

REVIEW ARTICLE

ESSENTIAL OILS: PHARMACOPeIAL IDENTIFICATION TESTS AND USES

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ABSTRACT

Essential oils are recognized for their medicinal importance since ancient time and they continue to be of paramount significance, proved by the number of studies conducted in biological sciences in recent years. This review deals with the chromatographic techniques for the identification of essential oils, their components, and medicinal uses. The various identification tests for essential oils described in the British Pharmacopoeia (BP) involve physical, chemical, and chromatographic tests. The focus of this study is chromatographic techniques which are based on thin layer chromatography (TLC) and gas-liquid chromatography (GLC). The techniques are presented in a tabular form which mentions its chromatographic conditions like stationary phase, mobile phase, methods of detection and the compounds detected in different essential oils by these techniques. Silica gel is the most commonly used stationary phase in TLC whereas macrogol 20000, bonded macrogol 20000 or poly (dimethyl) (diethyl) siloxane supported on fused silica as a stationary phase is commonly used in GLC. The mobile phase in TLC varies from toluene to its combination with ethyl acetate or menthol in different ratios while the mobile phase in GLC is helium. The detection methods used for TLC are UV light and chemical reactions whereas the detector used in GLC is flame ionization. The components of essential oils identified by these techniques are up to 10 or more. Almost all essential oils possess antioxidant, anticancer, antimicrobial, anti-inflammatory and insect repellent properties along with other specific properties.

Keywords: Essential oils, gas-liquid chromatography, identification tests, thin-layer chromatography.

1. INTRODUCTION

Herbal drugs are mainly whole, fragmented, or broken plants, parts of the plant, algae, fungi or lichen, in an unprocessed state, usually in dried form but sometimes fresh. Certain exudates that have not been subjected to a specific treatment are also considered to be herbal drugs. Herbal drugs are precisely defined by the botanical scientific name according to the binominal system (genus, species, variety, and author)¹.

Essential oils are odorous products, usually of complex composition, obtained from a botanically defined plant raw material by steam distillation, dry distillation, or suitable mechanical process without heating. Essential oils are usually separated from the aqueous phase by a physical process that does not significantly affect their composition. The

essential oil may be subjected to a suitable subsequent treatment. Thus an essential oil may be commercially known as being deterpenated, desesquiterpenated, rectified or 'x'-free¹.

Physical and chemical tests for the identification of essential oils and herbal drugs are described in various Pharmacopoeias. These tests are used to establish the identity, purity, and quality of the medicinal compounds. They provide a mean of verifying that the identity of the material being examined is in accordance with the label on the container. The identification tests for herbal drugs are carried out at a temperature of about 25°C¹. In the present review, the various identification tests described for essential oils in the British Pharmacopoeia (BP) are presented.

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2. IDENTIFICATION TESTS OF ESSENTIAL OILS

The various identification tests for essential oils described in the BP¹ involve physical, chemical, and chromatographic tests. The physical tests involve the determination of relative density, refractive index, optical rotation, freezing point, etc. The chemical tests include acid value and peroxide value. The chromatographic methods are based on thin-layer chromatography (TLC) and

gas-liquid chromatography (GLC) to check the purity and composition of the material and to detect the impurities present. All these tests are used to confirm the purity, identity, and quality of the essential oils. The physical and chemical tests for essential oils are given in Table 1 and the TLC and GLC conditions for the detection of chemical components of essential oils are reported in Table 2. The essential oils may contain up to ten or more terpenes and other components.

Table 1. Physical and chemical tests for the identification of essential oils¹

Essential Oil	Relative Density	Refractive Index	Optical Rotation	Acid Value
Star anise oil	0.979–0.985	1.553–1.556	+15° to +19°	–
Caraway oil	0.904–0.920	1.484–1.490	+65° to +81°	Maximum 1.0 ^a
Cassia oil	1.052–1.070	1.600–1.614	–1° to +1°	–
Ceylon cinnamon bark oil	1.000–1.030	1.572–1.591	–2° to +1°	–
Clove oil	1.030–1.063	1.528–1.537	–2° to 0°	–
Coriander oil	1.860–1.880	1.462–1.470	+7° to +13°	–
Citronella oil	0.881–0.895	1.463–1.475	–4° to +1.5°	–
Eucalyptus oil	0.906–0.927	1.458–1.470	0° to +10°	–
Bitter fennel fruit oil	0.961–0.975	1.528–1.539	+10.0° to +24°	–
Juniper oil	0.857–0.876	1.471–1.483	–15° to –0.5°	–
Lavender oil	0.878–0.892	1.455–1.466	–12° to –6.0°	Maximum 1.0 ^b
Lemon oil	0.850–0.858	1.473–1.476	+57° to +70°	–
Mandarin oil	0.848–0.855	1.474–1.478	+64° to +75°	–
Dementholised mint oil	0.888–0.910	1.456–1.470	–16.0° to –34°	Maximum 1.0 ^b
Cineol type niaouli oil	0.904–0.925	1.463–1.472	–4° to +1°	–
Nutmeg oil	0.885–0.905	1.475–1.485	+8° to +18°	–
Dwarf pine oil	0.857–0.868	1.474–1.480	–7° to –15°	–
Pine sylvestris oil	0.855–0.875	1.465–1.480	–9° to –30°	Maximum 1.0
Rosemary oil	0.895–0.920	1.464–1.473	–5° to +8°	Maximum 1.0
Sage oil	0.890–0.908	1.456–1.466	–26° to –10°	Maximum 1.0
Spanish sage oil	0.907–0.932	1.465–1.473	+7° to +17°	Maximum 2.0 ^a
Tea tree oil	0.885–0.906	1.475–1.482	+5° to +15°	–
Turpentine oil	0.856–0.872	1.465–1.475	–40° to –28°	Maximum 1.0

^a Determined on 5.0 g.

^b Determined on 5.0 g of the substance to be examined, dissolved in 50 ml of the prescribed mixture of solvents.

Table 2. Chromatographic tests for the identification of components of essential oils¹

Chromatographic Conditions						
Essential Oil / Source	TLC			GLC		
	Stationary Phase	Mobile Phase	Detection	Compound Detected	GLC System	Detection
Star anise oil (<i>Illicium verum</i>)	Silica gel F ₂₅₄	Ethyl acetate-toluene (7:93 v/v)	Ultraviolet light at 254 nm or spray with methyl 4-acetyl benzoate reagent and heating at 100–105°C for 10 min; Examine the still hot plate in daylight within 10 min	Anethole, anisaldehyde, linalool	Column: fused silica l = 30 m, ϕ = 0.25 mm; Stationary phase: macrogol 20000 (film thickness 0.25 μ m); Carrier gas: helium with a flow rate of 1.0 ml/min; Split ratio: 1:1	Flame ionization
Caraway oil (<i>Carum cari</i>)	Silica gel F ₂₅₄ (4–40 μ m) or silica gel (2–10 μ m)	Ethyl acetate-toluene (5:95 v/v)	Ultraviolet light at 254 nm or spray with anisaldehyde solution and heating at 100–105°C for 5–10 min; Examine immediately in daylight	Carvone, carveole	Column: fused silica l = 30 m, ϕ = 0.53 mm; Stationary phase: macrogol 20000; Film thickness 1 μ m; Carrier gas: helium with a flow rate 1.5 ml/min; Split ratio 1:50	Flame ionization
Cassia oil (<i>Cinnamomum cassia</i> Blume)	Silica gel	Methanol-toluene (10:90 v/v)	Ultraviolet light at 365 nm or spray with anisaldehyde solution, examine in daylight while heating at 100–105°C for 5–10 min	Coumarin, trans-cinnamic aldehyde	Column: fused silica l = 60 m, ϕ = 0.25 mm; Stationary phase: bonded macrogol 20000; Carrier gas: helium with a flow rate of 1.5 ml/min; Split ratio 1:100	Flame ionization
						Trans-cinnamic aldehyde, cinamyl acetate, eugenol, trans-2-methoxycinnamaldehyde, coumarin

Ceylon cinnamon bark oil (<i>Cinnamomum verum</i>)	Silica gel	Methanol-toluene (10:90 v/v)	Spray with anisaldehyde solution and heating at 100–105°C for 5–10 min; Examine in daylight	Trans-cinnamic aldehyde, eugenol, linalool, α -caryophyllene	Column: fused silica l = 60 m, ϕ = 0.25 mm; Stationary phase: bonded macrogol 20000; Carrier gas: helium with a flow rate of 1.5 ml/min; Split ratio: 1:100	Flame ionization	Cineole, linalool, β -caryophyllene, saffrole, trans-cinnamic aldehyde, eugenol, coumarin, trans-2-methoxycinnam aldehyde, benzyl benzoate
Clove oil (<i>Eugenia caryophyllus</i> , <i>Syzygium aromaticum</i>)	Silica gel F ₂₅₄	Toluene	Ultraviolet light at 254 nm or spray with anisaldehyde solution; Examine in daylight while heating at 100–105°C for 5–10 min.	Eugenol, acetyl eugenol, beta-caryophyllene.	Column: fused silica l = 60 m, ϕ = 0.25 mm; Stationary phase: macrogol 20000; Carrier gas: helium with a flow rate of 1.5 ml/min; Split ratio: 1:100	Flame ionization	Eugenol, acetyl eugenol, β -caryophyllene
Corriander oil (<i>Coriandrum sativum</i>)	Silica gel F ₂₅₄ (5–40 μ m) [or silica gel F ₂₅₄ (2–10 μ m)]	Ethyl acetate-toluene (5:95 v/v)	Treat with anisaldehyde solution and heating at 100–105°C for 5 min; Examine in daylight	Linalool, geranyl acetate	Column: fused silica l = 60 m, ϕ = 0.25 mm; Stationary phase: macrogol 20000 (film thickness 0.25 μ m); Carrier gas: helium with a flow rate of 1 ml/min; Split ratio: 1:65	Flame ionization	α -pinene, limonene, gamma-terpinene, ρ -cymene, camphor, linalool, α -terpineol, geranyl acetate, geraniol
Citronella oil (<i>Cymbogon winterianum</i>)	Silica gel	Ethyl acetate-toluene (10:90 v/v)	Spray with anisaldehyde solution and heating at 100–105°C for 10 min; examine in ultraviolet light at 365 nm	Citronellal, citronellol, geraniol, (neral and geraniol may be absent)	Column: fused silica l = 60 m, ϕ = 0.25 mm; Stationary phase: macrogol 20000 (0.2 μ m); Carrier gas: helium with a flow rate of 1 ml/min; Split ratio: 1:100	Flame ionization	Limonene, citronellal, citronellyl acetate, neral, geraniol, geraniol acetate, citronellol, geraniol

Eucalyptus oil (<i>Eucalyptus globulus</i> labill. <i>Eucalyptus polybaratea</i> and <i>Eucalyptus smithi</i>)	Silica gel (5–10 μm) [or silica gel (2–10 μm)]	Ethyl acetate-toluene (10:90 v/v)	Spray with anisaldehyde solution and heating at 100–105°C for 5–10 min; Examine in daylight	α -pinene, beta pinene, α -phlenderene, limonene, 1, 8-cineole, (sabinene and camphor may be present in the chromatogram)	Column: fused silica l = 60 m, ϕ = 0.25 mm; Stationary phase: macrogol 20000 (film thickness 0.25 μm); Carrier gas: helium with a flow rate of 1.5 ml/min; Split ratio: 1:50	Flame ionization	α -pinene, β -pinene, sabinene, α -phlenderene, limonene, 1,8-cineole, camphor
Bitter fennel fruit oil (<i>Foeniculum vulgare</i> Miller, var. <i>ssp. vulgare</i> , var. <i>vulgare</i>)	Silica gel	Ethyl acetate-toluene (5:95 v/v)	Spray with the freshly prepared 200 g/L solution of phosphomolybdic acid in ethanol (96%) and heating at 105°C for 15 min; Examine in daylight	Anethol, Fenchone.	Column: fused silica l = 60 m, ϕ = 0.25 mm; Stationary phase: macrogol 20000 (film thickness 0.25 μm); Carrier gas: helium with a flow rate of 1 ml/min; Split ratio: 1:200	Flame ionization	α -pinene, limonene, fenchone, estrogole, cis-anethole, trans-anisaldehyde
Juniper oil (<i>Juniperus communis</i> L.)	Silica gel	Ethyl acetate-toluene (5:95 v/v)	Treat with anisaldehyde solution and heating at 100–105°C until the zone appears; Examine in daylight	Terpinen-4-ol α -terpineol	Column: fused silica l = 30 m, (a film thickness of 1 μm may be used) to 60 m (a film thickness of 0.2 μm may be used), ϕ = 0.25–0.35 mm; Stationary phase: poly (dimethyl) (diphenyl) siloxane; Carrier gas: helium with a flow rate of 2.0 ml/min; Split ratio 1:50	Flame ionization	α -pinene, β -pinene, sabinene, β -myrcene, α -phlenderene, limonene, terpinen-4-ol, bornyl acetate, β -caryophyllene

Lavender oil (<i>Lavandula angustifolia</i> Mill.), (<i>Lavandula officinalis</i> chaix))	Silica gel (5–40 μm) [or silica gel (2–10 μm)]	Ethyl acetate-toluene (5:95 v/v)	Spray with anisaldehyde solution and heating at 100–105°C for 5–10 min; Examine in daylight	Linalyl acetate, 1, 8-cineole, linalool	Column: fused silica l = 60 m, ϕ = 0.25 mm; Stationary phase: macrogol 20000 (film thickness 0.25 μm); Carrier gas: helium with a flow rate of 1.5 ml/min; Split ratio: 1:50	Flame ionization	Limonene, 1, 8-cineole, 3-octanone, camphor, linalool, linalyl acetate, terpinen-4-ol, lavandulyl acetate, lavandulol, α -terpineol
Lemon oil (<i>Citrus lemon</i> L. Burman fil.)	Silica gel GF ₂₅₄	Ethyl acetate-toluene (15:85 v/v)	Ultraviolet light at 254 nm and 365 nm	Bergamotin, citral, 5 geranyloxy-7-methoxycoumarin, citropten, psoralen derivatives biakangelicin	Column: fused silica l = 30 m, (a film thickness of 0.2 μm may be used), ϕ = 0.25–0.53 mm; Stationary phase: macrogol 20000; Carrier gas: helium with a flow rate of 1.0 ml/min; Split ratio 1:100	Flame ionization	β -pinene, sabinene, linonene, α -terpinene, β -caryophyllene, neral, α -terpineol, nerl acetate, geranial, geranyl acetate
Mandarin oil (<i>Citrus reticulata</i> Blanco)	Silica gel (5–40 μm) [or silica gel (2–10 μm)]	Ethyl acetate-toluene (15:85 v/v)	Ultraviolet light at 365 nm or spray with a 200 g/L solution of phosphomolybdic acid in ethanol (96%) and heat at 100°C for 10 min; Examine in daylight.	Guaiazulene, α -terpineol	Column: fused silica l = 60 m, ϕ = 0.25 mm; Stationary phase: poly (dimethyl) (diphenyl) siloxane (film thickness 0.25 μm); Carrier gas: helium with flow rate of 1.4 ml/min; Split ratio 1:70	Flame ionization	α -pinene, β -pinene, sabinene, β -myrcene, ρ -cymene, limonene, γ -terpinene, methyl n-methylanthranilate

Matricaria oil (<i>Matricaria recutita</i> L.) (<i>Chamonilla recutita</i> L. Rauschaert))	Silica gel	Ethyl acetate-toluene (5:95 v/v)	Examine in day light or spray with anisaldehyde solution and heating at 100–105°C for 5–10 min; Examine immediately in daylight	Chamazulene, en-yne-dicycloether, (-)- α -bisabolol	Column: fused silica l = 30 m, (a film thickness of 1 μ m may be used) to 60 m (a film thickness of 0.2 μ m may be used), ϕ = 0.25–0.53 mm, when using a column longer than 30 m, an adjustment of the temperature programmed may be necessary; Stationary phase: macrogol 20000; Carrier gas: helium with flow rate of 1–2 ml/min; Split ratio 1:100	Flame ionization	β -farnesene, bisabolol oxide B, bisabolone, (-)- α -bisabolol, chamazulene bisabolol oxide A
Dementholised mint oil (<i>Mentha bcanadensis</i> L., <i>Mentha aruensis</i> , separation of menthol by crystallization)	Silica gel F ₂₅₄	Ethyl acetate-toluene (5:95 v/v)	Ultraviolet light at 254 nm or spray with anisaldehyde solution and heating at 100–105°C for 5–10 min; Examine in daylight	Carvone, pulegone, menthyl acetate, menthol	Column: fused silica l = 30 m, (a film thickness of 1 μ m may be used) to 60 m (a film thickness of 0.2 μ m may be used), ϕ = 0.25–0.53 mm; Stationary phase: macrogol 20000; Carrier gas: helium with flow rate of 1.5 ml/min; Split ratio 1:100	Flame ionization	Limonene, cineole, menthone, isomenthone, menthylacetate, isopulegol, menthol, pulegone, carvone
Cineol type Niaouli oil (<i>Melaleuca quinquenervia</i>)	Silica gel (5–40 μ m) [or silica gel (2–10 im)]	Ethyl acetate-toluene (5:95 v/v)	Treat with anisaldehyde solution and heating at 100–105°C for 3 min; Examine in daylight	1, 8-cineole	Column: fused silica l = 60 m, ϕ = 0.25 mm; Stationary phase: macrogol 20000 (film thickness 0.25 μ m); Carrier gas: helium with a flow rate of 1.3 ml/min; Split ratio 1:50	Flame ionization	α -pinene, α -pinene, linonene, 1, 8-cineole, p-cymene, benzaldehyde, α -terpineol, trans-nerolidol, viridiflorol

Nutmeg oil (<i>Myristica fragrans</i>)	Silica gel	Ethyl acetate-toluene (5:95 v/v)	Spray with vanillin reagent, heating at 100–105°C for 10 min; Examine in daylight	Myristicine, saffrole, hydrocarbons	Column: fused silica l = 25–60 m, ϕ = about 0.3 mm; Stationary phase: bonded macrogol 20000 (film thickness 0.25 μ m); Carrier gas: helium with a flow rate of 1.5 ml/min; Split ratio: 1:100	Flame ionization	α -pinene, β -pinene, car-3-one, linonene, terpinen-4-ol, γ -terpinene, myristicine, saffrole
Dwarf pine oil (<i>Pinus mugo</i>)	Silica gel (5–40 μ m) [or silica gel (2–10 μ m)]	Ethyl acetate-toluene (5:95 v/v)	Spray with anisaldehyde solution and heating at 100–105°C for 5–10 min; Examine in daylight	Bornyl acetate	Column: fused silica l = 60 m, ϕ = 0.25 mm; Stationary phase: macrogol 20000 (film thickness 0.25 μ m); Carrier gas: helium with a flow rate of 1.5 ml/min; Split ratio: 1:50	Flame ionization	α -pinene, camphene, β -pinene, car-3-one, β -myrcene, limonene, β -phellandrene, p-cymene, terpinolene, bornyl acetate, β -caryophyllene
Pine Silvestris oil (<i>Pinus sylvestris</i> L.)	Stationary phase: TLC silica gel plate R (5–40 μ m) [or TLC silica gel plate R (2–10 μ m)]	Ethyl acetate R, toluene (5:95 v/v)	Treat with anisaldehyde solution R and heat at 100–105°C for 5–10 min; Examine in daylight	Bornyl acetate hydrocarbons	Column: fused silica l = 60 m, ϕ = 0.22 mm; Stationary phase: macrogol 20000 (0.2 μ m); Carrier gas: helium with flow rate of 1.5 ml/min; Split ratio: 1:100	Flame ionization	α -pinene, camphene, β -pinene, car-3-one, β -myrcene, limonene, β -phellandrene, p-cymene, terpinolene, bornyl acetate, β -caryophyllene

Rosemary oil (<i>Rosmarinus officinalis</i>)	Silica gel	Ethyl acetate-toluene (5:95 v/v)	Spray with vanillin reagent, heating the plate at 100–105°C for 10 min and examine immediately in daylight	Bronyl acetate, cineole, broneol	Column: fused silica l = 30 m (a film thickness of 1 µm may be used) to 60 m (a film thickness of 0.2 µm may be used), $\phi = 0.25-0.53$ mm; Stationary phase: macrogol 20000; Carrier gas: helium with a flow rate of 1.5 ml/min; Split ratio: 1:50	Flame ionization	α -pinene, camphene, β -pinene, car-3-one, β -myrcene, limonene, cineole, ρ -cymene, camphor, bronyl acetate, α -terpineol, broneol, verbenone
Sage oil (<i>Salvia sclarea</i> L.)	Silica gel	Ethyl acetate-toluene (5:95 v/v)	Spray with vanillin reagent, heating the plate at 100–105°C for 10 min and examine in daylight within 5 min	α -terpineol, linalyl acetate, linalool	Column: fused silica l = 30 m (a film thickness of 1 µm may be used) to 60 m (a film thickness of 0.2 µm may be used), $\phi = 0.25-0.53$ mm; Stationary phase: macrogol 20000; Carrier gas: helium with a flow rate of 1.5 ml/min; Split ratio: 1:100	Flame ionization	α -thujone, β -thujone, linalool, linalyl acetate, α -terpineol, germacrene-D, sclareol
Spanish sage oil (<i>Salvia lavandulifolia</i>)	Silica gel (5–40 µm) [or silica gel (2–10 µm)]	Ethyl acetate-toluene (5:95 v/v)	Spray with a freshly prepared 200 g/L solution of phosphomolybdic acid in ethanol (96%) and heating at 105°C for 10 min; Examine in daylight	Cineole	Column: fused silica l = 60 m, $\phi = 0.25$ mm; Stationary phase: macrogol 20000 (film thickness 0.25 µm); Carrier gas: helium with a flow rate of 1.5 ml/min; Split ratio: 1:50	Flame ionization	α -pinene, sabinene, limonene, 1, 8-cineole, thujone, camphor, linalool, linalyl acetate, terpinene-4-ol, sabinyl acetate, α -terpinyl acetate, borneol

Tea tree oil (<i>Melaleuca alternifolia</i> , <i>Melaleuca linariifolia</i> , <i>Melaleuca dissiflora</i> and other species of <i>Melaleuca</i>)	Silica gel	Ethyl acetate- heptanes (20:80 v/v)	Spray with anisaldehyde solution and heating at 100–105°C for 5–10 min; Examine in daylight	Cineole, terpinen-4-ol, α -terpineol	Column: fused silica l = 30 m (a film thickness of 1 μ m may be used) to 60 m (a film thickness of 0.2 μ m may be used), ϕ = 0.25–0.53 mm; Stationary phase: macrogol 20000; Carrier gas: helium with a flow rate of 1.3 ml/min; Split ratio: 1:50	Flame ionization	α -pinene, sabinene, α -terpinene, limonene, cineole, γ -terpinene, ρ - cymene, terpinolene, terpinen-4-ol, aromadendrene, α -terpineol
Turpentine oil (<i>Pinus pinaster</i> and <i>Pinus</i> <i>massoniana</i> D. Don.)	Silica gel (5–40 μ m) [or silica gel (2–10 μ m)]	Ethyl acetate- toluene (5:95 v/v)	Treat with anisaldehyde solution and heating at 100–105°C for 5–10 min; Examine in daylight	α -caryophyllene, caryophyllene oxide	Column: fused silica l = 60 m, ϕ = 0.25 mm; Stationary phase: macrogol 20000 (film thickness 0.25 μ m); Carrier gas: helium with a flow rate of 1.5 ml/min; Split ratio: 1:50	Flame ionization	α -pinene, camphene, β -pinene, car-3-one, β -myrcene, limonene, longifolene, β -caryophyllene, caryophyllene oxide

3. USES OF ESSENTIAL OILS

Essential oils extracted from plants are used for many purposes. These oils are chemically heterogeneous in nature and are very complex. In the last few years, many biological properties of essential oils have been evaluated. The most recognized properties of essential oils are having antioxidant, anticancer and antimicrobial activities²⁻⁵. The biological properties of essential oils are discussed below.

3.1. Caraway Oil

Caraway oil possesses insecticidal, antioxidant and anticancer properties. It also bears antibacterial and antifungal activities. Its effectiveness in functional dyspepsia, abdominal discomfort and pain has been reported. In advanced stages of sepsis, it probably plays a protective role against oxidative stress. It is effective in the self-management of irritable bowel syndrome (IBS) and it is hepatoprotective as well⁶⁻¹³.

3.2. Cassia Oil

The antibacterial properties of cassia oil have been reported. Cinnamaldehyde is an important constituent of cassia oil, which is responsible for its anti-tyrosinase activity^{14,15}.

3.3. Clove Oil

Clove oil is used as an analgesic. It is also known for its anesthetic, antibacterial, antifungal, antioxidant, anti-parasitic, antithrombotic, antidotal, antiperspirant, antiseptic, carminative, deodorant, digestive, rubefacient, stimulant, stomachic, tonic, vermifugal and anti-inflammatory activities. It is also useful for various skin diseases including acne, pimples, skin irritations, skin burns and also used for skin sensitivity. Because of its warm nature, it plays an important role in treating vomiting, diarrhea and morning sickness. It is also used as mosquito repellent. It increases the primary as well as a secondary humoral immune response on administration. The compound found in essential oil, acetyl eugenol is a potent platelet inhibitor¹⁶⁻²⁷.

3.4. Matricaria Oil

It is extracted from shade dried flower by hydro-distillation and is commercially used in hair dyes and dyeing fabrics. It also possesses ulcer protective, spasmolytic and antiphlogistic activities. The compound present in this oil is α -bisabolol which shows analgesic, antibiotic, anti-inflammatory and anticancer activities. It is also reported to have fungicidal, antimycotic and antibacterial effects. This essential oil is well known for the treatment of skin conditions like psoriasis and minor skin inflammation, boils, burns, cuts and insect bites. Antihyperalgesic and antiedematous activities of matricaria oil in a rat model of inflammation were also reported²⁸⁻³⁴.

3.5. Citronella Oil

Citronella oil is an effective mosquito repellent and is also used in deodorants. It reduces colds, headaches, and menstrual irregularity. The antiseptic, antispasmodic, diuretic, and febrifuge properties of citronella oil have been reported. It possesses antifungal, antibacterial and antioxidant properties. It is also used in skin care products^{22,34-38}.

3.6. Cinnamon Oil

Cinnamon oil contains various bioactive compounds which exhibit anesthetic, antibacterial, antifungal, anti-inflammatory, antiulcer, and antiviral actions. Its hypotensive, antioxidant and strong lipolytic functions are also mentioned. It improves digestion, rheumatism, and immune system. It is also known to alleviate headaches, other pains, and menstrual cramps. Its anticarcinogenic activity has also been reported. Various terpenoids found in essential oils are believed to account for cinnamon's medicinal effects. It is very beneficial in the treatment of type 2 diabetes. The most important compounds found in cinnamon oil are eugenol and cinnamaldehyde. It is also effective as mosquitocidal, ovicidal and adulticidal^{26,27,34,39-46}.

3.7. Coriander Oil

Coriander oil possesses antioxidant, antiviral, antibacterial, antifungal, diuretic, expectorant, laxative, antipyretic, antiseptic properties and is also used as a drug for indigestion, against worms,

rheumatism, pain in the joints, bed cold, seasonal fever, nausea, vomiting, stomach disorders and aflatoxin. It possesses insecticidal, antirheumatic and antiarthritic activities and it helps to cure ulcer, spasm, and acts as an expectorant. It is anticarcinogenic, anticonvulsant, antihistaminic and hypnotic. It protects and soothes liver and cures inflammation^{34,47-55}.

3.8. Nutmeg Oil

Nutmeg oil is aromatic, stimulant and carminative but in large doses it acts as narcotic. Concentrated oil acts as rubefacient and volatile oil as laxative. It is used to treat urinary tract infections, halitosis, dyspepsia, flatulence, impotence, insomnia and diseases related to the skin. It has pronounced antimicrobial, insecticidal, antioxidant, antiangiogenic, antiamebic, antiparasitic, nematocidal and anticancer activity⁵⁶⁻⁶².

3.9. Fennel Oil

Fennel oil acts as a carminative, stimulant and has spasmolytic actions on the smooth muscles. It possesses antioxidant, hepatoprotective, anticancer, antibacterial, antiviral, antifungal, acaricidal, anti-inflammatory, antithrombotic, antihirutism and vasorelaxant activities. Fennel oil also acts as an antidiabetic agent and is also effective in cardiovascular diseases. It is also a remedy against nausea and its estrogenic activity has been reported. It reduces the intensity of contraction of smooth muscles, promotes menstruation, reduces the symptoms of female climacteric, and increases libido. It is effective in primary dysmenorrhea and is also used as a mosquito repellent⁶³⁻⁶⁹.

3.10. Eucalyptus Oil

It is used as an expectorant in chronic bronchitis and its antibacterial, antiviral and analgesic activities have also been reported. Its anti-inflammatory and antimicrobial activity has been studied and positive results were observed. It is also effective in asthma^{61,70-77}.

3.11. Turpentine Oil

Turpentine oil in small doses stimulates kidney and acts as a diuretic increasing the output of urine.

Turpentine oil with other volatile oil has been used as a carminative to relieve flatulence and as also act as an expectorant⁷⁸.

3.12. Rosemary Oil

It improves circulation, eases arthritis and rheumatic pain. It also relieves muscles cramps and fights against hair loss. It possesses antibacterial and antifungal activities; in fact it is more useful in the drug-resistance infections. The antioxidant, anti-inflammatory and antinociceptive effects of the oil have also been reported. Its effect on the digestive system, with relieving the symptoms of indigestion, constipation and colitis has been mentioned. It also has a tonic effect on liver and gallbladder. It maintains the blood pressure and prevents the hardening of arteries. It is used in the treatment or prevention of peptic ulcer, hepatotoxicity, bronchial asthma, ischemic heart disease, cancer and poor sperm motility. It is effective in hysteria and paralysis because of its nerve stimulant property. Its free radical scavenging activity is beneficial for the patients with dementia and Alzheimer's disease^{6,48,79-85}.

3.13. Dwarf Pine Oil

It is used as an analgesic ointment, in several cough and cold medicine, vaporizer fluids and nasal decongestants⁸⁶.

3.14. Pine-Silvestris Oil

It is a potent mucolytic agent and is also used for muscles and joint pain. Scott pine oil is also reported to have endocrine stimulating effect which gives adrenal support⁸⁶.

3.15. Tea-Tree Oil

It has antiviral, antibacterial, analgesic, antiprotozoal, anti-inflammatory, antioxidant, anticancer, antifungal and antimicrobial activities^{71,87-89}.

3.16. Sage Oil

Sage oil possesses antimicrobial, antioxidant and antifungal activities^{6,48,90}.

3.17. Lemon Oil

Lemon oil exhibits antidiabetic and

antihypertensive actions. It has shown activity against dementia induced by scopolamine. Its antibacterial and antioxidant activities have also been reported⁹¹⁻⁹³.

3.18. Mandarin Oil

It is reported for its antibacterial, antioxidant and anticancer activities. It is acaricidal and antiproliferative in nature⁹³⁻⁹⁵.

3.19. Spanish Oil

This oil is used as a regulator of redox balance. It is antibacterial, antioxidant and antifungal. Spanish sage oil is also helpful in the treatment of Alzheimer's disease. Its anticholinergic, antioxidant, anti-inflammatory and estrogenic activities have also been reported⁹⁶⁻¹⁰⁰.

3.20. Juniper Oil

It is a stimulating diuretic. It also acts as antibacterial and antifungal. The topical formulations containing juniper oil gives promising results in the treatment of acne. It has analgesic, antiseptic, antispasmodic, astringent, digestive, diuretic and sedative properties^{81,101-103}.

3.21. Niaouli Oil

It is reported to act as an antibacterial. It also has antifungal, anti-inflammatory, antiseptic, antispasmodic, aphrodisiac, carminative, sedative and tonic properties^{81,104}.

3.22. Peppermint Oil

This oil has an analgesic effect. It alleviates abdominal discomfort and pain. It also acts as antibacterial, anticarcinogenic, anti-inflammatory, antiparasitic, antispasmodic, antiviral and digestive^{10,73,81}.

3.23. Star-Anise Oil

In traditional medicines, it has been used for the treatment of skin inflammation, rheumatism, asthma, and bronchitis. It has been reported to possess potent antimicrobial properties. It also acts as an anti-inflammatory, anticholinergic, antioxidant, antifungal and antimycotoxigenic agent¹⁰⁵⁻¹⁰⁹.

3.24. Lavender Oil

It has antioxidant, antibacterial, antifungal, carminative, sedative and antidepressive properties. It is also effective for burns, insect bites, dysmenorrhea and menstrual cramps¹¹⁰⁻¹¹².

4. CONCLUSION

The importance of investigation of plant materials which have been used since ancient medicine as a potential source of biologically active compounds is scientifically high. In some health conditions, essential oils can be used as a non-medicinal product or combined with other conventional care under the consideration of safety and quality issues. Thus, the identification methods used for the detection of such compounds have relatively high value in the field of science. As per this review, the components of essential oils can be identified through TLC and GLC on the basis of their physical and chemical characteristics. Essential oils can be used for the development of new potentially useful therapeutic agents after detailed investigation and clinical trials. The scope of research on essential oils is huge and could be further exploited in future as a source of active compounds for the pharmaceutical industry.

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CONFLICT OF INTEREST

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