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Chapter

Introductory Chapter: Terpenes and Terpenoids

Shagufta Perveen

1. Terpenes and terpenoids

Terpenes are the largest class of secondary metabolites found in nature (plants, fungus, marine organisms, animals). Terpenes are mainly present as a main constituent of essential oils. It consists of isoprene units \((\text{CH}_2=\text{C(\text{CH}_3)} \text{CH}=\text{CH}_2, \text{C}_5\text{H}_8)\) which are known as the building block of all types of terpenes, containing five carbon and eight hydrogen atoms. Monoterpenes have two isoprene units \((\text{C}_{10})\), sesquiterpenes have three \((\text{C}_{15})\), diterpenes have four \((\text{C}_{20})\), sesterpene have five \((\text{C}_{25})\), triterpenes have six \((\text{C}_{30})\) and tetraterpenes have eight isoprene units \((\text{C}_{40})\). Terpenes and terpenoids based chemical constituents are characterized by different chemical diversity with a wide range of therapeutic effects. This class of metabolites has been an enormous source of novel medicinal agents. Many terpenoids or terpenoid derivatives are used as traditional drugs with different medicinal values identified from different natural sources. *Artemisia annua* (sweet wormwood) a medicinal plant belongs to the family Asteraceae provided a drug artemisinin and its related derivatives which used as an antimalarial drug all over the world. Scientists Professor Tu Youyou was awarded Nobel Prize 2015 in Physiology or Medicine for her efforts toward the discovery of this important drug. Artemisinin and its derivatives are mainly sesquiterpenes (fifteen Carbons containing terpenes) which is known as a magical drug which served as the foundation for antimalarial treatment. Currently, many research groups have been reported the therapeutic potential of terpenes and its extract (terpene rich plant extracts) against anticancer, anti-inflammatory and SARS-CoV-2 and performed many tests and screenings. Many studies have been done for testing the efficacy of cannabis terpene for the treatment of this new viral infections [1, 2]. This chapter provides information about recently published terpenes which showed significant biological activities have unique skeletons.

2. Hemiterpene

Hemiterpenes are the basic unit of terpenes and its consists of five carbon atoms \((\text{CH}_2=\text{C(\text{CH}_3)} \text{CH}=\text{CH}_2)\) or one isoprene unit. It is usually found in different types of plants especially Coniferous, Willow and Oaks. Many types of hemiterpenes have isolated from different marine derived fungi (*Acremonium persicum*, *Penicillium bialowiense*) which are known as merohemiterpenoid. Herein, we are discussing some of the recently published chemical diverse emiterpenes (*Table 1*, *Figure 1*).
3. Monoterpenes

These types of terpenes consist on ten carbon atom or two isoprene units. Each type of monoterpenes has a particular aroma for the related plant such as: Citrus, grapes, rose etc. Many monoterpenes and their isomers have been isolated from different marine sources. Herein, we are discussing some of the recently published monoterpenes (Table 2, Figure 2).

Table 1. Source and biological activities of some hemiterpenes.

<table>
<thead>
<tr>
<th>Name</th>
<th>Source</th>
<th>Activity</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Securiterpenoside G</td>
<td>Securidaca inappendiculata found in China</td>
<td>The potential anti-inflammatory activities of compounds were evaluated through inhibiting nitric oxide (NO) overproduction in LPS-stimulated mouse macrophage RAW264.7 model. Cell viability was measured by the MTT assay. None of them showed the obvious cytotoxicity at the dosage of 50 μM and significant anti-inflammatory activities (IC50 145.3, 57.5 μM, respectively). Dexamethasone was used as positive control (IC50 2.5 μM).</td>
<td>[3]</td>
</tr>
<tr>
<td>(±)-Cytorhizophin A, Cytorhizophin B</td>
<td>Endophytic fungus Cytospora rhizophorae from the plant Morinda officinalis</td>
<td>These compounds were evaluated for antimicrobial activities against the bacteria Escherichia coli and Staphylococcus aureus. However, all of them were found to be devoid of significant activity even at a concentration of 100 μg mL⁻¹.</td>
<td>[4]</td>
</tr>
</tbody>
</table>

Table 2. Source and biological activities of some monoterpenes.

<table>
<thead>
<tr>
<th>Name</th>
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<th>Activity</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-glucopyranosyl vincosamide, vincosamide</td>
<td>Psychotria leiocarpa Leaves found in Brazil</td>
<td>Vincosamide with a preliminary dose-dependent activity inhibiting at 50 μg mL⁻¹ 99% of DENV infectious particles in the conditioned medium of infected HepG2 culture can be highlighted among the other isolated alkaloids as a potential anti-dengue agent.</td>
<td>[5]</td>
</tr>
</tbody>
</table>
4. Sesquiterpenes

Sesquiterpenes are the class of terpenes with C15 carbon atoms having many uses like medicine, sanitary, agriculture, cosmetics and foods. These types of terpenes have many biological activities like, antibacterial, antifungal, antiviral and...
ant insecticidal which provokes the researcher to work on the sesquiterpene rich natural sources. It is usually found in Asteraceae family plants. Herein we are tabulating few important sesquiterpene with their structure and biological information (Table 3, Figure 3).

<table>
<thead>
<tr>
<th>Name</th>
<th>Source</th>
<th>Activity</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Minusolide G</td>
<td>Carpesium minus</td>
<td>It exhibited cytotoxic activities against MDA-MB-231, A549, and HCT-116 cells with IC50 values of 6.1 ± 0.2, 8.4 ± 0.6, and 3.7 ± 0.6 μM, respectively. It induced the apoptosis of HCT-116 cells via suppression of PARP and promoting cleavage of PARP.</td>
<td>[9]</td>
</tr>
<tr>
<td>Penisarins A &amp; B</td>
<td>Endophytic Penicillium sp. found in China</td>
<td>Penisarin B showed significant cytotoxicities against two human cancer cell lines, HL-60 and SMMC-7721, with IC50 values of 3.6 ± 0.2 and 3.7 ± 0.2 μM, respectively.</td>
<td>[10]</td>
</tr>
<tr>
<td>Cedrol</td>
<td>Cedrus atlantica Cedarwood oil</td>
<td>Cedrol-treated mice exhibited no significant differences in body weight and improved TMZ-induced liver damage. These results imply that cedrol may be a potential novel agent for combination treatment with TMZ for GBM therapy that deserves further investigation.</td>
<td>[11]</td>
</tr>
</tbody>
</table>

Table 3.
Source and biological activities of some sesquiterpenes.

Figure 3.
Structure of sesquiterpene.

5. Diterpenes

It consists on C20 carbon atom having four isoprene units. These are very famous class of compounds as many are using in market for curing cancer.
disease such as; Taxol and etc. Herein, we are summarizing few recently published diterpenes structures, sources, origin and biological activities (Table 4, Figure 4).

### 6. Sesterpenes

Sesterpenes are the small class of terpenoids family which consists on twenty-five carbon atoms (tricyclic 5-8-5 carbocyclic core, five isoprene units). These types of constituents usually found in plants, fungus culture, insects and marine organism. Sesterterpenes type compounds has complex structures due to the presence of many ring systems which makes its unique skeletons. These compounds have significant biological activities such as cytotoxic, nematocidal, anti-influenza, enzyme inhibition, anti-inflammatory and antimicrobial activities. In this chapter we are discussing, some recently published sesterterpene, including their structures, source, origin and pharmacology (Table 5, Figure 5).

### 7. Meroterpenes

Meroterpenes are mainly found in marine organisms and abundant in brown algae and other natural sources like microorganisms and invertebrates (sponges and
Figure 4. Structure of diterpene.

<table>
<thead>
<tr>
<th>Name</th>
<th>Source</th>
<th>Activity</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manoalide derivatives</td>
<td>Sponge <em>Luffariella variabilis</em> from the South China Sea</td>
<td>manoalide derivatives demonstrated cytotoxic activities against several human cancer cell lines with IC₅₀ values ranging from 2 to 10 μM.</td>
<td>[19]</td>
</tr>
<tr>
<td>Drophiobolins A &amp; B</td>
<td><em>Drechlorella gigantea</em> s found in China</td>
<td>Both of the newly identified ophiobolins showed significant phytotoxicity. Drophiobolins A &amp; B exhibited cytotoxicity against Hela B cells with an IC₅₀ value of 10 μM.</td>
<td>[20]</td>
</tr>
</tbody>
</table>

Table 5. Source and biological activities of some sesterpenes.
tunicates). These types of compounds have many chemical diversities. Herein, we are discussing some recently published biological active meroterpenes (Table 6, Figure 6).

<table>
<thead>
<tr>
<th>Name</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Penic lactone C</td>
<td>Endophytic fungus Penicillium sp. GDGJ-285</td>
<td>Bioassays showed that penic lactone C inhibited nitric oxide production in lipopolysaccharide-induced RAW 264.7 macrophage cells with an IC₅₀ value of 39.03 μM.</td>
<td>[21]</td>
</tr>
<tr>
<td>Gancochlearols E – I</td>
<td>Ganoderma cochlear</td>
<td>Biological results revealed the significantly inhibitory effects of the Gancochlearols E – I on COX-2 activity and the migration of TNBC cells. In results not only enrich the structure type of meroterpenoids in Ganoderma, but also present novel structural template for developing nonsteroidal anti-inflammatory drug (NSAID) and anti-cancer drug against metastatic TNBC.</td>
<td>[22]</td>
</tr>
</tbody>
</table>

Table 6. Source and biological activities of some meroterpenes.
Terpenes and Terpenoids—Recent Advances

<table>
<thead>
<tr>
<th>Name</th>
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<th>Activity</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arenarosides A</td>
<td><em>Polycarpaea arenaria</em> found in Brazil</td>
<td>Compound displayed promising antiangiogenesis effects with ( IC_{50} ) values &lt;5 ( \mu )M in the test system used. It exhibited the most potent inhibitory effects, not only in cancer cell proliferation but also in angiogenic activities.</td>
<td>[23]</td>
</tr>
<tr>
<td>Ganoweberianones A &amp; B</td>
<td>Fruiting bodies of Basidiomycete <em>Ganoderma weberianum</em></td>
<td>These compounds were evaluated for Ganoweberianone A exhibited significant antimalarial activity against <em>Plasmodium falciparum</em> K1 (multidrug-resistant strain) with an ( IC_{50} ) value of 0.050 ( \mu )M.</td>
<td>[24]</td>
</tr>
<tr>
<td>Longipetalol A</td>
<td><em>Dichapetalum longipetalum</em></td>
<td>Compound exhibited inhibitory effects on nitric oxide production in lipopolysaccharide-induced RAW264.7 macrophages.</td>
<td>[25]</td>
</tr>
<tr>
<td>Periploside A5</td>
<td>Root barks of <em>Periploca sepium</em></td>
<td>Periploside showed significant suppressive effects on T lymphocyte proliferation with ( IC_{50} ) values ranging from 0.16 to 3.9 ( \mu )M and displayed potent inhibitory activity on B lymphocyte proliferation with ( IC_{50} ) data at between 0.17 and 5.9 ( \mu )M. ( IC_{50} ) data of Periploside A5 were 0.30 ( \mu )M and 0.55 ( \mu )M for T and B lymphocytes, and with the most favorite selective index values 176 and 96.9, respectively.</td>
<td>[26]</td>
</tr>
</tbody>
</table>

Table 7.
Source and biological activities of some triterpenes.

![Figure 7](image)
Structure of triterpene.
8. Tripterpenes

A major class of secondary metabolites are known as triterpenes and it usually contains thirty carbons consisting of six isoprene units. Different class of triterpenes are known as lanostanes, euphanes, holostanes, tetranortriterpenoids, cycloartanes, cucurbitanes, dammaranes, tirucallanes, quassinoids, oleananes, lupanes, friedelanes, ursanes, hopanes, serratanes, isomalabaricanes which derived from the squalene biosynthesis (Table 7, Figure 7).
References


[10] Li W, Shao YT, Yin TP, Yan H, Shen BC, Li YY, Xie HD, Sun ZW, Ma YL. Penisarins A and B, Sesquiterpene Coumarins Isolated from an Endophytic Penicillium sp. Journal of Natural Products. 2020, 83(11):3471-3475. DOI: 10.1021/acs.jnatprod.0c00393


