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REVIEW

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Artemisia vulgaris Linn: an updated review on its multiple biological activities

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Abstract

Background: *Artemisia vulgaris* Linn, an annual herb, is also known as Mugwort or Wormwood in English, Nagadouna in Hindi, Mashibattiri, or Machipatri in Tamil. Native habitats are temperate Asia, Europe, Northern Africa and Alaska. Ethnomedicinally, it is used in traditional treatments to treat depression, epilepsy, irritability, insomnia and stress. This plant is called Herbaka in the Philippines and is used to alleviate hypertension. It is utilized as a culinary herb in western countries and is often used to flavor rice dishes and tea in Asia.

Main body of the abstract: Botanical description, holistic approaches, ethnomedical uses and phytochemical screening of *A. vulgaris* along with its various *in vitro/in vivo* pharmacological activities reported are the prime focus of this literature. The primary phytoconstituents and diverse pharmacology of this plant have been fully uncovered in order to learn about its previously unrecognized ethnomedicinal uses and provide scientists with new knowledge to advance their study of this plant.

Short conclusion: This review includes various principle phytoconstituents (hydroxybenzoic acid, rutoside, camphen, 1, 8-cineole and α-thujone) which are extensively shown biological activities such as analgesic, anti-fungal and anti-bacterial. However, further investigations are needed for identifying chemical constituents responsible for the claimed ethnomedicinal uses along with their mechanism of action. It is also anticipated here that the review will be the current understanding of *Artemisia vulgaris* application in complementary and alternative medicine.

Keywords: *Artemisia vulgaris*, Holistic practice, Traditional uses, Phytochemistry, Ethnomedicinal, Pharmacologically

Background

Artemisia vulgaris known as Mugwort (English) and *Nagadouna* (Hindi), and *Mashibattiri* or *Machipatri* (Tamil) reflect in Indian System of Medicine, belongs to Family *Asteraceae* which consist of more than 500 species found worldwide in temperate and cold-temperature zones [1]. The term "*Artemisia*" is derived from the word "Artemis," which is used in folk medicine for women's diseases and corresponds to Diana, a Greek Goddess [2]. About 107 Latin synonyms of *Artemisia vulgaris* have been reported in the authorized website "The Plant List" (established by Global Strategy for Plant Conservation and World Flora Online) such as including *Artemisia affinis* Hassk. [3], *Absinthium spicatum* (Wulfen ex Jacq.) Baumg [3], *Artemisia vulgaris* var. indica (Willd.) Hassk, *Artemisia vulgaris* subsp. *vulgaris* [3], *Artemisia opulenta* Pamp. [3]. Moreover, extensive spreading of this class is recognized by a variety of unusual names, containing *Armoise citronnelle* (French), altamis, altamiza, altamisa (Spanish), amarelle (Italian), Ajenjo, altamiza, armoise, Carline Thistle, common mugwort, Cingulum Sancti Johannis, Chiu Ts'Ao, common mugwort, Chrysanthemum weed, Beifußkraut (German), common wormwood (English), beiai (Chinese), moxa (Japan), Nagadamani (Ayurvedic) and Polynesian snare (Russian) [3–5]. It is a perpetual weed that grows wild throughout Europe, Asia and North America [3–5]. *Artemisia*, which consists of harsh plants and shrubs recognized for their volatile oils, has been widely utilized around the world. The main

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morphological feature which distinguishes the plant is an aggressive weed which can be easily propagated from small rhizome fragment [6]. The plant is 2.0 m tall with simple, branching or grooved erect red-purplish stems and dark green leaves, small symmetrical scented flower heads with numerous fair-haired or dark pink petals and small symmetrical aromatic floret crowns with many fair-haired or dark red petals. The plant flourishes in undeveloped fields and wastelands, along roadsides, on the edges of woods and along riverbanks, where it forms thick colonies [6]. Fresh plants have a strong pungent odor and a spicy, sharp bitter taste [7]. In western culture, mugwort is an important culinary herb which has been used for herbal remedy as well as flavoring purposes [7]. In Oriental medicine, plant is used as an analgesic and in conjunction with acupuncture therapy [8, 9]. The leaves are harvested in August and can be dried for later uses such as appetizer, diuretic, hemostatic, stomachic and stem is used as antispasmodic, antirheumatic and stomachic, whereas roots are energizer and antispasmodic [10, 11]. Plant possesses various traditional uses, most of them claim in pharmacologically proved. However, comprehensive, evaluation of the former studies is recommended. Consequently, in this review, some aspects of this plant such as taxonomic description, historical practice, traditional uses, pharmacological activities and phytochemical screening will be elaborated.

Research strategy

Using various bibliographic databases, including Scopus (https://www.scopus.com), ScienceDirect (http://www.sciencedirect.com), PubMed (https://www.ncbi.nlm.nih.gov/pubmed/) and Google Scholar (https:// scholar.google.com/), this review aims to compile all the research pertaining to the taxonomical, geographical, pharmacological and phytoconstituents studies conducted on specifically, the scientific term "*Artemisia vulgaris*" or the popular name "common wormwood," followed by the required study area, were combined as the relevant keywords in this paper's study design (such as taxonomy, or pharmacology, etc.). Following that, the Boolean link "and" was used to separate the two terms (*Artemisia vulgaris* and pharmacology, e.g.). The annotated bibliographic part includes 77 references, including books and sections of books from 1902 through 2020, as well as original and review articles.

Main text

Geographical description

About 500 diverse species of class *Artemisia* are spread primarily in different portions of the world. However, vulgaris class of this pant indicated excessive growth. It is a wild plant highly cultivated in North Europe, North America and several regions of Asia as it is richly available in the world's temperate and cold temperate zones [12]. Throughout Mediterranean basin and northwestern Himalayas, it grows profusely in all parts of northern India zones, semiarid or arid environments. It may be found in South Africa's Eastern Cape Province, but its natural habitats include Europe, Iran, Siberia and North Africa [13]. However, this plant is medicinally used throughout the world or especially, in Europe, in Middle East Countries, Afghanistan, Pakistan, India, China, Korea, etc. [14]. Its regional habitat is mainly found at open or shady places at the grasslands and edges of the forest. It is distributed in Sirohi (Mt. Abu), Udaipur and Jodhpur districts of Rajasthan [14].

Botanical description

The rhizomatous perennial plant *A. vulgaris* L. (mugwort) infests landscapes, agronomic settings, waste areas and roadsides. It is a species of the Compositae family (Asteraceae). The genus originates from the Greek queen of shooting animals. *Artemisia*'s etymology has discovered alternative origin for the name. The spouse of the Greek/Persian King Mausolus was queen *Artemisia*, a notable medicinal and botanical expert, designed the Mausoleum monument. The term vulgaris refers to something that is ordinary, vulgar or common [15]. Mugwort, common wormwood, chrysanthemum weed, felon herb, sailor's tobacco, St. naughty man, old Uncle Henry, old man and John's plant are all names for this herb species. There have been reports of the plant's vernacular names in several languages and cultures (Table 1) [15].

Morphological characteristics

A. Vulgaris L. is a deciduous perennial with a well-developed rhizome that spreads quickly after being introduced. It is a long-stemmed herb, high-branched shrub with a height of 70–150 cm with several heads and creeping stems that lack rosette or runners. Despite the fact that the plant is densely branched and short, in various places of the world, unbranched and tall *Artemisia* has also been

Table 1 The botanical description of the plant

Botanical name	*Artemisia vulgaris* Linn
Family	Asteraceae/compositae
Hindi	Nagadouna
English	Mugwort
Sanskrit	Nagadaman
Tamil	Mashibattiri or Machipatri
Gujrat	Damro
Marathi	Davan

documented. The leaves of *A. vulgaris* are pinatissect or bipinatissectas, with lanceolate oroblong segments and a delicate, white-silver dorsal surface. Roots, aerial portions and dry branches of mugwort are utilized in a variety of medications [16]. It has a uniform distribution of green or bicolor basal (petiole), sessile leaves in which the superior surface is the glabrous, inferior surface is covered with densely matted filaments and juvenile. The flowering & fruiting season appears during August–January. Plant's fresh and upper part are collected by the commencement of winter and it has xanthous or red-brown flower and nearly hairless [16]. It can be utilized for various functional foods, cosmeceuticals, pharmaceutics and possible inflammation, antioxidant and antibacterial actions against ageing, infectious illnesses and food science applications inflammation, owing to occurrence of vital oil [17].

History of remedial practice

Owing to its extensive distribution, *A. vulgaris* was distinguished in earliest Greece, Egypt and Rome. Its name is taken from the Greek idol Artemis, who is the supporter of expecting women and new mothers. Isis, Artemis and Diana are the goddesses worshipped. *A. vulgaris* was important in religious rites since of its favorable effects on menstruation and pregnancy-related diseases. Reported therapeutic qualities of this species in remedial work were labeled as initial as the earliest century A.D. Dioscorides in "*Materia medica*" [18]. It was suggested for the management of urological surroundings like dysuria and nephrolithiasis due to its heating and dehydrating properties. *A. vulgaris*, also known as "*mater herbarum*" (mother of herbs), was used externally in unenlightened medicine to cure injuries, avoid gout and relieve leg tiredness, as well as to deal with illness. Also, the plant used for the treatment of gastrointestinal problems caused by a cold [18–20], such as stomach pain, diarrhea and intestinal colic. It was thought to be useful against jaundice when offered with wine and goiter when used as a poultice. The holistic medicine flourished in Europe throughout the Revival, which lasted until the eighteenth century. The therapeutic coverage of this plant to women's ailments was broadened at that time to cover spleen and liver illnesses. Neurosis and Epilepsy remained listed amongst the signals for mugwort management throughout the nineteenth-century development of modern medicine. Scientific and workshop investigation of the composition of *A. vulgaris* in the twentieth century led to the declaration that the herb is not appropriate for curative use and can only be used in culinary applications and that its place in the home is the kitchen, not the medication cabinet, due to its highly sensitive potential [16, 18–20].

Traditional uses of *A. vulgaris*

In folk medicine, rational establishments are warped with elements of magic. Developments in rational premises are based on surveillance of the natural environment and investigating substances that reduces disease symptoms. In destitute countries, this is the better way in which people can improve their health due to poverty in society or hard to access a research-based medicine. *A. vulgaris* was termed "mother of herbs" in the intermediate eternities. Traditionally, *A. vulgaris* is known as Brahmajata, Daanta, Devashekhara, Gandhotkata, Munisuta, Muni, Nagdamanak, Pushpachamara, Vineeta, Kalapatraka, Pundaraka, Panduraga, Pavitraka, Tapodhana, Rishiputra, Kulaputraka, Tapasvi, Vineeta, Saptadhatri.

Its traditional classical categorization has been given below [21]:

Bhavprakasha: Pushpa varga.
Raja Nighantu: Karaveeradi Varga.
Dhanvantari Nighantu: chandanadi varga.
Kaiyyadeva Nighantu: Oushadhi varga.

It was commonly used by Romans, who used to plant it along the roadsides so that marching soldiers could carry it in their shoes and relieve aching feet. For many years, it was employed in the practice of moxibustion. Moxibustion is a technique that entails wrapping mugwort into sticks or cones, lighting it and waving it completed the area that has to be treated [16]. The heat from the herb's chemical components stimulates the acupuncture point. Some studies enlightened that acupuncture pooled with moxibustion may lessen the need for oxytocin by reducing the number of cesarean deliveries (a hormone that regulates the uterus's contraction during labor). It was originally used in China to treat cholera and leprosy and it was utilized by Asian to relieve gastrointestinal discomfort and treating gynecological diseases. Other manifestation includes hemorrhagic disorders such as blood in sputum, feces, or vomit, as well as nosebleeds. Moreover, this species' essential oil was utilized in a popular herbal medication known as "Ai Hao" which treats ulcers and diarrhea [5]. It is also considered a substitute for cannabis. It is used in traditional Hindu medicine (Unani) as "Arq-e-Afsanteen" for liver irritation and obstruction, "Dava-ul-Luk" for abnormally inflamed liver or spleen and nephrolithiasis and "Qurs-e-Gul" for prolonged fever as a liver tonic and dysmenorrheal in the form decoctions from the plant. Its ayurvedic properties, part uses, dosage, uses and formulation have been mentioned in given Table 2. Its herb is used to promote gastric juice secretion, relieves colic by relaxing the GI tract and bile ducts, while the experimental laxative effect is utilized in European folk medicine for treatment of obesity [5, 22]. Other

Table 2 Ayurvedic properties, part used and dosage of *A. vulgaris* [21]

Sanskrit name	Brahmajata, Daanta, Devashekhara, Gandhotkata, Nagdamanak, Gandhotkata, Kalapatraka, Pavitraka, Tapodhana, Tapasvi, Pushpachamara, Rishiputra, Muni, Kulaputraka, Pundaraka, Panduraga, Munisuta, Vineeta, Saptadhatri, Kalapatraka
Medicinal properties	Rasa (Taste)—Tikta (Bitter), Veerya (Potency)—Ushna (Hot), Guna (Potentials)—Laghu (Light for digestion), Kashaya (Astringent), Ruksha (Dry in nature), Teekshna (Strong), Vipaka—Katu (Endures Strong perception after ingestion), Karma (Movements)—Tridosha shamaka, Tridoshahara (lessens entirely the dosha in the organization)
Part used	Panchanga (entire plant)
Dosage	Fresh juice—5–10 ml; Powder—0.5–1 g
Ayurvedic uses	Hrudya—acts as cardiac tonic, pleasant for heart Indications: Kandu—itching, pruritis, Kushta—skin diseases, Kleda—relieves clammy skin, Visha—Toxic conditions, poisoning, Graharoga—Psychiatric disorders, Visphota—boils, blisters
Ayurvedic preparations	Sri Gopala Taila: It's therapeutic oil for alternative sources in vata disorders includes diabetes and neurological problems. It also assists in the development of remembering, learning and wisdom. It aids in neuron, muscle and blood vessel strengthening. This oil can be applied gradually to the abdomen of pregnant women to improve core muscles and prevent pregnancy. It reduces menstruation pains in women while applied on the skin to the abdomen. It is effective in patients with schizophrenia

traditional uses for *A. vulgaris* include therapy of nervous system diseases like depression, excessive stress, epilepsy and insomnia [23]. Additionally, it can also be used to treat hypertension and induce labor or miscarriage [23].

Ethnomedicinal uses

Whole plant

The component of the plant is traditionally used as anthelminthic, antibacterial, carminative, antispasmodic, amenorrhoea, cholagogue, choleretic, digestive, diaphoretic, dysmenorrhea, emmenagogue, expectorant, epilepsy, nervine, stimulant, purgative, slightly tonic besides, in arrangement for psychoneurosis, irritability, anxiety, depression, insomnia and stress [9, 10, 24–26]. In folk medicine, infusions of plant stems and leaves have been used to treatment a variation of illnesses including bacterial infection, diabetes, dermatitis, epilepsy, malaria, insomnia, menopausal and menstrual symptoms and tumors [27–30]. In the past, South Africans used a hydroalcoholic extract of the entire plant [31]. The plant used as substitute medicine in the treatment of hypertension in the Philippines [32]. British Columbia and Canada used to treat abdominal difficulties and endoparasites in pigs and pets [32]. In traditional medicine, this plant is used as an emmenagogue [32].

Aerial parts

Hepatic problems are treated by an infusion of aerial portions of the plant [33]. The plant possesses numerous curative practices and applications in gastrointestinal tracts problem such as stomach boils, dyspepsia and liver disorders in folk medicine [30, 34]. The aerial parts of this plant are employed as anthelminthic, an antispasmodic, an antiseptic and in hepatitis and traditionally used as antitumor activity [30, 35, 36].

Leaves

Artemisia vulgaris has been used to enhance suppressed or unbalanced menstruation; menstrual pain cramps and induces a miscarriage [30]. Leaves are used as appetizer, stomachic, diuretic and hemostatic [35]. It is also used for skin disease in the form of paste or powder [34, 37, 38]. The plant is utilized as palliative agent, in combination with acupuncture therapy. Roots are used as tonic and spasmodic [39]. All parts of the plant, along with their activities in each country, are listed in Table 3.

Phytochemical screening

The chief compounds of the plant are camphor, camphene, 1, 8-cineole, camphene, germacrene D, β-caryophyllene, β-thujone, α-thujone, borneol, germacrene D and α-zingiberene. Table 4 lists the many chemical constituent structures of the plant [27, 38, 40, 41]. The aerial parts contain carbohydrates (40%), amino acids, phenolic compounds (9.8%), protein (2.9%), triterpenoids, steroids, glycosides, saponins and flavonoids [42, 43]. Twenty known flavonoids, namely apigenin, eriodictyol, chrysoberyl, eupafolin, eriodictyol, homoeriodictyol, isorhamnetin, jaceosidin, diosmetin, luteolin, luteolin 7-glucoside, kaempferol 3-glucoside, kaempferol 7-glucoside, kaempferol 3-rhamnoside, kaempferol 3-rutinoside, quercetrin, quercetin 3-glucoside, quercetin 3-galactoside, rutin, tacrine and vitexin, are observed [3]. Sixty-four essential components extracted from the aerial components of the plant contain menthol (9.71%), α-pinen (23.56%) and β-eudesmol (8.297%); spathulenol (4.582%) is the chief constituent of the plant [44, 45]. The methoxylated flavones are ayanin and 3-o-glucosides, quercetin, rutinosides of kaempferol and isohamnetin [46]. The presence of artemisic acid, artemisinin B, flavonoids, coumarins, sesquiterpenes lactones and volatile oil is observed [36, 47]. The major alkaloids

Table 3 The traditional uses of the various part of *Artemisia vulgaris*

S.no	Part used	Activities	Country	References
[1]	Whole plant	Anthelminthic, antiseptic, carminative, cholagogue, diaphoretic, digestive, emmenagogue, expectorant, nervine, slightly tonic, seduces spasm, stimulant, purgative	China	[9, 10, 25–27]
		Amenorrhoea, choleretic, dysmenorrhoea	Japan	[27, 38]
		Hypertension	Philippines	[2]
		Analgesic agent, acupuncture therapy, nasty flavoring agent in fat, meat and fish	China	[3]
[2]	Aerial parts	Hepatic disorders	Brazil	[29]
		Stomach ulcers, dyspepsia and liver disorders	USA	[30, 33, 36]
		Anthelminthic, reduces spasm and hepatosis disorders	London	[35]
		Reduces tumor activity	Europe	[36]
[3]	Leaves	Suppressed menstruation, menstrual pain cramps and induce miscarriage	New York	[37]
		Appetizer, diuretic, hemostatic, stomachic	China	[35]
		Flavoring of foods and drinks	Philippines	[38]
		Skin disease and fever	Japan	[27, 38]
		Moxibustion (Traditional Chinese Therapy)	China	[11]
[4]	Stem	Bacterial infection, diabetes, dermatitis, depression, epilepsy, insomnia, malaria, tumor, menopausal and menstrual complaints	Philadelphia	[25, 26, 30]
		Suppressed rheumatic, reduces spasm and stomachic	Nepal	[39]
[5]	Roots	Tonic and spasmodic	China	[35]
[6]	Essential oil	Diabetes, depression, epilepsy, irritability, insomnia and anxiety, psychoneurosis, stress, stomach obstacles and endoparasites in pets and pigs	British Columbia, Canada	[32]

Table 4 The phytochemical screening of the various part of *Artemisia vulgaris*

S.no	Part used	Constituent	Country	References
[1]	Whole plant	Rutinosides of kaempferol, 3-o-glucosides and isohamnetin, quercetin	USA	[46, 47]
		Protoberberine alkaloids and berberine	Indonesia	[35]
		Eriodictyol and luteolin	Philippines	[7]
		Essential oil is borneol, bornyl acetate, camphor, cineote, linalool, isoborneol, isobornyl, terpinen-4-ol, (α + β)-thujone, nonanone-3, myrcene, β-pinene, limonene, α-terpinene	Egypt	[41]
[2]	Aerial parts	Eudesmane acids and eudesmane dialchol	Spain	[51]
		Camphor, piperitone, D-limonene and artemisia ketone, 1,8-cenol, D-fructose, artinnium b	Jordan	[48]
		Isoquercetrin, kaempferol, hydroxycinnamic acids and quinic acid derivatives	Brazil	[27]
		Essential oils are artemisia ketone, β-anole (21.7%), α-thujone (56.13), β-thujone (12.02), camphor (10.9%), 1,8 cineole (8.47), 1,8-cineole (2.6–17.6%), 1, 8-Cineol (18.64%), caryophyllene oxide (10.19), caryophyllene (2.5–12.2%), trans-caryophyllene (24.76%), chrysanthenyl acetate (0–23.6%), caryophyllene oxide (31.1%), β-cubebene (11.82%), α-pinen (23.56%), menthol (9.71%), hexadecanoic acid (6.3%), isobornyl 2-methylbutyrate (5.3%), β-eudesmol(8.297%), germacrene D (5.3–15.1%), spathulenol (4.582%), β-pinene (0.1–12.9%), cis-thujone (0–12.9%), trans-thujone (0–20.2%), *Trans*-salvene (14.87%), 2-heptadecanone (5.1%), β-pinene (10.2%) and α-pinene (9.1%)	Iran, Turkey, North Lithuania, Iran, Cuba, Vietnam	[35, 45, 50, 52–54]
[3]	Leaves	Yomogin and 1,2,3,4-diepoxy-11(13)-eudesmen-12,8-olide	UK	[55]
		Luteolin and morin	India	[35]
		Essential oil is chrysanthenone (4.48%), camphene (5.5%), camphor (26.99%), β-caryophyllene (24.1%), β-caryophyllene oxide (15.87%), β-cubebene (12%), borneol (4.44%), germacrene D (8.42%), α-thujone (12.3%), β-thujone (19.19%), α-humulene (0.72%), sabinene (11.29%)	Egypt, India	[35, 41, 56]
		Carbohydrates (40%), phenolic compounds (9.8%), protein (2.9%), amino acids, triterpenoids, steroids, glycosides, saponins and flavonoids	India	[41, 43]
[4]	Seeds	Alpha linolenic acid, camphor, eucalyptol	India	[41]

protoberberine and berberine were also reported in methanol extract of this plant [35]. The main components are artinnium b, artemisia ketone, D-fructose, 1, 8-cenol, D-limonene, yomogin, 1, 2, 3, 4-diepoxy-11(13)-eudesmen-12, 8-olide camphor, piperitone, present in the plant [48]. The flavonoids isoquercetrin, hydroxycinnamic acids, kaempferol, gentisic, caffeic, p-coumaric, camphor (11.89%), ferulic acids b-thujone (19.19%), borneol (4.44%), chrysanthenone (4.48%), sabinene (11.29%) and germacrene D (8.42%) and several quinic acid derivatives chlorogenic, 3-caffeoylquinic, 1,5-dicaffeoylquinic, 1,3-dicaffeoylquinic, 3,4-dicaffeoylquinic, 3,5-dicaffeoylquinic, 1,4-dicaffeoylquinic and 4,5-dicaffeoylquinic acids, 5-feruloyl, quinic and other phenolic compounds are present in the plant [27, 35, 43]. α-Thujone, caryophyllene oxide, 1, 8 cineole are the major vital oil [49]. Hairy root of this plant contains essential oil such as camphor (20.8%), camphene (5.5%), β-caryophyllene (5.7%) and α-thujone (12.3%) [50]. All aspects of the plant, together with their constituents, are summarized in Table 4 for each country and its essential structure in Table 5.

Pharmacological uses

A number of pharmacological activities are being reported using various parts of this plant such as antifertility, hepatoprotective activity, antihypertensive, etc. A brief review of these activities is summarized in Table 6 and graphical representation of pharmacological action of plant given in Fig. 1.

Table 5 Structure of different chemical constituents of the *Artemisia vulgaris* Linn

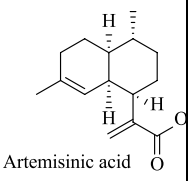
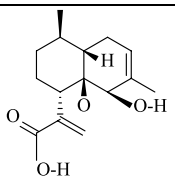
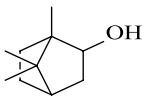
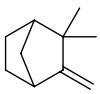
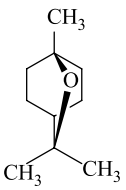
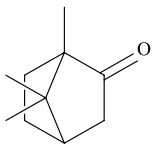
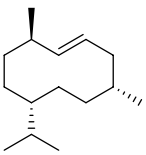
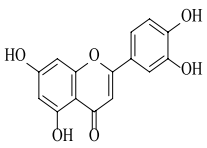
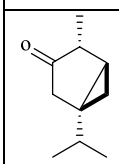
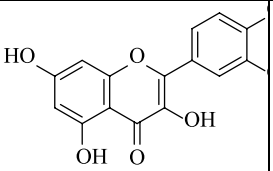
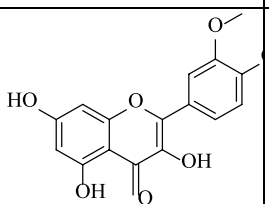
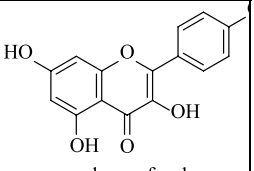
 Artemisinic acid	 Artemisinin B	 Borneol	 camphene
 1,8-Cineole	 camphor	 germacrene D	 Luteolin
 alpha thujone	 Quercetin	 Isohamnetin	 kaempferol

Table 6 Reported pharmacological activities of *Artemisia vulgaris*

Pharmacological action	Evidence	Responsible compounds	References
Analgesic	Slightly marginal anti-nociceptive effect	Maybe due to hydroxybenzoic acid derivatives, rutoside and caffeic acid its derivatives	[49]
Anthelmintic	Action in contradiction of *Trichinella spiralis*	NA	[50]
Antimalarial	Action in contradiction *Plasmodiumyoelii* and *P. berghei*	NA	[57]
Antiallergenic	Diminution in eye and skin sensitivity	NA	[58]
Antifungal and antibacterial	Oil fraction showed inhibitory action on the expansion of *Aspergillus niger, Escherichia coli, Candida albicans, Salmonella enteritidis, Staphylococcus aureus, Klebsiella pneumoniae, Pseudomonas aeruginosa, Streptococcus mutans*	Maybe due to the presence of essential oils, camphen, 1,8-cineole and α-thujone	[8, 35, 45, 46]
Antihypertensive	Decrease the hypertensive action of noradrenaline. Moxibustion, when contrasted to antihypertensive medications, reduced blood pressure by activating acupoint KI 1	NA** Moxibustion is a traditional Chinese practice of stimulating acupuncture sites by using the warmth created by scorching herbal provisions using *A. vulgaris*	[4, 7, 10, 59]
Antispasmolytic	H1 histamine receptor antagonism	NA	[10, 11]
Anti-inflammatory	Quantization of blood fat profile, elevation of paraoxonase-1 actions, and reduction of serum malondialdehyde, nitric oxide and tumor necrosis factor-α level. The "Cotton Pellet Granuloma Method" and a lipoxygenase (LOX) inhibitory activity experiment were used to confirm it	NA	[60, 40, 61]
Hypolipemic	Standardized serum lipid spectrum, elevated paraoxonase-1 function, lowered serum malondialdehyde, nitric oxide, tumor necrosis factor and hydroxymethylglutaryl-CoA reductase action. Increasing HDL and decreasing total cholesterol, triglycerides, LDL, and VLDL while diminishing atherogenicity (aqueous extract of *A. vulgaris* roots)	NA	[54, 56]
Hepatoprotective	Prophylactic therapeutic potential in the liver parenchyma, decreasing inflammation, cellular edema, apoptotic cell count and hyperemia		[28]
MAO inhibition	Mouse brain monoamine oxidase (MAO) enzyme restriction	Coumarins: scopoletin, esculetin, esculetin-6-methylether, flavonoids: apigenin, quercetin, luteolin, jaceosidin, eupafolin	[53]
Estrogenic	The estrogen receptor is antagonistic, and gene transcription is activated. Eriodictyol and apigenin promote gene transcription. Female Wistar rats with anti-implantation and estrogenic activities	Flavonoids	[3, 62, 52]
Cytotoxic	Suppression of tumor cell proliferation in HeLa, A7R5, MCF7, 293 T, HL-60 and SW-480 cancer cell lines	Essential oil, flavonoids, phenolic compounds	[60, 63–65]

**NA stands for no data

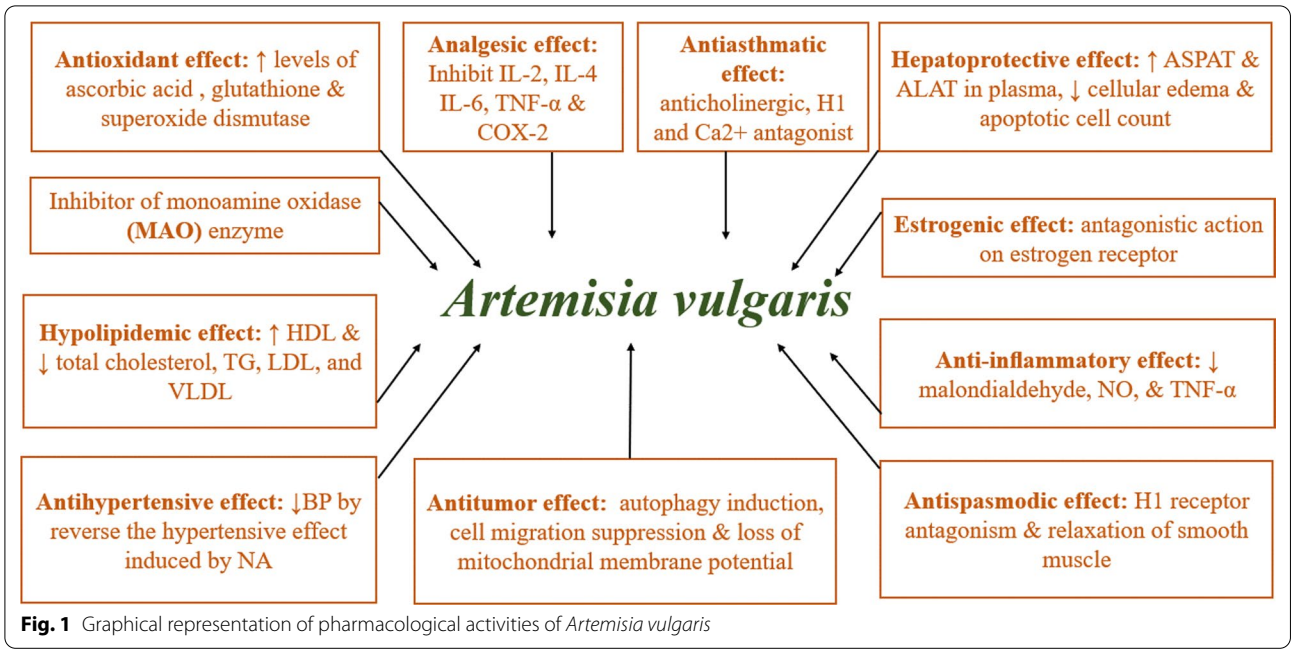


Fig. 1 Graphical representation of pharmacological activities of *Artemisia vulgaris*

Analgesic and anti-inflammatory activity

Anti-inflammatory properties have been reported in the methanolic leaves extract of the plant in Wistar albino rats at the doses 200 & 400 mg/kg which showed that the weight of wet cotton pellets was inhibited by 33% and 55.3%, respectively, whereas the weight of dry cotton pellets was inhibited by 20.07% and 64.06% [60]. Analgesic effect was found in the methanolic extract of aerial parts by tail flick and hot plate methods in albino rats and mice at dosages of 200, 400 and 800 mg/ml, with 71.3, 72.2 and 74.00% inhibition in paw edema at the end of 3 h, respectively [60]. Key enzymes involved in the production of the numerous inflammatory mediators, such as cyclooxygenase, lipoxygenase and inducible nitric oxide synthase isomers, may all be silenced by flavonoids [40]. Additionally, they have the ability to competitively bind to the ATP catalytic site to block the activity of the regulating enzyme protein kinase and reduce the inflammatory response [40]. By inhibiting the biological effects of bradykinin or other inflammatory mediators and changing the route for the manufacture of prostaglandins, saponins can display their anti-inflammatory activities [40]. Similar to this, terpenoids might reduce inflammatory response by inhibiting the activity of cyclooxygenase enzymes, prostaglandin production, tumor necrosis factor-α (TNF-α), cytokines (IL-2, IL-4 and IL-6) and inducible nitric oxide synthase enzymes [61]. Furthermore, a preclinical and clinical experiment with the explanation of the precise mechanism at the molecular level was required to establish the impact of the extract. Additionally, the abundance of tannins and sesquiterpenoids in *A. vulgaris* is linked to an enzyme known as cyclooxygenase (COX-2) that has an inhibitory influence on its ability to cause inflammation [40, 61]. To identify the precise mechanism of anti-inflammatory activity, more molecular research is required [40, 60, 61].

Antioxidant activity

The antioxidative characteristics of plant hydroalcoholic extract were evaluated, with effective reduction of DPPH radical scavenging (IC50: 0.976 g mLG1), xanthine oxidase (IC50: 112.51 g mLG1) and protein glycation (IC50: 968.4 g mLG1), as well as lipid peroxide inhibition (IC50: 968.4 g mLG1) [44]. The aqueous extract of *A. vulgaris* was able to scavenge 2,2-diphenyl-1-picrylhydrazyl (DPPH) radicals at an IC50 of 11.4 g/mL and nitric oxide (NO) radicals at an IC50 of 125 mg/mL in the first portion of the experiment, demonstrating the herb's antioxidant potential. Additionally, they determined that the overall amounts of phenols, flavonoids and flavanols were 19 ± 0.16 mg/g gallic acid equivalents, 7.96 ± 0.76 and 3.4 ± 0.0 mg/g rutoside equivalents, respectively. In the second stage of the study, they found that rats given the extract at a dose of 100 mg/kg body weight had significantly higher levels of ascorbic acid, glutathione and superoxide dismutase activity in their blood (BW). According to the study's findings, oxidative stress-related disorders can be treated with *A. vulgaris* since it has antioxidant properties [42]. Recent studies have shown that the whole plant, its aerial portions, leaf extract and its essential oil all have antioxidant properties [35, 42, 44].

The investigations mentioned above used a variety of contemporary approaches. Based on tests for lipid peroxidation, protein glycation, xanthine oxidase and DPPH radical scavenging, the extracts of *A. vulgaris* have a significant antioxidant capacity [42]. The antioxidant capacity of the aqueous extracts of *A. vulgaris* has been examined in vitro using the following techniques: ferric reducing power activity assay (for determining total antioxidant capacity), DPPH, hydroxyl, superoxide and NO scavenging assays, ABTS (2,2′-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid assay), hydroxyl and hydroxyl assays (for determining the inhibition of lipid peroxidation) [42, 44].

Antibacterial activity

Methanol extract was used to evaluate the antibacterial and antioxidant activities in the presence of polyphenols and flavonoids [35, 45]. Steam distillation was used to separate the oil from the plant's above-ground and subterranean portions. The zone of suppression of pathogen growth on paper filters was looked at after 10- and 30-fold dilutions. Due to the high concentrations of 1,8-cineole and β-thujone, the oil obtained from the aerial parts exhibited inhibitory activity against a number of bacteria and fungi, including *C. albicans* and *Aspergillus niger* and *Escherichia coli, Salmonella enteritidis, Pseudomonas aeruginosa, Klebsiella pneumoniae* and *Staphylococcus aureus.* On the other hand, due to the low concentration of 1,8-cineole and the absence of β-thujone in the roots, the oil taken from the plant's subterranean portions only had a weak action against the specified infections. The study's findings revealed that *A. vulgaris* has antioxidant potential and may therefore be effective in the treatment of oxidative conditions. This discovery would contribute to the development of synthetic antioxidant and antibacterial medications, while more in vivo investigation and clinical studies are required to validate and evaluate its economic potential [35, 46].

Anti-diabetic activity

At oral dosages of 250 and 500 mg/kg b.w. of ethanol plant leaf extract, diabetic nephropathy rats showed a substantial reduction in diabetes assessment parameters such blood glucose. As diabetic nephropathy rats received streptozotocin (60 mg/kg, i.p), daily treatment with two dose levels of ethanolic extract of leaf *Artemisia vulgaris* (EEAV) showed a significant dose-dependent decrease in various renal function parameters like urinary albumin excretion rate (UAER), type IV collagen excretion, total proteins in urine, creatinine, advanced glycation end products, excretion of glycosaminoglycans and a significant increase in urinary creatinine, glycosaminoglycans, urine volume. Rats with diabetic nephropathy's kidneys showed altered normal morphological alterations upon histological examination. Animals treated with both doses of EEAV showed recoverable morphological abnormalities in their separated kidneys. As a consequence of anti-diabetic, antioxidant and protective morphological alterations, their study's findings show that EEAV lessens renal damage in diabetic nephropathy rats [47].

Antifertility activity

Alcoholic plant extract proved 80% anti-implantation activity on female albino rats with an increase in the metestrus within the estrous cycle and p.o exhibited at a high dose of 3000 mg/kg nontoxic effect [62]. It has been used as an anti-inflammatory, anthelmintic, antispasmodic and carminative in the treatment of painful menstruation (dysmenorrhea), as well as in the induction of labor or miscarriage [9]. Methanolic leaves extract of the plant at doses 600 mg/kg (100%) and 300 mg/kg (50%) possess significant dose-dependent inhibition of implant formation and estrogenic activities [62]. Aerial part of the plant showed estrogenic activity due to the presence of flavonoids. In the experiment, Saccharomyces cerevisiae fungus with an expression plasmid containing the cDNA of the human estrogen receptor and a reporter plasmid having the α-galactosidase gene were utilized [7]. The polarized extract (extraction with ethyl acetate) exhibited the estrogenic effect, which was 5% relative to 17-β-estradiol, but the less polar ethanolic extract exhibited no activity. After examining the plant's various flavonoids, it was found that eriodictyol and apigenin dramatically increased the reporter gene's transcription. Additionally, it was revealed that the activity was concentration-dependent [7]. The potent anti-implantation and estrogenic effects were validated in the *A. vulgaris* leaf extracts on female Wistar rats [7, 52, 62].

Hepatoprotective activity

In mice with 1 g/kg lipopolysaccharide and 700 mg/kg d-galactosamine-induced hepatitis, elevated levels of hepatic function indicators alanine aminotransferase (ALAT) and aspartate aminotransferase (AST) confirmed liver inflammation (ASPAT), an aqueous-methanolic extract of aerial portions of the plant had a protective effect. Pretreatment of mice with various doses of extract (150–600 mg/kg) decreased the generated toxin and demonstrated hepatoprotective effects. ASPAT and ALAT activities in plasma were significantly reduced and histological examination of the liver, revealed a decrease in cellular edema and apoptotic cell count, as well as no hyperemia of the hepatic parenchyma. Plant infusions have in vivo hepatoprotective properties used in carbon tetrachloride-induced hepatoxicity which

investigated the protective and probable mechanism in mice [28].

MAO inhibitory activity

Eighty percent aqueous extract of whole plant of *A. vulgaris* reported flavonoids (jaceosidin, eupafolin, luteolin, quercetin, apigenin) and coumarins (esculetin, esculetin-6-methylether, scopoletin) are good inhibitors of mouse brain monoamine oxidase (MAO) enzyme with IC50 values of 19.0, 25.0, 18.5, 12.5, 1.0, 31.1, 32.2 and 45.0 µmol, respectively [53].

Hypolipidemic activity

The root extract of *A. vulgaris* developed hyperlipidemia after being fed a high-fat diet for 30 days in rats. The rodents were fed a regular diet for the next month. The researchers discovered that the *A. vulgaris* root extract had a substantial ability to normalize lipid profiles. Total cholesterol (TC) was reduced to 180 mg/dL, triglycerides (TG) to 147.2 mg/dL, low-density lipoprotein (LDL) cholesterol to 126.3 mg/dL and very low-density lipoprotein (VLDL) cholesterol to 28.2 mg/dL, while high-density lipoprotein (HDL) cholesterol and atherogenicity indicator (AI) increased to 68 and 2.63 mg/dL, respectively [54]. A plant extract used for the analysis of anti-inflammatory and hypolipidemic properties in hypercholesterolemic rats. Rats were given an 8-week high-fat diet that contained 3% cholesterol in oleic oil to cause hypercholesterolemia. In contrast to the healthy control group, this resulted in a significant rise in the serum levels of triglycerides, TC, LDL cholesterol, malondialdehyde, NO and tumor necrosis factor-α and a significant fall in the levels of HDL cholesterol, the liver enzyme hydroxymethylglutaryl-CoA reductase and the enzyme paraoxonase-1. In contrast to animals given a high-fat diet, rats given an extract of *A. vulgaris* at a dose of 100 mg/kg per day for four weeks had their serum lipid profiles normalized, their paraoxonase-1 activity significantly increased and their levels of malondialdehyde, NO and tumor necrosis factor-α decreased. In addition, the extract reduced the activity of hydroxymethylglutaryl-CoA reductase when compared to mice given a high-fat diet and control animals [56].

Anticonvulsant effect

Picrotoxin-induced seizures in mice were studied using an aqueous plant leaves and stems extract, which late the beginning of seizures and reduced death rate [66]. The methanol extract of the leaves of *Artemisia vulgaris* has the anticonvulsant and calming effects. To evaluate the anticonvulsant effect, methanol extract doses of 50, 100 and 300 mg/kg were given to Swiss albino mice. The convulsant pentylenetetrazol 100 mg/kg, picrotoxin 10 mg/kg, strychnine 2 mg/kg, pilocarpine 600 mg/kg and lidocaine 200 mg/kg had an adverse effect on the animals. The elevated plus-maze and the marble-burying test have been used to assess the plant's ability to reduce anxiety in rats (EPM and MBT). In all of the experimental models, diazepam 2 mg/kg was employed as the standard medication. In all of the experiments, the methanol extracts showed outstanding anticonvulsant action and prolonged the interval between the onset of the first seizure. 100 and 300 mg/kg of the methanol extract were the optimum doses. The EPM and MBT were also used to track the anxiolytic action. According to the findings of this study, methanol extract activity during PTZ increased synaptic inhibition mediated by GABA, decreased neuronal excitability and raised the seizure threshold [66, 67].

Antihypertensive activity

Aqueous and chloroform extracts of *A. vulgaris* aerial parts investigated the plant's hemodynamic efficacy by infusing a 10% solution of the aqueous extract into the segregated transfused mesentery of rats effectively. They rectified the hypertensive effect induced by noradrenaline, but not the baseline blood pressure or heart rate [7, 10]. On the isolated artery, this plant has dual opposing properties: contraction and relaxation, which may contribute to elucidate the contradictory signals for the treatment of hypertension. Skin prick tests were used to determine the plant's specific IgE in vitro [7]. Based on a survey of articles published in databases from 1980 to 2013, comprehensive review of randomized controlled trials (CENTRAL, PubMed, CBM, CNKI, VIP and online clinical trial registry websites) was conducted by the Chinese team. They show that moxibustion (a traditional Chinese treatment that employs the heat generated by burning herbal preparations including *A. vulgaris* to activate acupuncture sites) reduced blood pressure in randomized controlled trials when compared to antihypertensive medications by stimulating acupoint KI 1 [59]. Moxibustion plus antihypertensive medicines (such as Metoprolol, Nifedipine and Enalapril) had superior effects on systolic blood pressure (WMD: 4.91 [7.54, 2.28]), but no superior effects on diastolic blood pressure (WMD: 6.38 [17.17, 4.41]) according to a meta-analysis [59].

Antiallergic activity

Twenty-five patients with seasonal rhinoconjunctivitis for longer than two years and only two clinically significant allergies—either to *A. vulgaris* and *Betula verrucosa* or to *A. vulgaris* and *Phleum pratense*—were studied for the specificity and effectiveness of immunotherapy using *A. vulgaris* extracts. A two-year course of targeted immunotherapy was completed by 20 patients. Eleven individuals

received either *B. verrucosa* or *P. pratense* extracts in addition to the nine patients who received extracts of *A. vulgaris*. After receiving *A. vulgaris* treatment, skin and ocular sensitivity to *A. vulgaris* significantly decreased, but not to *B. verrucosa* or *P. pratense*. The patients who were treated with *B. verrucosa* or *P. pratense* showed a significant decrease in medication consumption and symptom scores in the *B. verrucosa* or *P. pratense* season but not in the *A. vulgaris* season. These patients also experienced a significant decrease in skin and eye sensitivity to these organisms but not to *A. vulgaris*. With one mysterious exception, both patient groups (*A. vulgaris* and *B. verrucosa* or *P. pratense*) reported lower skin sensitivity to *A. vulgaris*, the therapy was successful and targeted [58].

Antimicrobial and antiplasmodial activity

The in vitro antimicrobial activity of the aqueous, alcoholic, petroleum ether and benzene extracts of the plant's leaves was investigated using the agar diffusion method, showing the highest inhibitory activity of gram-positive and negative organisms when compared to standard antibiotics. The yield of methanol, methanol–water and water extract of the plant showed 17.1%, 11.4%, 8.6%, respectively, with 70% (7.5), 3.0, 6.5 EC50 or percent cell growth (at concentration µg/ml) of the above mention extracts of the plant [68]. A 50% concentration of the plant's essential oil showed the best larvicidal and insect repellant performance against the dengue fever vector *Aedes aegypti* with a 60-min protection time [69].

Anticancer activity

The effects of methanolic extract of aerial part of plant on human cancer cell lines (including MCF7, an estrogen-dependent breast adenocarcinoma cell line, A549, a non-small cell lung cancer cell line, and HeLa, a cervical cancer cell line) and normal cell lines (including A7R5, a vascular smooth muscle cell line, and 293 T, a human embryonic kidney cell line transformed with SV40largeTantigen) were assessed Inhibitory concentrations for MCF7 (IC50 = 190 ng/mL), HeLa (IC50 = 284 ng/mL), A7R5 (IC50 = 382 ng/mL) and 293 T (IC50 = 317 ng/mL) cells were all much higher than those for A549 (IC50 = 778 ng/mL) which had a much less pronounced impact [63]. The tumor necrosis factor related apoptosis-inducing ligand (TRAIL)-sensitive and insensitive triple negative breast cancer cell lines, MDA-MB-4 and MDA-MB-231, both responded significantly to different extracts of *A. vulgaris*. *A. vulgaris* suppresses the phosphorylation of p65 which act as a resistant mechanism to TRAIL [64]. The essential oil of the plant was extracted from the leaves and buds and the MTT assay was used to assess the viability of the human HL-60 promyelocytic leukemia cell line and other cell lines [60]. N-hexane, methanol, dichloromethane, ethyl acetate and extracts from the plant's aerial portions were employed in cytotoxicity tests on MCF-7 cells [64]. MTT assay revealed that the methanol extract of a plant used to examine the in vitro HepG2 Hepatocellular carcinoma cell line for their apoptotic properties at IC 50 value was 0.1 mg. The antiproliferative action of an ethyl acetate extract of a plant was evaluated in a variety of cancer cell lines with an IC50 value of 57 g/ml [64, 65]. An investigation on methanolic extracts of the *A. vulgaris* plant was conducted in 2020. The scientists established the extracts' genotoxic and cytotoxic properties, both when used alone and in conjunction with a recognized mutagen (mitomycin C). They employed the MTT assay to check the proliferation of SW-480 human colon cancer cells and human periodontal ligament stem cells as a control, and the cytokinesis-block micronucleus assay to measure the frequency of micronuclei in human peripheral blood lymphocytes. The cytokinesis-block micronucleus assay revealed that both extracts, with the exception of the lowest concentration (10 g/mL), significantly increased the frequency of micronuclei in peripheral blood lymphocytes evaluated with the *A. vulgaris* extract. These results were true for all of the concentrations tested (10, 50, 100, and 250 g/mL). The extracts did not substantially alter the viability of the human periodontal ligament stem cells and only induced cytotoxic activity in co-treatment with mitomycin C after prolonged exposure. The flavonoids or other phenolic chemicals found in the plant, according to the researchers, stimulated these effects [63–65].

Immunomodulatory effects

The total number of leukocytes, differential leukocyte count, antibody titer and carbon elimination rate were all measured in order to assess immunomodulatory efficacy. Six groups made up of five male rats each were created from the treatment groups. For seven days, oral administration of the extract at dosages of 50, 100, 200 and 400 mg/kg bw was used. A UV–visible spectrophotometer was used to quantify the carbon removal. In comparison to the negative control group (CMC-Na 0.5%), *A. vulgaris* at dosages of 50, 100, 200 and 400 mg/kg body weight boosted carbon elimination and increased the number of total and differential leukocytes, particularly neutrophils and neutrophil rod segments ($p < 0.05$). Compared to a negative control group, the immunomodulatory effect of ethanol extract of the plant at doses of 50, 100, 200 and 400 mg/kg on (CMC-Na 0.5%) ($p < 0.05$) [70].

Table 7 Insecticidal activity on different species on essential oil and extracts of *A. vulgaris*

Essential oil and extracts	Part used	Insect species	Pathogenic	References
Essential oil	Leaves	*Aedes aegypti* (Egyptian mosquito)	Virus vector, Dengue fever	[72, 73]
Essential oil	Herb	*Aedes aegypti* (Egyptian mosquito)	Virus vector, Dengue fever	[73]
Nanoparticles	Leaf extract	*Aedes aegypti* (Egyptian mosquito)	Virus vector, Dengue fever	[74]
Extract	Leaves, stem, root	*Culex quinquefasciatus* Say. (*Culex fatigans*) (arbo virus)	Vector of avian malaria, vector of *wuchereria bancrofti*	[75]
Essential oil	Leaves, aerial parts	*Tribolium castaneum* (Herbst)	Deposited–produce insect vermin	[76]
Essential oil	Aerial parts	*Callosobruchus maculatus* (F.)	Deposited–produce insects	[77]
Essential oil	Aerial parts	*Rhyzopertha dominica*	Deposited–produce insects	[77]

Insecticidal activity

A. vulgaris essential oil was extracted and applied to *Aedes aegypti* larvae at different doses (Egyptian mosquito, dengue virus vector). At 10 ppm of concentration, insecticidal activity was present, but after 8 h of contact to the oil solution, 500 ppm of concentration produced good results. Larvae had a 100% mortality rate. In light of the aforementioned experimental data, it may be assumed that essential oils have insecticidal properties [71]. For evaluation of their ability to kill insects, essential oil and nanoparticles were obtained from leaf extracts shown in Table 7. Additionally, the effects of several *A. vulgaris* raw ingredients were tested against the *Culex quinquefasciatus* bug species [72, 73] as well as other insects found in stored goods.

Uses in food industry

The bactericidal, anti-inflammatory and antibacterial characteristics of *A. vulgaris* essential oil make food items more palatable. Additionally, the oil contains insecticide, nematocidal and larvicidal activities. *A. vulgaris* is well liked as a spice due to the aroma and bitter flavor of the herb as well as the sweet and spicy flavor of the roots. In Asia, rice dishes and tea are seasoned with the bitter leaves and buds that are picked just before flowering [63]. Additionally, the variety is used to flavor meat, poultry, fish, salads, vodka and herbal wines [63], as well as sweet and savory desserts (especially in Japan). Before the invention of hops, *A. vulgaris* was used to flavor beer. Despite its historical notoriety, *A. vulgaris* is only sometimes used as a spice in Poland. There are presently initiatives to boost its acceptance as a flavoring ingredient for soups, mutton, liver, cabbage, spinach and mushroom dishes. Additionally, *A. vulgaris* tincture is frequently employed as an aromatic sensory ingredient in animal feed [64]. The cultivation of vegetables and the use of *A. vulgaris* in agricultural areas, orchards and vineyards are all permitted, according to the European Food Safety Authority. The plant preys on a variety of insects, including the *Aedes aegypti* (Egyptian mosquito), *Musca domestica* (house fly) and *Tribolium castaneum* (red flour beetle). Because it poses fewer risks to both people and the environment than alternative preparations, people are growing more interested in utilizing the plant for this purpose. [75–77].

Conclusion

Artemisia vulgaris L. has long been used to treat a variety of illnesses. Furthermore, several research studies in the experimental animal have demonstrated its applications beyond ethnomedicinal ones. Antifertility, hepatoprotective, antidiabetic, analgesic and anti-inflammatory, hypolipidemic, antioxidant, antihypertensive, antiallergic, antispasmodic and anticancer, immunomodulatory and many more pharmacological actions have been investigated in various portions of the plant. Artemisic acid, artemisinin B, camphene, camphor, 1,8-cineole, γ-caryophyllene, β-thujone,germacrene D, quercetin, isohamnetin and luteolin are all claimed to be present and may be responsible for the diverse biological actions. As a result, we will be able to extract a purer form of phytopharmaceuticals that can be employed as a novel target for the treatment of a wide range of illnesses with high therapeutic activity. Extract standardization, phytopharmacology of diverse extracts, characterization and isolation of active phytopharmaceuticals, clarification of isolated compound's mechanism of action and clinical trials of the compounds are all important in the creation of quality herbal medicine.

Abbreviations

DPPH: 2,2-Diphenyl-1-picryl-hydrazyl-hydrate; IC50: Half-maximal inhibitory concentration; ATCC: American type culture collection; MIC: Minimum inhibitory concentration; TRAIL: TNF-related apoptosis-inducing ligand; MTT: 3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium.

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Author contributions

We declare that this work was done by the authors named in this article: DS comprehended and designed the study. MN assisted in the data analysis and corrected the manuscript. All the authors read and approved the final manuscript. DN assisted in providing the traditional data. All authors read and approved the final manuscript.

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Availability of data and materials
All the information in the manuscript has been referred from the included references and is available upon request from the corresponding author.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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