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Review Article

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# A REVIEW ON TERPENOIDS: SOURCES, ISOLATION AND CHARACTERISTICS OF MENTHOL AND CITRAL

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**Abstract**

Terpenoids represent a vast and chemically diverse class of natural products formed from isoprene building blocks, extensively distributed throughout plants, where they predominantly occur in essential oils.They play an important role in pharmacognosy due to their aromatic properties and significant pharmacological activities such as antimicrobial, anti-inflammatory, carminative, and analgesic effects. Menthol and citral are important monoterpenoid constituents commonly used in pharmaceutical, cosmetic, and food industries.Menthol is obtained mainly from Mentha piperita and related Mentha species, while citral is isolated from Cymbopogon citratus (lemongrass) and Cymbopogon flexuosus. Isolation of menthol is generally carried out by steam distillation of peppermint oil followed by cooling and crystallization, whereas citral is isolated by steam distillation and fractionation of lemongrass oil.

***Keywords:*** *Terpenoids, Menthol, Citral, Isolation, Identification, Pharmacognosy.*

## INTRODUCTION

Naturally occurring compounds are classified into several groups, among which terpenoids represent one of the largest and most diverse classes. Terpenoids are predominantly of plant origin, although a limited number have also been reported from microbial and animal sources. These compounds are largely responsible for the characteristic aroma and flavor of many plants and flowers due to their volatile nature. They are widely distributed in the leaves, fruits, and secretory tissues of higher plants, particularly in conifers, citrus species, and eucalyptus.The term *terpene* was originally introduced for compounds isolated from turpentine, a volatile liquid obtained from pine trees. Simple monoterpenes and sesquiterpenes constitute the major components of essential oils derived from plant sap and tissues, whereas diterpenoids and triterpenoids are generally non-volatile and are commonly found in plant gums and resins. Tetraterpenoids form a distinct subgroup known as carotenoids [1].

In contemporary usage, the term *terpenoids* encompasses both hydrocarbon terpenes and their oxygenated derivatives. By modern definition, terpenoids are plant-derived compounds based on the general formula $(C_5H_8)_n$, including their oxygenated, hydrogenated, and dehydrogenated forms. Structurally, these molecules are constructed from isoprene units, a concept formalized in the isoprene rule proposed by Otto Wallach, which states that terpenoid skeletons are built from two or more $C_5$ isoprene units. Thermal degradation of many terpenoids yields isoprene, further supporting this biosynthetic relationship. Terpenoids, also referred to as isoprenoids, constitute approximately 60% of known natural products, with more than 80,000 compounds identified to date, making them the largest class of plant secondary metabolites. They exhibit remarkable structural diversity and significant pharmacological potential, attracting considerable interest in medicinal chemistry. Many terpenoids display important biological activities and are utilized as therapeutic agents, flavoring substances, and fragrance ingredients.

In plants, terpenoids play essential ecological roles, functioning as defense compounds against pathogens and herbivores, as well as attractants for pollinators and predators of herbivores [2]. They also contribute to the characteristic colors and aromas of many species, such as the scent of eucalyptus, the flavors of cinnamon, cloves, and ginger, the yellow pigmentation of sunflowers, and the red coloration of tomatoes. Representative terpenoids include menthol, citral, camphor, ginkgolides from *Ginkgo biloba*, salvinorin A from *Salvia divinorum*, cannabinoids from *Cannabis* species, and β-carotene, a carotenoid precursor of vitamin A.

Terpenoids also serve as biosynthetic precursors of steroids and sterols in animals. In some cases, terpenoid moieties are covalently attached to proteins through a process known as isoprenylation, which enhances protein association with cell membranes.

From a pharmacognostic perspective, terpenoids are classified according to the number of isoprene units present: monoterpenoids ($C_{10}$, two units), sesquiterpenoids ($C_{15}$, three units), diterpenoids ($C_{20}$, four units), triterpenoids ($C_{30}$, six units), and tetraterpenoids ($C_{40}$, eight units, carotenoids) [3]. Further classification is based on structural features such as acyclic, monocyclic, and polycyclic frameworks, as well as functional groups. Several terpenoids have been developed into clinically important drugs, including artemisinin and paclitaxel (Taxol), highlighting their significance in modern therapeutics.

Identification of these terpenoids involves organoleptic evaluation, physical constants, and chemical tests. Menthol is characterized by its peppermint odor, cooling sensation, crystalline pharmaceutical, cosmetic, and food industries. Menthol is obtained mainly from Mentha piperita and related Mentha species, while citral is isolated from Cymbopogon citratus (lemongrass) and Cymbopogon flexuosus. Isolation of menthol is generally carried out by steam distillation of peppermint oil followed by cooling and crystallization, whereas citral is isolated by steam distillation and fractionation of lemongrass oil. Iddentification of these terpenoids involves organoleptic evaluation, physical constants, and chemical tests. Menthol is characterized by its peppermint odor, cooling sensation, crystalline nature, and positive tests such as ester formation. Citral is identified by its strong lemon-like odor, aldehydic nature, and positive Schiff's and Tollens' tests. These identification characteristics help in assessing purity, quality, and authenticity of the crude drugs and essential oils. Thus, menthol and citral represent important terpenoids with significant pharmaceutical and industrial value [4].

## KEY CLASSIFICATION BY ISOPRENE UNITS

- Monoterpenoids (C10): Two isoprene units (e.g., Limonene, Geraniol, Pinene).
- Sesquiterpenoids (C15): Three isoprene units (e.g., Artemisinin, Humulene, Farnesol).
- Diterpenoids (C20): Four isoprene units (e.g., Abietic acid, Taxadiene, Kahweol).
- Sesterterpenoids (C25): Five isoprene units (e.g., Manoalide).
- Triterpenoids (C30): Six is oprene units.

## MONOTERPENOIDS

Monoterpenoids are characterized by a $C_{10}$ carbon framework derived from two isoprene units and are structurally classified into acyclic, monocyclic, and bicyclic types. Members of each category may occur as simple unsaturated hydrocarbons or as oxygenated derivatives such as alcohols, aldehydes, and ketones [5]. Typical acyclic monoterpenoids include myrcene, citral, geraniol, lavandulol, and linalool. Prominent monocyclic representatives comprise α-terpineol, limonene, thymol, menthol, carvone, eucalyptol, and perillaldehyde. Bicyclic monoterpenoids are further differentiated based on the size of the second ring, with all classes containing a six-membered primary ring combined with a secondary ring of three, four, or five members. Compounds such as thujone and $\Delta^3$-carene belong to the 6+3 ring system, α- and β-pinene represent the 6+4 category, whereas borneol and camphor exemplify the 6+5 framework.

Sesterterpenoids constitute a comparatively small and rare subgroup of terpenoids, biosynthesized primarily via cyclization of the linear precursor geranylfarnesyl diphosphate (GFPP). Despite their limited occurrence, sesterterpenoids are distributed across higher plants, microorganisms, insects, and marine invertebrates-particularly sponges-and display a wide range of biological activities, including anticancer, anti-inflammatory, antiprotozoal, antitubercular, and antifeedant effects. The first characterized sesterterpene synthase, AcOS, was identified from *Aspergillus clavatus* and exhibits dual functionality as both a class I sesterterpene synthase and a prenyltransferase, highlighting the unique biosynthetic machinery involved in sesterterpenoid formation.

Sesquiterpenoids represent an exceptionally diverse group of natural products derived from the $C_{15}$ precursor farnesyl pyrophosphate (FPP). Their structural diversity originates from complex carbocation-driven cyclization reactions catalyzed by sesquiterpene synthases (STSs), which generate a wide array of hydrocarbon skeletons. These backbones are subsequently modified by regio- and stereoselective cytochrome P450 monooxygenases, leading to oxygenated derivatives. Both STSs and P450 enzymes belong to large supergene families distributed throughout bacteria, fungi, and plants, and together they play a central role in expanding terpenoid diversity [6].

## DITERPENOIDS

Diterpenoids are twenty-carbon terpenoids derived from four isoprene units. Although broadly distributed in nature and known for diverse biological activities, this class has received relatively limited attention. The discovery of paclitaxel, a taxane diterpenoid from

*Taxus brevifolia* (Pacific yew), has stimulated renewed research into diterpenoids.

**Forskolin, a diterpenoid:** Diterpenoids possess relatively high molecular weights, rendering them non-volatile and therefore essentially odorless. Owing to their pronounced lipophilic nature, these compounds often exhibit intense taste characteristics and are predominantly localized in plant resins. Unlike several other classes of secondary metabolites, diterpenoids rarely occur in glycosidic form. Although comprehensive pharmacokinetic data remain limited, their high lipophilicity suggests efficient oral absorption.Biologically, diterpenoids demonstrate a broad spectrum of pharmacological activities comparable to those observed for lower-molecular-weight terpenoids. Among the most notable examples is paclitaxel, a diterpenoid that exerts potent anticancer effects by stabilizing microtubules through promotion of tubulin polymerization, ultimately leading to apoptosis in rapidly dividing cancer cells.

## TRITERPENOIDS

Triterpenoids comprise a class of $C_{30}$ compounds biosynthesized from six isoprene units, originating from the linear precursor squalene [7]. These metabolites typically exhibit structurally complex cyclic frameworks and are most commonly encountered as alcohols, aldehydes, or carboxylic acids. Sterols represent an important subgroup of triterpenoids characterized by the cyclopentane perhydrophenanthrene nucleus.

In plants, sterolscollectively referred to as phytosterolssuch as β-sitosterol, stigmasterol, and campesterol are widely distributed across higher plant species. Less frequently occurring sterols, including α-spinasterol, an isomer of stigmasterol, have been reported in spinach, alfalfa, and senega root. Additional sterol variants are predominantly associated with lower plants, including algae and liverworts.

Triterpenoids are ubiquitous in nature and display substantial structural diversity, giving rise to multiple subclasses with distinct biological properties. Among these, triterpenoid saponins constitute a notable group of amphiphilic compounds recognized for their surfactant and foam-forming characteristics, which contribute to their wide range of pharmacological and industrial applications.They are often found in plants and have historically been used as detergents. Triterpenoid saponins have potential medicinal properties and are being studied for their anticancer effects.

**MENTHOL:** Menthol is a cyclic monoterpene alcohol that occurs naturally as a principal constituent of the essential oils of several Mentha species, particularly Mentha × piperita (peppermint). It is characterized by its distinctive mint aroma, cooling sensation, and diverse pharmacological properties, which underpin its extensive use in medicinal, flavoring, and cosmetic applications. Menthol is commonly isolated from mint leaves through steam distillation [8].

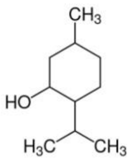
The genus *Mentha*, belonging to the family Lamiaceae, comprises aromatic perennial herbs widely cultivated for their essential oils and bioactive constituents. These plants are globally valued in food, beverage, cosmetic, and pharmaceutical industries, as well as in traditional and modern medicine for their digestive, analgesic, and antimicrobial activities. Major commercial species include peppermint (*M. piperita*), Japanese mint (*M. arvensis*), and spearmint (*M. spicata*), all of which are readily propagated and thrive in cool, moist environments. Peppermint extracts, rich in menthol, have been employed for centuries in traditional medicine for the management of infections, insomnia, gastrointestinal disorders, and as insect repellents.

Chemically, menthol is a monoterpenoid that appears as a colorless to white crystalline solid at room temperature, melting slightly above ambient conditions. The naturally predominant enantiomer is (−)-menthol, possessing the (1R,2S,5R) configuration. Menthol exerts its characteristic cooling effect primarily through activation of transient receptor potential channels, especially TRPM8 and TRPA1. Interaction with TRPM8 leads to increased intracellular calcium levels and subsequent signaling of cold perception at the site of application.

Beyond its sensory effects, menthol demonstrates a range of biological activities, including analgesic, cytotoxic, and antiproliferative effects in cancer cells. It also modulates γ-aminobutyric acid (GABA) receptors and sodium ion channels, contributing to its pain-relieving properties. Consequently, menthol is widely incorporated into topical formulations for minor pain relief and throat irritation due to its local anesthetic and counterirritant actions.

Despite its therapeutic potential, menthol-induced cold sensitivity has been reported to mask mucosal detection of nicotine and other toxins in mentholated tobacco products, raising concerns regarding possible adverse effects [9]. Nevertheless, menthol remains an important lead compound for drug development, owing to its ability to interact with multiple molecular targets and elicit diverse pharmacological responses. Historically and presently, mint-derived menthol continues to be valued for its cooling sensation, therapeutic benefits, and flavor-enhancing properties. Menthol induces a subjective feeling of nasal decongestion despite lacking objective decongestant activity, while nasal inhalation in humans has been shown to provide perceivedrelief from nasal obstruction.

Menthol



## EXTRACTION AND ISOLATION

### 1.Hydro distillation

- Take accurate weighed coarse powder of Mentha Piperita leaves.
- Extract the oil by water/hydro distillation method using Clevenger apparatus.
- Collect the oil (present above the water layer) from the collecting tube or separate the oil from water by using separating funnel and allow cooling.
- Crystals of menthol will separate out.
- Collect the crystals by centrifugation [10].
- Recrystallize menthol from acetone or any other suitable solvent of low boiling point.

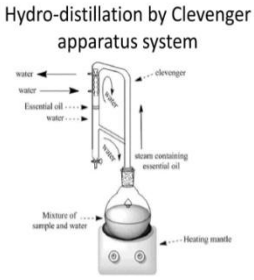


Fig 01: Clevenger apparatus

### 2. Steam distillation

An appropriate quantity of air-dried *Mentha* plant material is loaded into a stainless-steel distillation unit equipped with a perforated base. Steam generated under pressure in a boiler is introduced into the still and allowed to percolate through the plant matrix, facilitating the release of volatile constituents [11]. The resulting vapor mixture, comprising water vapor and essential oil, is directed into a condenser, where it is cooled and converted back into the liquid phase.

The condensate is collected in a separator, where mentha oil naturally rises to the surface due to its lower density relative to water. The oil layer is subsequently separated, decanted, and filtered to remove residual impurities. Upon cooling, menthol crystallizes from the oil and is collected for further purification.

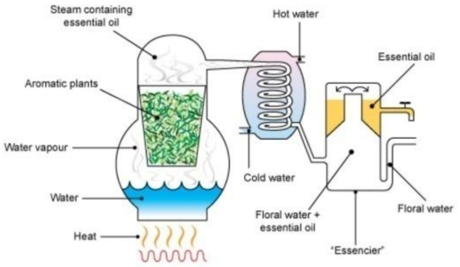


Fig 02: Steam distillation

### 3. Method of Isolation

Peppermint essential oil is initially obtained by combined steam and water distillation of *Mentha* plant material [12]. To eliminate residual moisture, the collected oil is dried by passing it through anhydrous sodium sulfate. The dehydrated oil is then transferred into tightly sealed containers and subjected to freezing at approximately −60 °C for seven days, leading to crystallization of menthol.

The resulting menthol crystals are recovered by filtration, while the remaining mother liquor contains residual menthol along with other terpene constituents. This filtrate is subsequently treated with boric acid and heated under reflux for approximately three hours, followed by distillation to remove menthone. The formed menthyl borate is then hydrolyzed by refluxing with sodium hydroxide solution, facilitating the liberation of additional menthol. After cooling, further menthol crystals separate out and are collected, combined with the initial fraction, and finally dried in a desiccator to obtain purified menthol [13].

### Identification

Take few crystals of menthol and mix with 5ml nitric acid and heat on water bath. Within a few minutes, the solution develops blue colour and after sometime, it becomes golden yellow colour which indicates the presence of menthol.10mg crystals of methanol first dissolved in 4 drops of conc. H2SO4, and then add few drops of Vanilline-H2SO4 reagent [14]. Formation of yellowish orange colour which on addition to water changes to violet. A few crystals of menthol aredissolved in acetic acid and a mixture of 3 drops sulphuric acid and 1 drop nitric acid is added to it. If it does not produce bluish or greenish colour, menthol is present. Take a few grams of menthol crystals in a porcelain dish and heat. All the menthol crystals are evaporated leaving no residue [15-20].

### Analysis by TLC

For chromatographic analysis, approximately 1 mg of menthol was dissolved in 1 mL of methanol to prepare the test solution, while authentic menthol was used as the reference standard. TLC was performed on silica gel 60 $F_{254}$ plates as the stationary phase. Development was carried out using either pure chloroform or a mixture of hexane and ethyl acetate (8:2, v/v) as the mobile phase [15]. After development, the plates were air-dried and visualized by spraying with 1% vanillin–sulfuric acid reagent followed by heating at 110 °C for 10 min. Alternatively, anisaldehyde–sulfuric acid reagent was employed with subsequent heating at 115 °C for 10 min to enhance spot visualization. Menthol exhibited Rf values in the range of 0.34 and 0.48–0.62 under the respective solvent systems.

### Utilization

Menthol is widely employed in multiple dosage forms for its cooling effect and flavoring capability, in addition to its carminative, antispasmodic, and antipruritic properties.

### Storage

It should be kept in airtight, well-closed containers, protected from light, and stored in a cool place.

## COMMERCIAL APPLICATIONS

**Analgesic/Counter-irritant:** Used in topicalcreams, gels, and patches for muscle pain, headaches (migraines, tension), and chest rubs, activating TRP channels (like TRPM8) for cooling and pain relief [16].

**Antimicrobial:** Shows antibacterial andantifungal activity, used in oral care (mouthwash, toothpaste) and potentially in formulations against resistant pathogens**.**

**Respiratory Relief:** Inhalers, cough drops,and nasal sprays for decongestion and soothing throat irritation.

**Gastrointestinal Aid: Enteric-coated:** capsules for Irritable Bowel Syndrome (IBS) due to carminative and smooth muscle relaxant effects.

**Penetration Enhancer:** Improves skinabsorption of other hydrophilic drugs (e.g., lidocaine, ketoprofen).

### Source of Menthol

### Natural Source

- Peppermint (Mentha piperita)
- Corn mint (Mentha arvensis)
- Japanese mint
- Synthetic Source
- Prepared chemically for large-scale pharmaceutical and cosmetic use [17].

### Characteristics

The leaves are shortly petiolate, measuring approximately 5 cm in length and 2–4 cm in width, with finely serrated margins and smooth surfaces on both sides. The stems typically attain heights of 60–120 cm and often exhibit a purplish coloration. The flowers are reddish-violet and arise in the axils of the upper leaves, forming loose, interrupted inflorescences. The plant possesses a characteristic aromatic odor, and when tasted initially produces a warm, pungent sensation followed by a distinct cooling effect in the oral cavity, attributable to the presence of menthol. During storage, the essential oil gradually becomes thicker and acquires a reddish hue; however, prolonged storage is reported to enhance its mellowness, even over extended periods of up to 14 years. From a pharmacognostic perspective, menthol occurs as white crystalline solids with a characteristic mint aroma, sharp taste, and pronounced cooling action. It exhibits a melting range of approximately 41–44 °C and is sparingly soluble in water while readily soluble in organic solvents such as alcohol, ether, and chloroform. These physicochemical properties are of particular importance in its extraction, purification, and formulation for topical therapeutic preparations and flavoring applications [18].

### Here are its key physical properties

**Appearance:** Colorless to white crystalline solid, sometimes waxy or flaky.

**Odor:** Strong, characteristic, pleasant peppermint smell.

**Taste:** Pungent, followed by a distinct cooling sensation (due to TRPM8 receptor activation).

**Melting Point:** Around 41-44°C (106-111°F), varying slightly with purity [19].

**Solubility:** Slightly soluble (sparingly soluble) in water, but highly soluble in ethanol, ether, chloroform, and other organic solvents.

## MORPHOLOGICAL CHARACTERS

The plant exhibits a distinctive aromatic odor and an initially pungent taste followed by a pronounced cooling sensation. The stem is herbaceous and perennial, quadrangular in cross-section, and ranges in color from green to dark purple. It is nearly glabrous, bearing occasional scattered, deflexed hairs [20]. Leaves are arranged oppositely in a decussate pattern and are petiolate, with ovate to lanceolate morphology. Leaf coloration varies from light to dark green, often accompanied by a purplish tint. The adaxial (upper) surface is dark green and almost glabrous, whereas the abaxial (lower) surface is lighter in color and exhibits pubescence along the veins. The leaf apex is acute, with an acute to rounded base, and the margins are distinctly and sharply serrated. The petiole is relatively long and slightly hairy.

## CITRAL

Citral ($C_{10}H_{16}O$) is a pale yellow liquid characterized by a strong lemon-like aroma and is chemically identified as 3,7-dimethyl-2,6-octadienal. It is insoluble in water but readily soluble in organic solvents such as ethanol, mineral oil, and diethyl ether. Citral is extensively utilized in the manufacture of perfumes and other fragrance compounds. Chemically, citral consists of a mixture of two geometrical isomers, geranial and neral, which possess identical molecular formulas but differ in structure. Owing to its distinctive and pleasant lemon fragrance, citral is highly valued in the flavor and fragrance industries. Furthermore, citral serves as an important precursor in the synthesis of aroma chemicals such as methyl ionone and ionone [21].

## CITRAL

**Biological source** –Citrali samono terpene aldehyde obtained from the oils of lemon grass (Cymbopogon flexuosus). Family – Gramineae (Poaceae).

### Chemical Constituents

It contains methyl heptanone, geraniol, limonene, citronellal, β-terpineol, decyl aldehyde, etc.

### Citral – Occurrence

Citral is an acyclic monoterpenoid. It occurs abundantly in:

- **Lemon myrtle** (cultivated in Australia)
- **Lemongrass** (India, Southeast Asia, and Africa)
- **Lemon tea-tree** (Kenya, South Africa, and Australia)
- **Lemon balm** (south-central Europe, North Africa, the Mediterranean region, and Central Asia)

### Biological Source (B.S.)

Lemongrass oil is obtained from *Cymbopogon flexuosus* or *Cymbopogon citratus* (family **Gramineae/Poaceae**). Lemongrass oil contains about **75–85% citral**.

Figure 03: Citral

**Physical properties of citral** Citrali saclear yellow-colored liquid with a lemon-like odor. Themelting point of citralis less than−10°C. The density of citral is about 0.9 $g/cm^3$.22

**Stability:** Citral is unstable in the presence of alkanes and strong acids. When heated to decomposition, it gives off acrid smoke and irritating fumes [22].

**Isolation of Citral:** Citral is obtained from lemongrass oil, which is extracted from lemongrass by steam distillation.

**Method:** Chopped or whole lemongrass is placed in a distillation flask for the process.

### Isolationo fcitral

Lemongrass oil is shaken with 5% sodium bisulphite solution for 25–30 minutes

↓

The resulting adduct is separated using a funnel and washed with solvent ether or ethanol

↓

Citral is regenerated by decomposing the sodium bisulphite adduct with dilute sodium hydroxide solution

↓

Citral is obtained free from citral impurities during the regeneration process from the bisulphite adduct

↓

Neral (citral B) is isolated from the citral mixture by shaking with alkaline cyanoacetic acid solution

↓

Citral A and Citral B are separated based on melting point differences, where

- Citral A has a melting point of 108°C
- Citral B has a melting point of 110°C

### Characterization of citral

Citral is an acyclic monoterpenoid aldehyde ($C_{10}H_{16}O$) that occurs naturally as a major constituent of essential oils obtained from *Cymbopogon citratus* (lemongrass), *Litsea cubeba*, citrus peels, and several other aromatic plants. Structurally, citral exists as a mixture of two geometric isomers: geranial (citral A, trans-isomer) and neral (citral B, cis-isomer), which together account for its intense lemon-like aroma.

Physically, citral appears as a pale yellow to colorless liquid with a strong citrus odor. It is practically insoluble in water but readily soluble in organic solvents such as ethanol, ether, chloroform, and hexane. Owing to its aldehydic functional group, citral is chemically reactive and susceptible to oxidation and degradation under acidic conditions, light, and elevated temperatures, necessitating careful storage.

From an analytical perspective, citral is commonly characterized using thin-layer chromatography, gas chromatography, and spectroscopic techniques such as IR, NMR, and MS. In IR spectra, citral exhibits characteristic absorption bands corresponding to the aldehyde carbonyl group and conjugated double bonds. Chromatographic analysis typically resolves the two isomeric forms, geranial and neral, enabling qualitative and quantitative assessment.

Biologically, citral demonstrates a broad spectrum of pharmacological activities, including antimicrobial, anti-inflammatory, antioxidant, and anticancer effects. In addition to its therapeutic potential, citral is extensively employed in the flavor and fragrance industries and serves as an important intermediate in the synthesis of vitamin A, ionones, and other value-added aroma chemicals.

### Thin-layer chromatography (TLC)

Thin-layer chromatography was performed using silica gel G as the stationary phase. Plate development was carried out employing either cyclohexane–ethyl acetate (85:15, v/v) or hexane–ethyl acetate (90:10, v/v) as the mobile phase. Prior to sample application, TLC plates (Merck, Germany; 20 × 20 cm, 0.25 mm thickness) were activated by heating at 110 °C for 10 min.

Test solutions were prepared by dissolving 5 μL of the sample in 1 mL of methanol. Aliquots of 5 μL each of standard menthol and the analyzed wild mint oil were carefully spotted onto the activated plates and allowed to air-dry. The plates were then developed in the respective solvent systems and subsequently dried.23

Visualization of the separated components was achieved using iodine vapor and UV illumination. Authentic menthol was employed as the reference standard. Under these chromatographic conditions, menthol exhibited Rf values in the range of 0.45–0.50, confirming its presence in the investigated samples.

### Identification test

- Citral is very sensitive to oxidizing agent and yield linalool which have intense yellow colour.
- Geranial with tollens reagent (ammonical silver nitrate) gives geranic acid.
- Giranil upon hydrogenation with sodium amalgum in acidic solution gives citronellol.
- Geranial gets converted into p-cymene on treatment with potassium bisulphate or dil H2SO.

### USES

Citral is extensively utilized in the fragrance and flavor industries and serves as an important intermediate in the synthesis of several value-added chemicals, including vitamin A. In addition to its industrial significance, citral exhibits notable biological activities. It demonstrates insect-modulating properties, functioning as a mild repellent against certain species, and has also been reported to act as a sex pheromone in the green-veined white butterfly, where it is released by males to attract females. Furthermore, citral possesses pronounced antimicrobial activity, contributing to its growing interest as a natural bioactive compound in pharmaceutical and agricultural applications [24].

## CONCLUSION

Terpenoids, commonly known as isoprenoids, constitute one of the largest families of natural organic compounds and are extensively distributed in plants, where they are key contributors to the sensory properties and biological activities of essential oils and plant-derived extracts. Menthol, a cyclic monoterpenoid predominantly sourced from Mentha species (especially Mentha × piperita and Mentha canadensis), is typically isolated by steam distillation of mint oils followed by fractionation and purification. It also occurs in several stereoisomeric forms, although (−)-menthol is the primary biologically active and commercially important isomer. Citral is typically extracted by steam distillation or solvent-based methods and further purified by fractional distillation and chromatographic techniques. It serves as a key intermediate in flavor and fragrance industries and exhibits antimicrobial, antioxidant, anticancer, anti-inflammatory, and other bioactivities.

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