-9 (MMP-9) were noted, indicating that the healing process impacted by A. aspera may entail extracellular matrix remodeling.[3]

Controlling inflammation is also necessary for effective supports healing of injured tissues. Prolonged inflammation impedes healing and harms newly produced tissue, although early inflammation is required to eliminate debris and pathogens. Solvent fractions of leaf extract may lessen edema and granuloma development while promoting wound contraction, according to studies assessing *A. aspera*'s anti-inflammatory properties.[4] It is important to remember that this specific study has been retracted; its conclusions should be read with caution and should not be regarded as confirmatory evidence in the absence of independent validation.[4] Studies on tannins derived from *A. aspera* provide more evidence for their anti-inflammatory and wound-healing properties. Condensed tannins showed anti-inflammatory activity in paw edema models and improved healing outcomes in several wound models, including excision, incision, dead space, and burn wounds.[5] These results suggest that polyphenolic components may be important for tissue healing and inflammatory regulation.

A. aspera has demonstrated encouraging antibacterial potential outside of certain laboratory tests, and infection control is still a significant obstacle to effective wound healing. In addition to showing antibacterial, antifungal, and anthelmintic activity, a study examining leaf extracts from several geographic sites also revealed regional differences in functional phenolic acids. This implies that geographic origin, extraction technique, and chemical standardization, all crucial factors for future product development, may affect the biological potency of *A. aspera*.[6] In addition, dietary supplementation with *A. aspera* seed improved immune parameters and decreased mortality in fish infected with Aeromonas hydrophila in an infection survival model, indicating broader host-defense support relevant to infection resistance.[7] A clinical and microbiological study in chronic periodontitis reported positive effects when *A. aspera* gel was administered subgingivally as an adjunct to scaling and root planing, supporting its antimicrobial and anti-inflammatory potential in humans, despite the lack of clinical evidence for skin wound healing.[8] This study offers important translational evidence that *A. aspera* can affect infection-driven inflammatory tissue damage in a clinical environment, even though periodontal tissues are different from skin wounds.[8]

According to the evidence that is currently available, this plant may promote wound healing and infection control through a variety of complementary mechanisms, such as antimicrobial action, antioxidant protection, inflammation regulation, cell migration stimulation, and enhancement of collagen-based tissue strength.[7]

SOURCES OF INFORMATION

This comprehensive review examines the plant in wound healing and infection control. To gather relevant information, various databases were searched using specific keywords such as *A. aspera*, wound healing, Infection control, antimicrobial activity, anti-inflammatory activity, antioxidant, phytochemicals, topical formulation, and re-epithelialization. Emphasis was placed on retrieving articles related to frog-derived toxins and their medicinal, pharmacological, and therapeutic uses, including treatments for skin cancer, as well as their anti-inflammatory, immunomodulatory, and anticancer activities. Additional references were obtained by reviewing citations within existing studies. Both individual and combined search terms were employed to ensure a thorough literature review. To incorporate recent developments and update the information, research articles, books, conference proceedings, and reports from public health organizations were selected and compiled. Searches were conducted across platforms such as Web of Science, PubMed, PMC, and Google. Using this standard approach, key discoveries and findings were identified and summarised in the final review.

ETHNOMEDICINAL USES

A. aspera is used in traditional medical systems to treat some ailments, such as gynecological disorders, asthma, eye and dental issues, hemorrhoids, and growths in the abdomen. In addition, it is used to treat insect and snake bites, promote wound healing, and facilitate birthing.[9] In the Uttara Kannada district of Karnataka, an ethnomedical investigation identified 106 plant species that have historically been used to cure various wounds.[10] This work offers important ethnomedical insights into plants used by indigenous populations to treat one of the most common illnesses affecting the central nervous system (CNS).[11] *A. aspera* extracts demonstrated notable cholinesterase inhibitory activity, whereas *Valeriana wallichii* chloroform and ethyl acetate fractions showed considerable inhibition of butyryl and acetyl cholinesterase (58 µg/mL and 61 µg/mL, respectively).[12] The results show that the extract has significant antifungal and antibacterial action against tested microorganisms, such as *Sclerotium* and *Phytophthora* species.[13]

PHARMACOLOGICAL ACTIVITIES

Antimicrobial Activity

Microbial illnesses and antibiotic resistance are becoming more common. *A. aspera's* antibacterial activity has garnered significant attention. Numerous investigations have shown that the plant's various extracts have strong antibacterial activity against a range of harmful microbes. Both Gram-positive and Gram-negative bacteria, such as *B. subtilis*, *E. coli*, and *S. aureus*, have been demonstrated to be inhibited by extracts made from the plant's leaves, roots, and aerial portions. To evaluate the antibacterial and anti-inflammatory properties of several solvent extracts of *Leucas aspera* leaves and examine their phytochemical composition [Figure 2].[14]

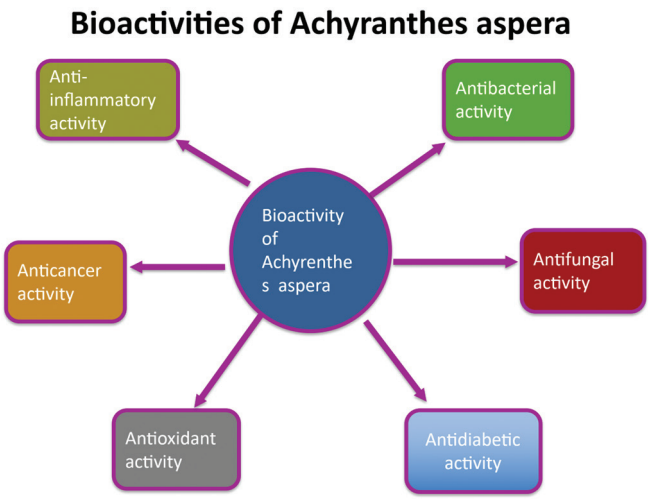

Figure 2: Biological activity of *Achyranthes aspera*

Disc diffusion and other *in vitro* antimicrobial tests have been used in experiments to confirm that extracts from *A. aspera* are effective against a variety of bacterial species. The plant's potential as a natural antibacterial agent was also shown by previous studies that showed different solvent extracts of the plant had inhibitory efficacy against numerous clinically significant pathogens.[13] Strong antibacterial activity in aqueous extracts suggests that they could be useful antimicrobial resources and therapeutic agents [Figure 2].[15]

Anti-inflammatory Activity

A. aspera has been shown in numerous experiments to have strong anti-inflammatory activity. Several *in vivo* models, including cotton-pellet granuloma in experimental animals and carrageenan-induced paw edema, have been used to assess the plant's anti-inflammatory properties. *A. aspera's* alcoholic extract dramatically decreased paw edema in rats in one study, demonstrating its efficacy in both acute and chronic inflammatory situations. This function is thought to be influenced by the suppression of inflammatory mediators such as prostaglandins and other chemical mediators.[16] The ethyl acetate fraction of the crude extract of *A. aspera* and *V. wallichii* can be used to isolate novel anti-inflammatory lead compounds, according to the combined *in vitro* and *in vivo* anti-inflammatory screening.[12] Carrageenan-induced paw edema and excision and incision wound models were the most popular *in vivo* methods for the anti-inflammatory and wound healing assays, respectively.[17] Achyranthes aspera Ethanolic Extract (Aa-EE) inhibited Nuclear Factor kappa B (NF-κB) promoter activity induced by tumor necrosis factor alpha (TNF-α) and adaptor molecule MyD88 (approximately 70% and 40%, respectively).[18] Acyclovir-treated HSV-infected cells, suggesting that Methanolic Extract (ME) and Oleanolic Acid (OA) likely prevent the early stage of multiplication (2–6 h after infection).[19] In EELA2-treated arthritic rats, histopathological analyses verified full cartilage regeneration and nearly normal joints [Figure 3].[20]

Bioactive components of *A aspera* restrict the production of exudate during inflammatory processes and prevent the release of inflammatory mediators.[21] The ethyl acetate fraction of *A. aspera* and *V. wallichii* may offer novel anti-inflammatory lead compounds, according to *in vitro* and *in vivo* anti-inflammatory research.[12] At 1000 µg/mL, the ME-extract demonstrated potent dose-dependent antibacterial activity against *P. aeruginosa, B. subtilis, E. coli, S. aureus*, and *Klebsiella pneumonia*.[22] The traditional usage of *Saussurea lappa, Argyreia speciosa,* and *A. aspera* in inflammatory disorders is supported by the anti-inflammatory and anti-arthritic properties of their ethanolic extracts.[23]

Antioxidant Activity

Several *in vitro* antioxidant tests have demonstrated the potent free-radical scavenging activity of *A. aspera* extracts.

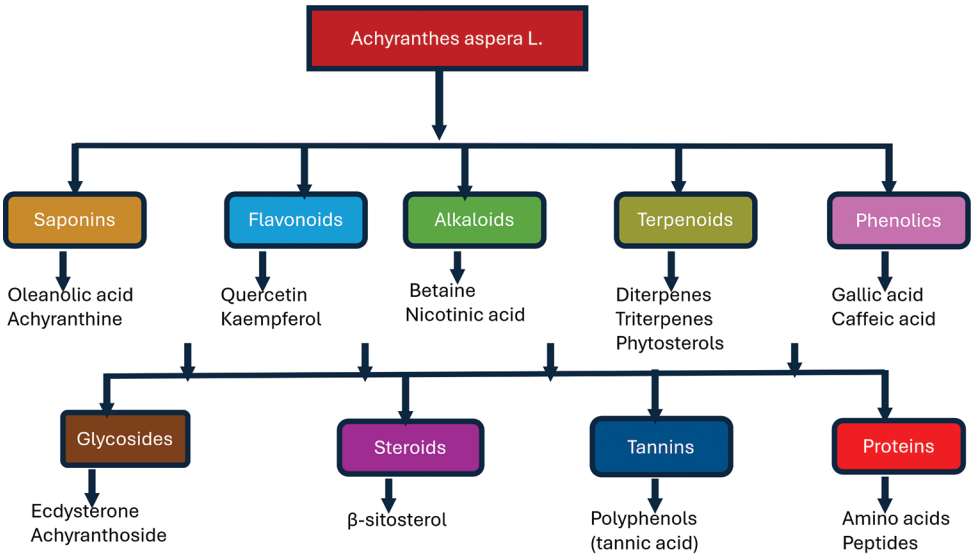

Figure 3: Phytoconstituents of *Achyranthes aspera*

For example, the plant's methanolic and aqueous extracts showed strong antioxidant capacity by scavenging DPPH radicals and lowering oxidative stress indicators, suggesting the presence of strong antioxidant components in the plant bioactive extract.[1]

By lowering lipid peroxidation and raising antioxidant enzyme activity, *A. aspera* extracts considerably enhanced the antioxidant state of experimental animals in a different investigation. These results imply that the plant can shield biological systems from free radical-induced oxidative damage.[24]

Similar to this, studies on saponin fractions extracted from *A. aspera* seeds showed significant antioxidant activity in tests like FRAP and ABTS. According to the study, treating experimental mice with these fractions greatly increased serum antioxidant levels, demonstrating the plant's ability to fight oxidative stress.[25] In addition, pharmacological studies have shown that *A. aspera's* antioxidant pathways may be responsible for its preventive properties in several illness situations, including metabolic and neurological disorders. Thus, many of the plant's therapeutic effects are thought to be largely dependent on its antioxidant qualities [Figure 3].[26]

Immunomodulatory Activity

A. aspera extracts have been demonstrated in experiments to improve immune responses by promoting both humoral and cell-mediated immunity. For example, a study by Gokhale *et al*.[23] showed that giving plant extracts to experimental rats greatly boosted macrophage phagocytic activity and antibody production, indicating immunostimulatory potential. Similar to diazepam, the ethanol extract of *A. aspera* has strong anxiolytic and CNS depressive effects.[21]

Additional pharmacological research has suggested that the plant's bioactive substances, including alkaloids, flavonoids, and saponins, may be responsible for *A. aspera*'s immunomodulatory effects. It is well recognized that these phytoconstituents affect cytokine release and immune cell proliferation, which in turn control immunological responses. Although more research is required to evaluate their individual and combined efficacy in treating lung and other malignancies, the results indicate that polyphenolic components of *Achyranthes aspera* components have synergistic anticancer, immunomodulatory, and DNA-restorative characteristics [Figure 3].[27]

Anticancer Activity

By decreasing Protein Kinase C alpha (PKCα) signaling activity and triggering apoptosis via the mitochondrial route, acute myeloid leukaemia (AML) may successfully stop dalton's lymphoma (DL) progression.[28] *A. aspera* methanolic extract has bioactive components that have significant antiproliferative actions, especially against pancreatic cancer cells.[29] *A. aspera* leaf extracts exhibit encouraging promise as a natural source of anticancer activity.[30] Reduction of anti-apoptotic proteins B-cell lymphoma 2 (Bcl-2) and activation of caspase-3, caspase-9, and pro-apoptotic proteins (Bax).[31] Although more research is required to completely understand the underlying signaling processes, administration of 125 mg/kg alkaloid fraction of *Achyranthes aspera* Linn (AAL) reduced tumor growth in breast cancer-bearing mice [Figure 3].[32]

Antidiabetic Activity

According to additional research, extracts of *A. aspera* enhance the activity of antioxidant enzymes and lessen oxidative stress linked to diabetes. The plant's antioxidant potential may contribute to its antidiabetic effects because oxidative stress is a major factor in the development of diabetic problems.[24] *In vitro* models, leaves have shown superior antidiabetic and

Table 1: Comparative overview of phytochemistry and pharmacological properties of Achyranthes species

S. No.	Species name	Plant parts	Major compounds	Biological activity	References
1	*Achyranthes aspera* L.	Leaves	Saponins, flavonoids	Antibacterial	[1]
2	*Achyranthes bidentata Blume*	Roots	Ecdysterone	Anti-osteoporosis activity, neuroprotective effect	[35]
3	*Achyranthes japonica* (Miq.) Nakai	Roots	Phytoecdysteroids	Anti-osteoporotic effects.	[36]
4	*Achyranthes coynei* Santapau	Whole plant	Saponins, Flavonoids, Alkaloids	antioxidant activity	[37]
5	*Achyranthes longifolia* (Makino) Makino	Leaves	Saponins, Flavonoids, Alkaloids	Anti-inflammatory mechanism	[38]
6	*Achyranthes fauriei* H.Lév. & Vaniot	Whole plant	saponins, flavonoids, alkaloids,	anti-inflammatory, antioxidant, antitumor	[9]
7	*Achyranthes ferruginea* Roxb.	Whole plant	saponins, flavonoids, alkaloids, and triterpenoids.	Ethnomedical uses	[39]
8	*Achyranthes sicula* (L.) All.	Whole plant	Triterpenoid saponins (genus-reported)	Putative anti-inflammatory and antioxidant potential	POWO, Royal Botanic Gardens, Kew, UK
9	*Achyranthes argentea* Lam.	Whole plant	saponins, flavonoids, alkaloids	Ethnobotanical	Tropicos, Missouri Botanical Garden
10	*Achyranthes talbotii* C.B.Clarke	Whole plant	saponins, flavonoids	Rare medicinal	Flora of India, BSI
11	*Achyranthes canescens* R.Br.	Whole plant	Saponins, Triterpenoids, Flavonoids, Alkaloids, Sterols	Analgesic, wound-healing activities	Royal Botanic Gardens, Kew, UK
12	*Achyranthes australis* R.Br.	Whole plant	flavonoids, alkaloids	Ethnobotanical	POWO, Royal Botanic Gardens, Kew, UK
13	*Achyranthes fruticosa* Desf.	Whole plant	saponins, flavonoids.	Traditional	POWO
14	*Achyranthes grandifolia* Moq.	Whole plant	saponins, flavonoids, and triterpenoids.	anti-inflammatory, antimicrobial	Tropicos
15	*Achyranthes indica* (L.) Mill.	Whole plant	sterols, and phenolic compounds	antimicrobial, antioxidant	POWO, Royal Botanic Gardens, Kew, UK
16	*Achyranthes obtusifolia* Lam.	Whole plant	saponins, flavonoids	Ethnomedicinal	eFlora of India
17	*Achyranthes obovatifolia* Stokes	Whole plant	saponins, flavonoids,	Analgesic activity, Anti-arthritic activity	Royal Botanic Gardens, Kew, UK
18	*Achyranthes ellipticifolia* Stokes	Whole plant	sterols, and phenolic compounds	Taxonomic	POWO, Royal Botanic Gardens, Kew, UK
19	*Achyranthes robusta* C. H. Wright	Whole plant	alkaloids, and triterpenoids.	Taxonomic	POWO, Royal Botanic Gardens, Kew, UK
20	*Achyranthes daito-insularis* Tawada	Whole plant	saponins, flavonoids	Regional flora	POWO
21	*Achyranthes okinawensis* Tawada	Whole plant	saponins, flavonoids	Regional flora	Royal Botanic Gardens, Kew, UK
22	*Achyranthes asperoides* Pires de Lima	Whole plant	saponins, flavonoids	Taxonomic	Tropicos
23	*Achyranthes porphyristachya* Hook.f.	Whole plant	saponins, flavonoids	Taxonomic	Flora of China

(*Contd...*)

Table 1: (*Continued*)

S. No.	Species name	Plant parts	Major compounds	Biological activity	References
24	*Achyranthes pubescens* (var.)	Whole plant	saponins, flavonoids	Morphological variant	POWO, Royal Botanic Gardens, Kew, UK
25	*Achyranthes aspera* var. indica	Whole plant	saponins, flavonoids	Variant	Royal Botanic Gardens, Kew, UK
26	*Achyranthes aspera* var. obtusifolia	Whole plant	saponins, flavonoids	Variant	POWO
27	*Achyranthes aspera* var. porphyristachya	Whole plant	saponins, flavonoids	Variant	Royal Botanic Gardens, Kew, UK
28	*Achyranthes atollensis*	Whole plant	saponins, flavonoids	Taxonomic	Tropicos
29	*Achyranthes mutica*	Whole plant	saponins, flavonoids	Taxonomic	POWO
30	*Achyranthes villosa*	Whole plant	saponins, flavonoids	Ethnobotanical	eFlora of India

POWO: Plants of the World Online

antioxidant effects. The activity of the nonpolar solvent extract was marginally higher than that of the polar solvent extract.[33] *A. aspera*'s ethylacetate fraction showed notable activity against the enzymes acetylcholinesterase (IC50: 61 µg/mL) and butyrylcholinesterase (IC50: 61 µg/mL). Furthermore, *A. aspera*'s phytochemical components, such as saponins, flavonoids, and alkaloids, are thought to improve insulin secretion and boost peripheral tissues' absorption of glucose. These bioactive substances may enhance insulin sensitivity and control the metabolism of carbohydrates.[25] The ethanolic extract of *A. aspera* (400 mg/kg, i.p.) demonstrated decreased locomotion, muscle relaxation, and anxiolytic effect. Phytochemical screening revealed triterpenoids, saponins, alkaloids (betaine and achyranthine), and steroids as important ingredients [Figure 3].[21]

Wound Healing Activity

Inflammation, proliferation, and tissue remodeling are all part of the dynamic, multi-stage process of healing activity. Due to their antibacterial, antioxidant, and anti-inflammatory qualities, medicinal plants are being investigated extensively for their potential to improve this process. *A. aspera* has demonstrated encouraging wound-healing properties in several experimental investigations. *A. aspera* extracts have been shown in pharmacological investigations to shorten the epithelialization period and speed up wound contraction considerably. Topical administration of plant extracts boosted the tensile strength of repaired tissue and wound closure rates in an experimental investigation, suggesting improved collagen synthesis and tissue regeneration.[2] The combination function of anti-inflammatory and antioxidant mechanisms in the plant's ability to heal wounds has also been highlighted by recent studies. Its therapeutic potential was further supported by the fact that treated mice showed improvements in collagen deposition and a decrease in inflammatory response.[4] *A. aspera*'s methanolic leaf extract showed remarkable wound-healing activity, suggesting its potential for the creation of plant-based medicinal products.[3] Overall, the information that is now available indicates that *A. aspera* improves wound healing through a variety of processes, such as control of inflammatory responses, stimulation of collagen synthesis, antibacterial action, and antioxidant protection. *A. aspera* extract has the potential to cure wounds due to its powerful antibacterial and wound-healing properties, as well as its ability to increase Vero cells and promote *in vitro* wound healing.[1] Tannins from *O. basilicum* callus cultures demonstrated the greatest outcomes for wound healing, while condensed tannins from *A. aspera* leaf callus cultures demonstrated the best anti-inflammatory action.[5] The effectiveness of *Apamarga Ksharodaka* in treating wounds, emphasizing the important bioactive ingredients of homovanillic acid and biochanin A.[34]

CHEMICAL COMPOSITION

Bioactive phytochemicals such as flavonoids, alkaloids, saponins, and triterpenoids may be crucial for lowering tissue swelling and inhibiting inflammatory reactions [Figures 3 and 4]. *A. aspera* contains tannins, steroids, proteins, phytosterols, nicotinic acid, oleanolic acid as the aglycones, Ecdysterone, an insect moulting hormone, and long-chain alcohols are also found in *A. aspera* [Table 1].

THERAPEUTIC APPLICATIONS

A. aspera has antibacterial and antifungal qualities that aid in inhibiting harmful microorganisms, which is one of its

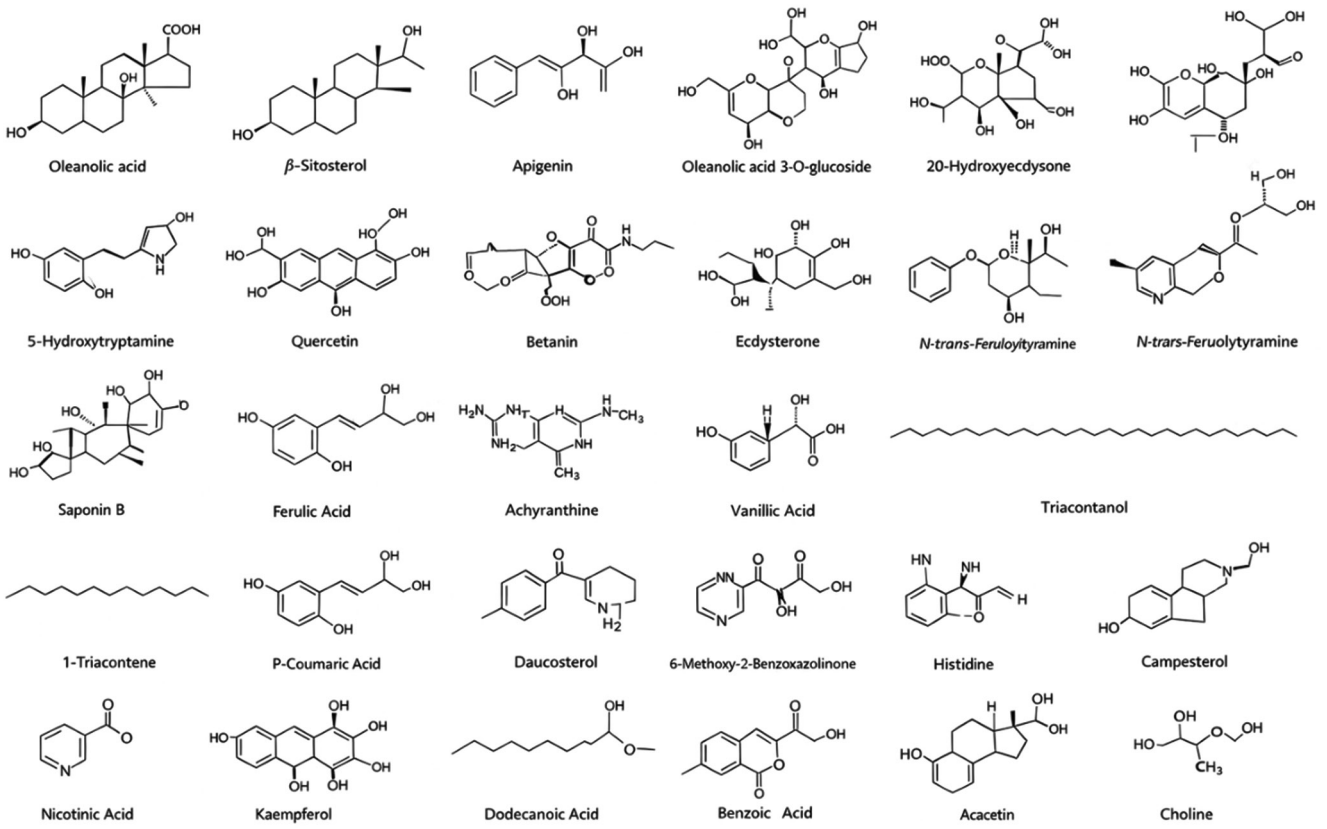

Figure 4: Chemical structure of *Achyrenthes aspera*

main medicinal applications. Its traditional use in treating infectious illnesses has been supported by experimental research that displays its efficacy against several bacterial strains.[40] The goal of the *A. aspera* study is to investigate the potential therapeutic uses and future research directions of *A. aspera* in neurodegenerative disorders.[41] *A. aspera* extracts have anxiolytic effects similar to those of diazepam, but more research is needed to completely determine their therapeutic potential in anxiety disorders.[42] For "no-option" individuals in particular, gene therapy provides an alternate and possibly more successful treatment option.[43]

CONCLUSION

A. aspera L. is a significant medicinal plant that has drawn interest due to its diverse biological properties. The plant's medicinal properties are attributed to several bioactive substances, including flavonoids, alkaloids, phenolic constituents, and saponins. It has antibacterial, anti-inflammatory, antioxidant, antidiabetic, anticancer, immunomodulatory, and wound-healing qualities, according to scientific research. Plant components can be used for microbial treatment, inflammation, and tissue repair. up. To sum up, *A. aspera* exhibits great promise as a natural remedy and depository of novel compounds. It could be a useful source for new medications and therapeutic approaches.

ACKNOWLEDGMENTS

The authors are thankful to the HOD and Dean of the Faculty of Science.

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Source of Support: Nil. **Conflicts of Interest:** None declared.