



ISSN 2959-1864 (Online)  
ISSN 2958-0536 (Print)  
Volume 4, Number 1  
March 2025

# Acta Botanica Caucasica



**AZƏRBAYCAN RESPUBLİKASININ  
PREZİDENTİ YANINDA  
ALİ ATTESTASIYA KOMİSSİYASI**



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PHYTOCHEMISTRY, TRADITIONAL USES AND PHARMACOLOGICAL POTENTIAL OF  
*JURINEA DOLOMIAEA* SUSTAINING IN HARSH ALTITUDES OF PIR PANJAL RANJE POONCH,  
JAMMU AND KASHMIR

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Article Info:

DOI: <https://doi.org/10.30546/abc.2025.4.1.610>

Pages: 27-54

Received: January 10, 2025 | Revised: February 5, 2025 | Accepted: February 25, 2025

**Abstract.** *Jurinea dolomiaea* is a plant that belongs to the Asteraceae family and is native to alpine regions in Myanmar, China, India, Nepal, and Pakistan. It contains a variety of bioactive compounds such as sesquiterpene lactones, sterols, triterpenoids, saponins, tannins, flavonoids, glycosides, steroids, phenolic compounds, fixed oils, fats, terpenes, and lignans.

Traditionally, this plant has been used in herbal medicine for its aphrodisiac properties and for treating rheumatism, fever, colic, gout, and puerperal fever. It is also used in the incense industry and as an insect repellent due to its pleasant aroma.

Pharmacological studies have shown that *J. dolomiaea* has antileishmanial, antioxidant, antibacterial, antimalarial, analgesic, and hepatoprotective properties. It also has potential benefits for reproductive health and may help protect DNA. In addition, silver nanoparticles synthesized from *J. dolomiaea* have significant pharmacological potential. Moreover, its phytochemicals have analgesic, antinociceptive, anxiolytic, sedative, anticancer, immunomodulatory, antimicrobial, lipid-regulating, anti-inflammatory, hepatoprotective, wound-healing, respiratory-protective, antidiabetic, and antioxidant effects.

**Keywords:** Keywords: *Jurinea dolomiaea*, *Jurinea macrocephala*, silver nanoparticles, Pir Panjal Range, reproductive health.

### Introduction

Plants have been substantially used in all ancient medicine systems, including Ayurveda, Chinese, and Unani traditional medicine systems, as well as in the Indian traditional system of medicine (Prajapati et al., 2003). Modern drugs are primarily derived from medicinal plants; plants contribute to 20–30% of modern pharmaceuticals, and even synthetic compounds are

analogues of natural plant compounds (Brower, 2008). There are twelve mega biodiversity centers, and India is one of them, hosting 45,000 plant species across sixteen different agro-climatic zones, ten vegetation types, and fifteen biotic provinces (Kala & Sajwan, 2007). The Himalayas are globally famed as a treasure trove of medicinal plants. Approximately 30% of indigenous species are found in India (Nautiyal,

1998). Many high-medicinal-value plant species are native to the Himalayas. The genus *Jurinea*, from the Asteraceae family and Cardueae tribe, comprises 21 species worldwide, specifically found in the alpine regions of Myanmar, Nepal, India, Pakistan, and China (Wang et al., 2007; Shih & Raab-Straube, 2011; Shen et al., 2020). A few species of this genus also exist in Turkey and Iran (*eFlora of India*). It was previously classified under *Saussurea*; species from this genus can survive at elevations of up to 5000 m (Kasana et al., 2021). Plants belonging to the genus *Jurinea* in the family Compositae are ubiquitous. *J. dolomiaea* has synonyms such as *J. himalaica*, *J. macrocephala*, *Jurinea macrocephala*, *Tibetica*, and *Dolomiaea macrocephala* (common names: dhup, dhuplakdi, and googl) (*e-Flora of India*; *Flora of Peninsular India*; Kasana et al., 2021). *J. dolomiaea* has been used in indigenous healing remedies to treat various health issues such as colic, puerperal fever, aphrodisiac use, gout, and rheumatism. It is also utilized for its fragrant roots in the aromatics industry and to repel insects (Sharma et al., 2004). The roots are brewed into a decoction and recommended as a soothing remedy for colic and puerperal fever. The roots of *J. dolomiaea* are applied as a poultice for epidermal eruptions, and its juice is used to treat fever (Chopra et al., 1986). Rustaiyan et al. (1981) found sesquiterpene lactones as the major constituents of the plant. *J. dolomiaea*, in addition to its use in traditional medicine, has also shown potential in various pharmacological activities, including antibacterial, antileishmanial, hepatoprotective, and anticancer properties. It has also demonstrated applications as a DNA-protective, antiulcer, antitoxic, antioxidant, and analgesic agent. Besides the plant's numerous properties benefiting human health, compounds extracted from it have exhibited a wide range of pharmacological properties, making it a potential therapeutic agent for further research and studies.

## Materials and Methods

*Jurinea dolomiaea* samples were collected from the Pir Panjal Range, Poonch, Jammu, and Kashmir, India, and identified based on morphological characteristics. The dried plant

material was powdered and extracted using methanol, ethanol, chloroform, ethyl acetate, n-hexane, and aqueous solvents via Soxhlet extraction. Phytochemical screening was conducted to detect flavonoids, tannins, saponins, terpenoids, alkaloids, phenolic compounds, and glycosides. High-performance liquid chromatography (HPLC) was used to quantify caffeic acid, apigenin, rutin, and gallic acid.

Silver nanoparticles (AgNPs) were synthesized by mixing aqueous root extract with silver nitrate ( $\text{AgNO}_3$ ) and incubating at room temperature. The formation of AgNPs was confirmed using UV-Vis spectrophotometry, FTIR, and TEM analysis. The antioxidant potential was assessed using DPPH and FRAP assays, while antibacterial activity was evaluated against *Escherichia coli*, *Staphylococcus aureus*, *Xanthomonas vesicatoria*, and *Ralstonia solanacearum* via agar well diffusion and minimum inhibitory concentration (MIC) tests.

The anticancer activity of *J. dolomiaea* extracts and AgNPs was tested against HeLa and MCF-7 cell lines using the MTT assay, with apoptosis confirmed via fluorescence microscopy. Hepatoprotective effects were studied in  $\text{CCl}_4$ -induced liver toxicity models, measuring SGOT, SGPT, ALP, and bilirubin levels. Reproductive health effects were analyzed by evaluating testosterone levels and testicular tissue histopathology in experimental animals.

All experiments were performed in triplicate, and data were analyzed using one-way ANOVA (SPSS v25), expressed as mean  $\pm$  SD, with statistical significance set at  $p < 0.05$ .

## Results and Discussion

### *J. dolomiaea* Morphology

*J. dolomiaea* is a stemless perennial herb that thrives in the harsh alpine climate. Its unique structural adaptations enable it to survive at such high altitudes (Table 1 & Figure 1). The leaves are elliptic, densely woolly on the underside, and hairy on the upper surface, measuring 20–30 cm in length with petioles. The lobes are pinnatifid with denticulate margins. This plant produces numerous floral capitula (3–15 in number), either sessile or borne on short stalks, measuring 4–5  $\times$  2.5–3.2 cm, and

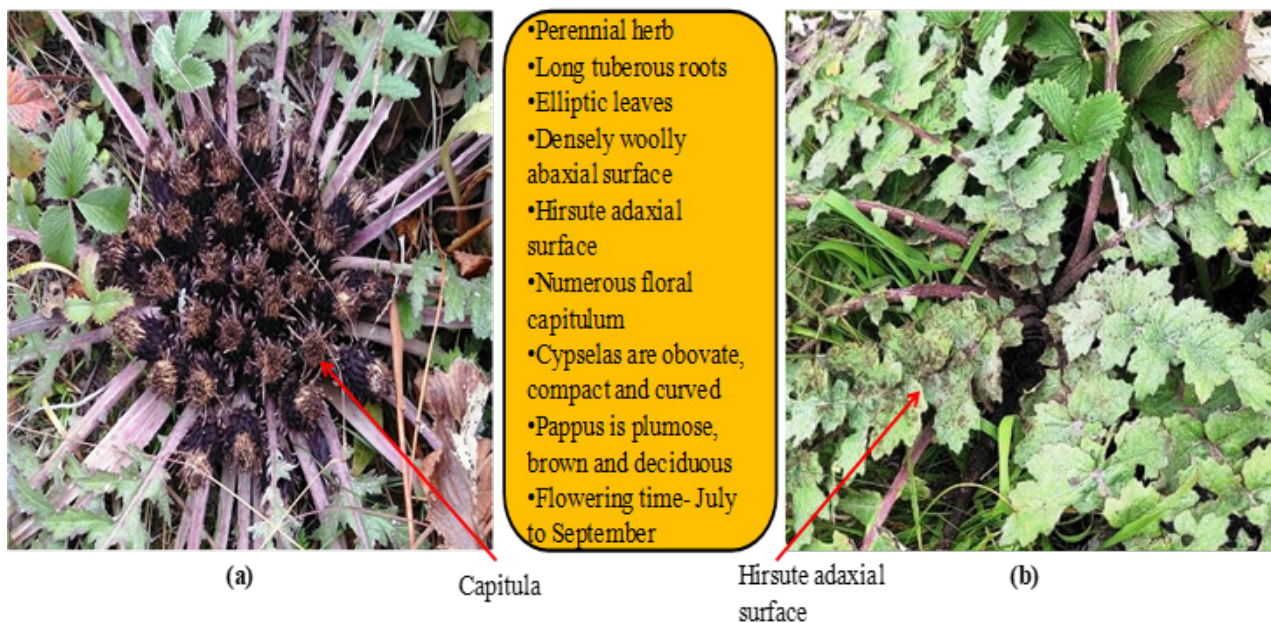
covered in pubescence. Its involucre bracts are multilayered, varying from ovate to narrowly elliptical in shape, with a rough texture, generally membranous and dry. The linear tubular corollas reach up to 3.5 cm in length and are typically purple in color. *J. dolomiaea* flowers from July to September. The cypselae are obovate, compact, curved, and glabrous, with black wavy fringes at the apex. Its pappus is plumose, brown, and deciduous (Kasana et al., 2021).

#### Habitat and Distribution

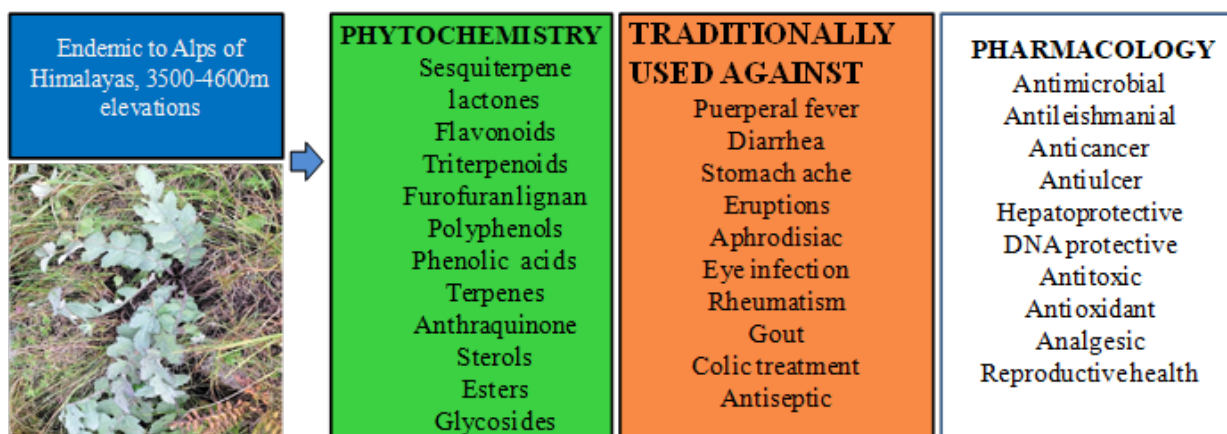
*J. dolomiaea* is found in alpine habitats, including open grassy slopes, rocky terrains, morainic deposits, and scree fields (Figure 2). It thrives at elevations ranging from 3,500 to 4,600 meters (Kasana et al., 2021). It is endemic to the Himalayas and is commonly found at elevations between 3,000 and 4,300 meters on open slopes (Chauhan, 1999). The genus *Jurinea*, belonging to the Cardueae tribe of the Asteraceae family, comprises 21 species globally. It is distributed across northwest India, Myanmar, Nepal, China, and Pakistan (Funk et al., 2009; Shih & Raab-Straube, 2011; Shen et al., 2020).

#### Traditional Medicinal Uses

*J. dolomiaea* is widely utilized in traditional medicinal systems, including Unani, Homeopathy, Naturopathy, Ayurveda, and Traditional Chinese Medicine (Table 2 & Figure 2). The roots are brewed into a decoction and recommended as a soothing remedy for colic and puerperal fever, and they are also applied as a poultice for epidermal eruptions (Chopra et al., 1986; Verma & Tewari, 2016). In Nepal, its aromatic properties make it valuable in the incense industry, and its root extract is used for fever treatment (Manandhar, 2002). Traditionally, this plant is also employed as an aphrodisiac to enhance libido and sexual vitality (Sekar et al., 2005). In the Jammu and Kashmir region, *J. dolomiaea* is used to treat eye infections, while oil extracted from its roots is applied in the treatment of gout, diarrhea, rheumatism, and stomach ailments. Additionally, it serves as an insect repellent and antiseptic (Kumar et al., 2009; Sharma et al., 2004; Kunwar et al., 2006; Haq et al., 2021). The raw roots of *J. dolomiaea* are used for dental hygiene (Haq et al., 2023a). In some regions, the roots are cooked with maize flour and consumed for the treatment of internal fractures, while root extracts are used as a tonic to aid bone recovery (Ahmad & Habib, 2014).



**Figure 1.** A schematic representation of *Jurinea dolomiaea* taxonomy: (a) Capitula (sessile and shortly peduncled). (b) Leaves are hirsute adaxial and densely woolly beneath.



**Figure 2.** A schematic representation of *Jurinea dolomiaea* distribution, phytochemistry, pharmacology and traditional medicinal uses.

### Phytochemistry

Phytochemical investigations of *J. dolomiaea* have identified a diverse range of bioactive compounds present in its roots and aerial parts (AP), including saponins, tannins, flavonoids, glycosides, steroids, phenolic compounds, fixed oils, fats, terpenes, and lignans (Table 3 & Figure 2) (Bhat et al., 2022a; Bhat et al., 2022c; Shah et al., 2014a). Kumar and Agnihotri (2020) isolated several bioactive compounds from the roots, including lupenone,  $\beta$ -sitosterol, physcion, 20, 21 $\alpha$ -epoxytaraxastan-3 $\beta$ -ol, chlorogenic acid, and ptiloepoxide. Among these,  $\beta$ -sitosterol is a well-known phytosterol with reported anticancer, antidiabetic, hypolipidemic, neuroprotective, and chemopreventive properties (Babu & Jayaraman, 2020). Lupenone, a major compound of *J. dolomiaea*, exhibits therapeutic potential against viral infections, inflammation, diabetes, Chagas disease, and cancer (Xu et al., 2018).

Further research has identified three novel compounds—4-hydroxy pectorolide, pinorelinol monomethyl ether- $\beta$ -D-glucoside (PMG), and hydroxypectorolide-14-O-acetate—extracted using adsorption chromatography on dichloromethane (DCM) extract. These compounds were tested for cytotoxic activity against human cervical cancer (HeLa) and metastatic breast carcinoma (MDA-MB-231) cell lines, with PMG demonstrating the highest potency against HeLa cells (IC<sub>50</sub> = 3.54  $\mu$ g/mL) (Atabaki et al., 2021). Gürbüz et al. (2022) identified 12 compounds from the aerial parts of the plant

using chloroform and butanol extraction, including four triterpenes (lupeol, hennadiol, taraxasterol acetate, and lupeol acetate) and eight flavonoids. These flavonoids were assessed for cytotoxicity against A549 lung cancer and MCF-7 breast cancer cell lines and docked against aromatase binding sites, revealing that flavonoids lacking sugar moieties exhibited the highest binding affinities. The pharmacokinetic properties of these flavonoids suggest their potential as promising oral drug candidates for breast cancer treatment.

### Pharmacological Activities of *J. dolomiaea* Compounds

Phytochemicals isolated from *J. dolomiaea* exhibit a broad spectrum of pharmacological activities (Table 4).  $\beta$ -sitosterol has been extensively studied for its neuroprotective, chemopreventive, antioxidant, and antidiabetic properties (Babu & Jayaraman, 2020). Khan et al. (2022) further highlighted its hepatoprotective, antioxidant, anti-inflammatory, antimicrobial, cardioprotective, and anticancer effects. Lupenone has demonstrated anticancer, antidiabetic, anti-inflammatory, and antiviral properties (Xu et al., 2018). Physcion has been reported to exhibit antimicrobial, hepatoprotective, anticancer, antiproliferative, laxative, and anti-inflammatory activities (Pang et al., 2016). Chlorogenic acid (CGA) is recognized for its liver-protective, immunomodulatory, anticancer, hypoglycemic, antiviral, antibacterial, anti-inflammatory, and antioxidant properties (Miao & Xiang, 2020). Pentanoic acid (C<sub>5</sub>H<sub>10</sub>O<sub>2</sub>) is

primarily utilized for its hepatoprotective effects against cancer (Han et al., 2020).

### Pharmacological Activities of *J. dolomiaea*

Pharmacological studies on *J. dolomiaea* have demonstrated its antileishmanial, anti-oxidant, antimalarial, antibacterial, antiulcer, DNA-protective, analgesic, hepatoprotective, and anticancer potential. Additionally, *J. dolomiaea* has applications in reproductive health (Table 5, Figure 2).

#### Antibacterial Activity

*J. dolomiaea* extracts prepared using different solvents (methanol, aqueous, ethanol, chloroform, and ethyl acetate) and its silver nanoparticles (AgNPs) have exhibited antibacterial activity against multiple bacterial strains, including *Escherichia coli*, *Staphylococcus aureus*, *Xanthomonas vesicatoria*, and *Ralstonia solanacearum* (Dwivedi et al., 2014; Singh et al., 2015; Riaz et al., 2018). The methanolic extract demonstrated the highest zone of inhibition (ZOI), measuring 9, 10, 12, and 12 mm against *S. aureus*, *E. coli*, *R. solanacearum*, and *X. vesicatoria*, respectively. The chloroform extract (CHCl<sub>3</sub>) of *J. dolomiaea* also exhibited significant inhibitory activity, with ZOI values of 4, 8, 4, and 4 mm against the same bacterial strains (Dwivedi et al., 2014). The minimum inhibitory concentration (MIC) for both phytopathogenic and clinical bacteria ranged from 0.25 to 4.0 mg/mL and 0.35 to 4.0 mg/mL, respectively (Dwivedi et al., 2014). Riaz et al. (2018) synthesized AgNPs from the aqueous root extract of *J. dolomiaea* and evaluated their biological activities. The nanoparticles exhibited significant antimicrobial activity against *Pseudomonas aeruginosa* and *E. coli*, with an inhibition zone of 11.0 mm, which was greater than that of the methanolic root extract (8.0 mm).

#### Antileishmanial Activity

Crude methanolic extract and solvent fractions of varying polarity (n-hexane, chloroform, ethyl acetate, n-butanol, methanol, and water) were evaluated against *Leishmania tropica* promastigotes (KWH23). The ethyl acetate fraction (JDEE) exhibited the highest potency, with an

IC<sub>50</sub> value of 5.3 ± 0.2 µg/mL, in comparison to the crude methanolic extract (IC<sub>50</sub> = 10.9 ± 1.1 µg/mL) and the standard drug Glucantime (IC<sub>50</sub> = 5.6 ± 0.25 µg/mL) (Shah et al., 2014b). The toxicity of *J. dolomiaea* extracts and their fractions was further assessed using the brine shrimp lethality assay, with all extracts demonstrating toxicity within the safety range (LC<sub>50</sub> >100 µg/mL) (Shah et al., 2014b).

#### DNA Protection Activity

High doses of the water, chloroform, and hexane fractions exhibited DNA protective effects, while the butanol fraction induced DNA degradation instead of protection. In contrast, the methanol and ethyl acetate fractions remained inactive, providing no protection against Fenton reaction-induced DNA degradation (Shah et al., 2014a).

#### Antioxidant Activity

The antioxidant activity of *J. dolomiaea* root extracts was evaluated in methanolic, n-hexane, chloroform, ethyl acetate, butanol, and aqueous fractions using various in vitro assays. The study assessed total phenolic content (TPC) and total flavonoid content (TFC), revealing that the ethyl acetate fraction (JDEE) had the highest TFC (807 ± 7.2 mg rutin equivalent/g sample), while the chloroform extract (JDCE) contained the highest TPC (757 ± 9.4 mg gallic acid equivalent/g sample) (Shah et al., 2014a). Riaz et al. (2018) evaluated the total phenolic acid and flavonoid content of methanolic *J. dolomiaea* extract, which demonstrated strong antioxidant potential due to its high phenol and flavonoid concentration. Furthermore, Ahmed et al. (2019) investigated the antioxidant potential of aqueous crude extracts from roots and leaves, along with their AgNPs. The study revealed that *J. dolomiaea* leaf extract and its nanoparticles exhibited higher antioxidant activity compared to the root extract and its nanoparticles.

#### Antimalarial Activity

The antimalarial activity of ethanol root extract of *J. dolomiaea* was assessed in both in vitro and in vivo models. The extract exhibited moderate activity, with an in vitro IC<sub>50</sub> value of

$65.39 \pm 1.22 \mu\text{g/mL}$  and an in vivo  $\text{IC}_{50}$  value of  $49.27 \pm 1.02 \mu\text{g/mL}$  (Misra et al., 1991).

### Antiulcer Activity

*J. dolomiaea* demonstrated significant antiulcer activity against ethanol (70%)-induced gastric mucosal injuries in rats. Pretreatment with the aqueous root extract inhibited mucosal damage in a dose-dependent manner (Bhat et al., 2022b).

### Anticancer Activity

The anticancer activity of *J. dolomiaea* was evaluated using Ehrlich Ascites Carcinoma cell lines. Root and leaf extracts exhibited significant scavenging activity compared to the standard antioxidant butylated hydroxytoluene (BHT). Goat red blood cells (RBCs) (2%) were agglutinated by *J. dolomiaea* root and leaf extracts at concentrations of  $12.5 \mu\text{g/mL}$  and  $50.0 \mu\text{g/mL}$ , respectively. The extracts demonstrated  $53.96 \pm 2.34\%$  and  $62.54 \pm 2.41\%$  cell growth inhibition, while the standard anticancer drug bleomycin exhibited  $79.43 \pm 1.92\%$  inhibition. Nuclear condensation and fragmentation, indicative of apoptosis, were observed under a fluorescence microscope (Bhat et al., 2022a). Further studies on crude extracts and AgNPs synthesized from *J. dolomiaea* roots and leaves demonstrated potent cytotoxic effects against HeLa cervical cancer cell lines, with a comparatively lower effect on MCF-7 breast cancer cell lines (Ahmed et al., 2019).

### Analgesic Effect

Treatment with the aqueous root extract of *J. dolomiaea* significantly inhibited acetic acid-induced writhing in mice. The inhibitory effects followed a dose-dependent pattern (Bhat et al., 2022b).

### Hepatoprotective Activity

The hepatoprotective effects of hydroalcoholic root extracts of *J. dolomiaea* were

evaluated against carbon tetrachloride ( $\text{CCl}_4$ )-induced liver injury by assessing serum glutamate pyruvate transaminase (SGPT), serum glutamate oxaloacetate transaminase (SGOT), and alkaline phosphatase (ALP) levels. A significant reduction in these serum enzyme levels was observed following a seven-day treatment with *J. dolomiaea* extract (Bhat et al., 2022b).

### Reproductive Health

Shah and Khan (2017) evaluated the antioxidant effects of *J. dolomiaea* ethyl acetate fraction (JDEE) in mitigating oxidative stress induced by  $\text{CCl}_4$  in rat testes.  $\text{CCl}_4$  exposure led to a decline in key antioxidant enzymes, including peroxidase (POD), catalase (CAT), superoxide dismutase (SOD), glutathione peroxidase (GPx), glutathione reductase (GR), glutathione-S-transferase (GST), and glutathione (GSH), while increasing nitrite, lipoperoxide (TBARS), and  $\text{H}_2\text{O}_2$  levels. Additionally, testosterone levels were significantly reduced. Treatment with JDEE in combination with silymarin (200–400 mg/kg) counteracted these toxic effects, enhancing serum testosterone levels and improving primary germ layer thickness in testes (Shah & Khan, 2017).

### Conclusion

*J. dolomiaea* is a valuable medicinal plant of the northwest Himalayan alpine region. Its tuberous roots and leaves have been traditionally used to treat various ailments. Phytochemicals extracted from *J. dolomiaea* have demonstrated therapeutic potential, particularly in antibacterial, antileishmanial, anticancer, hepatoprotective, and antioxidant applications. The enhanced pharmacological activities observed in AgNPs derived from *J. dolomiaea* highlight their potential as antimicrobial and anticancer agents. Further research is warranted to explore its full pharmaceutical potential.

Table 1.

Botanical description of *Jurinea dolomiaea*.

Plant parts	Botanical descriptions	References
Herb	Perennial	Kasana <i>et al.</i> , 2021
Roots	Long tuberous roots	Shah <i>et al.</i> , 2014b
Leaves	Leaves are elliptic, 20–30 cm long with petioles, lobes are pinnatifid and denticulate margins, its leaves are densely wooly, beneath and hairy on the upper surface	Kasana <i>et al.</i> , 2021
Flower (capitulum)	3-15 in number, attached directly to base with or without a stalk Multilayered involucre bracts and purple in color, Flower filaments are smooth; anther bases bear caudate bandages, and lacerate tails, Flowering and fruiting time is July to September	

Table 2.

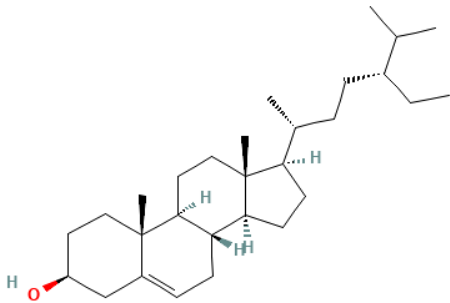
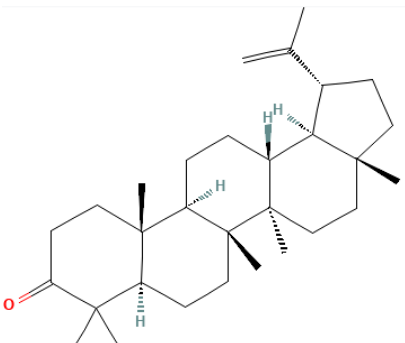
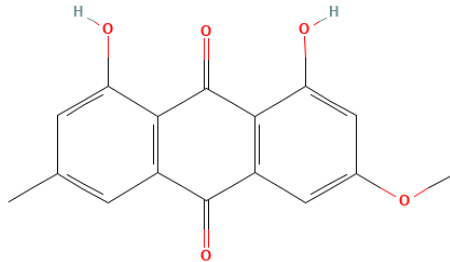
Traditional medicinal uses of *Jurinea dolomiaea*.

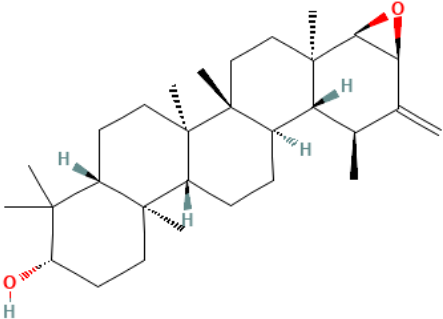
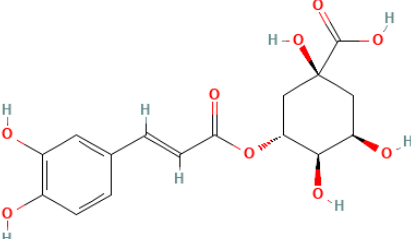
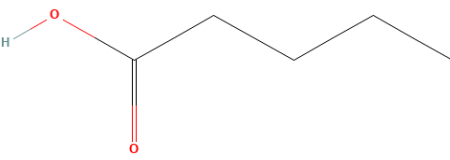
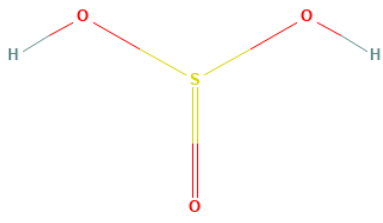
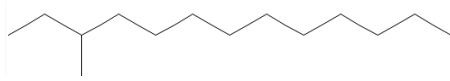
S. No.	Diseases	Part used	Formulations	References
1	Antiseptic	Root and bark	Roots and bark are used as antiseptic	Bisht <i>et al.</i> , 2013; Haq <i>et al.</i> , 2021
2	Arthritis	Root	Roots were boiled and the extract was mixed with ghee and wheat flour to make a halwa that's considered energetic and consumed before bedtime	Lone & Bhardwaj, 2013
3	Aphrodisiac	-	-	Sekar & Srivastava, 2005
4	Body pain	Roots and leaves	-	Ahmed & Akhtar, 2016
5	Breathing trouble	Whole plant	Incense of plant is used to cure breathing trouble	Rawat <i>et al.</i> , 2013
6	Cough, cold and headache	Roots and leaves	Juice of fresh roots given orally, Roots powder tea is consumed	Lone & Bhardwaj, 2013; Lone <i>et al.</i> , 2015; Puri & Saha, 2020
7	Colic	Roots and leaves	Roots decoction was consumed to cure colic, Leaves juice taken orally	Sharma <i>et al.</i> , 2010; Sarver <i>et al.</i> , 2013; Bano <i>et al.</i> , 2014
8	Demon repellent	Roots	Dried roots are burnt to produce smoke	Lone & Bhardwaj, 2013
9	Diabetes/ Sugar	Roots	Powdered roots are taken empty stomach with water	Haq <i>et al.</i> , 2023a
10	Diarrhea	Roots	Root paste consumed during diarrhea	Dovydaitis, 2017
11	Eye infection	-	-	Kumar <i>et al.</i> , 2009
12	Fever/ Fever after child birth	Roots	Stimulant roots were given in fever after child birth Root juice used for fever, Root poultice applied topically on forehead, Roots are considered to be stimulant & used to cure fever	Singh & Rawat, 2011; Lone & Bhardwaj, 2013; Sarver <i>et al.</i> , 2013; Sharma <i>et al.</i> , 2010; Bhat & Gulfishan, 2015; Jain & Khare., 2015; Bano <i>et al.</i> , 2014; Verma & Tewari, 2016

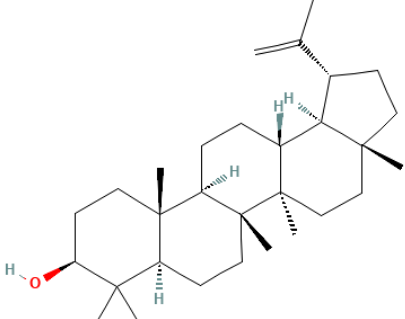
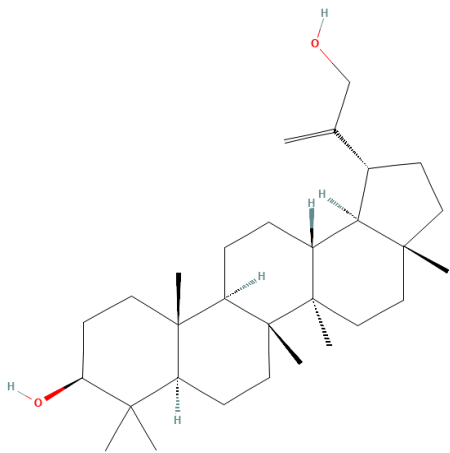
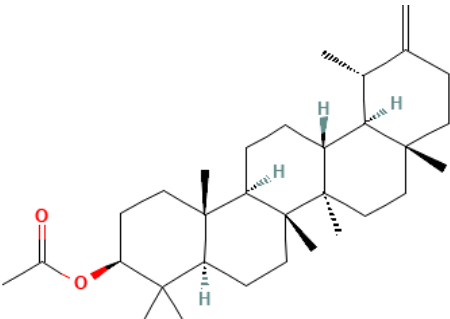
S. No.	Diseases	Part used	Formulations	References
13	Foot & mouth disease	Roots	Juice of fresh Roots given orally	Puri & Saha, 2020
14	Gout & rheumatism	Roots	Leaves and roots are used against rheumatic pains	Singh and Attri, 2014; Ishtiyak & Hussain, 2017; Verma & Tewari, 2016; Surmal <i>et al.</i> , 2021; Haq <i>et al.</i> , 2021
15	Gynic problems	Roots	-	Rana & Rawat, 2019
16	Incense	Roots	Roots are aromatic and used to form a main ingredient of dhoop industry	Manandhar, 2002; Singh & Rawat, 2011; Gupta <i>et al.</i> , 2013; Sarver <i>et al.</i> , 2013; Ishtiyak & Hussain, 2017; Devkota <i>et al.</i> , 2017
17	Nervous convulsion	Roots	Root decoction	Ahmed & Akhtar, 2016
18	Skin diseases, eruptions/ burns	Roots and leaves	Root powder is applied on cuts and skin eruptions, Juice of fresh Roots given orally, Roots powder was mixed with common salt and oil and applied as a paste on wounds for its quick healing and on boils that makes them burst	Ishtiyak & Hussain, 2017; Lone & Bhardwaj, 2013; Bano <i>et al.</i> , 2014; Bhat & Gulfishan, 2015; Lone & Rather, 2020; Abdullah & Andrabi, 2021; Ji <i>et al.</i> , 2023; Haq <i>et al.</i> , 2023b
19	Stomachache	Roots	Root juice is used	Kunwar <i>et al.</i> , 2006; Shah and Khan, 2017
20	Thirst & whitening of tongue	Roots and leaves	Roots powder tea consumed	Lone & Bhardwaj, 2013; Lone <i>et al.</i> , 2015
21	Tooth cleaning	Roots	Raw roots used for tooth cleaning	Haq <i>et al.</i> , 2023a
22	Weakness of bones and Internal fractures	Roots	Roots cooked with maize flour and consumed for internal fractures, Roots extract is consumed as tonic for the recovery of bones weakness	Ahmad & Habib, 2014

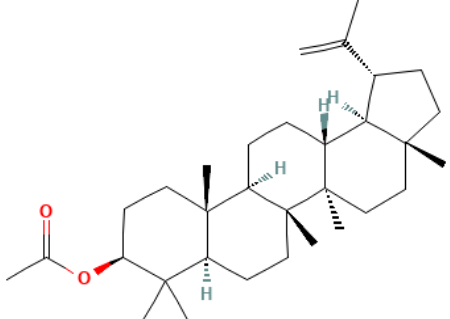
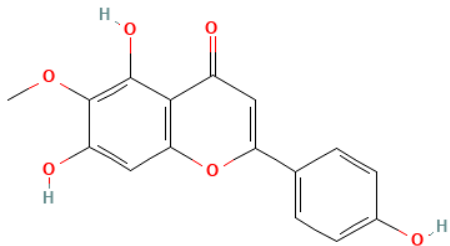
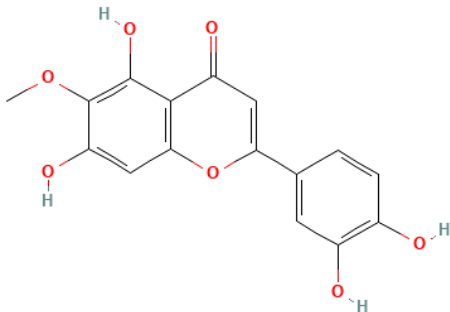
Table 3.

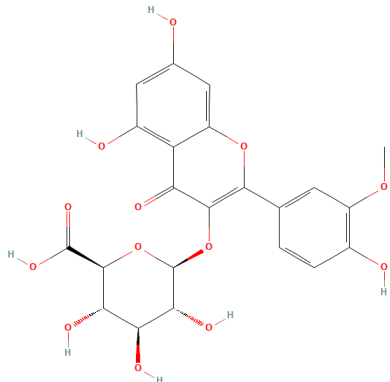
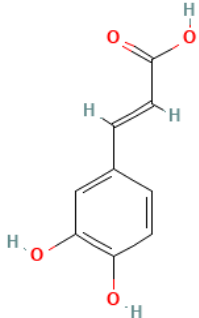
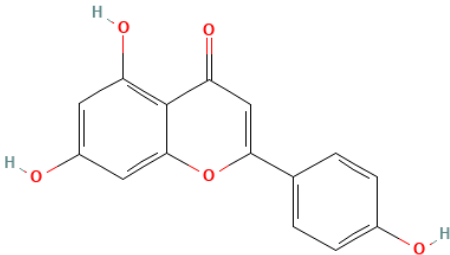
List of phytochemicals and their structures extracted from various parts of *J. dolomiaea*.

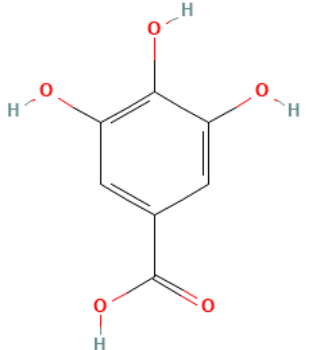
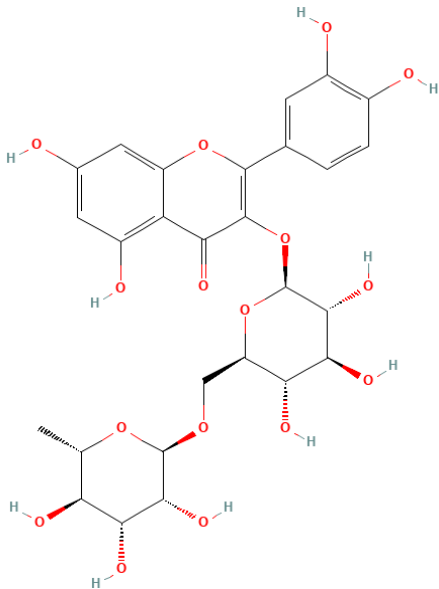
S. No	Compounds	Structures (Pubchem)	Plant part	Class	References
1	$\beta$ -sitosterol		Root	Phytosterol (C <sub>29</sub> H <sub>50</sub> O)	Kumar & Agnihotri., 2020
2	Lupenone		Root	Terpene (C <sub>30</sub> H <sub>48</sub> O)	Kumar & Agnihotri., 2020
3	Physcion		Root	Anthraquinone (C <sub>16</sub> H <sub>12</sub> O <sub>5</sub> )	Kumar & Agnihotri., 2020

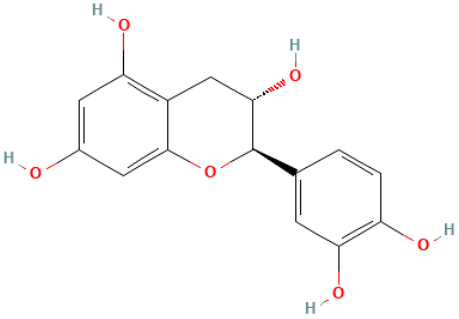
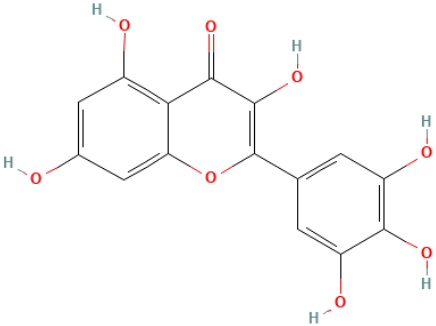
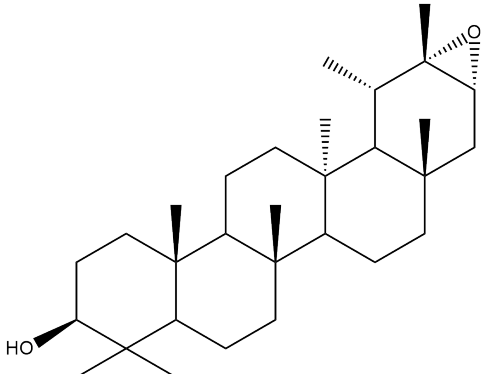
S. No	Compounds	Structures (Pubchem)	Plant part	Class	References
4	Ptiloepoxide		Root	Ether (C <sub>30</sub> H <sub>48</sub> O <sub>2</sub> )	Kumar & Agnihotri., 2020
5	Chlorogenic acid		Root	Terpene (C <sub>16</sub> H <sub>18</sub> O <sub>9</sub> )	Kumar & Agnihotri., 2020
6	Pentanoic acid		Root	Triterpenoid (C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> )	Bhat <i>et al.</i> , 2022c
7	Sulfurous acid		Root	Triterpenoid (H <sub>2</sub> O <sub>3</sub> S)	Bhat <i>et al.</i> , 2022c
8	Methyltridecane		Root	Triterpenoid (C <sub>14</sub> H <sub>30</sub> )	Bhat <i>et al.</i> , 2022c

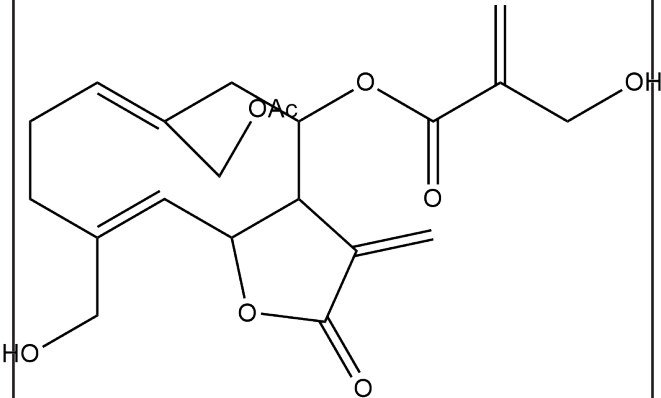
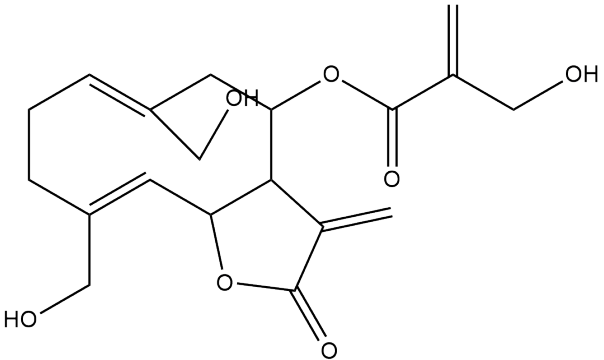
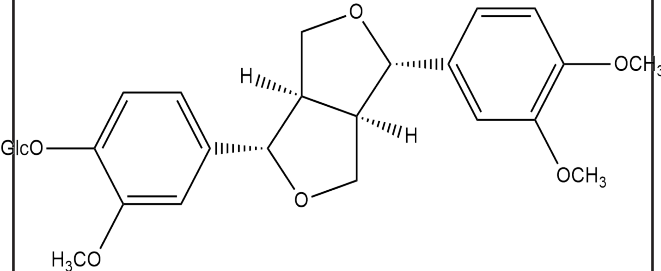
S. No	Compounds	Structures (Pubchem)	Plant part	Class	References
9	Lupeol		Root, AP	Triterpene (C <sub>30</sub> H <sub>50</sub> O)	Gürbüz <i>et al.</i> , 2022; Bhat <i>et al.</i> , 2022c
10	Hennadiol		AP	Triterpene (C <sub>30</sub> H <sub>50</sub> O <sub>2</sub> )	Gürbüz <i>et al.</i> , 2022
11	Taraxasterol acetate		AP	Triterpene (C <sub>32</sub> H <sub>52</sub> O <sub>2</sub> )	Gürbüz <i>et al.</i> , 2022

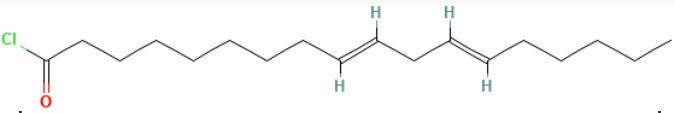
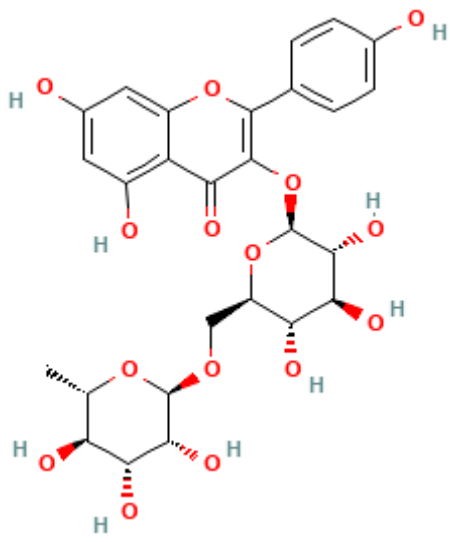
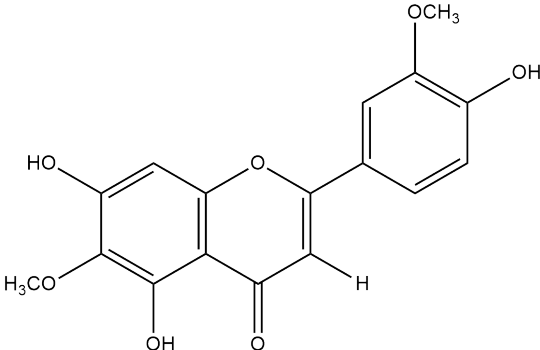
S. No	Compounds	Structures (Pubchem)	Plant part	Class	References
12	Lupeol acetate		AP	Triterpene (C <sub>32</sub> H <sub>52</sub> O <sub>2</sub> )	Gürbüz <i>et al.</i> , 2022
13	6-methoxyapi- genin		AP	Flavonoid (C <sub>16</sub> H <sub>12</sub> O <sub>6</sub> )	Gürbüz <i>et al.</i> , 2022
14	6-methoxylute- olin (Nepetin)		AP	Flavonoid (C <sub>16</sub> H <sub>12</sub> O <sub>7</sub> )	Gürbüz <i>et al.</i> , 2022

S. No	Compounds	Structures (Pubchem)	Plant part	Class	References
15	Isorhamnetin 3-O-glucuro- nide	 The structure shows a flavonoid core (isorhamnetin) where the 3-hydroxyl group is linked via an oxygen atom to a glucose molecule. The glucose is in its cyclic pyranose form with hydroxyl groups at the 2, 3, and 6 positions.	AP	Flavonoid (C <sub>22</sub> H <sub>20</sub> O <sub>13</sub> )	Gürbüz <i>et al.</i> , 2022
16	Caffeic acid	 The structure consists of a benzene ring with hydroxyl groups at the 3 and 4 positions. A propenoic acid side chain is attached to the ring at the 1 position.	Root	Phenol (C <sub>9</sub> H <sub>8</sub> O <sub>4</sub> )	Shah <i>et al.</i> , 2014b
17	Apigenin	 The structure is a flavone with a 5,7-dihydroxyflavone core. A 4-hydroxyphenyl group is attached to the 3-position of the flavone ring.	Root, AP	Flavonoid (C <sub>15</sub> H <sub>10</sub> O <sub>5</sub> )	Shah <i>et al.</i> , 2014b; Gürbüz <i>et al.</i> , 2022

S. No	Compounds	Structures (Pubchem)	Plant part	Class	References
18	Gallic acid	 <p>The structure shows a benzene ring with three hydroxyl groups (-OH) at the 2, 4, and 6 positions. A carboxylic acid group (-COOH) is attached to the 1 position of the ring.</p>	Root	Phenolic acid (C <sub>7</sub> H <sub>6</sub> O <sub>5</sub> )	Shah <i>et al.</i> , 2014b
19	Rutin	 <p>The structure shows a flavonoid core consisting of a chromone ring system. It is substituted with a gallic acid moiety at the 3-position and a rhamnoside moiety at the 3'-position. The rhamnoside moiety is a six-membered ring with hydroxyl groups at the 2, 3, and 6 positions.</p>	Root	Flavonoid (C <sub>27</sub> H <sub>30</sub> O <sub>16</sub> )	Shah <i>et al.</i> , 2014b

S. No	Compounds	Structures (Pubchem)	Plant part	Class	References
20	Catechin	 <p>The structure shows a flavan-3-ol core. It consists of a chromane ring system with a phenyl ring attached at the 2-position. The phenyl ring has hydroxyl groups at the 2, 3, and 4 positions. The chromane ring has hydroxyl groups at the 5 and 7 positions.</p>	Root	Flavonoid (C <sub>15</sub> H <sub>14</sub> O <sub>6</sub> )	Shah <i>et al.</i> , 2014b
21	Myricetin	 <p>The structure shows a flavonoid core. It consists of a chromone ring system with a phenyl ring attached at the 3-position. The phenyl ring has hydroxyl groups at the 2, 3, and 4 positions. The chromone ring has hydroxyl groups at the 5 and 7 positions.</p>	Root	Flavonoid (C <sub>15</sub> H <sub>10</sub> O <sub>8</sub> )	Shah <i>et al.</i> , 2014b
22	20,21 $\alpha$ -epoxytaraxastan-3 $\beta$ -ol	 <p>The structure shows a complex polycyclic terpenoid skeleton. It features a pentacyclic core with a hydroxyl group at the 3-position and an epoxy group at the 20,21-positions. The structure is highly branched and contains several methyl groups.</p>	Root	Terpene (C <sub>16</sub> H <sub>18</sub> O <sub>9</sub> )	Kumar and Agnihotri., 2020

S. No	Compounds	Structures (Pubchem)	Plant part	Class	References
23	Hydroxy-pectorolide-14-o-acetate		AP	Sesquiterpene lactones	Atabaki <i>et al.</i> , 2021
24	4-Hydroxy pectorolide		AP	Sesquiterpene lactone	Atabaki <i>et al.</i> , 2021
25	Pinoresinol monomethyl ether-β-D-glucoside		AP	Furofuran-type lignan	Atabaki <i>et al.</i> , 2021

S. No	Compounds	Structures (Pubchem)	Plant part	Class	References
26	(9E, 12E)-9,12-Octadecadienoyl chloride (dienylchloride)		Root	Triterpenoid (C <sub>18</sub> H <sub>31</sub> C <sub>10</sub> )	Bhat <i>et al.</i> , 2022c
27	Kaempferol-3-O-rutinoside (Nicotiflorin)		AP	Flavonoid (C <sub>27</sub> H <sub>30</sub> O <sub>15</sub> )	Gürbüz <i>et al.</i> , 2022
28	6-methoxyluteolin 3'-methyl ether		AP	Flavonoid	Gürbüz <i>et al.</i> , 2022

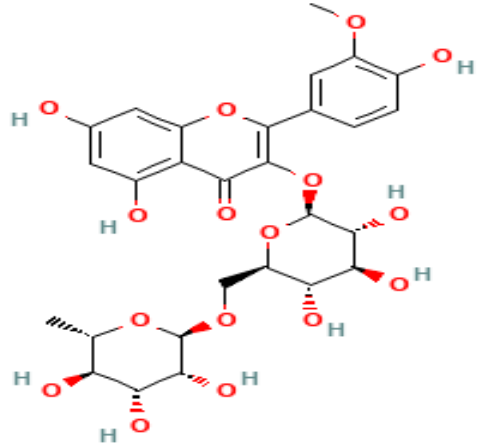
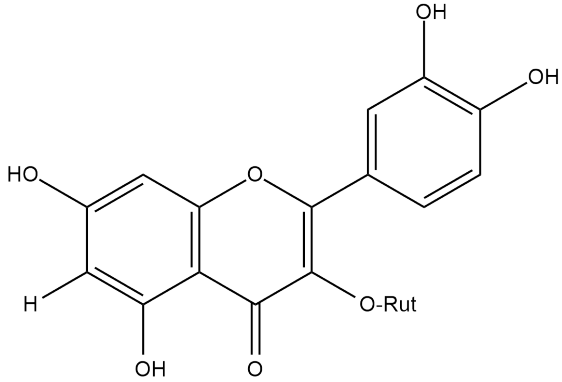
S. No	Compounds	Structures (Pubchem)	Plant part	Class	References
29	Isorhamnetin 3-O- $\beta$ -rutinoside (Narcissin)		AP	Flavonoid(C <sub>28</sub> H <sub>32</sub> O <sub>16</sub> )	Gürbüz <i>et al.</i> , 2022
30	Quercetin 3-O-rutinoside		AP	Flavonoid	Gürbüz <i>et al.</i> , 2022

Table 4.

**Biological activities of compounds extracted from *Jurinea dolomiaea*.**

Sr. No	Compounds	Biological activities	References
1	$\beta$ -sitosterol	Analgesic, antinociceptive, anxiolytic & sedative effects, anti-cancer, immunomodulatory, antimicrobial, lipid lowering effect, anti-inflammatory, hepatoprotective, wound healing, protective effect on respiratory diseases, anti-diabetic and antioxidant	Babu and Jayaraman, 2020
2	Lupenone	Liver protection, anti-inflammatory, anti-tumor, anti-Chagas disease, immune regulation and antiviral	Xu <i>et al.</i> , 2018
3	Physcion	Hepatoprotective, laxative, anti-inflammatory, anti-proliferative and anti-microbial	Pang <i>et al.</i> , 2016
4	Chlorogenic acid	Hepatoprotective, antioxidant, anti-diabetic, antimicrobial, anti-carcinogenic, anti-inflammatory, and anti-obesity	Kim and Park, 2019
5	Lupeol	Anticancer, antioxidant, anti-inflammatory, antimicrobial and antiprotozoal	Liu <i>et al.</i> , 2021
6	Taraxasterol acetate	Anti-inflammatory, anti-oxidative, anti-carcinogenic anti-viral, antimicrobial and anti-tubercular	Jiao <i>et al.</i> , 2022
7	Lupeol acetate	Anticancer, antiprotozoal and anti-inflammatory	Gallo <i>et al.</i> , 2009
8	Caffeic acid	Anti-inflammatory antioxidant and anticarcinogenic activity	Espíndola <i>et al.</i> , 2019
9	Apigenin	Muscle relaxing, sedative, antioxidant, anti-inflammatory, anti-amyloidogenic, neuroprotective, cognition-enhancing, anti-alzheimer	Salehi <i>et al.</i> , 2019
10	Gallic acid	Anti-inflammatory, antioxidant, antineoplastic properties, gastrointestinal, metabolic, cardiovascular disorders and neuropsychological activity.	Kahkeshani <i>et al.</i> , 2019
11	Rutin	Antioxidative, antimicrobial, antifungal, anti-allergic, antioxidant, antihypertensive and neuroprotective	Abdullah Al-Dhabi <i>et al.</i> , 2015
12	Catechin	Anti-diabetic, anti-inflammatory, anti-cancer, bactericidal, neuroprotective, memory enhancer, hepato-protective and anti-arthritis	Baranwal <i>et al.</i> , 2022
13	Myricetin	Anti-oxidant, anticancer, anti-inflammatory, analgesic, antitumor, hepatoprotective and antidiabetic	Semwal <i>et al.</i> , 2016
14	Pinoresinol Monomethyl Ether- $\beta$ -D-Glucoside	Anticancer	Atabaki <i>et al.</i> , 2021
15	Kaempferol-3-O-rutinoside	Central nervous system (CNS) prevention, anticarcinogenic, anti-inflammatory, antifungal, antibacterial, antiprotozoal	Ma <i>et al.</i> , 2017; Periferakis <i>et al.</i> , 2022

**Table 5.**
**Pharmacological activities of *Jurinea dolomiaea***

Part used	Extraction solvents	Pharmacological activities	Details	References
Leaves	Aqueous, MeOH, EtOH, ETAC and chloroform	Antibacterial activity (Zone of inhibition)	<i>E. coli</i> (10 mm Methanol, 8 mm chloroform)	Dwivedi <i>et al.</i> , 2014; Singh <i>et al.</i> , 2015; Riaz <i>et al.</i> , 2018
			<i>S. aureus</i> , (9 mm Methanol, 4 mm chloroform)	
			<i>X. vesicatoria</i> , (12 mm Methanol, 4 mm chloroform)	
			<i>R. solanacearum</i> , (12 mm Methanol, 4 mm chloroform).	
			Silver nanoparticles (inhibition zone of 11 mm) against <i>P. aeruginosa</i> and <i>E. coli</i>	
			Methanol extract (12 mm & 15 mm) against <i>S. aureus</i> and <i>E. coli</i> .	
			Ethyl acetate extract (10 mm & 13 mm) against <i>S. aureus</i> and <i>E. coli</i> respectively.	
		Both the extracts did not show any activity against <i>S. typhirium</i> and <i>K. pneumoniae</i> .		
		Antibacterial activity (Minimum inhibitory concentration)	MIC- <i>X. vesicatoria</i> , <i>R. solanacearum</i> - 0.25 to 4.0 mg/mL and <i>E. coli</i> , <i>S. aureus</i> - 0.35 to 4.0 mg/mL.	
Roots	Methanol, chloroform, n-hexane, ethyl acetate, water and n-butanol	Antileishmanial activity (IC <sub>50</sub> )	IC <sub>50</sub> = 5.3 ± 0.2 µg/mL (Ethyl acetate fraction)	Shah <i>et al.</i> , 2014b
			IC <sub>50</sub> value of 5.6 ± 0.25 µg/mL (Standard drug Glucantime)	
			R2 value: 0.81 to 0.91 IC50 = 10.9 ± 1.1 µg/mL (Methanol extract)	

Part used	Extraction solvents	Pharmaceutical activities	Details	References
Roots	Methanol, n-hexane, chloroform, ethyl-acetate, butanol and aqueous	Antioxidant activity	Ethyl acetate showed best fraction with IC <sub>50</sub> (41.1 ± 1.0 µg/mL) via DPPH (RSA)	Shah <i>et al.</i> , 2014a; Riaz <i>et al.</i> , 2018; Singh <i>et al.</i> , 2015
			IC <sub>50</sub> (42.2 ± 0.9 µg/mL) via Hydrogen peroxide (SA)	
			IC <sub>50</sub> (3,3 ± 4.7, 4 µg/mL) via Hydroxyl (RSA)	
			IC <sub>50</sub> (46.7 ± 0.6 µg/mL) via ABTS (RSA),	
			Methanol-extract showed high antioxidant potency IC <sub>50</sub> (0.494 µg/mL)	
		Anti lipid peroxidation activity	Ethyl acetate with IC <sub>50</sub> (54.3 ± 1.6 µg/mL)	
			Ethyl acetate, butanol with IC <sub>50</sub> (82.8 ± 0.6; 86.5 ± 1.1 µg/mL) respectively via β-carotene bleaching activity	
			Chloroform with IC <sub>50</sub> (91.7 ± 1.3 µg/mL) via Superoxide anion (RSA)	
Chloroform with IC <sub>50</sub> (92.0 ± 1.0 µg/mL) via Nitric oxide (RSA)				
Roots	Ethanol	Antimalarial activity	Ethanol extract <i>in-vitro</i> IC <sub>50</sub> (65.39±1.22 µg/mL)	Misra <i>et al.</i> , 1991
			Ethanol extract <i>in-vivo</i> IC <sub>50</sub> (49.27±1.02 µg/mL)	
Root and leaf	Water	Anticancer activity	MIC: 12.5 µg/mL in root	Ahmed <i>et al.</i> , 2019; Bhat <i>et al.</i> , 2022a
			MIC: 50.0 µg/mL in leaf	
			Cell growth inhibition: 62.54±2.41% in leaf	
			Cell growth inhibition: 53.96±2.34% in root	
			Standard drug (Bleomycin) growth inhibition: 79.43±1.92%	
			Cervical cancer cell lines (HeLa) and breast cancer cell lines (MCF-7) with an IC <sub>50</sub> value of 55±0.51µg/mL	
Root	Methanol, chloroform, n-hexan, ethyl acetate, aqueous and n-butanol	DNA protection activities	Chloroform+water+hexane fractions showed DNA protection only at high concentrations	Shah <i>et al.</i> , 2014a
			High dose of butanol showed degrading effect on plasmid DNA	

Part used	Extraction solvents	Pharmaceutical activities	Details	References
Root	Methanol, chloroform, n-hexan, ethyl acetate, water and n-butanol	Antitoxic activities	Methanol extract moderate toxicity $LC_{50}$ : $733.0 \pm 15.1 \mu\text{g/mL}$	Shah <i>et al.</i> , 2014b
			Ethyl acetate fraction higher toxicity	
			Water fraction lowest toxicity	
			R2: 0.92 to 1.0.	
Root	Water	Antiulcer activity	Exhibited in dose dependent pattern	Bhat <i>et al.</i> , 2022b
			Effects of the water extract of root at the dose of 50, 100 and 200 mg/kg with inhibitions of 67.7, 61.1 and 77.8% respectively	
			Doses of water extract of root were statistically significant ( $p < 0.005$ )	
			Famotidine also significantly reduced ethanol-induced gastric lesions for 34.4%.	
Root	Water	Analgesic effect	Exhibited in dose-dependent pattern	Bhat <i>et al.</i> , 2022b
			Inhibitory effects of WER at the dose of 50, 100 and 200 mg/kg with 62.1, 70.4 and 89.2% respectively.	
			Metamizol also significantly ( $p < 0.01$ ) reduced acetic acid-induced writhing with 39.4%.	
Root	Hydroalcoholic	Hepato-protective activity	100 and 200 mg/kg of hydroalcoholic roots extract significantly reduced elevated marker enzymes (SGOT, SGPT, ALP) and total bilirubin levels induced by $\text{CCl}_4$	Bhat <i>et al.</i> , 2022b
Root	Ethyl acetate	Reproductive health	$\text{CCl}_4$ diminished the levels of POD, CAT, SOD, GST, GPx, GSH, GR and enhanced the levels of (TBARS), nitrite and $\text{H}_2\text{O}_2$ in (testes) sample of male rats	Shah & Khan, 2017
			JDEE altered (histopathological) changes induced by $\text{CCl}_4$ and inhibited $\text{CCl}_4$ induced toxicity in rats.	
			JDEE increased (GSH) level in testes and the quantity of testosterone in serum samples. It also increased the thickness of germinal layers in testes dose dependently.	

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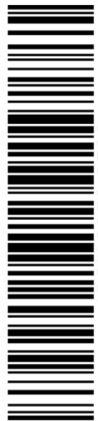
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ISSN 2958-0536



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