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Exploring the therapeutic landscape of *Achyranthes aspera* L.: From traditional uses to modern pharmacological applications and phytochemical insights

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Abstract
Achyranthes aspera L., often referred to as Apamarg, is a well-respected medicinal plant widely utilized in folk medicine across various cultures. This thorough review consolidates the existing scientific knowledge regarding its diverse phytochemical profile and extensive pharmacological properties. Phytochemical investigations indicate that *Achyranthes aspera* L. is a notable source of bioactive substances, including alkaloids, saponins, flavonoids, tannins, glycosides, and terpenoids, which collectively support its medicinal capability. This includes demonstrating potent analgesic, anti-inflammatory, anti-diabetic, anticancer, antioxidant, and antimicrobial potential against bacteria, fungi, and viruses.
The overall data highlight the fact that *Achyranthes aspera* L. has significant potential in the context of new drug discovery and therapeutic development. Nevertheless, additional strenuous studies, such as clinical studies, extensive toxicological experimentation, and mechanistic research, should be carried out to maximize its potential as a medicine and to make it easier to implement into the present healthcare system.

Keywords: *Achyranthes aspera* L., Amaranthaceae, Apamarg, Latjeera, Phytochemical analysis, Traditional uses

1. Introduction
The overall search of new therapeutic agents has been long supported with the great biodiversity of natural world, and medicinal plants can be considered as invaluable reservoir of discovery and development of drug. The traditional medical system with their millennial-long development deeply used the plant derived compounds in their therapeutic effect, and they provide an abundant ethnobotanical tradition ready to be scientifically proved. The systematic study of these traditional remedies is of a significance that has never been encountered before in an epoch where antimicrobial resistance is on the rise as well as the prevalence of chronic diseases [1, 2].
Among the multitude of botanicals with profound ethnomedicinal significance, *Achyranthes aspera* L., commonly named "Apamarg" or "Prickly Chaff Flower" (Family: Amaranthaceae), stands out as a prominent species [3]. Widely distributed across tropical and subtropical regions of Asia, Africa, America, and Australia, this herbaceous plant has been extensively utilized in diverse traditional healthcare practices for a spectrum of ailments [4] .Historically, *Achyranthes aspera* L. has been employed to manage conditions ranging from respiratory diseases like asthma and cough, to inflammatory states, dermatological issues, gastrointestinal complaints, and even venomous bites, underscoring its broad therapeutic applicability [5].
Contemporary scientific research has increasingly aimed at clarifying the biochemical foundations of these conventional uses. Phytochemical studies have consistently shown that *Achyranthes aspera* L. serves as a rich source of bioactive secondary metabolites, which include a variety of alkaloids (such as achyranthine and betaine), flavonoids (like quercetin and kaempferol), saponins, tannins, glycosides, and terpenoids (sitosterol and ecdysones), in addition to several phenolic acids. It is believed that these various compounds work together

synergistically, enhancing the plant's diverse pharmacological characteristics [6, 7].

Recent pharmacological investigations have substantiated many traditional claims and, in various instances, identified new therapeutic potentials. Research has highlighted its significant antimicrobial, antioxidant, anti-inflammatory, analgesic, anti-cancer, anti-diabetic, and cardiovascular functions. [8]. For instance, specific compounds from *Achyranthes aspera* L. have shown promise in inhibiting pathogenic microbes, mitigating oxidative stress, ameliorating inflammatory responses, exhibiting cytotoxic effects against cancer cells, regulating glucose metabolism, and influencing cardiac dynamics and blood pressure [9, 10].

The proposed comprehensive review will be an attempt to synthesize the existing scientific literature relating to *Achyranthes aspera* L. It closely breaks down the phytochemical makeup of the plant, outlines its different traditional uses and critically examines the current pharmacological evidence surrounding the use of the plant in terms of its inefficacy in therapy. The paper aims to give a overarching account of the medicinal value of *Achyranthes aspera* L. and its potential as a drug source in future by combining the ethnobotanical knowledge with the modern pharmacological understanding of this plant.

2. Systematic classification

Table 1: Systematic classification of *Achyranthes aspera* L.

Kingdom	**Plantae**
Super Division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Caryophyllidae
Order	Caryophyllales
Family	Amaranthaceae
Genus	*Achyranthes*
Species	*aspera*

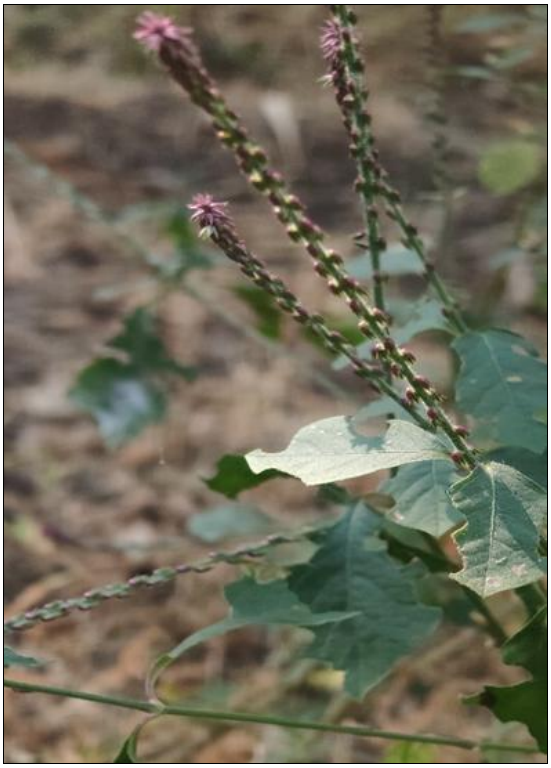

Fig 1: *Achyranthes aspera* L. in their natural habitat

Table 2: Vernacular name of *Achyranthes aspera* L. in different languages

Language	**Vernacular Name(s)**	**Language**	**Vernacular Name(s)**
Sanskrit	Apamarga, Aghata	Bengali	Apang, Uputhlengra
Hindi	Aghara, Latjira, Chirchira, Chirchita	Assamese	Apang
Marathi	Aghada, Agadha	Tamil	Naayuruvi, Nayurivi, Shiru-Kadaladi
Gujarati	Safad Aghedo, Aghedi	Telugu	Antisha, Apamargamu, Uttaraene

3. Geographical distribution

Tropical and Subtropical regions: *Achyranthes aspera* L. is widely distributed across tropical and subtropical areas of Asia, Africa, America and Australia.

Asia: the plant is common throughout India, Sri Lanka, Bangladesh, China, Korea, and the Philippines, and is also found in Pakistan and Myanmar.

Africa and Arabia: Africa is a major center of diversity for the genus, with several native species and varieties. The plant is present across East, West and tropical Africa, as well as the Arabian Peninsula.

Australia and the Americas: It is found in Australia and has been reported in the USA and Central America, often as a weed in distributed habitats.

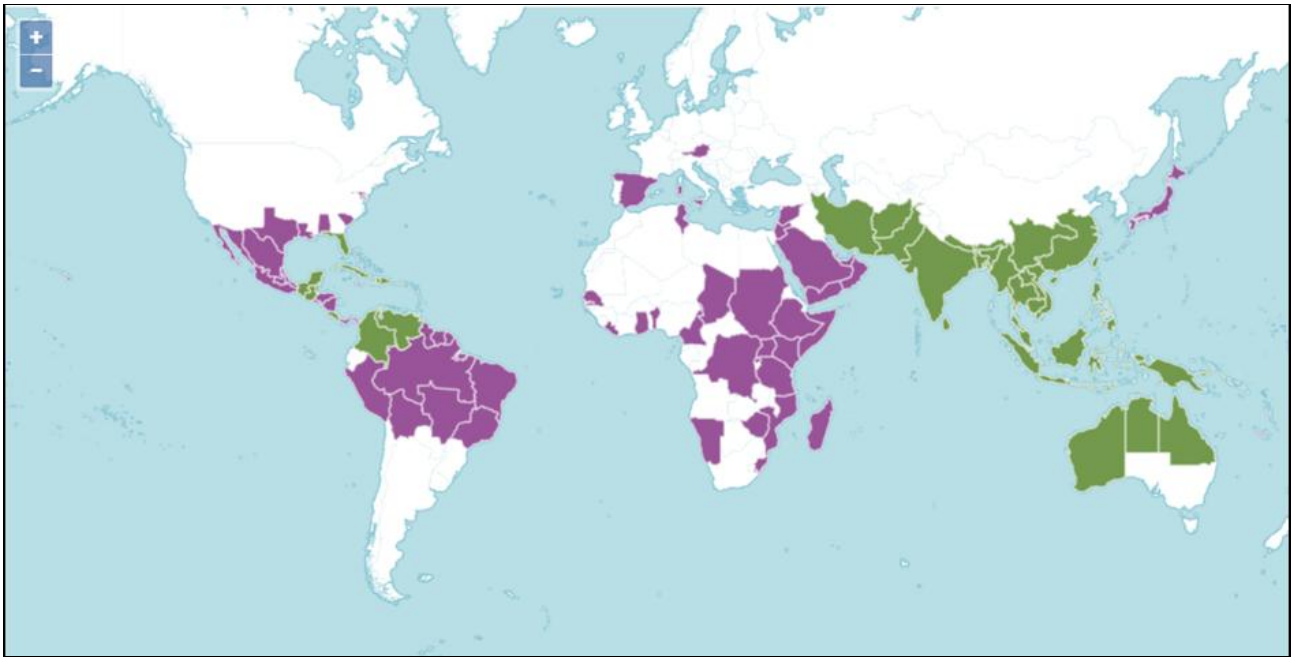

Fig 2: Worldwide distribution of *Achyranthes aspera* L. This map displays the green and purple area for *Achyranthes aspera* L. worldwide distribution. Green area shows the native place of *Achyranthes aspera* L. and in purple are it is introduced. Image is accessed from Plants of the World Online (POWO), Royal Botanic Gardens Kew [11].

4. Botanical description

***Achyranthes aspera* L. as a Firm-Wedge Herb-**

Height: ranging from 0.2 to 2.0 meters. The stem is woody, angular or ribbed, simple or branching, with enlarged nodes that frequently have a pink tint [3, 4].

Root: The roots are cylindrical, 0.1-1.0 cm thick, somewhat ribbed, gradually tapering, and yellowish-brown in color, with secondary and tertiary roots present [12].

Stem: When dry, it is square, firm, hollow, branching, hairy, and yellowish-brown.

Leaf: The leaves are simple, subsessile, somewhat acuminate, estipulate, with wavy margins; obovate, petiolate or elliptic, ovate or broadly rhombate; opposite, decussate, and pubescent due to a dense coat of long, simple hairs. They measure 5-22 cm long and 2-5 cm wide, varying in size. Anomocytic stomata are present on the lower epidermis [13, 14].

Branch: Terete or quadrangular, striate, pubescent branches with thick leaves are present [15].

Flower: The flowers are arranged in long spikes forming inflorescences, measuring 8-30 cm in length and 3-7 mm in width. They are bisexual, greenish-white, numerous, sessile, bracteate with two bracteoles (one spine-lipped), actinomorphic, hypogynous, with five membranous perianth segments, five stamens featuring short filaments and two-celled anthers, and a bicarpellary, syncarpous gynoecium with a superior ovary bearing a single ovule, a style, and a single stigma. The flowers are white or red and appear during summer [13, 16].

Fruit: An indehiscent, persistent, dry utricle with bracteoles enclosing it.

Seed: These have a brown colour, are endospermic, rounded at the base, sub cylindric, and truncate at the apex [12, 14].

Inflorescence: Elongated terminal spikes, which can be up to 60-75 cm long, bearing numerous small, greenish-white, bisexual, sessile flowers [17].

5. Methodology

The present analysis was carried out using a detailed and integrative approach to assess the ethnomedicinal relevance, bioactive substances and their therapeutic applications of *Achyranthes aspera* L. synthesizing information from both scientific and traditional knowledge sources. An analysis involving 50 original papers, 19 review articles, and 4 educational websites was performed. Information was sourced from a range of databases including PubMed, Scopus, Web of Science, SpringerLink, and Google Scholar. Information on bioactive molecules and their pharmacological effects, therapeutic uses of *Achyranthes aspera* L. are systematically compiled.

6. Traditional uses

Achyranthes aspera L. is a medicinal herb utilized for curing of several diseases including COPD, asthma, and cough. It is applicable in treating various medical disorders like oedema, boils, piles, rashes, dropsy, and diuretics. It has also got purgative, laxative, and diuretic effects. Remedy of pneumonia is the boiled extract made of the crushed plant materials. The roots infusion is employed in the treatment of constipation. Toxic snake bites, reptile bites, night blindness and skin ailments are cured by use of the external application of the blossoming buds and seeds with water. A snake bite victim is administered with plant roots mixed with water in paste form till he passes out without losing any of his consciousness [12]. The plant serves as a remedy for rheumatism, scabies, liver conditions, and numerous dermatological issues. It also exhibits sedative effects [3].

6.1 Folk Cure and Customary Applications

Achyranthes aspera L. has a long-standing heritage of application in traditional medicine in curing a diverse range of disorders. Its uses vary between respiratory and skin related disorders, gastro intestinal and even in the treatment of venous bites. The plant is used in different forms such as boiled extracts, infusions, pastes, as well as powders depending on the condition to be treated [18]. Some of the traditional uses and methods of *Achyranthes aspera* L. as medicine are as follows:

Table 3: Traditional uses of *Achyranthes aspera* L. as medicine

Plant part used	Method	Treatment
Whole plants	Boiled in water for 20-30 min.	Renal dropsies, aphrodisiac purposes
	Two tablespoons of the decoction are eaten thrice daily	Beriberi
	Hot water extract administered twice per day	Pneumonia
	Decoction in water taken three times daily	Bronchial infection.
	powder taken two times daily with lukewarm water or milk	arthritis and blindness in cattle.
	Take three times a day (juice)	toothaches.
Root	Boil in water and consume a decoction twice a day	pneumonia.
	Take two teaspoons of powder once at night	astringent effects, digestive issues, night-Stomachic and digestive.
Leaves	twice as strong as water (leaf juice)	syphilitic ulcers.
	leaves Juice mixed with opium taken two times daily with water	Gonorrhoea.
	leaves Juice taken with water bed time	Digestive problems, hemorrhoids, dermatosis.
	leaves Decoction of powdered leaves taken two times daily	Initial stages of diarrhoea.
flower	Crushed flowers paste taken daily	Abnormal menstrual cycle problems.
	Grounded into paste as external use	Snakes and reptiles' bites.
Fruit	Unripe fruits taken three times daily	pulmonary disease
Seed	Raw seeds taken three times daily	Brain Tonic.
	Raw seeds taken two times daily	Bleeding piles.

7. Pharmacological activities

7.1 Antimicrobial properties

The inflorescence-based methanolic extract of *Achyranthes aspera* L. manifested significant antimicrobial activity against Bacillus subtilis and Pseudomonas aeruginosa bacteria and Candida albicans and Alternaria alternate fungi; however, the antifungal activity was also significantly more evident compared to the antibacterial one [19]. The seeds extract of *Achyranthes aspera* L. grown on cow dung manure exhibited antibacterial potential against *Salmonella typhimurium*, *Pseudomonas cichorii*, and *Bacilus subtilis* bacterial strains [20]. An 80% concentrated ethanolic extract of the leaves and stem, at 25 mg/ml, was observed to supress proliferation of *Bacillus subtilis and Staphylococcus aureus* in another investigation [21]. *Achyranthes aspera* L. leaf extract in diethyl ether demonstrated inhibitory activity against *Salmonella sp., Epidermophyton floccosum, Trichophyton rubrum, Trichophyton mentagrophytes, Aspergillus sp., Proteus vulgaris, Klebsiella sp.,* and *Escherichia coli* [22]. Both quantitative and qualitative methods were used to evaluate the antibacterial potential of the finished fabric derived from *Achyranthes aspera* L. against common textile-associated bacteria, including *Staphylococcus aureus*, Gram positive and Gram negative, and *Escherichia coli*. The cotton fabrics that were produced demonstrated bacterial reduction percentages of 92 and 50 against *Staphylococcus aureus* and *Escherichia coli*, respectively [23].

7.2 Anti-oxidants Activity-

Achyranthes aspera L. has a high antioxidant activity in many plant organs (leaves, seeds, roots, stems, and whole plant) and using different methods of extraction. Various researches with the DPPH, ABTS, FRAP, and other assays reveal high levels of free radical scavenging and reducing power and some extracts have an IC50 value equal or nearly lesser than ascorbic acid. Different phytochemicals are found in *Achyranthes aspera* L. that have high antioxidant activity such as quercetin, myricetin, caffeic acid, ferulic acid, and gentisic acid [24, 25, 26].

The *Achyranthes aspera* L. seed extract was found significant antioxidant activity as shown by DPPH radical scavenging activity of the extract with an IC50 of 26.586 µg/mL, ABTS radical scavenging activity with an IC50 of 28.2641 µg/mL and H2O2 radical scavenging activity with an IC50 of 15.7931 µg/mL [26]. The methanolic extract derived from the stem and leaves of *Achyranthes aspera* L. demonstrates strong antioxidant capabilities, as indicated by an IC50 value of 30.5 µg/ml obtained from a radical scavenging assay [27].

7.3 Anti-cancer activity

Plant possess various phytochemicals that exhibit anticancer properties, demonstrating their efficacy by not only hindering the growth and proliferation of cancer cells but also by directly inducing cell death in tumour cells. The whole methanolic extract showed very strong anticarcinogenic activity (76%) in the *in vivo* two-stage mouse skin carcinogenesis test [28]. It was shown that the non-alkaloid components of the plant may have anticancer properties. The leaves extracted in methanol showed inhibitory activity against human pancreatic cancer cells, suggesting that they had anti-proliferative and anti-cancer potential. Preliminary mechanistic studies suggested that the leaf extract significantly suppressed the transcription of metalloproteases (MMP-1 and MMP-2), their inhibitors (TIMP-2), and angiogenic factors (VEGF-A and VEGF-B) in pancreatic cancer cells (MiaPaCa-2) [29]. Further research indicates that the methanolic extract of *Achyranthes aspera* L. demonstrates cell lysis against several human cancer cell lines, including AGS, MCF-7, A549, and COLO 320 DM, with varying IC50 values depending on exposure duration [30]. Cytotoxicity screening of extract demonstrated a heightened anti-proliferative effect of the water-based extract of *Achyranthes aspera* L. on COLO-205 cells. A

series of events that were typified by apoptosis had a considerable decrease in cell viability, condensation of chromatin and fragmentation of DNA in the extract treated cells. The level of mRNA expression of caspase-9, caspase-3, Bax, p16, p21, and p27 was markedly increased in the extract treated cells and the level of Bcl-2 significantly minimized [31]. The research demonstrated that methanol derived leaf extract of *Achyranthes aspera* L. significantly inhibited cell proliferation, reduced mitochondrial membrane potential, altered morphological structure, and induced apoptosis. Moreover, the methanol derived leaf extract of *Achyranthes aspera* L. seemed to promote the release of cytochrome c by altering Bcl-2 family proteins, which subsequently activated caspase-9 and -3, resulting in the induction of cell apoptosis. Simultaneously, in DL cells exposed to methanol-derived leaf extract of *Achyranthes aspera* L., the protein kinase Cα pathway was inhibited in a concentration-dependent manner [32].

7.4 Anti-Inflammatory activity

The methanolic extract derived from the aerial parts of *Achyranthes aspera* L. has shown considerable anti-inflammatory properties by effectively diminishing inflammation caused by different agents [33]. To illustrate, ethanol extracts of *Achyranthes aspera* L. effectively inhibited both acute and chronic inflammatory responses in mice and rats at doses ranging from 100 to 200 mg/kg, specifically addressing carrageenan- and Freund's complete adjuvant-induced models [33]. This anti-inflammatory mechanism operates by suppressing pro-inflammatory mediators and cytokines, leading to less swelling and a decrease in leukocyte infiltration at the inflammation site [16].

The anti-inflammatory properties of *Achyranthes aspera* L. are linked to various phytochemicals, particularly α-spinasterol, saponins, flavonoids, tannins, and triterpenoids. Isolated from the plant, α-spinasterol effectively lowers pro-inflammatory cytokines (IL-6, TNF-α, PGE2), inhibits the COX-2 and 5-LOX enzymes, and influences critical signaling pathways by inhibiting NF-κB and activating Nrf2/HO-1, which results in reduced inflammation in cellular models [34].

An alcohol extract of *Achyranthes aspera* L. administered at 375 mg/kg and 500 mg/kg showed maximum edema inhibition in the carrageenan-induced rat paw edema model, achieving 65.38% and 72.37% reductions, respectively, at the end of 3 hours [35].

7.5 Anti-Dandruff Activity

Achyranthes aspera L. has been assessed for its potential as an anti-dandruff treatment, with research demonstrating the effectiveness of its extracts in suppressing fungal proliferation linked to scalp disorders. Clinical studies have evaluated the efficacy of a polyherbal hair conditioner that contained the methanol leaf extract of *A. aspera*. It was demonstrated that coumarin, a component identified in the crude extract of *A. aspera*, is effective in reducing dandruff scales and inhibiting the growth of *Pityrosporum ovale* (now known as *Malassezia furfur*), a fungus often linked to dandruff [12, 36] .The ethanolic extract obtained from *Achyranthes aspera* L. leaves shows notable antifungal efficacy against typical fungi that cause dandruff, particularly Candida albicans [37].

7.6 Anti-diabetic activity

Numerous research studies indicate that extracts of *Achyranthes aspera* L. (including aqueous, methanolic, ethanolic, and preparations from roots and seeds) substantially lower blood glucose levels in diabetic rats and mice induced by alloxan and streptozotocin. The administration of aqueous extracts from A. aspera significantly reduces blood glucose levels, comparable to the standard anti-diabetic medication metformin (1 mg). Furthermore, the extract demonstrates a notable increase in glucokinase activity when compared to untreated diabetic rats [38]. The fraction of ethyl acetate dissolved from the methanolic extract of *Achyranthes aspera* L. (EAAA) has been evaluated for its anti-hyperglycemic effects in rats that were induced with streptozotocin. The administration of EAAA shows a significant effect on hyperglycemia induced by streptozotocin, as it increases serum insulin levels and GLUT2 levels, thus improving the functionally of β cells in diabetic rats induced by streptozotocin [39].

The investigation into the anti-diabetic properties of three distinct cytotypes (diploid, tetraploid and hexaploid) and two morphotypes (obovate and ovate) of *Achyranthes aspera* L. was conducted using alloxan-induced diabetic Swiss albino male rats. The findings revealed that the diploid cytotype displayed the most significant anti-diabetic activity. Among the two morphotypes, the obovate-leaf morphotype demonstrated a more pronounced effect when compared to the ovate-leaf morphotype. UPLC analysis revealed that the diploid cytotype possessed the highest concentration of the active compound oleanolic acid, succeeded by the tetraploid and hexaploid cytotypes [40].

7.6 Activity against cardiac disease

Achyranthes aspera L. contains a wealth of bioactive compounds, including saponins, flavonoids, and alkaloids, which demonstrate considerable antioxidant and anti-inflammatory properties. These characteristics are crucial in combating cardiovascular diseases (CVDs) that are affected by oxidative stress and chronic inflammation [27, 41]. Additionally, pre-treatment with A. aspera extracts ameliorates drug-induced dyslipidemia and cardiotoxicity, further supporting its protective role in cardiac health [42].

The plant has demonstrated cardiovascular effects, with achyranthine, a water-soluble alkaloid obtained from *Achyranthes aspera L.*, exhibiting the potential to decrease blood pressure and heart rate, while also dilating blood vessels and augmenting both respiratory rate and amplitude in experimental models [33, 43]. Saponins extracted from the seeds of *Achyranthes aspera* L. which exhibit antihyperlipidemic and antioxidant characteristics, led to a substantial decrease in total cholesterol, total triglycerides, and LDL-C, alongside a notable increase in HDL-C levels in hyperlipidemic rats over a four-week oral administration period, thereby improving the serum lipid profile and blood antioxidant levels [44].

8. Phytochemical diversity

The rich phytochemical diversity of *Achyranthes aspera* L. features a variety of compounds such as alkaloids, flavonoids, saponins, and phenolics, contributing to its broad spectrum of pharmacological properties [45, 46]. Among these, achyranthine, a water-soluble alkaloid, has been distinctly isolated and recognized as a significant factor in the cardiovascular effects of the plant, which encompass

vasodilation and hypotension [43, 16]. Additional significant secondary metabolites, including ecdysterone, oleanolic acid, and several glycosides, further highlight the therapeutic potential of the plant by demonstrating a variety of bioactivities, such as anti-inflammatory and anti-diabetic effects [5]. Collectively, these phytochemicals support the traditional uses of the plant as an analgesic, anti-periodic, diuretic, and hepatoprotective agent, illustrating its diverse pharmacological properties [33, 47].

8.1 Alkaloids

The leaves of *Achyranthes aspera* L. were subjected to ethanol extraction, which revealed the presence of the alkaloid betaine and achyranthine. Furthermore, the application of hexane, chloroform, ethyl acetate, and methanol extracts from the leaves resulted in the identification of 27-cyclohexyheptacosan-7-ol, 16-hydroxy-26-methylheptacosan-2-one, and 4-pentatriacontanol, while methanol and water extracts provided isobetanin and betanin. Additionally, cuscohygrine was isolated from the extracts of leaves, roots, and stems using ethyl acetate, acetone, ethanol, and methanol [3, 13].

8.2 Flavonoids

Several flavonoids have been identified in *Achyranthes aspera* L. Eupatorine was detected in ethyl acetate, acetone, ethanol, and methanol extracts. Quercetin, kaempferol, and chrysin were isolated from the aqueous extract. The ethyl acetate fraction of *A. aspera* seeds yielded the bioactive flavonoid 6-prenyl apigenin. Quercetin-3-O-D-galactopyranoside was identified using TLC, followed by HPTLC analysis of methanol and water extracts. Taxifolin and the 7ethyl acetate fractions provided rutin, kaempferol-3-O-glucoside, isoquercetin, apigenin-7-O-hexuronide-4'-O-rhamnoside, kaempferol-3-O-neohesperidoside, kaempferol-3-O-rutinoside, and tiliroside. Methanolic extracts of leaves and roots also yielded quercetin [3, 13, 48].

8.3 Saponins

Achyranthes aspera L. leaves and roots aqueous extract contained bisdesmosidic saponin. The methanolic extract of *Achyranthes aspera* L. contained β-D glucopyranosyl 3-(O-β-D-glucopyranosyl oxy)-oleanolate and β-D galactopyranosyl (1→2)-oleanolate. Chikusetsu saponin-IV, a butyl ester, zingibroside R1, bidentatoside, bidentatoside II, and momordin Ib were recovered from the aqueous and acetonitrile extracts of *Achyranthes aspera* L. Gas chromatography and mass spectroscopy revealed sapogenin [49].

8.4 Terpenoids and Steroid

β-sitosterol and spinasterol were detected in *Achyranthes aspera* L. leaf extracts prepared with hexane, chloroform, ethyl acetate, and methanol [49]. Aspera extract included 6b, 11b, 16a, 4a, 21-pentahydroxy pregna-1, 4-diene-3, 20 dione 16, 4-acetonide (terpene), 3-Deoxy-3-azido -25-hydroxyvitamin D3 (secosteroid), and 3-Hydroxy lidocaine glucuronide (steroid). Aspera leaf and root aqueous solutions yielded an ecdysterone [50]. The extracts from *Achyranthes aspera* L. comprised beta-ecdysone, 20, 26-dihydroxyecdysone, stachysterone D, and inokosterone (20, 22-O-(Rethylidene) inokosterone as well as (25S)-inokosterone-20, 22-acetonide (19S). A. Aspera generated ecdysone, nerol, spathulenol, spinasterol, and β-sitosterol. HPLC detected lupeol and beta-sitosterol using toluene, ethyl acetate, and formic acid (9:1:0.1). From petroleum ether, achyrantheric, corrosolic, and ursolic acids were separated. From methanol, 20-ydroxyecdysone was isolated [51].

8.5 Phenolic substances

Extracts from *Achyranthes aspera* L. exhibited the following phenolic acids: gallic, vanillic, ferulic, isoferulic, protocatechuic, syringic, salicylic, gentisic, *p*-coumaric, trans-cinnamic, *p*-hydroxybenzoic, chlorogenic, sinapic, and caffeic acids [52]. Additional phenolic compounds were isolated and identified, including salicylic acid-O-hexoside, 4-caffeoylquinic acid, 4,5-dicaffeoylquinic acid, 3,5-dicaffeoylquinic acid, 3,4,5-tricaffeoylquinic acid, protocatechuic acid, and chlorogenic acid. The methanol extract of *Achyranthes aspera* L. yielded methyl caffeate. Behenic and myristic acids were also found, while *Achyranthes aspera* L. contains the phenylpropanoid asaron. Proanthocyanidin was separated from the roots and inflorescences of *Achyranthes aspera* L. using benzene, petroleum ether, chloroform, ethyl acetate, ethanol, and water [5, 49, 52, 53].

Table 4: Notable phytochemicals and their Therapeutic actions

S.N.	Phytochemical Name	Chemical Class	Main Therapeutic Potentials	Citations
1.	Achyranthine	Alkaloid	Vasodilatory, antihypertensive, anti-inflammatory	[5, 54]
2.	Apigenin	Flavonoid	Antioxidant, anti-inflammatory, neuroprotective	[5, 54]
3.	Betaine	Alkaloid	Hepatoprotective, metabolic support	[5, 54]
4.	Corosolic acid	Triterpenoid	Antidiabetic, anticancer	[5, 54]
5.	Ecdysterone	Steroid	Adaptogenic, anti-arthritic, metabolic regulation	[5, 54]
6.	Ferulic acid	Phenolic acid	Antioxidant, anti-inflammatory, anti-diabetic	[25]
7.	n-Hexadecanoic acid	Fatty acid	Antioxidant, antimicrobial	[19, 26]
8.	Oleanolic acid	Triterpenoid	Anti-inflammatory, antidiabetic, antirheumatic	[5, 55, 54]
9.	Saponins	Glycosides	Antimicrobial, anti-inflammatory, immunomodulatory	[5, 54]
10.	Stigmasterol	Phytosterol	Antimicrobial, anti-inflammatory	[19]
11.	Ursolic acid	Triterpenoid	Anticancer, anti-inflammatory	[5, 54]
12.	α-Spinasterol	Phytosterol	Potent anti-inflammatory (NF-κB, Nrf2/HO-1 mod.)	[34]

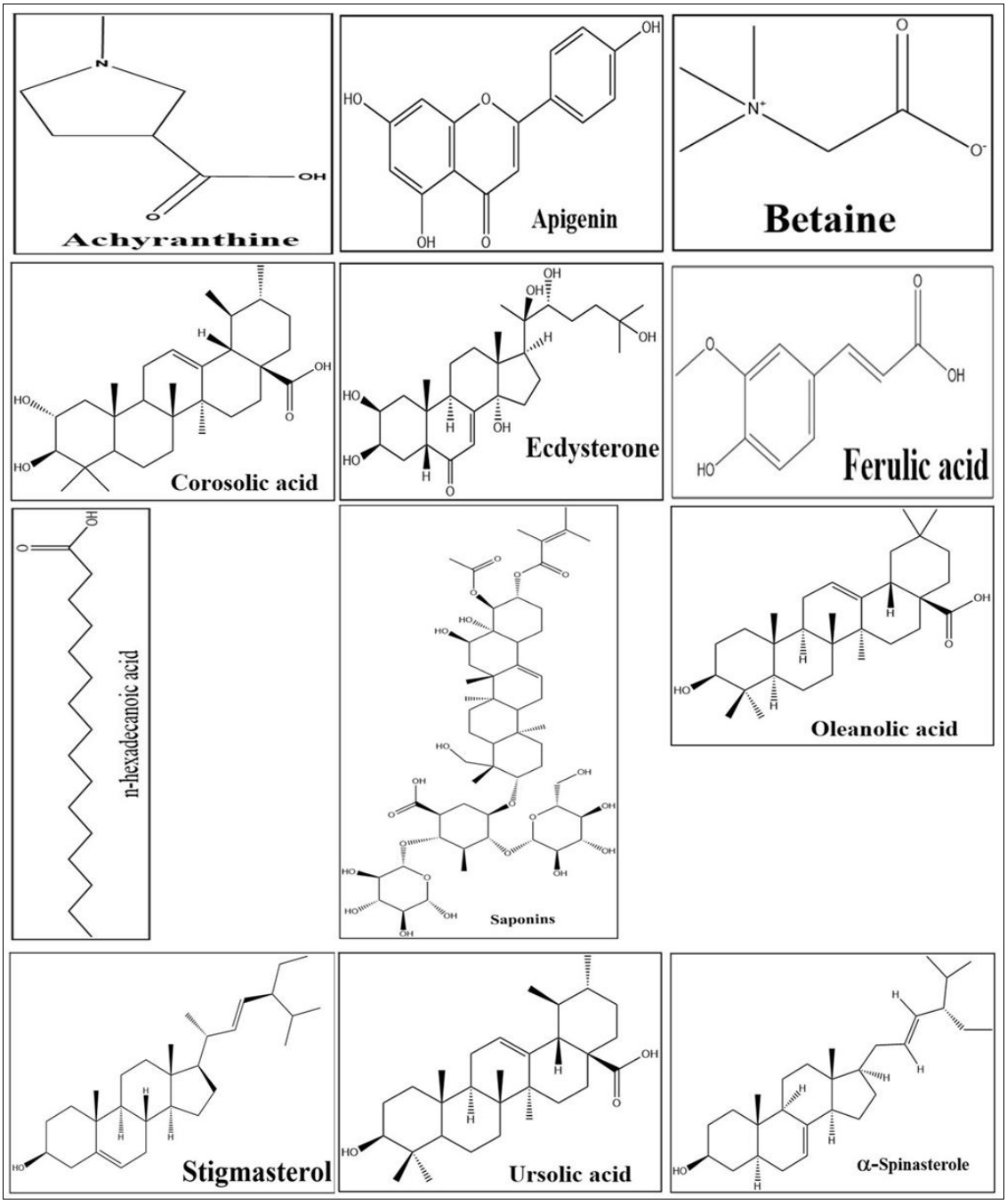

Fig 3: Phytochemicals of *Achyranthes aspera* L.These phytochemicals contain numerous pharmacological potentials, including anti-inflammatory, anti-cancer, anti-diabetic, hepatoprotective, anti-oxidant, and antimicrobial

9. Conclusion

Achyranthes aspera L., known as "Apamarg," is a vital medicinal plant with a rich history in traditional medicine for diverse ailments. This review highlights its therapeutic significance by integrating ethnobotanical wisdom with scientific validation of its phytochemical profile and pharmacological activities. The plant is abundant in alkaloids, flavonoids, saponins, tannins, glycosides, and terpenoids, which are responsible for its wide range of reported benefits. Scientific investigations affirm its powerful analgesic, anti-inflammatory, and antioxidant attributes, along with significant antimicrobial action against bacteria and fungi. Moreover, *Achyranthes aspera* L. reveals potential anti-cancer, anti-diabetic (notably through D-pinitol), and cardiovascular effects, which include the regulation of blood pressure and cardiotonic functions. While these discoveries emphasize its therapeutic capabilities, additional rigorous studies, encompassing extensive clinical trials, detailed toxicological analyses, accurate mechanistic explanations, and extract standardization, are imperative. Such endeavors will support the thorough integration of *Achyranthes aspera* L. into modern medical practices, offering effective and accessible natural health solutions.

10. Authors' contributions

Ashish Patel has written the whole manuscript. Ashish Patel carried out the conceptualization, literature review, data collection and analysis. Literature review and editing, biochemical structure prepared by Ranjeet Kumar and provided technical support to write the manuscript. Devendra Kumar Patel supervised the writing of the

manuscript in a proper format and approved the final manuscript. All authors read and approved the final.

11. Conflict of Interest

Authors do not have any conflict of interests to declare.

12. Acknowledgements

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