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ESSENTIAL OIL TRIO: A REVIEW ON PHARMACOGNOSTIC PROFILE OF CLOVE, VETIVER, AND TULSI

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ABSTRACT: Essential oils are concentrated hydrophobic liquids containing volatile chemical components obtained from plants. They are well-known for their medicinal effects and numerous uses. This paper examines the pharmacognostic profiles of clove (*Syzygium aromaticum*), tulsi (*Ocimum sanctum*), and vetiver (*Vetiveria zizanioides*), highlighting their phytochemical composition, medicinal qualities, and pharmacological activity. Clove oil, high in eugenol, has been extensively studied for its antibacterial, anti-inflammatory, and analgesic qualities, making it an important element in dental and topical formulations. Tulsi, regarded as a sacred plant in Ayurveda, produces an essential oil rich in eugenol, methyl eugenol, and beta-caryophyllene, which has adaptogenic, immunomodulatory, and anti-stress properties. Vetiver, also known as "khus," generates an essential oil rich in sesquiterpenes such as khusimol and vetiverol, known for their relaxing, anti-inflammatory, and antioxidant properties. The pharmacognostic examination of these essential oils covers macroscopic and microscopic properties, phytochemical screening, and quality control measures. Their broad-spectrum antibacterial action and few side effects have positioned them as promising options in current therapies. Furthermore, the synergistic potential of these oils in combination formulations is investigated, which suggests improved efficacy in aromatherapy, cosmetics, and alternative medicine. This study emphasizes the need to combine traditional knowledge with current scientific methodologies in order to maximize the usage of clove, tulsi, and vetiver essential oils. Additional studies into their mechanisms of action, standardization, and clinical validation may pave the road for their wider use in the pharmaceutical and wellness sectors.

INTRODUCTION: Essential oils are volatile fragrant molecules derived from many sections of plants, including the leaves, flowers, stems, roots, and seeds. These oils have several bioactive ingredients, including terpenes, phenols, and aldehydes, which give them medicinal and functional qualities and make them useful for pest management, cosmetics, and medicine.

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Due to their distinct chemical compositions, these oils are known to have antibacterial, antioxidant, and anti-inflammatory qualities as well as the ability to act as natural cockroach repellents. Eugenol is the primary compound of clove and is responsible for its insecticidal activity. Eugenol and other terpenes contribute to the Tulsi's effectiveness against pests, including cockroaches.

The main constituents of Vetiver are Vetiverol, khusimol, and isovalencenol. Its deep earthy aroma makes it particularly effective as a natural repellent. These substances prevent cockroaches from being present by interfering with their sensory systems. Combined, these oils can increase the effectiveness of natural pest control methods and provide a more environmentally friendly option than synthetic pesticides. Other essential oils contain drugs with repellent properties, such as Lemongrass Oil, which contains citral and geraniol, effective insect repellents; Peppermint Oil, which is rich in menthol and menthone, repels cockroaches and other pests; Eucalyptus Oil, which contains cineole, known for its insecticidal properties; and Neem Oil, which contains Azadirachtin and other limonoids that provide repellent and insect growth regulatory effects.

Clove:
Biological Source: Clove consists of dried flower buds of *Eugenia caryophyllus*, *Syzygium aromaticum*, family Myrtaceae.

Description: *Syzygium aromaticum*, commonly known as clove, belongs to the Myrtaceae family [1]. It is native to the Maluku Islands, off the coast of east Indonesia [2]. It is a medium-sized, branched, glabrescent, evergreen tree growing to 6-15m tall with a conical or pyramidal canopy and a greyish bark. It thrives in warm, humid climates [3]. The most commonly used part of the plant is its flower buds, pale yellowish-green turning green and then developing into a bright crimson color when ready for harvesting. Cloves are harvested when 1.5-2 cm long, with four spreading sepals and four unopened petals which form a small ball in the center. The leaves are green, glossy, and lanceolate, while flowers consist of a sub-cylindrical, solid, and glandular calyx tube, terminating in 4 concave ovate lobes [4].

Essential Oil Composition:
Three Essential Oils are Available from Clove Species: clove bud oil, clove stem oil, and clove leaf oil. Each clove essential oil differs in chemical composition, flavor, and color [5]. Approximately, 72-90% of the essential oil extracted from clove has Eugenol. Other essential oil ingredients of clove oil are acetyl eugenol, beta-caryophyllene, vanillin, crategolic acid, tannins, gallotannic acid, methyl salicylate, flavonoids eugenin, kaempferol, rhamnetin, eugenitin [6].

Pharmacognostic Characteristics:
Macroscopic Characteristics: The dried flower buds are reddish brown and possess a strong, aromatic odor with a pungent taste. They consist of four distinct parts: a short stalk, a hypanthium, four-pointed sepals, and a dome-shaped head containing undeveloped petals and numerous stamens. The texture is woody and slightly oily due to the high content of essential oil, predominantly eugenol. This characteristic appearance and aroma make them easily recognizable [7].

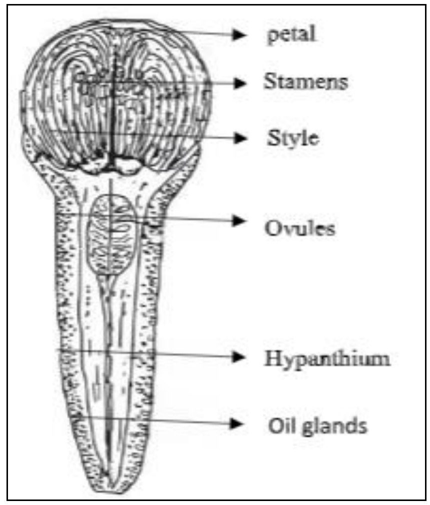

FIG. 1: MACROSCOPIC CHARACTERISTICS

Microscopic Characteristics: The microscopy of clove includes the presence of polygonal epidermal cells with a thick cuticle; numerous schizogenous oil glands are distributed throughout the tissues, responsible for the aromatic and therapeutic properties of clove; bundles of rosette-shaped calcium oxalate crystals; also contains abundant starch grains and tannin [7].

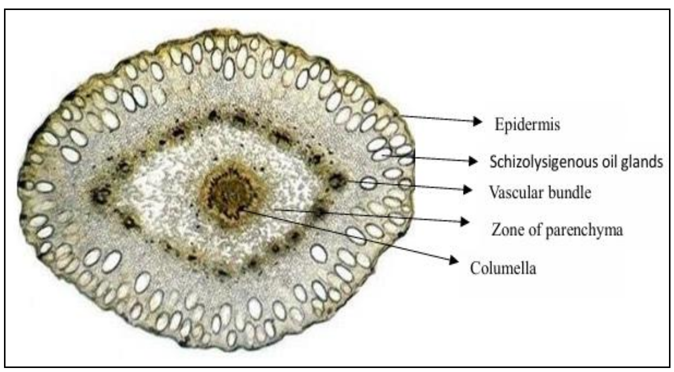

FIG. 2: MICROSCOPIC CHARACTERISTICS

Therapeutic Uses: The therapeutic uses of *Syzygium aromaticum* include antimicrobial, antioxidant, antifungal, anticancer, anti-inflammatory, radio-protective, anti-hypertensive and cardio-protective activity, hepatoprotective activity, anthelminthic activity, analgesic activity, CNS depressant activity, antipyretic activity, antidiabetic activity, antiulcer activity, antiarthritic activity, adaptogenic activity, anesthetic activity, anticoagulant, immunomodulatory, antifertility, memory enhancer [8].

Vetiver:

Biological Source: Vetiver is obtained from the roots of the plant *Chrysopogon zizanioides*, family Poaceae.

Description: Vetiver, (*Chrysopogon zizanioides*) is a perennial grass of the family Poaceae, the roots of which contain an oil used in perfumes. Vetiver is native to tropical Asia and has been introduced into the tropics of both hemispheres; it has escaped cultivation and become a weed in some regions.

The plant is sometimes grown as a hedge and is useful in dry land restoration to reduce soil erosion. Vetiver is a large tufted bunchgrass and can reach up to 1.5 meters (5 feet) in height. The thin leaves and stems are erect and rigid, and the plant bears small brown-purple flowers in long spikes. The fragrant roots grow downward in the soil and can attain depths of more than 3 meters (10 feet) [9].

Essential Oil Composition: Steam-distilled essential oil of *V. zizanioides* was purchased from Lorien Vana Biotech, Inc. (Taiwan) and then analyzed by GC–MS. The results are listed in **Table 2.**

For VZ-EO, 25 constituent compounds were identified and are listed in **Table 2**, along with the retention times and Kovats indices [9]. Our results show that the most plentiful constituent of VZ-EO is cedar-8-en-13-ol (12.4%), and the other major compounds are α-amorphene (7.80%), β-vatirenene (5.94%) and α- gurjunene (5.91%)

Pharmacognostic Characteristics:

Macroscopic Characteristics: Size, color, and other visual inspections of crude drugs were examined. Anatomical and histological characters were determined as follows: transverse sections and powdered samples (ground and sifted through a 250-micronsieve) were inspected respectively undera microscope (OlympusBX41) with a magnification of 4x, 10x, and 40x and compared the scale with the 0.01mmmicrometer [10].

FIG. 3: MACROSCOPIC CHARACTERISTICS

Microscopic Characteristics: The transverse section is circularin outline. Angular colllen chymatous tissues are present below 3-4 layered epidermis. Aerenchyma (air spaces) is present and surrounded by the parenchymatous cells. Endodermis and xylem vessels are also present. Callose plugs inside the sieve tubes appear dark blue due to staining with aniline blue. Pith is present at the center, and pith cells are parenchymatous [15].

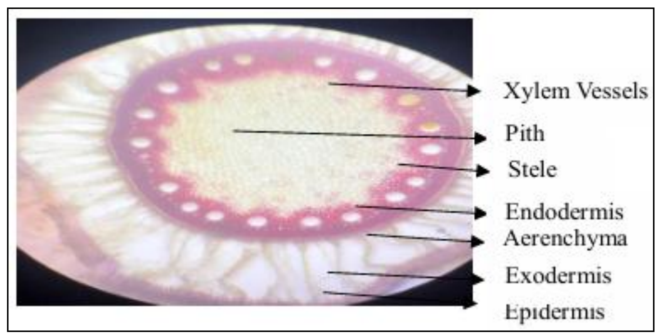

FIG. 4: MICROSCOPIC CHARACTERISTICS

Therapeutic use: Vetiver has a broad history of traditional medicinal uses, but only a handful of research articles have reported its utility in treating diseases. Unfortunately, no work has been reported on the anti-inflammatory activity of its plant extract and inflammatory-linked diseases. Hence, the present review focuses on investigating several presumptions that can be put forward to explain its anti-inflammatory properties [11].

Tulsi:

Biological Source: Tulsi consists of fresh and dried leaves of *Ocimum tenuiflorum* L, family Lamiaceae.

Description: Tulsi (*Ocimum tenuiflorum* L.*)* is anaromatic shrub or a perennial herbaceous plant belonging to the family Lamiaceae. Tulsi or holy basil originated in north-central India, now it is cultivated as a native species in the eastern tropics of the world. Tulsi is one of the most well-known examples of Ayurveda's holistic approach to healthcare. Tulsi has been included in lifestyle and spiritual practices in India, due to its wide range of health benefits. It is a popular home remedy for many ailments such as wounds, liver diseases, bronchitis, otalgia, lumbago, hiccough, catarrhal fever, ophthalmia, gastric disorders, genitourinary disorders, skin diseases, various forms of poisoning and psychosomatic stress disorders [3].

Essential Oil Composition: Terpenes, or terpenoids, are the most abundant and diversified class of naturally occurring chemicals in natural plants. They are categorized as mono, di, tri, tetra, as well as sesquiterpenes depending on the number of isoprene units they contain. They are categorized into monoterpene, oxygenated monoterpenes, sesquiterpene hydrocarbons, oxygenated sesquiterpenes, and other compounds present in tulsi. Among monoterpene hydrocarbons, both plants are enriched with α-Pinene, β-Pinene, Limonene, and Camphene.

Besides, some compounds suchas 1.8-Cineole, α-Terpineol, β-Caryophyllene, Germacrene D, δ-Cadinene, α-Selinene, α-Cadinolcontained bysesquiterpenes are the most common in these two natural herbs. The following table categorizes monoterpene, oxygenated monoterpenes, sesquiterpene hydrocarbons, oxygenated sesquiterpenes, and other compounds present in tulsi [3].

TABLE 1: ESSENTIAL OIL COMPOSITION

Terpenes	Phytochemical constitutes
Monoterpene Hydrocarbons	α-Pinene, Camphene, Sabinene, β-Pinene, Limonene
Oxygenated Monoterpenes	1, 8-cineol, cis-Sabinenehydrate, Linalool, Camphor, Borneol, α-terpinenol, D-carvone, Anethole, Eugenol
Sesquiterpene Hydrocarbons	γ-Eleneme, β-Elemene, α-Gurjunene, β- Caryophyllene, β-cubebene, β-gurjunene, Alloaromadendrene, δ- Cadinene Germacrene D, β-Selinene, α-Selinene, β-Bisabolene, 1-4, Cadinadiene, α-Calacorene
Oxygenated Sesquiterpenes	Nerolidol, Spathulenol, Caryophylleneoxide, α-Cadinol, Aromadendrene oxide
Others Compounds	Eicosane, Tricosane

Pharmacognostic Characteristics:

Macroscopic Characteristics: Krishna tulsi is an erect, many-branched sub-shrub, 30–60 cm (12–24 in) tall with hairy stems. Leaves are green or purple; they are simple, petioled, with an ovate, up to 5 cm (2.0 in)-long blade which usually has a slightly toothed margin; they are strongly scented and have a decussate phyllotaxy. The purplish flowers are placed in close whorls on elongated racemes

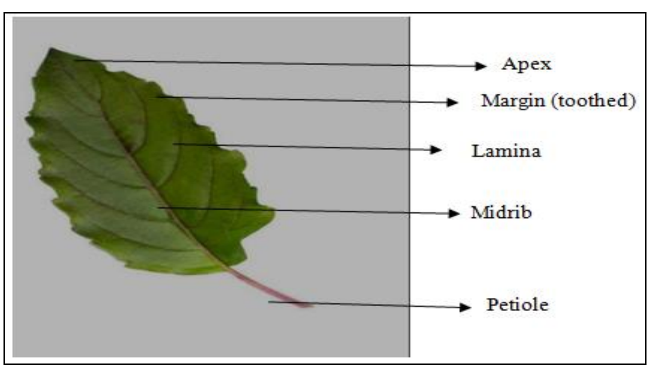

FIG. 5: MACROSCOPIC CHARACTERISTICS

Microscopic Characteristics: The young stem is quadrangular in outline. The outermost layer is the epidermis composed of tangentially elongated isodiametric cells and covered by their cuticle. The hypodermis is slightly collenchymatous. The cortex is parenchymatous with air space. Vascular bundles are collateral and open. Xylem (Xy) is without fiber tracheid with libriform fibers. The pith in the center consists of lignified parenchymatous cells. sclerenchyma and fibers, at the end of the large phloem vascular bundles are present. Scleranchymatous tissue surrounds the phloem group of vascular bundles [13].

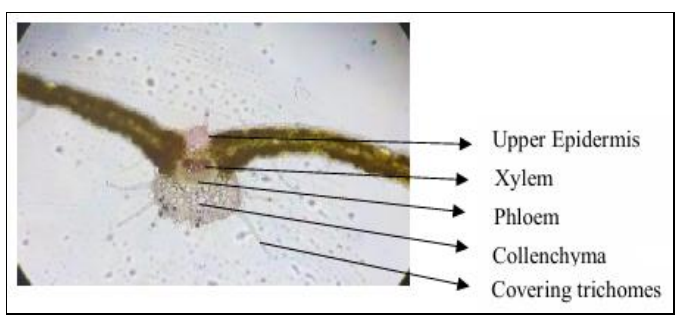

FIG. 6: MICROSCOPIC CHARACTERISTICS

Therapeutic Use: The Ocimum species has been suggested to possess antifertility, anticancer, antidiabetic, antifungal, antimicrobial, hepato-protective, cardioprotective, antiemetic, anti-spasmodic, analgesic, and diaphoretic actions. It is a popular home remedy for many ailments such as wounds, bronchitis, liver diseases, catarrhal fever, otalgia, lumbago, hiccough, ophthalmia, gastric disorders, genitourinary disorders, skin diseases, various forms of poisoning and psychosomatic stress disorders. Leaves of this plant are used for antipyretic, analgesic, antioxidant, antibacterial, antifungal, anti-inflammatory, and anticancer activity. In the Indian Materia Medica tulsi leaf extracts are described for treatment of bronchitis, rheumatism, and pyrexia. Reported therapeutic uses include the treatment of epilepsy, asthma or dyspnea, hiccups, cough, skin and hematological diseases, parasitic infections, neuralgia, Mid rib Petiole Lamina Apex Margin (toothed) Upper Epidermis Xylem Phloem Collenchyma Covering trichomes headache, wounds, inflammation, and oral conditions. The juice of the leaves has been applied as a drop for earache, while the tea infusion has been used for the treatment of gastric and hepatic disorders. The roots and stems were also traditionally used to treat mosquito and snake bites and for malaria [14].

CONCLUSION: Essential oils from clove, vetiver, and tulsi exhibit a variety of pharmacological and medicinal qualities. The connection between historical customs and modern pharmacy is shown by their incorporation into existing formulations. Their applicability in the health and wellness industries may be increased by more research into synergistic mixes and improved extraction techniques. Because of their unique pharmacognostic profiles, the essential oils of vetiver (*Vetiveria zizanioides*), clove (*Syzygium aromaticum*), and tulsi (*Ocimum sanctum*) are useful in both conventional and alternative medicine. Eugenol, a compound abundant in clove oil, has strong antibacterial, analgesic, and anti inflammatory effects. Tulsi oil is well known for its adaptogenic, immunomodulatory, and antibacterial properties. It is rich in ursolic acid and eugenol. Vetiver oil has sedative, anti-inflammatory, and antioxidant properties due to its complex sesquiterpene composition. All of these oils show a broad range of therapeutic effects, which supports their use in formulations that address a variety of illnesses, including inflammation, infections, and problems linked to stress. Given their potential for synergy, the trio is even more valuable in holistic treatments, underscoring the need for additional study and development to maximize their use in pharmaceutical sciences and pharmacognosy.

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