Determination of Terpenoid Profile in Dry Cannabis Flowers and Extracts Obtained from Different Cannabis Varieties

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Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

ABSTRACT

Aim: The aim of this study was to determine the terpenoid profile in dried cannabis flowers obtained from different varieties of cannabis plant and in cannabis extracts in order to investigate quantity of terpenes lost during extraction and purification process.

Methods: GC/MS method for determination of terpenes was verified. The concentration of terpenes was determined in dry flowers as raw material and in decarboxylated and distillated cannabis extracts, using the same GC/MS analytical method. The extraction was performed using 96% ethanol as a solvent.
**Results:** The obtained results indicate that dry cannabis flowers from different cannabis plant can be distinguished only by their terpenoid profile. The use of standardized cannabis-based extracts can be confirmed by determination of terpenoid profile. The purification process of the cannabis extracts removes terpenes. The percentage of major terpene beta-Mycene decreased from 68% in dry flower to 15% in decarboxylated and, 1.9% in distillated cannabis oil after purification. The percentage of second major terpene alpha-Pinene decreased from 15% in dry flower to 5% in decarboxylated and, 0.7% in distillated cannabis oil after purification.

**Conclusion:** Terpenes act synergistically with cannabinoids. Following the monograph for quality testing of cannabis extracts in the German Pharmacopoeia, the purification process is necessary to achieve a final concentration of cannabinoids (Tetrahydrocannabinol) of more than 95% in the final active pharmaceutical ingredient. The purification process removes terpenes that have proven synergistically pharmacological effects with cannabinoids.

**Keywords:** Terpenes; terpenoid profile; cannabis extracts; GC/MS determination; fingerprint.

1. **INTRODUCTION**

*Cannabis sativa* L. (Cannabaceae) is the frequently used plant, yet notorious and controversial, but considered to have therapeutic potential [1]. Several cannabis-based medicines are now available for the treatment of various pathological conditions such as treatment of pain in cancer patients, treatment of nausea and vomiting induced by chemotherapy, loss of appetite and treatment of cachexia in patients with cancer and acquired immunodeficiency syndrome (AIDS), treatment of neuropathic and chronic pain and spasticity in multiple sclerosis [2-6].

Cannabis is a plant that contains more than 1,000 different chemical ingredients, which vary depends on the chemotype (chemical phenotype) of the strain. Chemotypes denote plants of the same genus that are practically identical in appearance but produce essential oil containing different major ingredients that vary within one botanical strain [7].

1.1 **Importance of Terpenes / Terpenoids**

An essential oil (extract) derived from cannabis plats primarily contains cannabinoids which are the main carriers of pharmacological effects and terpenes / terpenoids, which act synergistically with cannabinoids in exhibiting a pharmacological effect. Terpenes / terpenoids are responsible for the characteristic aroma of cannabis extracts.

Terpenes / terpenoids itself have a wide range of pharmacological actions, such as antifungal, antiviral, anticancer, anti-inflammatory, anti hyperglycemic, antiparasitic, antioxidant and antimicrobial. For example, monoterpane myrcene which is the smallest terpene, has antipsychotic, antioxidant, analgesic, anti-inflammatory, sedative, muscle relaxant and anticancer effects [8-10]. Caryophyllene has gastroprotective, analgesic, anticancer, antifungal, antibacterial, antidepressant, anti-inflammatory, antiproliferative, antioxidant, and neuroprotective effects [11]. α-pinene has antibacterial, anti-inflammatory, broncho dilatory, antiseptic and gastroprotective pharmacological effects, while β-pinene has only an antiseptic effect [12]. Linalol is a terpene that acts as a sedative, antipsychotic, anconvulsant, anxiolytic, anesthetic, antidepressant, analgesic, antiepileptic and antineoplastic [8]. Terpineol has an antioxidant, antimicrobic, and relaxing effect, while carophyllene has analgesic, anticancer and antifungal effects [13]. Other terpenes like phellandrene and ocimene, has on only an antifungal effect and they are used to treat different digestive disorders [14-15]. Camphene helps in treatment of cardiovascular diseases, while guaioil has an antitumor effect [16]. α-humulene has antibacterial, anti-inflammatory, and antitumor effects [17], nerolidol antiparasitic [18, 19], and citral has an antifungal, antimicrobial, antiproliferative, cytotoxic, anticancer, and antitumor effect [20–25].

Due to their synergistic effect, several therapeutic approaches based on the combined use of cannabinoids and terpenes have recently been developed [26-29]. Considering that different terpenes have different pharmacological effects, standardization of these products, which can be very heterogeneous [30] depending on the variety of plants from which they are obtained, is an important prerequisite for confirming the quality and expected pharmacological effect [31]. This is especially important if we consider that the terpenoid profile
is a fingerprint or a specificity that is characteristic of each variety.

Therefore, our goal was to develop or verify the GC/MS method for determination of 35 terpenes and to monitor their content in a cannabis dry flower from different varieties as well as in cannabis extracts obtained after extraction process of the same flowers in order to investigate quantity of terpenes lost during extraction and purification process.

2. MATERIALS AND METHODS

2.1 Chemicals and Reagents

Standards for cannabis terpenes as a Reference material were supplied by Restek and Sigma Aldrich (Table 1). Helium gas was supplied by Messer.

2.2 Apparatus

Terpene analysis were performed on a GCMS-QP2010SE single quadrupole mass spectrometer with static headspace (HS-20) with loop and autosampler for sample introduction.

2.3 Instrument Operating Conditions and Method Parameters

Instrument operating conditions and method parameters [32] are shown in Table 2. Verification of the method was fully implemented.

2.4 Standard Solutions and Calibration Curves

Three sets of standards were used to obtain a more complete terpene profile. Standard one, purchased from Restek in a 2500 μg/mL stock solution, and Standard two and three, purchased from Sigma Aldrich (SPEX mix A and SPEX mix B) in a 100 μg/mL stock solution. 35 different terpenes were identified and quantified in total.

Full evaporation headspace technique (FET) was used for quantification. A five-point calibration curves were created from the Restek terpene standard with concentration ranging from 78-2500 μg/mL and Sigma Aldrich terpene standards (mix A and mix B) with concentrations ranging from 12.5-100 μg/mL. An aliquot of 10μL of the standard was placed in a 10mL headspace vial and capped. All points on the calibration curve were run in replicates of six.

2.5 Verification of the Method

The proposed method was verified according to the guidelines set by the International Conference of Harmonization for validation of analytical procedures [33, 34]. The precision and reproducibility of the proposed method were evaluated by performing six replicate analyses of the standard solutions for five different concentrations. Relative standard deviations were calculated to obtain the precision of the method. The full mass scan was done for all standard mix solutions to confirm the specificity / selectivity of the method. To confirm the linearity of the method standard solutions in at least five different concentrations was prepared for all analytes. The limit of detection and limit of quantification for each analyte were calculated from standard error, slope, and analyte response.

2.6 Extraction Process

The extraction process was performed using 96% ethanol as a solvent. Maceration was performed in a cold chamber (refrigerator at -20°C). The duration of the maceration was 30 minutes in total. Stirring was done on every 10 minutes. After maceration was completed, the macerated material (cannabis flowers) was manually squeezed with a stainless-steel strainer. The resulting macerate was filtered. After that the ethanol was evaporated. After evaporation of the ethanol, the obtained crude oil was decarboxylated by heating until the temperature of the crude extract reached 125-130°C. After decarboxylation, additional purification was performed to obtain an extract (distillated cannabis oil) having more than 95% THC according to the monograph in the German Pharmacopoeia.

2.7 Sample Preparation (dry flower or cannabis extract)

FET was used for quantitation. 30mg of the dry cannabis flower or cannabis extract (decarboxylated or distillated oil) were weighed into a headspace vial and capped. Calculations of the quantity of different terpenes were done using calibration curve for each terpene separately. Analyze was done on nine different
strains of cannabis plant and two decarboxylated and two distilled cannabis extracts obtained from two different strains of cannabis plant. The extraction was performed using 96% ethanol as a solvent through maceration.

3. RESULTS AND DISCUSSION

3.1 Verification of the Method

The precision and reproducibility of the proposed method were evaluated by performing six replicate analyses of the standard solutions for five different concentrations used for creation of calibration curves. Relative standard deviations (RSD) were calculated for each terpene. RSD for each terpene in each concentration after 6 replicate determinations was lower than 7% [35].

The typical chromatograms and calibration curves of the standard solutions of each terpene are shown in Figure 1-1, Figure 1-2 and Figure 1-3. Coefficient of correlation was greater than 0.99.

The full mass scan was done for all standard mix solutions to confirm the specificity / selectivity of the method. At least 2 qualifier ions were used for identification and one quantifier ion for quantification. The results are shown in Table 3.

Limit of detection / Limit of quantification were calculated from standard error, slope, and analyte response. The results calculated as numerical (absolute) value from the calibration curve are shown in Table 4.
Fig. 1-a. Typical chromatograms (GS/MS) and calibration curves of the standard solutions for terpene testing
Fig. 1-b. Typical chromatograms (GS/MS) and calibration curves of the standard solutions for terpene testing
Geranyl acetate  alpha-Cedrene

beta-Caryophyllene  alpha-Humulene

cis-Nerolidol  trans-Nerolidol

Guaiol  Cedrol

alpha-Bisabolol  beta-Eudesmol

Phytol

Fig. 1-c. Typical chromatograms (GS/MS) and calibration curves of the standard solutions for terpene testing
Table 3. Retention time and analyte transition for different terpenes

| Terpene             | Retention time (min) | Precursor Ion | Product Ion (Quantifier) | Product Ion (Qualifier) |
|---------------------|----------------------|---------------|--------------------------|-------------------------|
| alpha-Pinene        | 5.93                 | 93            | 92                       | 91                      |
| Camphene            | 6.24                 | 93            | 121                      | 79                      |
| beta-Myrcene        | 6.61                 | 93            | 41                       | 69                      |
| beta-Pinene         | 6.65                 | 93            | 69                       | 41                      |
| 3-Carene            | 7.015                | 93            | 91                       | 79                      |
| Alpha terpinene     | 7.16                 | 121           | 93                       | 136                     |
| trans-beta-Ocimene  | 7.245                | 93            | 92                       | 91                      |
| Limonene            | 7.325                | 68            | 93                       | 67                      |
| Cymene              | 7.38                 | 119           | 134                      | 91                      |
| beta-Ocimene        | 7.485                | 93            | 91                       | 80                      |
| gamma-Terpinene     | 7.76                 | 93            | 91                       | 80                      |
| Terpinolene         | 8.275                | 93            | 121                      | 136                     |
| Linalol             | 8.88                 | 71            | 93                       | 55                      |
| L-Fenchone          | 9.055                | 81            | 69                       | 41                      |
| Fenchol, exo-       | 9.59                 | 81            | 80                       | 43                      |
| Isopulegol          | 9.97                 | 67            | 81                       | 69                      |
| Camphor             | 10.265               | 95            | 81                       | 108                     |
| Isoborneol          | 10.4                 | 95            | 110                      | 93                      |
| Menthol             | 10.47                | 81            | 71                       | 95                      |
| Borneol             | 10.59                | 95            | 110                      | 41                      |
| alpha-Terpineol     | 10.76                | 59            | 93                       | 121                     |
| Citronellol         | 11.165               | 96            | 41                       | 55                      |
| Geraniol            | 11.6                 | 69            | 41                       | 68                      |
| Pulegone            | 11.685               | 81            | 152                      | 67                      |
| Geranyl acetate     | 13.31                | 69            | 41                       | 43                      |
| Alpha-Cedrene       | 14.145               | 119           | 93                       | 105                     |
| beta-Caryophyllene  | 14.255               | 93            | 133                      | 69                      |
| alpha-Humulene      | 14.805               | 93            | 80                       | 121                     |
| cis-Nerolidol       | 15.79                | 69            | 93                       | 41                      |
| trans-Nerolidol     | 16.22                | 69            | 93                       | 41                      |
| Guaiol              | 17.09                | 161           | 59                       | 105                     |
| Cedrol              | 17.505               | 95            | 150                      | 151                     |
| alpha-Bisabolol     | 18.075               | 109           | 119                      | 69                      |
| beta-Eudesmol       | 18.095               | 59            | 149                      | 108                     |
| Phytol              | 19.325               | 95            | 68                       | 82                      |

Table 4. Limit of detection / Limit of quantification of different terpenes, calculated as numerical (absolute) value from the calibration curve

| Terpene             | Limit of Detection (μg/mL) | Limit of Quantification (μg/mL) |
|---------------------|----------------------------|---------------------------------|
| alpha-Pinene        | 0.544                      | 1.649                           |
| Camphene            | 0.445                      | 1.349                           |
| beta-Myrcene        | 0.547                      | 1.658                           |
| beta-Pinene         | 0.508                      | 1.539                           |
| 3-Carene            | 0.478                      | 1.449                           |
| Alpha terpinene     | 0.387                      | 1.174                           |
| trans-beta-Ocimene  | 0.573                      | 1.738                           |
| Limonene            | 0.483                      | 1.464                           |
| Cymene              | 0.327                      | 0.993                           |
| beta-Ocimene        | 0.521                      | 1.580                           |
| gamma-Terpinene     | 0.454                      | 1.376                           |
| Terpinolene         | 0.446                      | 1.35                            |
| Linalol             | 0.661                      | 2.003                           |
### Table 5. Terpenoid profile of different cannabis strains, calculated as percentage of total terpenes

| Cannabis strain | BB*  | AK*  | WW*  | HE*  | SG*  | LS*  | GE*  | FC*  | AFG* |
|-----------------|------|------|------|------|------|------|------|------|------|
| Terpene         |      |      |      |      |      |      |      |      |      |
| alpha-Pinene    | 10.997 | 16.314 | 15.287 | 11.487 | 1.453 | 2.682 | 4.917 | 2.869 | 5.611 |
| Camphene        | 0.396 | 0.360 | 0.303 | 0.508 | 0.426 | 0.455 | 0.653 | 0.995 | 0.802 |
| beta-Mycene     | 62.998 | 55.347 | 68.887 | 48.943 | 38.367 | 11.562 | 10.048 | 11.540 | 17.471 |
| beta-Pinene     | 3.678 | 7.414 | 0.396 | 0.360 | 0.303 | 0.508 | 4.917 | 2.869 | 5.611 |
| 3-Carene        | 0.274 | ND   | ND   | ND   | 0.094 | 0.038 | 0.611 | 0.022 | 0.151 |
| Alpha-terpinene | 0.268 | 0.157 | 0.161 | 0.085 | 0.062 | 0.711 | 0.047 | 0.020 | 0.078 |
| trans-beta-Ocimene | ND   | ND   | ND   | ND   | 0.209 | 0.162 | 0.257 | 0.168 | 0.264 |
| Limonene        | 4.804 | 4.460 | 2.339 | 12.970 | 15.036 | 14.493 | 17.182 | 22.887 | 23.841 |
| Cymene          | ND   | ND   | ND   | ND   | ND   | ND   | ND   | ND   | ND   |
| beta-Ocimene    | ND   | ND   | ND   | ND   | 6.266 | 2.588 | 9.511 | 2.484 | 0.672 |
| gamma-Terpinene | 0.536 | 0.320 | 0.335 | 0.149 | 0.075 | 0.526 | 0.066 | 0.152 | 0.078 |
| Terpinolene     | 0.587 | 0.349 | 0.357 | 0.245 | 0.194 | 15.210 | 0.214 | 0.474 | 0.970 |
| Linalol         | 5.853 | 6.842 | 2.405 | 2.437 | 6.197 | 3.291 | 8.303 | 8.158 | 3.471 |
| L-Fenchone      | ND   | ND   | ND   | 0.188 | 0.292 | 0.181 | 0.451 | 0.574 | 0.382 |
| Fenchol, exo-   | ND   | ND   | ND   | 1.083 | 3.634 | 2.914 | 4.273 | 6.154 | 5.447 |
| Isopulegol      | ND   | ND   | ND   | ND   | ND   | ND   | ND   | ND   | ND   |
| Camphor         | ND   | ND   | ND   | 0.007 | 0.006 | 0.006 | 0.009 | 0.015 | 0.010 |
| Isoborneol      | ND   | ND   | ND   | ND   | ND   | ND   | ND   | ND   | ND   |
| Menthol         | ND   | ND   | ND   | ND   | ND   | ND   | ND   | ND   | ND   |
| Borneol         | 0.247 | ND   | ND   | 0.359 | 0.627 | 0.556 | 0.569 | 1.119 | 0.863 |
| alpha-Terpineol | 1.604 | 1.176 | 0.347 | 1.147 | 2.359 | 2.150 | 2.640 | 4.115 | 2.957 |
| Cannabis strain | BB* | AK* | WW* | HE* | SG* | LS* | GE* | FC* | AFG* |
|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|------|
| Citronellol     | ND  | ND  | ND  | 0.001 | 0.002 | ND  | ND  | 0.030 | ND   |
| Geraniol        | ND  | ND  | ND  | ND  | ND  | ND  | ND  | ND  | ND   |
| Pulegone        | ND  | ND  | ND  | ND  | ND  | ND  | ND  | ND  | ND   |
| Geranyl acetate | ND  | ND  | ND  | 0.014 | ND  | ND  | ND  | ND  | ND   |
| Alpha-Cedrene   | ND  | ND  | ND  | ND  | ND  | ND  | ND  | ND  | ND   |
| beta-Caryophyllene | ND  | ND  | ND  | 4.542 | 18.268 | 23.480 | 33.033 | 25.800 | 19.883 |
| alpha-Humulene  | 7.759 | 7.260 | 3.141 | 2.932 | 4.962 | 5.844 | 7.798 | 6.783 | 5.440 |
| cis-Nerolidol   | ND  | ND  | ND  | ND  | ND  | ND  | ND  | ND  | ND   |
| trans-Nerolidol | ND  | ND  | ND  | 0.169 | 1.114 | 1.181 | 2.272 | 1.322 | 1.120 |
| Guaiol          | ND  | ND  | ND  | 1.154 | 1.303 | ND  | ND  | 0.181 | ND   |
| Cedrol          | ND  | ND  | ND  | ND  | ND  | ND  | ND  | ND  | ND   |
| alpha-Bisabolol | ND  | ND  | ND  | 0.571 | 1.019 | 0.183 | 0.243 | 0.604 | 0.680 |
| beta-Eudesmol   | ND  | ND  | ND  | 1.371 | 1.620 | 0.099 | 0.105 | 0.146 | 0.315 |
| Phytol          | ND  | ND  | ND  | 0.014 | ND  | ND  | ND  | ND  | ND   |

*Cannabis species: BB (Big Bud), AK (AK-47), WW (White Widow), HE (Herijuana), SG (Strawberry Glue), LS (La S.A.G.E), GE (Gelato), FC (French Cookies), AFG (Afghan Berry), ND – Not Detected

Table 6. Determination of major terpenoids in cannabis extracts obtained from different varieties of cannabis flower

| Cannabis strain | Terpene   | WW*     | Terpenes (%) in dry cannabis flowers | Terpenes (%) in Decarboxylated oil | Terpenes (%) in Distillated oil |
|-----------------|-----------|---------|-------------------------------------|-------------------------------------|--------------------------------|
|                 | alpha-Pinene | 15.287 | 4.089                                 | 0.69                                 |                                |
|                 | beta-Mycene     | 68.887 | 15.225                                 | 1.90                                 |                                |
|                 | beta-Pinene     | 6.438  | 2.860                                  | 0.11                                 |                                |

| Cannabis strain | Terpene   | Terpenes (%) in dry cannabis flowers | Terpenes (%) in Decarboxylated oil | Terpenes (%) in Distillated oil |
|-----------------|-----------|-------------------------------------|-------------------------------------|--------------------------------|
|                 | alpha-Pinene | 10.997 | 1.27                                  | 0.73                                 |                                |
|                 | beta-Mycene     | 62.998 | 42.91                                 | 3.76                                 |                                |
|                 | Limonene        | 4.804  | 3.70                                  | 1.07                                 |                                |

*Decarboxylated and Distillated oil obtained from cannabis strain WW (White Widow) and BB (Big Bud)

Fig. 2. Typical chromatogram for chromatographic separation of terpenes in standard solution
Fig. 3. Typical chromatogram for chromatographic separation of terpenes in cannabis flower

Fig. 4. Typical chromatogram for chromatographic separation of terpenes in cannabis extract

3.2 Determination of Terpenoid Profile in Cannabis Dry Flowers and Cannabis Extracts

Results from determination of terpenoid profile on nine different varieties of cannabis plant are shown in Table 5.

Results from determination of three major terpenoids in cannabis extracts (two decarboxylated and two distillated oils) obtained from two different varieties of cannabis dry flowers compared with quantity (in %) of terpenes in the cannabis dry flowers used for process of extraction are shown in Table 6.

Typical chromatogram for chromatographic separation of all terpenes in standard solution is shown in Fig. 2.

Typical chromatogram for chromatographic separation of all terpenes in cannabis flower is shown in Fig. 3.

Typical chromatogram for chromatographic separation of all terpenes in cannabis extract is shown in Fig. 4.

4. DISCUSSION

Terpenes, which are the basic ingredients of essential oils in many plants have been used for thousands of years for different therapeutic purposes. Studies in animal models and humans have identified analgesics, antimicrobials, anti-inflammatory and similar therapeutic properties. The main focus of researchers for the therapeutic purposes of cannabis-based medicines have been cannabinoids primarily Δ9-tetrahydrocannabinol (THC), while terpenes and potential interactions between terpenes and cannabinoids has barely been studied at all when the cannabis-based medicines are consumed for medical purposes [36].

The hypothesized synergistic interactions between different cannabinoids and terpenes to obtain unique pharmacological effects have been investigated in several preclinical and some clinical studies. There is skepticism in the literature and remains unclear with insufficient evidence from preclinical studies whether terpenes can act synergistic with cannabinoids [37-39]. If terpenes can be shown to modulate cannabinoid activity, it could provide a powerful tool to improve cannabinoid therapy.

Recently studies have been conducted to evaluate the functional and modulatory actions of various terpenes in vivo and in vitro, both alone and in combination with an established cannabinoid agonist. The results of this studies establish direct interaction between cannabinoids.
and terpenes demonstrating that terpenes can selectively modulate pharmacological agonist activity of cannabinoids. This study is the first that shows that terpenes and cannabinoids can produce an additive effect when combined [36]. The mechanisms of synergistic action between terpenes and cannabinoids at the molecular level is still unknown. Two alternatives are (1) direct modulation of membrane shifting CB1 receptors activation and (2) terpene modulation of endocannabinoid synthesis or degradation, which results in CB1 receptors activation. But the notable aspect of this study was the generally high concentrations of terpenes needed to see activation [36].

In our case, we conducted tests for determination of terpenes in cannabis dry flowers and extracts. Since there is no monograph in the European Pharmacopeia (Ph.Eur.) for quality testing of cannabis flower and extracts, currently a revised monograph for cannabis flower (cannabis floss) and cannabis extracts, published in the German Pharmacopoeia in 2018 (3) and 2020, by the Federal Institute for Drugs and Medical Devices (BfArM) has instructed the obligatory procedure for quality testing of cannabis flowers in the European Union [40]. Following these monographs, the purification process of the cannabis crude extract is necessary to achieve a final concentration of THC of more than 95% in the final active pharmaceutical ingredient. With the analysis performed we have shown that the purification process removes terpenes from the final extracts. The percentage of major terpene beta-Myrcene which has proven antipsychotic, antioxidant, analgesic, anti-inflammatory, sedative, muscle relaxant and anticancer effects decreased from 68% in dry flower to 15% in decarboxylated and, 1.9% in distillated cannabis oil after purification. The percentage of second major terpene alpha-Pinene which has proven antibacterial, anti-inflammatory, broncho dilatory, antiseptic and gastroprotective pharmacological effects decreased from 15% in dry flower to 5% in decarboxylated and, 0.7% in distillated cannabis oil after purification. The question that arises is connected to the pharmacological effect on cannabis-based medicines obtained from cannabis active pharmaceutical ingredients in which terpenes have been removed.

5. CONCLUSION

The main carriers of pharmacological effects in cannabis flowers or extracts are cannabinoids. Terpenes itself have a wide range of pharmacological actions and act synergistically with cannabinoids in exhibiting a pharmacological effect. At the same time terpenes are fingerprint or a specificity that is characteristic of each variety, which is very important for standardization of the cannabis-based extracts. Following the German monograph for cannabis extracts the purification process is necessary to achieve a final concentration of THC of more than 95% in the final active pharmaceutical ingredient. With the analysis performed we have shown that the purification process removes terpenes from the final extracts. The percentage of major terpene beta-Myrcene which has proven antipsychotic, antioxidant, analgesic, anti-inflammatory, sedative, muscle relaxant and anticancer effects decreased from 68% in dry flower to 15% in decarboxylated and, 1.9% in distillated cannabis oil after purification. The percentage of second major terpene alpha-Pinene which has proven antibacterial, anti-inflammatory, broncho dilatory, antiseptic and gastroprotective pharmacological effects decreased from 15% in dry flower to 5% in decarboxylated and, 0.7% in distillated cannabis oil after purification. The question that arises is connected to the pharmacological effect on cannabis-based medicines obtained from cannabis active pharmaceutical ingredients in which terpenes have been removed.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

It is not applicable.
ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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