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(REVIEW ARTICLE)

A comprehensive review on phytochemistry of *Achyranthes aspera* Linn.: An Indian medicinal plant

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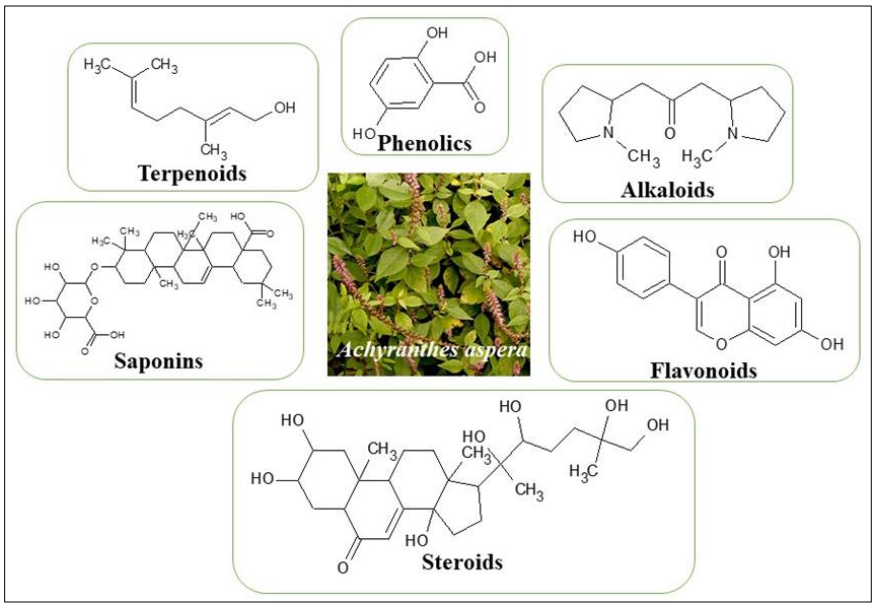
Abstract

Medicinal plants have been used as a source for medicine since ancient times. They have always been at the frontline in all cultures of civilization. They are rich sources of phytochemicals and from these phytochemicals may of the modern medicines are discovered. *Achyranthes aspera* is an erect perennial herb that comes under the family Amaranthaceae. *A. aspera* is a bitter plant that consists of secondary metabolites such as alkaloids, saponins, tannins, flavonoids, glycosides, steroids, essential oil and fatty acids that play a significant role in exhibiting increased bioactivity against a variety of diseases. The phytoconstituents are present in various parts of the plant including seeds, roots, shoots and leaves. The main focus of this present review is to highlight the various types of secondary metabolites from *A. aspera*, which have a great potential for the development of effective therapeutics.

Graphical abstract



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Keywords: *Achyranthes aspera*; Amaranthaceae; Phytochemistry; Secondary metabolites

1. Introduction

Natural resources are the essential wealth of the nation and provide fundamental health-related services to human beings. Around 30% of the population relies on plants as a source of food and medicine since ancient days. Nearly 35,000-70,000 plant species are used for medication worldwide. Secondary metabolites such as alkaloids, flavonoids, glycosides, phenol, phlobatannin, tannins, terpenoids, volatile oils and other metabolites improve the effectiveness of plants in treating a variety of disorders, ranging from minor headaches to life-threatening diseases. These plant-based medicines are cheap and safer for human beings than modern synthetic medicines [1, 2].

Achyranthes aspera belongs to the family Amaranthaceae, an important Indian medicinal plant distributed in the tropical and subtropical regions of India. Almost all the parts including the leaves, seeds and roots of the plant are highly responsible for its medicinal uses. It is traditionally used in treating asthma, cough, diarrhea, dropsy, dysentery, piles, rheumatism, scabies, skin diseases and snake bites. Achyranthine, a water-soluble alkaloid present in *A. aspera* is highly responsible for dilation of blood vessels, cardiac depression, blood pressure reduction and increasing the amplitude and rate of respiration [3-5].

A wide range of literature surveys was performed and we found that a review article in 2017, reported the phytochemistry and pharmacological activities of the entire genus *Achyranthes* [6]. Rafia rehman et al., in 2018 published a review that is mainly focused on the pharmacognostical aspects of *A. aspera* [7]. This review aims to provide a summary of existing knowledge on phytochemistry of the Indian medicinal plant, *A. aspera* and to critically analyze the reported studies. The present review focused on the collection of data from 2011-2021 from standard literature that are indexed in ScienceDirect, PubMed, Springer, Google Scholar, ResearchGate and EMBASE databases using the keyword *A. aspera.*

2. Plant Profile

Achyranthes aspera is an erect perennial herb belonging to the family Amaranthaceae. It is widely distributed throughout the world, particularly in the tropical countries. In India, it is predominantly grown on the wasteland and on the edges of cultivated land as a weed. Various parts including leaves, roots and seeds were used for therapeutic purposes. *A. aspera* is widely used as an abortifacient, expectorant, emetic and used in the treatment of renal dropsy, piles, stomach ache, skin eruptions, diarrhea, dysentery, stimulating labor pain, nose-bleeding, snake-bites, asthma, gonorrhea, wound healing, cancer and menorrhagia [3, 4, 8, 9].

3. Ethnopharmacology

Achyranthes aspera have been used for various types of ailments in traditional and folk medicine. Ethnopharmacological claims revealed that *A. aspera* played a major role in treating a large number of diseases from ancient days. It is used in the traditional system of medicine in many countries. In India, it is used in the treatment of asthma, abdominal tumor, hemorrhoids, gynecological disorders, ophthalmia, odontalgia, snake bites and in wound healing. In Bangladesh, it is used for the treatment of injured skin and abdominal tumor. In Kenya, it is also used in relieving malarial symptoms. In Sri Lanka and Pakistan, it is used for cardiac edema, dermatological disorders, diabetes mellitus and renal edema. In South Korea, *A. aspera* is used in treating arthritis, contraception, delayed menses, induced absorption and osteoarthritis [6, 8].

4. Phytochemistry

In *A. aspera*, the presence of secondary metabolites including alkaloids, terpenoids, proteins, tannins, saponins, phenolic compounds, phytosterol, cardiac glycosides, carbohydrates, amino acids, anthraquinones, steroids, reducing sugars, fatty acids, glycoproteins, volatile oil, proanthocyanidins, anthocyanidins, anthocyanins, carotenoids, coumarins, anthracenes and some other constituents are reported and they playing a major role in exhibiting greater bioactivity against various diseased conditions [9, 10].

4.1. Alkaloids

Achyranthine and betaine alkaloids were identified from the ethanolic extract of the leaves of *A. aspera* [11, 12]. From the leaves extract of *A. aspera*, 27-cyclohexyheptacosan-7-ol, 16-hydroxy-26-methyl heptacosan-2-one, 17-

pentatriacontanol using hexane, chloroform, ethyl acetate and methanol extracts. Isobetanin and betanin were isolated using methanol and water (9:1) with HPLC analytical technique [13-16]. Using ethyl acetate, acetone, ethanol and methanol extracts, Cuscohygrine was extracted from the leaves, roots and stem of *A. aspera* [17]. The structures of alkaloids from *A. aspera* are given in Fig.1

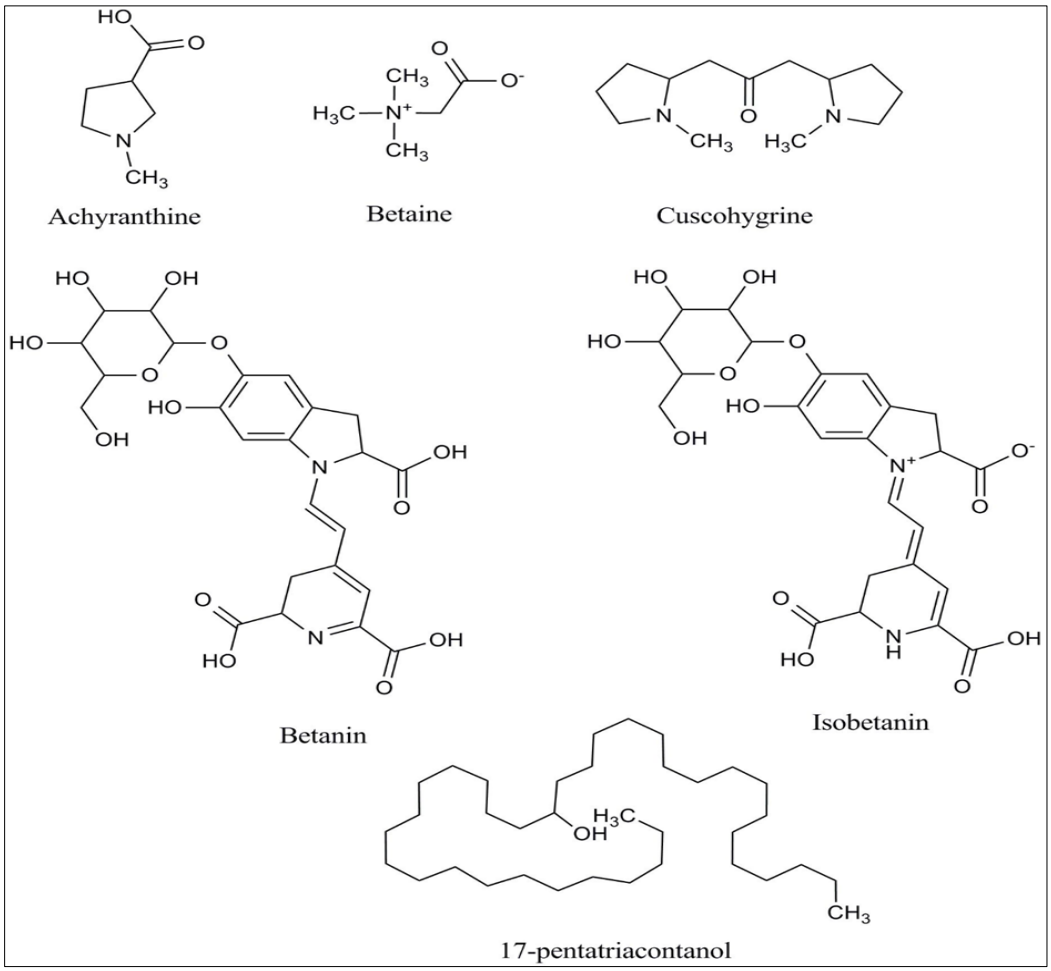

Figure 1 Structures of alkaloids from *A. aspera*

4.2. Flavonoids

Eupatorin was identified using the various extracts namely ethyl acetate, acetone, ethanol and methanol [17]. Narayan and co-workers identified chrysin, quercetin and kaempferol from the aqueous extract of the plant [18]. 6-prenyl apigenin, a bioactive flavonoid obtained from the ethyl acetate fraction of seeds of *A. aspera* [19]. Taxifolin and isoflavone namely genistein were isolated from the methanolic extract [20]. Quercetin-3-O-β-D-galactopyranoside was identified using TLC followed by the HPTLC technique using methanol and water extract [21]. Using dichloromethane and ethyl acetate fractions, rutin, kaempferol-3-O-glucoside, isoquercetin, apigenin-7-O-hexuronide-4'-O-rhamnoside, kaempferol-3-O-neohesperidoside, kaempferol-3-O-rutinoside, and tiliroside were isolated [22]. The methanolic extract of leaves and roots of *A. aspera* were used to isolate quercetin [23]. The structures of flavonoids are given in Fig. 2.

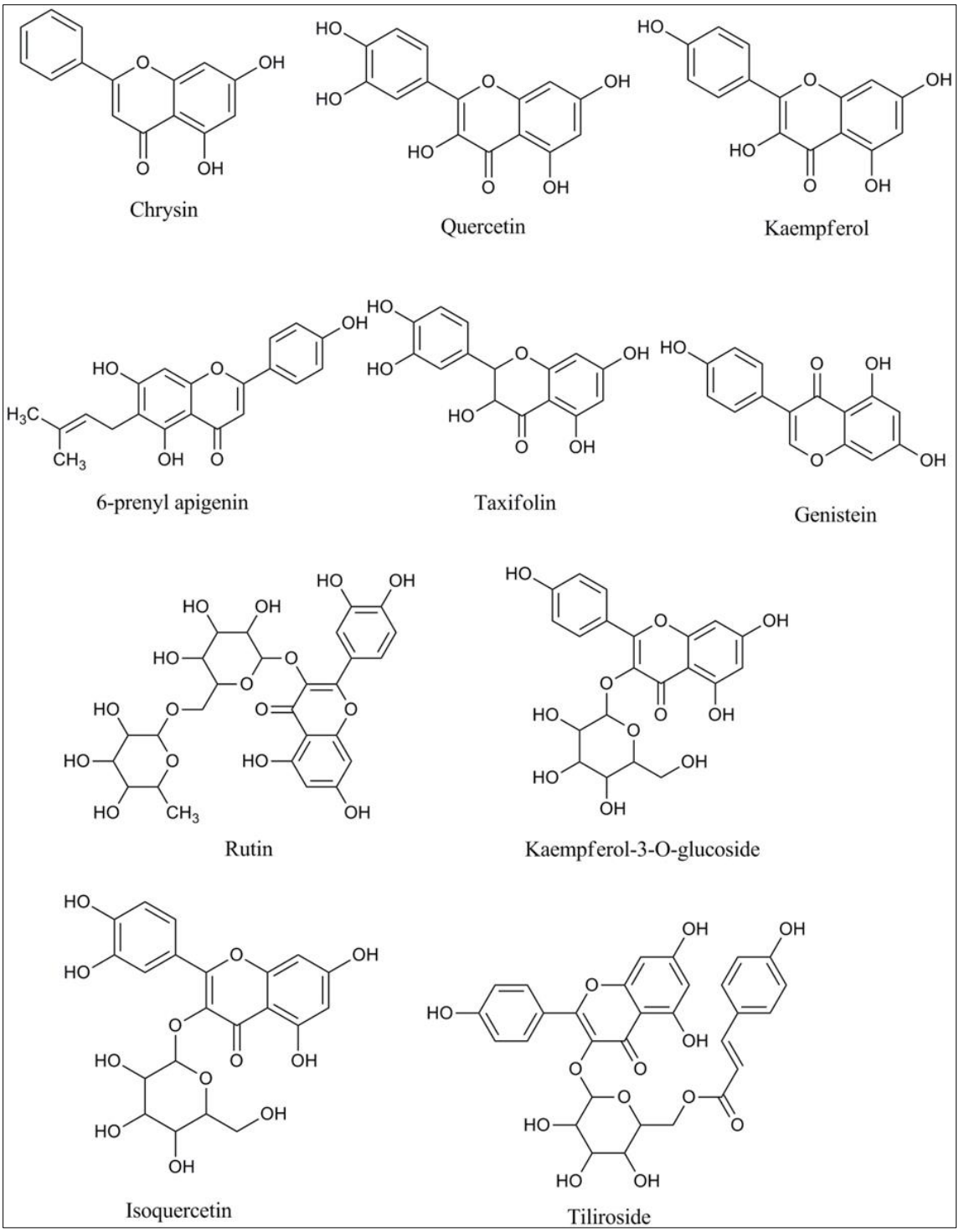

Figure 2 Structures of flavonoids from *A. aspera*

4.3. Saponins

Bisdesmosidic saponin was identified from the aqueous extract of leaves and roots of *A. aspera* [24]. β-D-Glucopyranosyl 3-(O-β-D-glucopyranosyl oxy)-oleanolate and β-D-Glucopyranosyl 3-(O-β-D-galactopyranosyl (1→2)(O-β-D-glucopyranosyl oxy)-oleanolate were identified from the methanolic extract of *A. aspera* [25]. Chikusetsu saponin-IV a butyl ester, zingibroside R_1, bidentatoside, bidentatoside II and momordin Ib were isolated from the aqueous and acetonitrile extracts of the plant *A. aspera* [26]. Sapogenin was identified using gas chromatography and mass spectroscopic analytical techniques [27]. The structures of saponins from *A. aspera* are given in Fig. 3.

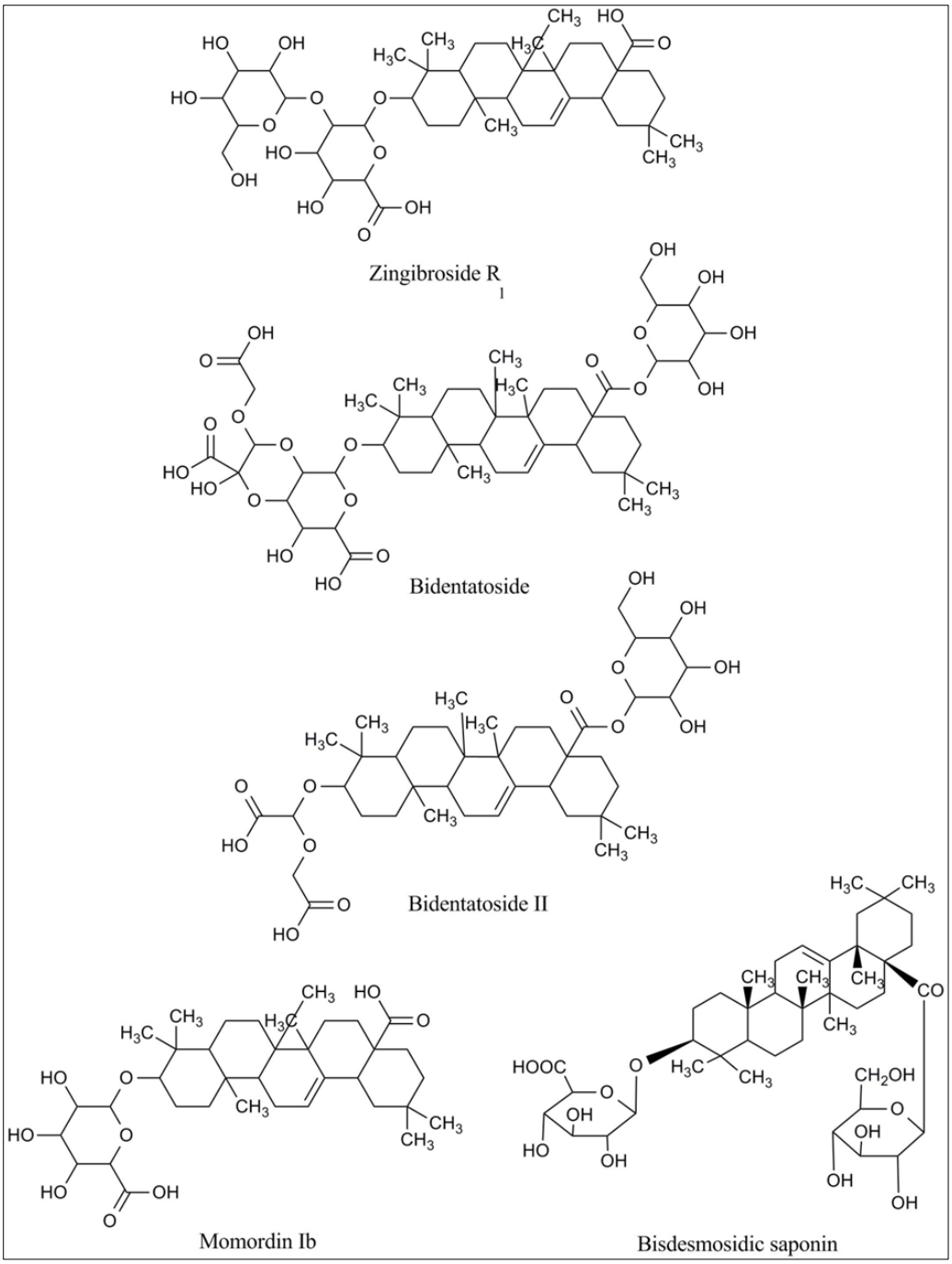

Figure 3 Structures of saponins from *A. aspera*

4.4. Terpenoids and Steroids

β-sitosterol and spinasterol were identified from the leaves of *A. aspera* using hexane, chloroform, ethyl acetate and methanol extracts [15]. 6b, 11b, 16a, 17a, 21-pentahydroxy pregna-1, 4-diene-3, 20 dione 16, 17-acetonide (terpene), 3-Deoxy-3-azido-25-hydroxyvitamin D3 (secosteroid) and 3-Hydroxy lidocaine glucuronide (steroid) were identified from the extract of *A. aspera* [17]. An ecdysterone was isolated from aqueous preparations of leaves and roots of *A. aspera* [24]. Beta-ecdysone, 20, 26-dihydroxyecdysone, stachysterone D, (25S)-20, 22-O-(Rethylidene) inokosterone, and (25S)-inokosterone-20, 22-acetonide were reported from the extracts of *A. aspera* [26]. Nerol, spathulenol (terpenoid), spinasterol, β-sitosterol, ecdysone (steroids) were reported from *A. aspera* [27]. Using HPLC analytical technique, a steroid namely β-sitosterol and terpenoid namely lupeol using toluene, ethyl acetate and formic acid (9:1:0.1) were identified [28,29]. From the extract of petroleum ether, terpenoids namely achyrantheric acid, corrosolic acid and ursolic acid were isolated [30]. From the methanolic extract, 20-hydroxyecdysone was isolated [31]. The structures of terpenoids and steroids from *A. aspera* are given in Fig. 4.

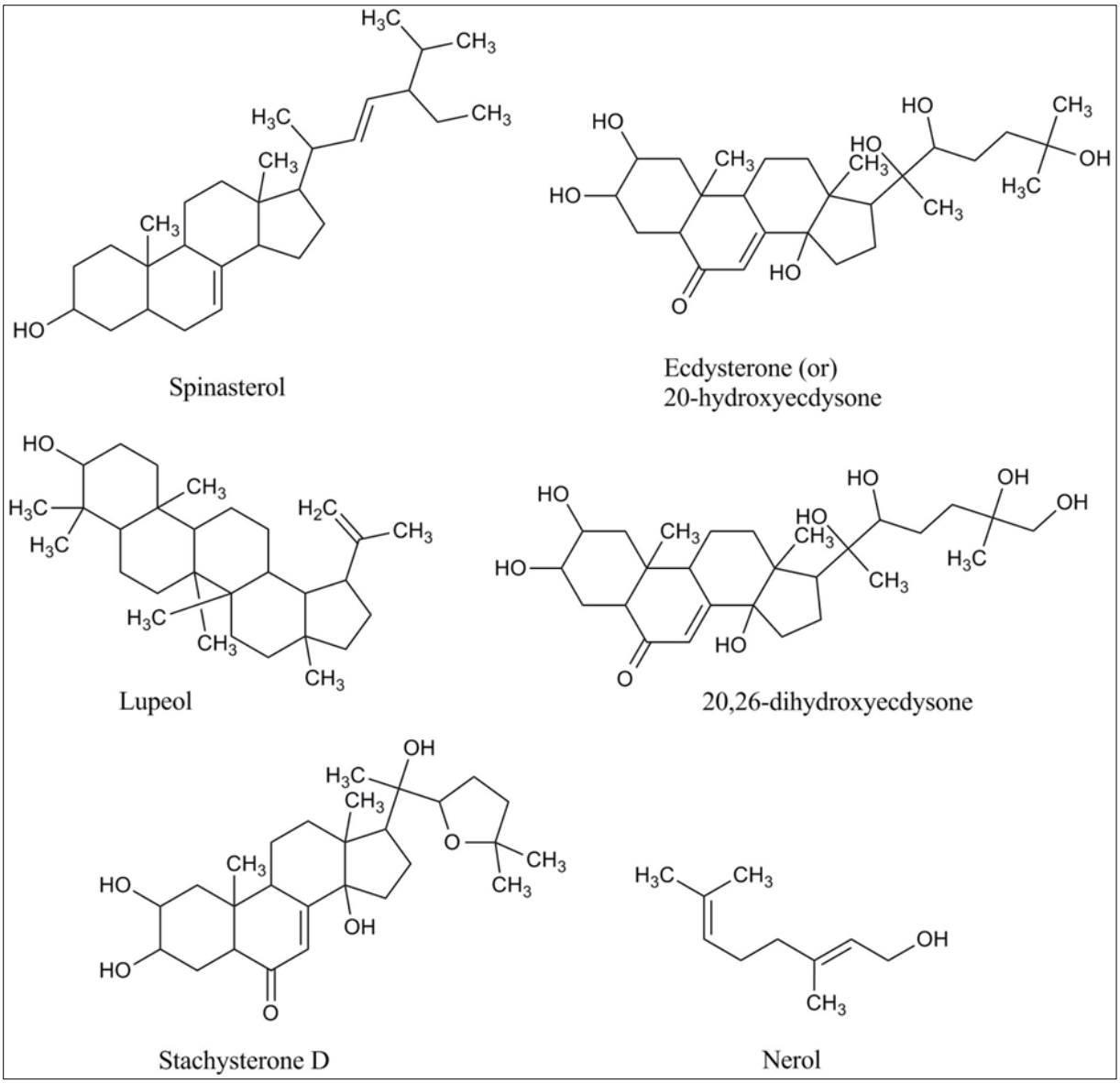

Figure 4 Structures of terpenoids and steroids from *A. aspera*

4.5. Phenolic compounds

Phenolic acids namely gallic acid, vanillic acid, ferulic acid, isoferulic acid, protocatechuic acid, syringic acid, salicylic acid, gentisic acid, p-coumaric acid, trans-cinnamic acid, p-hydroxybenzoic acid, chlorogenic acid, sinapic acid and caffeic acid were identified from various extracts of *A. aspera* [20]. Other phenolic compounds namely protocatechuic acid, salicylic acid-O-hexoside, chlorogenic (5-caffeoylquinic) acid, 4-caffeoyl quinic acid, 4,5-dicaffeoyl quinic acid, 3,5-dicaffeoyl quinic acid and 3,4,5-tricaffeoyl quinic acid were isolated and identified [22]. Methyl caffeate was isolated from methanol extract of *A. aspera* [25]. Phenolic acids namely behenic acid and myristic acid were also identified [26]. The presence of phenylpropanoid namely asaron was identified in the plant *A. aspera* [27]. Polyphenol namely proanthocyanidin was identified from the roots and inflorescences extracts of *A. aspera* using various solvents including petroleum ether, benzene, chloroform, ethyl acetate, ethanol and water [32]. The structures of phenolic compounds are given in Fig. 5.

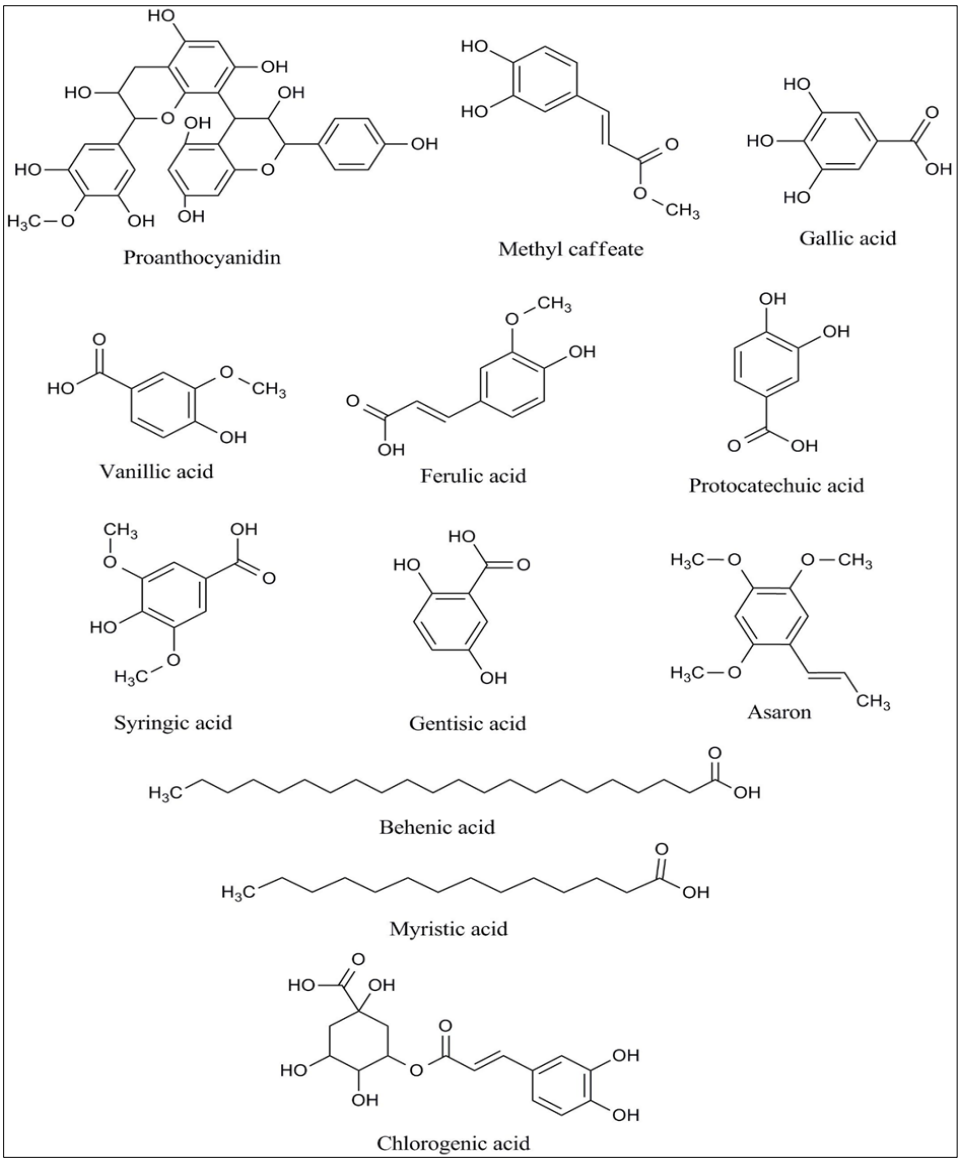

Figure 5 Structures of phenolic compounds from *A. aspera*

4.6. Fatty acids

Omidiani and co-workers identified the presence of fatty compounds including 10-keto tridecanoic acid, N-(2-hydroxy ethyl) icosanamide, N-(3-oxo-octanoyl)-homoserine lactone (fatty acyl), 2E, 4Z, 6Z, 8Z-Decatetraenedionic acid, N-(2-hydroxy ethyl) oleamide, docosanedioic acid and hexacosanedioic acid (fatty acid) [17]. Sinan and co-workers identified 32 number of fatty acids namely azelaic acid, undecanedioic acid, dodecenedioic acid (traumatic acid), dodecanoic acid (lauric acid), linolenic acid, 8-hydroxy-9,11,13-heptadecatrienoc acid, 12-hydroxy-6-heptadecenoic acid, 9-hydroxy-10,11,13,15-octadecatetranoic acid, 13-hydroxy-9,11,15-octadecatrienoic acid, 15-hydroxy-9,11,13-octadecatrienoic acid, 13-hydroxy-9,11-octadecadienoic acid, 9-hydroxy-7-octadecenoic acid, 15-hydroxy-9-oxo-10,12,14-octadecatrienoic acid, 14-hydroxy-9-oxo-11,13,15-octadecatrienoic acid, 9,10-dihydroxy-12,14,16-octadecatrienoic acid, 9,10-dihydroxy-11,13,16-octadecatrienoic acid, 9,10-dihydroxy-12,15,16-octadecatrienoic acid, 11,12-dihydroxy-9,14,15-octadecatrienoic acid, 15,16-dihydroxy-9,12-octadecadienoic acid, 9,10-dihydroxy-12,14-octadecadienoic acid, 9,10-dihydroxy-10,13-octadecadienoic acid, 12,13-dihydroxy-9-octadecenoic acid, 9,10-dihydroxy-12-octadecenoic acid, 9,10-dihydroxy-octadecanoic acid, 9,10,13-trihydroxy-11,15-octadecadienoic acid, 9,12,13-trihydroxy-10,15-octadecadienoic acid, 11,12,15-trihydroxy-9,12-octadecadienoic acid, 11,12,13-trihydroxy-9,12-octadecadienoic acid, 9,10,15-trihydroxy-12,15-octadecadienoic acid, 11,12,15-trihydroxy-9,12-octadecadienoic acid, 9,10,13-trihydroxy,12-octadecenoic acid and 9,12,13-trihydroxy,10-octadecenoic acid [22]. Palmitic acid, oleic acid (monosaturated fatty acid) and linoleic acid (polyunsaturated fatty acid) were identified [28]. The structures of fatty acids identified from *A. aspera* are given in Fig. 6.

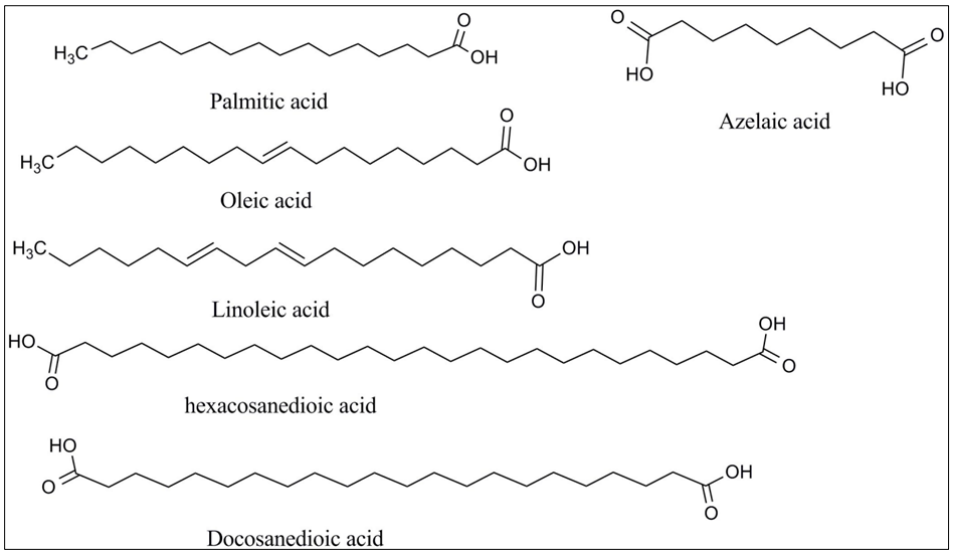

Figure 6 Structures of fatty acids from *A. aspera*

4.7. Miscellaneous compounds

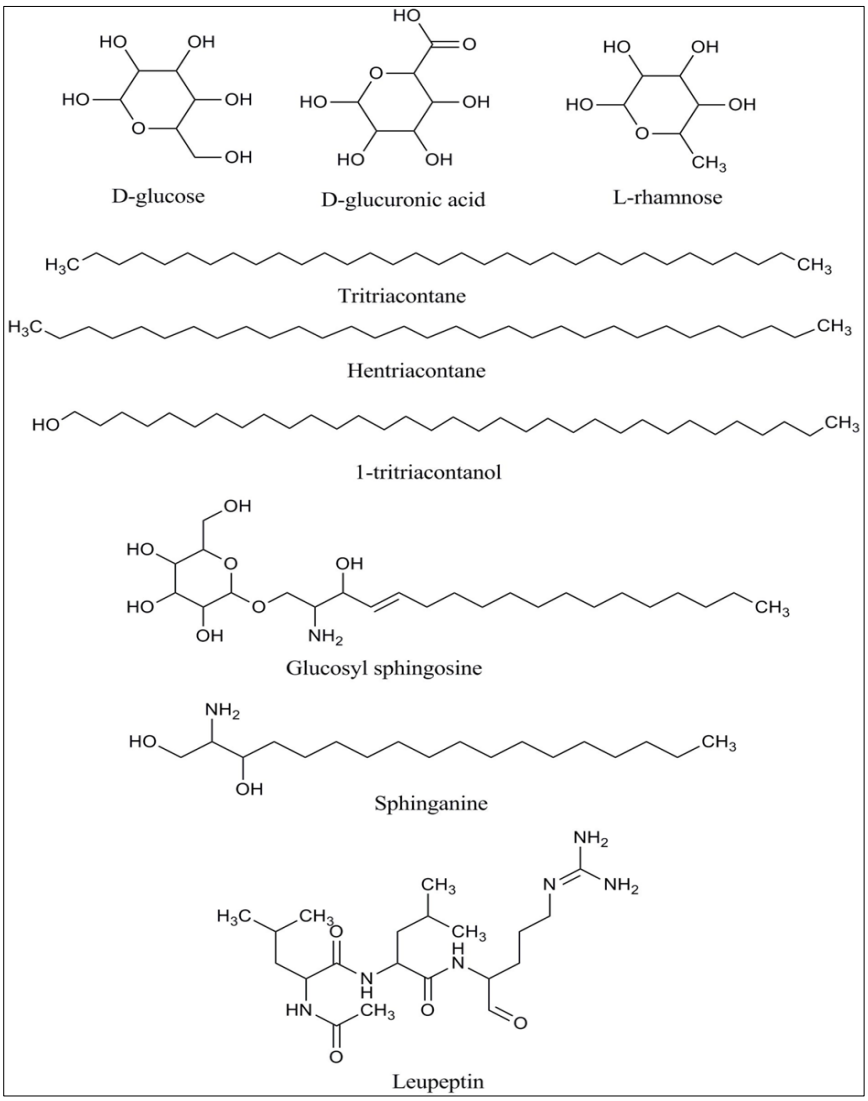

Figure 7 Structures of organic acids, sphingolipids, carbohydrates and long chain alkanes from *A. aspera*

Organic acids including Nε,nε,nε-trimethyl lysine, argphegln and leupeptin were identified. Sphinganine, glucosyl sphingosine, phytosphingosine, N-stearoyl-D-sphingosine like sphingolipids were identified along with 2-benzoyl-5-methoxy benzoquinone (benzenoids), rhapontin, 10-deoxy methymycin (Aromatic polyketide) were identified [17]. Carbohydrates namely D-glucose, D-glucuronic acid, L-rhamnose and rhamnose were identified [21]. Long chain alkanes namely 1-tritriacontanol, 17-penat triacontanol, N-hexacos-14-enoic acid, stigmasta-5,22-dien-3-ol, tritriacontane, hentriacontane, 10-tricosanone, 3-tritriacontanone, 2-octacosanone, hexatriacontane were identified [27,33]. The structures of miscellaneous compounds from *A. aspera* are given in Fig. 7.

5. Conclusion

The review highlighted the presence of various phytochemicals present in stem, root, seeds and leaves of *A. aspera* used in the treatment of several diseases. The potent pharmacological activity observed by various researchers was due to the presence of diverse phytochemical moieties such as achyranthine, ecdysterone, oleanolic acid, spinasterol, apigenin, achyrantheric acid, ursolic acid, corrosolic acid and betaine. Especially, oleanolic acid, achyranthine and ecdysterone contributed their role in various biological applications. Flavonoids and phenolic compounds are found to have better antioxidant potential. The presence of alkaloids, tannins, terpenoids, flavonoids and steroids in *A. aspera* contributed significantly to its antimicrobial activity. Achyrantheric acid, ursolic acid and corrosolic acid are responsible for the treatment of cancer. Furthermore, studies are required to obtain the optimum efficacy of this multidisciplinary plant.

Compliance with ethical standards

Acknowledgments

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Authors contribution

All the authors have contributed equally.

Disclosure of conflict of interest

The authors hereby disclose no conflicts of interest regarding the publication of this paper.

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