Medicinal Plant Tax A Dorsteniacontrajerva L. and its Bioactive Compounds Isolation by Lc-Ms Analysis

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Abstract

The present investigation of the bioactive compounds isolated from D. contrajervausing various solvent extractions, including acetone, benzene, ethyl acetate, hexane, and methanol. The acetone extract effectively isolated Capsaicin, D-(-)-Salicin, Sinapic acid, Diosgenin, Apigenin, and Folic acid, demonstrating the solvent's broad utility in extracting compounds with varying polarities. The benzene extract successfully yielded Indole-3-carbinol, Artemisin, and Kaempferol-3-O-glucoside, highlighting benzene's effectiveness in isolating non-polar and glycosylated compounds with significant therapeutic potential. Ethyl acetate was shown to be an excellent solvent for moderately polar compounds, as evidenced by the isolation of Astaxanthin, Lupeol, and Artemisinin. The hexane extract effectively isolated Hirsutine, Baicalin, and Quercetin-3-O-beta-D-galactoside, indicating its ability to selectively extract bioactive compounds with varying polarities. Finally, the methanol extract efficiently isolated Oxycodone, Gabapentin, and (-)-Epicatechin, underscoring methanol's suitability for extracting highly polar compounds with therapeutic applications. These findings demonstrate the diverse pharmacological potential of D. contrajervaand the effectiveness of different solvents in isolating bioactive compounds with significant health benefits.

Keywords: Dorsteniacontrajerva, Solvent Extraction, LC-MS Chemical Profiling, Bioactive Compounds, Phytochemistry, Health Benefits.

Introduction

Medicinal plants have been integral to healthcare for millennia, with ancient civilizations in India, Egypt, China, Greece, and Rome documenting their therapeutic benefits (Ravichandran et al., 2023; Bhat, 2021). The WHO reports that many people worldwide still rely on traditional medicine, particularly herbal remedies (Ravichandran et al., 2023).

These plants are important not only in traditional systems like Ayurveda and Traditional Chinese Medicine but also in modern drug development, providing safer alternatives to synthetic drugs (Sharangi & Peter, 2022; Bhat & Sharma, 2022). In India, the rich biodiversity of medicinal plants supports healthcare and the

economy but faces threats from overharvesting and climate change, prompting the need for conservation efforts (Mahato et al., 2023; Behera & Bhandra, 2024). Over 80% of the global population turns to plant-based medicine due to its perceived safety (Parveen, 2024; Niazi & Monib, 2024), and the WHO promotes integrating these treatments into national health systems (Clair et al., 2023). Collaboration between traditional healers and researchers is essential for the scientific validation of medicinal plants (Jha et al., 2024; Pradhan et al., 2024). Economically, medicinal plants are vital for rural livelihoods, and the global herbal market is growing due to a preference for natural remedies (Nath et al., 2023; Yakhtanigova et al., 2023; Gautam et al., 2023).

Assessing the antioxidant activity of medicinal plants is crucial due to their role in combating oxidative stress, which is linked to various health issues like cancer, aging, and neurodegenerative diseases (Pande & Chanda, 2020; Pathak et al., 2023; Khumalo et al., 2024). Rich in secondary metabolites such as phenolic acids and flavonoids, these plants' antioxidant properties are essential for drug discovery (Saavedra-Molina et al., 2024; Waris et al., 2022).

D. contrajerva of the Moraceae family is traditionally used to treat fevers, digestive issues, and respiratory infections due to its anti-inflammatory and analgesic properties (Diaz, et al., 2017). Phytochemical studies have identified bioactive compounds like "Bergapten" and "Contrajervin", which show antimicrobial, anti-leishmanial, and potential anti-HIV activities (Tovar-Miranda et al., 1998; Peniche-Pavíaet al., 2018; Bokeschet al., 2004). The taxonomic identification of D. contrajerva and LC-MS analysis of its extracts were conducted to explore its bioactive compounds, providing insights into its traditional and potential medicinal uses.

Materials and Methods

Plant Material and Identification

The plant was discovered growing naturally on the grounds of the Regional Institute of Education at the Manasagangotri campus of the University of Mysore, Mysuru, and was subsequently collected for research purposes. Taxonomic identification was conducted by Dr. G.V. Gopal, Professor of Botany at the Regional Institute of Education, Mysuru, and Dr. S. Leelavathi, Research Supervisor and Professor at the Department of Studies in Botany, Manasagangotri, Mysuru. This identification was verified against herbarium specimens housed at the Department of Studies in Botany, Manasagangotri, University of Mysore, Mysuru. Herbarium sheets were prepared and dispatched to the Foundation for Revitalisation of Local Health Traditions (FRLHT), located at 74/2 Jarakabande Kaval, Post Attur, Via Yelahanka, Bangalore. The specimen was authenticated by Dr. S. Noorunnisa Begum, Associate Professor and Curator at the Foundation for Revitalisation of Local Health Traditions, Bangalore, and was assigned FRLHT accession number 124305.

Sample Extraction and Preparation

The rhizome samples of D. contrajervawere processed using the Soxhlet extraction technique. Initially, 30 grams of rhizome has been cleansed with tap water to remove any contaminants and then air-dried in a shaded area to reduce moisture. The dried rhizomes were then ground into a coarse powder and subjected to sequential Soxhlet extraction. This process utilized solvents of increasing polarity, starting with hexane and followed by chloroform, ethyl acetate, acetone, methanol, and finally water. This sequence was designed to extract different compound groups based on their polarity.

Post-extraction, the solvents were evaporated using a rotary evaporator to yield crude extracts, which were then solidified and stored in clearly marked vials for subsequent analysis.

LC-MS Analysis

The LC-MS analysis was performed using an XEVO-G2XSQTOF instrument with a 10 µL sample injection on an Accucore C-18 column. The mobile phase consisted of Formic Acid and Acetonitrile, with a gradient elution from 90% to 5% Formic Acid over 13 minutes at a 0.4 mL/min flow rate. Electrospray ionization in both positive and negative modes was employed, with data acquired across a 50-1500 Da mass range. The MassLynx 4.1 software ensured accurate data collection and analysis, with the method optimized for reliable detection and quantification of bioactive compounds.

Results

The study demonstrated the effectiveness of various solvents—acetone, benzene, ethyl acetate, hexane, and methanol—in isolating a diverse range of bioactive compounds from D. contrajerva. Acetone successfully extracted both polar and non-polar compounds, including Capsaicin, D-(-)-Salicin, Sinapic acid, Diosgenin, Apigenin, and Folic acid. Benzene efficiently isolated non-polar compounds like Indole-3-carbinol and Artemisin, along with the glycosylated flavonoid Kaempferol-3-O-glucoside. Ethyl acetate was effective for moderately polar compounds, yielding Astaxanthin, Lupeol, and Artemisinin. Hexane, typically used for non-polar extractions, successfully isolated Hirsutine, Baicalin, and Quercetin-3-O-beta-D-galactoside. Methanol proved ideal for highly polar compounds, effectively isolating Oxycodone, Gabapentin, and (-)-Epicatechin. These findings highlight each solvent's specific capabilities in extracting therapeutically significant bioactive compounds (Table 1).

Table 1 The Unique Bioactive Compounds Identified through LC-MS Analysis from Various Solvent Extracts of D. Contrajerva

Acetone Extract	Benzene Extract	Ethyl Acetate Extract	Hexane Extract	Methanol Extract
Capsaicin	Indole-3-carbinol	Astaxanthin	Hirsutine	Oxycodone
D-(-)-Salicin Sinapic acid	Artemisin	Lupeol	Baicalin	Gabapentin
Diosgenin	Kaempferol-3-O-glucoside	Artemisinin	Quercetin-3-O-beta-D-galactoside	(-)-Epicatechin
Apigenin				
Folic acid				

Structure of Indole 3 Carbinol

Chemical structure of Isolated Bio-active Compounds

1. Disogenin: It's a steroid aslycone, It is also sapogenin
2. Apigenin:
3. Folic acid
4. Sinapic acid

Discussion

The acetone extract of D. contrajerva. effectively isolated several bioactive compounds, each with significant therapeutic potential. Capsaicin, recognized for its chemopreventive, anti-inflammatory, and metabolic effects, inhibits key signaling pathways such as NF-kB, AP-1, and STAT3, crucial for cancer cell proliferation and survival (Oyagbemiet al. 2010). D-(-)-Salicin, a precursor to aspirin, exhibits anti-inflammatory properties, highlighting acetone's effectiveness in isolating therapeutically relevant compounds for pain relief (Koriem& Gad 2022). Sinapic acid, known for its strong antioxidant and anti-inflammatory activities, mitigates oxidative stress and

inflammation-related diseases, further supporting acetone's utility in extracting compounds with significant health benefits (Saeedavi et al. 2022).

Diosgenin, a steroidal sapogenin, offers anti-inflammatory, anticancer, and hepatoprotective properties, making it valuable in treating atherosclerosis, cancer, and liver diseases (Rismawanti & Saidah 2024; Ganesan & Umapathy 2023). Apigenin, with its antioxidant, anti-inflammatory, and anticancer effects, further emphasizes the acetone extract's capacity to isolate compounds with broad therapeutic applications (Adhikari & Saha 2024). Lastly, folic acid, essential for DNA synthesis and repair, plays a critical role in preventing megaloblastic anemia and cardiovascular diseases, and may possess antiviral properties, particularly against SARS-CoV-2 (Kurowska et al. 2023; Rashediet al. 2018). These findings underscore the efficacy of acetone in isolating a diverse range of bioactive compounds with significant therapeutic potential.

The benzene extract of D. contrajerva effectively isolated three bioactive compounds: Indole-3-carbinol (I3C), Artemisin, and Kaempferol-3-O-glucoside, each with significant therapeutic potential. I3C, derived from cruciferous vegetables, is known for its cancer-preventive and anti-inflammatory properties, modulating key pathways like NF-κB and promoting apoptosis in cancer cells (Singh et al. 2021; Weng et al. 2008; Takada et al. 2005). Artemisin, a derivative of Artemisinin, is renowned for its antimalarial efficacy but also shows promise in treating various other conditions, including cancer and viral infections, by inducing apoptosis and interfering with viral replication (Liu et al. 2023; Farmanpour-Kalalaghet al. 2022; Zeng et al. 2022). Kaempferol-3-O-glucoside, a flavonoid glycoside, exhibits neuroprotective, anti-inflammatory, and antiviral properties, although its low bioavailability presents a challenge for therapeutic use (Santos et al. 2021; Fang et al. 2022; Choi et al. 2020; Gómez-Mejíaet al. 2021). These findings highlight benzene's effectiveness in isolating compounds with diverse pharmacological activities, contributing to the ongoing research and therapeutic potential of D. contrajerva.

The ethyl acetate extract of D. contrajerva successfully isolated Astaxanthin, Lupeol, and Artemisinin, each demonstrating significant therapeutic potential. Astaxanthin is a powerful antioxidant that surpasses other carotenoids like beta-carotene and lycopene in neutralizing reactive oxygen species and protecting against oxidative damage. Its anti-inflammatory properties have been shown to reduce inflammation and oxidative stress, benefiting cardiovascular health and potentially aiding in cancer and diabetes management (Kidd 2011; Bachmann 2015; Wang & Zhao 2017; Fassett & Coombes 2011).Lupeol, a pentacyclic triterpene, exhibits substantial anti-inflammatory and antioxidant effects, particularly in neuroinflammation and ischemia-reperfusion injuries. It also shows strong anticancer activity by selectively targeting cancer cells and modulating critical signalling pathways, making it a promising agent for treating various cancers and metabolic disorders like NAFLD and PCOS (Choe et al. 2024; Fatma et al. 2024; Azzam et al. 2024). Artemisinin, known for its antimalarial efficacy, also shows potential in cancer therapy by inducing apoptosis and inhibiting angiogenesis. Its anti-inflammatory properties extend to treating cardiac hypertrophy and autoimmune diseases, highlighting its broad therapeutic applications (Singh et al. 2010; Karunajeewa 2011; Augustin et al. 2020; Ho et al. 2014).These findings underscore the effectiveness of ethyl acetate in isolating bioactive compounds with diverse pharmacological activities, supporting ongoing research into their therapeutic potential.

The hexane extract of D. contrajerva effectively isolated three key bioactive compounds: Hirsutine, Baicalin, and Quercetin-3-O-beta-D-galactoside (Q3G), each with significant therapeutic potential. Hirsutine, an indole alkaloid, is known for its cardioprotective, neuroprotective, and anticancer properties. It ameliorates myocardial ischemia-reperfusion injury by enhancing mitochondrial function and inducing apoptosis, and it shows promise in treating breast cancer and T-cell leukemia by inducing apoptosis and cell cycle arrest (Jiang et al. 2023; Meng et al. 2022;

Hu et al. 2021). Baicalin, a flavonoid from Scutellariabaicalensis, demonstrates strong anti-inflammatory and antioxidant properties by modulating key pathways like NF-κB and NLRP3. It also exhibits antiviral activity against the infectious bronchitis virus (IBV) and inhibits lung cancer progression by targeting the SOCS1/NF-κB/STAT3 axis, making it a promising candidate for cancer therapy (Lu et al. 2024; He et al. 2024; Yue et al. 2024).Quercetin-3-O-beta-D-galactoside (Q3G) is a flavonoid glycoside with antioxidant, anti-inflammatory, and anti-melanogenic properties, showing potential in both therapeutic and cosmetic applications. It reduces oxidative stress, protects against acetaminophen-induced liver injury, and may stabilize transthyretin, offering potential in treating amyloid diseases (Karadeniz et al. 2023; Hu et al. 2020; Ciccone et al. 2022).These findings underscore hexane's efficacy in extracting compounds with diverse pharmacological activities, supporting their further research and potential therapeutic applications.

The methanol extract of D. contrajerva successfully isolated three significant bioactive compounds: Oxycodone, Gabapentin, and (-)-Epicatechin.Oxycodone is a potent opioid analgesic acting primarily on mu- and kappa-opioid receptors, providing effective pain relief, particularly in severe cancer and neuropathic pain. It has broader physiological impacts, including reducing lung and myocardial injury through anti-inflammatory mechanisms, and influencing hematopoietic progenitor cells and brain endothelial cells, suggesting roles in myocardial and cerebral protection (Smith et al. 2001; Li et al. 2021; Yu et al. 2024; Hu et al. 2020; Shao et al. 2022). Gabapentin is an anticonvulsant and analgesic effective in treating partial seizures and neuropathic pain. Its unique mechanism, which bypasses liver metabolism, reduces drug interaction risks, making it safer than traditional antiepileptic drugs. Gabapentin's favorable side effect profile also suggests potential in psychiatric disorder management (Dougherty &Rhoney 2001).(-)-Epicatechin is a flavonoid with extensive health benefits, particularly in cardiovascular protection, muscle health, and cancer prevention. It enhances cardiovascular function, protects against myocardial ischemia-reperfusion injury, and reduces metabolic complications, showing potential in managing metabolic syndrome and muscle atrophy. Its anticancer properties, especially in inhibiting breast cancer cell proliferation, further emphasize its therapeutic value (Ávila-Avilés et al. 2024; Kong et al. 2024; German et al. 2024; Connolly et al. 2023; Pérez-Durán et al. 2023).These findings demonstrate the methanol extract's efficacy in isolating bioactive compounds with significant therapeutic potential across various medical conditions.

Conclusion

This study successfully demonstrated the effectiveness of various solvents—acetone, benzene, ethyl acetate, hexane, and methanol—in isolating a wide range of bioactive compounds from D. contrajervaeach with significant therapeutic potential. The acetone extract proved highly versatile, efficiently isolating both polar and non-polar compounds such as Capsaicin, D-(-)-Salicin, Sinapic acid, Diosgenin, Apigenin, and Folic acid. Benzene was particularly effective in extracting non-polar compounds like Indole-3-carbinol and Artemisin, as well as the glycosylated flavonoid Kaempferol-3-O-glucoside. Ethyl acetate demonstrated its suitability for moderately polar compounds, successfully isolating Astaxanthin, Lupeol, and Artemisinin. Hexane, typically associated with non-polar extractions, also successfully isolated compounds like Hirsutine, Baicalin, and Quercetin-3-O-beta-D-galactoside, highlighting its selective extraction capabilities. Lastly, methanol was effective in isolating highly polar pharmaceutical compounds such as Oxycodone, Gabapentin, and (-)-Epicatechin. Collectively, these findings underscore the diverse pharmacological potential of D. contrajervaand the importance of solvent selection in maximizing the yield of therapeutically relevant bioactive compounds. This research supports the continued exploration of D. contrajervaas a valuable source of natural bioactive agents with broad therapeutic applications.

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