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Tarmo Nuutinen

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Medicinal properties of terpenes found in *Cannabis sativa* and *Humulus lupulus*

Tarmo Nuutinen[1,2,*]

[1] Department of Environmental and Biological Sciences, Univerisity of Eastern Finland (UEF)
[2] Department of Physics and Mathematics, UEF
[*] Email: tarmon@uef.fi

Abstract

Cannabaceae plants *Cannabis sativa* L. and *Humulus lupulus* L. are rich in terpenes – both are typically comprised of terpenes as up to 3-5% of the dry-mass of the female inflorescence. Terpenes of cannabis and hops are typically simple mono- and sesquiterpenes derived from two and three isoprene units, respectively. Some terpenes are relatively well known for their potential in biomedicine and have been used in traditional medicine for centuries, while others are yet to be studied in detail. The current, comprehensive review presents terpenes found in cannabis and hops. Terpenes' medicinal properties are supported by numerous *in vitro*, animal and clinical trials and show anti-inflammatory, antioxidant, analgesic, anticonvulsive, antidepressant, anxiolytic, anticancer, antitumor, neuroprotective, anti-mutagenic, anti-allergic, antibiotic and anti-diabetic attributes, among others. Because of the very low toxicity, these terpenes are already widely used as food additives and in cosmetic products. Thus, they have been proven safe and well-tolerated.

Keywords

Monoterpene; sesquiterpene; *Cannabis sativa*; *Humulus lupulus*; medicine; medicinal property

Introduction

Plants produce terpenes for interactions with other organisms [1]. Terpenes protect plants against pathogens like mold, fungus and bacteria, and can attract pollinating insects or repel herbivores. Thousands of terpenes have been found across the *plantae*, but only a small percentage of all terpenes have been identified [2]. Despite the diversity of the known terpenes, some are concentrated in certain *phyla* or families such as *Cannabaceae*. Terpenes found in *Cannabis sativa* (cannabis) and *Humulus lupulus* (hop), or more precisely, in their essential oils (EOs), are mainly mono- and sesquiterpenes: up to 99% of all terpenes found in the EO of hops [3] and up to 98% in cannabis EO [4]. Cannabis and hop produce and accumulate a terpene-rich resin in glandular trichomes, which are most abundant on the surface of female inflorescences. Some terpene synthases are specialized to produce strictly one terpene, while others are multi-substrate enzymes producing more than one terpene [5]. Recently, a transcriptome analysis of trichomes of the hemp variety "Finola" identified 33 complete terpene synthase (TPS) genes and an additional 18 putative TPSs. At the protein level, 40 enzymes involved in the synthesis of terpenes were identified in hop [6].

Cannabis and hops have been used in traditional medicine for millennia around the world. However, all of the active constituents and their mechanisms of action have not yet been explored. Naturally, the action of cannabis is mostly based on cannabinoids, but not all of its medicinal properties. Hops, which are devoid of cannabinoids, have been used as sedative means e.g. for the treatment of insomnia, depressive symptoms, irritation, nervous tension, delirium, anxiety and digestive disorders [7]. Cannabis has been used in traditional Chinese medicine for the treatment of pain,