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Phytochemical Profile and Therapeutic Potential of *Clematis terniflora*: A Comprehensive Review

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Abstract

Clematis terniflora is a plant belonging to the Ranunculaceae family. It is a folk medicinal plant which is found widely in China. According to the Chinese medical system, Clematis terniflora is a widely distributed folk remedy that is used to cure rheumatoid arthritis, asthma, syphilis, gout, malaria, dysentery and used as analgesic, antitumor, anti-inflammatory, diuretic, antibacterial, antioxidants, and anti-inflammatory etc. It is distributed around the world such as China, Japan, Korea, Mongolia, Russia (Siberia), Taiwan, United States, and India. Triterpenes, flavonoids, lignans, coumarins, alkaloids, volatile oils, steroids, organic acids, macrocyclic compounds, polyphenols, and other substances are among its numerous beneficial phytochemicals. Among the principal components of the plant are lignans, flavonoids, triterpenoids, and saponins. Hederagenin and oleanolic saponins make up the majority of bidesmosidic saponins; at both C-3 and C-28, oligosaccharide chains are replaced. Among the oligosaccharide chains, groups of acetyls, caffeoyl, isoferuloyl, p-methoxy cinnamyl, and 3,4-dimethoxy cinnamyl replace a minority of the chains. The flavonoids from the Clematis species are mainly flavonols, flavones, isoflavones, flavanones, xanthones, and their glucosides (sugar moieties are related to the aglycone through either the oxygen or the carbon atoms); the aglycones of these are primarily quercetin, apigenin, kaempferol, and luteolin. Most of the lignans in clematis are composed of eupomatene lignans, cyclolignans, monoepoxylignans, bisepoxylignans, and lignanolides. The present review covered the introduction, plant profile, cultivation, phytochemical constituents, chemical tests, pharmacological activity of the plant Clematis terniflora. There is still much to learn about the many purposes of Clemantis terniflora, despite the fact that very few studies have been done on it.

Keywords: *Clematis terniflora*, *Clematis sp.*, antinociceptive activity, anti-inflammatory, phytochemical tests

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INTRODUCTION

Clematis terniflora is a plant belonging to the family Ranunculaceae. It is a folk medicinal plant which is found widely in China. According to the Chinese medical system, *C.terniflora* is a widely distributed folk remedy that is used to cure rheumatoid arthritis. Researchers have also discovered that the plant has anti-inflammatory properties [1]. *C. ternifora* is a climber; sweet autumn *Clematis* in buttercup family is considered as an invasive plant in Florida and other countries [2]. In India it is used as an ornamental plant for decorations. However, these plants have some pharmacological effects in the treatment of asthma, syphilis, gout, malaria, dysentery, and rheumatoid arthritis [3] and used as analgesic, antitumor, anti-inflammatory, diuretic, antibacterial and antioxidants. Triterpenes, flavonoids, lignans,

coumarins, alkaloids, volatile oils, steroids, organic acids, macrocyclic compounds, polyphenols, and other substances are among the many ingredients found in *Clematis* species. Triterpenoids, saponins, flavonoids, and lignans are some major constituents of the plant [4–6].

TAXONOMICAL CLASSIFICATION

The taxonomical classification of *C. terniflora* is given in Table 1 [5].

COMMON NAMES

Common names of *C. terniflora* are Sweet autumn Clematis, Travellers joy [6]. Some of the common names of *C. terniflora* is given in Table 2.

DISTRIBUTION

World: China, Japan, Korea, Mongolia, Russia (Siberia), Taiwan, United States, India.

India: Karnataka, Kerala, Maharashtra, Andhra Pradesh, Gujarat, Assam, Himalaya, Western Ghats.

PLANT PROFILE

C. terniflora (Buttercups) is widely distributed around the world and belongs to the plant family Ranunculaceae, which has 59 genera and more than 2200 species. The buttercup family is one of the most primitive taxa in the eudicots and among the angiosperms in general [7]. *C. terniflora*, also known as sweet autumn Clematis, is a fragrant autumn flower. It is a robust, deciduous, twining vine with an incredibly wild growth pattern. If supported, it quickly ascends using tendrilous leaf petioles that can reach a length of 20–25 feet [8]. If left unsupported, it spreads out across the ground to form a dense, tangled ground cover that may grow up to 12 inches tall and 10 feet wide, suffocating most weeds in the process. Abundant blooming usually covers the foliage from late August to October. The fragrant, cruciform, pure white flowers have a diameter of 1" and are perfumed. Each flower has four thin, petal-like sepals. Pretty, plume-like seed heads replace the flowers; compound, leathery-textured, glossy green leaves with 35 elliptical-to-oval leaflets and cordate bases are present. In many areas of the United States, especially in the East and Midwest, sweet autumn Clematis has escaped cultivation and naturalised. It can self-seed vigorously in the landscape. Although *C. paniculata* is a distinct species that is native to New Zealand, it is sometimes sold under the names *C. maximowicziana*, *C. paniculata*, and *C. dioscoreifolia* [9].

Table 1. Taxonomical classification.

Kingdom	Plantae
Clade	Tracheophytes, Angiosperms, Eudicots
Order	Ranunculates
Family	Ranunculaceae
Genus	*Clematis*
Species	*terniflora*

Table 2. Common names of *C. terniflora.*

S.N.	Languages	Common names
1.	Kannada	Barijwarada balli, Talejadaari
2.	Assamese	Jui lahara, Jui phul lata
3.	Gujarati	Morvel
4.	Hindi	Bel kangu, Churanhar, Marorphali, Moorva
5.	Konkani	Shendvel
6.	Malayalam	Nikitakkoti
7.	Marathi	Morvel
8.	Sanskrit	Morata, Murva
9.	Telugu	Pedutiva

Figure 1. *C. terniflora* [10].

Table 3. Plant profile of *C.terniflora.*

Common name	Sweet autumn Clematis
Botanical name	Clematis terniflora
Family name	Ranunculaceae
Plant type	Perennial vine
Mature size	15–30 feet long
Sun exposure	Full sun to partial shade
Soil type	Moist, well-drained
Soil pH	Acidic, neutral (6–7)
Flower color	Creamy white
Bloom time	Summer, Fall
Hardiness zones	4–9
Native area	Japan

The members of this family are distinguished from related species categorised as belonging to primitive groupings of dicotyledonous herbs by a number of unique characteristics. Additionally, the morphology of buttercups exhibits a great deal of variation, which is mostly shown in the variety of floral development patterns and flower structure within this family [11].

Triterpenoids, saponins, flavonoids, coumarins and lignans are some major constituents of the plant which is used in the treatment of asthma, syphilis, gout, malaria, dysentery, and rheumatoid arthritism and used as analgesic, antitumor, anti-inflammatory, diuretic, antibacterial and antioxidants [12] (Figure 1 and Table 3).

CULTIVATION

Sweet autumn Clematis may climb a building, like a fence or pergola, or spread out as a ground cover. For a typical trellis, it is considerably too boisterous. With its thick leaves and rambunctious growth pattern, it can swiftly engulf a chain link fence, arbor, or other structure to produce a seasonal screen, hide eyesores like rotting stumps, or conceal an ugly building or wall. Without assistance, it grows into a tangled mass of vines that will suffocate surrounding vegetation. Although it could be permitted to grow through tall shrubs, caution would need to be exercised to prevent the other plant's growth from entirely obscuring it. Due to its delightful vanilla-like sweet smell, try to situate it where the scented flowers can be appreciated. Although it can tolerate little shade, full light is preferred for blooming. This species blooms on new growth, thus it can be severely clipped in the autumn after flowering or in

Table 4. Cultivation parameters of *C. terniflora*.

Light	Plant sweet autumn Clematis in full sun for best flowering. However, these vines can tolerate a considerable amount of shade.
Soil	The plant is not fussy about soil conditions if there is good drainage. The ideal soil will have a slightly acidic to neutral soil pH, but even slightly alkaline soils generally support the plant quite well.
Water	Sweet autumn Clematis has average water needs. Roughly one inch of water per week, through rainfall or irrigation, is generally sufficient.
Temperature	Range from USDA growing zones 4–9.
Humidity	It does not have particular humidity requirements.
Fertilizer	Apply a low-nitrogen fertilizer, such as 5-10-10, in the spring.
Pruning	After the late-fall flowering period has ended, prune Sweet autumn Clematis since this vine blooms on fresh wood. By doing this, self-sowing will be avoided by removing the seed heads.
Propagating	Stem cuttings can also be easily rooted.

the early spring to partially control its rabid growth. In late winter or early spring, each stem can be pruned back to a few sturdy buds about a foot or two off the ground. It prefers "cool feet," like all Clematis, therefore the soil near its base needs to be mulched or shaded by other plants. The soil need to be uniformly moist all through the growing season and must be fertilized in the spring with a low-nitrogen fertilizer.

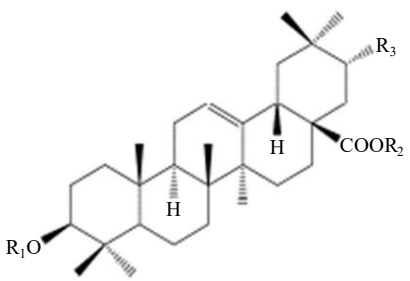
Deer do not prefer this plant, and it has minimal insect or disease concerns. This vine can be cultivated close to black walnut trees because it is not jug lone-affected. It can be easily multiplied from softwood cuttings taken in the spring, semi-ripe cuttings taken in the early summer or seed placed outdoors in the autumn. Plants produced from seeds may take up to five years to blossom [13] (Table 4).

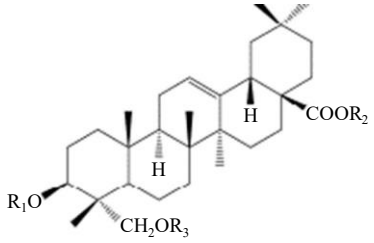
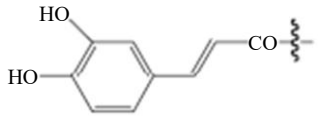
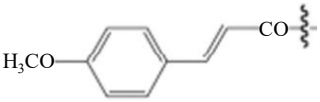
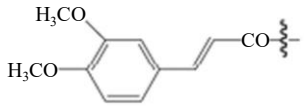
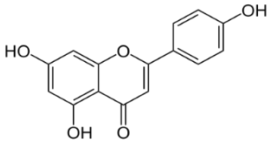
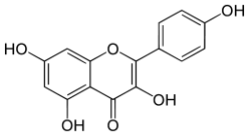
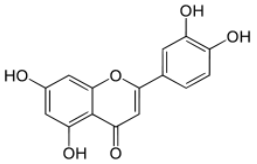
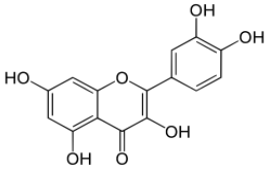
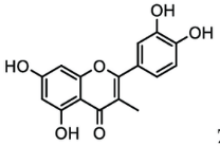
PHYTOCHEMICAL CONSTITUENTS

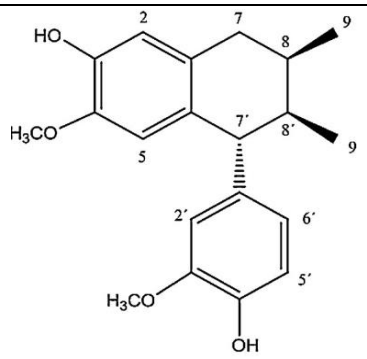
C. terniflora contains wide varieties of different chemical constituents. Different pharmacological or biological effects are present in each and every chemical constituent. Alkaloids, volatile oils, lignans, coumarins, flavonoids, organic acids, polyphenols, macrocyclic compounds, and steroids are among the substances that include triterpenes. Among the main components of the plant are lignans, flavonoids, coumarins, triterpenoids, and saponins.

Hederagenin and oleanolic saponins make up the majority of bidesmosidic saponins; at both C-3 and C-28, oligosaccharide chains are replaced. Groups of acetyl, caffeoyl, isoferuloyl, p-methoxy cinnamyl, and 3,4-dimethoxy cinnamyl replace a lesser portion of the oligosaccharide chains. The flavonoids from the *Clematis* species are mainly flavonols, flavones, isoflavones, flavanones, xanthones, and their glucosides (sugar moieties are related to the aglycone through either the oxygen or the carbon atoms); the aglycones of these are primarily quercetin, apigenin, kaempferol, and luteolin. Most of the lignans in Clematis are composed of eupomatene lignans, cyclolignans, monoepoxylignans, bisepoxylignans, and lignanolides [14] (Tables 5–11).

Table 5. Phytochemicals of C.terniflora.

1.	Triterpenoid saponin	 Oleanolic type

		 Hederagenin type
2.	Bidesmosidic saponins	 Caffeoyl  p-methoxy cinnamyl  3,4-dimethoxy cinnamyl
3.	Flavonoids	 Apigenin  Kaempferol  Luteolin  Quercetin
4.	Lignans	 Monoepoxylignans

		 Cyclolignans

Phytochemical Tests [15]

The phytochemical tests conducted revealed the presence of alkaloids, flavonoids, triterpenoids, coumarins, Saponin, steroids in the sample.

Table 6. Test for alkaloids.

Test	Observation	Inference
1. *Drangandroff's test:* Add 1ml of potassium bismuth iodide to 2 ml of extract.	Orange red precipitate was formed	Alkaloids are present
2. *Mayer's test:* Extract is treated with few drops of potassium mercuric iodide	Formation of creamy white precipitate	Alkaloids are present
3. Extract is treated with few drops of tannic acid solution	Formation of buff-coloured precipitate	Alkaloids are present

Table 7. Test for flavonoids.

Test	Observation	Inference
1. *Shinoda test:* Alcoholic solution of extract adds Mg metal/ HCl	Orange, red or violet colour is produced	Flavonoids are present
2. *Lead subacetate test:* Add lead subacetate to extract	Yellowish precipitate is formed	Flavonoids are present
3. *Antimony pentachloride test:* Alcoholic solution of extract adds antimony pentachloride	Red or violet colour is produced	Flavonoids are present

Table 8. Test for triterpenoids.

Test	Observation	Inference
Salkovaski test: Alcoholic extract of drug was evaporated to dryness and extracted with $CHCl_3$, add conc. H_2SO_4 from sidewall of test tube to the $CHCl_3$ extract.	Formation of yellow colored ring at the junction of two liquid, which turns red after 2 min.	Presence of triterpenoids

Table 9. Test for coumarins.

Test	Observation	Inference
$FeCl_3$ test: Few drops of alcoholic $FeCl_3$ solution was added to the concentrated alcoholic extract of drug.	Formation of deep green colour, which turned yellow on addition of conc. HNO_3	Presence of Coumarins

Table 10. Test for saponin.

Test	Observation	Inference
Foam test: About 1 ml solution of extract was diluted with distilled water to 20 ml and shaken in a graduated cylinder for 15 min.	Development of stable foam	Presence of saponins

Table 11. Test for steroids.

Test	Observation	Inference
Salkowski test: About 2 ml of extract+ 2 ml of chloroform +2 ml of conc. Sulphuric acid. Shake mixture	Chloroform layer appears red and acid layer appears greenish	Steroids are present

Pharmacological Activities of *C. terniflora*

Anti-Inflammatory Activities

The right ears of vehicle-treated controls showed overt signs of inflammation, including redness and swelling, with a computed percentage of swelling of 106.99%. Aspirin, a positive pharmacological control, or ethanol extract of *C. terniflora DC (*EECTD) medicated mice, on the other hand, showed a considerable reduction in edema. EECTD therapy exhibited a stronger anti-inflammatory impact on acute xylene-induced inflammation. The paws of the vehicle-treated rats started to enlarge one hour after the carrageenan injection and reached a maximal edema of 48.99% at six hours in the carrageenan-induced model. The paw edema in rats pre-treated with EECTD (300 mg/kg) was dramatically reduced from 2 hours to 6 hours. This decrease in edema approximated that of the reference medicine and positive control, aspirin. The lower EECTD doses (75 mg/kg and 150 mg/kg), also reduced edema, but the effect lasted for 3–6 h. The histological examination of mice treated with carrageenan 6 hours later revealed clear signs of acute inflammation, including a considerable number of neutrophils, lymphocytes, and other inflammatory cells. However, rats pre-treated with EECTD had much less inflammatory cell infiltration and significantly less tissue damage. Rats given EECTD treatment for six days demonstrated a clear reduction of granuloma development as compared to the vehicle control group. Aspirin, a positive pharmacological control, had an inhibitory effect that was most similar to this one. Additionally, two of the EECTD-treatment conditions (300 mg/kg and 150 mg/kg) considerably reduced the dry weight of the cotton pellet granuloma in comparison to controls [16].

Antinociceptive Effects

The results of acetic acid-induced writhing test showed that EECTD made from *C. terniflora* DC. reduced the amount of writhing. A high dose of EECTD (300 mg/kg) exhibited a noticeable inhibitory effect as compared to the vehicle group (81.78%), which was equivalent to the effective drug control (aspirin, 88.48%). The writhing test was employed in our studies to look into peripheral analgesic activity. The hot-plate assay was employed to assess the extract's central antinociceptive effects in mice. Our findings suggested that the extract lengthened the delay to respond to hyperthermic stimulation. In addition, compared to the vehicle group, those two EECTD doses (300 mg/kg body and 150 mg/kg) significantly prolonged the time spent licking paws [16].

Immunomodulatory Effects

According to the results of the acetic acid-induced writhing test and the data on the mice's ear swelling rate in the delayed type hypersensitivity test, mice pre-treated with EECTD did not exhibit any appreciable changes in the inhibition or enhancement of ear edema. These findings suggested that *C. teniflora* DC. extract had no discernible influence on the cellular immunological response [16].

Anticancer Activity

After being exposed to strong ultraviolet (UV)-B radiation levels and then being incubated in the dark, it was found that indole alkaloid (6-hydroxyl-1H-indol-3-yl) carboxylic acid methyl ester increased in *C. terniflora* leaves by a factor of seven. A decrease in photosynthesis and glucose metabolism, respectively, is revealed by analyses using proteomics and metabolomics. On the other hand, this binary stress triggered the activation of metabolism of amino acids, namely the overexpression of genes related to the metabolic pathway that produces L-tryptophan from shikimate. The metabolites anthranilate, indole, and L-tryptophan increased by two, 441, and one-fold, respectively, and were part of the indole biosynthesis (shikimate metabolic) pathway. Moreover, *C. terniflora* leaves' activities of L-serine deaminase (L-SD) and L-tryptophan synthase increased by two and nine times, respectively, following exposure to intense UV-B radiation [17, 18].

Antipyretic Activity

C. terniflora is a vine that is mostly planted in western China, Japan, and Korea. The aqueous extract of *C. terniflora* exhibits antipyretic properties. Aurantiamide acetate, which is abundant in lignin, aurantiamide, and flavonoids in *C. terniflora*, has been found in pharmacological studies to be able to

prevent the formation of tumours. Additionally, a prior study on *C. terniflora* under UV-B stress revealed that the amount of coumarin in the leaves rose, indicating that UV-B radiation can enhance *C. terniflora's* therapeutic qualities [19].

Antifungal Activity

The majority of 24 lignans that were isolated from Clematis are cyclolignans, lignanolides, monoepoxylignans, bisepoxylignans, and eupomatene lignans. Isolated coumarin compounds were six in number. Aporphine and terpenoid alkaloids are the two groups of eleven alkaloids that have been identified from Clematis. Strong antifungal properties were demonstrated by two aporphine alkaloids.

Antibacterial Activity

Two novel saponins from *C. argentilucida* showed notable cytotoxicity against glioblastoma, hepatocellular carcinoma, and human leukemia cells, [3] *C. mandshurica's* triterpene saponins suppress human colon cancer cells. Four triterpene glycosides from *C. ganpiniana*, exhibited antibacterial and cytotoxic effects on cancer cells [20].

CONCLUSION

The review of *C. terniflora* was conducted through a literature review of numerous research articles. It was discovered that the particular plant had been the subject of various activities, including anti-inflammatory, antinociceptive effects, antifungal activity, antipyretic activity, anticancer activity, and antibacterial activity. It contains wide varieties of different chemical constituents. Different pharmacological or biological effects are present in each and every chemical constituent. Alkaloids, volatile oils, lignans, coumarins, flavonoids, organic acids, polyphenols, macrocyclic compounds, and steroids are among the substances that include triterpenes. Triterpenoids, flavonoids, saponins, coumarins, and lignans are some of the plant's main components. Even though just a small number of studies have been conducted on *C. terniflora* there is still much to learn about this plant's multiple functions.

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