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Characterization of Essential Oils of the Leaves and Fruits of *Adenanthera pavonina* L. by GC/MS

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ABSTRACT

The characterization of the hydro distilled essential oils of the leaves and fruits of *A. pavonina*, growing in Egypt, was analyzed by gas chromatography-mass spectrometry (GC-MS) using Rtx-5MS fused bonded column. The results revealed the identification of 27 compounds in the leaves and fruits oils. The leaves oil consisted mainly of monoterpene hydrocarbons (68.01%). The major compounds from the leaves oil were sabinene, accounting for 27.9% of the oil content followed by D-limonene (14.79%), 3-carene (8.46%), caryophyllene (6.57%), and *γ*-terpinene (6.16%). The fruits oil consisted mainly of sesquiterpene hydrocarbons (62.8%). The major compounds were *β*-element (39.6%) followed by sabinene (11.7%) and caryophyllene (11.38%). These findings will assist in the differentiation between the volatile oils from different parts of *A. pavonina* is a step to establish the first monograph for this plant. This study summarized the chemical profiles of *A. pavonina* leaves and fruits essential oils growing in Egypt for the first time. The leaves essential oils of *A. pavonina* demonstrated different composition compared with the oils from the fruits.

Keywords: *Adenanthera pavonina; Fabaceae; GC/MS; Essential oil composition; Sabinene; β-Elemene.*

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1. INTRODUCTION

Plants containing essential oils were reported to exert various biological activities including antioxidant, antibacterial, and anti-parasitic effects due to the presence of various volatile ingredients with potent effects on various biological receptors. Chemical constituents of essential oils were classified into monoterpenes, sesquiterpenes, isothiocyanates, and phenylpropanoids **[1, 2]**. The chemical constituents of the volatile oils in different plant organs depend on various factors including the time of collection and plant habitat **[3]**.

Fabaceae (Leguminosae) is considered one of the most important families of flowering plants, comprising 727 genera and 19300 species distributed throughout the world **[4]**. *Adenanthera pavonina* L. belongs to the Fabaceae. *A. pavonina* L. is commonly known as redwood and a red-bead tree that is described as a deciduous tree with an erect stem, 18-25 m tall, and 60 cm in diameter **[5]**.

Leaves are compound, bipinnate with a large swollen pulvinus. The leaflets are oblong to ovate, dull green and turn yellow with age. Fruits are large pods, flattened, dark brown, filled with a sticky brown sweet pulp, dehiscent from the top to bottom by twisting valves **(Fig. 1) [6]**.

Fig. 1. *Adenanthera pavonina* leaves and fruits (× 0.1) http://www.somemagneticislandplants.com.au/.

The leaves of *A. pavonina* L. showed various biological activities including anti-inflammatory and analgesia **[7-9]**, antihypertensive **[10]**, hepatoprotective **[11]**, hyperlipidemia **[12]** and antibacterial effects **[13]**. *A. pavonina* L. fruits demonstrated anti-inflammatory, antidiabetic **[14]** and antioxidant **[15]** activities. Phytoconstituents of *A. pavonina* L. were classified as flavonoids glycosides, saponins and steroids **[16-18]**. Despite the widespread use of the plant essential oils in traditional medicine, the chemical components of the oil obtained from the plant grown in Egypt was never studied before. Therefore, the study aimed to characterize the chemical constituents of the essential oils obtained from different organs of *A. pavonina* (leaves and fruits) growing in Egypt for the first time.

2. MATERIAL AND METHODS

2.1. Plant material

The leaves and fruits of *A. pavonina* **(Fig. 1)** were harvested from El-Orman Botanical Garden, Giza, Egypt. The plant was identified by Mrs. Tereize Labib, the Taxonomy Specialist at El-Orman Botanical Garden. A voucher sample, PHG-P-AP-286 was maintained at the herbarium of the Department of Pharmacognosy, Faculty of Pharmacy, Ain-Shams University.

2.2. Extraction of the essential oil

The volatile components of *A. pavonina* leaves and fruits were isolated by hydro-distillation for 4 h using a Clevenger-type apparatus at the Pharmacognosy Department, Faculty of Pharmacy, Ain-Shams University to yield 100 μL/100 g of the oil. The yielded oil was stored at -4 °C in sealed vials.

2.3. Analysis of essential oil by GC-MS

A. pavonina oil was analyzed on Shimadzu GCMS-QP2010 (Tokyo, Japan) the operating conditions were as follows: (a) Rtx-5MS fused bonded column (30 m × 0.25 mm i.d. × 0.25 μm film thickness) (Restek, USA), (b) the initial temperature of column was adjusted at 45 °C for 2 min (isothermal) and gradually increased to 300 °C at a rate of 5 °C/min and remained at 300 °C for 5 min (isothermal), (c) the temperature of the injector was 250 °C, (d) the flow rate of the helium carrier gas was 1.41 mL/min a split injector, (e) samples (1% v/v) were injected with split ratio 1:15. Certain conditions adjusted to record mass spectra include Filament emission current (equipment current), 60 mA; ionization voltage, 70 eV; ion source, 200 °C.

3. RESULTS

The volatile constituents are listed in **Table 1**. The identification of the oil components was dependent on the retention index (RI), molecular ion peaks and fragmentation patterns, then these data were compared with the reported data of the reference compounds analyzed under the same conditions in NIST Mass Spectral Library (December 2005) and other reported data **[19, 20]**.

The chromatogram of leaves essential oil revealed the presence of 21 components **(Fig. 2)** representing 97.9% of the leaves oil content and 14 components representing 98.7% of the fruit's oil.

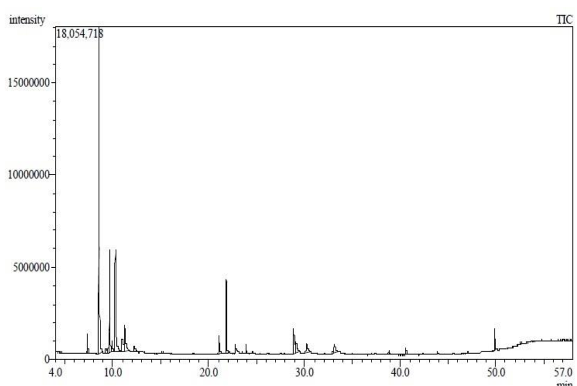

Fig. 2. Chromatogram of *Adenanthera pavonina* leaves oil

The chemical analysis of the leaves oil showed that the major classes of constituents were monoterpene hydrocarbons (68.01%) and sesquiterpene hydrocarbons (16.8%). Among the 21 compounds, the major identified components were sabinene (27.9%) followed by D-limonene (14.79%), 3-carene (8.46%), caryophyllene (6.57%) and *γ*-terpinene (6.16%) **(Fig. 3)**. Regarding the fruit's oil, the results **(Fig. 4)** showed that the main classes of constituents were sesquiterpene hydrocarbons (62.8%) and monoterpene hydrocarbons (20.44%). The fruits oil consisted of *β*-elemene as the main component (39.6%) followed by sabinene (11.7%), caryophyllene (11.38 %), 3-carene (7.2%) **(Fig. 3)**.

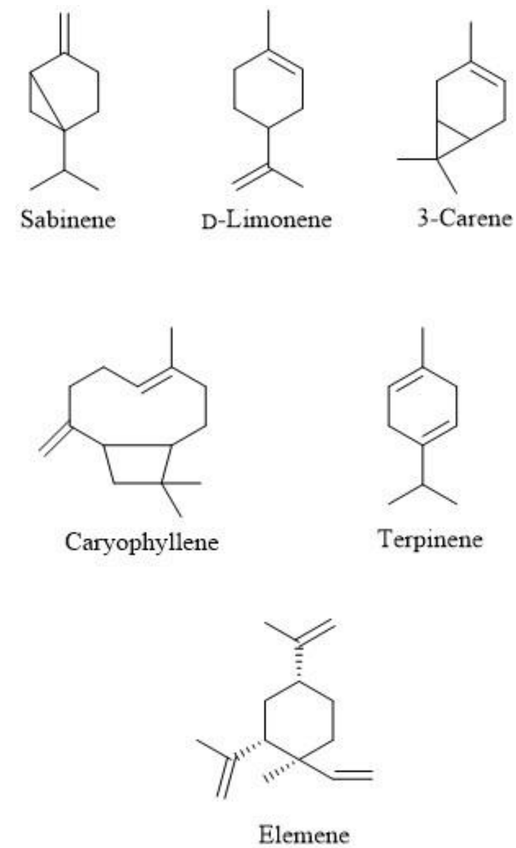

Fig. 3. Structure of sabinene, D-limonene, 3-carene, caryophyllene, *γ*-terpinene, *β*-elemene

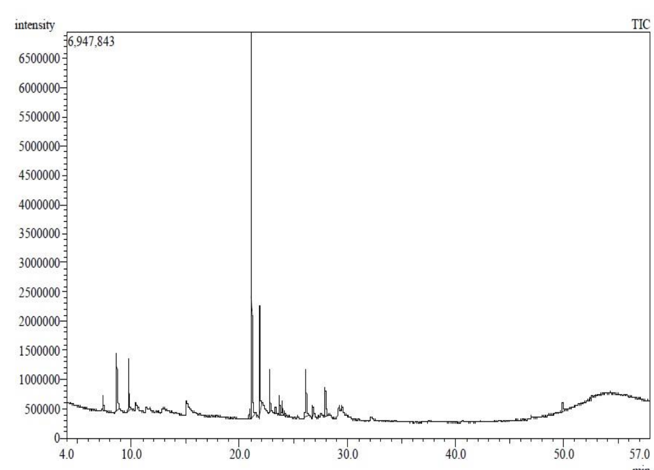

Fig. 4. Chromatogram of *Adenanthera pavonina* fruits oil

Table 1: GC–MS analysis of the essential oil

No.	Component	RI observed	RI literature	%Area Leaves	%Area Fruits	Molecular formula	Method
1.	*α*-Pinene	929	932	1.64	1.52	$C_{10}H_{16}$	KI, MS
2.	Sabinene	961	969	27.93	11.7	$C_{10}H_{16}$	KI, MS
3.	*β*-Myrcene	984	988	1.31	________	$C_{10}H_{16}$	KI, MS
4.	*α*-Phellandrene	996	1002	0.71	________	$C_{10}H_{16}$	KI, MS
5.	3-Carene	1001	1008	8.46	7.2	$C_{10}H_{16}$	KI, MS
6.	*α*-Terpinene	1008	1017	1.79	________	$C_{10}H_{16}$	KI, MS
7.	D-Limonene	1020	1024	14.79	________	$C_{10}H_{16}$	KI, MS
8.	*β*-Ocimene	1043	1044	3.29	________	$C_{10}H_{16}$	KI, MS
9.	*γ*-Terpinene	1051	1054	6.16	________	$C_{10}H_{16}$	KI, MS
10.	Terpinolene	1082	1086	1.67	________	$C_{10}H_{16}$	KI, MS
11.	*β*-Elemene	1383	1389	2.24	39.6	$C_{15}H_{24}$	KI, MS
12.	Caryophyllene	1411	1417	6.57	11.38	$C_{15}H_{24}$	KI, MS
13.	Humulene	1447	1452	0.48	4.43	$C_{15}H_{24}$	KI, MS
14.	*β*-Chamigrene	1469	1476	________	0.93	$C_{15}H_{24}$	KI, MS
15.	*β*-Selinene	1482	1489	________	2.78	$C_{15}H_{24}$	KI, MS
16.	Bicyclogermacrene	1491	1509	0.85	3.05	$C_{15}H_{24}$	KI, MS
17.	*α*-Bulnesene	1501	1509	________	0.65	$C_{15}H_{22}$	KI, MS
18.	Caryophyllene oxide	1578	1582	________	6.82	$C_{15}H_{24}O$	KI, MS
19.	Humulene epoxide I	1604	1608	________	1.08	$C_{15}H_{24}O$	KI, MS
20.	*cis*-Cadin-4-en-7-ol	1652	1658	________	6.26	$C_{15}H_{26}O$	KI, MS
21.	*β*-Sinensal	1693	1699	6.7	________	$C_{15}H_{26}$	KI, MS
22.	2Z,6E-Farensal	1705	1715	3.02	________	$C_{15}H_{26}O$	KI, MS
23.	*α*-Sinensal	1752	1755	3.51	________	$C_{15}H_{22}O$	KI, MS
24.	*n*-Nonadecane	1881	1900	2.7	________	$C_{19}H_{40}$	KI, MS
25.	Heneicosane	2180	2190	0.57	________	$C_{21}H_{44}$	KI, MS
26.	Nonacosane	2854	2900	2.97	________	$C_{29}H_{60}$	KI, MS
27.	Tetratetracontane	3028	3065	0.36	1.31	$C_{44}H_{90}$	KI, MS
Monoterpene hydrocarbons				67.75	20.44		
Sesquiterpene hydrocarbons				16.84	62.8		
Oxygenated sesquiterpenes				6.7	14.1		
Others				6.6	1.31		
Total identified				97.9 %	98.7%		

Compounds are listed in order of their elution on a DB-5 GC column; RI observed, Kovats index determined experimentally on a RTX-5 column relative to C8–C28 n-alkanes. RI literature, published Kovats index on a DB-5 column; MS, identification was based on mass spectral data; RI, identification was based on comparison with published Kovats retention indices in NIST Mass Spectral Library (Wiley Registry of Mass Spectral Data, 8th edition) and literature.

4. DISCUSSION

The results of oils characterization demonstrated that there was a significant difference in the chemical profile of the volatile oil obtained from the leaves and fruits of *A. pavonina*. Monoterpene was the main class of oil from the leaves with sabinene as the major identified compound. On the other hand, the results of the fruit's oil showed that sesquiterpene was the major class of oil with *β*-elemene as the major identified component.

The results revealed that essential oils obtained from the leaves and fruits of *A. pavonina* can be used as a potential source for different components with various biological activity such as sabinene which exhibited sedative activity **[21]**, potent anti-fungal, anti-bacterial **[22]** and anti-inflammatory activity by the inhibition of NO production **[23]**. D-Limonene is used in dietary supplements as it showed antioxidant activity **[24]** and antibacterial activity **[25]**. In addition, D-limonene showed antifungal **[26]** and antibacterial activities **[27, 28]**. Therefore, it was used in the preservation of food. As the essential oil of *A. pavonina* leaves contains sabinene and D-limonene as the major constituents, it is recommended to study the antimicrobial activity of the oil. Concerning the components of the fruit's oil, *β*-elemene showed considerable antiproliferative effects on many types of cancer cell lines. It has was reported to inhibit brain cancer cell growth and proliferation **[29]** and showed significant anti-inflammatory activity and antimicrobial activity **[30]**. Biological investigations on the fruit's oil are recommended to identify the potential applications of the oils.

This study focused on the chemical profiles of *A. pavonina* leaves and fruits essential oils growing in Egypt for the first time. Identification of the nature of oil constituents is the first step in studying the biologic activities of the oil. Based on the composition of the oils, further biological investigations can lead to the discovery of new leads as antimicrobial agents.

Conflict of Interest

We declare that we have no conflict of interest.

Declarations

Ethics approval and consent to participate

Not applicable

Consent to publish

Not applicable

Availability of data and materials

All data generated or analyzed during this study are included in this published article in the main manuscript.

Competing interests

The authors declare that no competing interests exist

Funding Statement

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Authors' contributions

The manuscript was drafted and written by all authors. All authors have read and approved the final manuscript.

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List of abbreviations:

Eos, Essential oils; GC-MS, Gas chromatography and mass spectrometry; RI, Refractive index; NIST, National Institute of Standards and Technology.

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