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A New Perspective on Arnica Montana L: A Focus on Antifungal Activity

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ABSTRACT

The plant species, Arnica montana L., belongs to the Asteraceae family and is traditionally used to treat bruises, trauma, pain and inflammatory conditions. It is rich in active ingredients including sesquiterpene lactones, helenalin, flavonoids and phenolic acids that contribute to many pharmacological activities. The plant has been widely studied for its anti-inflammatory, antioxidant and wound-healing activities. However, recent experimental studies have demonstrated antifungal activities. This review will focus on the phytochemical components, traditional uses and pharmacological activities of this plant, particularly highlighting antifungal activities. Studies have shown antifungal activities against a range of fungal species, including Malassezia furfur, Microsporum gypseum and some plant pathogenic fungi. This review will also discuss the potential mechanisms of action and factors that may influence activity, such as extraction method, solvent and concentration. Although promising results have been found, further studies are needed to understand the true mechanisms of action and to confirm effectiveness through well-designed experimental studies.

Keywords: *Arnica montana, Antifungal activity, Helenalin, Medicinal plants, Phytochemicals*

INTRODUCTION

Arnica montana L. is a medicinal plant in the Asteraceae family and ranks among the traditionally recognized medicinal species of European herbal medicine.[1] The plant, especially its flower heads, has been used traditionally and in herbal preparations to manage blunt injuries, bruising, inflammation, and musculoskeletal complaints.[2] As a result, pharmacological research on A. montana has largely concentrated on its anti-inflammatory, analgesic, antioxidant, and wound-related properties. However, experimental studies have also reported antimicrobial activities, including antifungal effects, which suggests that the biological potential of A. montana may extend beyond its usual association with trauma and inflammation.[1]

The pharmacological properties of A. montana are linked to a complex mixture of secondary metabolites.[1] Sesquiterpene lactones, especially helenalin and 11α,13-

dihydrohelenalin and their ester derivatives, are important constituents of the flower heads.[2] The plant also contains flavonoids, phenolic acids, coumarins, essential-oil constituents, polyacetylenes, triterpenes, and other phytochemicals. The qualitative and quantitative composition of these constituents may vary depending on geographical origin, plant material, chemotype, harvesting conditions, and extraction procedure. Such variation is especially important when comparing the biological activity of different A. montana preparations. [2]

Fungal infections are an important area of biomedical research, since pathogenic fungi include both opportunistic yeasts and filamentous fungi that can cause superficial as well as systemic infections.[3] Candida species, in particular, are important opportunistic fungal pathogens, while dermatophytes are responsible for a wide range of superficial infections.[3] Fungal infections are an important area of biomedical research, since pathogenic fungi include both opportunistic yeasts and filamentous fungi that can cause superficial as well as systemic infections. Candida species, in particular, are important opportunistic fungal pathogens, while dermatophytes are responsible for a wide range of superficial infections. The ongoing search for naturally derived antimicrobial compounds has heightened interest in medicinal plants as potential sources of compounds with antifungal activity.[4]

This review aims to examine the antifungal potential of Arnica montana L., with particular emphasis on its phytochemical constituents, experimental evidence against pathogenic fungi, the influence of extraction methods, possible mechanisms of antifungal action, limitations of the existing evidence, and future research perspectives.

MATERIALS & METHODS

The current review article is based on information obtained from authenticated textbooks and cited from indexed journals

REVIEW OF LITERATURE

CLASSIFICATION

Botanical name: Arnica montana L
Family: Asteraceae (Compositae)
Common names: Arnica; mountain arnica; mountain tobacco

Distribution

It is native to Europe and occurs mainly in temperate and mountainous areas, including the Alps, the Pyrenees, the Balkan Mountains, and parts of Scandinavia and the Baltic region.

Morphology

A perennial herbaceous plant that forms a basal rosette of leaves and produces an erect flowering stem. It produces distinctive yellow capitula (flower heads) made up of ray and disc florets.

Plant parts used medicinally

The flower heads, aerial parts and roots have all been used medicinally; the flower heads, however, are the main and most widely recognized medicinal material.

Flower heads

The dried flower heads, referred to as Arnicae flos, are the medicinal part that has been studied most extensively. They contain sesquiterpene lactones such as helenalin and 11α,13-dihydrohelenalin, as well as flavonoids and volatile constituents.[5]

PHYTOCHEMISTRY

Sesquiterpene lactones

The main compounds are helenalin and 11α,13-dihydrohelenalin, along with their esters formed with low-molecular-weight carboxylic acids such as acetic, isobutyric, methacrylic, methylbutyric and tiglic acids. The flower drug usually contains roughly 0.2–0.8% sesquiterpene lactones, though levels vary considerably from one population to another.[6]

Flavonoids

Arnica montana contains a range of flavonoid aglycones and glycosides.

Flavonoid content may vary considerably depending on geographical and environmental factors, including altitude.[7]

Phenolic acids

Key phenolic constituents include caffeic acid derivatives and caffeoylquinic acids, among them compounds such as chlorogenic acid and cynarin. These phenolic compounds are part of what gives the plant its antioxidant and possibly anti-inflammatory properties.[8]

Essential oils

The essential oil of A. montana consists of a complex blend of sesquiterpenes, monoterpenes and thymol derivatives. Its makeup varies with the plant organ and with geographical and environmental conditions. Volatile constituents that have been reported include E-caryophyllene, caryophyllene oxide, germacrene D, farnesyl acetate and dodecanal, especially in the oil of the flower heads.[9]

Coumarins

Coumarin derivatives such as umbelliferone and scopoletin have been reported in A. montana. These compounds are part of the phenolic/coumarin fraction of the plant.[8]

Carotenoids and polyacetylenes

The flower heads also contain carotenoids and polyacetylenic compounds. These constituents add to the chemical diversity of A. montana and may play a part in its biological activities.[2]

Other constituents

Other phytochemical groups that have been reported include triterpene alcohols and their esters, diterpenes, lignans, pyrrolizidine alkaloids and oligosaccharides. The presence and concentration of these compounds can vary depending on the plant part and the growing conditions.[1]

HELENALIN

Helenalin, a sesquiterpene lactone of the pseudoguaianolide type, is one of the main bioactive constituents of Arnica montana and is regarded as an important contributor to its pharmacological properties. The activity that has been studied most extensively is its anti-inflammatory effect, which is mainly linked to selective inhibition of the NF-κB signalling pathway. Helenalin has been demonstrated to modify the p65 subunit of NF-κB directly by interacting with reactive cysteine residues, thus suppressing NF-κB-dependent transcription of inflammatory genes. Helenalin also displays immunomodulatory, antimicrobial and cytotoxic activities in experimental models. These properties make helenalin a key phytochemical constituent for understanding the biological and therapeutic potential of A. montana.[10]

The most important bioactive sesquiterpene lactone; strong pharmacological evidence exists, but direct antifungal evidence in A. montana is limited

TRADITIONAL USES

Arnica montana L. has a long history of use in European traditional medicine, especially for the topical treatment of bruises, contusions, sprains, localized muscular pain and inflammatory conditions linked to minor trauma. Historical records also document its use for rheumatic muscle and joint complaints, oedema associated with injury, insect-bite inflammation and other inflammatory conditions.[2]

PHARMACOLOGICAL USES OF ARNICA MONTANA L.

Pharmacological activity	Description
Anti-inflammatory	Inhibition of inflammatory pathways, including NF-κB, COX-2 and 5-lipoxygenase.
Analgesic	Possible reduction of pain associated with inflammatory and musculoskeletal conditions.
Anti-edematous	Reduction of oedema associated with inflammation.
Antioxidant	Scavenging or modulation of reactive oxygen species and oxidative processes.

Antimicrobial	Activity against selected microorganisms in experimental studies.
Antifungal	Antifungal activity reported for A. montana extracts.
Immunomodulatory	Modulation of inflammatory and immune responses.
Wound-healing	Possible influence on tissue repair and wound-healing processes.
Cytotoxic/Antitumor	Cytotoxic effects reported for helenalin and related sesquiterpene lactones [1].

ANTIFUNGAL ACTIVITY OF ARNICA MONTANA

The antifungal activity of Arnica montana may be linked to its sesquiterpene lactones, especially helenalin and 11α,13-dihydrohelenalin and their ester derivatives. Helenalin contains reactive electrophilic groups that can interact with cellular nucleophiles, including thiol-containing molecules, which may disrupt essential cellular processes and contribute to antimicrobial activity. However, the exact molecular mechanism behind the antifungal activity of A. montana extracts, and the specific contribution of helenalin, have not yet been conclusively established. Therefore, the antifungal effect likely involves the combined action of several phytoconstituents rather than helenalin alone.[1]

Possible mechanisms to discuss include:

1. Membrane disruption
   Plant secondary metabolites, particularly lipophilic compounds and volatile constituents, may interact with fungal cell membranes.
2. Oxidative stress
   Phenolic compounds and other constituents may influence oxidative balance in microorganisms.
3. Impact on fungal growth
   Several plant metabolites are capable of interfering with:

- cell proliferation
- integrity of membranes
- enzyme systems
- cellular metabolism

4. Activity related to biofilms

Arnica montana may additionally show antimicrobial effects by disrupting microbial adhesion and the formation of biofilms. Biofilms are organized microbial communities that can improve microbial survival and tolerance to antimicrobial agents. Research involving Candida albicans has indicated that extracts of A. montana may influence microbial adherence and biofilm development, suggesting that its antimicrobial activity may go beyond inhibiting free-living microorganisms.[11]

"The exact molecular mechanism behind the antifungal activity of A. montana is still not sufficiently characterized.

The antifungal activity of Arnica montana may be linked to its varied secondary metabolites, especially sesquiterpene lactones such as helenalin, 11α,13-dihydrohelenalin and their ester derivatives. These compounds contain reactive chemical groups that can interact with cellular proteins and may help interfere with essential cellular processes. A. montana also contains flavonoids, phenolic acids and essential-oil constituents, which may add to its overall antimicrobial activity. However, the exact molecular mechanisms underlying the antifungal effects of A. montana have not yet been fully determined and call for further mechanistic investigation.[6]

FACTORS INFLUENCING ANTIFUNGAL ACTIVITY

Factor: Possible effect

Plant part: Varying phytochemical composition

Geographic origin: Variation in chemotype

Time of harvesting: Can change constituent concentration

Extraction solvent: Alters which compounds are extracted

Temperature of extraction: May influence the chemical profile

Pressure during extraction: Significant in supercritical extraction

Concentration of the extract: Affects MIC/MFC

Fungal species: Varying susceptibility

Strain: Can change the response

Storage: May modify constituents [2]

A recent study reported that the 70% ethanolic extract contained roughly 2.5 times more sesquiterpene lactones than the aqueous extract (1.645% versus 0.670%).[12] "Of the solvent-based preparations studied, the hydroalcoholic, ethanolic and glycolic extracts of Arnica montana have shown antifungal activity against Candida species.

PRIOR RESEARCH ON THE ANTIFUNGAL ACTIVITY OF ARNICA MONTANA

Gayathri et al. (2025) assessed the in-vitro antifungal activity of Arnica montana Q, together with Jaborandi Q and Ceanothus americanus Q, against Malassezia furfur. Antifungal activity was measured using the agar disc diffusion (Kirby–Bauer) method on Sabouraud Dextrose Agar. After 24 hours of incubation, Arnica montana Q produced an inhibition zone of 11 mm, while Jaborandi Q and Ceanothus americanus Q produced zones of 12 mm and 5 mm, respectively. The ethanol control exhibited no inhibition (0 mm). Of the three preparations tested, Jaborandi Q displayed the largest inhibition zone, whereas Arnica montana Q showed notable antifungal activity against M. furfur. The authors concluded that the homoeopathic mother tinctures tested possessed antifungal activity and proposed that their effects warrant further investigation.[13]

Kumar et al. (2023) examined the in-vitro antifungal activity of Arnica montana, together with Thuja occidentalis, sulphur and silicea, against five significant plant pathogenic fungi: Fusarium oxysporum f. sp. lycopersici, Alternaria solani, Ascochyta rabiei, Septoria lycopersici and Phomopsis vexans. The treatments were assessed at concentrations of 50, 100, 150 and 200 ppm by means of the poisoned food technique on potato dextrose agar (PDA), with three replications. Arnica montana exhibited inhibition of fungal mycelial growth that depended on concentration. The strongest inhibition by A. montana was seen against A. rabiei, where 200 ppm yielded 64.22% inhibition of mycelial growth at 8 days after inoculation. Against F. oxysporum f. sp. lycopersici, 200 ppm of A. montana gave 68.66% inhibition, whereas against A. solani it gave 75.35% inhibition. However, inhibition was comparatively lower against S. lycopersici and P. vexans, reaching a maximum of 52.50% and 47.30%, respectively, at 200 ppm. Taken together, the study showed that A. montana displayed in-vitro antifungal activity against several plant pathogenic fungi, with the extent of inhibition differing according to the fungal species and the concentration tested.[14]

Sowjanya and Vardhini (2026) assessed the in-vitro antifungal activity of four homoeopathic mother tinctures—Aconitum napellus, Arnica montana, Arsenicum album and Agaricus muscarius—against the keratinophilic fungus Microsporum gypseum. The drugs were tested at concentrations of 1%, 2%, 3%, 4% and 5% by means of the poisoned food technique on Sabouraud Dextrose Agar. Arnica montana produced pronounced inhibition of fungal growth in a concentration-dependent manner. By the 7th day, Arnica montana had reduced colony growth from 3.60 cm in the control to 1.83, 1.45 and 0.93 cm at 1%, 2% and 3% concentrations, respectively, whereas complete inhibition occurred at 4% and 5%. Of the four drugs, Aconitum napellus displayed the strongest inhibitory effect, followed by Arnica montana, Arsenicum album and Agaricus muscarius. The study thus offers in-vitro evidence of the antifungal potential of Arnica montana against M. gypseum and supports further research into its antifungal properties.[15]

Verre et al. (2024) examined the anti-inflammatory effects of Arnica montana mother tincture and various homeopathic dilutions (1C, 3C, 5C and 9C) across several human and murine cell culture models. The study assessed a number of inflammatory and oxidative stress markers, including tumour necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), cyclooxygenase-2 (COX-2), monocyte chemoattractant protein-1 (MCP-1), intercellular adhesion molecule-1 (ICAM-1) and reactive oxygen

species (ROS). Arnica montana mother tincture markedly lowered TNF-α production in inflamed macrophages, while decreases in IL-6 and MCP-1 were seen in human microglial cells. The mother tincture and the 1C dilution also lowered ICAM-1 expression in inflamed endothelial cells, and 1C produced a significant reduction in COX-2 expression in murine fibroblasts. In addition, the mother tincture and the 1C, 3C, 5C and 9C dilutions significantly decreased ROS production in inflamed microglial cells, with 1C having the greatest effect. On the whole, the results showed anti-inflammatory and antioxidant effects of A. montana mother tincture and homeopathic dilutions in several in-vitro human and murine cell models.[16]

Lăcătusu et al. (2026) examined the wound-healing and antioxidant potential of Arnica montana extract incorporated into nanostructured lipid carriers (NLCs), either alone or combined with Ruscus aculeatus, with hyaluronic acid (HA) modification. The study assessed the formulations using BJ fibroblast cells derived from human skin along with antioxidant assays. NLCs loaded with Arnica montana showed notable antioxidant activity, and formulations containing A. montana achieved up to 79.4% inhibition of DPPH free radicals. The plant extracts also demonstrated high entrapment efficiency, exceeding 96%, within the lipid nanocarriers. In the wound-healing assay, HA-modified NLCs led to faster fibroblast migration and wound closure than conventional NLCs. The strongest wound-closure response came from HA-NLC-Ruscus aculeatus, followed by the combined HA-NLC-Arnica montana-Ruscus aculeatus formulation. The findings suggest that A. montana has considerable antioxidant potential and, when incorporated into a suitable nanocarrier system, may help enhance skin regeneration and wound-healing applications.[17]

RESEARCH GAPS

1. Limited antifungal studies: In contrast to anti-inflammatory research, dedicated antifungal studies on A. montana are still limited.
2. Lack of standardisation: Variations in plant parts, solvents, extraction methods and concentrations make comparisons between studies difficult.
3. Unclear mechanisms: The precise mechanisms and fungal targets underlying the antifungal activity are not yet sufficiently established.
4. Limited in vivo evidence: Most available studies are in vitro, with limited in-vivo validation.
5. Limited compound-specific studies: The individual and combined antifungal effects of helenalin, dihydrohelenalin, flavonoids and volatile constituents need further investigation.
6. Need for standardised methodology: Future studies should clearly report plant authentication, plant part, geographical origin, extraction method, phytochemical profile, MIC/MFC (Minimum Inhibitory Concentration/Minimum Fungicidal Concentration), fungal strain and appropriate controls.

DISCUSSION

Traditionally Arnica montana L. has been used for its anti-inflammatory and wound healing properties. However, it has been shown to have antifungal properties in recent experiments. It contains a variety of compounds such as sesquiterpene lactones, flavonoids, phenolic acids and thymol derivatives which could be responsible for its various actions. A. montana has shown antifungal effects against different fungi species such as Candida albicans, Candida tropicalis, Candida krusei, Candida glabrata and some dermatophytes.

Antifungal effects have been reported to differ between species, extract type, concentration and method. This could be due to differences in extraction methods and therefore affecting the availability of active compounds in the plant. Although there are antimicrobial compounds present within A. montana, there is still not enough

information available on what compounds are causing the antifungal effects.

More research needs to be carried out to produce standardised extracts, identify the active antifungal compounds and determine the mechanism of action. More in vitro, in vivo and clinical trials need to be carried out to ensure safety and effectiveness. Overall Arnica montana is an interesting plant to carry out further antifungal research on.

CONCLUSION

The experimental studies found Arnica montana L. to have an antifungal effect against selected fungal strains including Malassezia furfur, Microsporum gypseum as well as plant pathogens such as Fusarium oxysporum, Alternaria solani and Ascochyta rabiei. The extent of fungal cell inhibition was dependent on the preparation type, concentration and fungal strain. This demonstrates that there is potential for A. montana to be used for more than just treating injuries and inflammatory conditions. However, evidence is limited to in vitro studies and it is unclear which compounds are responsible for the antifungal activity. Standardised extracts, active compounds and in vivo studies are required to determine if A. montana has antifungal potential and possible uses.

Declaration by Authors

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