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A SYSTEMATIC REVIEWS OF TERPENES & TERPENOIDS & THEIR ROLES IN HUMAN HEALTH

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ABSTRACT

Terpenoids are the predominant class of organic chemicals found in all organisms. Plant-derived aromatic compounds encompass bioactive constituents, particularly terpenes and terpenoids that can exhibit a diverse array of biological effects, such as, anti-inflammatory, antioxidant, antibacterial and antiallergic properties. The current state of research definitively demonstrates that essential oils (E0s) possess both food preservation and antimicrobial capabilities, making them a viable option for use in the food sector. The aim of this study is to provide a brief summary of the current understanding of the use of aromatic compounds in the pharmaceutical and medical fields, as well as their potential use as food preservatives in the food business. Over the past few decades, there has been an increasing worldwide effort to encourage the use of natural goods in daily life. One example of a natural product is products derived mineral oils. Aromatic compounds from essential oils are a type of plant-based liquid that is highly concentrated, oil-resistant, and categorized based on its physical and chemical properties. Aromatic compounds pharmacological effects, which include antimicrobial, anthelminthic, antiviral, antioxidant, anti-inflammatory, and insecticidal characteristics, have been the subject of substantial investigation in a number of research

KEYWORDS: Aromatic compounds, Anticancer, Anti-inflammatory, food preservatives, Terpenes &, Terpenoids

INTRODUCTION

Terpenes and their oxidised derivatives, referred to as terpenoids, are predominantly produced by plants and are also present in fruits, flowers, trees, and spices. (1). They are a diverse group of organic compounds that occur naturally and are made up of isoprene units, each containing five carbon atoms, linked together in a specific arrangement. A wide variety of structures involving different levels of oxidation, unsaturation, functional groups, and ring closures are also possible for these compounds. This leads to a diverse array of structural categories and the continuous identification of novel frameworks. Due to their biological activity, the majority of them are extensively utilised as components of essential oils in diverse industries including tastes, scents, spices, perfumeries, cosmetics, and food additives.. (4–7). Terpenes serve as constituents in over-the-counter drugs, operate as active chemicals in pharmaceuticals, and function as excipients to enhance skin penetration (8). Terpenoids are a distinct group of hydrocarbons that contain oxygen. These are terpenes that have been altered by adding or removing functional groups and oxidised methyl groups at different positions. Terpenes are hydrocarbon compounds characterised by their uncomplicated structures, which encompass pinene, myrcene, limonene, terpinene, and p-cymene. The user's input is "(9)." The name "terpene" in 1866 was coined by Dumas, originating, Latin word "turpentine" which denotes a liquid extract made from pine trees. (10–11). Additional terpenes are present in the essential oils of certain plants, including citronellal (derived from lemon grass), geraniol (found in roses), menthol (obtained from mint), and S- and R-limonene (extracted from lemon and orange trees)(12). The parent nucleus of an organism can include one or more isoprene units, which is the basis for categorising terpenes and terpenoids (substances similar to terpenes) (13).Terpenoids are organic compounds that serve as important tools in drug discovery research, exhibiting diverse and fascinating biological activity with potential medical applications. Extensive studies in the fields of biology and chemistry have revealed a wide range of chemical, physical, and biological effects exerted by terpenoids. (14).

CLASSIFICATION OF TERPENES

Different kinds of terpenes are defined by the number of isoprene units (n) in the molecule. From monoterpenes (C10H16) to hemiterpenes (C_5H_8) , diterpenes ($C_{20}H_{32}$), sesquiterpenes (C15H24), triterpenes ($C_{30}H_{48}$), tetraterpenes ($C_{40}H_{64}$), and polyterpenes (C_5H_8), there are several families of these compounds (15). Isoprene can be produced in large quantities by oceanic phytoplankton, as well as by bacteria and animals. It appears that plants manufacture isoprene as a defense mechanism to safeguard other processes, like photosynthesis, from potential stress. (16).

HEMITERPENES

Hemiterpene is the most basic kind of terpene. These chemicals are distributed throughout many anatomical regions of plants, as depicted in (Figure 1). (17). Isoprene, a primary hemiterpene, is a naturally occurring volatile chemical that is commonly present in the environment and is emitted by leaves as a result of plant metabolism (18,19). Plants have the ability to synthesise several hemiterpenes, including angelic, isovaleric, and senecioic acids, as well as isoamyl alcohol, which contribute to the production of tastes and aromas. (20,21).

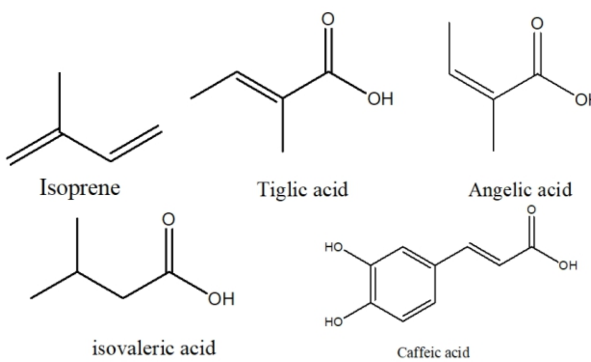

Fig. 1: Structure of Some Hemiterpenoids.

MONOTERPENES

Composed of ten carbon atoms and 2 isoprene units, monoterpenes which have the chemical formula $C_{10}H_{16}$. The fragrance company brags about its capacity to extract monoterpenes-important fragrant molecules present in nature in more than four different configurations-from the leaves, flowers, and fruits of different plants. The biotechnological synthesis of natural aromatic chemicals compounds utilized in the food and medicinal sectors also benefits greatly from these as starting materials. (22). It is known that monoterpenoids can be found in around 30 distinct carbon skeletons. (23) The Figure 2 shows that out of the total number, about 20 can be classified as bicyclic, acyclic or monocyclic . Unsaturated hydrocarbons and molecules having functional groups, including ketones, alcohols, and aldehydes, are the two main types of monoterpenoids.

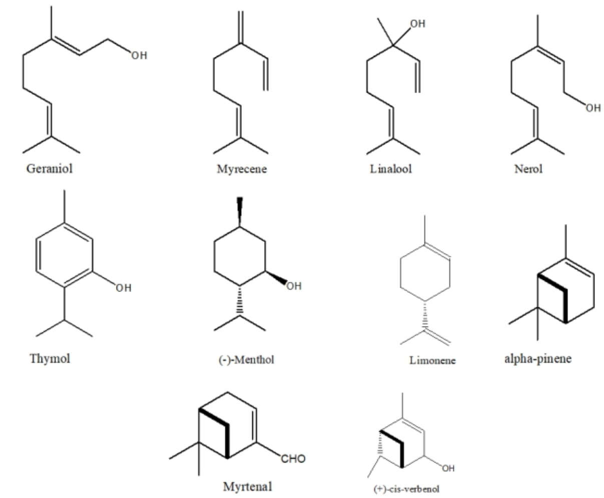

Fig. 2: Division of Monoterpenes (Acyclic, Monocyclic, and Bicyclic).

SESQUITERPENES

Sesquiterpenes are secondary metabolites that exist in linear, cyclic, bicyclic, and tricyclic structures. They consist of three isoprene units, each with a chemical formula of C15H24. In addition, lactone rings can be found as sesquiterpenes. Natural forms of these compounds include lactones, alcohols, acids, aldehydes, and ketones, as well as hydrocarbons in oxygenated forms (24). Sesquiterpenes are categorised into many classes based on their structure, namely whether they are cyclic or linear (Figure 3). Most sesquiterpenes possess cyclic structures, save for the basic farnesane and a small number of atypical acyclic sesquiterpenoids have been found in a wide range of pharmacological, including, antifungal (35–39), antibacterial (40), antiviral (39), antifeedant (32), anti-inflammatory (41–42), antinociceptive (43), antimalarial (25–29), cytotoxic (29–34) ,lymphocyte

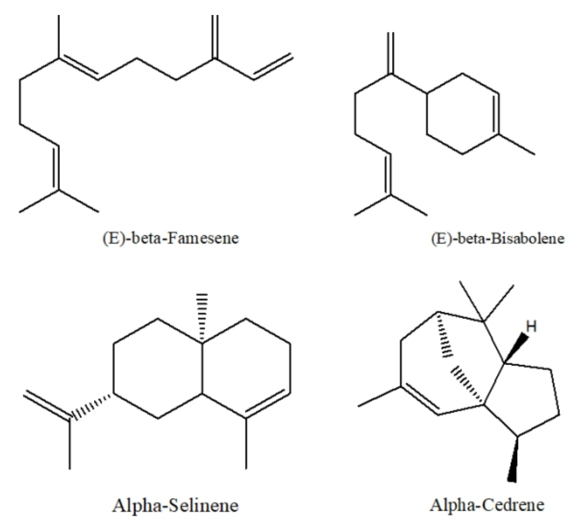

Fig. 3: Division of Sesquiterpenes (Acyclic, Monocyclic, Bicyclic, and Tricyclic).

proliferation, inhibition of NO production (41), antileishmanial (44), lipid peroxidation effect (45), and (-OH) radical scavenging.

DITERPENES

With a molecular formula of ($C_{20}H_{32}$) and four isoprene units, diterpenoids are a diverse group of chemical components. Figure 4 shows that they are present in a variety of natural places. The cytotoxic, anti-inflammatory, and anticancer effects of diterpenes are just a few of their numerous medicinal uses (46). Even though essential oils rarely contain volatile diterpenes, you might find a trace amount of them occasionally. Diaterpenes are categorised as either linear, bicyclic, tricyclic, tetracyclic, or pentacyclic according to their skeletal structure. (47).

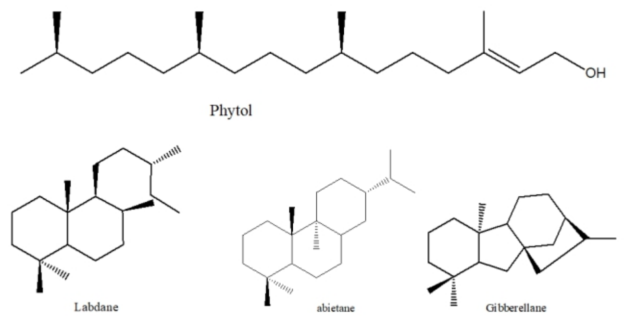

Fig. 4: Division of Diterpenes (Linear, Bicyclic, Tricyclic, Tetracyclic, Pentacyclic).

SESTERTERPENES

There are 25 carbon atoms and 5 isoprene units in a sesterterpene's chemical formula, which is ($C_{25}H_{40}$). Insects, sponges, lichens, fungi, and marine life all contain these compounds naturally. Their structural diversity includes linear, monocyclic, bicyclic, tricyclic, tetracyclic, and macrocyclic configurations, among many others. Fig. 5 shows the diagram.. (48, 49).

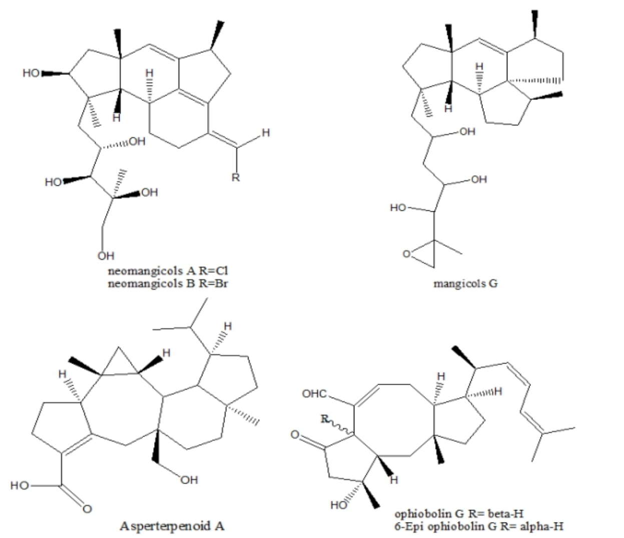

Fig. 5: Structures of some Sesterterpenes

TRITERPENES

Triterpenes are a kind of isoprenoids that usually consist of C_{30} atoms and are derived from six isoprenyl residues (50). The compounds exhibit complex cyclic structures, predominantly consisting of aldehydes, alcohols, or carboxylic acids. (51). The key triterpenes are illustrated in (Figure 6).

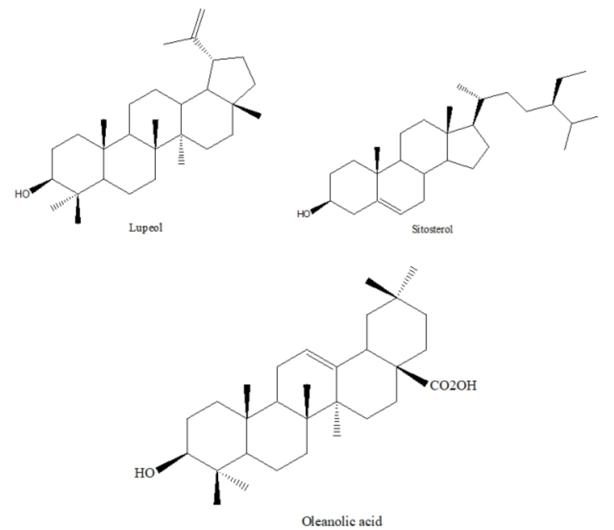

Fig. 6: Structures of some Triterpenes

TETRATERPENES

Tetraterpenoids are composed of 8 isoprene units and have the chemical formula $C_{40}H_{64}$. Carotenoids (Figure 7) are the most prevalent type of Tetraterpenoids (52). The normal process that involves, condensation of 8 isoprene molecules to derive from lycopene. Carotenoids are classified into two distinct groups: carotenes and oxygenated xanthophylls. (53-55).

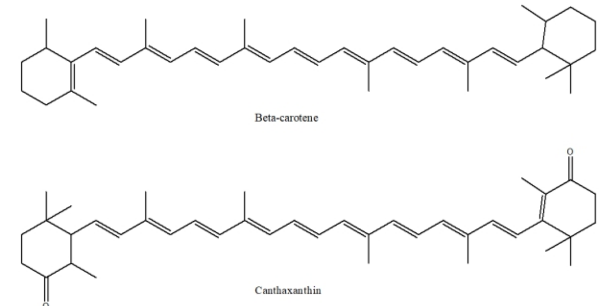

Fig. 7: Structures of some Tetraterpene

POLYTERPENES

Traditionally, this category of compounds has been verified to encompass the rubbers. Polyterpenoids are hydrocarbon polymers composed of over eight isoprene units (Figure 8). The molecular structure of natural rubber is cis-configured isoprene units, making it a high-molecular-weight polymer. (58).

Components of aromatic essential oils are notoriously unstable due to their low molecular weights. The main ingredients of essential oils are terpenes. Hemiterpenoids, monoterpenoids, and sesquiterpenoids are the only types of terpenoids that are considered essential oils (EOs) because of how volatile they are. It is well-known that the main components of essential oils are hydrocarbons of the mono-, sesqui-, and diterpene classes, together with their oxygenated derivatives. (59,62).

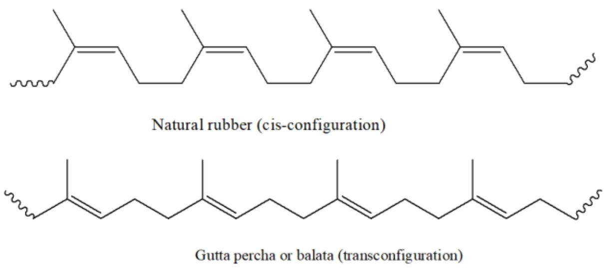

Fig. 8: Structures of some Polyterpenoids

EXTRACTION OF AROMATIC ESSENTIAL OILS

Solvent extraction, steam distillation, pressure expression, microwave-assisted extraction, and subcritical water extraction are some of the ways that aromatic compounds can be extracted from plants. (63,66).

EXTRACTION BY USING STEAM DISTILLATION

The fundamental principle is that the vapor pressures of various substances, when combined, reach equilibrium with the surrounding pressure at around 100°C. This means that substances that are volatile and have boiling temperatures between 150 and 250 degrees Celsius is vaporized at a temperature similar to water. Steam distillation utilizes the compound's high volatility to evaporate when exposed to steam and its hydrophobic properties to separate into an oil phase upon condensation. (67).

SOLVENT EXTRACTION

This approach, can be known as the liquid-liquid partitioning, relies on the concept of solubility in an organic solvent that does not mix with water. This method is employed on fragile vegetation to generate larger quantities of essential oils at a reduced expense. The method's effectiveness is constrained by the solubility of the drug in the chosen solvent, the lengthy duration of the extraction process, the comparatively large amount of solvent required, and the frequently inadequate reproducibility and purity of the results. (68).

SOXHLET EXTRACTION

The solid-liquid extraction procedure is used when desired chemical has limited solubility in a certain solvent, while the contaminant remains insoluble in the same solvent. There are numerous benefits associated with employing this methodology. The benefits encompass: Minimizing solvent usage allows for a greater quantity of raw material to be processed. This is achieved by continuously exposing the raw material to fresh sections of the solvent, which prevents the solvent from becoming saturated with extractable substances. Additionally, this process improves the extraction of the analyte from the surrounding matrix. Furthermore, the system's temperature is in close proximity to the solvent's boiling point. This enhances the rate of extraction in the system. Drawbacks of this method include the lengthy time required for completion, which might span several hours or even days. Additionally, the sample is diluted in a significant amount of solvent. Heating might cause the components to degrade thermally and evaporate. Additionally, esters can undergo hydrolysis to produce alcohols and carboxylic acids. (69).

THE IMPACT OF TERPENES AND TERPENOIDS ON DISEASE PROGRESSION

Various research conducted in recent decades have shown the substantial impact of terpenes and terpenoids on maintaining human health. The main class of organic molecules present in aromatic compounds (EOs) of various plants is composed of these bioactive chemicals, which are made up of several isoprene units. The user's text is "(70)". Numerous studies have examined the effects of glycoside compounds, monoterpenes, sesquiterpenes, diterpenes, and triterpenes in both laboratory and living organism settings. These compounds have useful properties as anti-inflammatory, antioxidant, anti-cancer, anti-allergic, neuroprotective, anti-aggregator, anti-coagulation, sedative, and analgesic. According to Rodriguez-Concepcion et al. (2018), the chemical in issue is present in numerous human health and nutrition products due to its high vitamin content. (70). The molecules within this category, such as carotenoids and tocopherols, serve as significant vitamin sources, especially for organisms like humans. Terpene compounds are widely employed in many industries including pharmaceuticals, nutraceuticals, food and drinks, cosmetics, perfumes, synthetic chemicals, rubber goods, scent and flavour additives, and the biofuel industry. These molecules have a substantial impact on the daily existence and well-being of humans. (71).

Recent study has shown the physiological importance of terpenes and terpenoids in lowering symptoms of inflammation, possibly by obstructing several harmful stages of the inflammatory process. (72).Inflammation is the host's protective response to external things, often resulting from bacterial infection or tissue damage. Acute and chronic inflammatory disorders caused by deregulation of inflammatory responses can lead to excessive or permanent tissue damage.

Furthermore, oxidative stress and autophagy are crucial cellular mechanisms that make a considerable contribution to inflammation. Reactive oxygen species (ROS), generated by many mechanisms such as mitochondria, affect leukocyte mobility and junctional permeability through multiple signalling pathways. Moreover, a recent study has shown that reactive oxygen species (ROS) directly disrupt NF-κB signals, hence controlling the release of IL-1β.

Topical application of terpenes and terpenoids has been proven to successfully decrease inflammation in the respiratory tract, atopic dermatitis, arthritis, and neuroinflammation.(71)

CONCLUSION

This review provides evidence that plant-based aromatics and their active ingredient(s) are significant in the pharmaceutical industry and clinical based fields due to their wide range of possible effects, such as, antibacterial, anti-inflammatory, anti-allergic and anti-cancer. However, further study is needed to completely comprehend the processes underlying the biological effects of the aromatic chemicals found in EOs. Accurately identifying and understanding the major bioactive components of essential oils is vital for improving their efficacy in sickness treatment. In addition to their health benefits, aromatic compounds from essential oils hold a lot of promise as natural food preservatives in the food industry.

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DISCLOSURE STATEMENT

The authors affirm the absence of any conflicting financial interests or other conflicts.

AVAILABILITY OF DATA

The authors verify that the data substantiating the conclusions of this study may be found in the journal itself or its additional resources.

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