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REVIEW ARTICLE

Phytoconstituents and Pharmacological Potential of *Sisymbrium irio* L.: A Review

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ABSTRACT

Sisymbrium irio L. (often referred to as London rocket or Khaksi) is an annual herb of the Brassicaceae family and has been traditionally used in the treatment of respiratory conditions like cough, asthma, sore throat, and bronchitis, and in fever, infections, and weakness. Numerous phytochemical and pharmacological studies during the last few decades have supported many of these uses. Phytochemical studies of its seeds and aerial parts identify a diverse array of bioactive metabolites consisting of flavonoids like isorhamnetin, glucosinolates, phenolic acids, alkaloids, sterols, saponins, tannins, and terpenoids. Fatty acid composition of its seed oil features appreciable contents of linolenic, linoleic, oleic, and erucic acids, testifying to both nutritional and medicinal significance. These constituents are responsible for the varying pharmacological activities described for S. irio, which include antioxidant, anti-inflammatory, antimicrobial, anticancer, gastroprotective, and bronchodilatory activities. Experimental evidence indicates that its mode of action is by free radical scavenging, inhibition of inflammatory mediators, and antimicrobial activity through glucosinolate-derived isothiocyanates. The variability of phytoconstituents, combined with new preclinical data, makes S. irio a potential candidate for novel therapeutic compounds. This review synthesizes and critically reviews recent knowledge on its phytochemistry and pharmacological attributes thus summarizes the information for further studies

Keywords: *Sisymbrium irio*, Phytoconstituents, Glucosinolates, Flavonoids, Pharmacological activities, Antioxidant, Anti-inflammatory

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INTRODUCTION

Herbs and their phytoconstituents have been used in traditional medicine for centuries and continue to play an important role in modern healthcare. They contain bioactive compounds like alkaloids, flavonoids, terpenoids, and glycosides, which show diverse therapeutic effects. For example, curcumin from turmeric has anti-inflammatory properties, while glycyrrhizin from licorice helps in respiratory conditions. Herbal medicines are widely explored for treating chronic diseases such as diabetes, cancer, cardiovascular disorders, and infections due to their safety and effectiveness. With growing interest in natural remedies, herbs and phytoconstituents are becoming a promising source for novel drug discovery [1,2].

Sisymbrium irio L., commonly known by vernacular names such as Khubkalan (Hindi), Naktrasa (Punjabi), and Khakshir (Persian), is a tall, erect shrub of the Cruciferae family found in Northwest India and the temperate Himalayas. *Sisymbrium irio* is known by other names in different languages which are mentioned in (Table 1).

It is a weed that belongs the Brassicaceae(mustard) family. Its seeds help with fever and cough and balance the Vata Dosha. It is new to the Ayurvedic pharmacopoeia and is not listed in the Nighantus or Ayurvedic Samhitas. It also comprises a number of globally significant crops renowned for their unique flavour and health advantages. London Rocket is a species that is extensively dispersed and found in many different parts of the world. Originating from temperate Asia, Europe, and North Africa, abundantly naturalized in Australia, North America, and South Africa. It is now a native weed in South Africa, North America, and Australia. Either intentionally for therapeutic purposes or by unintentionally through seed transfer, the spread took place. The Indian states of Srinagar, Jammu, Punjab, Northern Rajasthan, Delhi, and Western Uttar Pradesh are home to it. Growing in the Punjab plains throughout the winter, it exhibits a range of ploidy levels (2n, 3n, 4n,

Table 1: Common name in different languages [3]

S. No	*Language*	*Common name*
1.	English	London Rocket, Desert Rocket, Rocket Mustard
2.	Rajasthani	Parjan
3.	Urdu	Khubkalan, Khaksi
4.	Sindh	Junglisurson
5.	Spanish	Matacandil, Rabanilloamarillo
6.	Japanese	Hosoegarashi, Haruzaki-yamagarasu
7.	Swedish	Vallsenap

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6n, and 8n) and adjusts to moisture and sunlight. It has been reported from Delhi, Pakistan, Northern Rajasthan, Srinagar, Jammu, and Western Uttar Pradesh in India, prefers temperate and semi-arid areas, and it grows primarily in the plains during the winter [4,5].

Traditional medicine makes extensive use of the *Sisymbrium* genus' species, with *S. irio* being particularly well-known for its usage as a medicinal plant in Ayurvedic and Unani treatments. *Sisymbrium irio* contains important phytochemicals such as flavonoids, glucosinolates, phenolic acids, and alkaloids. These bioactive compounds contribute to its pharmacological properties. Traditionally, the plant has been used for treating cough, asthma, sore throat, and infections. Scientific studies report that the plant shows antioxidant, anti-inflammatory, antimicrobial, and anticancer activities. The presence of glucosinolates and flavonoids plays a key role in protecting cells from oxidative stress and microbial damage. Thus, *Sisymbrium irio* is considered a valuable herb with therapeutic potential [6].

Traditionally, the seeds are valued as expectorant, stimulant, restorative, and febrifuge, and have been employed in asthma treatment. When applied externally, ground seeds are used as a stimulating poultice to relieve local inflammation and respiratory congestion. Leaves of the plant are consumed as leafy vegetables, rich in calcium, phosphorus, iron, vitamin C, carotene, and protein. Leaf infusions are used in chest and throat conditions like cough and hoarseness. Seeds, with a sharp and hot taste, exhibit restorative, rubefacient, and expectorant properties, and may contain mustard oil and isorhamnetin. Ethnomedicinally, the plant is widely used for respiratory ailments such as asthma, bronchial irritation, cough, hoarseness, fever, general weakness, and external swellings [7,8]. This review focuses about phytochemistry and pharmacological activities of *Sisymbrium irio.*

Phytochemistry

It is rich in diverse phytochemicals that contribute to its medicinal value. Seeds and aerial parts of the plant contain flavonoids such as quercetin, kaempferol, and isorhamnetin, which exhibit strong antioxidant and anti-inflammatory properties. Glucosinolates, including sinigrin, are important sulfur-containing compounds reported in the plant, and their hydrolysis products are linked to antimicrobial and anticancer effects. Phenolic acids like caffeic acid and ferulic acid, along with tannins, enhance its free radical scavenging activity. The presence of mustard oil glycosides has also been noted, which impart the pungent taste and therapeutic effects. In addition, alkaloids, sterols, and proteins have been reported, highlighting its nutritional and pharmacological potential. These phytoconstituents collectively explain the plant's traditional uses in respiratory ailments, fever, inflammation, and general weakness [7,8,9].

Ten flavonoids were isolated for the first time from the aerial parts of *Sisymbrium irio* L. cultivated in Saudi Arabia through chromatographic techniques. These compounds were identified as apigenin, apigenin-7-galactoside, apigenin-7-O-β-D-glucoside, luteolin-7-O-glucoside, apigenin-7-diglucoside, apigenin-7-O-(6′′-acetyl) glucoside, apigenin-7-O-(6′′–10′′) rhamnoside, apigenin-7-O-(6′′–10′′) rhamnoside-5-methoxide, kaempferol, and kaempferol-3-xyloside-7-galactoside [6]. Phytochemical investigation of the aerial parts of collected from northern Jordan led to the isolation of two new compounds, sitosteryl-6′-O-undecanoate-β-D-glucoside (1) and (Z)-8,11,12-trihydroxyoctadec-9-enoic acid (2), along with twelve known compounds, ten of which are reported for the first time from this species. The structural elucidation of all compounds was carried out using spectroscopic and chemical techniques [10].

When the various extracts of the Indian variety seeds were subjected to phytochemical analysis, the presence of flavonoids, , saponins, phenols, terpenoids and other bioactive metabolites include cis, cis, cis-7, 10, 13-Hexadecatrienal, 9,12-Octadecadienoic acid (Z,Z)-, n-Hexanoic acid, 1,3-Cyclohexanedione, 3,5- Dimethyoxyacetophenone, 1-Heptacosanol, O-ethyl-S-2-dimethylaminoethylethylphosphonothi oate, γ-Tocopherol, Isosorbide, 3-Methylcrotonitrile, Cholesterol, 4-Isothiocyanato-1-Butene, 2, 4-Di-tert-butylphenol, Sinapic acid ester, 9, 12, 15-Octadecatrienoic acid, 1,2-Cyclopentadiene, (R)-(-)-14-methyl-8-hexadecyn-1-ol, ethyl ester(Z, Z, Z), 7- Tetradecenal and γ-Sitosterol. The major fatty acid profile of cold pressed seed oil contained, Linolenic acid (36.29%), Linoleic acid (17.99%), Oleic acid (12.58%), cis-11- Eicosenoic acid (9.2%), Erucic acid (9.19%), Palmitic acid (6.66%), Stearic acid (2.2%), Arachidic acid (1.75%) and cis-11, 14-Eicosenoic acid (0.95%) 3. Various phytoconstituents reported and their significance have been listed in (Table 2).

Pharmacological activities Anti-inflammatory Activity

Sisymbrium irio has been reported to exhibit significant anti-inflammatory activity, primarily through studies on its seeds and, to some extent, its aerial parts such as leaves, stem, and flowers. The anti-inflammatory effects have been demonstrated using in vivo animal models and in vitro assays. In rats, the cotton pellet-induced granuloma model revealed a significant reduction in granuloma weight following oral administration of seed extract at doses of 100–300 mg/kg, indicating potent

Table 2: Reported phytochemicals and their pharmacological significance [13-18]

S. No	Category	Phytochemicals	Pharmacological significance
1.	Terpenoids	γ-Tocopherol (Vitamin E); (R)-(-)-14-methyl-8-hexadecyn-1-ol	Antioxidant, membrane protection
2.	Flavonoids	Isorhamnetin and its glucosides, Apigetrin (apigenin-7-glucoside), Apigenin, Isoquercetin (quercetin-3-glucoside)	Contribute to antioxidant, anti-inflammatory properties
3.	Phenols	2,4-Di-tert-butylphenol; Sinapic acid ester; 3',5'-Dimethoxyacetophenone	Strong antioxidant and antimicrobial activity
4.	Sterols & Alcohols	Cholesterol; γ-Sitosterol; 1-Heptacosanol	Maintain membrane stability, cholesterol-lowering potential
5.	Saponins	Detected (qualitative test)	Antimicrobial, immune-modulatory activity
6.	Fatty acids & Esters (GC–MS identified)	9,12-Octadecadienoic acid (Z,Z)-; 9,12,15-Octadecatrienoic acid, ethyl ester (Z,Z,Z); n-Hexanoic acid; cis,cis,cis-7,10,13-Hexadecatrienal; 7-Tetradecenal	Precursors of bioactive lipids, antimicrobial
7.	Major fatty acid profile (cold-pressed seed oil)	Linolenic acid (36.29%); Linoleic acid (17.99%); Oleic acid (12.58%); cis-11-Eicosenoic acid (9.2%); Erucic acid (9.19%); Palmitic acid (6.66%); Stearic acid (2.2%); Arachidic acid (1.75%); cis-11,14-Eicosenoic acid (0.95%)	Rich in polyunsaturated fatty acids (PUFAs), especially omega-3 linolenic acid
8.	Major fatty acid profile (cold-pressed seed oil)	Linolenic acid (36.29%); Linoleic acid (17.99%); Oleic acid (12.58%); cis-11-Eicosenoic acid (9.2%); Erucic acid (9.19%); Palmitic acid (6.66%); Stearic acid (2.2%); Arachidic acid (1.75%); cis-11,14-Eicosenoic acid (0.95%)	Rich in polyunsaturated fatty acids (PUFAs), especially omega-3 linolenic acid
9.	Other metabolites	1,3-Cyclohexanedione; O-ethyl-S-2-dimethylaminoethylethyl phosphonothioate; 3-Methylcrotonitrile; 1,2-Cyclopentadiene; 4-Isothiocyanato-1-butene; Isosorbide	Includes isothiocyanates (anticancer, antimicrobial) and nitriles
10	Major fatty acid profile (cold-pressed seed oil)	Linolenic acid (36.29%); Linoleic acid (17.99%); Oleic acid (12.58%); cis-11-Eicosenoic acid (9.2%); Erucic acid (9.19%); Palmitic acid (6.66%); Stearic acid (2.2%); Arachidic acid (1.75%); cis-11,14-Eicosenoic acid (0.95%)	Rich in polyunsaturated fatty acids (PUFAs), especially omega-3 linolenic acid
11.	Minerals/Proteins	Iron, Manganese, Sodium, Potassium, Protein	Nutritional support, restorative, essential for enzymatic functions

anti-inflammatory action [19]. Bronchial asthma models in rats and guinea pigs confirmed bronchoprotective and anti-inflammatory benefits, further supported by mast cell stabilization assays[20,21]. In vitro studies on rat mesenteric mast cells demonstrated that ethanolic seed extracts inhibited mast cell degranulation, thereby preventing mediator release such as histamine. These findings align with observations that the extract provides protective effects against histamine-induced bronchospasm, highlighting its direct anti-inflammatory mechanism. Additionally, antioxidant activity of the aerial parts contributes indirectly to anti-inflammatory effects through free radical scavenging [22]. The safety profile was confirmed in acute toxicity studies, where no adverse effects were observed up to 1000 mg/kg in animal models [23]. The anti-inflammatory and anti-asthmatic effects are attributed to the presence of bioactive phytochemicals such as flavonoids, alkaloids, glycosides, phenolic compounds, and steroids, particularly β-sitosterol, which modulates inflammatory signaling pathways Moreover, immunomodulatory properties of the plant have been reported, suggesting additional therapeutic relevance in airway inflammation and general inflammatory conditions. Thus, *S. irio*, especially its seeds, exhibits a multi-mechanistic anti-inflammatory profile supported by antioxidant, mast cell stabilization, and immunomodulatory actions.

Antimicrobial activity

It exhibits potent antimicrobial activity, primarily through its ethyl acetate leaf extract, which effectively inhibits multidrug-resistant bacterial strains and *Candida albicans*, with Minimum Inhibitory Concentration (MIC) values ranging from 31.25 to 125 μg/ml and Minimum Bactericidal Concentration (MBC) values from 62.5 to 250 μg/ml. These effects are attributed to phytochemicals such as flavonoids, terpenoids, steroids, and glycosides, which disrupt microbial cell membranes, inhibit cell wall

synthesis, and interfere with microbial metabolism [24,25].

A total of 13 solvent extracts were prepared and tested against three bacterial strains using the agar well-diffusion method. Among these, the ethanolic extract exhibited broad-spectrum inhibition, suppressing the growth of all tested bacteria. To explore its chemical basis, the ethanolic extract was subjected to GC–MS analysis, which identified 25 distinct phytochemical constituents. Drug-likeness screening of these compounds using Molinspiration software shortlisted four candidates for further in silico evaluation. Molecular docking studies performed with AutoDock Vina against two bacterial targets—DNA gyrase subunit B and dihydrofolate reductase—revealed that "Benzene-1,2-dicarboxylic acid, monoamide, N-(1-cyano-1-methylethyl)" demonstrated the strongest inhibitory interaction with DNA gyrase subunit B. These findings suggest that *S. irio* seeds possess significant antibacterial potential, with specific phytochemicals offering promise as lead compounds for the development of novel antibacterial agents [9].

Antioxidant activity

The antioxidant activity of *Sisymbrium irio* L. grown in Saudi Arabia was investigated through in vitro assays, revealing significant free radical scavenging potential across different plant organs and solvent extracts. The study evaluated the total phenolic content (TPC) and total flavonoid content (TFC) using the Folin-Ciocalteu method and 1,1-diphenyl-2-picryl-hydrazyl (DPPH) radical scavenging protocol, with Trolox as the standard. Methanolic extracts of the aerial parts exhibited the highest TPC (42.7861 mg GAE/g) and notable antioxidant activity (15.20725 mg AAE/g), while TFC was lower (5.72175 mg AAE/g). These findings suggest that phenolic compounds, including flavonoids, are key contributors to the antioxidant capacity of S. irio, with variations observed across leaves, stems, seeds, and flowers due to differences in secondary metabolite profiles. The potent antioxidant activity underscores the plant's therapeutic potential, particularly for mitigating oxidative stress-related conditions [26].

The antioxidant activity of leaves was also investigated, comparing wild and controlled-environment samples. Wild leaves exhibited significantly higher total phenolic content (up to 575 mg GAE/100 g fresh weight) and flavonoid content (up to 337 mg QE/100 g fresh weight) compared to controlled-environment leaves (455 mg GAE/100 g and 205 mg QE/100 g, respectively). Antioxidant capacity, assessed via DPPH and ABTS assays, was also greater in wild plants, with values of 8.03–8.67 mmol Trolox equivalents/100 g dry weight for DPPH and 6.49–6.81 mmol Trolox equivalents/100 g dry weight for ABTS. These results indicate a strong positive correlation between phenolic content and antioxidant potency [5].

Anticancer activity

Sisymbrium irio L. exhibits promising anticancer activity due to its rich phytochemical composition, including flavonoids (notably apigetrin), phenolics, phytosterols (particularly β-sitosterol glucoside), and unsaturated fatty acids. Studies have demonstrated significant antiproliferative effects of extracts against human colorectal (HT-29, HCT-116), breast (MCF-7), and liver (HepG2) cancer cell lines, with the n-hexane fraction showing potent cytotoxicity (IC_{50} values of 11.7–13.4 μg/mL, and 5.42 μg/mL for HCT-116) and ethanol extracts displaying moderate inhibition on HT-29 cells (GI_{50} of 210–380 μg/mL after 72 hours) [5,27]. The anticancer mechanisms include apoptosis induction via modulation of TNFα, NF-κB, PTEN/PI3K/AKT, and STAT3/JAK2 pathways, enhanced reactive oxygen species (ROS) production causing oxidative stress, selective cytotoxicity toward cancer cells (selectivity indices of 2.8–3.4 in colorectal models), and disruption of cancer cell membranes and signaling cascades by β-sitosterol glucoside.

Analgesic and Antipyretic activity

The seeds exhibit significant analgesic and antipyretic activities, as demonstrated in animal models using crude ethanolic seed extracts. A study reported a pronounced antipyretic effect, with fever reduction beginning within one hour, peaking at three hours, and persisting beyond five hours. The analgesic effect was statistically significant ($p < 0.001$), indicating effective pain suppression. Although specific mechanisms were not fully clarified, the antipyretic activity is likely mediated by inhibiting prostaglandin synthesis in the hypothalamic thermoregulatory center, while analgesia may involve modulation of central or peripheral pain mediators. These pharmacological effects align with traditional uses of *S. irio* seeds for fever reduction, pain relief, and respiratory ailments, supported by bioactive phytochemicals such as glycosides, flavonoids, alkaloids, and steroids [28].

Bronchodilator activity

Various studies have demonstrated the protective effects of *S. irio* in experimental models of bronchial asthma. Another study aimed to evaluate the protective potential of seed extracts in mast cell stabilization and active anaphylaxis models in experimental animals. Ethanolic seed extract exhibited significant protection against histamine aerosol-induced bronchoconstriction, mast cell degranulation induced by Compound 48/80, and

Table 3: Pharmacological activities and their outcomes [22,25,26,27,28,29]

S. No	Pharmacological activity	Extract Used	Dose	Experimental Model	Outcome
1.	Anti-inflammatory	Ethanolic extract (seeds)	100–300 mg/kg orally	Cotton pellet-induced granuloma in rats	Significant reduction in granuloma weight (anti-inflammatory effect)
2.	Anti-inflammatory	Ethanolic extract (seeds)	Not specified	Mast cell stabilization (in vitro, rat)	Inhibition of mast cell degranulation
3.	Anti-inflammatory	Ethanolic extract (seeds)	100 & 200 mg/kg orally	Swim stress immobility test in rats	Anti-inflammatory stress response
4.	Bronchoprotective & Anti-inflammatory	Seed extracts	Not specified	Bronchial asthma in rats and guinea pigs	Bronchoprotective and anti-inflammatory effects
5.	Antimicrobial	Ethyl acetate extract (leaves)	MIC 31.25–125 µg/mL	MDR bacteria and fungi	Inhibition of bacterial and fungal growth
6.	Antioxidant	Leaf extracts	Not specified	Wild vs. cultivated plants	High phenolic & flavonoid content; strong antioxidant capacity
7.	Anticancer / Antiproliferative	N-hexane & ethanol extract	IC_{50}: 5.42–13.4 µg/mL	HT-29, HCT-116, MCF-7, HepG2 cell lines	Cytotoxicity, apoptosis induction, ROS generation, selective cytotoxicity
8.	Analgesic & Antipyretic	Crude ethanolic extract (seeds)	Not specified	Animal models (fever and pain)	Significant antipyretic and analgesic effects

active anaphylaxis. These effects are attributed to the rich content of glycosides, steroids, alkaloids, and flavonoids in the seed extract. Notably, steroids, flavonoids, and alkaloids have been reported to exert beneficial effects in clinical asthma, supporting the traditional use of *S. irio* seeds as a therapeutic agent for respiratory disorders [29].

Pharmacological studies on seeds have provided experimental support for their traditional use in gastrointestinal, respiratory, and vascular disorders. A 70% aqueous-methanolic extract demonstrated dual spasmogenic and spasmolytic effects on isolated rabbit jejunum, with atropine-sensitive activity indicating an antimuscarinic mechanism. The extract also inhibited high K^+-induced contractions and shifted Ca^{2+} response curves, suggesting calcium channel blockade. Similar relaxant effects were observed in tracheal and aortic preparations, comparable to reference drugs such as dicyclomine and verapamil, confirming the coexistence of Ca^{2+}-antagonistic and antimuscarinic properties. Importantly, oral administration of the extract up to 6 g/kg was found to be non-toxic in mice. Collectively, these findings validate the folkloric claims and highlight the potential of S. irio seeds as a source of bioactive compounds with antispasmodic, bronchodilatory, and vasorelaxant activities [30]. Various pharmacological activities and their outcomes have been mentioned in (Table 3).

CONCLUSION

Sisymbrium irio L is a powerful medicinal plant packed with natural compounds like flavonoids, glucosinolates, phenolic acids, alkaloids, sterols, saponins, tannins, and fatty acids. These compounds give the plant its wide range of health benefits. Recent studies have confirmed its traditional uses for treating coughs, fevers, infections, and inflammation, while also showing it has even more potential. The plant has strong antioxidant, anti-inflammatory, antimicrobial, anticancer, pain-relieving, fever-reducing, and asthma-soothing effects. These benefits come from actions like fighting harmful molecules, reducing inflammation, triggering cancer cell death, and relaxing muscles in the airways. Key compounds like isorhamnetin, sinigrin, and β-sitosterol, along with a good safety record in early studies, make it a promising source for new medicines. Nevertheless, additional investigations are essential to elucidate its mechanisms of action, optimize extraction methodologies for its bioactive constituents, and evaluate its efficacy and safety in human clinical trials. Comprehensive studies employing *in silico* modeling and *in vivo* experimental models are recommended to assess its potential therapeutic applications. *Sisymbrium irio* represents a promising botanical resource for the development of safe, naturally derived pharmacotherapies and merits rigorous exploration in the disciplines of phytochemistry and clinical medicine.

REFERENCES

1. Pandey, M. M., Rastogi, S., & Rawat, A. K. (2013). Indian traditional Ayurvedic system of medicine and nutritional supplementation. Evidence-Based Complementary and Alternative Medicine, 2013, 376327. https://doi.org/10.1155/2013/376327

2. Newman, D. J., & Cragg, G. M. (2020). Natural products as sources of new drugs over the nearly four decades from 1981 to 2019. Journal of Natural Products, 83(3), 770–803. https://doi.org/10.1021/acs.jnatprod.9b01285
3. Hailu, T., Gupta, R. K., & Rani, A. (2019). Sisymbrium irio L.: A herb used in the Unani system of medicine for broad-spectrum therapeutical applications. Indian Journal of Traditional Knowledge, 18(1), 140–143.
4. Paliwal, P. C., & Maurya, S. S. (2021). Study of fodder plants in Ramnagar of Nainital district in Uttarakhand, India. Plant Archives, 21(1), 1–5.
5. Chileh-Chelh, T., da Cunha-Chiamolera, T. P., Urrestarazu, M., Ezzaitouni, M., López-Ruiz, R., Nájera, C., et al. (2024). London rocket (Sisymbrium irio L.) as healthy green: Bioactive compounds and bioactivity of plants grown in wild and controlled environments. Molecules, 30(1), 31. https://doi.org/10.3390/molecules30010031
6. Al-Jaber, N. A. (2011). Phytochemical and biological studies of Sisymbrium irio L. growing in Saudi Arabia. Journal of Saudi Chemical Society, 15(4), 345–350. https://doi.org/10.1016/j.jscs.2010.10.004
7. Nadkarni, K. M. (2002). Indian Materia Medica (Vol. 1, 3rd ed., A. K. Nadkarni, Ed.). Mumbai: Popular Prakashan. p.1142.
8. National Institute of Science Communication and Information Resources (CSIR). (2003). The Wealth of India: A Dictionary of Indian Raw Materials and Industrial Products (Vol. IX, Rh–So). New Delhi: NISCAIR. pp. 361–362.
9. Tiwari, M., & Bhargava, P. (2024). In vitro and in silico evaluation of antibacterial activities of different solvent extracts made from Sisymbrium irio L. seeds. Journal of Applied and Natural Science, 16(3), 1344. https://doi.org/10.31018/jans.v16i3.4640
10. Al-Qudah, M. A., & Abu Zarga, M. H. (2010). Chemical composition of essential oils from aerial parts of Sisymbrium irio from Jordan. Journal of Chemistry, 7(1), 6–10. https://doi.org/10.1155/2010/103185
11. Akhtar, R., Javaid, A., & Qureshi, M. Z. (2020). Bioactive constituents of shoot extracts of Sisymbrium irio L. against Fusarium oxysporum f. sp. cepae. Planta Daninha, 38, e020200961. https://doi.org/10.1590/s0100-83582020380100016
12. Fatima, I., Waheed, S., & Zaidi, J. H. (2013). Elemental analysis of Anethum graveolens, Sisymbrium irio Linn., and Veronia anthelmintica seeds by instrumental neutron activation analysis. Applied Radiation and Isotopes, 71(1), 57–61. https://doi.org/10.1016/j.apradiso.2012.09.006
13. Câmara, J. S., Perestrelo, R., Ferreira, R., Berenguer, C. V., Pereira, J. A., & Castilho, P. C. (2024). Plant-derived terpenoids: A plethora of bioactive compounds with several health functions and industrial applications—A comprehensive overview. Molecules, 29(16), 3861. https://doi.org/10.3390/molecules29163861
14. Dias, M. C., Pinto, D. C., & Silva, A. M. (2021). Plant flavonoids: Chemical characteristics and biological activity. Molecules, 26(17), 5377. https://doi.org/10.3390/molecules26175377
15. Lin, D., Xiao, M., Zhao, J., Li, Z., Xing, B., Li, X., et al. (2016). An overview of plant phenolic compounds and their importance in human nutrition and management of type 2 diabetes. Molecules, 21(10), 1374. https://doi.org/10.3390/molecules21101374
16. Gurr, M. I., Harwood, J. L., Frayn, K. N., Murphy, D. J., & Michell, R. H. (2016). Lipids: Biochemistry, Biotechnology and Health (6th ed.). Oxford: John Wiley & Sons.
17. Zhang, W., Zhao, J., Ma, Y., Li, J., & Chen, X. (2022). The effective components of herbal medicines used for prevention and control of fish diseases. Fish & Shellfish Immunology, 126, 73–83. https://doi.org/10.1016/j.fsi.2022.04.020
18. Calder, P. C. (2015). Functional roles of fatty acids and their effects on human health. JPEN Journal of Parenteral and Enteral Nutrition, 39(1 Suppl), 18S–32S. https://doi.org/10.1177/0148607115595980
19. Khan, I., Khan, M. A., Aslam, M., Ahmad, S., Janbaz, K. H., & Gilani, A. H. (2016). Pharmacological basis for the medicinal use of Sisymbrium irio in airway disorders. Bangladesh Journal of Pharmacology, 11(3), 719–726. https://doi.org/10.3329/bjp.v11i3.27596
20. Zia-Ul-Haq, M., Ćavar, S., Qayum, M., Khan, I., & Ahmad, S. (2012). Antioxidant, anti-inflammatory, and antiulcer properties of London rocket (Sisymbrium irio). Natural Product Research, 26(23), 2225–2229. https://doi.org/10.1080/14786419.2011.652963
21. Bukhari, I. H., Arshad, R., Saleem, F., & Bukhari, S. I. (2022). Studies on the ethanolic extract of Sisymbrium irio L. seeds on in vitro rat mast cells. International Journal of Development Research, 12(1), 53973–53976.
22. Sharma, V., Chaudhary, U., & Agrawal, R. C. (2014). Adaptogenic and antioxidant activity of plant extracts in stress models. Asian Pacific Journal of Tropical Disease, 4(Suppl 2), S758–S762. https://doi.org/10.1016/S2222-1808(14)60723-4
23. Singh, R. K. (2015). Acute toxicity, anti-inflammatory, and bronchial smooth muscle investigation of Sisymbrium irio Linn. (seeds) in experimental animal models. International Journal of Research, 48–53.
24. El-Sherbiny, G. M., Moghannem, S. A., & Sharaf, M. H. (2017). Antimicrobial activities and cytotoxicity of Sisymbrium irio L. extract against multi-drug resistant bacteria (MDRB) and Candida albicans. International Journal of Current Microbiology and Applied Sciences, 6, 1–3.
25. Mehreen, A., Waheed, M., Liaqat, I., & Arshad, N. (2016). Phytochemical, antimicrobial, and toxicological evaluation of traditional herbs used to treat sore throat. BioMed Research International, 2016, 8503426. https://doi.org/10.1155/2016/8503426
26. Khalil, H. E., Aljeshi, Y. M., & Saleh, F. A. (2017). Phytochemical analysis and in vitro antioxidant properties of Sisymbrium irio L. growing in Saudi Arabia: A comparative study. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 8, 2533–2540.
27. Al-Massarani, S. M., El Gamal, A. A., Alam, P., Al-Sheddi, E. S., Al-Oqail, M. M., & Farshori, N. N. (2017). Isolation, biological evaluation, and validated HPTLC-quantification of the marker constituent of the edible Saudi plant Sisymbrium irio L. Saudi Pharmaceutical Journal, 25(5), 750–759. https://doi.org/10.1016/j.jsps.2017.03.010
28. Vohora, S. B., Naqvi, S. A., & Kumar, I. (1980). Antipyretic, analgesic, and antimicrobial studies on Sisymbrium irio. Planta Medica, 38(3), 255–259. https://doi.org/10.1055/s-2008-1074868
29. Singh, R. K. (2016). Studies on ethanolic extract of Sisymbrium irio Linn. (seeds) on in vitro rat mast cells. International Journal of Development Research, 9(7), 8336–8338.
30. Hussain, M., Waqas, H. M., Raza, S. M., Farooq, U., Ahmed, M. M., & Majeed, A. (2016). Anti-cholinergic and Ca^{2+}-antagonist mechanisms explain the pharmacological basis for folkloric use of Sisymbrium irio Linn. in gastrointestinal, airways, and vascular system ailments. Journal of Ethnopharmacology, 193, 474–480. https://doi.org/10.1016/j.jep.2016.09.039