CHEMICAL COMPOSITION AND PHARMACOLOGICAL ACTIVITIES OF CLOVE AND CORIANDER ESSENTIAL OILS: A REVIEW

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Abstract: Essential oils (EOs) from various plant sources have been used for their pharmaceutical potential since ancient times. They are extracted by steam or water distillation. EOs mainly consist of terpenes, including monoterpenes and sesquiterpenes as well as phenolic compounds. Their single bioactive constituents inhibit several pathogens and are responsible for most of the antimicrobial activities. EOs have recently gained significant attention for their potential as natural antimicrobial agents. The current review presents various pharmacological activities (antioxidant, anti-inflammatory, antimicrobial, and anticancer) of Eos, applicable in the cosmetic and food industries as well as healthcare sector. The chemical composition and biological activities of clove and coriander oil are also discussed further. Eugenol is the main bioactive component of clove oil, followed by β-caryophyllene and eugenyl acetate. Coriander oil mainly consists of linalool, is edible and non-toxic, prevents spoilage of food, and exhibits numerous biological activities. Further information is provided on their single bioactive constituents and applications. Various EOs are potential candidates for natural drugs; however, further investigation is required for their development and efficient use in agriculture, pharmaceutical, and food industries.

Keywords **- Essential oil, *Coriandrum sativum*, *Syzygium aromaticum*, pharmacological activity.**

INTRODUCTION

Many medicinal and aromatic plants are in high demand because of their potential applications in the culinary, cosmetic, perfumery, and pharmaceutical industries. Essential oils (EOs) are natural compounds extracted from different plant parts, such as stems, flowers, roots, leaves, seeds, barks, etc., through mechanical processes such as cold pressing or steam distillation. EOs are grouped as aromatic and aliphatic compounds, and hydrocarbon terpenes (isoprenes) and terpenoids (isoprenoids). The major constituents of EOs are secondary metabolites of aromatic plants with oxygenated structures such as alcohols, ketones, aldehydes, and esters. It is necessary to understand the complex composition and biological activities of EOs for novel applications in agriculture and chemical industries for the production of natural drugs that can replace synthetic drugs.

EOs are volatile and soluble in certain oils, alcohols, and ethers. These oils emit various scents, and thus are used in cosmetics, perfumery, and aromatherapy. EOs also exhibit antibacterial activities and possess hydrophobicity, which makes them more permeable through the lipids of the cell membrane of the bacteria, causing disruption of the structure and leakage of ions or other cellular molecules [1–5]. EOs with a high level of phenolic compounds such as carvacrol, eugenol, and thymol show high antibacterial activity [6–8]. Phenolics and secondary metabolites with conjugated double bonds usually show remarkable antioxidative properties [9].

EOs with scavenging capacity of free radicals may play an important role in some disease prevention, such as brain dysfunction, cancer, heart disease, and immune system decline [10, 11]. EOs have been used in clinical settings to treat inflammatory diseases, such as rheumatism, allergies, or arthritis [12]. Numerous studies have reported the repellent, insecticidal, and allelopathic activities of several EOs [13]. Moreover, the volatile constituents of EOs potentially possess anticancer activity and cytotoxicity against various cancer cell lines [14].

Further information has been provided focusing on the classification, chemical constituents, and applications of the EOs of clove and coriander.

Scientific classification of Clove and Coriander

	Clove	**Coriander**
Kingdom	Plantae	Plantae
Subkingdom	Tracheobionta	Tracheobionta
Superdivision	Spermatophyta	Spermatophyta
Division	Magnoliophyta	Magnoliophyta
Class	Magnoliopsida	Magnoliopsida
Subclass	Rosidae	Rosidae
Order	Myrtales	Apiales
Family	Myrtaceae	Apiaceae
Genus	*Syzygium*	*Coriandrum*
Species	*Syzygium aromaticum*	*Coriandrum sativum*

CLOVE OIL

Syzygium aromaticum (commonly known as clove) belongs to the family Myrtaceae. Clove is an aromatic spice tree, conical in shape and medium sized, growing up to 15 m in height. The flower bud **(Fig. 1)** of the clove tree resembles a nail, which is known as 'clou' in French and hence the name 'clove'. Clove is traditionally used in the treatment of toothaches, oral ulceration, digestive problems, and muscle cramps. Clove is commercially promoted for its pharmacological properties, including antioxidant, anti-inflammatory, and anti-viral, etc. It is also used in perfumes and repellents. Eugenol is the main constituent of clove oil and is widely used in dentistry for its anesthetic and antibacterial activity. It also prevents platelet aggregation and thromboxane synthesis [15]. Eugenol functions as an antipyretic, anti-carcinogenic, anti-diabetic and reportedly reduces high-fat diet-induced obesity. Clove inhibits hydroxyl radicals, showing the highest antioxidant activity [16]. The oil possesses antimicrobial activities against various species of Staphylococcus, *Escherichia coli, Klebsiella pneumoniae, Aspergillus niger, and Candida albicans* [17]. In addition, it exhibits cytotoxicity and anti-ulcer activity.

Fig. 1 Clove flower buds

Dried cloves

CORIANDER OIL

Coriandrum sativum of family Apiaceae is an upright annual herb with slender branching stems growing up to 70 cm in height. It is commonly known as Cilantro, Chinese parsley, and Arab parsley. Coriander is mainly cultivated for its seeds and foliage, and its EO is extracted by hydro-distillation. The *C. sativum* oil extracted from ripened and dried seeds can be described as colorless, aromatic, with a distinct odor, and linalool is its major component [18]. Other major constituents are camphor, geraniol, α-pinene, γ-pinene, γ-terpinene, geranyl acetate, and limonene. Coriander oil exhibits various biological activities such as antibacterial, antifungal, antioxidant, insecticidal and pharmacological activities such as anti-inflammatory, anxiolytic, diuretic, cognitive improvement, antidiabetic, antiseptic, antihypertensive, lipolytic, myorelaxant, anti-carcinogenic, antimutagenic, etc. [19] Coriander plant is edible, non-toxic and used extensively in foods (flavors and preservatives) and perfumes (lotions).

Coriander seeds

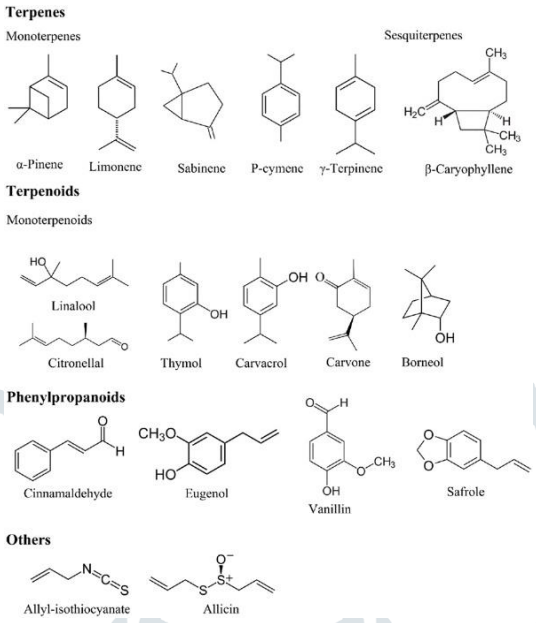
Coriander flower

CHEMICAL COMPOSITION

Clove is considered to be one of the major sources of phenolic compounds such as flavonoids, hydroxybenzoic acids, hydroxycinnamic acids, and hydroxyphenyl propenes. Other phenolic acids found in clove are caffeic, ferulic, elagic, and salicylic acids. Flavonoids such as kaempferol, quercetin and its derivatives (glycosylated) are found in clove, but in lower concentrations. Gallic acid and its derivatives, such as hydrolyzable tannins, are present in higher concentrations (2 375.8 mg/100 g) [21]. Other

volatile compounds such as β-pinene, limonene, farnesol, benzaldehyde, 2-heptanone, and ethyl hexanoate are present in lower concentrations in clove oil. Eugenol, the principal bioactive compound of clove, was found in concentrations ranging from 9 381.70 to 14 650.00 mg per 100 g of fresh plant material [20].

The presence and amount of secondary metabolites are affected by various conditions such as the nature of the soil, climate, cultivation techniques, and genetic factors [22, 23]. Concentrations up to 18% of EO can be found in clove flower buds, where approximately 89% of the EO is eugenol and 5%–15% is eugenol acetate and β-cariofileno [24]. Another important compound found in clove EO is α-humulen (up to 2.1%).

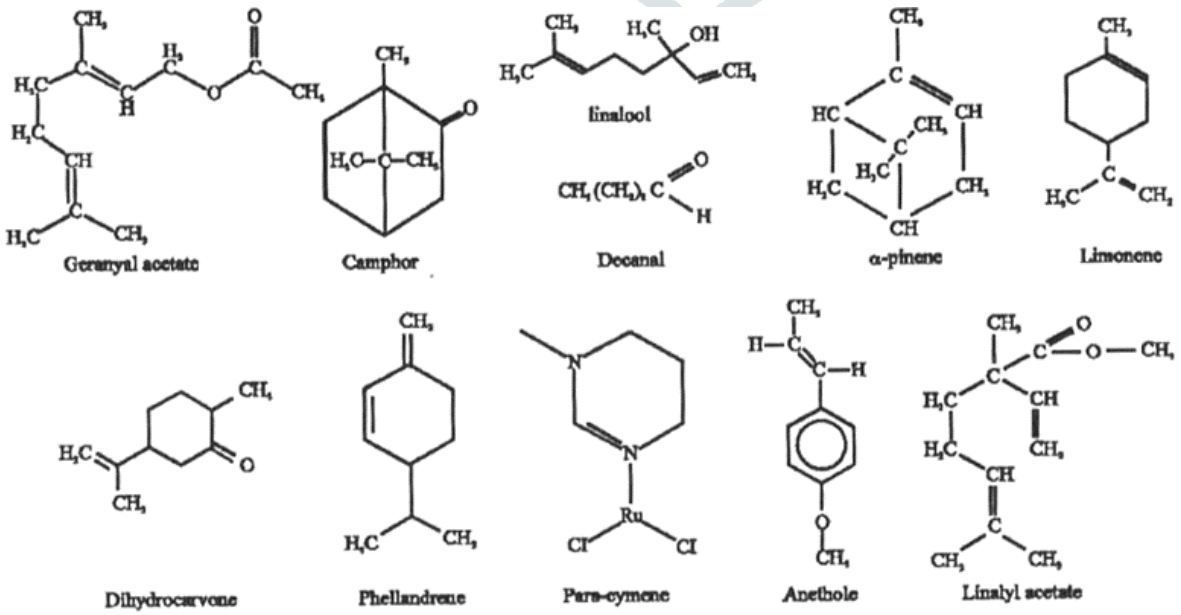


Major compounds in clove oil

The aroma of the coriander herb differs from that of its fruit due to the presence of aliphatic aldehydes (mainly C10–C16 aldehydes), which are the main components of the herb's EO [25]. Oil distilled from the fruit contains linalool and other oxidized monoterpenes as well as monoterpene hydrocarbons [26]. Coriander fruit contains approximately 0.2%–1.5% of volatile oil and 13%–20% of fat oil; [27] however, some studies showed records of up to 2.6% of volatile oil [28]. Zawislak [29] reported that the EO content ranged between 1.87% and 2.33%. The fatty oil composition of ripe fruits mainly included petroselinic acid (68.8%), linoleic acid (16.6%), oleic acid (7.5%), and palmitic acid (3.8%) [28].

Coriander plant is a potential source of lipids and EOs (rich in linalool) due to the presence of petroselinic acid, which is a major fatty acid in *C. sativum* seed EO (CSEO).

Coriander seeds contain starch (11%), fat (20%), protein (11%) and crude fiber (30%), and have p-linoleic acid, oleic acid, and palmitic acid. The major components of EO, which is up to 1%, are linalool (67.7%), followed by α-pinene (10.5%), γ-terpinene (9.0%), geranyl acetate (4.0%), camphor (3.0%) and geraniol (1.9%). Minor components in the EO are β-pinene, camphene, myrcene, limonene, p-cymol, dipentene, α-terpinene, borneol, and acetic acid esters.



Structure of compounds present in coriander oil

PHARMACOLOGICAL ACTIVITIES

Antioxidant activity

Clove has the highest antioxidant property and mainly consists of polyphenols. It has an inhibitory effect on hydroxyl radicals and acts as an iron chelator. The antioxidant activities of eugenol and eugenol acetate are similar to those of natural antioxidants [16].

Gulcin *et al*. [30] observed inhibition of (97.3%) lipid peroxidation of linoleic acid emulsion when treated with 15 µg/ml of clove oil. However, standard antioxidants such as trolox, butylated hydroxyanisole, α-tocopherol, and butylated hydroxytoluene showed inhibition of 95.6, 95.4, 84.6, and 99.7%, respectively, under the same conditions.

The antioxidant content in food can be increased by adding coriander, and it may function as a natural antioxidant by inhibiting unwanted oxidation processes [31]. The high content of linalool, α-pinene, β-pinene, p-cymene, and l-terpinene in the microwave-treated coriander seeds resulted in higher antioxidant activity (57.3%) than that in conventional roasted coriander seeds (55.5%) [32]. Wangensteen *et al.* [33] found that the scavenging activity of CSEO was higher than *C. sativum* leaf EO.

Antimicrobial activity

The antimicrobial activity of clove oil has been reported against several gram-positive bacteria (*Listeria innocua, Carnobacterium divergens, Bacillus cereus, Enterococcus faecalis, and Staphylococcus aureus*) and gram-negative bacteria (*Salmonella typhimurium, E.coli, Serratia liquefaciens, Shewanella putrefaciens, Penicillium aeruginosa, Staphylococcus chloeraesius, and Yersinia enterocolitica*) [34, 35]. Warnke *et al.* tested clove bud oil against six Staphylococcus strains, including methicillin-resistant Staphylococcus aureus (MRSA), three Candida strains, and four Streptococcus strains. An agar diffusion test showed considerable antimicrobial activity within the diameter of the inhibition zone of 12–20 mm [36].

Coriander oil shows considerable antibacterial activity against *Streptococcus pyogenes and* MRSA [37]. EOs from commercial coriander samples were analyzed by gas chromatography-mass spectrometry and assayed for their antibacterial, antifungal and antioxidant activities. The EOs showed a high degree of inhibition against all tested microorganisms [38]. Coriander oil showed fungicidal activity against Candida strains and a synergistic effect between coriander oil and amphotericin B was observed for *C. albicans* strains, whereas for *C. tropicalis* strains, an additive effect was observed. This study can be applied to formulate novel candidiasis medication [39, 40]. According to a study, CSEO inhibited the formation of primary and secondary oxidation products, resulting in the prevention of fungal growth in a cake, stored for 60 days at room temperature [41].

OTHER ACTIVITIES

Eugenol reduces fever through a central action similar to that of acetaminophen. Clove oil is cytotoxic to human fibroblasts and endothelial cells. It also has a stimulating effect on the mind and acts as a stress reliever. Flavonoids have an anti-inflammatory effect against muscle cramps and headache. Coriander oil showed remarkable insecticidal activity against *Sitophilus oryzae, Callosobruchus chinensis, and Corcyra cephalonica,* and is a potential fumigant [42]. The crude extract of *C. sativum* exhibited considerable larvicidal activity against *Culex quinquefasciatus* [43]. Patel *et al.* [44] reported that *C. sativum* extract is non-toxic and safe for consumption. However, it is essential to analyze and control microbial toxic metabolites [45]. Coriander also possesses many other health benefits, which include control of swellings, diarrhea, mouth ulcers, anemia, menstrual disorders, small pox, eye care, conjunctivitis, and skin disorders, etc. [46]

CONCLUSION

Various studies and literature mentioned in this review suggested that EOs could treat several health disorders and diseases such as cancer. Many researchers and scientists are focusing on EOs to study and identify novel bioactive compounds that can be used as natural alternatives for chemicals or synthetic drugs in pharmaceutical and agrochemical industries. Due to their pharmacological safety, EOs may be used individually or as supplements to enhance therapeutic effects and reduce toxicity. Clove oil possesses medicinal properties to treat health conditions such as migraine, diarrhea, nausea, cough, stress and gas. It is widely used in dental care and is added to several dental products, such as tooth paste and mouth wash. Eugenol, its main component, can be used to develop a novel natural drug. It is essential to conduct clinical trials on postulated pharmaceutical actions to confirm its efficiency and safety. Coriander oil is rich in phytonutrients and non-toxic; therefore, it is used as a flavoring agent, preservative, and in perfumes. The EOs of clove and coriander exhibit various biological activities, including antioxidant, antibacterial, and antifungal suggesting potential disease-control activity and further investigation of the components to replace synthetic compounds in the food and pharmaceutical industries. In conclusion, the plant-based EOs mentioned in this review are considered promising natural drugs and possess remarkable pharmaceutical applications. However, further research is required to study their mode of action and their probable toxicological effects in order to optimize their potential uses. More specific studies are required to identify novel natural drugs and produce health-oriented products, including nutraceuticals.

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