

Chemical Composition of *Farsetia aegyptia* Methanol Extract and Its Potential Antioxidant and Allelopathic Activities

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Abstract *Farsetia aegyptia* Turra (Family Brassicaceae) is a perennial woody desert shrub native to Saharan Arabia. The current study aims to define the chemical composition of the *F. aegyptia*, collected from Rawdat-Khuraim, Riyadh Region, Saudi Arabia, and evaluate the extract's allelopathic, and antioxidant properties. Fourteen components from the extracted plant were identified using the GC/MS method, making up all of the volatile chemicals in the plant. Whereas, (-)-spathulenol (26.71%) is considered to be the main constituent, but other constituents with higher percentages of composition were also categorised, including carvacrol (12.34%), pivalate limonen-6-ol (6.83%), glafenin (7.67%), 13,16-octadecadienoic acid, methyl ester (9.79%), and β -sitosterol (8.99%). The shoot extract is the most potent of the components of *F. aegyptia* that were isolated, with an IC_{50} value of 37.26 mg.L^{-1} and percentage of radical scavenging activity (RSA) of 67.60%. The methanolic extract showed a substantial allelopathic inhibitory action against the germination, seedling root, and shoot development of *C. murale* with IC_{50} values of 0.921, 0.747, and 0.551 mg.mL^{-1} . It is suggested that additional study be done on the mechanisms and mode(s) of action of these compounds as antioxidants or allelochemicals, as well as on the main compound action of authentic, pure materials, either alone or in combination.

keywords: *Farsetia aegyptia*, GC/MS, allelochemicals, wild plants, antioxidants

1. Introduction

Plants have played a vital role throughout human history and in every region of the world. Weed management is a difficult problem for sustainable agriculture since weeds are a serious danger to cultivated plants [1]. Currently, weeds are managed with herbicides, which have negative effects on the environment and human health and cause weeds to become resistant to them [2]. The allelopathy phenomenon, which is seen in several plants that release substances into the ecosystem from either their shoot system or underground parts in the form of volatilization or decaying plant tissue, root exudation, and leaching by dews and rains, may therefore offer a diverse biological weed management method. These substances discharged into the environment may have an impact on the growth and development of weeds, other plants, animals, and microbes, among other things [3,4].

The natural molecules (allelochemicals) may in reality serve as a foundation for new herbicidal templates due to their phytotoxic activity, distinctive molecular structures, novel sites of action, and quick biodegradation. Allelochemicals have previously been found as possible natural insecticides, fungicides, and herbicides from fungi, lichens, plants, and other living things [5,6]. On the other hand, a group of chemicals known as antioxidants collaborate to stop certain molecules from oxidizing in food, industrial products, or living things. These substances help to inhibit the production of reactive oxygen species (ROS) in biological systems [7]. According to Lopez et al. [8], plants provide a source of substances that have antioxidant activity, including vitamins, phenolic compounds, flavonoids (i.e., anthocyanins and tannins), and carotenoids,

which may be exploited to make pharmaceutically effective medicines.

Many common vegetables and medicinal plants are found in the Brassicaceae (syn. Cruciferae) family, which includes large number of plant species that are grown worldwide. Brassicaceae plants have attracted a lot of scientific attention because of their commercial and agricultural relevance [9]. In Egypt, 53 genera and 107 species belong to the family [10,11]. *Farsetia aegyptia* Turra, *F. longisiliqua* Decne., and *F. stylosa* R. Br. are the three species that make up the genus *Farsetia* in Egyptian flora. *Farsetia aegyptia* is a long-lived perennial (low shrub), not exceeding 40 cm and densely ramified from the base that may be found growing on gravelly soils, sandy plains, rocky wadis, and slopes. It is found in North African deserts, Eastern Mediterranean region, Asia, Arabia, Pakistan, and Afghanistan [11]. Studies have reported antiallergic, antibacterial, antifungal, antioxidant, cytotoxic, antirheumatic, antidiabetic and antispasmodic properties of *F. aegyptia* [12].

The current study aimed to characterize the chemical composition of *F. aegyptia* aerial parts by GC-MS and assess the allelopathic activity of the *F. aegyptia* methanolic extract against the weed *Chenopodium murale*, as well as antioxidant activity of its extract.

2. Materials and Methods

2.1. Plant Material and Extraction Process

The shoot system of *F. aegyptia* were collected from Rawdat-Khuraim, Riyadh Region, Saudi Arabia. In March (Spring), the samples were gathered, placed in paper bags, and delivered to the lab. The samples were processed into a fine powder, sealed in a paper bag, and allowed to dry for one week in the shade at room temperature (25°C). According to Collenette [13], plant specimen identification was done.

2.2. Gas chromatography-mass spectrometry analysis (GC-MS)

The extracted *F. aegyptia* chemical make-up Following a previously documented methodology [14], the methanolic extract of selected plant was characterized by using the crude extract on a Trace-GC-TSQ mass

spectrometer (Thermo-Scientific, Austin, T.X., USA) with a direct capillary column TG-5MS (30m × 0.25mm × 0.25m film thickness) [14]. Additionally, by assessing the mass spectrum data to those of the mass spectrometry lists WILEY-09 and NIST, it was possible to ascertain the chemical composition of each of the numerous isolated plant components.

2.3. Antioxidant activities

According to the Miguel [15] technique, the antioxidant activity was evaluated based on the plant's capacity to diminish the colour of the fixed radical 2, 2- diphenyl-1-picrylhydrazyl (DPPH) (Sigma-Aldrich, Germany). In brief, several concentrations of *F. aegyptia* MeOH extract (5, 10, 20, 30, 40, and 50 mg mL⁻¹) were made in aqueous methanol (70%). Two mL of each concentration are added to the reaction mixture, along with two mL of newly made 0.3 mM DPPH in MeOH extract. The reaction mixture was well blended and incubated for 15 min. at room temperature (27 °C) in the dark. A spectrophotometer was used to detect the absorbance at 517 nm. following incubation (Spectronic 211D model). Calculations for radicle scavenging activity were made as follows:

$$\% \text{ Inhibition} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100$$

Similar methods were used to test catechol's antioxidant activity as a standard synthetic antioxidant (10–50 mg/mL). Using MS-Excel (2016), visual calculations were used to determine the IC₅₀ (amount of extract necessary for a 50% decrease in DPPH absorbance).

3.4 . Allelopathic Activity

The allelopathic potential of the methanolic extract of *F. aegyptia* aerial shoot versus the weed *C. murale* was investigated. The healthy and pure seeds were treated with 0.3% sodium hypochlorite, to three minutes to surface-sterilize them, followed by sterile water washing and drying on sterile filter paper. Dimethyl sulfoxide (DMSO) (Sigma-Aldrich, Germany) concentrations of 0.2, 0.4, 0.6, 0.8, and 1.0 mg mL⁻¹ were made to test the MeOH extract's allelopathic potential. 20 *C. murale* seeds were put in Petri plates with Whatman No. 1 filter paper after that, 4mL of each concentration was added. A control treatment using DMSO in place of the MeOH extract,

three replications of the experiment were included in the design. Parafilm® tape (Sigma, USA) was used to seal the plates, which were then incubated at 25°C, and 16 hours of artificially regulated daylight and 8 hours of artificial darkness⁷⁹. After the selected seeds had been incubated for 7 days, the number of seeds that germinated and the lengths of all the seedlings' roots, and shoots were measured. The following formula was used to determine whether germination or seedling length was inhibited:

$$\% \text{ Inhibition Growth (IG)} = \frac{\text{No/LC} - \text{No/LT}}{\text{No/LC}} \times 100$$

Which LC: length of control, LT: length of treatment.

2.5 . Statistical Analysis

Utilizing the Costat software, the antioxidant and allelopathic activity experiments were performed three times with three replications (CoHort Software, Monterey, CA, USA). The results of a one-way ANOVA were then used to assess the significance of the sample differences.

3. Results

3.1. Gas chromatography-mass spectrometry analysis (GC-MS)

By using GC-MS analysis, the chemical composition, and structures of the *F. aegyptia* MeOH extract were detected. The correlation between the relative quantity of the various components detected by the extracted plant and the retention time at which a specific component was discovered was shown in Figure 1. The findings in Table 1 demonstrated that the isolated plant included 15 distinct components. Typically, (-)-spathulenol is listed as the main ingredient that was discovered after 18.69 minutes. Other natural constituents were then classified with a higher % of composition, for example, carvacrol (12.34%), Pivalate limonen-6-ol (6.83%), glafenin (7.67%), 13,16-octadecadienoic acid, methyl ester (9.79%), and β-sitosterol (8.99%). The distinguished components were classified under various naturally occurring groups such as terpenes (47.15%), oxygenated hydrocarbons (14.60%), fatty acids derivatives (13.79%), alkaloids (12.48), and steroids (11.98%) (Table 1).

3.2. Biological characteristics of the plant extracts

3.2.1. Antioxidant activity - DPPH assay

By contrasting the methanolic extract of *F. aegyptia* with ascorbic acid in terms of its capacity to scavenge DPPH free radicals, its antioxidant properties were determined. The DPPH radical-scavenging capacities of plant extracts were expressed as half maximal inhibitory concentration (IC₅₀) values and the standard (Table 2). The information in Table 2 showed that the MeOH extract from the shoot system exhibited the greatest antioxidant scavenging capacity, with an IC₅₀ of 37.26 mg/L. The primary factor governing the processes involved in determining the extract under study's antioxidant capacity is the predominance of terpenes; sesquiterpene ((-)-spathulenol, 26.71%) and monoterpene (carvacrol (12.34%), oxygenated hydrocarbons (14.60%), fatty acids derivatives (13.79%), alkaloids (12.48), and steroids (11.98%) (Table 1). The findings of *F. aegyptia* were agreed with by El-Amier et al. [14] and Cornara et al. [16]. Spathulenol (26.71%), a tricyclic sesquiterpenoid, has also been extensively studied in recent years [17], showing antioxidant, anti-inflammatory, antiproliferative, and antimycobacterial activities [18]; insecticidal efficacy [17] and immunomodulatory response effects [19]. Lukic et al. [20] suggested that carvacrol (12.34%) is a more effective antioxidant. Moreover, the antioxidant capacities of carvacrol were similar to commercial antioxidants [21].

The fatty acids and lipids in *Sisymbrium irio*, *Aesculus indica*, and *Abies pindrow*, on the other hand, had good antioxidant capability for scavenging the free radicals in the solution [22]. The antioxidant capacity of bioactive substances is commonly determined by the capability of reactive oxygen species, such as phenolics, fatty acids, terpenes, oxygenated hydrocarbons, or carbohydrates, to scavenge or stabilize free radicals [23,24]. Studies have reported antiallergic, antibacterial, antifungal, antioxidant, cytotoxic, antirheumatic, antidiabetic and antispasmodic properties of *F. aegyptia* [12].

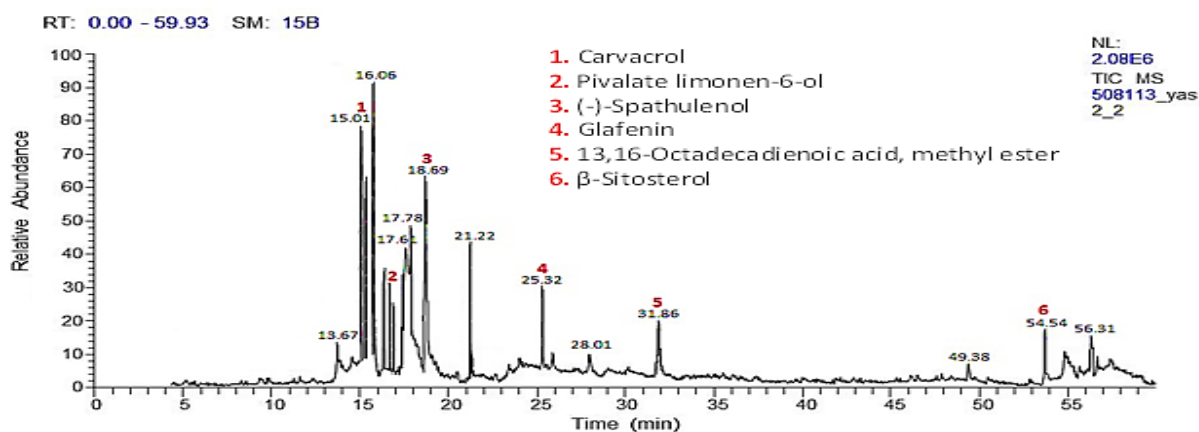


Fig 1. Chromatogram and structures of main constituents of the methanol extract from *F. aegyptia* shoots were examined by GC-MS.

Table 1. The described chemical components were isolated from the MeOH extract of *F. aegyptia* shoots.

No.	Chemical name	Classification	RT (min.)	MW	MF	Conc. %
Terpenes						
1	Carvacrol	Monoterpene	15.01	150	C ₁₀ H ₁₄ O	12.34
2	p-Cymen-7-ol	Monoterpene	15.38	150	C ₁₀ H ₁₄ O	4.36
3	2-ethylidene-6-methyl-3,5-Heptadienal	Monoterpene	16.12	150	C ₁₀ H ₁₄ O	3.74
4	(-)-Spathulenol	Sesquiterpene	18.69	220	C ₁₅ H ₂₄ O	26.71
Oxygenated hydrocarbon						
5	4-(2,2-Dimethyl-6-methylenecyclohexyl) butanal	Oxygenated hydrocarbon	16.06	194	C ₁₃ H ₂₂ O	2.20
6	Pivalate limonen-6-ol	Oxygenated hydrocarbon	16.46	236	C ₁₅ H ₂₄ O ₂	6.83
7	2,6-Dimethyl-8-oxoocta-2,6-dienoic acid, methyl ester	Oxygenated hydrocarbon	16.74	196	C ₁₁ H ₁₆ O ₃	3.91
8	3,3a,4,5,6,7,8,8b-octahydro-8,8-dimethyl-2H-Indeno[1,2-b]furan-2-one	Oxygenated hydrocarbon	17.60	206	C ₁₃ H ₁₈ O ₂	1.66
Alkaloid						
9	3-Indolizinecarboxylic acid, 8-ethyl-2-(methylthio), ethyl ester	Alkaloid	17.78	263	C ₁₄ H ₁₇ NO ₂ S	4.81
10	Glafenin	Alkaloid	21.22	372	C ₁₉ H ₁₇ ClN ₂ O ₄	7.67
Fatty acid derivatives						
11	2,3-Bis(acetyloxy)propyl laurate	Fatty acid derivatives	25.32	358	C ₁₉ H ₃₄ O ₆	4.00
12	13,16-Octadecadienoic acid, methyl ester	Fatty acid derivatives	31.86	294	C ₁₉ H ₃₄ O ₂	9.79
Steroid						
13	β-Sitosterol	Steroid	54.54	414	C ₂₉ H ₅₀ O	8.99
14	(3β)-Lup-20(29)-en-3-ol, acetate	Steroid	56.31	468	C ₃₂ H ₅₂ O ₂	2.99

RT: retention time (min.), MW: Molecular Weight, MF: Molecular Formula

Table 2. Scavenging activity percentage of DPPH and the IC₅₀ values by MeOH extract of *F. aegyptia* and catechol as standard.

Treatment	Conc. (mg/mL)	Scavenging activity (%)	IC ₅₀ (mg/mL)	LSD _{0.05}
<i>F. aegyptia</i>	50	67.60±2.34	37.26	1.83***
	40	61.14±2.11		
	30	46.58±1.98		
	20	34.68±1.07		
	10	23.20±0.85		
	5	17.80±0.12		
Ascorbic acid	20	67.11±1.04	13.02	1.23***
	15	55.87±0.89		
	10	47.92±0.67		
	50	38.42±0.56		
	2.5	8.64±0.05		
	1	2.02±0.02		

Values are average (n = 3) ± standard deviation. LSD_{0.05} expressed the calculated least of the smallest significance between two means as each test was run on those two means (calculated by Factorial ANOVA).

3.2.1. Allelopathic Effect of the MeOH Extract

MeOH extract from *F. aegyptia* shown substantial concentration-dependent allelopathic action against the weed, *C. murale* (Figure 2). The seed germination, radical, and plumule development of *C. murale* were all significantly slower than controls at the high-level concentration of the plant sample extract (1 mg/mL). The desert samples' respective IC₅₀ values for germination, radical and plumule growth were 0.921, 0.747, and 0.551 mg/mL.

Spathulenol and carvacrol are two allelochemicals that have been linked to the allelopathic effects of *F. aegyptia* [18,21]. The essential oils of oregano (*Origanum vulgare*), thyme (*Thymus vulgaris*), pepperwort (*Lepidium flavum*), wild-bergamot (*Citrus aurantium bergamia*), and other plants contain carvacrol, a phenolic monoterpenoid. The most prevalent and efficient allelochemicals in the ecosystem are phenolic acids, according to research [25]. When ingested by plants, phenols spread into the ecosystem and prevent germination and growth [26].

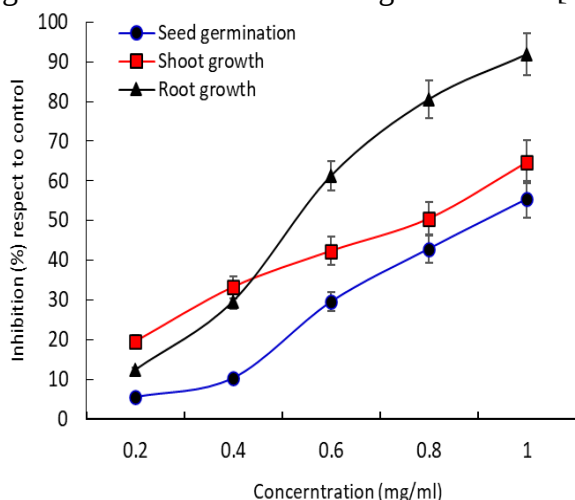


Figure 2. Effect of different doses of MeOH extracts of *F. aegyptia* aerial parts as an allelopathic inhibitor

4. Conclusion

The GC-MS analysis of *F. aegyptia* MeOH extract revealed the presence of 15 compounds. Spathulenol, carvacrol, pivalate limonen-6-ol, glafenin, 13,16-Octadecadienoic acid-methyl ester, and β -Sitosterol are the major compounds. With an IC₅₀ value of 37.26 mg/mL, shoot extract had the strongest antioxidant activity and had a greater ability to snare free radicals in the DPPH solution.

Additionally, compared to control, the methanol extract of *F. aegyptia* showed increased potential allelopathic activity, with significant inhibition against the weed *Chenopodium murale*.

5. References

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