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Volatiles from *Acer truncatum* Flowers

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Abstract

Plant volatile organic compounds (Biogenic Volatile Organic compounds, referred BVOCs) have a significant impact on the atmospheric environment, air quality and human health. This experiment takes *Acer truncatum* flowers as the research object, uses solid-phase micro-extraction combine GC-MS (SPME-GC-MS) to detect the main component of volatiles released by the flowers from 10 individual trees of *Acer truncatum* (*Acer truncatum* Bunge). The results showed that 37 kinds of volatiles were detected and they are belonged to four types organic compouds, such as terpenoids, alcohols, ketones, esters. According to the analysis of the main components of *Acer truncatum* flower volatiles includes Fluorene, 4,8 -Dimethyl-1,3 (E), 7-Nonene, (cis, trans)-2,6-Dimethyl-2,4,6-triene-Partenkirchen, Myrcene, Basil hexene, 3-Carene, (E)-Basil, Camphene, Caryophyllene, Linalool, *α*-Terpinolene, O-cymene, 3-Vinyl-1,2-dimethyl-1, *Eucalyptus* alcohols and Alcohol vinegar-12. However, there were no significant differences between individual trees in terms of obscure material O-cymene, *Eucalyptus* alcohols, Alcohol vinegar-12, as well as the significant differences in terms of remaining volatiles.

Keywords

Acer truncatum, Flower, Volatiles, SPME, GC-MS

1. Introduction

When the green plant absorbs CO_2 to release O_2, it will synthesize low-boiling and volatile small molecular organic compounds, which is well known as plant volatile organic compounds (VOCs) [1], with its secondary metabolic pathway. The discovery of its role in the ecosystem has attracted wide attention with further research [2] [3]. Plant VOCs contain the active ingredients have function about antibacterial, health care, air purification and so on. Extraction of some

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plant VOCs are widely used in food, medical care and health care etc. as the development of the aroma analysis technology and the close combination between various disciplines. Some VOCs can induce feelings of relaxation and comfort [4] and some aromatic VOCs have been reported to lower blood pressure and improve mood [5] [6]. Therefore, systematic investigation of plant volatile components, aimed at promotes the development of community ecology theory to make urban green system to play great role in urban ecological balance and sustainable development. Plant VOCs plays an important role in improving the quality of urban air and protecting citizen's physical and mental health.

Acer truncatum Bunge, a member of the *Aceracae* family, is endemic to China, Korea and Japan but is also found in Europe and North America [7] [8] The genus *Acer* (*Aceraceae*), commonly known as maple, comprises approximately 129 species that primarily grow in the northern hemisphere, especially in the temperate regions of East Asia, eastern North America, and Europe [9]. There have been many phytochemical investigations focusing on *Acer truncatum*, as this species has great commercial value and numerous applications in traditional Chinese medicine and drinks production.

To date, 331 compounds have been identified from 34 species of the genus *Acer*, including flavonoids [10], tannins, phenyl propanoids, diarylheptanoids, terpenoids, benzoic acid derivatives and several other types of compounds [11] [12], such as phenylethanoid, glycosides and alkaloids [13] [14] [15] [16]. But no research has been conducted concerning the chemical constituents and pharmacological activities of *Acer truncatum* flowers. In order to identify the volatiles of *Acer truncatum* flowers, we report on their essential oils using the headspace solid-phase microextraction (HS-SPME) followed by GC-MS for the first time.

This research focuses on the development and utilization of this new type of resource—*Acer truncatum* flowers, which is based on the release of flower volatiles, and explores whether it could be exploited extensively in the aspects of environmental optimization or new resources development of traditional Chinese medicine.

2. Materials and Methods

2.1. Plant Materials

The flowers of *Acer truncatum* were collected from 10 individual trees at Mountain Taishan in Shandong Province, China, in March 2017. The sampled *Acer truncatum* tree was approximately 5.3 ± 1.2 m in height and 14.5 ± 1.7 cm in diameter at breast height (DBH). The trees No.8, No.9 and No.10 at the foot of the mountain and the remaining test materials, surrounded by more adequate sunshine, were all located in the valley. The branches with flowers facing the south were selected in the middle of the trees. The collected flower samples were deposited in the laboratory of College of Horticulture Science and Engineering, Shandong Agricultural University.

2.2. Analysis of Volatile Compounds of the Flowers

Firstly, 1 g of fresh *Acer truncatum* flower was separately taken and weighed from different single plants, placed into 10 ml extraction glass bottle, sealed with aluminum foil, and separately marked. Then, the extraction was conducted at 40˚C using tips of 50/30 μm DVB/CAR/PDMS (divinyl benzene/carbon molecular sieve/polydimethylsiloxane). The tips were then inserted into the injection port of a GC–MS and desorbed at 250˚C for 3 min. The GC oven was programmed for 2 min at 40˚C, followed by a temperature increase at the rate of 6˚C min^{-1} to 90˚C, and then by an increase of 10˚C min^{-1} to 200˚C, and finally by an increase of 15˚C min^{-1} to 250˚C, where it was maintained for 5 min. The flow rate of He, carrier gas, was 1.0 m·L·min^{-1}. The MS of the eluting compounds were generated at 80 eV, and recorded each second 45 - 450 m·z^{-1}. The ion source was electron impact (EI), which has a temperature of 200˚C and interface temperature of 250˚C. The volatiles were identified by screening the NIST 08 and NIST 08 S libraries for comparable mass spectra and via comparison with authentic reference compounds. The relative percentages of the compounds were calculated using the areas of peak normalization method.

2.3. Data Analysis

Statistical analyses were conducted using Excel 2007 for Windows and Statistical Program for the Social Sciences (SPSS 22.0) were used for a one-way analysis of variance(ANOVA), a Least Significant Difference (LSD) method was used for statistical evaluations, and the differences between the each treatment group were examined for significance at the 5% level($P < 0.05$).

3. Results

The volatiles of *Acer truncatum* flowers are presented in **Table 1**. Thirty-seven compounds were identified, which comprised by so many organic compounds. The type of volatile constituents of *Acer truncatum* flowers were abundant. The proportion of various volatiles was shown in **Figure 1**. Terpenoids (85.23%) was the highest volutile constituent，followed by alcohols (3.05%), ketones (1.67%), esters (0.91%).

The most important discovery was that Fluorene was one of the representative key volatiles of *Acer truncatum* flowers. Its derivatives Fluorene as pharmaceutical intermediates used to produce anti-cancer drugs, antispasmodic agent, the sympathetic nerve inhibitors, blood pressure medications and antispasmodic drugs, as a pesticide intermediates, fluorenone could be used for the preparation of herbicides, fungicides, plant growth regulator, etc [17]. The demand for Fluorene has increased greatly in domestic and foreign markets, so it was becoming more and more important to study the extraction and refining methods of Fluorene. Some people have begun to study its refining work [18].

Table 1. Components and relative contents of volatiles from flowers of *Acer truncatum* (mean ± *SE*).

Compound	Relative content/%										Average content/%
	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	
Fluorene	1.57 ± 0.087	4.48 ± 0.075	0.62 ± 0.144	0.57 ± 0.052	0.57 ± 0.053	0.42 ± 0.087	0.51 ± 0.231	0.46 ± 0.098	0.66 ± 0.098	0.51 ± 0.115	1.037
4,8 -Dimethyl -1,3 (E), 7-nonene	25.9 ± 0.481	68.8 ± 12.93	26.25 ± 0.563	6.18 ± 0.234	9.62 ± 0.334	26.6 ± 0.446	24.06 ± 0.583	26.82 ± 0.521	15.61 ± 0.36	7.39 ± 0.228	23.723
(cis, trans) -2,6-Dimethyl-2,4,6-triene-Partenkirchen	19.08 ± 0.332	-	13.54 ± 0.292	18.12 ± 0.267	20.41 ± 0.54	11.62 ± 0.600	15.12 ± 0.321	13.31 ± 1.145	8.44 ± 0.170	16.02 ± 0.362	13.566
Myrcene	0.33 ± 0.000	-	0.44 ± 0.087	0.85 ± 0.052	0.72 ± 0.092	0.73 ± 0.110	0.55 ± 0.064	0.59 ± 0.046	1.08 ± 0.162	1.17 ± 0.134	0.646
Ocimene	-	4.51 ± 0.548	0.48 ± 0.179	0.69 ± 0.173	0.81 ± 0.866	0.36 ± 0.635	0.55 ± 0.04	0.51 ± 0.104	0.45 ± 0.751	0.89 ± 0.751	0.0925
3-Carene	39.85 ± 0.440	-	40.74 ± 0.321	50.16 ± 0.416	51.2 ± 0.655	31.04 ± 0.621	44.54 ± 0.616	40.94 ± 0.688	43.12 ± 0.95	-	34.159
(E)-Ocimene	1.79 ± 0.043	-	-	3.32 ± 0.140	3.27 ± 0.035	2.13 ± 0.103	2.46 ± 0.052	2.5 ± 0.072	2.23 ± 0.148	4.43 ± 0.101	2.213
Camphene	1.77 ± 0.000	-	0.42 ± 0.058	-	-	0.17 ± 0.035	-	0.69 ± 0.069	7.58 ± 0.606	0.38 ± 0.046	1.01
Caryophyllene	2.73 ± 0.000	-	2.2 ± 0.121	-	-	5.69 ± 0.185	1.42 ± 0.133	-	1.51 ± 0.395	0.87 ± 0.087	1.442
Linalool	-	-	4.01 ± 0.127	9.7 ± 0.191	1 ± 0.075	-	-	2.46 ± 0.202	-	2 ± 0.318	1.917
3-Vinyl-1,2-dimethyl-1	-	-	1.63 ± 0.225	-	2.37 ± 0.121	-	1.9 ± 0.133	2.26 ± 0.098	3.51 ± 0.087	-	1.167
α-Terpinolene	-	-	-	0.46 ± 0.040	0.58 ± 0.040	-	0.51 ± 0.092	-	-	1.44 ± 0.115	0.299
1-Isopropyl-2-methylbe nzene	-	-	-	-	0.66 ± 0.038	0.42 ± 0.036	0.62 ± 0.026	-	0.54 ± 0.040	-	0.224
1,3-Pentadiene, 4-methyl-	0.45	-	-	-	-	0.19	-	0.43	-	-	0.107
Cosmene	1.29	-	-	-	-	-	0.55	-	-	0.57	0.241
Eucalyptus alcohols	-	-	0.46 ± 0.029	-	-	-	-	0.21 ± 0.058	0.26 ± 0.040	-	0.093
Matrine	-	-	-	0.55	-	-	-	-	-	2.25	0.280
Alcohol vinegar-12	-	-	-	0.24	-	0.32	0.16	-	-	-	0.072
Alpha-Pinene	0.35	-	-	-	-	-	-	-	-	0.12	0.047
Aaromatic alcohol	4.11	3.75	-	-	-	-	-	-	-	-	0.786
Cis-jasmone	-	-	-	-	0.38	0.17	-	-	-	-	0.055
1-Acenaphthenone	0.65	2.07	-	-	-	-	-	-	-	-	0.272
Alloaeromadendrene	-	5.5	-	-	0.52	-	-	-	-	-	0.602
2,6-Dimethyloctane-1,3, 5,7-tetraene	-	-	0.4	-	-	-	-	0.59	-	-	0.098
Dihydrocarveol	-	-	-	1.45	0.58	-	-	-	-	-	0.023
2,5-Dimethyl-3-methyle ne-1,5-heptadiene	-	-	-	-	-	-	-	1.01	1.17	-	0.218
Trans-hex-3-en-1-ol	0.58	-	-	-	-	-	-	-	-	-	0.058

Continued

Cis-3-hexenyl acetate	3.42	-	-	-	-	-	-	-	-	-	0.342
Hexyl acetate	0.4	-	-	-	-	-	-	-	-	-	0.04
Butyric acid	0.49	-	-	-	-	-	-	-	-	-	0.049
Piperonyl alcohol	1.13	-	-	-	-	-	-	-	-	-	0.113
1,2,4-Methyl azulene	-	-	0.27	-	-	-	-	-	-	-	0.027
2-Furfuryl alcohol	-	-	-	0.55	-	-	-	-	-	-	0.055
Benzene	-	-	-	1.52	-	-	-	-	-	-	0.152
Safranal	-	-	-	-	-	0.23	-	-	-	-	0.023
4-Isopropyltoluene	-	-	-	-	-	-	-	0.8	-	-	0.08
3,7-Dimethyl 1,3,6 octadecadiene	-	-	-	-	-	-	-	-	-	55.31	5.531

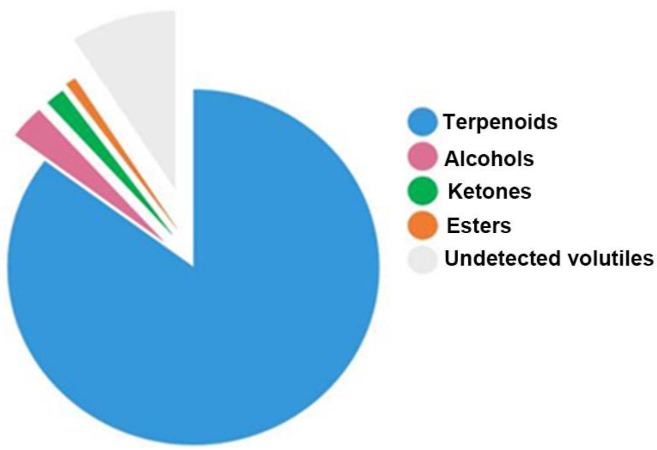

Figure 1. Classification of volatiles from flowers of *Acer truncatum*.

Recent research showed that 3-Carene had sedative and analgesic, digestion and analgesic, antimicrobial effects. [19] Sinem Milanos [20] on the metabolism of Linalool and Linalool the regulation process has been studied and the results confirm that Linalool is well-known for its calming effect in the field of medicine. β-Pinene has obvious antibacterial activity in vitro [21], and Caryophyllene also has strong bacteriostatic action [22].

4. Discussion

Plant volatile organic compounds (Biogenic Volatile Organic compounds, referred BVOCs) have significant impact on the atmospheric environment, air quality and human health. Different VOCs from different plants have positive or negative impact on the circulatory system, and different human gender responded differently, for example Roger Atkinson *et al.* [23] introduced so many species and of selected classes of volatile organic compounds (VOCs), include alkanes, alkenes, aromatic hydrocarbons. Kikuchi *et al.* [24] found that *Rosa rugosa* aroma caused an increase in heart rate while *Citrus limonum* aroma had a calming effect and caused a reduction in heart rate. These VOCs could improve the respiratory and circulatory system according to the data.

There are several studies on the volatile compounds of *Acer*. For example, the main volatile compounds from *Acer truncatum* leaves included 3-hexen-1-ol acetate, 3-hexen-1-ol, acetic acid hexyl ester [25]. However, the main volatile compounds from *Acer oliverianum* leaves were terpenoids [26]. This is the firstly research of flower volatiles from *Aceracae* family.

Acer truncatum is an important species in *Aceracae* family. The leaves of *Acer truncatum* contain flavonoids, organic acids, proteins, polysaccharides and tannins [27]. They are widely applied in many fields, such as medical, food and chemical industry. *Acer truncatum* comprehensive application value was very high, but previous studies have focused on the leaf and fruit. The study on the chemical constituents from flowers of *Acer truncatum* has not been reported, this study reveals the kinds of volatiles of *Acer truncatum* flower contains most of the ingredients, pharmacological activity significantly, with further development and application potential.

5. Conclusions

The kinds of the volatiles of *Acer truncatum* flower are rich. 37 kinds of volatile components were detected, the main ingredient includes Fluorene, 4,8-Dimethyl-1,3 (E), 7-Nonene, (cis, trans)-2,6-Dimethyl-2,4,6-triene-Partenkirchen, Myrcene, Basil hexene, 3-Carene, (E)-Basil, Camphene, Caryophyllene, Linalool, *α*-Terpinolene, O-cymene, 3-Vinyl-1,2-dimethyl-1, *Eucalyptus* alcohols, Alcohol vinegar-12. However, there were no significant differences between individual trees in terms of O-cymene, *Eucalyptus* alcohols, Alcohol vinegar-12 and the significant differences in terms of the remaining volatiles. Furthermore, the representative substance of ketone plants, Fluorene is the first discovery of key volatiles from *Acer truncatum* flowers. Fluorene can be used in making medicine such as antispasmodic, sedatives, analgesic, and antihypertensive drugs. Therefore, the flowers of *Acer truncatum* may be new natural resources for pharmaceutical manufacturing.

This research not only provides theoretical and technical guidance for creating eco-healthy urban green space, but also lays a scientific foundation for the development and utilization of *Acer truncatum* scented tea and new resources of traditional Chinese medicine.

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