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Characterization of secondary metabolites of leaf and stem essential oils of *Achillea fragrantissima* from central region of Saudi Arabia

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Abstract In this paper, a detailed study on chemical characterization of essential oils (EOs) constituents of leaves and stems of *Achillea fragrantissima* were carried out using GC-FID and GC–MS analysis employing two different stationary phase columns. In the studied plant which is collected from the central region of Saudi Arabia, *trans*-sabinyl acetate and *trans*-sabinol have been identified as the major components. To the best of our knowledge, these components are being reported for the first time as the major constituents in the EOs of *A. fragrantissima*. The results showed that chief chemical components of both (leaves and stems) oils were found to be almost same, however, their contents varied noticeably from each other. Among 108 identified components in the leaves oil, the major components were *trans*-sabinyl acetate (20.7 ± 0.00), *trans*-sabinol (14.9 ± 0.13), artemisia ketone (12.7 ± 0.46), santolina alcohol (10.1 ± 1.30), *β*-sesquiphellandrene (5.5 ± 0.01), *β*-thujone (5.1 ± 0.11). Whereas, in the stem oil 85 components were identified and *trans*-sabinyl acetate (24.0 ± 0.19), *trans*-sabinol (19.2 ± 0.01), artemisia ketone (16.3 ± 0.74), santolina alcohol (10.4 ± 1.50), and *β*-sesquiphellandrene (4.8 ± 0.01) were found to be the major components. Among the identified components form both oils, 23 components were specific to only leaves oil, whereas 85 components were found to be common in both oils.

1. Introduction

Recently, due to the growing environmental concerns the interest of the scientific community in medicinal and other aromatic plants derived from the traditional sources of knowledge has been renewed (Martins and Brijesh, 2018; Petrovska, 2012). *Achillea fragrantissima*, which is traditionally used (in the form of tea, infusion, extracts and phytomolecules) for various med-

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ical purposes in the Arabian region against different types of diseases such as hepatobiliary disorders, inflammatory and spasmodic gastrointestinal complaints, skin inflammations and wound healing etc. (Bartolotti et al., 2018; Patocka and Navratilova, 2019). Besides, this plant is also known for its excellent anti-oxidative and anti-inflammatory properties, which are typically ascribed to its rich contents of polyphenols, flavonoids, terpenes and alkamides (Mudawi et al., 2017).

A. fragrantissima (Forssk.) Sch. Bip. (synonym *Santolina fragrantissima* Forssk.) belongs to the family Asteraceae and is locally known in Arabic as Qaysum, which is widely distributed in the North African, eastern mediterranean coastal and Middle Eastern regions (Barel et al., 1991). It is a desert flowering plant of the genus *Achillea*, which include more than 100 species and is chemically characterized by the accumulation of sesquiterpenic lactones and flavonoids (Hammad et al., 2014). So far, a variety of bioactive substances have been identified from the extracts of different parts of *A. fragrantissima* including different types of phenolic acids like protocatechuic, vanilic, chlorogenic etc., a variety of flavonoids like apigenin, apigenin-glycoside, luteolin, vitexin and so on. Besides various types of bioactive flavonoids other class of phytomolecules such as lignans (sesamin), terpenic lactones (achillolid A) and alkamides (pellitorin, 8,9-Z-dehydropellitorin, anacyclin) have also been extracted from *A. fragrantissima* (El-Ashmawy et al., 2016). However, the amount of these bioactive compounds present in *A. fragrantissima* varies widely depending upon the region where the plant grows.

Interestingly, *A. fragrantissima* has demonstrated enormous chemical diversity due to the presence of a variety of different chemotypes in the plants grown in different regions of the world. Although, few studies have been reported on the medicinal applications and isolation of bioactive phytochemicals of *A. fragrantissima* from Saudi Arabia. For instance, in a recent study, the phytochemical constituents of essential oils (EOs) extracted through a hydro-distillation process of dried aerial parts of *A. fragrantissima* cultivated in Egypt and Madinah Monawara, Saudi Arabia, were analyzed and compared using gas chromatography. Notably, the plant collected from Madinah contained α-thujone, whereas the plant from Sharkia (Egypt) has exhibited santolina alcohol as the major component (Farouk et al., 2019). However, to the best of our knowledge, detailed analysis of the chemical profile of the EOs of *A. fragrantissima* plant grown in the central region of Saudi Arabia has not been performed yet. Therefore, the study of the chemical constituents of *A. fragrantissima* cultivated in this region of Saudi Arabia is highly desirable. Herein, we study the chemical compositions of essential oils extracted from the leaves and stems of *A. fragrantissima* grown in the Riyadh region of Saudi Arabia. The chemical profiling of EOs was performed by GC-FID and GC–MS characterization techniques on two unlike stationary phase (polar and non-polar) columns.

2. Materials and methods

2.1. Plant material

Entire aerial parts of *A. fragrantissima* were collected from Rawdat Khuraim (Fig. 1) area of Riyadh, Saudi Arabia in February 2011. Identification of *A. fragrantissima* were authenticated by Dr. J. T. Pandalayil, a botanist at KSU. A specimen sample (AFR-21) of *A. fragrantissima* is retained in our research laboratory.

Fig. 1 Geographic coordinate (via GPS) of the plant material collection location.

2.2. Essential oil extraction from the leaves and stems of *A. fragrantissima*

Firstly, the leaves and stems from the freshly collected aerial parts of *A. fragrantissima* were carefully separated from each other. The separated leaves (150 g) and stems (95 g) were chopped into small pieces (0.2–0.3 cm) and separately subjected to a Clevenger apparatus for hydro-distillation as described earlier (Khan et al., 2016b). After 3 h of distillation 2.5 g and 0.72 g yellow color oils were obtained from leaves and stems of *A. fragrantissima,* respectively. The yields of the oils from the leaves and stems of *A. fragrantissima* were 1.7% and 0.8% (*w*/*w*) on a fresh weight basis, respectively. The EOs obtained from leaves and stems of *A. fragrantissima* were dried over anhydrous Na_2SO_4 and stored at 4 °C until they were analyzed.

2.3. Chemicals

Analytical grade DEE (diethyl ether) from Sigma–Aldrich, Germany was used for the dilution of leaves and stems EOs of *A. fragrantissima*. Pure volatile constituents, *e.g.,* α-pinene, α-terpinene, β-pinene, terpinen-4-ol, 1,8-cineole, eugenol, and α-bisabolol, along with volatile oils with high contents of limonene, sabinene, β-myrcene, β-phellandrene, α-terpinolene, germacrene D, bicyclogermacrene, caryophyllene oxide, α-thujene and α-terpinene were available with us and used for co-injection/comparative analysis.

2.4. GC and GC–MS analysis of *A. fragrantissima* EOs

Chemical analysis for the determination of *A. fragrantissima* leaves and stems EOs constituents were carried out by GC-FID and GC–MS analysis having two different stationary phase columns (HP-5MS and DB-Wax) applying the same method as described earlier (Khan et al., 2016a). Detailed methodology is provided in Supplementary materials (S1). The identified constituents of *A. fragrantissima* leaves and stems EOs and their relative percentages are provided in Table 1 and constituents are listed according to their elution order on the HP-5MS column.

2.5. Calculation of linear retention indices (LRIs)

LRIs values of *A. fragrantissima* leaves and stems EOs constituents were determined following a previously reported method (Khan et al., 2016a), and these are listed in Table 1. Detailed methodology is provided in Supplementary materials (S2).

2.6. Identification of volatile components

Identification of the *A. fragrantissima* leaves and stems EOs constituents were carried out via analysis on DB-Wax and HP-5MS columns as described previously (Khan et al., 2016a). Detailed methodology is provided in Supplementary materials (S3). GC–FID chromatogram for the identified constituents of *A. fragrantissima* leaves and stems EOs on HP-5MS column is given in Fig. 1s and Fig. 2s, respectively (Supplementary materials).

3. Results and discussion

For the purpose of the detail analysis of the essential oil (EO) components of the aerial parts of *A. fragrantissima*. The EOs of leaves and stems of *A. fragrantissima* were extracted through a hydro-distillation process for three hours using a Clevenger-type apparatus (Khan et al., 2016b). The detail analysis of the as-obtained EOs was performed using a gas chromatography–mass spectrometry (GC–MS) and gas chromatography–flame ionization detector (GC–FID) using both polar and nonpolar columns. The analysis has revealed the presence of 108 compounds in the EO of leaves, whereas a total of 85 compounds were identified in the stems oil. Among the 108 compounds identified in both oils, 85 compounds were found to be present in both the oils. Whereas, 23 components were specifically present in the leaves oils. All the identified components and their respective amounts are provided in the Table 1 according to their elution order on a nonpolar (HP-5MS) column.

According to the results presented in the Table 1, oxygenated monoterpenes were found to be dominated in both oils. For example, the stems oil contained 83.5% of oxygenated monoterpenes, whereas, the leaves oil exhibited the presence of 75.8% of these components. Sesquiterpene hydrocarbons were present at distant second position in the studied oils, which were present in the amount of 8.3% in the stems oil and 12.6% in the leaves oil, respectively. After these two types of compounds which were mainly dominated, monoterpenes hydrocarbons (2.9% and 4.6%) and oxygenated sesquiterpenes (3.5% and 4.2%) were also present in appreciable amount in the stems and leaves oils of *A. fragrantissima,* respectively. Apart from these, some other classes of compounds were also found in negligible amount which include, aliphatic hydrocarbons, oxygenated aliphatic hydrocarbons, diterpenoids and aromatics etc. Notably, most of these compounds are present in both the studied oils, however their contents varied significantly.

Out of 85 compounds which were identified in the stems oil, most of the oil is constituted with only few compounds which include, *trans*-sabinyl acetate (24.0 ± 0.19), *trans*-sabinol (19.2 ± 0.01), artemisia ketone (16.3 ± 0.74), santolina alcohol (10.4 ± 1.50), and β-sesquiphellandrene (4.8 ± 0.01). Whereas the major chunk of the leaves oil is occupied by *trans*-sabinyl acetate (20.7 ± 0.00), *trans*-sabinol (14.9 ± 0.13), artemisia ketone (12.7 ± 0.46), santolina alcohol (10.1 ± 1.30), β-sesquiphellandrene (5.5 ± 0.01), β-thujone (5.1 ± 0.11). The results confirmed that chief chemical components of both (leaves and stems) oils were found to be almost same, however, their contents varied noticeably from each other (Fig. 2). Notably, the dominant volatile (more than 20% of the total oil) of the currently studied *A. fragrantissima* population seems to be *trans*-sabinyl acetate which belongs to a class of rare natural products (Radulović et al., 2015). In both stems and leaves oils, *trans*-sabinyl acetate is found to be the major component demonstrating a presence of 24 and 20% in the studied oils, respectively. According to a study published in 1964, sabinene, sabinol and sabinyl acetate are highly toxic metabolites (Casares, 1964).

However, an extensive literature survey about the phytochemical constituents of *A. fragrantissima* population belonging to the different regions of world has revealed that, none

Table 1 Percentage compositions of leaf and stem EOs of *A. fragrantissima* from central Saudi Arabia.

No.	Compound	LRI_{Lit}	LRI_{Exp}[a]	LRI_{Exp}[p]	AFL (%)[b]	AFS (%)[b]
1	Isoamyl acetate	–	875	1123	t	t
2	Heptanal	–	901	1184	t	t
3	**Santolina triene**	**906**	**907**	**1032**	**1.5 ± 0.41**	**1.2 ± 0.38**
4	Artemisia triene	923	–	1067	t	t
5	Ethyl 3-Methyl-2-Butenoate	–	–	1226	t	t
6	α-Thujene	924	926	–	0.1	0.1
7	Ethyl tiglate	929	–	1238	t	t
8	α-Pinene	932	933	1019	0.2	0.2
9	Sabinene	969	973	1119	1.0	0.6
10	β-Pinene	974	976	1104	0.1	0.1
11	2-Pentyl furan	984	990	–	0.1	0.1
12	Myrcene	988	992	1164	0.6	0.1
13	**Yomogi alcohol**	**999**	**999**	**1395**	**2.1 ± 0.57**	**2.4 ± 0.49**
14	δ-3-Carene	1008	1012	–	0.1	0.1
15	α-Terpinene	1014	1016	1177	0.1	0.1
16	*p*-Cymene	1020	1024	1269	0.3	0.2
17	Limonene	1024	–	1196	0.1	0.1
18	β-Phellandrene	1025	1029	1205	0.2	–
19	1,8-Cineole	1026	1031	1208	0.4	0.3
20	(*Z*)-β-Ocimene	1032	1034	1238	0.1	0.1
21	**Santolina alcohol**	**1034**	**1038**	**1409**	**10.1 ± 1.30**	**10.4 ± 1.50**
22	γ-Terpinene	1054	1059	1245	0.2	–
23	(*E*)-2-Octenal	–	–	1431	t	t
24	**Artemisia ketone**	**1056**	**1063**	**1352**	**12.7 ± 0.46**	**16.3 ± 0.74**
25	*cis*-Sabinene hydrate	1065	1068	–	0.1	0.1
26	*n*-Octanol	1063	1070	1556	0.2	0.2
27	Artemisia alcohol	1080	1083	1511	0.8	0.9
28	α-Terpinolene	1086	1089	1282	t	–
29	Isobutyl tiglate	1088	1098	1361	t	0.1
30	Isopentyl 2-methylbutanoate	1100	1100	1280	0.1	0.1
31	Isopentyl isovalerate	1102	1104	1297	0.1	0.1
32	**α-Thujone**	**1101**	**1107**	**1424**	**3.9 ± 0.03**	**3.6 ± 0.03**
33	1-Octen-3-yl acetate	1110	1115	1378	0.1	0.1
34	**β-Thujone**	**1112**	**1118**	**1445**	**5.1 ± 0.11**	**3.2 ± 0.08**
35	***trans*-Sabinol**	**1137**	**1144**	**1710**	**14.9 ± 0.13**	**19.2 ± 0.01**
36	*trans*-Verbenol	1140	1147	1687	0.1	t
37	Camphor	1141	1149	–	0.1	–
38	**Sabina ketone**	**1154**	**1157**	**–**	**1.3 ± 0.11**	**0.3 ± 0.06**
39	Isoborneol	1155	1160	–	0.1	0.1
40	Pinocarvone	1160	1165	1568	0.1	0.1
41	Lavandulol	1165	1167	1683	0.4	0.4
42	Artemisia acetate	1169	1172	–	0.3	0.3
43	Terpinen-4-ol	1174	1179	1608	0.5	0.3
44	Isoverbanol	–	1182	–	t	0.1
45	α-Thujenal	–	1186	1630	0.1	0.2
46	Cryptone	1183	1189	–	0.1	t
47	α-Terpineol	1186	1191	1705	0.1	–
48	Myrtenol	1193	1194	1800	0.1	0.1
49	Methyl chavicol	1195	1199	1673	0.4	0.3
50	(*E*)-Ocimenone	1235	1238	–	0.1	0.1
51	Cuminaldehyde	1238	1242	–	0.1	0.1
52	Ethyl phenyl acetate	–	1246	1789	t	–
53	Lavandulyl acetate	1288	–	1610	0.3	0.2
54	***trans*-Sabinyl acetate**	**1289**	**1297**	**1659**	**20.7 ± 0.00**	**24.0 ± 0.19**
55	*trans*-Pinocarvyl acetate	1298	1302	–	t	–
56	Myrtenyl acetate	1324	1325	1693	0.1	–
57	*p*-Mentha-1,4-dien-7-ol	1325	–	2062	t	t
58	δ-Elemene	1335	1341	1472	0.6	0.3
59	Eugenol	1356	1359	2171	0.1	0.1
60	*cis*-Carvyl acetate	1365	1364	–	0.1	–
61	β-Elemene	1389	1395	1592	0.1	0.1
62	(*Z*)-Jasmone	1392	1401	1950	0.4	0.3
63	Methyl eugenol	1403	1404	2017	0.1	0.1

(*continued on next page*)

Table 1 (*continued*)

No.	Compound	LRI_{Lit}	LRI_{Exp}[a]	LRI_{Exp}[p]	AFL (%)[b]	AFS (%)[b]
64	α-Gurjunene	1409	1417	–	0.1	0.1
65	Cuminyl acetate	–	–	1972	t	t
66	β-Caryophyllene	1417	1425	1599	0.2	0.1
67	β-Copaene	1430	1434	1594	0.1	0.1
68	*trans*-α-Bergamotene	1432	1438	1538	0.1	–
69	(*E*)-β-Farnesene	1454	1458	1669	0.9	0.1
70	β-Acoradiene	1469	1465	1665	0.1	0.1
71	Isoamyl phenylacetate	–	1481	2006	0.1	–
72	**Germacrene D**	**1484**	**1488**	**1714**	**3.3 ± 0.33**	**1.8 ± 0.28**
73	β-Selinene	1489	1493	1723	0.1	0.1
74	Bicyclosesquiphellandrene	–	–	1749	t	–
75	Bicyclogermacrene	1500	1503	1739	0.8	0.3
76	α-Muurolene	1500	1505	1729	0.2	0.2
77	*trans*-β-Guaiene	1502	1509	–	0.1	–
78	(*E,E*)-α-Farnesene	1505	–	1751	0.1	0.1
79	δ-Guaiene	–	–	1618	0.1	0.1
80	7-*epi*-α-Selinene	1520	1519	1764	0.1	–
81	**β-Sesquiphellandrene**	**1521**	**1529**	**1775**	**5.5 ± 0.01**	**4.8 ± 0.01**
82	δ-Cadinene	1522	–	1761	0.1	t
83	(*Z*)-Nerolidol	1531	1539	–	0.1	–
84	Elemol	1548	1554	2086	0.2	0.2
85	Germacrene D-4-ol	1574	1577	2056	0.1	–
86	Spathulenol	1577	1584	2131	0.3	0.1
87	Caryophyllene oxide	1582	1591	1990	0.1	t
88	Viridiflorol	1592	–	2092	0.1	t
89	Humulene epoxide II	1608	1606	2045	t	t
90	Isoeugenyl acetate	1614	1612	2404	0.1	–
91	1,10-*di*-*epi*-Cubenol	1618	1617	2067	0.4	0.3
92	1-*epi*-Cubenol	1627	1623	–	0.1	–
93	γ-Eudesmol	1630	1630	2178	0.2	0.2
94	α-Acorenol	1632	1635	2126	0.4	0.3
95	β-Eudesmol	1649	1658	2238	0.8	1.5
96	α-Cadinol	1652	1661	2243	0.1	–
97	7-*epi*-α-Eudesmol	1662	1666	–	0.1	0.1
98	β-Bisabolol	1674	1676	2152	0.2	0.1
99	*epi*-α-Bisabolol	1683	1688	–	0.3	0.1
100	α-Bisabolol	1685	1692	2222	0.2	–
101	(2*Z*,6*Z*)-Farnesol	1698	1694	2324	0.3	0.5
102	Tetradecanoic acid	–	1764	–	0.1	–
103	α-Costol	1773	1774	2590	0.1	0.1
104	Palmitic acid	1959	1958	–	0.1	0.2
105	(*E*)-Phytol	1942	2108	2618	0.3	0.1
106	*n*-Tricosane	2300	2300	2300	0.1	–
107	*n*-Pentacosane	2500	2500	2500	0.1	t
108	*n*-Heptacosane	2700	2700	2700	t	–
Monoterpene hydrocarbons					**4.6**	**2.9**
Oxygenated monoterpenes					**75.8**	**83.5**
Sesquiterpene hydrocarbons					**12.6**	**8.3**
Oxygenated sesquiterpenes					**4.2**	**3.5**
Aliphatic hydrocarbons					**0.3**	**0.1**
Oxygenated aliphatic hydrocarbons					**0.8**	**0.9**
Diterpenoid					**0.3**	**0.1**
Aromatics					**0.1**	**0**
Total identified					**98.7**	**99.3**

*Components are recorded as per their order of elution from a nonpolar column.

[b] Mean percentage calculated from FID data and compounds higher than 1.0% are highlighted in boldface and their ± SD (n = 2) are mentioned; LRI_{Lit} = Linear retention index from the literature (Adams, 2007); LRI_{Exp}

[a] Computed LRI with reference to *n*-alkanes mixture (C8-C31) on nonpolar column; LRI_{Exp}

[p] Computed LRI with reference to *n*-alkanes mixture (C8-C31) on polar column; AFL = *A. fragrantissima* leaves EO; AFS = *A. fragrantissima* stem EO; t = trace (< 0.05%).

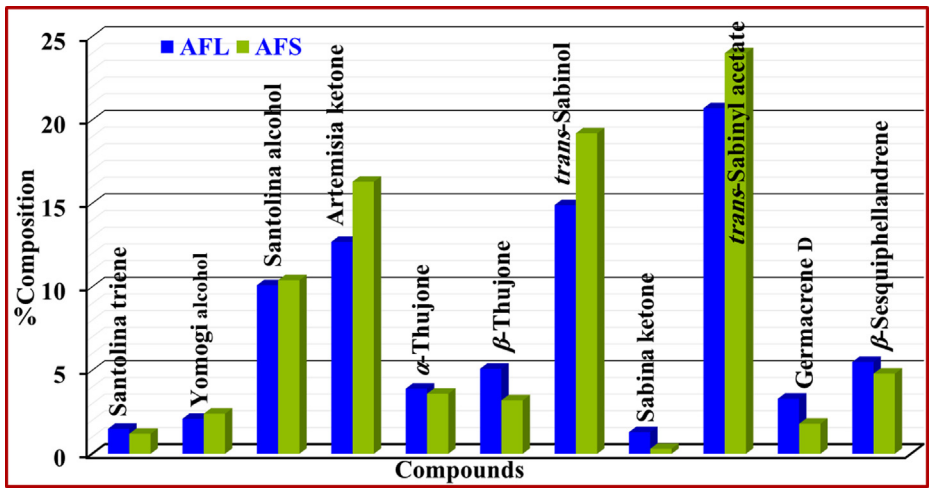

Fig. 2 Comparison of major components in *A. fragrantissima* leaves and stems EOs.

of the study published so far (to the best of our knowledge) has indicated towards the presence of *trans*-sabinyl acetate as the major component (Table 2).

Since, *A. fragrantissima* plant is highly used in the Saudi Arabia for various medicinal purpose, the biological/toxicological profile of the phytochemical constituents of this plant may provide valuable information. Particularly, the evaluation of the *in vitro* and *in silico* toxicity of *trans*-sabinyl acetate which is rarely dominant in the *A. fragrantissima* population is highly required which we planned to perform in our future study. Moreover, the FDA (US Food and Drug administration) has included *Juniperus sabina* in the list of Poisonous Plant Database, due to the presence of *trans*-sabinol and its derivatives like sabinene, sabinol and sabinyl acetate as the major components (Asili et al., 2010; Severino, 2009). This toxic *Juniper* species, due to the presence of toxic sabinol derivatives causes congestion of the kidneys with hematuria, congestion of other abdominal viscera, menorrhagia and abortion (Craig et al., 2004; Pages et al., 1996). Besides, the *Artemisia absinthium* EO rich in *trans*-sabinyl acetate (45.2% of the

Table 2 Chemotypes in EO of *A. fragrantissima* L. grown in various parts of the world.

Country	City	Chemotype	Major components (%)	Reference
Egypt	Sinai	α-Thujone	α-Thujone (29.5), santolina alcohol (18.3), artemisia ketone (15.2), β-thujone (10.8), *trans*-pinocarveol (6.8) and yomogi alcohol (4.4)	(El-Shazly et al., 2004)
	Allamain	α-Thujone	α-Thujone (28.4), santolina alcohol (16.1), artemisia ketone (14.8), β-thujone (12.5), pinocarvone (4.7) and yomogi alcohol (3.2).	(Almadiy et al., 2016)
	Sinai	Santolina alcohol	Santolina alcohol (18.3), artemisia ketone (15.2), α-thujone (28.4), β-thujone (12.5) and *trans*-pinocarveol (4.7)	(Nenaah, 2014; Nenaah et al., 2015)
	Saint Catherine	α-Thujone	α-Thujone (34.0), *trans*-2,7-dimethyl-4,6-octadien-2-ol (24.4), 2,5,5-trimethyl-3,6-heptadien-2-ol (8.2), eucalyptol (8.2), 1,5-heptadien-4-one-3,3,6-trimethyl (7.7), artemisia alcohol (3.5)	(Zeedan et al., 2014)
	Sharkia	Santolina alcohol	Santolina alcohol (27.2–30.8), α-thujone (11.8–18.9), artemisia ketone (11.8–14.5), lavandulol (0.33–12.5), β-thujone (7.2–8.6), 4(10)-thujen-3-ol (1.6–8.3) and *trans*-sabinyl acetate (4.7–8.3)	(Farouk et al., 2019)
Jordan	Mafraq	Artemisia ketone	Artemisia ketone (19.9), β-sesquiphellandrene (14.6), carvacrol (13.4), α-thujone (12.4) and artemisyl acetate (6.1)	(Alsohaili and Al-fawwaz, 2014)
	Mafraq	β-Thujone	β-Thujone (11.3–22.1), *trans*-sabinyl acetate (0.8–10.2), α-terpineol (3.5–9.4), *trans*-menth-2-en-1-ol (6.5–13.3)	(Alsohaili, 2018)
	Amman	α-Thujone	α-Thujone (13.8–33.8), β-thujone (11.9–24.1), artemisia ketone (3.0–22.0), santolina alcohol (3.5–18.3), santolina triene (1.8–7.3), yomogi alcohol (1.7–5.8) and *trans*-sabinyl acetate (1.2–5.2)	(Al-Jaber et al., 2018)
Saudi Arabia	Madinah	α-Thujone	α-Thujone (14.3–31.6), β-thujone (2.6–24.6), 4-terpineol (3.4–12.9), artemisia ketone (1.3–12.6), santolina alcohol (3.6–8.2) and *trans*-pinocarveol (0.0–6.5).	(Farouk et al., 2019)
	Riyadh	*trans*-Sabinyl acetate	*trans*-Sabinyl acetate (20.7–24.0), *trans*-sabinol (14.9–19.2), artemisia ketone (12.7–16.3), santolina alcohol (10.1–10.4), β-thujone (3.2–5.1) and β-sesquiphellandrene (4.8–5.5)	Present study
Yemen	Dhamar province	Artemisia ketone	Artemisia ketone (49.5), camphor (14.7) and α-bisabolol (11.2)	(Mansi et al., 2019)

total oil) has also shown the toxic effect (Judzentiene et al., 2012).

4. Conclusion

Herein, we have studied the phytochemical constituents of stems and leaves EOs of *A. fragrantissima* collected from central region of Saudi Arabia. The information gathered about the volatile constituents of studied plant is extensively compared with the EOs of *A. fragrantissima* collected from other regions of the world, including Egypt, Jordon, Yemen and Saudi Arabia. The EOs of aerial parts of *A. fragrantissima* have displayed considerable variation in their chemical compositions when compared to the plants collected from other regions. In this study, the investigated plant has exhibited *trans*-sabinyl acetate as major component, which is rarely obtained in such a large amount (~24%) in *A. fragrantissima* collected from other parts of the world. According to FDA, the plants containing *trans*-sabinyl acetate have been classified as poisonous plants category; therefore, the application of this particular plant for any medicinal purpose may have adverse effect on health. Besides, the studied plant also contains *trans*-sabinol (14.9 ± 0.13), artemisia ketone (12.7 ± 0.46), santolina alcohol (10.1 ± 1.30), *β*-sesquiphellandrene (5.5 ± 0.0 1), *β*-thujone (5.1 ± 0.11) in significant amount which have several industrial applications.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

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