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A Systemic Review of Beta-Caryophyllene

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ABSTRACT

A naturally occurring sesquiterpene known as Beta-Caryophyllene (BCP) is present in many essential oils, spices, and plants including black pepper, cloves, and cannabis. A thorough assessment of the pharmacological traits, biological functions and therapeutic potential of BCP is given in this article. Due to its singular capacity to interact with the CB2 receptor of the endocannabinoid system without having any psychoactive effects, BCP has drawn a lot of attention. Consequently, it has shown a variety of intriguing medicinal applications.

Keywords: Beta-caryophyllene; Phytoconstituents; Biological activities

NOMENCLATURE

BCP : Beta-caryophyllene
CB2 : Cannabinoid receptor type 2
THC : Tetrahydrocannabinol

1. INTRODUCTION

BCP, also known as beta-caryophyllene or -caryophyllene, is a fascinating and adaptable sesquiterpene molecule that is widely present in many different plants, especially in the essential oils of numerous herbs and spices. Its distinctive chemical structure, which also adds to its extraordinary features and possible health advantages, makes it unique[1]. This detailed introduction will develop deep into the world of beta-caryophyllene and examine its history, molecular makeup, and wide range of uses. Beta-caryophyllene is a naturally occurring hydrocarbon that is widely distributed in the natural environment. It is a botanical treasure since it is notably present in plants like hops, cannabis, black pepper, cloves, and peppermint. Its importance in the Flavors and fragrance industries has grown as a result of the distinctive spicy, woody, and peppery scent it emits[2]. Notably, it is essential in determining the distinctive aroma of black pepper, which affects both the flavour and the appeal of the aroma. The distinctive structure of beta-caryophyllene, which consists of a bicyclic ring system with a smaller cyclobutene ring bonded with a bigger cyclohexane ring, distinguishes it from other compounds which is shown in (fig. 1). The secret to its wide range of biological activities and interactions with the human body is in its unique configuration[3].

The extraordinary capacity of beta-caryophyllene to preferentially interact with the endocannabinoid system, particularly the CB2 receptors, is what sets it apart from other compounds. Due to its possible medicinal uses, this particular characteristic has generated a great deal of interest in the substance[4].

Numerous promising health benefits of beta-caryophyllene have been discovered via extensive investigation. It has antioxidant, analgesic (pain-relieving), and anti-inflammatory effects, making it a hot topic of research in the area of alternative medicine. Additionally, its interaction with CB2 receptors suggests that it has a role in controlling immunological responses and may be useful in treating diseases like arthritis, autoimmune disorders, and neurodegenerative problems that are associated with inflammation[5].What sets beta-caryophyllene apart from other chemicals is its unique structure, a bicyclic ring system with a larger cyclohexane ring connected to a smaller cyclobutene ring[6].

In summary, beta-caryophyllene is a remarkable sesquiterpene with an excellent chemical structure and a wide range of prospective applications in the pharmaceutical, flavouring, and fragrance sectors. Scientific research is constantly being sparked by its special relationship with the endocannabinoid system and its favourable therapeutic properties, highlighting its promise as an important natural substance for improving human health and general well-being[7]. Beta-caryophyllene may become an essential resource for holistic health and the larger scientific community as this field of study develops.

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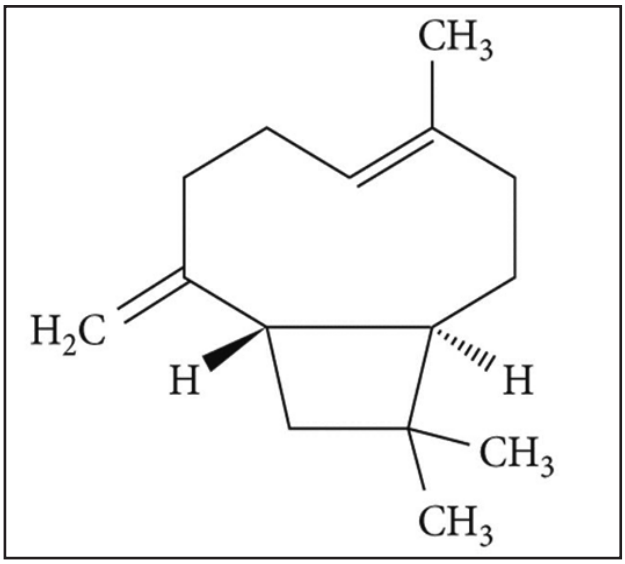

Figure 1. Structure of beta-caryophyllene chemical name :4,11,11-trimethyl-8-methylidenebicyclo[7.2.0]undec-4-ene.

2. PLANT DESCRIPTION

2.1 Chemical Structure

- A bicyclic sesquiterpene, beta-caryophyllene is also referred to as -caryophyllene or BCP. The hydrocarbon has a unique tricyclic structure and the chemical formula C15H24.

2.2 Aroma and Flavour

- A spicy, woodsy, peppery scent with undertones of clove and black pepper characterizes beta-caryophyllene. It has a flavour that is similar to these spicy undertones[8].

2.3 Natural Sources

- Numerous plant species essential oils include beta-caryophyllene. A few noteworthy sources include:
- Cannabis sativa, also known as marijuana or hemp, contains this important terpene.
- Black pepper (Piper nigrum): The high beta-caryophyllene content in black pepper makes it well-known.
- Cloves (Syzygium aromaticum): The beta-caryophyllene content of clove essential oil is substantial.
- Copaiba (Copaifera spp.): Copaiba trees produce an oleoresin that is high in beta-caryophyllene.
- This terpene is also present in the essential oil of oregano (Origanum vulgare)[9,10].

2.4 Medicinal and Therapeutic Uses

A lot of interest has been paid to beta-caryophyllene because of its possible therapeutic uses.

2.5 Some of Its Reported Properties Include

- Anti-inflammatory: Studies have shown that beta-caryophyllene has anti-inflammatory characteristics, which may be useful for illnesses that include inflammation.
- Analgesic (pain-relieving): It might aid in easing discomfort and suffering.
- As an antioxidant, it can aid in preventing oxidative stress and cell damage.
- Potentially reducing anxiety and depression: Some research points to a possible interaction between beta-caryophyllene and the endocannabinoid system, which is involved in mood regulation[11,12].

2.6 Interaction with the Endocannabinoid System

- Because it selectively activates the CB2 (cannabinoid receptor type 2) receptor, one of the receptors in the endocannabinoid system, beta-caryophyllene stands out among terpenes. Its possible therapeutic benefits are influenced by this interaction[13].

2.7 Common Uses

- Because of its distinctive perfume and potential therapeutic effects, beta-caryophyllene is frequently used in aromatherapy, where it is added to essential oil mixes.
- It can also be found in a variety of cosmetic and personal care items, especially those that are touted as having calming or anti-inflammatory effects[14].

3. PHYTOCONSTITUENTS

The primary components of the phytoconstituents that make up beta-caryophyllene are carbon, hydrogen, and occasionally oxygen atoms organised in a certain molecular structure. Beta-caryophyllene has a molecular weight of around 204.35 grams per mole and the chemical formula C15H24. The cyclobutane ring, a bicyclic ring structure, is fused to a bigger cyclohexane ring in its structural formula[15].

Some key points about the phytoconstituents of beta-caryophyllene include

- **Terpenes:** These are fragrant molecules that are present in a variety of plants, and beta-caryophyllene is one form of terpene. Many plants and essential oils have distinctive aromas and fragrances that are attributed to terpenes.
- **Hydrocarbons:** Beta-caryophyllene is a hydrocarbon since it only has carbon and hydrogen atoms. Its stability and function as a volatile aromatic molecule are both facilitated by the chemical structure's simplicity[16].
- Alpha-caryophyllene and beta-caryophyllene are the two isomers of beta-caryophyllene. The most prevalent and biologically active type is beta.
- **Cannabimimetic Activity:** The interaction of beta-caryophyllene with the endocannabinoid system is one of its special characteristics. It functions as a selective agonist of the CB2 cannabinoid receptor, which is mostly present in peripheral tissues and immune cells. The modulation of the endocannabinoid system by beta-caryophyllene may have therapeutic uses, according to this relationship[17].

- **Pharmaceutical Qualities:** Numerous research have shown that beta-caryophyllene possesses anti-inflammatory, analgesic (pain-relieving), and antioxidant activities. Its potential application in treating ailments like pain, inflammation, and anxiety is also being researched.
- **Food &Flavouring:** Spices and herbs used to flavour food and beverages frequently contain beta-caryophyllene. Foods like black pepper and cloves benefit from the spiciness and pepperiness in their flavour characteristics[18].

4. BIOLOGICAL ACTIVITIES

4.1 Cannabinoid Receptor Interaction

Although beta-caryophyllene is a naturally occurring terpene present in many plants, including cannabis, it is not a cannabinoid in and of itself. Beta-caryophyllene interacts with the endocannabinoid system in a special way despite not being a cannabinoid. The human body's intricate endocannabinoid system regulates a number of physiological functions, including the perception of pain, mood, appetite, and inflammation[19].

The CB2 receptor, one of the endocannabinoid system's components, is where beta-caryophyllene interacts with the body the most. CB1 and CB2 receptors are the two primary types found in the endocannabinoid system. While CB2 receptors are more prevalent in immune cells and peripheral organs, particularly in regions linked to inflammation, CB1 receptors are largely present in the brain and central nervous system.

Because it can only bind to CB2 receptors, beta-caryophyllene stands out among terpenes as a CB2 receptor agonist. It can cause the body to react in a number of ways when it binds to these receptors, including the control of immunological response and the lowering of inflammation. Beta-caryophyllene has potential therapeutic benefits due to its interaction with CB2 receptors, especially in the treatment of diseases marked by inflammation and immune system dysregulation[20].

Beta-caryophyllene can activate CB2 receptors, but it does not have the same psychoactive effects as cannabinoids like THC, which primarily act on CB1 receptors in the brain. This is a crucial distinction to make. It is an intriguing substance for further research in the fields of natural medicine and cannabis-based therapies because it instead offers possible therapeutic benefits without mind-altering effects[21].

4.2 Anti-Inflammatory Effects

A natural substance called beta-caryophyllene is present in many plants, including cannabis, black pepper, and cloves. It is well known for having possible anti-inflammatory properties. The body's endocannabinoid system, specifically

The CB2 receptors, which are mostly present in immune cells and tissues linked to inflammation, are influenced by beta-caryophyllene[22].

Beta-caryophyllene can affect the immune system and lessen inflammation when it binds to CB2 receptors. Through this interaction, inflammation-related symptoms including pain and swelling could be lessened.

While studies on the anti-inflammatory effects of beta-caryophyllene have shown promise, further research is necessary to completely comprehend these effects and their potential therapeutic uses. Additionally, the source and concentration of the chemical can affect beta-caryophyllene's efficacy[23].

4.3 Analgesic (Pain Relief)

A naturally occurring substance called beta-caryophyllene is present in many different plants, including cannabis and several spices like black pepper and cloves. It is well known for having possible pain-relieving properties, principally as a result of its interactions with the endocannabinoid system of the body.

The control of pain and inflammation in the body is largely dependent on the endocannabinoid system. Because it selectively activates the CB2 receptors in the endocannabinoid system, beta-caryophyllene stands out from other terpenes (aromatic chemicals present in plants). The majority of peripheral tissues, particularly those connected to the immune system, contain CB2 receptors.

Beta-caryophyllene may lessen pain and inflammation when it binds to CB2 receptors. Effects on inflammation: Inflammation, which can be a source of discomfort in illnesses like arthritis or muscular injuries, may be reduced by beta-caryophyllene[24].

Analgesic (pain-relieving) properties: Beta-caryophyllene may help reduce pain signals delivered to the brain and provide relief from a variety of pain via regulating CB2 receptors.

Effects on neuroprotection: Some studies indicate that beta-caryophyllene may have protective effects on the nervous system, which may be advantageous for diseases that cause nerve pain or injury[25].

4.4 Neuroprotective Properties

Natural sesquiterpenes like beta-caryophyllene, which can be found in plants like cannabis and black pepper, are thought to have neuroprotective qualities. Through a number of ways, this substance has shown the potential to shield brain and nervous system nerve cells. First, it reduces chronic inflammation that can damage neurons by interacting with the CB2 cannabinoid receptor, which is largely located in immune cells. Beta-caryophyllene also functions as an antioxidant, scavenging damaging free radicals that result in oxidative stress and cellular damage, two factors that might contribute to neurodegenerative disorders. Although continuing studies are highlighting its potential, particularly in diseases like Alzheimer's, Parkinson's, and multiple sclerosis, more research is required to fully comprehend its mechanisms and possible therapeutic uses. Whether beta-caryophyllene is consumed through diet or supplements, its effectiveness may differ depending on the source and route of

delivery. Prior to contemplating its usage for potential neuroprotection, as with any natural substance or supplement, it is imperative to speak with a healthcare practitioner[26,27].

4.5 Antioxidant Activity

A natural substance called beta-caryophyllene is present in many plants, including cloves, black pepper, and cannabis. It has drawn attention because of its potent antioxidant qualities, which are essential for shielding the body from oxidative stress and free radical damage. By scavenging dangerous free radicals from the body, beta-caryophyllene functions as a powerful antioxidant that lowers the risk of a number of chronic diseases and aging-related ailments. Its capacity to activate the CB2 cannabinoid receptor, a component of the endocannabinoid system, which controls a number of physiological processes, including immune response and inflammation, is credited with its antioxidant action. Beta-caryophyllene is a promising natural substance with potential health advantages since it modulates this receptor, which can help fight oxidative stress and inflammation. Beta-caryophyllene's antioxidant abilities are still being studied, and there is considerable interest in its possible therapeutic uses in situations like cancer prevention, cardiovascular disease, and neurological diseases. To completely comprehend its mechanics and realize its therapeutic potential, more research is necessary[28,29,30].

4.6 Anti-Anxiety and Anti-Depressant Effects

A natural substance called beta-caryophyllene is present in many plants, including cloves, black pepper, and cannabis. Its possible anti-anxiety and anti-depressant benefits have attracted a lot of interest. The CB2 receptors, which are mostly present in the immune system and peripheral tissues, are thought to be the target of beta-caryophyllene's interactions with the endocannabinoid system. Beta-caryophyllene may have anti-inflammatory and neuroprotective effects through binding to these receptors, which can indirectly support its anti-anxiety and anti-depressant qualities. The release of neurotransmitters like serotonin and dopamine, both of which are essential for controlling mood and emotions, may also be modulated. Potentially, this modulation will lessen anxiety and depressive symptoms. Beta-caryophyllene's natural origin and encouraging preliminary results make it an appealing possibility for future study into complementary therapies for anxiety and depression, even if further studies are required to fully understand its mechanisms and therapeutic potential. The effects of beta-caryophyllene, however, may differ from person to person, therefore people should seek the advice of medical specialists before using it as a treatment for mental health issues[31,32].

4.7 Gastro protective Effects

The natural substance beta-caryophyllene, which is present in many plants including cloves, black pepper, and cannabis, is renowned for its possible gastroprotective properties. Due to its capacity to shield the gastrointestinal tract from harm and inflammation, this sesquiterpene has drawn interest. According to research, beta-caryophyllene preferentially targets the CB2 receptors, which are prevalent in the gut, in its interactions with the endocannabinoid system.

Beta-caryophyllene is a potential therapeutic agent for a variety of gastrointestinal conditions such gastritis, ulcers, and inflammatory bowel disease because activating these receptors can reduce oxidative stress and inflammation in the digestive tract. Additionally, by preventing the release of pro-inflammatory chemicals and encouraging tissue repair, beta-caryophyllene's anti-inflammatory and antioxidant capabilities may contribute to its gastroprotective benefits. Although more investigation is required to fully comprehend the scope of beta-caryophyllene's gastroprotective advantages and its ideal therapeutic uses, it shows promise as a natural substance that might support digestive health and possibly supplement current treatments for gastrointestinal conditions[33,34].

4.8 Antimicrobial Activity

Natural sesquiterpene beta-caryophyllene is mostly found in cannabis and spices like black pepper, cloves, and rosemary. According to research, beta-caryophyllene is antimicrobial, which means it has the power to prevent the development and spread of germs including bacteria, fungi, and even some viruses. Its distinctive molecular structure, which enables it to engage with certain cellular targets in these diseases, is credited with its antibacterial efficacy. In order to kill or inhibit these microorganisms, beta-caryophyllene works by interfering with the fungal cell wall and compromising the integrity of the cell membrane in bacteria. Additionally, it might have potential uses in the creation of new antimicrobial drugs, offering an alternate strategy for dealing with infections that are resistant to treatment and supporting continuing efforts to address the global problem of antimicrobial resistance. To completely comprehend the scope of beta-caryophyllene's antibacterial activities and its potential therapeutic benefits, more study is necessary[35].

5. CONCLUSION

A prospective participant in the field of natural medicines is beta-caryophyllene, a naturally occurring chemical that may be found in a variety of plants but is notably prevalent in cannabis and spices. The scientific community is becoming more and more interested in it because of its special qualities, which include selective binding to CB2 receptors and a wide variety of possible health advantages. Beta-caryophyllene may potentially play a significant role in the development of novel and organic treatments for a range of health ailments as research continues to uncover its secrets.

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