Biological relationship Between Terpenes and Cannabis

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1.0 Introduction

Terpenes and Terpenoids are one of the most diverse groups of compounds that exist naturally in the environment which provide the primary building blocks for essential oils and other compounds used in the characteristic properties of different strains of cannabis flower. From the different aromatic scents and flavor profiles, terpenes diversify both the physical and chemical properties of the plant allowing for a wide variety of medicinal uses ranging from aroma therapy to antiviral treatment, as well as antiseptic and antimicrobial properties (Cox-Georgian et al,. 2019). Both animals and plants can carry different terpene and terpenoid compounds; however, this report will focus on the physical and biochemical properties responsible for different cannabis flower strains. It is estimated there are over 750 strains of cannabis all containing unique terpene profiles allowing for a different experience of aroma, taste, and trip for each plant.

2.0 Terpenes

The many different terpenes within plants are not localized in a single point on a leaf or stem, but rather dispersed all throughout the organism. Terpenes are also known as isoprenoids which are composed of the hydrocarbon compounds specifically containing the basic 5-carbon isoprene unit (isopentadiene or 2-methylbuta-1,3-diene) while terpenoids refer to isoprene units that contain different functional groups attached to the 5-carbon isoprene unit (Paduch et al, 2007). Depending on the number of isoprene units it has the terpene can be classified as either a mono, di, tri, tetra, and sesquiterpenoid. ***Table 1*** in the appendix gives a clear picture of the different classes of terpenes and some related functions of each group after the addition of another 5-carbon isoprene unit. In general terpenes are lipid soluble molecules that are located in the cytoplasm of a cell and not in the storage organelle the vacuole and are formed via the mevalonate pathway to yield the actual active biosynthetic precursor of terpenes known as Isopentenyl Pyrophosphate (IPP or 3-methylbut-3-enyl-PP) (Sandmann, G, 1991). This process involved the alteration of three acetyl-CoA molecules and the enzyme IPP isomerase to convert IPP to dimethylallyl Diphosphate (DMAPP) which is a result of a migration of a double bond via electrophilic attack on the methylene carbon on IPP (Sandmann, G, 1991). This double bond

shift allows for a tail to head condensation to yield trans geranyl-PP (GPP) which is a monoterpenoid that is an important precursor for the biosynthesis of cannabinoid formation (Sandmann, G, 1991).

3.0 Cannabis

Cannabis comes from the family of Cannabaceae plant and is a dicotylate angiosperm and can give rise to either a male, female or hermaphrodite plant that contains both the male and female seeding organs needed for reproduction (Sommano et al,. 2020). Cannabis can be further taxonomized into three species known *as Sativa Linnaeus, Indica Lamarck, and C.ruderalis*, where the first species is a low THC hemp, the indica being the commercially and recreationally sold product, and the latter is a flower only found in eastern Asian countries (Sommano et al,. 2020). ***Table 2*** notes some differences between hemp and Cannabis where you can note the major difference in the levels of psychoactive THC contents which explains why the Indica variant is primarily sold for its sedative effects. While the Hemp Sativa variant poses a much greater CBD content and is lighter in color with less terpene contents giving it a more brittle and less sticky surface texture than its indica counterpart.

3.1 Trichomes

The term sticky is often used to describe good quality Marijuana, ones that are rich in trichomes which grow on the epidural surface of the plant leaves in three types of glandular forms capable of housing different terpenes in varying concentration ratios. The first type is known as Bulbous trichomes, they are the smallest and do not posses a stalk, while the sessile and stalked trichomes both have globular head with stalks, the latter containing the larger stalk ***Figure 3*** (Sommano et al,. 2020). Each of the trichomes posses different terpene concentrations as they are implemented in a number of adaptive processes for the plant such as physical and chemical protection for the organism. An example of such would be releasing attractants to signal pollinators to aid in the plants ability to disperse its seeds for fertilization (Schwachtje & Baldwin, 2008). Trichomes are separated from the plant by first freezing the flowers and then running the product through a sieve mesh, the separated product is known as kief and contains the abundance of terpenes and other secondary metabolites within. Kief has a number of uses as it can be pressed and rolled into making hash as well as hash oil which requires an organic

solvent such as alcohol to extract the terpenes and evaporate the solvent resulting in viscous essential oils (Sandmann, G, 1991).

4.0 Terpene Profiles in Cannabis

A method used by researchers to profile the terpenes found in the cannabis flower is using a gas chromatogram that is capable of mass spectrometry in order to analyze the terpene contents after extraction using an alcohol. Ternelli and colleagues applied this technique using butanol and was able to isolate a number of predominantly monoterpenoids as well as sesquiterpenoids. ***Figure 1*** shows the chromatogram of the terpene extract from the cannabis floral tissue. Predominant monoterpenes isolated from Cannabis flower leaflets are α-pinene and β-pinene, which is an inhibitor in the acetylcholinesterase activity in the brain and is suspected to reduce cognitive dysfunction commonly induced by THC intoxication (Ternelli et al, 2020). These two monoterpenoids are known for their pine scented aroma and posses antiseptic properties (Ternelli et al, 2020). β-myrcene is another common monoterpenoids isolated in cannabis flower which stimulates α2-adrenergic receptor which results in the transmission of an endogenous opioid (Ternelli et al, 2020). Levels of β-myrcene above 0.5% results in the "couch lock" effect commonly associated with the street indica flower while levels of β-myrcene less than 0.5% can leave users feeling euphoric and produce high energy, which is a key feature of street sativa flower and gives off a musky and hop aroma (Sommano et al,. 2020).

The most abundant sesquiterpenoid isolated in Cannabis flower is β-Caryophyllene, it gives off a pepper scent and is in its greatest quantity after heat stress which induces decarboxylation (Sommano et al,. 2020). This sesquiterpenoid can be found in many other plant species such as cloves, rosemary, hops, and induces pain relief via anti inflammatory pathways by affecting Cannabinoid receptor type 2 (CB2) in the brain (Sommano et al,. 2020). ***Figure 2*** shows an overview of some of the mono and sesquiterpenoids references here found in a variety of some common commercially sold strains of cannabis product.

Conclusion

Terpenes are the cornerstone in differentiating the many strains of cannabis flower in the aroma, taste, as well as its physiological effects once consumed, enhancing its medicinal functionality. Understanding the true nature of where cannabis strains get their differentiation is

important as the cannabis industry is set to reach an estimated 20 billion dollars by 2024 (Koby, 2020). Providing consumers of cannabis with the information about terpenes provides benefit in the users experience with the product as it allows them to understand the potential side effects as well as experience based on the terpene composition of the flower.

Appendix

Table 1: Mono, Di, Tri, and Sesquiterpenoid Examples and Related Medicinal Functions

Classification	Carbon atoms	Species produced from	Medicinal uses
Monoterpenes	C_{10}	*Quercus ilex*	Fragrances, repellent
Sesquiterpenes	C_{15}	*Helianthus annuus*	Treat malaria, treat bacterial infections, and migraines
Diterpenes	C_{20}	*Euphorbia, salvia miltiorrhiza*	Anti-inflammatory, cardiovascular diseases
Triterpenes	C_{30}	*Centella asiatica*	Wound healing, increases circulation

Based on the table above as you increase in the number of isoprene units, the complexity of function increases as well. (Sommano et al,. 2020).

Table 2: Comparison of Subtypes between *Cannabis Sativa L* Indica and Sativa

Characteristics	Cannabis (Marijuana)	Hemp
Genus	*Cannabis sativa* L.	*Cannabis sativa* L.
Sub variety	Indica	sativa
Utilized organs	leaves, flowers, stems and seeds containing trichomes	stem
Level of psychoactive THC	High (>1%/DW)	Low
Medicinal CBD	Can be high	Can be high
Leaf	Broad, darker leaf color	Thinner and greenish
Content of terpene (Rosin)	High (gluey)	Low

The street and store products of cannabis flower are the Indica subtype of the Cannabis Sativa L genus where the majority of the flower contains the terpenes used for marketing while the low THC hemp has a niche use for its low THC and higher CBD contents. (Sommano et al,. 2020).

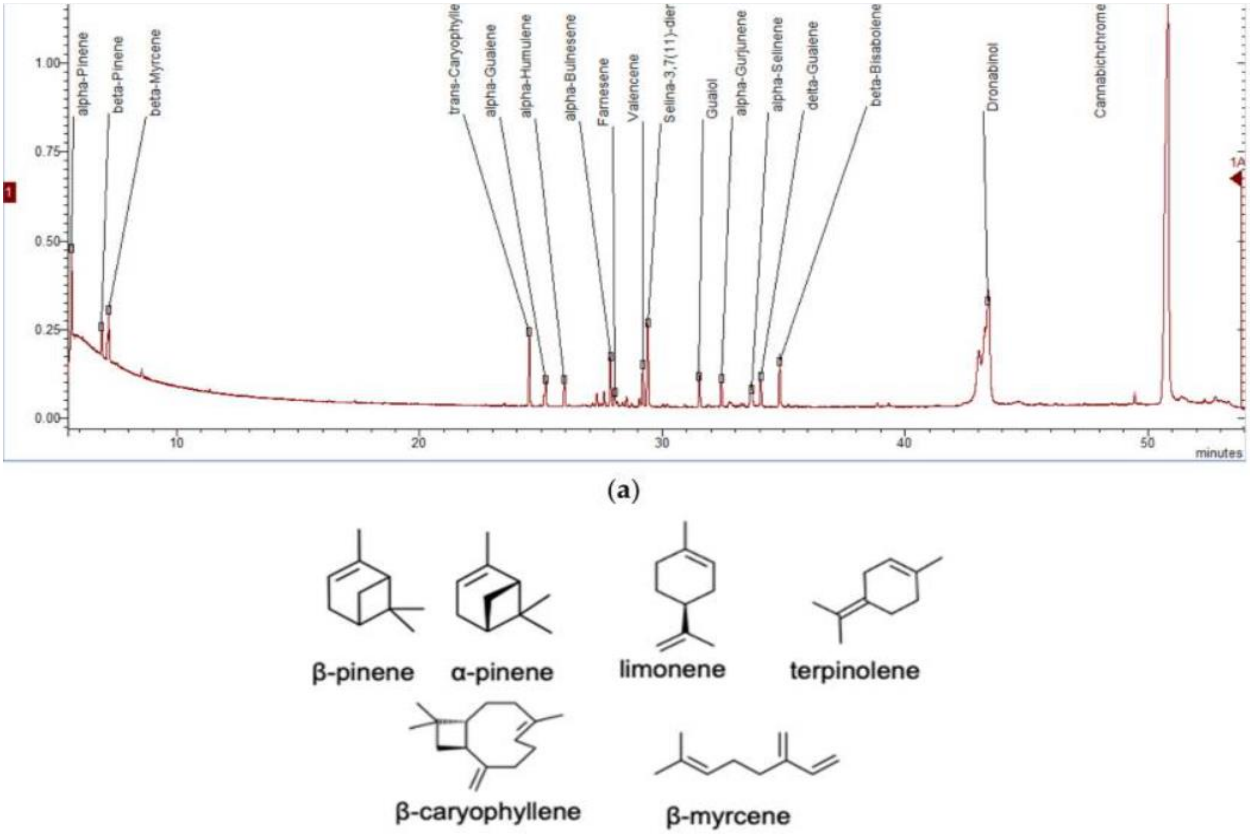

Figure 1: Chromatogram of a mass spectrometer applied to the floral tissue of the *Cannabis Sativa L* plant. The monoterpenoids have less weight due to less isoprene units so they create less prominent spikes. (Ternelli et al, 2020).

Cannabis Family (commercial)*	Stains (Commercial Names)	Seed Types	Level of Cannabinoid THC (Max = 5)	Chemotypic Catagories [1]					Descriptive Sensorial Categories [1]	
				(i) β-myrcene	(ii) α- and β-pinene	(iii) β-caryophyllene and Limonene	(iv) β-caryophyllene	(v) Terpinolene	(i) Earthy, Woody and Herbal	(ii) Citrus, Lemon, Sweet and Pungent
Afghani Kush	Banana Blaze®	F	3		pine					
	Auto Banana Blaze®	F, A	5					orange peel		
	Master Kush	F	3		pine					
	Night Queen®	F	4			lime				
Blue family	Auto Blue Berry®	F, A	3			lime				
	Auto Black Berry Kush®	F, A	4			lime				
	Blue Auto Mazar®	F, A	4		pine		spice			
CBD rich	CBD Charlotte's Angel®	F	1	hop		lime				
	CBD Skunk Haze®	F	2		pine		spice			

The odor representatives; hop; pine; lime; spice and orange peel

Figure 2: Table of Commercial Cannabis strains with terpene profile and associated aroma characteristics. (Shapira et al,. 2019).

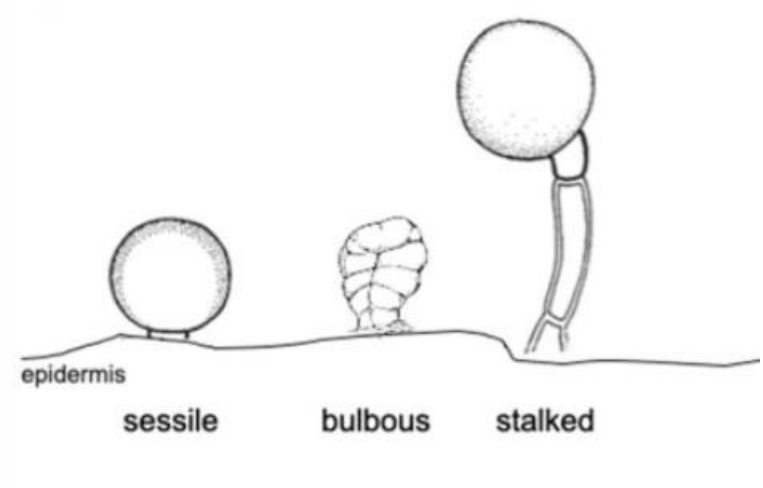

Figure 3: Three trichome structures found on cannabis leaves. (Sommano et al,. 2020).

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