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A comprehensive review on phytochemistry, pharmacology and therapeutic applications of Davana (*Artemisia pallens* Wall.)

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Abstract

Davana is an annual fragrant and important medicinal herb known for its antimicrobial property. It is an indigenous crop of India with rich phytochemistry, pharmacology and therapeutic uses. It is commercially cultivated as winter annual in Southern parts of India. Davana essential oil is one of its raw materials in confectionary and beverage industries. Besides, the essential oil is abundant in bioactive substances like davanone, linalool, and davana ether. Numerous pharmacological effects, such as antibacterial, anti-inflammatory, antioxidant, antidiabetic, hepatoprotective and anticancer qualities, are displayed by the essential oil. Davana has also long been used in traditional medicine to treat diabetes, skin infections, and respiratory conditions. The rich composition of sesquiterpenes, flavonoids and phenolic chemicals revealed by the plant chemical profile adds to its potential as a medicine. According to recent research, it can be genetically altered to produce more artemisinin, which makes it a promising option for metabolic engineering. Its specific pharmacological mechanisms, long-term toxicological effects, and regulatory standardization are still not fully understood. Future studies should concentrate on sustainable farming practices, clinical trials, and a deeper examination of its synergistic relationships with other bioactive substances. All things considered, davana offers a great deal of promise for industrial and therapeutic uses, especially in the fields of medicines, aromatherapy and perfumes.

1. Introduction

Davana (*Artemisia pallens* Wall.) is an annual aromatic herb of Indian origin. The spread of the genus *Artemisia* is noticed in northern hemisphere, subtropical Africa, South Africa, West America and South America. Genus *Artemisia* consists of 475 species (Yogendra *et al.,* 2024) and 47 species, 19 varieties are reported in Indian sub-continent (Karthikeyan *et al.,* 2009). Davana is said to bought from the Himalayan region and is believed to native of south India, even though the natural habitat is unknown (Singh *et al.,* 2015). Davana is an erect branched annual herb grows to a height 1.5 - 2.0 feet and has a greyish white tomentum (Kumara *et al.,* 2023). It prefers cool dry weather for its growth and commercially cultivated as winter annual aromatic crop in Southern Karnataka and Tamil Nadu (Ruikar *et al.,* 2009). *A. pallens* has widespread application traditional medicine to treat a range of illness, such as inflammation, digestive issues and infections. Its possible pharmacological properties including antibacterial, anti-inflammatory and antioxidant actions, have just come to light. The essential oil derived from the various species of *Artemisia* have been well known for their flavour intensifying properties and its contribution to the medicinal purpose (Juteau *et al.,* 2002). These essential oils are used for their diverse aromatic profiles and therapeutic values. These have been integral to the culinary and pharmaceutical purposes that enrich the flavour and aiding in various medicinal applications. The essential oil of Davana has a balanced effect that helps alleviate anxiety. When applied to the skin, it emits a unique scent on each individual, making it a prized ingredient in high end perfumes for creating distinctive fragrances. In traditional Indian medicine, Davana has been used to treat diabetes, immunomodulatory, anthelmintic, antipyretic and also in the wound healing purposes. Additionally, it serves a mood enhancer and aphrodisiac as well as an effective antiseptic and disinfectant (Dongare, 2022). Davana oil can also be used as a natural insect repellent and it is believed to reduce the risk chronic diseases, heart failure and cancer (Bakkali *et al.,* 2008). Certain species of *Artemisia* have long been prized for numerous therapeutic benefits in the field of Iranian traditional medicine poularly known as Parida. Interestingly, because of their antiviral properties and capacity to reduce spam, the locals have resorted to the aerial parts of the Davana (Ramezani *et al.,* 2005).

2. Botany

Artemisia is a member of Compositae family. The family Asteraceae (Compositae) includes the subtropical and temperate genus *Artemisia.* It is arachnose-tomentose herb that can grow up to two feet height and has a very pleasant aroma. Stem of this plant is cylindrical and upright with uni-pinnatified or bi-pinnatified pubescent leaves (Figure 1). The linear oblong leaf segments have obtuse apices and

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complete margins, with a short petiole narrowly winged. The inflorescence could be axillary, solitary or appear as terminal panicles as a result of the reduction of upper leaves. They also come in racemes with the inner florets being bisexual and the outer 1-2 rows of florets being female they are heterogamous. The yellow, five lobed, sessile or sub sessile florets have a bifid style and five stamens with free epipetalous filaments. The involucre bracts have arachnose-tomentose surface, oblong to elliptic-linear structures, entire margins and obtuse apices. The ovary has glabrous, oblong style that is 2 mm long and has two lobes, the apex of which are truncate and recurved. The achene has no pappus and is oblong and glabrous (Sheriff and Srinath, 1965). Other commercial species of *Artemisia* is *Artemisia annua*. It iscommonly known as sweet wormwood or Qinghao. It can grow up to two meters tall and is distinguished by its finely divided, aromatic leaves that have a feathery appearance. The plant produces small, yellowish flower heads arranged in panicles, and its slender, erect stem is typically green but may develop a purplish hue as it matures. Native to temperate regions of Asia, particularly China, *A. annua* thrives in warm, sunny environments with well-drained soils and has since been cultivated worldwide for its medicinal properties. It primarily reproduces through seeds, with flowering occurring between late summer and early autumn. It is well-known for its use is in medicine, as it contains artemisinin, a potent antimalarial compound widely used in treating malaria, especially in artemisinin-based combination therapies. Beyond malaria treatment, the plant exhibits antiviral, anti-inflammatory, and anticancer properties, making it a subject of research for various therapeutic applications. In traditional medicine, it has been used to treat fevers, digestive disorders, and infections. Additionally, *A. ann*ua is utilized in agriculture as a natural pesticide due to its bioactive compounds that deter pests (Ramezani *et al.,* 2005).

Figure 1: Davana plant with foliage and flowers. (Picture Source-Student's Research plot, Horticultiral College and Research Institute, Periyakulam).

3. Traditional uses

Davana (*A. pallens*) and its essential oil have been widely recognized for their traditional uses, particularly in Ayurvedic medicine, religious rituals, and perfumery. In Indian culture, Davana holds spiritual significance and is commonly used in religious offerings, particularly to Lord Shiva, as part of temple rituals and garlands (Gajjar *et al.,* 2019).

4. Chemical composition and their uses

The essential oil is the commercial product of Davana extracted from the foliage and flowers of the plant. It is extracted by hydro or steam distillation process. Davana (*A. pallens*) essential oil (DEO) is primarily composed of oxygenated sesquiterpenes, sesquiterpene hydrocarbons, and monoterpenes, which contribute to its distinct aromatic, medicinal, and antimicrobial properties. The most abundant compound is davanone (30-50%), a key oxygenated sesquiterpene responsible for the oil's strong balsamic, woody and fruity aroma as well as its antimicrobial activity. Davanol (5-15%), a sesquiterpene alcohol, plays a crucial role in enhancing antioxidant and antimicrobial effects, while davana ether (2-10%) improves the oil's fragrance longevity (Brunke *et al.,* 1986). Other significant sesquiterpenes, including bicyclogermacrene (2-8%) and germacrene-D (2-10%), contribute to anti-inflammatory and antimicrobial properties. Additionally, methyl davanone (1-5%) and geranyl acetate (0.5-2%) add floral and fruity notes, making the oil valuable in perfumery and aromatherapy. Monoterpenes like linalool (1-5%) provide a calming effect, while farnesol (1-5%) and β-caryophyllene (1-4%) exhibit antibacterial and skin-healing properties. Other minor compounds, such as eugenol (0.5-3%) and elemol (0.5-3%) further enhance the antimicrobial and therapeutic qualities of davana oil. Due to this rich chemical composition, Davana oil is widely used in cosmetics, medicine, perfumery and aromatherapy offering a unique combination of fragrance, therapeutic benefits, and antimicrobial action (Lamparsky and Klimes, 1985).

Inquiries were conducted into the volatile constituents of *A. pallens* essential oil and over 50 chemicals were found in the oil, 34 of which are recognized. The essential oil extracted is classified by davanone isomers, Davana ether isomers, and other furan derivatives (Thomas and Pitton, 1971).

4.1 Davanone

Davanone is a key bioactive compound found in DEO. It belongs to the oxygenated sesquiterpene class, characterized by its three isoprene units and oxygen-containing functional groups, which contribute to its distinct aromatic, antimicrobial, and therapeutic properties. It is the primary chemical constituent of Davana oil. It is odorless sesquiterpene ketone which ranges up to 30 to 65% (Mallavarapu *et al.,* 1999). Chemically, davanone has the molecular formula $C_{15}H_{24}O$ and is a pale yellow to amber-colored liquid with a sweet, balsamic, and woody aroma. This compound plays a vital role in the fragrance profile of Davana oil, making it highly desirable in the perfume and cosmetic industries. Apart from its olfactory significance, davanone exhibits potent antimicrobial activity, effectively inhibiting the growth of Gram-positive and Gram-negative bacteria, as well as fungal pathogens. Including that, perfumery and the flavour industries require and demand more amount of the davanone rich oil (Catalán *et al.,* 1990). The abundance of this enhances the overall aroma of the oil. This is because of the its fixative property which prolongs the aroma nature and slow down the evaporation (Suresh *et al.,* 2011). A sesquiterpene called $C_{15}H_{24}O_2$ was discovered when the components of Davana oil were being separated (Figure 2). The chemical and spectroscopic data presented indicated that this sesquiterpene's gross structure needs to be symbolized by I. davanone is the suggested name for this ketone. Besides perfumery industry davanone is also used in the aroma therapy for mental relaxation and mood enhancer (Sipma and Van der Wal, 1968).

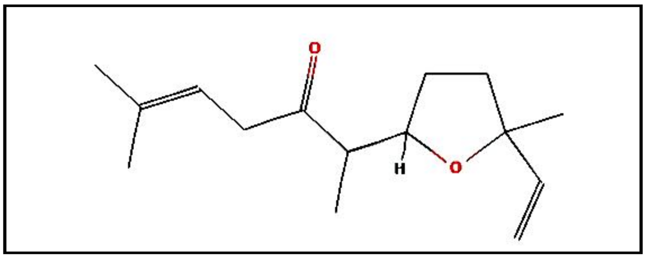

Figure 2: Structure of davanone.

4.2 Davanone isomers

The Cis-Davanone: The primary constituent, making up 45.8% of the total oil and 72.2% of the fraction. It has a fruity odor profile with raisin and dried plum notes, and weak herbal undertones (Figure 3). Iso-Davanone: Present at 1.2% in the essential oil and 1.9% in the fraction, with similar fruity, raisin and dried plum notes with slightly herbal characteristics. Allo-Davanone: Found at 0.6% in the essential oil and 0.1% in the fraction, with fruity, raisin and dried plum odor profiles (Catalán *et al.,* 1990).

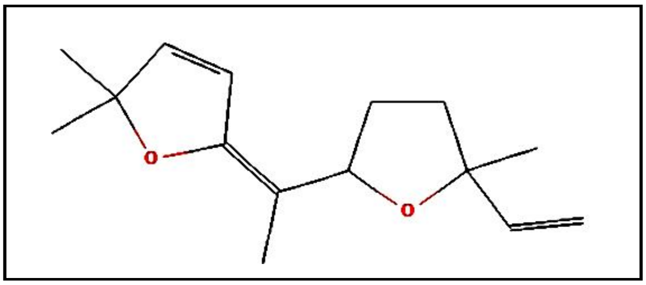

Figure 3: Structure of davanone isomer.

4.3 Ether and acetate isomers

Davanol ethers are created by replacing the hydroxyl group with ether; these derivatives have long-lasting aromatic effects and greater oxidation resistance, ensuring better shelf-life in fragrances and essential oils (Figure 4). Davana ether 2° consists of 5.2% of the fraction and 1.0% of the oil, with notes of dried plum, raisin, and dry fruit and Davana ether 3° contributes 2.1% of the fraction and 1.3% of the oil it has a comparable dry-fruity, raisin, and dried plum odor. Davanol acetate is produced by esterifying davanol with acetic acid, it enhances fragrance longevity and provides a fruity, floral aroma, making it widely used in perfume formulations. In acetate isomers davanyl acetate 1° has notes of fruit, raisin, and dried plum and makes up 0.7% of the oil and just traces levels in the fraction. Similar fruity properties are found in davanyl acetate 2°, which comprises 0.2% of the oil and 0.03% of the fraction. These ethers are mainly responsible for the fruity odour of the essential oil obtained from davana (Mallavarapu *et al.,* 1999).

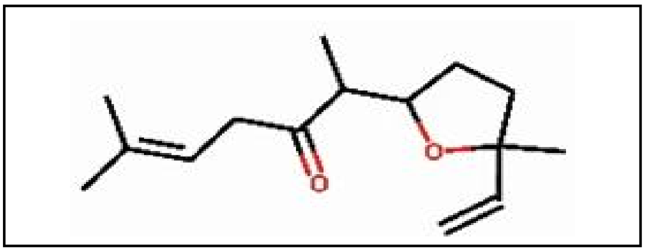

Figure 4: Structure of davanone ether isomer.

4.4 Davanol oxides and derivatives

Davanol oxides are formed through oxidation, these compounds exhibit strong antimicrobial and antifungal activities, increasing their value in cosmetics and natural preservatives (Figure 5). Davanol 1° contributes about 1.2% in the oil and fraction, with faint alcoholic undertones and notes of fruit, raisin, and dried plum. Similar fruity qualities and faint alcoholic undertones are present in davanol 2°, which is present at 1.0% in the oil and 0.6% in the fraction (Jirovetz *et al.,* 2005).

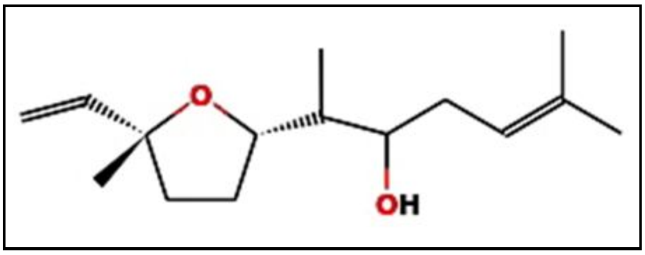

Figure 5: Structure of davanol 1°.

4.5 Chemical composition of essential oil

The composition of the chemical constituents found in the davana essential oil was determined by employing gas chromatography-mass spectroscopy (GC-MS) and revealed the identification 14 components (Table 1).

Table 1: Compound name, molecular weight, rotations per minute, percentage of area and molecular composition of chemical constituents

S.No.	Compound name	Molecular weight	Retention time (min)	% Area	Molecular composition	References
1	Isobutyl propionate	130	1.98	2.665	$C_7H_{14}O_2$	Sharma *et al*, 1934
2	2-Methyl,1,3-Propandediol,dipropaanoate	202	2.06	4.819	$C_4H_{10}O_2$	Pu *et al.,* 2010
3	4,5-Dimethyl-thiazole	113	5.82	20.024	C_5H_7NS	Kiran *et al.,* 2018
4	Ligustrazin	136	5.92	3.207	$C_8H_{13}ClN_2$	Cheng *et al.*, 2007
5	Dodeca-(2E,6Z)-dienal 12.41	180	12.41	1.672	$C_{12}H_{20}O$	Calvo-Martín *et al.,* 2022
6	Endo-2-norborneol 14.3 112	112	14.3	25.561	$C_7H_{12}O$	Calvo-Martín *et al.,* 2022
7	Nona-3,6-dien-1-ol	140	14.66	5.378	$C_9H_{16}O$	Cherniienko *et al.,* 2022
8	4-Methyl-cyclohex-2-en-1-ol 14.85	112	14.85	2.380	$C_7H_{12}O$	Cherniienko *et al.,* 2022
9	(Z)-3-Methyl-4-undecene	168	15.35	0.520	$C_{12}H_{24}$	Ser *et al.,* 2015
10	5-Isopropylidene-3,3-dimethyl-dihydrofuran-2 -on 16.59	154	16.59	4.594	$C_9H_{14}O_2$	Ser *et al.,* 2015
11	Hexahydro-3-(2-Methyl propyl)-pyrrolo(1,2-A) Pyrazine-1,4-dione	210	17.78	2.636	$C_{14}H_{16}N_2O_2$	Ben Bakrim *et al.,* 2022
12	Tetradecanoic acid	228	18.96	4.348	$C_{14}H_{28}O_2$	Bail *et al.,* 2008
13	9-Heptadecanol	256	20.88	6.581	$C_{17}H_{36}O$	Bail *et al.,* 2008
14	Octadecanoic acid 21.17 284	284	21.17	5.106	$C_{18}H_{36}O_2$	Bail *et al.,* 2008

5. Phytochemicals

The phytochemical components of Davana include davanone, Davana-ether, Davana furan and linalool are the major phytochemical constituents of Davana oil. Methyl cinnamate, ethyl cinnamate, bicyclogermacrene, Davana ether, 2-hydroxyisodavanone, farnesol, geranyl acetate, sesquiterpene lactones, germacranolides, *etc*., are also found. The contents of davanone, the major constituent of Davana oil, and linalool decreased while those of (Z)-and (E)-methyl cinnamate, (E)-ethyl cinnamate, bicyclogermacrene, Davana ether, 2-hydroxyisodavanone, and farnesol increased from flower heads emergence stage to the initiation of seed set stage. Five compounds, *viz.,* (Z)-and (E)-methyl cinnamates, (Z)-and (E)-ethyl cinnamates, and geranyl acetate, were identified for the first time in Davana oil (Ruikar *et al.,* 2011). Hexane, chloroform, ethanol and chloroform water extracts were subjected to phytochemical analyses, which revealed the presence of proteins, amino acids, carbohydrates, tannin, phenolic compounds, flavonoids, and saponins and phytosterols. It was determined that more significant chemical components for a range of pharmacological activity are present in all extracts (Mallavarapu *et al.,* 1999).

5.1 Volatile phytochemicals

Numerous volatile phytochemicals found in Davana oil which gives it distinct scent and medicinal qualities. Davanone and isodavanone are the two sesquiterpene ketones that give the oil its unique scent and antibacterial properties among the main volatile ingredients. Davana oil is useful in aromatherapy because of its other important components, which include linalool and dehydro-α-linalool, which have soothing and anti-inflammatory properties in addition to a pleasant, flowery perfume. Another volatile component, terpinen-4-ol, has antibacterial and antifungal qualities that improve the oil's application in natural disinfectants and dermatological products. The oil's therapeutic uses, including as wound healing and immunological support, are also facilitated by davanafurans, artemone, and eudesmanolide (Shreyas *et al.,* 2018).

5.2 Non-volatile phytochemicals

Davana oil has non-volatile phytochemicals in addition to its volatile constituents that contribute to its therapeutic effects. As natural emulsifiers, saponins add to the oil's possible ability to soothe skin. Alkaloids have anti-inflammatory and pain-relieving properties due to their pharmacological actions. Plant-based substances called sterol glycosides may support healthy metabolism and cholesterol control. Because it contains tannins, the oil has antibacterial and astringent qualities that help with wound healing and skincare. Furthermore, mucilage protects and moisturizes the skin, while phenols have anti-inflammatory and antioxidant properties. These non-volatile phytochemicals add medicinal benefits, which include its use in cosmetic products, traditional medicine, and natural treatments for a range of illnesses (Kumara *et al.,* 2023).

6. Therapeutic applications

The essential oil of *A. pallens* is used in the aromatherapy. The aroma producing compounds present in the oils are similar to that of the compounds that are present in various plant essential oil such as lavender. The essential oils interact with the body's physiological systems through a variety of methods of action. The main one is being inhalation and skin absorption. Essential oils' volatile compounds activate nasal cavity olfactory receptors when breathed, transmitting signals to the olfactory bulb, which interprets fragrance data. The limbic system, a part of the brain in charge of controlling emotions, memories, and bodily processes receives these messages after the fragrance is interpreted (Pragati Patil, 2024).

6.1 Aroma therapy

Davana essential oil's relaxing and mood-boosting qualities make it a popular choice in aromatherapy. Stress, worry, and emotional strain are lessened by the oil's sweet, fruity, and somewhat woody scent. It is frequently used in bath mixtures, massage oils, and diffusers to encourage emotional health and relaxation. Additionally, Davana oil is thought to have adaptogenic properties, which means it aids in the body's ability to adjust to both physical and emotional stress. It is frequently used to create a calming effect in holistic therapy and meditation techniques. Its antidepressant qualities also make it helpful for people who are experiencing anxiety, depression, or mental exhaustion. Davana oil helps balance emotions, improve mood, and foster a sense of general well-being by inhaling its calming aroma (Singh and Sharma, 2021).

7. Pharmacological properties

The various phytomolecules found in *A. pallens* give it a variety of biological and pharmacological possibilities (Table 2). It has properties such as antimicrobial, antiasthmatic and antioxidant properties (Yogendra *et al.*, 2024).

Table 2: Chemical compounds and their pharmacological activity with their uses and chemical class

S.No.	Chemical compound	Chemical class	Pharmacological activity	Uses	References
1.	Davanone	Sesquiterpene ketone	Antimicrobial, antioxidant, anti-inflammatory	Used in skincare, perfumes and antimicrobial formulations	Obistioiu *et al.*, 2014
2.	Linalool	Monoterpene alcohol	Sedative, anxiolytic (anti-anxiety), anti-inflammatory	Used in aromatherapy, perfumes and stress-relief formulations	Blagojeviæ *et al.*, 2006
3.	Nerol	Monoterpene alcohol	Antimicrobial, antifungal, antioxidant	Used in cosmetics, perfumes, and skin-repair creams	Juteau *et al.*, 2003
4.	Germacrene D	Sesquiterpene hydrocarbon	Antibacterial, antifungal, anti-inflammatory	Used in wound healing and antifungal treatments	Fernández-Calienes Valdés *et al.*, 2008
5.	Elemol	Sesquiterpene alcohol	Antioxidant, anti-inflammatory, insect-repellent	Used in mosquito repellents, skincare, and traditional medicine	Mucciarelli *et al.*, 1995
6.	Methyl davanone	Ketone derivative	Antimicrobial, fragrance enhancer	Used in perfume formulations and essential oil blends	Judzentiene *et al.*, 2009
7.	Borneol	Monoterpene alcohol	Analgesic (pain reliever), neuroprotective, anti-inflammatory	Used in traditional Chinese medicine for nerve health and pain relief	Kowalski *et al.*, 2007
8.	α-Copaene	Sesquiterpene hydrocarbon	Anticancer, anti-inflammatory, antimicrobial	Potential applications in cancer research, essential oils, and therapeutic formulations	Lopes-Lutz *et al.*, 2008
9.	β-Caryophyllene	Sesquiterpene	Anti-inflammatory, analgesic, gastro protective	Used in pain relief, digestive health, and neuroprotective treatments	Orav *et al.*, 2006
10.	Farnesol	Sesquiterpene alcohol	Antimicrobial, anti-inflammatory, anticancer	Found in antibacterial ointments and antiageing cosmetics	Chialva *et al.*,1983
11.	α-Pinene	Monoterpene	Anti-inflammatory, bronchodilator, neuroprotective	Used in asthma relief, respiratory care, and cognitive health	Kordali *et al.*, 2005
12.	β-Myrcene	Monoterpene	Analgesic, sedative, anti-inflammatory	Used in pain relief, muscle relaxation, and sleep-inducing therapies	Judþentienë and Buzelytë, 2006

7.1 Antimicrobial properties

The antimicrobial property of davana oil is well documented scientifically by many researchers. Bail *et al.*, 2008 investigated the davana oil's efficacy against a spectrum of microbial organisms, including both Gram-positive and Gram-negative bacteria, as well as various fungal strains. In Their findings Davana essential oil exhibited significant antimicrobial activity, potentially comparable to or exceeding that of conventional antibiotics or antifungal agents. They also documented specific bioactive compounds identified through gas chromatography mass spectrometry (GC-MS) analysis, which are responsible for the oil's antimicrobial properties. These compounds, such as oxygenated sesquiterpenes and monoterpenes, are known for their ability to disrupt microbial cell membranes and inhibit growth. Furthermore, the study could highlight possible applications of Davana oil in pharmaceuticals, food preservation, personal care products, or natural disinfectants, given its potent antimicrobial effects. Significant antibacterial activity against oral cavity illness is observed, when 0.2% chlorhexidine was used to test the antibacterial qualities of acetone and ethanol extracts, the ethanol extract showed greater promise against microbial illness in the oral cavity (Yogendra *et al.,* 2024). One important component of Davana oil, davanone, has antibacterial and antifungal properties (Schmidt *et al.,* 2010). Davana essential oil has shown antimicrobial behaviour against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella enterica* subsp. *enteric* and the yeast *Candida albicans* (Vajs *et al.,* 2004). A recent study examining the Davana root acetone extract and its isolates against *S. aureus*, *B. subtills*, *P. aeruginosa* and *E. coli* revealed the highest activity of the compounds had a minimum inhibitory concentration (MIC) value of 12.78 μM against *S. aureus* in comparison to the other strains (Kalaiselvi *et al.,* 2010).

7.2 Anti-inflammatory and analgesic property

Davana oil has long been used to treat melancholy, diabetes, coughing, colds, measles, and high blood pressure. Its anti-inflammatory and analgesic have all been shown in several studies. Analgesic and anti-inflammatory properties is due to its saponins and flavonoids, Davana's methanolic extract demonstrated strong anti-inflammatory effects on rats' carrageenin-induced paw edema. It also possesses strong analgesic effects (Singh *et al.,* 2022). Significant pro-inflammatory cytokine inhibitory capacity was demonstrated by davana oil and cis-davanone in a dose-dependent form in HaCat cell lines (Singh *et al.,* 2021). some bioactive compounds such as limonenecadinol that is present is both pepper and Davana help reduce inflammation, pain, and swelling by interacting with key biological pathways that regulate the body's immune and inflammatory responses (Vasantharaj, 2024).

7.3 Antiasthmatic property

Davana essential oil demonstrates remarkable potential as a natural remedy for asthma management due to its complex phytochemical profile. This medicinal plant produces an essential oil abundant in bioactive terpenoids and sesquiterpenes that exhibit significant antiasthmatic effects. The key compounds davanone (a sesquiterpene ketone with anti-inflammatory and bronchodilator properties), linalool (which provides muscle relaxant effects that ease bronchospasms), cineole or eucalyptol (known for mucolytic and expectorant properties), germacrene-D (with antioxidant and anti-inflammatory effects), and farnesol (which modulates immune responses and alleviates airway constriction) (Geng *et al.,* 2015). The antiasthmatic action of Davana essential oil operates through multiple mechanisms. Davana oil helps reduce inflammation in the body by acting on different pathways. It stops the production of certain chemicals called cytokines which triggers inflammation. It also prevents too many immune cells (eosinophils) from gathering in the airways, which can cause breathing problems, especially in conditions like asthma. Davana oil is beneficial for respiratory health as it helps open the airways, clear mucus, protect the lungs, and prevent allergic reactions. It contains natural compounds like linalool and cineole, which relax the muscles around the airways, making breathing easier similar to asthma medications. Cineole compound works as a mucolytic and expectorant that helps break down thick mucus so it can be cleared from the lungs more easily. Additionally, the oil contains flavonoids and terpenoids, which act as antioxidants to protect the lungs from damage caused by harmful molecules called free radicals. This reduces inflammation and prevents worsening respiratory issues. Davana oil also helps control allergic reactions by lowering the production of IgE (Immunoglobulin E) antibodies and stabilizing mast cells, which stops the release of histamines that trigger asthma symptoms like wheezing and coughing. Overall, its natural properties make it helpful for managing asthma, allergies, and other breathing problems as reported by Deshpande *et al.* (2018). Following that acetaminophen-induced toxicity was lessened by the extraction of essential oil from the Davana aerial parts using methanol (Honmore *et al.,* 2015). Davana methanol extract helps in treating asthma by reducing lung damage, inflammation, and allergic reactions. It protects the lungs from oxidative and nitrosative stress, which can worsen asthma symptoms. In a study on rats with asthma-like symptoms, the extract increased natural defence protein that activates antioxidants to protect lung cells. It also lowered IgE antibodies, which trigger allergic reactions, and reduced key inflammatory substances which cause swelling, mucus build up, and airway tightening. By working through these pathways, Davana extract helps improve breathing and reduce asthma symptoms effectively (Mukherjee *et al.,* 2017 ; Vengala, 2017).

7.4 Hepatoprotective and antioxidant activities

In the davana essential oil phenolic rich hepatoprotective fractions and free radical scavenging properties was found to be active when it caused oxidative stress in rats commonly flavonoids and phenolic acid neutralizes the content or the number of free radicals (Veeramani, 2024). In 1000 μg of Davana extract, the total flavonoids and phenolic concentrations were 312.60 ± 1.24 and 322.20 ± 1.39 μg, respectively. Hepatoprotective and free radical scavenging properties were assessed using test models for DPPH, hydroxyl radical, nitric oxide, and superoxide radicals. The observed hepatoprotective and free radical scavenging properties may be due to the presence of phenolic groups (Ashok *et al.,* 2019). The presence of phenols and flavonoids in the Davana methanolic extract resulted in good antioxidant activity (Ruikar *et al.,* 2011).

7.5 Anticancer activity

Anticancer potential of the phytochemical composition of davana has also been demonstrated by several studies. Presence of bioactive compounds such as flavonoids, terpenoids, sesquiterpene lactones, and polyphenols, contributed to their effectiveness against various cancer types. Sharmila and Padma (2013), demonstrated that anticancer effects of Davana species are primarily exerted through several key mechanisms, including apoptosis induction, inhibition of tumor proliferation, suppression of angiogenesis, and prevention of metastasis. Artemisinin, a potent sesquiterpene lactone from *Artemisia* sp. generates reactive oxygen species that cause oxidative stress and DNA damage in cancer cells, leading to apoptosis. Additionally, flavonoids such as quercetin and luteolin interfere with crucial signalling pathways disrupting cancer cell survival and proliferation. The extracts also inhibit vascular endothelial growth factor (VEGF), which is essential for new blood vessel formation, thereby cutting off the tumor's oxygen and nutrient supply. Furthermore, polyphenols and sesquiterpenes found in these plants can suppress matrix metalloproteinases (MMPs) and epithelial-mesenchymal transition (EMT), processes that facilitate cancer metastasis. Various studies have confirmed the effectiveness of *Artemisia* extracts against different cancers, including breast, lung, cervical, liver, and colorectal cancers, by halting tumor progression and triggering cancer cell death (Slezáková and Ruda-Kucerova, 2017). Notably, Davana essential oil, rich in davanone, exhibits cytotoxic properties against colon cancer cells. Given their promising anticancer activity, essential oil derived compounds are being explored as complementary or alternative therapies, with some entering clinical trials. Advances in drug delivery, such as nanoparticle formulations, are being investigated to enhance the bioavailability and targeting efficiency of these natural compounds (Vasanthkumar *et al.,* 2024). Bioactive substances that can stop the growth of tumors, stop the development of cancer, and kill cancer cells. Vajas *et al.* (2004) stated that cytotoxicity caused in leukaemia cell line by davanone may be a powerful treatment for acute myeloid leukaemia.

7.6 Antidiabetic activity

Diabetes is a chronic metabolic disorder that results from either insulin resistance or insufficient insulin production, leading to elevated blood glucose levels. The therapeutic effects of Davana essential oil in diabetes management are primarily attributed to its antioxidant, anti-inflammatory, and enzyme-inhibiting properties. One of the key mechanisms through which Davana oil exerts its antidiabetic effects is its strong antioxidant activity. Diabetes is often associated with oxidative stress, which damages pancreatic beta cells responsible for insulin production. The essential oil contains a rich blend of flavonoids, terpenes, and polyphenols, which helps to neutralize free radicals, thereby protecting the pancreas from oxidative damage and improving insulin secretion. Another major mode of action of davana oil is its ability to inhibit carbohydrate-digesting enzymes, specifically alpha-glucosidase and alpha-amylase. These enzymes play a crucial role in breaking down complex carbohydrates into glucose. By blocking their activity, Davana oil effectively slows the absorption of glucose in the intestines, thereby preventing sharp spikes in blood sugar levels after meals. This property makes Davana essential oil beneficial in controlling postprandial hyperglycemia (high blood sugar levels after eating), which is a critical aspect of diabetes management (Alam *et al.,* 2019).

Davana oil also plays a role in regulating lipid metabolism, which is crucial since diabetes is often accompanied by dyslipidemia (abnormal lipid levels). Studies have shown that Davana oil helps reduce levels of low-density lipoprotein (LDL, “bad” cholesterol) while increasing high-density lipoprotein (HDL, “good” cholesterol). This lipid-lowering effect reduces the risk of cardiovascular complications, which are commonly associated with diabetes. Furthermore, the anti-inflammatory properties of Davana oil contribute to its anti-diabetic activity. Chronic low-grade inflammation is a major factor in the development of insulin resistance. The essential oil contains sesquiterpenes and flavonoids that helps in reduction of inflammation, improving insulin signalling and glucose metabolism (Subramoniam *et al.,* 1996). Animal studies conducted on diabetic models (such as rats and mice) have demonstrated that davana essential oil significantly lowers fasting blood glucose levels. Treated animals also showed improved glucose tolerance in oral glucose tolerance tests (OGTTs), lower HbA1c levels (a long-term blood sugar marker), and enhanced pancreatic beta-cell function. These findings suggest that Davana oil may help improve long-term blood sugar control and support insulin-producing cells. Given its promising hypoglycaemic, antioxidant, and lipid-regulating effects, Davana essential oil has the potential to be used in herbal medicine and nutraceutical formulations for diabetes management. It may be incorporated into supplements, functional foods, and beverages designed to regulate blood sugar levels naturally. While preclinical studies show promising results, further clinical trials in humans are necessary to confirm its efficacy and safety in diabetic patients. The methanolic extract from the herbage portions of Davana has the ability to reduce blood glucose levels in rats with diabetes (Gobika *et al.,* 2024).

7.7 Anti-HIV activity

Davana essential oil has shown promising potential in combating HIV due to its diverse bioactive compounds, including sesquiterpenes, terpenoids, and oxygenated components. These compounds contribute to the oil’s antiviral properties, particularly against HIV. The anti-HIV activity of Davana essential oil primarily operates through multiple mechanisms. One of the key mechanisms involves inhibiting viral entry by preventing HIV from binding to essential host cell receptors such as CD4, CCR5 or CXCR4, which are critical for the virus to infect immune cells. Additionally, certain active constituents in Davana essential oil may inhibit the function of the HIV reverse transcriptase enzyme, thereby preventing the virus from converting its RNA into DNA, a crucial step in its replication cycle (Ingle *et al.,* 2017). Furthermore, the oil has been found to interfere with viral transcription and replication, thereby reducing the overall viral load within infected cells. Another important aspect of its action is its potential role in modulating the immune system, as some bioactive components in the oil may enhance immune response, thereby assisting in controlling HIV progression. Experimental research on the anti-HIV properties of davana essential oil has primarily been conducted through *in vitro* studies, where the oil is tested on HIV-infected cell cultures to observe its inhibitory effects. Additionally, molecular docking studies have been performed to simulate interactions between the active compounds in Davana essential oil and key HIV proteins, such as reverse transcriptase and protease, to assess their potential in blocking viral functions (Nitave *et al.,* 2016).

7.8 Anthelmintic and arthropod deterrent activity

Davana essential oil exhibits significant anthelmintic activity, making it effective against parasitic worms. Its bioactive compounds work by paralyzing or inhibiting the growth of these parasites, disrupting their metabolism and nervous system. Studies have shown that davana oil can be a natural alternative to synthetic anthelmintic drugs, demonstrating strong efficacy in eliminating worms. Experimental findings indicate that the oil’s potency is comparable to standard treatments, highlighting its potential use in traditional and herbal medicine for deworming and parasite control (Bharathy and Karthikeyan, 2025). It also exhibits potent anthelmintic action against tapeworms (*Taenia solium*), earthworms (*Pheretima posthuma*), and *Ascaris lumbricoides*, or roundworms (Nakhare and Garg, 1991). Davana essential oil, synthetic davanone, and hydroxy precursors found to have anti-disease vector effects on arthropods (Bhagavathy *et al.,* 2015).

7.9 Wound healing activity

Davana essential oil exhibits remarkable wound-healing properties due to its antimicrobial, anti-inflammatory, and antioxidant effects. Its strong antibacterial and antifungal activity helps prevent infections by inhibiting the growth of harmful microbes like *Staphylococcus aureus* and *Pseudomonas aeruginosa* (Pujar *et al.,* 2000). Additionally, its anti-inflammatory properties reduce swelling and pain by suppressing inflammatory mediators, thereby promoting faster tissue regeneration. The oil’s rich antioxidant content helps neutralize free radicals, minimizing oxidative stress that can delay healing. It also stimulates fibroblast activity, enhancing collagen production, which strengthens the wound site and accelerates tissue repair. Furthermore, Davana oil helps retain moisture in wounds, preventing excessive dryness and promoting skin regeneration, which reduces scarring. Commonly used in diluted form for direct application, it is also incorporated into ointments and creams for enhanced wound recovery (Shalu *et al.,* 2016).

8. Toxicology and safety profile

The toxicology and safety profiles of *Artemisia* species vary depending on the specific compounds present in each plant. While many species are widely used in traditional medicine, their bioactive constituents, such as terpenoids, flavonoids, and alkaloids, can have both therapeutic and toxic effects. One of the most concerning compounds is thujone, found in *Artemisia absinthium* (wormwood), which can cause neurotoxicity, including seizures and hallucinations, at high doses. Additionally, some *Artemisia* extracts have demonstrated cytotoxicity *in vitro*, suggesting potential anticancer benefits but also raising concerns about cellular toxicity at elevated concentrations. Chronic exposure to certain species has been linked to hepatotoxicity and nephrotoxicity, particularly when consumed in large quantities or for extended periods. Davana essential oil and extract generally have a low toxicity profile when used appropriately (Gilani *et al.,* 2005). Most research indicates that Davana is relatively safe for topical application and aromatherapy use at recommended dilutions. However, as with many essential oils, there are some important considerations. Despite their medicinal applications, *Artemisia* species can pose risks, especially for sensitive individuals. Allergic reactions, including contact dermatitis and respiratory irritation, have been reported, particularly in those with preexisting allergies to plants in the Asteraceae family. Moreover, interactions with pharmaceutical drugs, such as anticoagulants and sedatives, can lead to adverse effects, necessitating caution in their therapeutic use. Regulatory agencies emphasize the importance of dosage control and proper extraction methods to minimize toxicity risks. While most *Artemisia* species are considered safe in moderate amounts, excessive or prolonged consumption requires careful monitoring to prevent potential health hazards (Salehi *et al.,* 2021).

The safety profile of *Artemisia* species is influenced by factors such as dosage, duration of use, method of administration, and individual susceptibility. Many species of this genus have been traditionally used for medicinal purposes, particularly for their antimicrobial, antimalarial, and anti-inflammatory properties. However, the presence of bioactive compounds, including terpenoids, flavonoids, and alkaloids, necessitates careful usage to avoid potential toxicity. Regulatory bodies, such as the european medicines agency (EMA) and the U.S. food and drug administration (FDA), classify certain *Artemisia* species as safe for limited medicinal use but caution against excessive or prolonged consumption (Stebbings *et al.,* 2016).

9. Drug interactions and contraindications

Artemisia extracts may interact with various pharmaceutical drugs, altering their efficacy or increasing the risk of adverse effects. For instance, compounds in *Artemisia* may potentiate the effects of anticoagulants, increasing the risk of excessive bleeding. Additionally, sedative effects of some species can enhance the action of central nervous system (CNS) depressants, leading to excessive drowsiness or respiratory depression. Due to these interactions, individuals taking medications for blood disorders, epilepsy, or psychiatric conditions should consult a physician before using *Artemisia*-based products. Pregnant and breastfeeding women are also advised to avoid *Artemisia* due to potential uterine stimulation and toxicity risks to infants (Siddiqui *et al.,* 2018).

10. Safety and regulatory status

The safety and the regulation of the essential oils are governed by the organizations like research institute for fragrance materials (RIFM) and international fragrance association (IFRA) which set usage limits based on the toxicity studies. Agencies such as European Chemical Agency (ECHA) and the Organization for Economic Co-operation and Development (OECD) ensures the compliance with safety standards by assessing risks like skin sensitization and phytotoxicity. These evaluations help to determine the permissible concentrations of essential oils in consumer products (Api *et al.,* 2022). The flavor and extract manufactures association (FEMA) has granted Davana oil as GRAS (Generally Recognized as Safe) status for the use in the perfumery and flavoring ingredients (FEMA No. 2359) (Smith *et al.,* 2005).

11. Gaps in current knowledge

Despite extensive research on *A. pallens*, significant gaps remain in our understanding of its full potential. Current studies mainly focus on isolated compounds, lacking a comprehensive review of its overall therapeutic efficacy. Additionally, while genetic transformation techniques have been optimized, further research is needed to increase the production of key bioactive compounds. The pharmacological mechanisms underlying its medicinal properties, such as anti-inflammatory and antimicrobial effects need further strengthening. Furthermore, toxicology studies, especially concerning long-term exposure and dermal applications, are insufficient. Another challenge lies in regulatory standardization, as detailed pharmacopeial guidelines for its medicinal and cosmetic applications are still underdeveloped.

12. Future research prospects

To bridge these gaps, future research should focus on conducting extensive *in vivo* and clinical trials to validate the plant's medicinal properties. Metabolic engineering can be explored to enhance the biosynthesis of essential compounds like davanone. Additionally, studying the synergistic interactions between different phytochemicals may provide deeper insights into its therapeutic potential. Sustainable cultivation techniques need to be developed to ensure cost-effective and environmentally friendly production. Moreover, research into new therapeutic applications, including its role in neurological disorders and metabolic diseases, should be expanded. Investigating its efficacy against antibiotic-resistant pathogens and refining extraction techniques to maximize purity and yield will further unlock its full potential.

13. Conclusion

The phytochemistry and pharmacological uses of *A. pallens* are all thoroughly examined in this review study. It is concluded that Davana essential oil is abundant in bioactive substances like linalool, davanone, and Davana ether, is highly prized. These substances support its wide range of industrial and therapeutic uses. Antimicrobial, anti-inflammatory, antioxidant, antidiabetic, hepatoprotective, and even anticancer effects are all demonstrated by *A. pallens* pharmacologically. Additionally, it has been used historically to treat skin diseases, respiratory disorders, and diabetes.

Because of its unique scent and medicinal properties, its essential oil is important to the flavor and perfumery industries. There are still research gaps despite its encouraging promise, especially in the areas of standardizing pharmacological mechanisms, improving genetic transformation methods, and guaranteeing long-term safety profiles. To improve its industrial and medical uses, future research should concentrate on metabolic engineering, clinical trials, and sustainable cultivation. *A. pallens* may become a valuable medicinal and economic resource if further research is done on its potential neurological advantages and synergistic effects with other phytochemicals.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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