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Essential Oil Composition, Biological Activities and Ethano-Pharmacological Potential of Genus *Pleurospermum*: An Updated Overview

Rakesh Kumar Joshi [1*] Lucas Fornari Laurindo [2,3], Adriano Cressoni Araújo [3,4], Victória Dogani Rodrigues [2] and Sandra Maria Barbalho [3,4,5]

[1] Department of Education, Government of Uttarakhand, India
[2] Department of Biochemistry and Pharmacology, School of Medicine, Faculdade de Medicina de Marília (FAMEMA), Avenida Monte Carmelo, 800, Marília 17519-030, SP, Brazil
[3] Department of Biochemistry and Pharmacology, School of Medicine, University of Marília (UNIMAR), Avenida Hygino Muzzy Filho, 1001, Marília 17525-902, SP, Brazil
[4] Postgraduate Program in Structural and Functional Interactions in Rehabilitation, University of Marília (UNIMAR), Avenida Hygino Muzzy, Filho, 1001, Marília 17525-902, SP, Brazil
[5] Department of Biochemistry and Nutrition, School of Food and Technology of Marília (FATEC), Avenida Castro Alves, 62, Marília 17500-000, SP, Brazil

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Abstract: The Apiaceae botanical family and the *Pleurospermum* genus have been recognized as valuable reservoirs of natural antioxidants, finding extensive applications in medicinal, pharmaceutical, nutraceutical, cosmeceutical, and culinary realms. This is attributed to their rich array of bioactive phytochemicals and their diverse range of biological activities. Essential oils are complex mixtures of hydrocarbons, and their oxygenated derivatives arise from two different isoprenoid pathways. Glandular trichomes and other secretory structures, specialized secretory tissues primarily distributed on the surface of plant organs, notably flowers and leaves, generate essential oils. Essential oils play a crucial ecological role within the plant. In addition, since ancient times, essential oils have been used in many different traditional healing systems worldwide because of their biological activities. Moreover, this review will attract the attention of scientists from aroma industries, nutritionists, and pharmaceutical industries to improve the use of essential oils for nutraceutical purposes with commercialization to aid and promote healthy lifestyles, wellness, and well-being.

Keywords: Apiaceae; essential oils; *Pleurospermum*; antioxidant; antiviral.

1. Introduction

The Apiaceae family and *Pleurospermum* genus have been reported as good sources of natural antioxidants and used for their medicinal, pharmaceutical, neutraceutical, cosmeceutical, and food value (Figure 1) due to the presence of many bioactive phytochemicals and their versatile biological activities [1, 2]. The *Pleurospemum* genus is a member of the Apiaceae family, also known as Umbelliferae.

* Corresponding author: e-Mail: raakeshjoshi@rediffmail.com

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Apiaceae, classified under the order Apiales, encompasses approximately 434 genera and nearly 3,780 plant species found across diverse habitats, predominantly in the north temperate regions of the world. Many species are economically important, such as leaf and root vegetables, herbs, and spices, in addition to their roles as garden ornamentals [3, 4].

Essential oils (EOs) are secondary metabolites of aromatic plants with strong odors and volatile constituents composed of terpenoids (mono-, sesqui-, and di-terpenes), alcohols, ketones, aldehydes, alkanes, and phenylpropanoids. They protect plants against microbes, insects, and herbivores [5]. Since antiquity, humankind has used EOs and EO-containing plants as medicinals (ethnomedicine), perfumeries, incense, fragrances, and embalmment in culinary and preservation [6]. Spices and herbs are parts of various plants cultivated for their aromatic, pungent, or otherwise desirable substances. Spices and herbs comprise rhizomes, bulbs, barks, flower buds, stigmas, fruits, seeds, and leaves. Spice seeds are the tiny aromatic fruits and oil-bearing seeds of herbaceous plants such as anise, caraway, cumin, fennel, poppy, and sesame. Spices, spice seeds, and herbs are adjuncts to impart flavor, aroma, or piquancy to foods. Although the small amounts employed in culinary preparations offer limited dietary content, they stimulate the appetite and intensify flavors.

Many of the 'world's highly prized spices, such as cardamom, cinnamon, cloves, ginger, and pepper, are fragrant or aromatic plant products cultivated in tropical and subtropical regions. Within the modern food-processing industry, spices are employed in the preparation of numerous products, including processed meats, sausages, sauces, vinegar, mustards, pickles, chutneys, preserves, salad dressings, biscuits, cookies, cakes, confections, and many other beverages. Herbs and spices also contain essential oils, which are the flavoring components of extracts, and they are employed in producing perfumes, cosmetics, toiletries, lotions, hair products, toothpaste, and soaps. These essential oils and oleoresins (natural plant products that contain essential oils and resins) are the basis of several spice flavorings and seasonings employed in food manufacturing [7]. Figure 1 shows that EOs extracted from the *Pleurospermum* genus can produce antioxidant and anti-inflammatory actions and be used for industrial purposes.

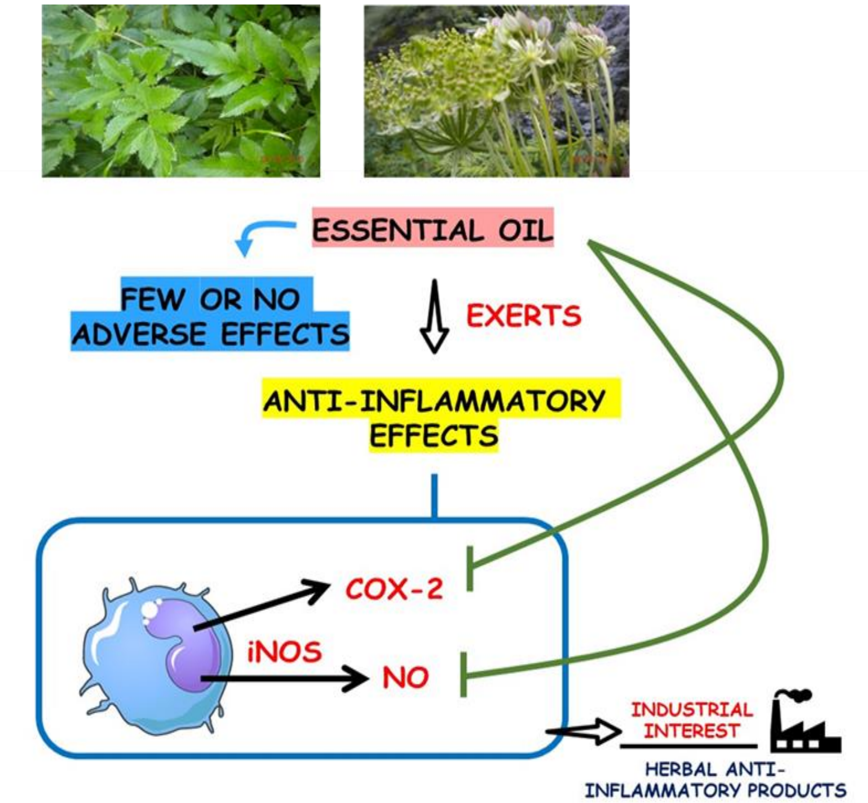

Figure 1. *Pleurospermum* genus essential oil

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Moreover, medicinal and aromatic plants play a vital role in developing new drugs, and India's forests have been a source of traditional medicines for millennia. Of the 17,000 species of higher plants described in India, 7500 are known for their medicinal uses [8, 9]. The Charak Samhita, a document on herbal therapy written about 300 BC, reports on producing 340 herbal drugs and their indigenous uses [10]. The Indian Himalayan Region is well known to have a great range of plant diversity. Uttarakhand is a part of the north-western Himalayas and maintains a dense vegetation cover (65%). Uttarakhand has been documented as having the highest number of medicinal plant species [11, 12]. This region alone supports about 18,440 plant species (Angiosperm: 8,000 spp., Gymnosperm: 44 spp., Pteridophytes: 600 spp., Bryophytes: 1,736. Lichens: 1,159 spp. and fungi: 6,900 spp.) [11]. According to Samant et al., out of the total vascular plant species, 1,748 are of medicinal use [13]. The main objective of this review is to focus on the essential oils component, biological activities, and other nutraceutical potential of essential oils and significant genus isolates *Pleurospmum*.

2. Materials and Methods

2.1. Literature Search and Inclusion of the Studies

The focal question for this review was, what are the described properties of *Pleurospermum* species? A comprehensive literature survey was conducted in Pubmed, Cochrane, Embase, and Google Scholar databases to find the studies performed with *Pleurospermum* species. The Mesh Terms used in the search were *Pleurospermum* species and essential oil composition, biological activity or pharmacological properties, antioxidant, anti-inflammatory, antimicrobial, anticancer, or health benefits.

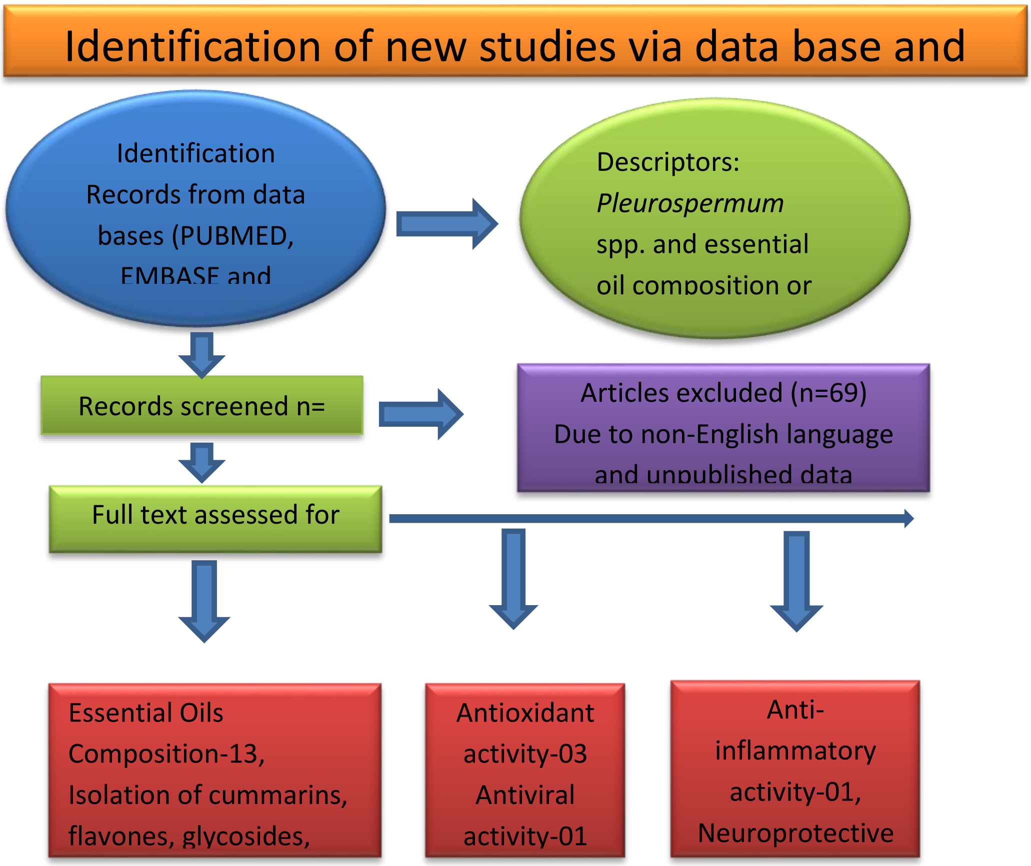


Figure 2. Flow chart showing the selections of the studies

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were followed [14, 15]. Only studies initially published in English were included. The search did not restrict time. The exclusion criteria were non-English. Figure 2 illustrates the PRISMA flow diagram depicting the process of literature search.

2.2. Taxonomy and Distribution of Pleurospermum Species

Pleurospermum species are typically one to three meters tall at the fully matured stage with seed. These are perennial or biennial herbs. Species of this genus are growing in the alpine zone at an altitude of 4500-5000m above sea level. These plants are indigenous to India, Yunnan, China, and Nepal. In Uttarakhand, one species is reported in Kumaun Himalaya at 3500 m [16]. These herbs are annual or perennial, rarely woody at the base. Fruits are dry, of two mericarps united by their faces (commissure). Between 250 and 440 (–455) genera and 3300–3700 species widely distributed in the temperate zone of both hemispheres, mainly in Eurasia and especially in C Asia; 100 genera (ten endemics) and 614 species (340 endemics) in China [17].

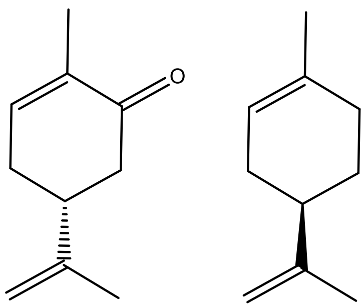
2.3. Traditional Uses

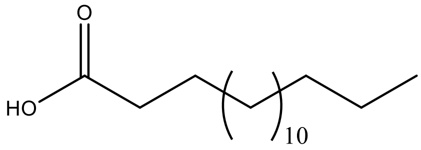
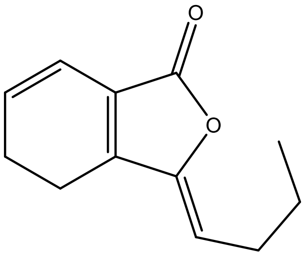
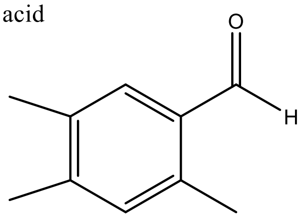
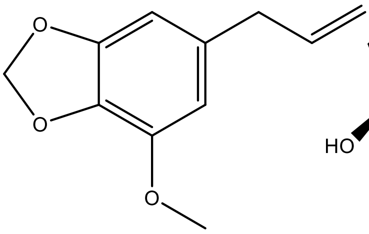
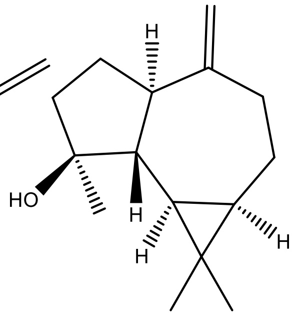
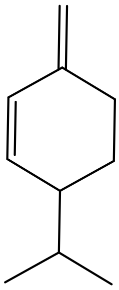
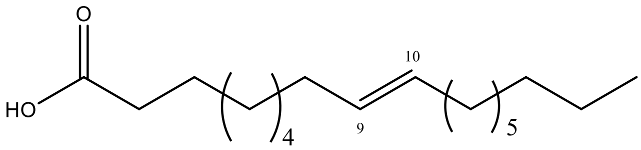
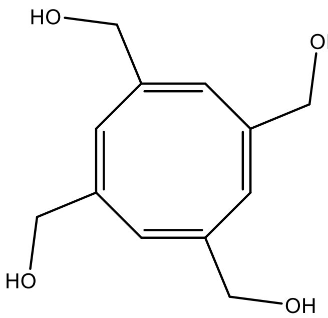
The roots of *Pleurospermum angelicoides* are used in folk medicine as antipyretic and diaphoretic agents [4]. It is locally known as Chippi" in the Himalayan region and is used for treating typhoid and dysentery in India and China [17]. Another species, *P. rivulorum,* is a Chinese traditional medicine used as an antipyretic, analgesic, antiarrhythmic, and diaphoretic agent in local villages of China [18]. *P. kamtschaticum* is traditionally used to treat colds, arthritis, fatigue, atherosclerosis, and impotence [19]. *P. govanianum* is regarded as an antiasthmatic, expectorant, and smooth muscle relaxant [20]. *P. lindleyanum* is used for hypertension, other heart-related problems, high altitude sickness, and hepatitis [20-21]. *P. amabile* is an antidote for febrifuge and dyspepsia [22]. *P. rivulorum* 'Yunnan Qiang 'Huo' is a Chinese folk medicine used as an antipyretic, analgesic, and diaphoretic agent in local areas of Yunnan province, China. It has been proved by pharmacological experiments that the water extract possesses an antiarrhythmic effect [18].

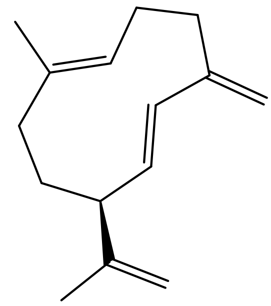
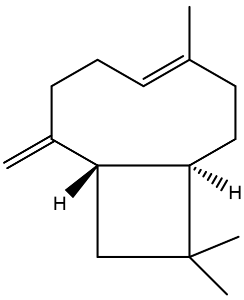
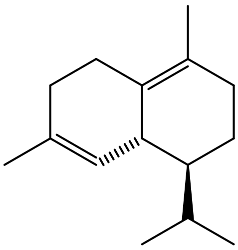
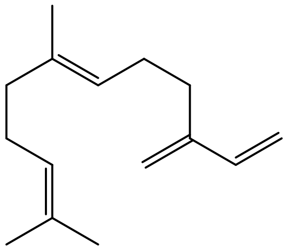
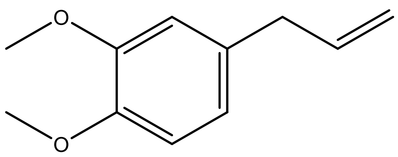
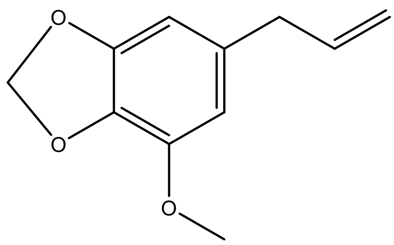
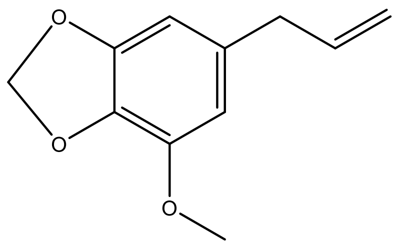
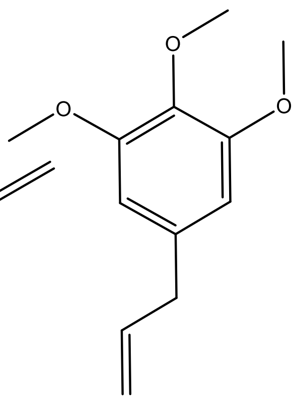
2.4. Essential Oil Composition

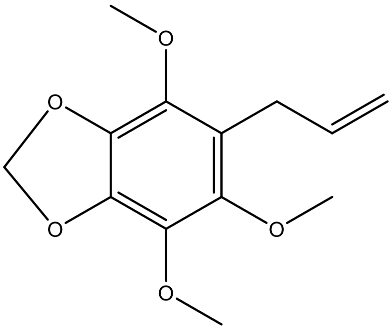
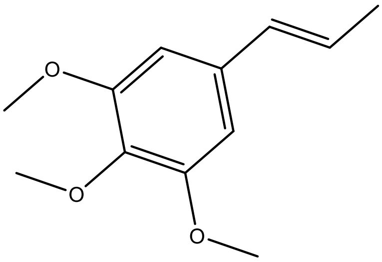
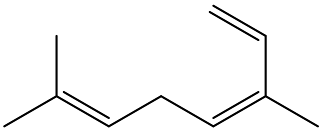
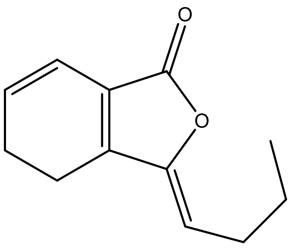
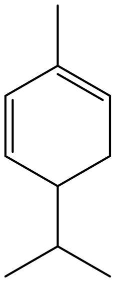
In Table 1, it is possible to find the essential oil composition of several species of *Pleurospermum*.

Table 1. Primary chemical composition of *Pleurospermum* species essential oil **QST1**

Name of species	Structure of major essential oil components	References
Pleurospermum giraldii	 L-Carvone D-Limonene	[23]

Pleurospermum hookeri	 Palmitic acid  Ligustilide  2,4,5-Trimethyl benzaldehyde	[24]
Pleurospermum lindleyani	 Myristicin  Spathulenol  β-Phellandrene	[25]
Pleurospermum wrightianum	 (*E*)-9-Octadecenoic acid  1,3,5,7-Cyclooctatetraene	[26]

Pleurospermum austriacum	 Germacrene D (66.5 % in the fruits, 62.4 % in the leaves, and 49.0 % in the stalks)	[27]
Pleurospermum austriacum	 β-caryophyllene (3.1-5.7 %),  δ-cadinene (3.6-5.0 %)  (E) β-farnesene (1.0-1.5%)	[27]
Pleurospermum amabile	 Methyl eugenol  (*E*)-Isomyristicin  (*E*)-Isoelemicin  (*E*)-Isoapiol	[22]

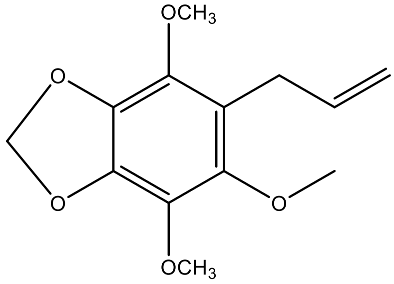
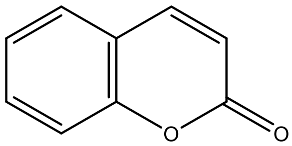
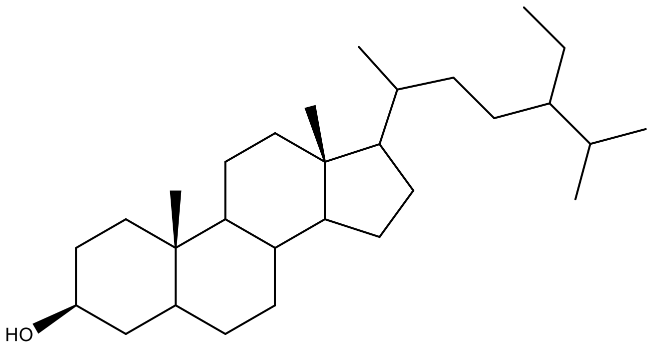
Pleurospermum angelicoides	 Nothoapiole (5-allyl-4, 6, 7-trimethoxy-benzo [1, 3] dioxide) was observed as a single major constituent (87.3%) in the roots essential oil)	[28]
Pleurospermum angelicoides	 α-Asarone leaf and flower essential oils (23.2%, 20.7%, respectively)	[28]
Pleurospermum angelicoides	   β-Ocimene (12.5 %) *Z*-Lingustilide (10.5 %) α-Phellandrene	[29]

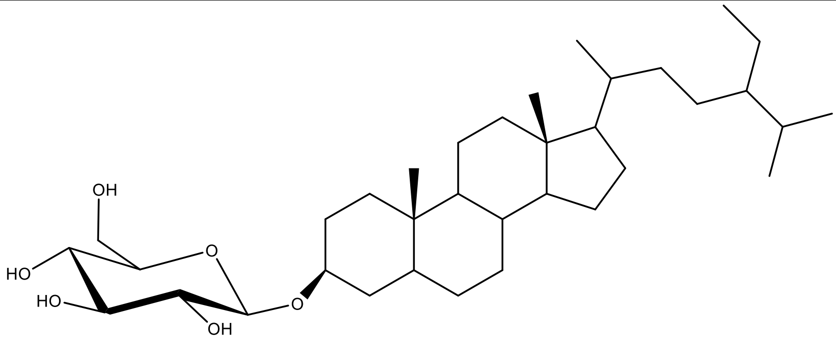
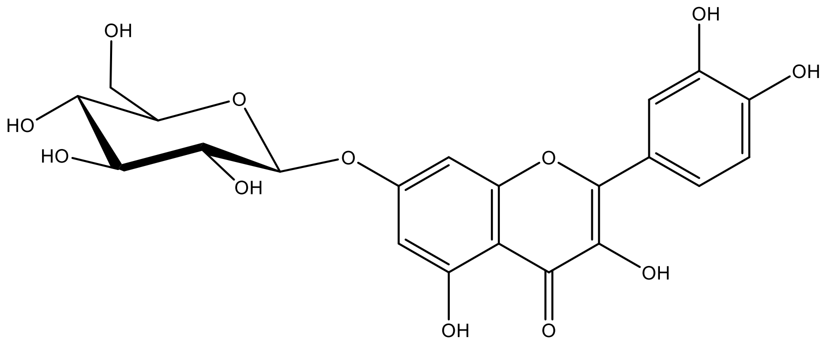
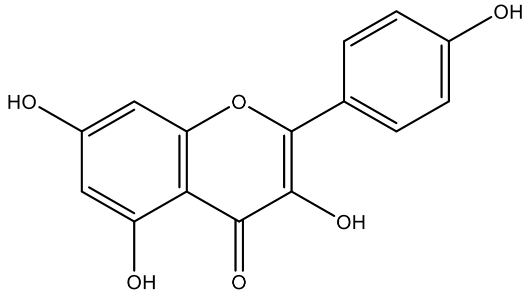
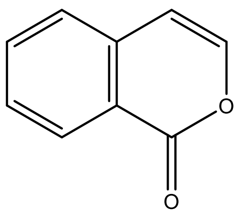
2.5. Chemical Isolates

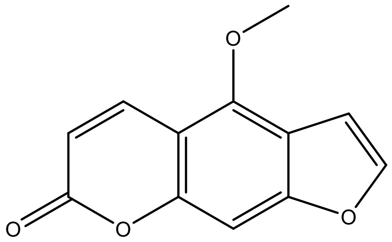
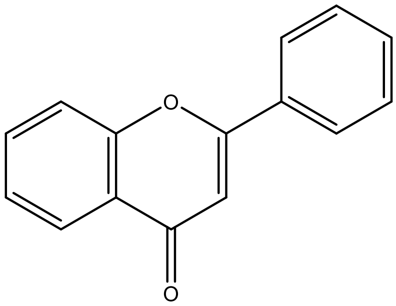
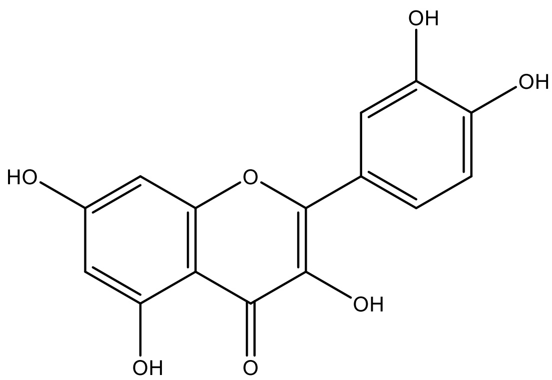
The chemical isolates of several species of *Pleurospermum* can be seen in Table 2.

Table 2. Major chemical composition of *Pleurospermum* species **QST2**

Name of Species	**Major components**	**Reference**
Pleurospermum angelicoides	Angelicoidenol	[30]
Pleurospermum angelicoides	bicyclic monoterpene	[31]

Pleurospermum angelicoides	 Nothoapiole (a) (5-allyl-4, 6, 7-tri methoxy-benzo [1, 3] dioxide) was observed as a single major constituent (87.3%) in the root essential oil	[28]
Pleurospermum densiflorum	 Ester and coumarins	[32]
Pleurospermum rivulorum	Two new bicoumarins, rivulobirins A and B	[18]
Pleurospermum rivulorum	Rivulobirin E and Rivulotririn C	[33]
Pleurospermum rivulorum	Three Novel Cyclospirobifurano coumarins, Cyclorivulobirins A—C	[34]
Pleurospermum franchetianum	 β−Sitosterol	[35]

	 22*E*,20*S*,24*R*)-5α,8α-Epidioxyergosta-6,22-dien-3-β-ol, Daucosterol  α-Spinasterol-3-O-β-Dglucopyranoside, quercetin-3,7-di-O-β-D-glucopyranoside  Kaempferol	
Pleurospermum angelicoides	 Isocoumarins	[36]

Pleurospermum lindleyanum	 Bergapten-8-ylsulfate	[37]
Pleurospermum lindleyanum	 Flavones	[38]
Pleurospermum densiflorum	Ester and fatty acid	[39,40]
Pleurospermum brunonis	 Flavones	[40,41]

2.6. Biological Activities

Specialized secretory tissues, including glandular trichomes, produce essential oils primarily distributed on the surface of plant organs, especially flowers and leaves. This ecological role is crucial for plants. Furthermore, essential oils have been used in many different traditional healing systems worldwide since ancient times due to their biological activities. Many preclinical studies have documented essential oils' antimicrobial, antioxidant, anti-inflammatory, and anticancer activities in a variety of cell and animal models, as well as elucidated their mechanism of action and pharmacological targets; however, the scarcity of human studies limits essential oils' potential as effective and safe phytotherapeutic agents. Plant-derived antioxidants and tyrosinase inhibitors have gained prime importance in the cosmaceutical industry and natural products, as they have functional ingredients protecting skin from pigmentation, aging, and other skin disorders. Various side effects of chemically synthetic skin remedies, like hydroquinone, make herbal skin remedies of prime importance.

The extensive use of antibacterial drugs has led to the development of drug resistance in pathogenic bacteria, making traditional antibiotics less effective. This poses a significant global health threat. So, there is a need to develop new antibacterial compounds to combat the growth of evolving bacteria [48]. Plants are the factories of nature that synthesize secondary metabolites of varying functions, including the defense against microbial infection and parasitic infestation [48]. Some biological activities observed in several studies for *Pleurospermum* species can be seen in Table 3 and Figure 3.

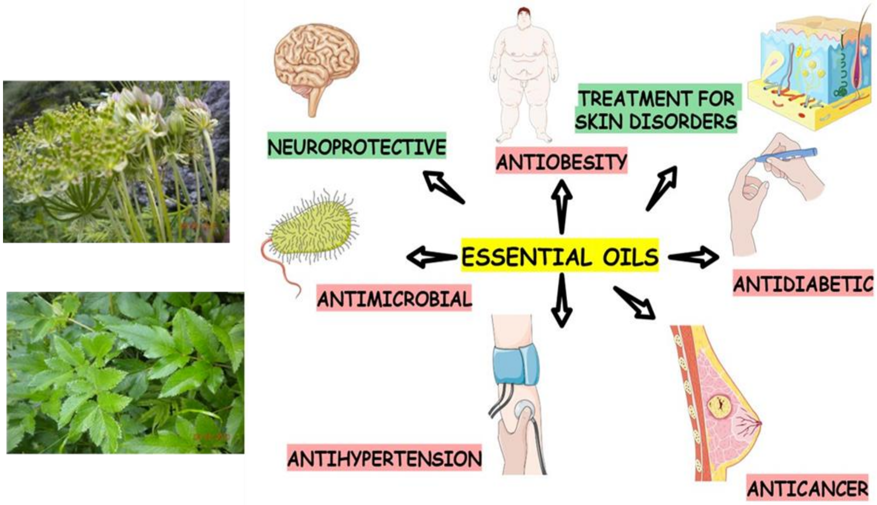


Figure 3. Biological activities shown by *Pleurospermum* species

Table 3. Biological activities of *Pleurospermum* species

Biological activities	Name of Species	Part of the plant/extract/EOs	Strain/mode of action	References
Antimicrobial activity	*P. brunonis*	Chloroform extract	*E. coli*	[48]
Antifungal activity	*P. angelicoides*	Leaf essential oil	*C. albicans* and *C. glabrata*	[29]
Antioxidant activity	*P. angelicoides*	Leaf, root, and flower essential oils	DPPH (1,1-diphenyl-2picrylhydrazyl	[29]
	P. kamtschaticum	Methanol extract from leaves	DPPH, and ABTS (2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) free radical scavenging	[43-46]
Anticancer activity	*P. kamtschaticum*	Methanol extract from leaves	Four human tumor cell lines A549, ovarian cancer cells (SK-OV-3), skin melanoma (SK-MEL-2), and HCT15	[47, 48]
Neuroprotective activity	*P. kamtschaticum*	Ethanolic extract	SK-N-SH neuronal cells and phosphorylation of P38 in brain neural cells to show neuroprotective activity	[49]
Antidiabetic activity	*P. kamtschaticum*	Edible plant powder	Decreased liver glycogen level and increased plasma insulin level in streptozotocin-induced diabetic rats	[48]
Anti-hyperlipidemic	*P. kamtschaticum*	Dried leaves and stems	Decrease of cholesterol levels	[44]
Anti-inflammatory	*P. candollei*	Dried whole plant material	Inhibition of nitric oxide production	[50]

3. Results and Discussion

This review showed that *Pleurospermum* species are rarely studied worldwide, and those studied are very important because of their essential oils, isolates, and different biological activities. The literature survey revealed that one of the species, P. candollei Benth. ex C.B. Clarke. from Pakistan, is used principally for taste and nutritional benefits. This species has also been used for different ailments and is commercially available in these regions. The whole plant is used to cure abdominal problems and stomach disorders. It also decreases cholesterol and blood pressure and relieves heart problems and gastric illnesses [51-52]. One teaspoonful of dried plant powder is used with milk once a week to treat headaches and fever and can also be used by cooking with leafy vegetables for this purpose [53]. It is employed for treating respiratory disorders, and the evidence also shows its sound effects in pain, unconsciousness, and cerebral disorders [54].

Stem powder of this plant has been used in joint problems and back pain in Gilgit-Baltistan. Male and female infertility have also been treated using preparations from this plant [51]. It is also used to treat diarrhea in animals [55]. Ali et al. [54] separated some compounds to correlate the anti-inflammatory properties of P. candollei. Total phenolic content and total flavonoid components were also studied for P. candollei, which is very positive and authenticates various plants' use in formulating new nutraceuticals, pharmaceuticals, and functional foods [56]. Data also revealed that methanolic extract of phenolic and flavonoid components of *P. candollei* are responsible for antioxidant potential. Fractions of extract *P. candollei* against α-glucosidase and α-amylase activity [56]. Except for EOs, some significant isolates shown essential activities, like buddlejasaponin isolated from the methanolic extract of P. kamtschaticum is responsible for intrinsic and extrinsic hyperlipidemia and hypercholesterolemia activity in rats [44] and Nothoapiole is isolated form *P. angeliciodes* from Uttarakhand, India also active for antioxidant and antimicrobial activity [29].

4. Conclusions

This review shows that the genus *Pleurospermum* is rich in beneficial chemical components in essential oils and different extracts. Essential oils and extracts exhibit significant biological and pharmacological activities. Several species are very useful in the present scenario for daily life in fragrance and perfumery. In addition to their use in aromatherapy and various other applications, aromatic plants, and essential oils are now widely employed in the cosmetic industry.

ORCID
Rakesh Kumar Joshi: 0000-0002-6930-5190
Lucas Fornari Laurindo: 0000-0003-3159-0982
Adriano Cressoni Araújo: 0000-0002-5716-2444
Victoria Dogani Rodrigues: 0009-0002-0283-5864
Sandra M. Barbalho: 0000-0002-5035-876X

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