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Phytochemical and Pharmacological Review on Pimenta dioica (Linn.) Plant

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Abstract: ***Throughout history, humans have relied on plants and natural products for food and medicine to treat and prevent illnesses. Today, more than 80% of the global population still depends on traditional and plant-based medicines. Plants are essential sources of medicinal compounds, and currently, approximately 25% of pharmaceutical prescriptions in the United States include at least one plant-derived ingredient. Pimenta dioica (Linn.) [(L)Merr]., which contains bioactive compounds such as alkaloids, flavonoids, tannins, and polyphenols, has been used to treat diseases due to its various pharmacological properties. This review aims to provide a comprehensive scientific assessment of the key phytochemicals in Pimenta dioica (Linn.) [(L)Merr]. and their pharmacological effects, highlighting their potential for developing new ethnomedicines in the future.***

Keywords: Pimenta dioica, medicinal plants, phytochemicals, ethnomedicine, plant-based medicine

1. Introduction

Allspice refers to the dried, immature berries of the *Pimenta dioica* (Linn.) [(L.) Merr.] plant. It is also commonly called Jamaican pepper, pimenta, or newspice. Native to Jamaica in the Caribbean, this species belongs to the Myrtaceae family. The term "Allspice" arises from its complex flavor, which combines the aromatic notes of clove, black pepper, cinnamon, and nutmeg.

P. dioica shares numerous chemical constituents with these spices. For example, compounds such as myrcene, limonene, methyl eugenol, α-terpineol, caryophyllene, and terpinolene are present both in allspice and nutmeg. Similarly, like clove, *P. dioica* contains eugenol, beta-caryophyllene, methyl eugenol, and humulene. In comparison with black pepper, it exhibits constituents including phenols, steroids, tannins, lignans, and limonene. Additionally, overlapping compounds with cinnamon include eugenol, beta-caryophyllene, myrcene, and methyl eugenol.

The *P. dioica* tree is an evergreen species that can reach heights of around 22 feet and, under favorable conditions, may grow up to 43 feet. This contrasts with black pepper, which is derived from the vine *Piper nigrum*, indigenous to South Asia. The allspice tree is characterized by its light gray bark and dark green leaves, which are typically 4–8 cm in length. During the summer months, it produces clusters of small white flowers. The green berries are picked before full ripeness and then dried in the sun, during which they darken and begin to resemble large peppercorns.

Originally, allspice was found in the tropical forests of the West Indies, along with regions of southern Mexico and Central and South America. Today, it is commercially cultivated in countries such as Jamaica, Cuba, Honduras, Mexico, and Trinidad. Another species, *Pimenta racemosa* (family Myrtaceae), native to Central America, is also used in the commercial production of allspice. However, its berries are larger and generally considered to be less aromatic. Jamaican-grown allspice is particularly esteemed due to its richer concentration of essential oils, which contributes to its enhanced flavor profile.[1]

Taxonomy:
Family: Myrtaceae (Myrtle family)
Latin name: Pimenta dioica (Linn.) (L.) Merrill
Synonyms: Pimenta officinalis Lindl.
Common names: Allspice, pimento, Jamaican pepper[2]

Table: Taxanomical Classification

Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Mytrtales
Family	Myrtaceae
Genus	Pimenta Lindl
Species	Pimenta dioica (Linn.)

Table 1 Taxanomical Classification of Pimenta dioica (Linn.) [3]

Vernacular Name:

Table 2: Vernacular names of Pimenta dioica (Linn.). [4]

Language	Vernacular Name
Arabic	Bahar
Danish	allehande
Dutch	Jamaica pepper
English	Jamaica pepper, Myrtle pepper, pimento, newspice
Russian	Yamaiskiy pjerets
Turkish	Yeni bahar

Cultivation and Collection of *Pimenta dioica*

Pimenta dioica (Linn.), commonly known as allspice, is native to Jamaica in the Caribbean. This plant was introduced to Europe in the 16th century. During his expeditions to the Americas in the 15th century, Christopher Columbus encountered the plant in Jamaica and mistakenly identified it as a type of pepper, coining the name "Jamaican pepper."

The flowers of *P. dioica* grow in cyme clusters and typically bloom between March and June. The fruit, which matures over 3–4 months, contains two kidney-shaped seeds. Once mature, the seeds are harvested and dried, taking on a dark color and a resemblance to large peppercorns. The plant prefers a tropical climate with an average temperature range of 18°C to 24°C. Since it thrives in forested environments, partial shade is beneficial during early growth. Like clove, it requires specific ecological conditions to flourish. Owing to its appealing form and aromatic qualities, *P. dioica* is also cultivated as an ornamental plant in tropical regions globally.

Geographical Distribution

The Myrtaceae family, to which *P. dioica* belongs, comprises over 3,000 woody plant species, most of which are found in tropical climates. The genus *Pimenta* includes approximately 18 aromatic shrubs and trees native to tropical areas of the Americas (Willis, 1966). Among its economically important members are *P. dioica*, the source of allspice, and *P. racemosa*, which is used to produce bay oil. Cytogenetically, *P. dioica* is diploid with a chromosome number of 2n = 22, and the genus has a base number of x = 11 (Purseglove et al., 1981).

Although Jamaica is considered its primary habitat, *P. dioica* is also found in surrounding regions, including Central America and the Caribbean islands. Historical records show that allspice was discovered by Columbus around 1494 and quickly adopted by Spanish settlers. Reports indicate that cultivation in Jamaica began by 1509. The berries reached London by 1601 and were being grown in heated greenhouses in England by 1732 (Weiss, 2002). Its popularity declined after World War II due to deforestation, and despite efforts to revive cultivation, production levels have not fully recovered[4].

The plant has been introduced into other Caribbean locations such as Grenada, Barbados, Trinidad, and Puerto Rico. While attempts were made to grow it in countries like India, Sri Lanka, Indonesia, and Malaysia, success was limited. In India, some trees have been planted in states such as Maharashtra, Tamil Nadu, Karnataka, and Kerala[5].

2. Botanical Description

Morphology

Pimenta dioica is a small evergreen tree that can grow up to 15 meters tall, with light brown bark. The leaves are opposite, simple, and entire, typically 6–20 cm in length and oblong-elliptical in shape. When crushed, the leaves emit a distinctive allspice aroma due to their glandular punctations.

The flowers are small, white, and fragrant, growing in cymes. Although morphologically hermaphroditic, the species functions dioeciously—male flowers contain over 100 stamens, while females have around 50. The calyx consists of four lobes that persist into the fruit, while the petals are deciduous. The inferior ovary is two-celled, with a single ovule per cell. Flowering occurs from March to June, and fruiting follows after 3–4 months. Fruits are harvested green for culinary uses and contain two kidney-shaped seeds[6].

Microscopic Features

The leaf of *P. dioica* displays a stomatal number of 34 per mm² and a stomatal index of 10.05. Vein islet and termination numbers are 10 and 14 per mm², respectively. Microscopic analysis reveals palisade mesophyll cells, epidermal trichomes, calcium oxalate crystals, volatile oil-containing cells, spongy parenchyma, lignified phloem fibers, simple starch grains, and paracytic stomata[7].

3. Extraction Methods

Crude Extraction

A sequential solvent extraction was conducted using petroleum ether, dichloromethane, and methanol in a 1:3 ratio (100 g plant powder to 300 mL solvent). The powdered material was soaked and agitated for 24 hours in each solvent, with repeated extraction to ensure efficiency. Leaves, bark, and roots were processed separately. Extracts were concentrated using a rotary evaporator and stored at −80°C for GC-MS analysis.[6]

Essential Oil Extraction

Essential oils were extracted using three methods: hydrodistillation (HD), solvent extraction (SE), and supercritical fluid extraction (SFE). HD and SE employed a 1:10 ratio (150 g powdered berries to 1500 mL solvent). SFE used 450 g of powdered berries with supercritical CO_2 and 1% ethanol as a co-solvent. Operational settings included: CO_2 flow at 89 mL/min, temperature range from 40°C–50°C, and pressure at 200 bar for a 60-minute run.[8]

GC-MS Analysis

Chemical analysis was performed using a Hewlett Packard 6890 GC system with an HP-5MS column and a 5973 mass selective detector. Samples (2 g each) were dissolved in a solvent system and subjected to centrifugation, followed by cleanup with magnesium sulfate and florisil. The final extract was analyzed using an Agilent GC-MS setup with specific temperature gradients and helium as the carrier gas. The method enabled detailed profiling of metabolites from different plant parts.[6]

Chemical Composition

The plant contains diverse bioactive compounds, notably alkaloids, tannins, flavonoids, and phenolics. These phytochemicals, though non-nutritive, have notable antimicrobial and therapeutic properties.

A solvent-based yield study revealed 81 phytocompounds in leaves (31 in methanol, 24 in petroleum ether, 26 in DCM), 18 in bark, and 12 in roots. Essential oil analysis using HD, SE, and SFE methods identified 43 compounds, covering 90.26% of HD oil, 75.40% of hexane-extracted oil, and 82.99% of SFE oil. Key groups included phenols, monoterpenes, sesquiterpenes, esters, fatty acids, and

steroids. Phenolic compounds—especially eugenol and methyl eugenol—dominated the oil composition.[3,6]

Table 2: Names of the phyto-constituents found in different parts of the plant[9,10]

Source	Name of phyto-constituents	References
Berries	**Phenylpropanoids** threo-3-chloro-1-(4-hydroxy-3-methoxyphenyl)propane-1,2-diol 3-(4-hydroxy-3-methoxyphenyl)propane-1,2-diol	[8]
	Glycosides **Galloyl glycosides** (4 S)-α-terpineol 8-O-β-D-(6-O-galloyl) glucopyranoside (4 R)- α-terpineol 8-O-β-D-(6-O-galloyl) glucopyranoside 3-(4-hydroxy-3-methoxyphenyl) propane-1,2-diol 2-O-β-D-(6-O-galloyl) glucopyranoside (2-hydroxy-3-methoxy-5-allyl) phenyl β-D-(6-O-Esinapoyl) glucopyranoside **Phenolic glycosides** (1′R,5′R)-5-(5-carboxymethyl-2-oxocyclopentyl)-3Z-pentenyl β -D-(6-Ogalloyl)glucopyranoside (S)-R-terpinyl [R-L-(2-Ogalloyl) arabinofuranosyl]-(1f6)- β -Dglucopyranoside (R)-R-terpinyl [R-L-(2-O-galloyl)arabinofuranosyl]-(1f6)-β-Dglucopyranoside	[9] [10]
	Tannins Vascalaginone Grandininol	[11]
	Essential Oil Constituents limonene 1,8 cineole Terpinolene β-caryophyllene β-selinene methyl eugenol	[12]
Leaf	**Glycosides** 6-hydroxy-eugenol 4-O-(6'-O-galloyl)- β-D-C1-glucopyranoside 3-(4-hydroxy-3-methoxyphenyl)-propane-1,2-diol-2-O-(2',6'-di-Ogalloyl)-β-D-C1-glucopyranoside	[11]
	Leaf oil constituents: Eugenol Methyl Eugenol β-caryophyllene Myrcene acetyleugenol, humulene chavicol cineole	[13, 14]
	Metabolites gallic acid methyl gallate nilocitin 1-O-galloyl-4,6-(S)-hexahydroxydiphenoyl-(α/)-d-glucopyranose 4,6-(S)-hexahydroxydi-phenoyl-(α/)-d-glucopyranose 3,4,6-valoneoyl-(α/)-d-glucopyranose pedunculagin casuariin castalagin vascalagin casuarinin grandinin methyl-flavogallonate ellagic acid	[15]
	Other compounds naphthalene, 1,2,3,5,6,8a-hexahydro-4,7- dimethyl-1-(1-methylethyl)-, (1S-cis)- copeane 3-carene caryophyllene γ-sitosterol	[6]
Bark	1,4-Methanoazulene, decahydro-4,8,8-trimethyl-9- methylene-, [1S-(1. alpha.,3a. beta.,4. alpha.,8a. beta.)] pregn-5-en-3-ol,21-bromo-20-methyl-, (3. beta.) stigmasta-5,22-dien-3-ol, acetate 1,4-methanoazulene, 7- bromodecahydro-4, 8, 8-trimethyl-9-methylene 2,2,7,7-tetramethyltricyclo [6.2.1.0(1,6) undec-4-en-3-one 9,19-cyclolanost-24-en-3-ol, acetate, (3. Beta)	[6]

Root	γ-sitosterol 2-tetradecene, (E) 1-Nonadecene 7-hexadecene, (Z) phenol,2,4-bis(1,1-dimethylethyl) 2-Chloropropionic acid hexadecyl ester	[6]

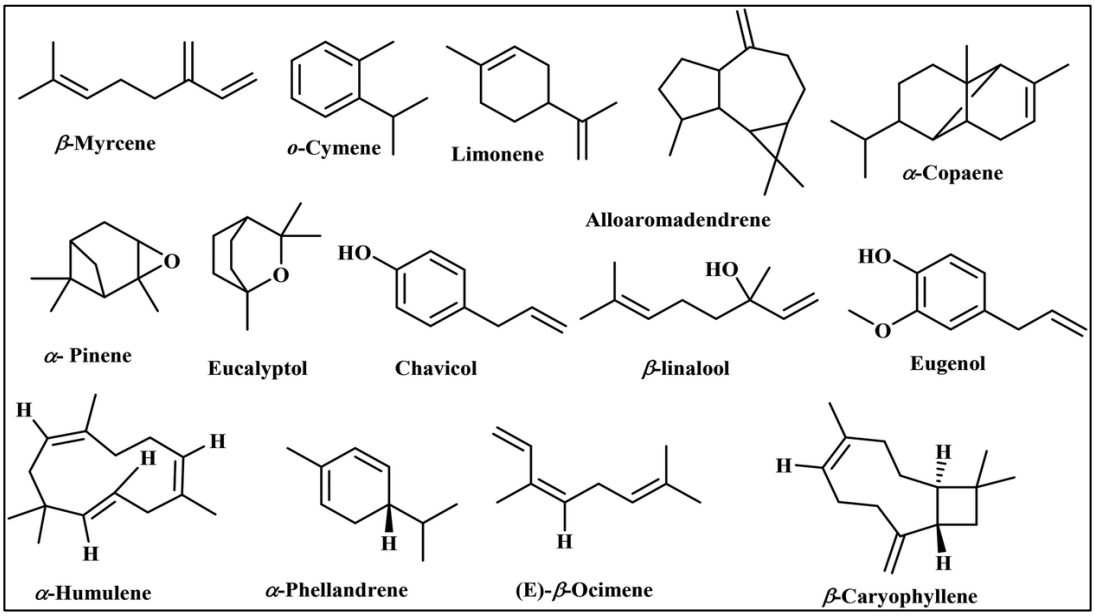

Figure 1: Phytochemical constituents of pimenta dioica (Linn)[12]

4. Therapeutic Applications

The green, unripe berries of *Pimenta dioica* (Linn.) are harvested and dried for use as a flavoring and curing agent in culinary and medicinal applications. Ground allspice is commonly used in desserts, relishes, sausages, and preserves. Additionally, the young woody stems are fashioned into walking sticks and umbrella handles.[13]

Traditionally, a water extract prepared from the berries has been used to manage gastrointestinal issues such as flatulence and diarrhea. The powdered form has been applied in treating corns, neuralgia, and rheumatism. The essential oils extracted from the leaves and berries of *P. dioica* are valued in the food industry—especially in meat processing and tanning—as well as in perfumery and cosmetic formulations.[14]

These essential oils are associated with a range of pharmacological effects, including anesthetic, analgesic, antimicrobial, antioxidant, antiseptic, acaricidal, carminative, muscle relaxant, rubefacient, stimulant, and tonic actions. Allspice oil is believed to support digestion and relieve cramps, bloating, indigestion, and nausea. In Cuban folk medicine, particularly among Haitian-descended communities in Camaguey, pimento seeds are ingested with rum and sugar to alleviate abdominal discomfort.[15]

5. Pharmacological Activities

1) Antibacterial Properties

Pathogenic bacteria are a major source of foodborne illnesses (USDA, 2012). With increasing consumer demand for natural and minimally processed foods, essential oils from spices and herbs are gaining popularity as natural preservatives. Research has demonstrated that aromatic plant oils, including those from *P. dioica*, exhibit antibacterial effects when incorporated into foods. For instance, Lorenzo-Leal et al. (2019) reported that allspice essential oil was effective against *Salmonella Typhimurium* and *Listeria monocytogenes* in alfalfa seeds.[16]

2) Anti-inflammatory, Sedative, and Spasmolytic Effects

Due to their ability to neutralize free radicals, essential oils are considered potential anti-inflammatory agents. Some compounds found in these oils may reduce pain sensitivity and anxiety. Extracts from *P. dioica* are also traditionally used to alleviate gastrointestinal disturbances.

3) Antioxidant Activity

Essential oils often act as antioxidants by scavenging harmful free radicals, which can contribute to the development of various diseases. This antioxidant effect is largely due to phenolic compounds, such as eugenol and methyl eugenol, which inhibit oxidative reactions. The hydroxyl groups in these compounds help prevent lipid peroxidation by donating hydrogen atoms, thereby interrupting free radical chain reactions.[17]

Antioxidant Properties of *P. dioica* Essential Oil
FRAP (mmol/100g): 100.4
DPPH Inhibition (%): 545.4
Total Phenolic Content (mg/g): 421.5

4) Anticancer Activity[12]

A glucoside found in allspice has shown promising anticancer activity by inhibiting the expression of early antigens of the Epstein-Barr virus at a concentration of 100 µg. The compound pedunculagin demonstrated strong cytotoxic effects on solid tumor cells, affecting both T-lymphocytes and

macrophages. In addition, extracts of *P. dioica* used in Tibetan medicine (PADMA 28) have been observed to induce apoptosis in T cell-derived leukemia cell lines such as CEM-C7H2.

5) Antifungal Properties[18]

Essential oil from *P. dioica* has exhibited inhibitory effects against various fungal strains, including *Fusarium oxysporum*, *Penicillium* species, and *Aspergillus* species, at a concentration of 1 µL/mL. It also shows activity against several *Candida* strains and *Saccharomyces cerevisiae*.

6) Antimicrobial Activity

Studies confirm that *P. dioica* extracts and essential oils can inhibit a wide range of pathogens, including *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *E. coli*, *Listeria monocytogenes*, and *Salmonella Typhimurium*. The oils also act against coagulase-negative *Staphylococci* and exhibit antifungal activity against *Aspergillus niger*.

7) Nematicidal Effects

At a concentration of 2 mg/mL, the essential oil of allspice berries was effective in killing the pinewood nematode (*Bursaphelenchus xylophilus*).

8) Antidiabetic Potential[17]

Ground allspice berries have demonstrated the ability to inhibit protein glycation, indicating potential use in the management of diabetes.

9) Menopausal Symptom Relief[17]

Around 70% of women approaching menopause experience related symptoms. While hormone replacement therapy (HRT) is commonly prescribed, many women in Central and South America rely on plant-based remedies instead. Research has shown that methanolic extracts of *P. dioica* act as selective estrogen receptor modulators (SERMs), enhancing estradiol-induced expression of pS2 mRNA and suppressing progesterone and PTGES mRNA expression.

10) Hypotensive Activity[17, 20]

Intravenous administration of aqueous *P. dioica* extracts to Sprague-Dawley rats produced a noticeable drop in blood pressure. The extract also exhibited central nervous system depressant, analgesic, and hypothermic effects without altering heart rate or body weight. Aqueous extracts were more potent than ethanolic ones in inducing hypotension. These effects were found to be independent of cholinergic, α-adrenergic, or β-adrenergic pathways, suggesting possible vasorelaxant mechanisms.

6. Conclusion

This review presents a detailed examination of the taxonomy, botanical characteristics, distribution, and pharmacological potential of *Pimenta dioica* (Linn.). Emphasis has been placed on its therapeutic relevance and bioactive compounds, underscoring its importance in traditional medicine and the potential for future pharmaceutical development.

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