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REVIEW ARTICLE

An overview of chemical, therapeutic and ecological insights on *Terminalia coriacea, Hydrolea zeylanica, Cytisus capitatus* and *Dorycnium pentaphyllum*

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Abstract

This review focuses on four critical medicinal plants' chemical, therapeutic and ecological importance, highlighting their bioactive compound, pharmacological significance and environmental impact. Observing findings of four medicinal plants, viz *Terminalia coriacea (Roxb.) Wight & Arn. – Combretaceae* (TC), *Hydrolea zeylanica (L.) Vahl – Hydroleaceae* (HZ), *Cytisus capitatus Scop. – Fabaceae* (CC), *Dorycnium pentaphyllum Scop. – Fabaceae* (DP) carried out and focused on their therapeutic efficacy and ethnopharmacological relevance. The cited articles for TC are ten, HZ is eight, CC is two and DP is nine from reputed data sources. The study suggests that TC has various chemical compounds, such as glycosides, terpenoids, phenolic compounds and flavonoids. Due to the presence of these constituents, it is helpful in hepatoprotective activity, antimicrobial activity, anti-inflammatory and wound healing activity. Similarly, research on HZ has revealed its potential in managing diabetes by targeting its antidiabetic pathways. This text explains how network pharmacology can help regulate blood glucose levels and reduce inflammation in diabetic rodents. The substance's antioxidant, antidiabetic and hepatoprotective characteristics have been confirmed through chemical composition analysis and pharmacological research. Recent research has revealed the remarkable antibacterial and anticancer properties of CC, shedding light on its potential as a natural weapon against cancer. Studies on DP have uncovered its significance in soil restoration and improving plant performance, providing insights into its medicinal and ecological value. These findings indicate that the plants possess potent chemical moieties that are functional for different therapeutic activities. The prospects for this compilation are to focus on the medicinal importance of these medicinal plants. The researchers may focus on exploring phytochemical investigation such as determinations, quantification and incorporation in novel dosage forms to enhance their solubility, absorption and bioavailability for better therapeutic efficacy.

Keywords

chemical composition; ethnopharmacology; medicinal plants; pharmacological activities; therapeutic potential

Introduction

Ethnobotany has disciplined mega documentation of the varieties of plants employed through regional communities. It is essential to understand why

this populace has chosen raw materials from plant sources to cure their ailments. Around 80 % of therapeutic agents are obtained from the plant kingdom. In ancient times, the human population has a vast history of using plant-based medication in different forms at different times. Progression in research to investigate these plant products will create a significant focus on ethnobotany and make the potential literature to enhance meta-analysis (1). The investigators reflected on the way to ethnobotanical research in the past three decades. The isolation of phytoconstituents through different techniques has been developed worldwide. The active phytochemical responsible for the therapeutic efficacy has been separated and incorporated into various formulations to enhance absorption and effectiveness. However, the area of this field is growing as the number of significant publications in the field. The methodological and theoretical approaches are the sectors that need to be focused on by researchers and implementation findings towards the community as a whole (2). Ethnobotany research in Brazil is remarkable based on scientific publications focusing on the recent knowledge gap in the country. This country has evident publications through its different organizations, which indicates the considerable exploration of plant-based drugs. Data available in national resources was screened and discussed, which revealed various facts on phytomedicines (3).

The screening targeted various groups of plants from different sources. Family plants with varying marker compounds may be responsible for the therapeutic efficacy. There is a lack of evidence on the reported ethnobotanical importance. Identifying their medicinal use and exploration is crucial to screen various useful phytoconstituents among plant kingdoms. Eighty-four studies were evaluated and a lack of knowledge among young researchers was found (4). The new era of the digital age has transformed the research in ethnobotany. It provides a novel tool to summarize data and manage and collect them effectively to investigate them. The AI-based digital tools are helping a lot in conducting such research to screen the active constituents. Digital research in ethnobotany includes social media, geographic information systems, development of data, mobile applications, big data analytics, remote sensing and machine learning (5).

It originates from the regional people's lives and their environment and culture. The documentation has been done for ethical considerations while performing ethnobotanical research. This study required interdisciplinary research in engineering, pharmacy, Ayurveda, and other alternative systems of medicine to determine the exact efficacy of phytoconstituents. The responsibilities of collaborators include agreements on intellectual properties and bioprospecting (6).In South Africa, ruler dealers and herbalists have broad information and practice strategies for making and using natural medicines to treat different ailments. This country also screened the various phytochemicals in their region to explore their therapeutic usage. Increasingly, the toxicity profile of those crude drugs is also part of scientific research. The drug-drug interaction and drug-food interactions are also significant parameters for their evaluations (7).

With the advanced knowledge of implementing information technologies and research models for traditional ethnobotanical investigation, researchers may better compile information on natural drugs. The AI-based fieldwork tools include phenotypic identification of plants and laboratory chemotype and pharmacological variations (8). Various research reveals that the different medicinal plants such as *Terminalia belerica*, *Terminalia arjuna, Cassia fistula, Phyllanthus emblica, Morus laevigata* and *Flacourtia indica* are the species comes under threatened species and their populations are reducing. If the conservation of these medicinal plants has not been taken seriously, it may lead to their complete loss from Jammu & Kashmir (9).

The selected plants exhibit potent pharmacological and therapeutic relevance. Despite their reported active compounds and therapeutic efficacy, a comprehensive review focuses on their therapeutic, chemical and ecological aspects. This review bridges the gap by consolidating unexplored information, highlighting their essential medicinal value, conservation status and environmental relevance. A holistic understanding is challenging for future applications, conservation plans and pharmacological utilization, making this work essential for researchers.

Materials and Methods

The literature survey employed different database sources, including journals and digital platforms, to investigate individual plants based on the content outlined in the title. Twenty-six publications were assessed, covering methodologies, ethnobotanical theories and specific pharmacology assessments. Key references include studies on the significance of ethnobotanicals of medicinal plants, reported therapeutic activity and phytochemical composition. TC was extensively analyzed for anti-inflammatory, hepatoprotective, antimicrobial and anti-nociceptive efficacy, while HZ was assessed for cognitive-enhancing effects and hepatoprotective efficacy. The gathered references provide a comprehensive perspective on the pharmacological efficacy of these important medicinal plants. The details of these reported efficacy have been complied with and given in this article.

Terminalia coriacea

Botanical description : Within the Combretaceae family, the genus Terminalia includes about 100 flowering plants that grow in tropical climates worldwide. These plants are enormous trees. TC is indigenous to the following countries: Bangladesh, Laos, Vietnam, Thailand, Nepal, India, Myanmar and Cambodia. It was discovered in southern India at 1000 m in dry, moist woodland (10). It is often available in Tamilnadu and Andhra Pradesh, where it is referred to as Tani in Telugu. The plant image is given in Fig. 1.

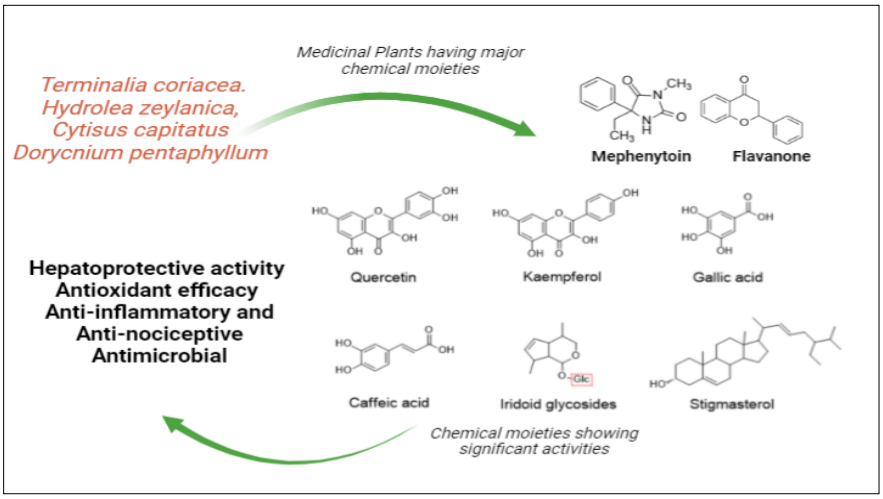

Fig. 1. Leaves and whole plant of TC.

Chemical composition : TC contains different bioactive constituents, such as phenolic compounds like ellagic and gallic acid and flavonoids like quercetin and kaempferol. It contains tannins such as chebulagic acid and chebulagic acid with epicatechin and catechin. Numerous literary works have disclosed that this species possesses a high concentration of tannins and phenolic substances. It has strong antioxidant properties (11). The different chromatographical investigations revealed that the plant is composed of various phyto-constituents such as Glyceraldehyde, Phenylcoumarin, Cucurbitacin E, Surfactant compound, Norbuprenorphine-d3, Quinazolinamine, Triflupromazine, Flavanone, Mephenytoin, Methyl coumarin acetate, Serpentine mineral cation. The essential chemical constituents reported in TC are given in Fig. 2.

Ethnobotanical prospect of TC : TC is traditionally employed in Indian medicine to cure liver disorders, diarrhoea, inflammation and wounds. Different parts such as fruits, bark and leaves possess hepatoprotective, antioxidant and antimicrobial properties, making them valuable in ethnobotanical practices for treating various disorders in Indigenous healthcare systems.

An introduction to TC and its importance in ethnobotany : TC is a medicinal plant that is available in different parts of India. It belongs to the Combretaceae family, with synonyms such as *Terminalia elliptica* and *Terminalia alata*. It is also known as Vidhitakaphala and Kaliyrukshaphala in Sanskrit. In Hindi, Bahada is the popular name and Tani in Telugu.

Therapeutic profile of TC : TC exhibits antioxidants that are hepatoprotective, antimicrobial, anthelmintic and anti-inflammatory. Rich in bioactive compounds in various parts such as leaves, bark and fruits, they are traditionally employed for wound healing, liver disorders and gastrointestinal issues, highlighting their therapeutic properties in herbal formulations and pharmaceutical utility.

The antibacterial activity of extracts from TC : The alcoholic extract of TC was investigated against Pseudomonas aeruginosa, *Klebsiella pneumonia*, *Escherichia coli*, *Staphylococcus aureus*, *Staphylococcus epidermidis* and *Bacillus subtilis* through disk diffusion and microdilution methods. It reveals antibacterial activity against Gram-positive and Gram-negative bacteria species commonly found in food products. The different activities and studies by various researchers are listed in Table 1. (12, 13, 15, 17).

The anti-inflammatory and anti-nociceptive properties of TC : A methanolic leaves extract of this plant was also investigated in the albino Wistar Rat model with the carrageenan increased paw edema model. The three doses were taken: 125, 250 and 500 mg/kg. Aspirin was given 100 mg/kg as standard. This evaluation reveals a reduction in paw edema and granulomatous tissue. This extract shows anti-inflammatory activity in leaf extracts (13).

The phytochemical profile and bioactive compounds present in TC : Rutin, gossypetin and robinin were isolated and characterized from the methanolic extract of this plant. The extract revealed significant anti-nociceptive activity in mice through glutamate-induced paw licking (14). Chrographic separation was performed for alcoholic leaf extract using GCMS. These techniques revealed almost 14 major constituents that proved biological efficacy. The chief chemical moieties raffinose, octadecatrienoic acid, β-sitosterol, 1H-inden-1one,2,3-dihydro-3,3,5,6-tetramethyl, stigmasterol and undecanoic acid (15).

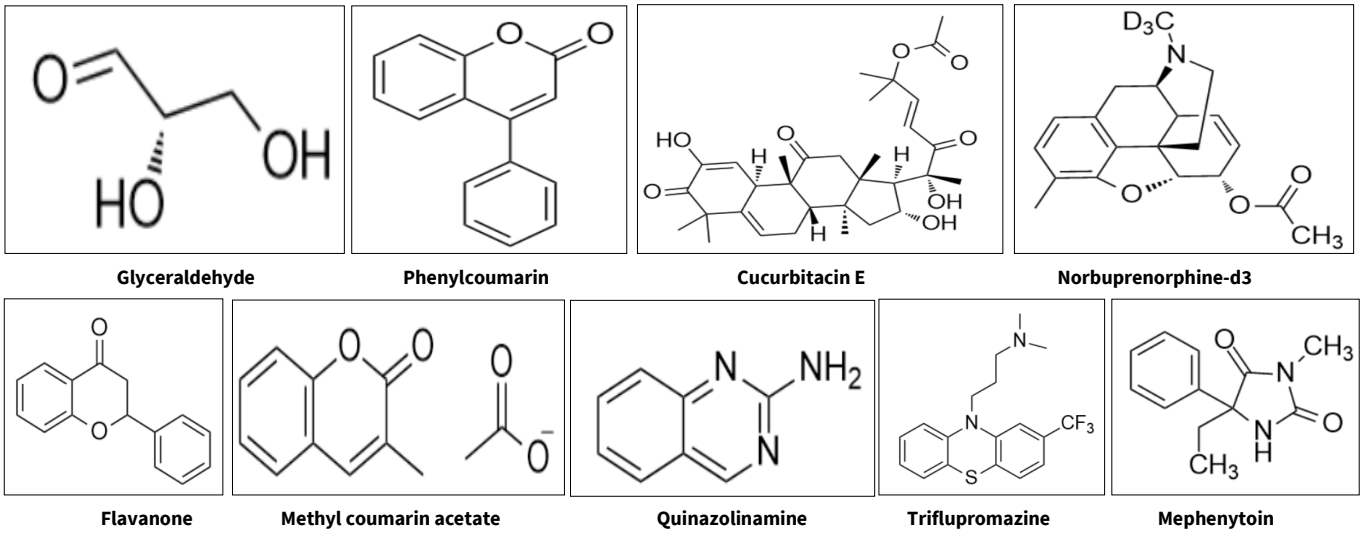

Fig. 2. Chemical Constituents reported in plant TC.

Table 1. Studies on TC extract: activity overview

S.N.	Activity	Study	References
1	Anti-inflammatory	Significant reduction in granulomatous tissue weights and paw edema was observed with 500 mg/kg extract, indicating anti-edematogenic and antiproliferative properties.	(13)
2	Antioxidant gastroprotection	Dose-dependent gastroprotective effects were observed, particularly at higher doses. The presence of flavonoids like Luteolin-7-O-glucoside and Quercetin-3-O-rutinoside is associated with anti-ulcer effects.	(13)
3	Wound healing	Promising healing properties were observed, with wounds starting to heal by the 17th and 19th days after injury, similar to standard treatment.	(13)
4	Anti-epileptic	Significant protection against seizures was observed, indicating potential anticonvulsant properties.	(10)
5	Anti-nociceptive	Higher doses of the extract demonstrated significant pain relief, comparable to paracetamol.	(13)
6	Hepatoprotective	Robust liver protection was observed, particularly at higher doses, supported by biochemical and histopathological data.	(15)
7	GCMS analysis	Fourteen bioactive compounds were identified, including 1H-inden-1-one, levoglucosan, phytol, stigmasterol and β-sitosterol, with notable biological effects.	(17)

The gastroprotective and antioxidant efficacy of TC : Antioxidant and anti-secretory efficacy-mediated gastroprotection have been investigated in alcoholic leaf extract on this plant. Different spectroscopic and chromatographic techniques are employed to identify phytoconstituents responsible for such effectiveness. The chief constituents traced are Quercetin-3-O-rutinoside, Myricetin hexoside, Isorhamnetin-3-O-rhamnosylglucoside and Quercetin-3-O-glucoside (16).

Hepatoprotective activity of TC : The plant can also be reported for hepatoprotective efficacy in methanolic leaf extract. Different rats were taken for test extract, standard, irritating agent and control group. The activity was observed using various parameters such as measurement of ALT, AST, ALP, direct bilirubin, total bilirubin, etc. These findings were also supported by histopathological investigations of isolated liver to healing progress in different groups. The results revealed significant hepatic healing in animals (17).

The plant is also investigated for phytochemicals in the preliminary stage and toxicity profile. The primary screening was for the anti-nociceptive potential of alcoholic leaf extract using the acetic acid-induced animal model's writhing model. Different chemical tests for glycosides, steroids, saponins, tannins, flavonoids and diterpenoids justified the phytochemical investigations. The study concluded that methanolic leaf extract at a higher dose of 500mg/kg was justified to have anti-nociceptive potential (18). The comparative investigation of various hepatoprotective plants was evaluated for better efficacy in different models. A total of six plants were taken to compare for better healing. The plants taken are TC, *Artocapus hirsutus, Cucumis melo, Buchania lanzaan, Diospyrus melaxylone* and *Solanum americanum*. The data was analyzed from published or reported articles and compared by dose-dependent biochemical markers and histopathological findings. It was found that TC and *Artocarpus hirsutus* were revealed to have better efficacy among all other plants concerning parameters and doses used during investigations. The details of therapeutic efficacy are shown in the Fig. 3 (19).

Ecological insight of TC : TC grows in dry deciduous forests, adapting in semi-arid and arid locations. It is vital in preventing erosion and supporting biodiversity and soil protection. As a drought-resistant species, it promotes ecological balance and afforestation steps in degraded landscapes.

Hydrolea zeylanica

This plant is called *Ceylon Hydrolea*, an aquatic plant with attractive flowers and lance-shaped leaves. The geographical source of these plants is India and the tropical Himalayas, which bear in the month of winter. It has been known to have various therapeutical efficacy. The plant image with leaves is given in Fig. 4.

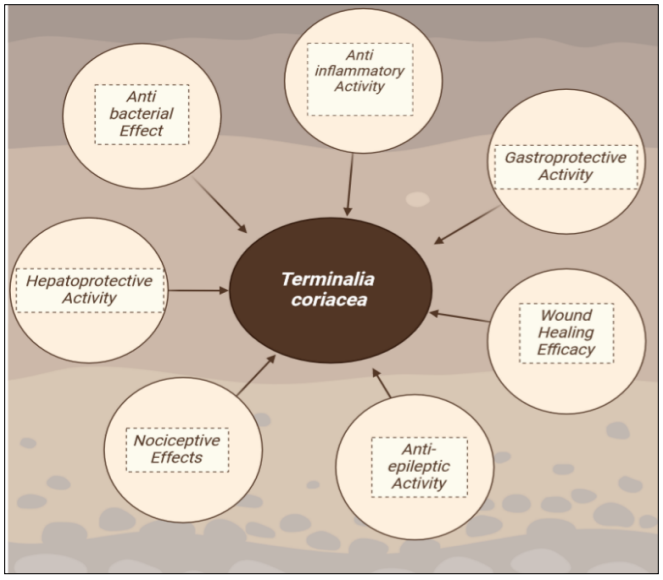

Fig. 3. Activity profile of TC: Insights into varied biological effects.

Fig. 4. Plants with leaves of HZ.

Chemical constituents

HZ is a source of a variety of bioactive compounds, such as flavonoids like quercetin and kaempferol, phenolic acids like gallic and caffeic acids, alkaloids like hydrogen, steroidal saponins, iridoid glycosides and phytosterols like stigmasterol and β-sitosterol. These constituents are responsible for the substance's antioxidant, anti-inflammatory and hepatoprotective properties. The structure of various chemical moieties present in the plant is given in Fig. 5.

Ethnobotanical prospect of HZ

HZ shows significant ethnobotanical worth, traditionally employed in the Asian system of medicines for curing different types of diseases and disorders, such as skin issues, inflammation and wound healing. Local communities use its bark, root and leaves for diuretics' antimicrobial and hepatoprotective activities. Its potential in herbal preparations highlights its cultural and medicinal values.

Antidiabetic mechanisms and bioactive compounds of HZ

An investigation has been done to screen out this plant's efficacy in managing diabetes. Evaluation has revealed that these plants' extracts can potentially reduce blood sugar and inflammation in animal models for diabetes type II. The chief chemical constituents present in this plant demonstrated the pathways and targets to heal.

HZ alleviates diabetic encephalopathy in rats

HZ is packed with different dietary fibres and nutrient matters, which help manage blood sugar levels and vascular-related dysfunction associated with type 2 diabetes. Investigation reveals hydroalcoholic extract improves animal models' inflammation, cognitive function and neurotransmitter signalling (20).

HZ mitigates oxidative stress in diabetic rats

This plant has potential efficacy in diabetes management with remarkable effects. Investigation reveals that the hydroalcoholic extract of these plant leaves found potential effects on diabetes recovery and antioxidant activity. It was found to improve organ function and glycemic management (21).

Hydrolea systematic position: Insights from floral development

The development methods in *Hydrolea palustris* are different from those of various other plants. There are divisions in segments of female reproductive organs, with petals fusing together at a big stage and a unique septal

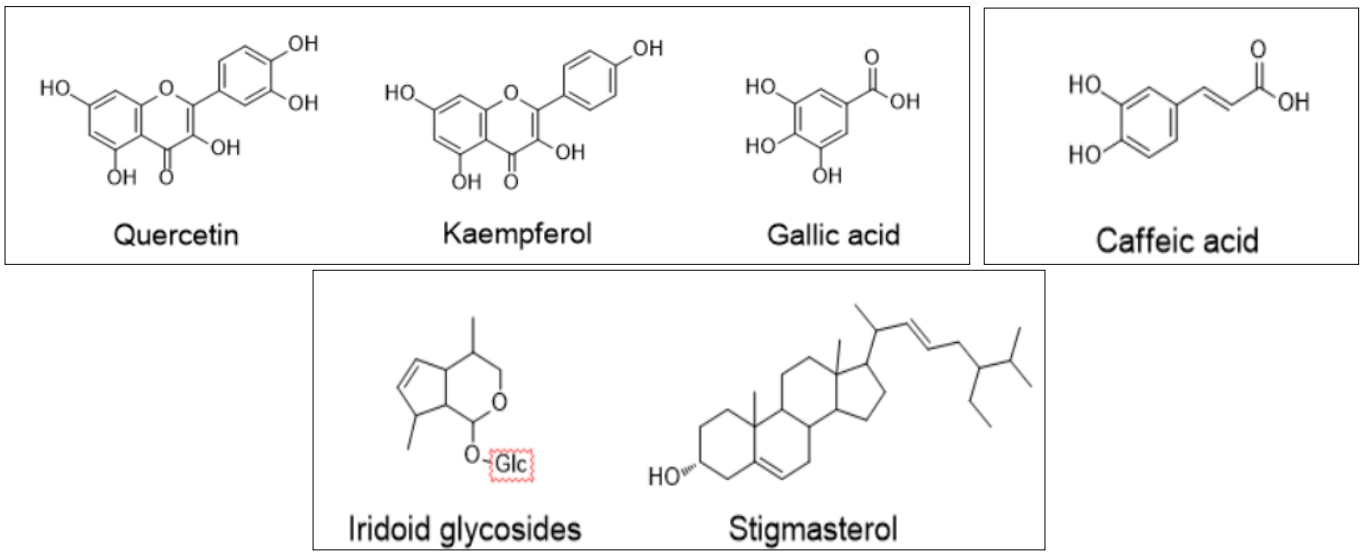

Fig. 5. Chemical present in HZ.

arrangement. The floral development of these plants gives them a unique position among them. The therapeutic efficacy is also connected with these botanical features, which makes it unique (22).

Impacts of HZ and Pistia stratiotes on rice growth and yield

HZ has been observed to influence the growth and yield of rice. Investigation reveals that planting directly seeded rice at high density with this plant can reduce yield. However, the productivity of transplanted rice was observed to decrease (23).

HZ leaf extract to protect the liver against damage

This plant's leaves have also been screened for hepatoprotective activity. The methanolic extract has been evaluated in different groups of Wistar albino rats. The carbon tetrachloride taken to damage the livers and standards was silymarin. Three different concentrations of extracts were given to other groups of animals. It was observed that it can effectively control AST, ALT, ALP and TB quantity and increase the level of protein. The histopathological investigation of liver cells was also assessed and significant recovery was found (24).

Ethno medicinal properties of Echinochloa Colona and HZ

There is a long history of this plant being used for different purposes, such as diabetes management, wound healing, various disorders and ulcer treatment. The geographical source of this plant is India and various other major countries such as Australia, Africa and Asia. The scientific approaches to reveal the therapeutic potential have been screened for important constituents and medical characteristics (25).

Chemical composition and wound healing in HZ

The traditional uses of this plant are also antiseptic, ulcer, burn and wound healing. The excision and incision wound model assessed the wound healing efficacy. Wistar albino rats were studied in different groups. Povidone iodine ointment is a standard and water-soluble ointment for negative control. The aqueous extract of leaves incorporated in the ointment is applied topically to create wounds. Significant healing was noted by plant test extract. The GCMS analysis was also conducted to determine the possible phytoconstituents in the plant leaves (26).

Standardization and analysis of HZ Leaves

A preliminary phytochemical, physicochemical and pharmacognostical investigation of leaves has been conducted to assess their identification and quality. The morphology and microscopic screening revealed the authentication parameters. The physicochemical examinations such as extractive value, moisture content, ash value and solubility suggested precise data as per monographs. The investigations for constituents suggested the presence of tannins, glycosides, volatile oils, carbohydrates, alkaloids and flavonoids. Diverse Biological Activities of HZ are shown in Fig. 6 (27).

Therapeutic profile of HZ

HZ exhibits different therapeutic efficacy, including antimicrobial, antioxidant, anti-inflammatory, hepatoprotective and wound-healing properties. Traditionally, it is employed to treat urinary disorders, liver issues and skin infections. Bioactive compounds help with pharmacological functions, making them promising agents for herbal preparation and pharmaceutical utilization.

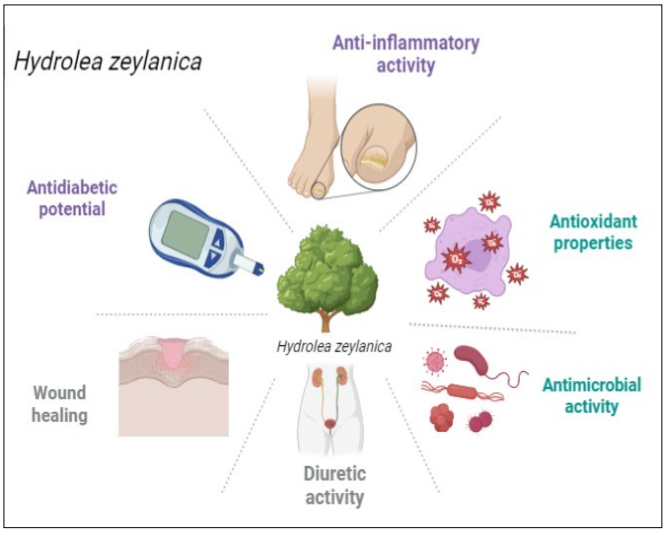

Fig. 6. Diverse biological activities of HZ.

Ecological insight of HZ

HZ thrives in paddy fields, marshes and riverbanks, playing a crucial role in managing ecological balance. It helps aquatic biodiversity, prevents soil erosion and serves food for insects and small living organisms, contributing to the freshwater ecosystem.

Cytisus capitatus

This plant belongs to the Fabaceae family, having pink or hairy mature flowering plants. The geographical sources of this plant are Italy, France, Spain, Portugal and Greece. The flowers are like dense clusters of purplish to pink. The height of the plant is approximately one meter, having a hairy stem. Leaves are arranged alternately and trifoliate. Chemical screening revealed the presence of various constituents, such as terpenoids, alkaloids and flavonoids. It is traditionally used as an expectorant, anti-inflammatory and diuretic. It is also used in urinary tract issues and as an antimicrobial. The whole plant image of CC is shown in Fig 7.

Fig. 7. Whole plant of CC.

Chemical constituents

CC is abundant in bioactive compounds, including phenolic ferulic and caffeic acids, alkaloids like cytisine and flavonoids like genistein and luteolin. The plant's antioxidant, antimicrobial and potential therapeutic properties are further enhanced by tannins, saponins and essential oils containing terpenoids such as α-pinene and limonene. The various chemical moieties reported from CC are shown in Fig. 8.

Ethnobotanical prospect of CC

CC has been traditionally employed in folk medicine for antimicrobial, anti-inflammatory and diuretics. Different cultures used its extracts to cure skin infections, urinary disorders and digestive problems. Additionally, it holds significant ethnoveterinary practice for maintaining livestock health problems.

Discovery of Camarosporium arezzoensis on Cytisus sp.

The investigation done in Italy that the fungus ascomycetes growing on Cytisus species. This fungus also appears in Cucurbitaria species, which is confirmed in the genetic analysis. By investigating Cytisus and Cucurbitaria species physical characteristics and genetic data, a new species is named *C. arezzoensis* (28).

Antimicrobial activity

The antibacterial efficacy of this plant has been assessed by determining bactericidal and inhibitory concentrations. *Staphylococcus aureus, Bacillus subtilis* and *Peudomonas aerogenosa* was employed to examine. The high quantity of flavonoids and total phenols that might be responsible for these activities was determined in the extract. The various therapeutic efficacies of CC are given in Fig. 9 (29).

Therapeutic profile of CC

CC exhibits potent therapeutic efficacy because of its anti-inflammatory, antioxidant, diuretic and antimicrobial efficacy. Traditionally employed for respiratory issues and urinary infections, it is a promising plant for pharmacological and medicinal uses.

Ecological insight of CC

CC plays a crucial role in nitrogen fixation, soil stabilization and improving soil fertility in native habitats. It grows in temperate areas and the Mediterranean, helping biodiversity. The adaptability of this plant in ecological restoration and managing soil erosion.

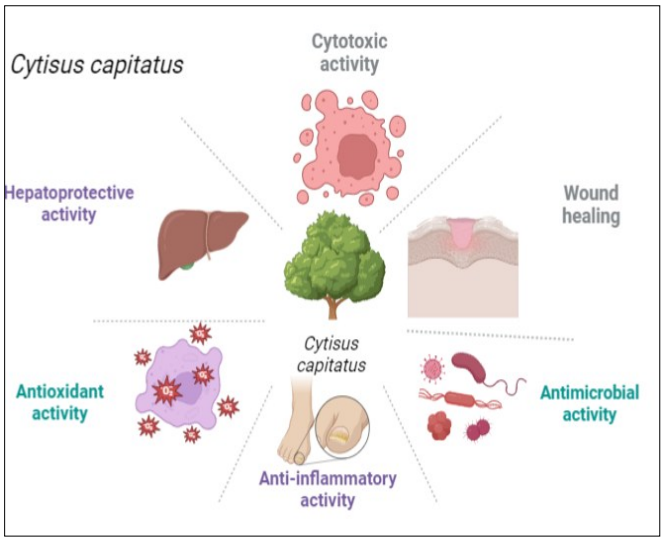

Fig. 9. Diverse biological efficacies of CC.

Dorycnium pentaphyllum

This plant also belongs to the family Fabaceae and is famous for its ecological and medicinal usage. The geographical sources are Mediterranean regions, rocky habitats and thrive in dry areas of Europe. Leaves with five leaflets; therefore, the species name is also "pentaphyllum". The chemical investigation showed the presence of tannins, saponins and flavonoids. Traditional uses include antidiarrheal, anti-inflammatory and diuretics. The plant image is shown in Fig. 10.

Chemical constituents

DP is a source of various bioactive compounds, such as flavonoids like quercetin and apigenin, phenolic acids like gallic and caffeic acids and tannins. It also contains coumarins, saponins, triterpenoids and essential oils rich in monoterpenes, such as limonene and α-pinene, which contribute to its antimicrobial, anti-inflammatory and antioxidant properties. The various chemical constituents of DP are given in Fig. 11.

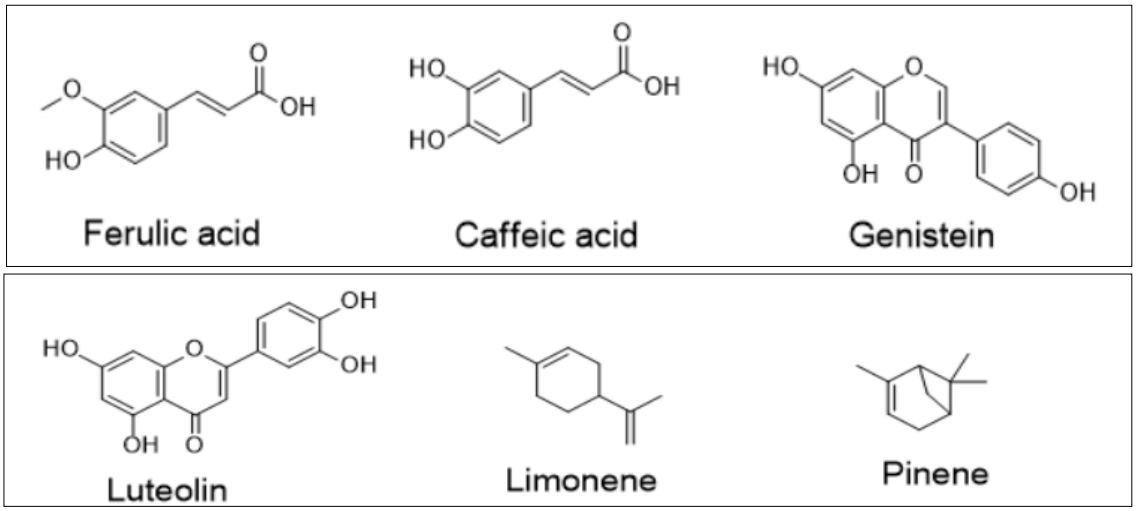

Fig. 8. Chemical moiety reported from CC.

Fig. 10. Plant and flowers of DP.

Ethnobotanical prospect of DP

DP has traditionally been employed in folk medicine to cure digestive ailments, skin infections and inflammation. Various societies use various parts for medicinal benefits. Additionally, it has been use in livestock fodder, ecological restoration and soil stabilization.

Enhancing DP growth with agro-waste amendments and microbial inoculation

The growth of this plant could be enhanced by using microbiologically agro-waste usage. The waste materials generated after the completion of cultivation and collection of crops can be helpful for compost preparation to improve the yield. It also increased the soil fertility up to a maximum extent. The excellent growth of this plant by this technique could result in good yields of chemical constituents of this plant (30).

Enhancing DP field performance: mycorrhizal vs. amendment

In a dry Mediterranean region, adding mycorrhizal fungi like *Glomus intraradices or Glomus deserticola*, along with sugar beet, rock phosphate and *Aspergillus niger*, had a positive impact on the soil and helped promote the growth of DP. The treated soil showed higher phosphorus levels and better soil structure, with increased enzyme activity and lower pH and bulk density, compared to the untreated soil after 18 months of planting (31)

Rooting ability of Dorycnium spp.

The ability of Dorycnium cuttings (specifically *D. hirsutum* and DP) to take root was not affected by where the cuttings came from. However, it was improved in warm weather and when treated with auxin, especially in the case of DP (32).

Heavy metal response in DP vegetative growth

The perennial Mediterranean shrub DP shows resistance to varying levels of cadmium (Cd) and zinc (Zn) at different stages of growth. The plant's physiological mechanisms for tolerating heavy metals depend on its age and the type of metal (33).

Dorycnium Mill. (Fabaceae) geographic study in the Czech Republic

The availability of *Dorycnium germanicum* and *Dorycnium herbaceum* in the Czech Republic, the two northernmost species of their genus. *D. germanicum* likes dry and warm areas, showing the Illyrian-Noric element, while *D. herbaceum*, a more adaptable species, is mainly found in southeast Moravia, representing the Carpathian element (34).

Antioxidant flavonol glycosides from Dorycnium hirsutum

Researchers found seven flavonol glycosides in the aerial parts of *Dorycnium hirsutum,* along with catechin, D-pinitol, β-sitosterol and stearic acid. They tested the antioxidant properties of these compounds using DPPH radical scavenging and lipoxygenase lipid peroxidation assays (35).

DP extract inhibits cervix and colon cancer cells

This plant extract has been investigated for its anticancer efficacy. The phytoconstituents present in this plant possess the killing effects of cancerous cells. These findings revealed the potential medicinal value of this plant (36).

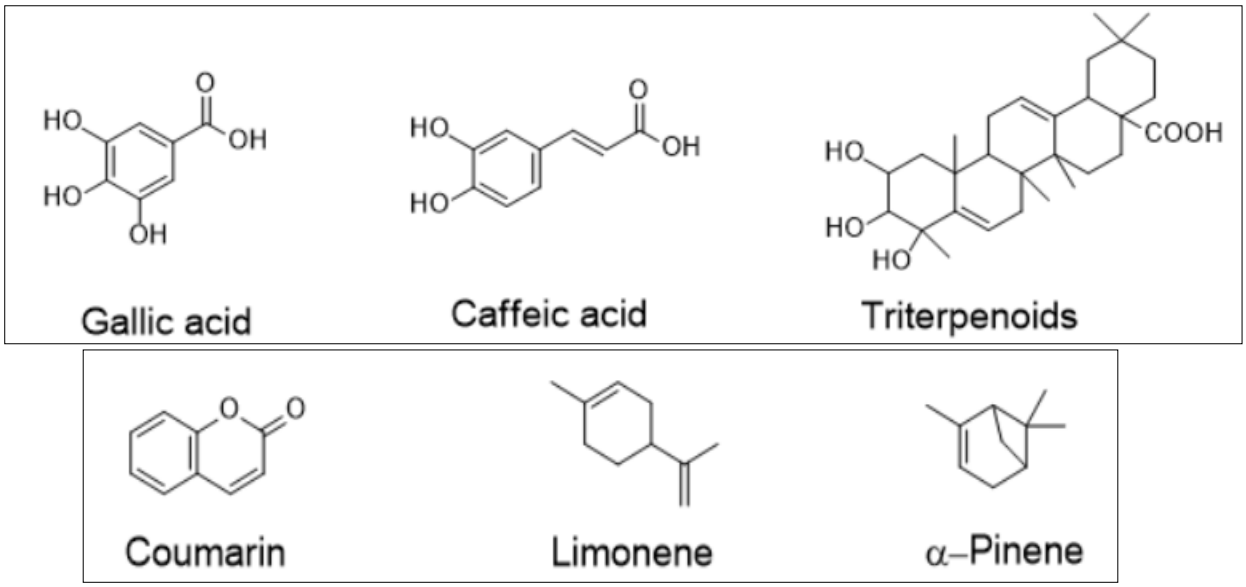

Fig. 11. DP phytoconstituents responsible for efficacy.

Assessing mycorrhizal symbiosis in DP with nitrate reductase

The impact of fungi such as *G. mosseae, G. intraradices* and *G. deserticola* on this plant in well-watered and drought circumstances. The finding reveals that water stress reduces growth and increases root nitrate reductase activity. These results indicate that nitrate reductase activity could be a valuable marker in investigating mycorrhizal symbiosis efficiency in water (37).

DP extract's anticancer effect on cell lines

The anticancer efficacy of these plants' specific extracts has been investigated and observed in breast cell lines regarding lipid peroxidation, invasion and adhesion. They observed that the extract had dose-dependent toxic efficacy on MCF-7 cancer cells from the breast. The quercetin in the extract significantly contributed to reducing the growth of cells. These findings showed that plant extract had the capability and could be a valuable source of bioactive compounds with significant anticancer efficacy against cancer cells from the breast. Different biological efficacy of other parts of the plant DP are shown in Fig. 12. (38)

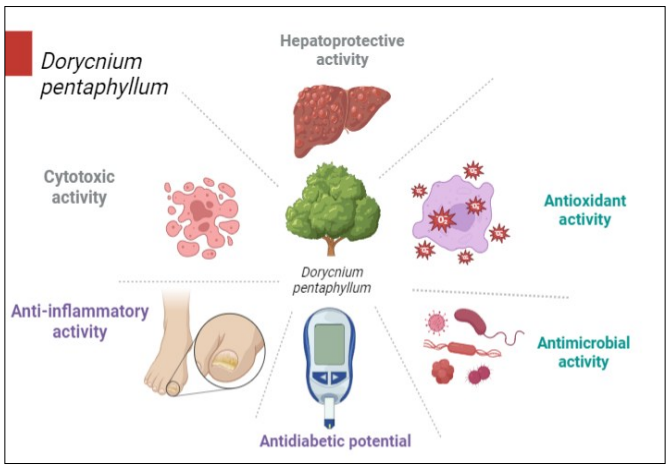

Fig. 12. Different biological efficacy of different parts of the plant DP.

Therapeutic profile of DP

DP exhibits therapeutic efficacy due to being rich in various phytoconstituents such as tannins, saponins and flavonoids. It possesses antioxidants, is anti-inflammatory and antimicrobial and can heal wounds. Its active constituents suggest potent application in hepatoprotective cardiovascular, indicating further exploration.

Ecological Insight of DP

DP is a drought-resistant and hard plant in Mediterranean regions. It is vital in nitrogen fixation, soil stabilization and biodiversity maintenance. Its adaptability to poor-quality soil makes it valuable for erosion control, ecological restoration and supporting ecosystems.

Discussion

Ethnobotany research is crucial to screen out the authenticated data from the traditional background. The investigation into four plants, TC, HZ, CC and DP, focused on their therapeutic efficacy and ethnopharmacological relevance. These examinations provide valuable insights into these plants' therapeutic activity, chemical constituents and medicinal application.

The ethnobotanical significance of TC, HZ, CC and DP encompasses ancient medical practices extensively employed for therapeutic purposes. TC is acknowledged in Ayurveda for its hepatoprotective, antibacterial and antioxidant attributes, frequently used in treating liver ailments and infections. HZ has been conventionally utilized for its wound healing, anti-inflammatory and diuretic properties, especially in traditional medicine. Likewise, CC has been used as an expectorant, diuretic and antibacterial agent in Mediterranean traditional medicine. DP is utilized in conventional medicine to mitigate digestive ailments, microbial infections and inflammation.

An analysis of these plants concerning previous studies underscores their pharmacological importance. For example, TC has hepatoprotective efficacy akin to *Terminalia chebula,* whilst HZ possesses antibacterial qualities similar to *Hydrolea spinosa*. CC demonstrates antioxidant capacity rich in flavonoids comparable to other species within the Cytisus genus. In contrast, DP corresponds with documented members of the Fabaceae family recognized for its antibacterial and gastroprotective attributes. These species contribute to biodiversity, habitat stabilization and adaptation to varied environmental situations. Nevertheless, additional phytochemical and pharmacological investigations are required to substantiate their traditional use, ensuring sustainable usage and incorporation into contemporary treatments.

Conclusion

This study emphasizes the notable ethnobotanical, pharmacological and ecological importance of TC, HZ, CC and DP. Our results corroborate their conventional medical uses, especially in liver protection, antibacterial efficacy and anti-inflammatory properties, consistent with other investigations on analogous species. The phytochemical diversity in these plants, encompassing flavonoids, tannins and alkaloids, indicates their potential for drug discovery. Nonetheless, deficiencies persist in their clinical validation and mechanistic comprehension. Future studies must prioritize thorough phytochemical characterization, sophisticated pharmacological investigations and toxicity assessments to ascertain safety and efficacy. Moreover, sustainable conservation efforts are essential to safeguard these valuable medicinal plants from overexploitation and habitat deterioration. Incorporating these species into contemporary herapeutic framework susing biotechnologicl methods and nanotechnology-based formulations may improve their bioavailability and therapeutic efficacy. Consequently, additional interdisciplinary research is necessary to exploit their therapeutic advantages while maintaining ecological sustainability.

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Authors' contributions

RP was responsible for visualizations and writing. While JP handled drafting and image creation, PK contributed to conceptualization and referencing. All authors read and approved the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

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