



# The five most traded compounds worldwide: importance, opportunities, and risks

**Farha Abdul Khaliq\* and Ayesha Mushtaq**

Department of Chemistry, University of Agriculture Faisalabad, Pakistan.

## Abstract

Demand of essential oil is increasing day by day due to its usage in the production of air fresheners, lotions, and other items. Countries that cannot produce desirable essential oils in enough quantities to meet the local demand must import them from some of the other countries. This article is designed to compile data of most traded essential oil compounds which are menthol, menthone, carvone, eugenol and linalool and are registered by EU as flavoring agent in food. The yearly consumption of menthol in all forms is estimated to exceed 7,000 metric tonnes, with a raw product value nearing \$300 million. Menthol is one of the world's most extensively used flavours and scents, with over 30,000 metric tonnes used each year. In 2000, the industry estimate for global linalool production was 12,000 tonnes. Over half of this is considered to be synthesized, while the remaining derived from naturally occurring plant terpenes. Unlike synthetic aromas, which can resemble some herbal aromas, essential oils are increasingly in demand due to increased knowledge of their health advantages validated by new discoveries, making them more attractive and appealing to customers. On that point, the essential oil industry's future appears bright, with new opportunities in the cosmetics and perfumery sectors. Their capability to impart a wide variety of unique and pleasant odors in cosmetic items, also as bioactive agents in anti-aging, antibacterial, UV protection, and whitening makes them highly desired components in cosmetic and personal care products.

**Keywords:** Essential oil, Steam Distillation, Trading of Compounds, Menthol, carvone

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## 1. Introduction

Essential oil is a volatile odoriferous oil that can be extracted from the essential parts of plants, such as leaves, bark, buds, seeds, and flowers [1-2]. Essential oils are products found in aromatic plants, and their odor and flavor depend on their constituents present in them [3-5]. Essential oil is a multicomponent mixture. Using advanced and well-calibrated analytical instruments, the identification of more than 400 chemical components is possible [6]. Terpenes are the largest group of chemicals present in essential oil [7-8]. Terpenes are made of 5-Carbon isoprene units ( $C_5H_8$ ). Classes of terpenes are based on isoprene units, but sesquiterpenes and monoterpenes are the most important constituents of essential oils [9]. Monoterpenes ( $C_{10}H_{16}$ ) has 2 isoprene units while sesquiterpenes ( $C_{15}H_{24}$ ) has 3 isoprene units [10-11].

EO mostly consist of lipophilic constituents and volatile secondary metabolites of plants with an estimated molecular weight of approximately 300, which may be physically separated from membranous tissues or plant components [12-13]. As defined by the International Organization for Standardization, the term 'essential oil' is often used to describe products derived from raw vegetable

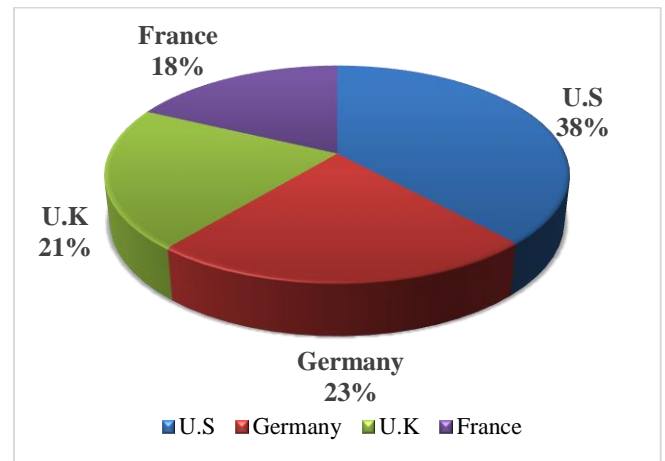
resources by distillation with water or steam [14]. Essential oils may be extracted from the stalks of many citrus fruits by mechanical pressing, generally known as dry distillation [15] [16-17]. Essential oils consist of volatile and non-volatile fractions. The volatile fraction was 90-95% which is consisted of monoterpenes and sesquiterpenes and their oxygenated derivatives (esters, aliphatic aldehydes, and alcohols). 5-10% of the whole oil is a non-volatile fraction that consists of fatty acids, sterols, waxes, carotenoids, and flavonoids [18-19]. People who use EO products have found that certain oils have distinctive effects on the central nervous system (CNS), such as improving intelligence, impacting sleep, boosting learning and memory, anti-anxiety and anti-depression, and drowsiness [20-21]. Aromatherapy can be defined as the use of EO in a number of methods, including inhalation through the nose, oral treatment, and oil massages [22]. Some researchers, nurses and doctors have experimented with aromatherapy in therapeutic treatment [23-25]. EOs are complex mixtures of volatile organic molecules that often contain over 500 components. Some compounds, such as camphene and linalool, are found in a number of plant EOs [1-9-26]. Some EOs have distinct constituents such as menthol and camphor [27]. Lavender

EO is a well-known EO that mostly consists of linalool acetate, linalool, perillyl alcohol, and (Eucalyptus globulus) [5-28]. Following data shows the market demand of essential oil from 2018-2025 worldwide (Table 1).

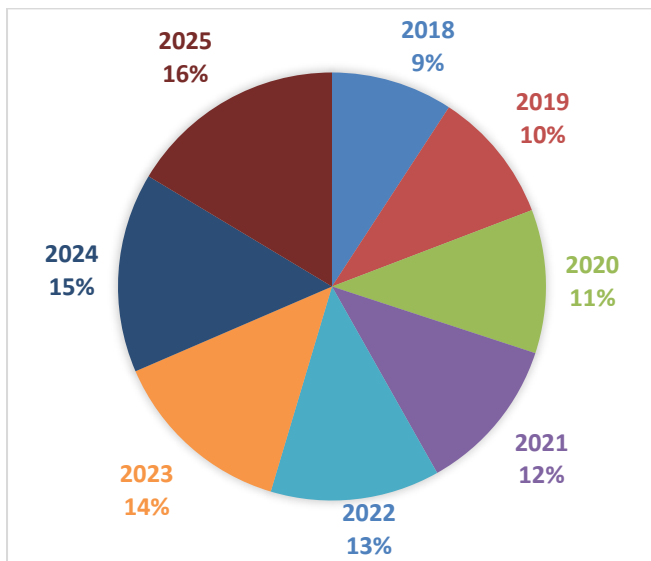
**Table 1.1:** Market demand of essential oil from 2018-2025 [29]

Year	Demand (Kilotons)
2018	226.9
2019	246.4
2020	276.6
2021	290.6
2022	315.6
2023	342.8
2024	372.2
2025	404.2

market share in the United States. Furthermore, France is the world’s largest supplier of essential oils and has a longstanding tradition of perfume production. In recent years, exportation of EO by the United States has increased by two billion dollars. Furthermore, certain countries that are unable to produce desirable EO in sufficient amounts to meet market demand need to buy from others. As For example, Lebanon imported the most essential oils in 2017, totaling more than 13.75 billion US dollars, while Northern European countries such as, the Netherlands, Germany and the U.K contributed almost 80 percent of total of orange essential oil import to Europe [30]. Top exporters and importers of EO in the world are illustrated in Fig. 2-3 [31].



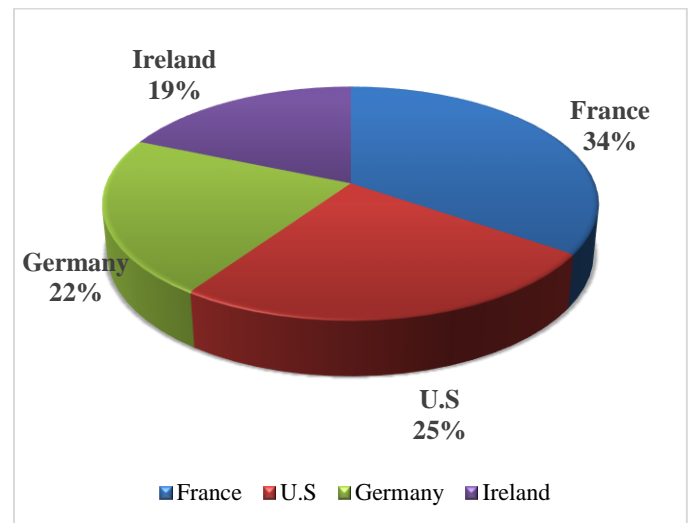
**Fig.2.** Top exporters of essential oil in 2016 [32]



**Fig.1.** Market demand of essential oil worldwide from 2018-2020 [29]

**2. Trading of essential Oil**

Europe holds a major share of the global essential oil market, with Asia Pacific (APAC) and Northern America coming in second and third places, respectively. EO are used to produce air fresheners, lotions, and other items. The essential oil sector in the US increased revenue by approximately 10% in 2017 and was predicted to reach a market value of roughly 7.3 billion dollars by 2024. Eucalyptus, corn mint, and orange EO have the highest



**Fig.3.** Top importers of essential oil in 2016 [32]

### 3. Five Most traded Compounds Worldwide

Following are the five most traded compounds worldwide Menthol, Eugenol, Menthone, Carvone and Linalool.

#### 3.1. Menthol

Menthol, a naturally produced cyclic monoterpene alcohol from a plant source, imparts a characteristic aroma and flavor to plants of *Mentha* species. In Japan, the peppermint plant, the major source of menthol, has been grown for therapeutic purposes for over two thousand years [33-35]. Menthol is a monocyclic terpene alcohol that produces a variety of isomers and has three asymmetrical C atoms in its ring (cyclohexane) (fig.4). When applied to the skin, the l-menthol isomer has a typical minty odor and flavor, as well as a cooling effect [36]. The other menthol isoforms have different taste and lacks the characteristic chilly effect that is produced by l-menthol [37].

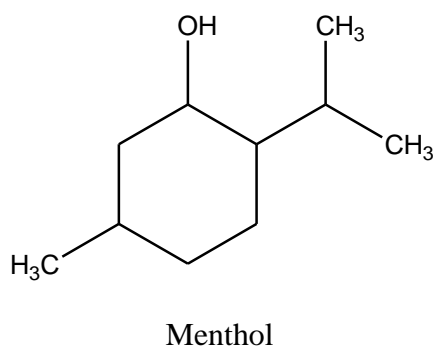


Fig. 4. Chemical Structure of Menthol

The odor of synthetic l-menthol is altered by impurities that develop during the crystallization process; therefore, natural menthol is often preferred [38-39]. When chewed, consumed, inhaled, or applied to the skin, menthol is known for its ability to chemically activate cold-sensitive transient receptor potential cation channels. This results in a cooling effect or a sensation [40]. Menthol cigarettes have lower cessation rates than non-menthol cigarettes [34]. Menthol is extensively used as an antibacterial, anesthetic, soothing, and external antipruritic compound. It is estimated that 30,000 (metric tons) of menthol is consumed annually [41]. The monoterpene you are referring to is likely menthol, which is widely utilized in a wide range of goods, including candies, drinks, tobacco products, mouthwash, and sports goods. It can be used externally in the form of sprays or gels, or internally as a mouth rinse or beverage. Menthol has a cooling effect, which is why it is sometimes used by athletes as a performance enhancer by mimicking the effects of cold [42].

*Mentha Arvensis* L. (menthol mint), is recognized and valuable due to high concentration of menthol in its oil [43]. Menthol is used in the food, medication, cosmetic, and perfumery sectors worldwide. Menthol, also known as a monoterpene alcohol, is one of the most common components of mint oil. Menthol is a distinctive and beneficial plant component that gives *mentha* plants a minty odor. Menthol exhibits a variety of reviving and cooling qualities or sensations when ingested, chewed, consumed, or topically applied to the skin because of its role in chemically

activating the cold-sensitive transient potential receptor cation channel. According to research, menthol is the most effective antifungal [44].

#### 3.1.1. Opportunities and Risks

Menthol is mostly naturally derived; in 2007, its worldwide production was 19,000 tonnes [37]. The yearly consumption of menthol in all forms is estimated to exceed 7,000 metric tonnes, with a raw product value of \$300 million. Menthol is synthesized commercially in several processes and is manufactured in pure crystalline form from steam-distilled essential oil of corn mint [45-46]. Because of its biological significance, biocatalyst potential, and especially high commercial demand for (-) menthol, which was 31,000 t/US-\$ 373-401 million annually indicated in 2016, (-) menthol and enzymes related to the biosynthesis process have received significant attention [47]. Since 2014, the market value of menthol has increased gradually. Fig.5 shows the market value of menthol in years 2014-2023.

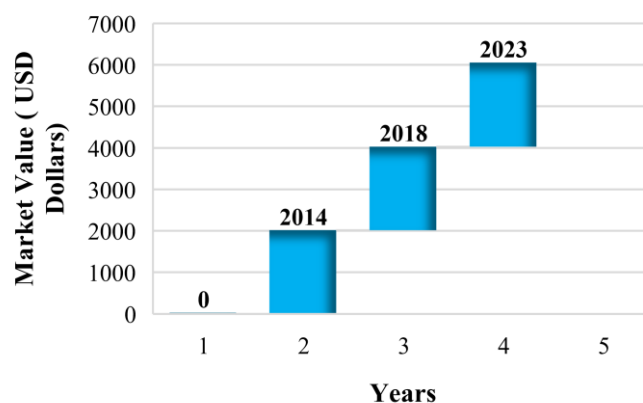


Fig. 5. Market value of Menthol worldwide 2014-2023 [48]

Inhaling large quantities of menthol vapor throughout the course of a workday may cause irritation in some people. This finding is comparable to a number of other studies that show that high doses of menthol can cause temporary irritation of the mucous membranes and the skin in certain conditions [49].

#### 3.2. Eugenol

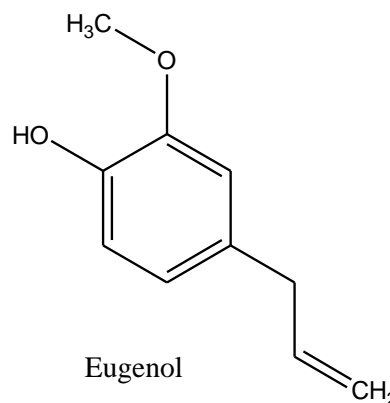


Fig. 6. Chemical Structure of Eugenol

Eugenol, with the molecular formula  $C_{10}H_{12}O_2$ , 2-methoxy-4-(2-propenyl) phenol, is a guaiacol with an allyl chain replacement (fig.6). It is a transparent, pale yellow, oily liquid that is moderately soluble in water and highly soluble in organic solvents. For their topical anesthetic qualities, clove oil and eugenol have been utilized in dental plasters, fillings, and cements. It is also used as a local antiseptic and analgesic in addition to these reasons. Both clove and eugenol are utilized in the aroma and food coloring industries [50].

The constituents of cloves can be used to produce a wide variety of essential oils. While the oil derived from clove leaves primarily contains eugenol (82-88%), very little eugenyl acetate, and other minor components, the oil extracted from clove flower buds primarily contains eugenol (60-90%), eugenyl acetate, caryophyllene, and other compounds. Ninety% to 95% of the eugenol in clove twig oil is eugenol. Additionally, synthetic eugenols can be produced by allylating guaiacol with allyl chloride [51-52].

Tulsi leaves also have high eugenol content, often ranging from 40-71%. Eugenol content in various parts of plants fluctuates seasonally. According to research, the fall season has the highest eugenol output when compared to the summer season [53]. It is an aromatic compound present in various plants including cinnamon, nutmeg, and clove. It is an important herbal substance owing to its potent health-promoting properties. Eugenol was first isolated from leaves and buds of the clove plant *Eugenia caryophyllata*. Guaiacol can be allylated with allyl chloride to produce eugenol, which has the same functional characteristics [54].

Eugenol increases skin penetration of several medicines. During storage, they are also applied to crops as fumigants and pesticides to prevent the growth of bacteria such as *Lactobacillus* and *Listeria monocytogenes* [55]. It ding has been found impactful against a variety of lifestyle related threats such as migraine headaches, gastrointestinal problems, hormonal problems, cholesterol level abnormalities, high blood pressure, increased blood sugar levels, fungal infection, chronic inflammation, and mutagenesis [56].

### 3.2.1. Opportunities and Risks

In 2022 worldwide trading of eugenol was decreased as compared to 2021. Fig 7 shows the worldwide trading of Eugenol in recent years.

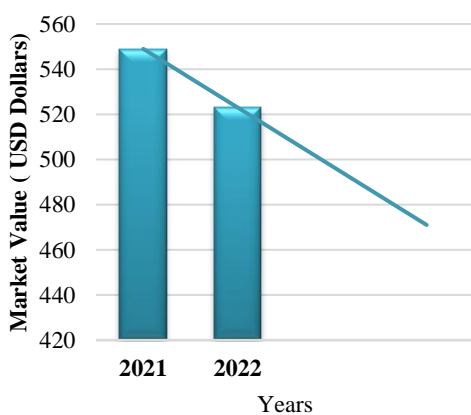


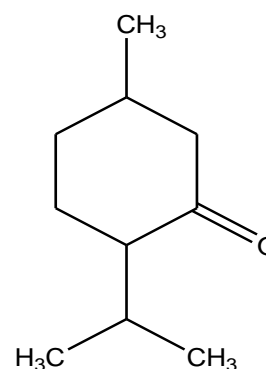
Fig .7. Worldwide Trading of Eugenol [57]

Despite its numerous beneficial characteristics, eugenol can also induce inflammation and allergies. Due to the use of eugenol in dentistry, there have been cases of allergic contact dermatitis exhibiting as hand rashes in dentistry technicians, such as dentists or nursing assistants, as well as allergic contact gums or burning oral sickness [58]. Methyl eugenol is not recommended for use as a cosmetic ingredient. The highest concentration of methyl eugenol in the final product should not be greater than that in perfumes (0.01%), eau de toilette (0.04%), deodorant (0.002%), oral hygiene products (0.0002%), and washing products (0.001%) when fragrance compounds containing methyl eugenol, which occur naturally in essential oils, are used as components in cosmetic products [59].

Certain adverse effects due to use of eugenol-containing dental products include acute skin irritation, ulcers, contact allergic dermatitis, cell lysis, poor healing, and, in rare cases, anaphylactic shock [60]. Eugenol is cytotoxic in high quantities and harmful to fibroblasts and osteoblast-like tissues. Therefore, it causes necrosis and slows healing at high concentrations. All patients could be affected by this effect in a dose-dependent manner. At small doses, eugenol can act as a skin allergen, resulting in a localized delayed-type hypersensitivity reaction. Ingestion of eugenol occasionally results in a more serious generalized allergic reaction. According to reports, one critically ill patient who having undergone a pulpotomy with ZnO and eugenol cement experienced anaphylactic-like shock [60].

### 3.3. Menthone

Menthone is a monoterpene with a minor smell that naturally occurs in a variety of essential oils. The most common isomeric form in nature is l-menthone, also known as (2S,5R)-trans-2-isopropyl-5-methylcyclohexanone. It is similar in structure to menthol, except that it contains a secondary alcohol instead of a carbonyl. Owing to its distinctive fragrant and minty smell, menthone is utilized as a flavoring agent, perfumery, and beauty product. Menthone is found in the essential oils of *Mentha arvensis*, peppermint, geraniums, and others. Menthone has been originally produced in 1881 by oxidizing menthol before being identified in EO in 1891[61].



Menthone

Fig.8. Chemical Structure of Menthone

Menthone has a minty aroma identical to menthol and is naturally found in peppermint oil. Menthone, like menthol, is utilized as an active component and in asymmetric syntheses [62].

### 3.3.1. Opportunities and Risks

By preventing histamine release from antigen-induced rat peritoneal mast cells, menthone was found to be effective at lowering type I allergic reactions [63]. From a statistical perspective, Germany is the top exporter of menthone because it supplies a large amount of menthone to other countries. Fig. 9 shows the major menthone exporters worldwide.

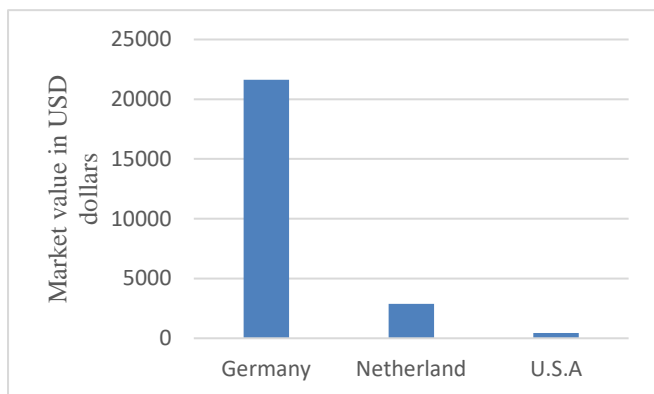
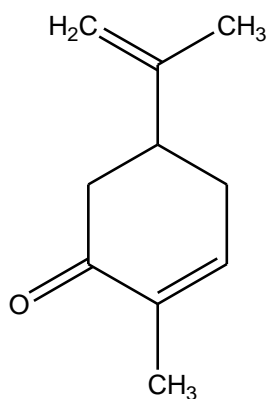


Fig. 9. Major Menthone Exporter Countries [64]

### 3.4. Carvone

Carvone, with the molecular formula C<sub>10</sub>H<sub>14</sub>O, is a monoterpenoid ketone found primarily in the essential oil of *Mentha* plants (67%) [65]. The monoterpenoid ketone carvone, p-mentha-6,8-dien-2-on, contains two optical antipodes for its chiral carbon in nature. The main component of *Mentha spicata* essential oil (Lamiaceae), which gives it a distinctive flavor and aroma, is the isomer R (-) carvone [66]. S (+) carvone, on the other hand, is the only antipode present in caraway essential oil (*Carum carvi* L. (Apiaceae)) and is responsible for the widely known caraway aroma [67].



Carvone

Fig.10. Chemical Structure of Carvone

D-carvone, an essential oil ingredient, is a colorless to light-yellow liquid. Caraway carvone has a warm, herbaceous, spicy, and flowery aroma. Carvone exerts anticancer and anthelmintic effects. Decomposing crystalline carvone compounds with hydrogen sulfide yielded pure carvone. Carvone is used in soap production to soap natural scents. Although carvone is a growing market, it has the potential to replace caraway seeds in the pharmaceutical and food markets [68]. Carvone is used as a taste and antibacterial agent in the skincare industry with an annual supply of over 3000 tons, the majority of which is produced by chemical synthesis. Despite the significant potentials and biological features of carvone and its derivatives, industrial usage of these chemicals has yet to grow and flourish [69].

In addition to being used in beauty products, mouthwash, bubble gum, and pharmaceuticals, caraway seeds are also used to flavor bread, cheese, cabbage, sweets, processed meats, condiments, and alcohol-based beverages. The main components of the seed were S (-) carvone (50–70 %) and (-) limonene (25–30 %). Pastries, sauces, veggies, sweet potatoes, meat and fish, fermented foods, and chutneys are all flavored with dill seeds. Approximately 40–60% of the dill seed oil is (S)- (-)-carvone. Most of the time, spearmint is used as a food. There is at least 51% (R)- (-)-carvone in spearmint oil[70].

### 3.4.1. Opportunities and Risks

Optical isomerism is significant in essential oil processing technologies because enantiomers of the same chemical frequently differ in odor, tone, and strength. For example, (S)-carvone smells like a dill, while (R)-carvone smells like cumin. Carvones may be derived from natural essential oils; however, chemical and biotechnological synthesis utilizing readily available limonene is currently more commonly used [71]. Inhaling R-carvone increased blood pressure and heart rate. As a result, back to the left form of carvone affects the central nervous system and increases activity in the brain. (S)-carvone, in its rightward form, activates the gastrointestinal system [72].

U.S is the major supplier of carvone worldwide. Fig 11 shows the major carvone supplier countries in 2018.

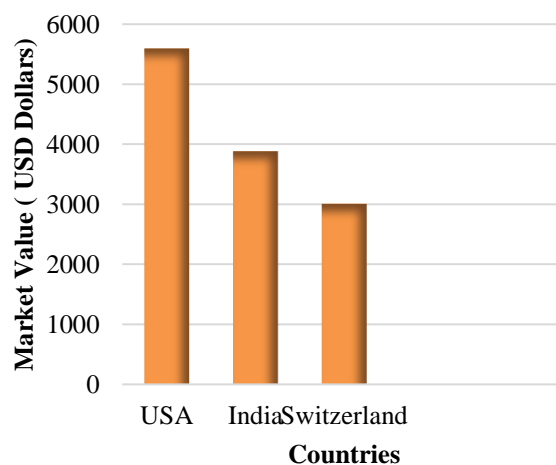
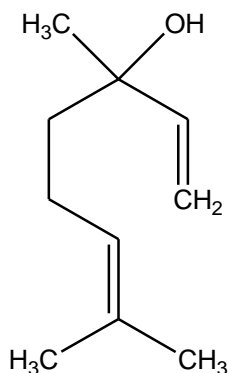


Fig .11. Carvone Supplier Countries [73]

### 3.5. Linalool

Linalool (3,7-dimethyl-1,6-octadien-3-ol) open chain monoterpene tertiary alcohol and one of nature's most important floral aromas. Linalool accounts for approximately 70% of the terpenoids in floral fragrances [74]. Linalool is an unsaturated monoterpene alcohol with the odour "soft and pleasant, floral-woody, with a touch of citrus [75]. Linalool is also the main component of several EO, and possess broad range of biological activities such as anti-bacterial and antiparasitic properties [76].



Linalool

Fig .12. Chemical Structure of linalool

Linalool is a major aromatic element in perfumery that appears in the top notes of many fragrances. As a result, linalool, primarily of synthetic origin, may be found in 60-90% of cosmetic goods such as Shampoos, body wash, soap, hairsprays, moisturizers, and deodorants [77]. Linalool is a fragrance component found in various fragrances. It may be found in cosmetics, fine aromas, hair products, personal care products, and other cosmetics, as well as in non-cosmetic products such as home cleansers and detergents. It is consumed in more than 1,000 metric tonnes per year worldwide [78]. Linalool and lavender essential oils have sedative-like behavioral effects by lowering anxiety, promoting parasympathetic neuronal activity, and reducing sympathetic nerve activity [79]. Epileptic diseases are chronic disorders that are caused by increased neural activity. Linalool and lavender oil have been shown to have the ability to reduce neuronal excitability in the context of anticonvulsant studies [80].

### 3.5.1. Opportunities and Risks

In 2000, the industry estimate for global linalool production was 12,000 t. Over half of this is synthesized, while the remainder is derived from naturally occurring plant terpenes [81]. Natural linalool is non-genotoxic and rarely induces allergic contact dermatitis [82]. Purified linalool production and industrial usage as an ingredient in fragrances, beauty products, cleansers, and surfactants, as a flavoring agent in food, and as a synthesizing intermediate, can be discharged into the environment by several industrial effluents. Linalool is readily biodegraded and does not accumulate in the marine environment. Its use as a pesticide causes direct discharge into the ecosystem. Linalool has very low toxicity to fish, algae, and daphnia in acute aquatic ecotoxicological testing [83]. Global linalool market value is

increasing day by day. Fig 13 shows the linalool market value.

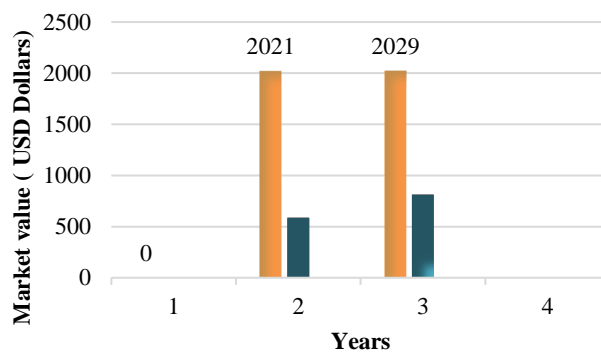


Fig.13. Global Linalool Market size [84]

## 4. Conclusion

In recent years, the interest in essential oils has increased. They are widely used as bioactive ingredients and aromas in the cosmetic industry. They are highly desirable ingredients in cosmetic and personal care products because of their capacity to impart a wide variety of distinctive and pleasant scents in cosmetic products, as well as their ability to act as anti-aging, antibacterial, UV protection, and whitening agents. As a result of the "back to nature" movement, herbal ingredients and fragrances are now used much more frequently than chemically synthesized and artificial ones, which are thought to be harmful to human health. Essential oils are more desirable and appealing to customers than synthetic aromas, which can resemble some herbal aromas owing to increased awareness of their health benefits supported by new discoveries. In this regard, the future of the essential oil industry seems promising, with fresh prospects in the cosmetics and perfumery industries. As complex mixtures of chemicals, some of which are known to be allergic and skin sensitizing agents, essential oils are typically thought to be nontoxic; however, they must be reported on cosmetic tags, particularly for consumers with sensitive, allergic skin, or chronic skin problems who may choose to spot test products before using them.

## 5. Future Perspective

Most traded essential oil components, menthol, Menthone, Carvone, Eugenol, and linalool, are registered by the EU as flavoring agents in food and have no health risks to consumers. However, their production cost is high and can be minimized only if they are produced commercially on a large scale. Therefore, switching from synthetic products to natural and organic products is required. The aroma and fragrance industries have an annual trade of \$ 18 billion, and the international trade in essential oils is growing at a 10% annual rate. The pricing of essential oils varies widely and is determined by the quality of the oil, price of the raw material, processing technique, oil yield, and popularity relative to its availability.

The price of lavender, which is also widely used as a scent in cosmetics, varies depending on the source. Bulgarian lavender, for example, is presently the costliest lavender, costing € 140-150 per kilogramme following consecutive droughts. According to industry estimates,

French lavender costs approximately € 100 per kilogramme. Rose oil (€ 8,000-9,000 per kilogramme) and sandalwood (approximately \$2,300-2,500 per kg) are costlier essential oils. Germany is a major and regular importer of oranges, peppermint, and other mint oils. Food companies frequently use these oils. Because of rising orange oil prices, Germany's imports of orange oil have increased significantly (14% annually over the last five years), reflecting the rest of Europe. Some essential oils, such as lavender, citrus, and mint oils, are widely traded and have established competitive markets. Significant quantities of these oils have been produced by European nations. To satisfy market and industrial needs, essential oil production and quality must be continuous, particularly in terms of elemental composition. Demand is largely determined by global economic growth. Oil demand generally increases as the economy grows. Oil demand often falls when global economic development decreases.

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