The Volatile Oil Composition of Fresh and Air-Dried Buds of Cannabis sativa

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Received January 12, 1995

The composition of the steam-distilled volatile oil of fresh and air-dried, indoor-grown marijuana was studied by GC/FID and GC/MS. In all, 68 components were detected of which 57 were fully identified. Drying of the plant material had no effect on the qualitative composition of the oil and did not affect the ability of individuals familiar with marijuana smell to recognize the odor.

The chemical composition of the volatile oil of Cannabis sativa L. was the subject of several investigations.1-7 A total of 58 monoterpenes and 33 sesquiterpenes was reported to have been identified from different cannabis preparations in a 1986 review article published by Turner et al.8 In a more recent study, Brenneisen and ElSohly10 reported on the GC/MS analysis of cannabis extracts and the use of the entire chromatographic characteristics (not just the cannabinoid) for identification of the variety of origin of confiscated marijuana. It was shown that the terpenes play an important part in that classification. Because all the work was carried out on dried material, we decided to compare the chemical composition of the cannabis volatile oil prepared from fresh vs. dried plants and to determine the effect of drying on the individuals' ability to recognize the smell.

Although marijuana odor has long been accepted to be recognizable by dogs, the recognition of the smell by law enforcement officers has recently been challenged in courts by the defense in criminal cases. The purpose of this paper is to identify the major components of the essential oil of cannabis and to study the effect of drying and storage of the plant material on the stability of the characteristic components of the oil odor or odor of the plant material. Olfactory testing of the different oils by human subjects familiar with marijuana smell was also used to verify the characteristic odor.

The volatile oil of fresh and dried marijuana was prepared by steam distillation, and the oil was collected using lighter-than-water volatile oil apparatus. Samples of fresh marijuana buds (15 g each) were acquired, with one sample being extracted immediately. Three samples were allowed to dry and were stored in a brown paper bag for 1 week and then stored in a brown paper bag for 1 month at room temperature. C: Volatile oil prepared from buds that had been dried at room temperature for 1 week and then stored in a brown paper bag for 1 month at room temperature. D: Volatile oil prepared from buds that had been dried at room temperature for 1 week and then stored in a brown paper bag for 6 weeks at room temperature.

Table 1. Effect of Drying on the Volatile Oil Composition of Fresh Buds

<table>
<thead>
<tr>
<th>Component</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of Volatile Oil in Buds (%)</td>
<td>0.06</td>
<td>0.07</td>
<td>0.08</td>
<td>0.09</td>
</tr>
<tr>
<td>Percentage of Loss in the Volatile Oil content during drying</td>
<td>31.0%</td>
<td>41.5%</td>
<td>53.2%</td>
<td></td>
</tr>
<tr>
<td>Composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>monoterpenes</td>
<td>52.0%</td>
<td>60.0%</td>
<td>66.0%</td>
<td>62.0%</td>
</tr>
<tr>
<td>sesquiterpenes</td>
<td>36.0%</td>
<td>24.0%</td>
<td>18.0%</td>
<td>38.0%</td>
</tr>
<tr>
<td>aliphatic alcohol</td>
<td>5.0%</td>
<td>5.0%</td>
<td>6.0%</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

A: Volatile oil prepared from freshly collected buds. B: Volatile oil prepared from buds that had been dried at room temperature for 1 week. C: Volatile oil prepared from buds that had been dried at room temperature for 1 week and then stored in a brown paper bag for 1 month at room temperature. D: Volatile oil prepared from buds that had been dried at room temperature for 1 week and then stored in a brown paper bag for 6 weeks at room temperature.

The data presented in Table 2 show that the fresh bud oil is composed mainly of monoterpenes (92%), with 7% sesquiterpenes and approximately 1% other chemical classes, such as simple ketones and esters. The two principal monoterpenes components are β-myrcene and limonene, representing ca. 67% and 16% of the oil, respectively.

Of the 68 components detected in the chromatogram of the fresh bud oil, 57 were identified (see Table 2). These include 2 aliphatic alcohols, 12 aliphatic alcohols, 12 monoterpenes, and 23 sesquiterpenes. Three of the identified monoterpenes and 14 sesquiterpenes
Table 2. Chemical Composition of the Volatile Oil of Cannabis Prepared from Fresh and Dried Buds

<table>
<thead>
<tr>
<th>No.</th>
<th>Components</th>
<th>Percentage</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>humulene, a-8-caryophyllene</td>
<td>2.98</td>
<td>17.20</td>
<td>17.66</td>
<td>16.26</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1,8-cineole</td>
<td>4.53</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>cis-camphene</td>
<td>4.53</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>trans-p-farnesene, epoxide, unknown</td>
<td>2.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

Have not been reported previously in cannabis odor or volatile oil. These aspirogenus are as follows: cis-sabinene hydrate (cis-ajuganol), ipedienol, cis-carveol, 1.5-ylangene, fidelemene, (Z)-2-cis-bergamotene, a-guaiene, a-cadinene, t-myrcene, a-cumene, e-terpinene, a-terpinene, a-pinene (pinene, 2-1,8-cineole, (eudesma-4(14),11-diene), a-humulene (a-caryophyllene), unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unknown, y-eudesmol (machilol, selinenol, uncineol), 1,8-cineole, unkno
Not unexpectedly, drying the plant material resulted in overall reduction in the percentage of the oil recovered. Most of the loss appears to take place after the first week of drying, with the oil content dropping from 3.0% to 2.2%. The oil contents after drying and storage for one and three months were 0.16% and 0.13%, respectively (see Table 1). The percentage composition of monoterpenes and sesquiterpenes in these oils is also presented in Table 1.

It is evident from Tables 1 and 2 that drying the plant material resulted in a significantly greater loss of monoterpenes than of sesquiterpenes. However, qualitatively speaking, none of the major components of the oil (\(t > 0.15\)) of the total completely disappeared in the drying process.

To evaluate the odor of the different oils, technicians experienced with marijuana smell were asked to identify the smell of the individual oils. The subjects were able to recognize the smell of all oils as that of marijuana.

**Experimental Section**

**Plant Material.** *Cannabis sativa L.* (Marijuana) plants were grown from seeds of a high potency hybrid under artificial lights with a light/dark cycle of 16/8 h. TheSecurity Products Co. of Del. Inc., Minneapolis, MN) before being inserted in the potting mixture and thoroughly watered. After 21 days at 16/8-h light/dark, the rooted cuttings were prepared.

**Preparation of the Volatile Oil.** Marijuana buds (60 g) were harvested on 9 Nov 1992, and divided into four equal parts:

1. The volatile oil was harvested immediately from the first part (15 g) by steam distillation (0.29% yield, wet weight) (sample A).

2. The second part (15 g) was air-dried at room temperature for one week to afford 3.77 g of dried material from which the volatile oil was prepared by steam distillation (0.26% yield based on wet material, wet weight) (sample B).

3. The third part (15 g) was air-dried at room temperature for one week then stored in a brown paper bag for one month to afford 3.7 g of dried material, from which the volatile oil was prepared by steam distillation (0.16% yield based on wet material, wet weight) (sample C).

4. The fourth part (15 g) was air-dried at room temperature for one week then stored in a brown paper bag for three months to afford 3.5 g of dried material from which the volatile oil was prepared (0.13% yield based on wet material, wet weight) (sample D).

**Reference Standards.** Reference standards of different monoterpenes, sesquiterpenes, and alkanes were obtained from Aldrich Chemical Co. Inc., Milwaukee, WI; Fluka Chemical Corp. (New York, NY); Rich C. M. Chemische Fabrik (Karlsruhe, Germany; Sigma Chemical Co., St. Louis, MO); and Varian Associates (Houston, TX). These reference standards included: tricyclene, c-pine, sabinen, \(\alpha\)-phellandrene, \(\delta\)-decenol, limonene, \(\beta\)-farnone, \(\alpha\)-terpinene, 

**Volatile Oil Solutions.** For GC/MS analysis the volatile oil samples (A–D) were dissolved in methanol at a concentration of 1 mg/mL.

**GCMS Analysis.** A Varian 3900 gas chromatograph interfaced to a Finnigan 7000 ion trap detector (ITD) was used. The gas chromatograph was equipped with dual capillary injectors and a flame ionization detector. ITD data were recorded using an IBM XT computer with an HP 3392 integrator. The ITD software is also equipped with a terpene library comprising over 600 entries of monoterpenes and sesquiterpenes. ITD data were recorded using a Hewlett-Packard 3392 integrator.

**References and Notes**


