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Research Article

Aroma profile of the essential oils from different parts of *Pycnocycla aucherana* Decne. ex Boiss.

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Abstract: The current study focused on the essential oil concentration and aroma profile in different parts of wild *Pycnocycla aucherana* Decne from Iran during two years 2017 and 2018. Plant samples of *P. aucherana* were collected from HajiAbad area located in Hormozgan province, Iran at reproductive stage on June 7, 2017 and 2018. Essential oil isolation was done by hydro-distillation method for 3 hours. For the qualification and quantification of components, gas chromatography/mass spectrometry (GC/MS) was applied. Results showed that the averages of essential oil percentage of shoot and leaf (SL) and seed in the first and second year were (0.13, 0.23%) and (0.4, 0.3%) respectively. The main chemotype was namely α-phellandrene (5.96-16%), *p*-cymene (3.07-27.4%), Limonene (0.72-6.80%), γ-cadinene (0.8-4.33%), Spathulenol (1.90-8.64%), Elemol (0.3-6.69%), β-eudesmol (0.8-9.27), and Bulnesol (0.91-3.40%). The highest amount of α-phellandrene (16%) and *p*-cymene (27.4%) was observed in the seed and (SL) of essential oils in the first year respectively. Elemol and Elemicin content increased during the second year in the seed of essential oils with amount of (6.69 %) and (25.69 %), respectively. Overall, the results showed that the geographic origin greatly influenced the chemical composition of *P. aucherana*.

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1. INTRODUCTION

Native medicinal plants play an important role in providing many food and medicine needs for local people in each region (Emami Bistgani & Sefidkon, 2019; Petropoulos *et al.*, 2020). Collecting endemic medicinal and range plants is one of the traditional cultures which have been conserved in numerous indigenous societies (Ghasemi *et al.*, 2013; Janaćković *et al.*, 2019). Endemic medicinal and range plants were gathered for different goals. Wild plants were

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usually consumed to provide our predecessor' substantial requirements comprising silage, food, fuel wood, and production supplies (Fallah *et al.*, 2020). These kind of collected herbs comprise favorite aroma profiles which function in pharmaceutical and cosmetic industries (Debbabi *et al.*, 2020). Prior research has revealed that wild medicinal and range plants contain upper bioactive compounds and pharmacological activity when compared to cultivated plants. For instance, a study conducted by Jung *et al.* (2005) indicated that the leaves of planted ginseng in the field have lower natural components than those of wild ginseng leaves. In addition, Soriano-Melgar *et al.*, (2012) indicated that domain as a wild shrub comprises greater antioxidant properties than the cultivated of that.

Pynocycla genus belongs to the Apiaceae family which is endemic to tropical areas. In Iran, it grows in Kermanshah, Khuzestan, Fars, Kerman, Hormozgan as well as Systan and Baluchestan provinces (Central and South parts of Iran) (Mozaffarian, 1996), *Pycnocycla* species are perennial and woody plants with multiple erect stem (Mozaffarian, 2007). Because of the aromatic nature of *Pycnocycla* species, different reports are available about chemical composition of the essential oil (Asgarpanah *et al.*, 2014; Asghari *et al.*, 2014; Sadraei *et al.*, 2016). Some studies conducted by Teimouri *et al.* (2005) and Alimirzaloo and Asgarpanah, (2017) indicated that □-phellandrene and p-cymene were the main compounds in the essential oil of the leaves in *Pycnocyla aucherana*. However, trans-isomyristicin was identified as the major component in the seed. Generally, diverse pharmacological activity of *P. aucherana* including antispasmodic (Sadraei *et al.*, 2016), anti-inflammatory (Jahandar *et al.*, 2018), and cytotoxic effects (Khodaei, 2012) have been reported by researchers.

As a matter of fact, the essential oil of the genus of *Pycnocycla* content that has effective aroma profiles and plays a significant role in pharmacological activities is ultimately used in the cosmetic and health industries (Askari *et al.*, 2022). For instance, terpenoids represent the most diverse and largest class of chemicals among the secondary metabolites produced by higher plants (Tholl, 2015). Monoterpenes and sesquiterpenes are as the main volatile constituents, which provide characteristic aroma and biological properties to the essential oils and are important flavoring and fragrance agents in food products, beverages, cosmetics, and pharmaceuticals (Askari *et al.*, 2022).

Up to now, limited studies have reported the aroma profile of *Pycnocycla aucherana* in Hormozgan province that is rich in essential oil (i.e., high yields) and phenolic monoterpenes (Askari *et al.*, 2022). Therefore, the aim of this research was to determine the phenolic profiling in shoot and leaf (SL) as well as seed in *P. aucherana* collected from natural habitats of Hormozgan province during two years (2017 and 2018).

2. MATERIAL and METHODS

2.1. Plant Materials

Plant samples of *P. aucherana* were collected from HajiAbad area located in Hormozgan province, Iran at reproductive stage on June 7, 2017 and 2018. Then the herbs were deposited in the herbarium of Research Institute of Forests and Rangelands, Tehran. The herbarium code number was TARI 5828. The shoot and leaf (SL) as well as seed were separated and dried at room temperature. 100 g of (SL) and 80 g seed were used for essential oil extraction. Essential oil isolation was done by hydro-distillation method and Clevenger-type apparatus for 3 hours. The essential oils were dried over anhydrous sodium sulfate and stored in sealed vials at 4 ^{o}C before analysis.

2.2. Analysis of The Essential Oil

To determination quantity and quality of the essential oil, gas chromatography (GC) and gas chromatograph-mass spectrometry (GC/MS) were applied in Chromatography Analysis

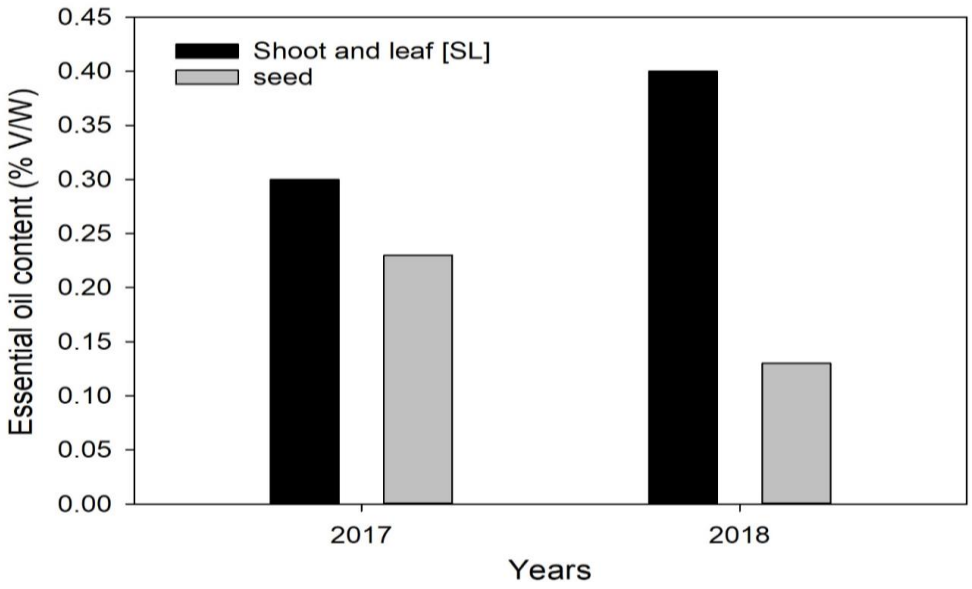
Laboratory of Medicinal plants and by-products Research department. To determine quantification of the essential oils, Ultra Gas chromatograph equipped with a DB-5 (Thermo model UFM) fused silica column (60 m x 0.25mm, film thickness 0.25 micron) was used. The temperature in oven was set on 50–270 °C at a flow rate of 40 °C /min and then detained at 280°C for 3 min. Injector and detector temperatures were 280 °C; a linear velocity of 32 cm/s was set out for the helium gas. GC–MS analyses were performed (Varian 3400 GC–MS system, Varian, Palo Alto, CA, USA) on DB-5 (60 m x 0.25mm, film thickness 0.25 micron). The oven temperature was set on 60–240 °C at a rate of 3 °C /min. The transfer and injector line temperatures were 260 and 240 °C, respectively. The carrier gas was helium at linear velocity of 32 cm/s. The split ratio was adjusted in 1:60, and in mode at ionization energy of 70 eV and a scan time 1. The Kovats retention index (RI) of constituents was calculated by their mass spectra with those of authentic compounds of n-alkanes (C_6–C_{24}) (Adams 2017).

3. RESULTS

3.1. Essential Oil Concentration In Different Parts of *Pycnocycla Aucherana* Decne

The essential oil extracted by Clevenger-type apparatus from the seed was colorless, while the essoil of shoot and leaf was pale yellow in *P. aucherana*. According to the obtained results, the averaential ge essential oil percentage of (SL) in the first and second year was 0.13 and 0.23%, respectively. On the other hand, the average essential oil percentage of seed was 0.4 and 0.3% in first and second year, respectively (Figure 1).

Figure 1. Essential oil concentration of shoot and leaf (SL) and seed in *Pycnocycla aucherana* Decne



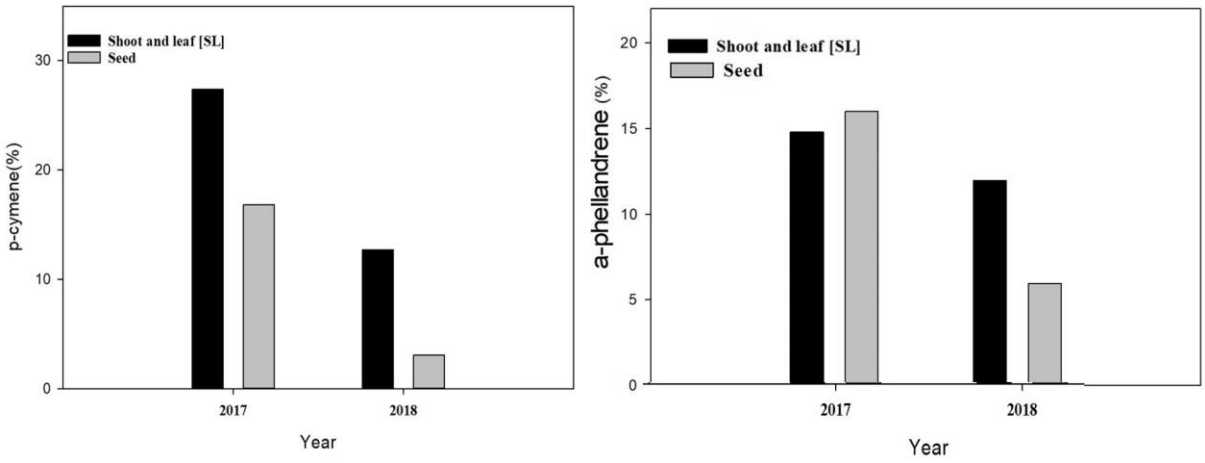
3.2. Volatile Profile of The Essential Oil in Different Parts of *Pycnocycla Aucherana*

Volatile profile of the essential oil obtained from the SL as well as seed of *Pycnocycla aucherana* is presented in Table 1. 22 to 28 components were identified in different samples including (SL and seed) which consisted of (86.31-98.3%) in the essential oils. In the essential oils of SL 22-26, chemical constituents recognized were approximately (91.62 -93.2%). In the essential oil of the seed, 27-28 chemical compounds were identified which present around (86.31- 98.3%) of total essential oil.

The main chemical compounds included α-phellandrene (5.96-16%), *p*-cymene (3.07-27.4%), Limonene (0.72-6.80%), γ-cadinene (0.8-4.33%), Spathulenol (1.90-8.64%), Elemol (0.3-6.69%), β-eudesmol (0.8-9.27), Bulnesol (0.91-3.40%) in SL and seed essential oils during

two consecutive years. The highest concentration of aroma profiles was allocated to *p*-cymene as the main aromatic organic compound in the SL in the first harvesting. The concentration of *p*-cymene fluctuated between (27.4-12.72%) in the essential oil of SL and (3.07-16.8%) in the essential oil of seeds (Figure 2).

Figure 2. *p*-cymene and α-phellandrene content of different part of the *P.aucherana*.



The percentage of α-phellandrene varied between (11.97-14.8%) in the essential oil of SL and (5.96-16%) in the essential oil of seed (Figure 2). The range of limonene as one of the important natural compounds varied between (0.72-5.50%) and (2.02-6.80%) in the seeds and SL in both years, respectively. In addition, Spathulenol as the tricyclic sesquiterpene alcohol varied between (1.9- 3.57%) and (2.20-8.64%) in the seed and SL, respectively.

Trimethylbenzaldehyde was detected in the essential oils of SL and seed in the second year of the harvested plants with amount of 13.32% and 5.84%, respectively. The percentage of Elemicin in SL and seed oil was 2.81% and 25.89% in the second year of the experiment, respectively. It should be noted that Sylvestrene (3.6, 2.7%), Terpinen-4-ol (3.9, 1.2%), linalool acetate (3.0, 0.9%), Sesquisabinene hydrate (5.4, 1.9%), Caryophyllene oxide (4.7, 2.3%) and β-bisabolol (8.8, 2.6%) were identified in SL and seed respectively in the first year of harvested plants. On the other hand, 1,8-cineole (3.55, 1.70%), Trimethylbenzaldehyde (13.32, 5.87%), δ-curcumene (2.86, 7.66%), Elemicin (2,81, 25.89%), and Guaiol (7.26, 7.71%) were observed in SL and seed respectively in the second year of harvesting plants. It is interesting to note that E-isoelemicin with amount of (26.2 %) was only observed in the seed of essential oils in the first year. Overall, it seems that changes in concentration were not almost the same trends in both years of experiment. It might be that the fluctuations of temperature and moisture were strong enough to stimulate the high concentration of chemical variability recorded. The difference in aroma profile in two years exhibited by the species was also to be related to the climatic conditions of the sampling area, as the plant was growing at a different altitude.

Table 1. Aroma profile in different parts of *P. aucherana* during two consecutive years.

			2017		2018	
Number	Aroma profile	RI	Shoot and leaf [SL]	Seed	Shoot and leaf [SL]	Seed
1	α-thujene	924	-	0.20	-	-
2	α-pinene	932	0.60	1.0	-	-
3	Sabinene	969	-	0.30	-	0.26
4	β-pinene	974	0.40	1.0	0.65	1.25
5	Myrcene	991	0.20	7.6	0.92	0.20
6	Octanal	998	-	0.30	-	-
7	α-phellandrene	1002	14.8	16.0	11.97	5.96
8	*p*-cymene	1020	27.4	16.8	12.72	3.07
9	Limonene	1024	6.80	5.50	2.02	0.72
10	Sylvestrene	1025	3.60	2.70	-	-
11	1,8-cineole	1026	-	-	3.55	1.70
12	Linalool	1095	-	0.50	-	0.18
13	Trans-pinocarveol	1135	-	-	1.11	0.48
14	Terpinen-4-ol	1174	3.90	1.20	-	-
15	Cryptone	1183	0.80	0.30	-	-
16	Citronellol	1223	0.40	-	-	-
17	linalool acetate	1254	3.0	0.90	-	-
18	(E-2) decanal	1260	-	-	0.38	0.44
19	Citronelly formate	1271	0.30	-	-	-
20	Bornyl acetate	1284	0.20	-	-	-
21	Thymol	1289	-	-	0.32	1.15
22	Trans-pinocarvyl acetate	1298	-	-	-	0.28
23	Carvacrol	1298	-	-	1.65	0.39
24	Terpinene-4-ol-acetate	1299	0.20	-	-	-
25	Trimethylbenzaldehyde	1313	-	-	13.32	5.84
26	Isoledene	1374	0.30	0.50	-	-
27	Methyl eugenol	1403	-	0.70	-	-
28	E-caryophyllene	1417	0.40	0.70	0.81	1.82
29	Aromadendrene	1439	-	-	-	0.48
30	α-humulene	1452	-	-	-	0.59
31	γ-munrolene	1478	0.50	2.30	-	-
32	δ-curcumene	1481	-	-	2.86	7.66
33	Germacrene D	1484	-	-	0.34	0.60
34	Bicyclogermacrene	1500	-	-	2.54	2.83
35	α-bulnesene	1509	0.70	0.80	-	-
36	γ-cadinene	1513	0.80	0.80	2.22	4.33
37	Sesquisabinene hydrate	1542	5.40	1.90	-	-
38	Elemicin	1555	-	-	2.81	25.89
39	Spathulenol	1577	2.20	1.90	8.64	3.57
40	Caryophyllene oxide	1582	4.70	2.30	-	-
41	Elemol	1584	0.70	0.30	4.72	6.69
42	E-isoelemicin	1586	-	26.2	-	-
43	Guaiol	1600	-	-	7.26	7.71
44	β-eudesmol	1649	2.7	0.80	9.27	7.80
45	Bulnesol	1670	3.40	2.20	0.91	1.75
46	β-bisabolol	1674	8.80	2.60	-	-
47	Total		93.2	98.3	91.62	86.31

4. DISCUSSION and CONCLUSION

Based on the results of evaluating the essential oil percentage which is extracted from various organs, the highest essential oil was obtained in the seed with amount of 0.40% and the lowest essential oil concentration was seen in SL with amount of 0.13% in the first year. Therefore, it seems that seed essential oil in the first year was approximately 25% more than that of the second year. The results obtained from this study were either in accordance or opposite with previous studies. For instance, essential oil content of various *Pycnocyla* species varied between 0.05%-3.8% (Alimirzaloo & Asgarpanah, 2017; Nasr & Asgarpanah, 2014). The essential oil percentage of fruit and seeds of *P. aucherana* collected from Hormozgan province was between 0.1% and 3.8% (v/w) (Alimirzaloo & Asgarpanah, 2017). Another report presented that essential oil percentage of this species was 0.12 % (Teimouri *et al.*, 2005). It seems that essential oil content varied according to the species, organs, and site of collection (Oueslati *et al.*, 2019). As a matter of fact, essential oil concentration and composition are affected by harvesting time, climate condition as well as plant parts (Emami Bistgani *et al.*, 2017a; Emami Bistghani *et al.*, 2012; Sefidkon & Emami Bistgani, 2021).

These results illustrated that although the production of secondary metabolites such as essential oils has a long evolutionary and genetic background; however, it is possible to observe fluctuations in the amount of essential oil of the aerial parts and seed plants collected from different habitats and areas (Mitić *et al.*, 2018; Delfine *et al.*, 2017).

p-cymene and *α*-phellandrene were attained in SL and seed for two years. The highest *p*-cymene as the phenolic monoterpenoids (27.4 %) was observed in SL sample and the maximum *α*-phellandrene (16%) was detected in the seed sample (Table 1). Interestingly, *p*-cymene and *α*-phellandrene were as the main compounds in *P. aucherana* in reports of (Teimouri *et al.*, 2005; Alimirzaloo & Asgarpanah, 2017). Also, *α*-phellandrene was found in *P. flabellifolia* (Mahboubi *et al.*, 2016).

Trimethyl benzaldehyde was observed in SL (13.32 %) and seed (5.87%) at the second year. This compound was reported in aerial part (13.2 %) of *Pycnocycla caespitosa* (Asgarpanah *et al.*, 2014) which are in agreement with our results in SL sample. Elemicin was also found in SL (2.81%) and seed (25.89 %) in the second year of the experiment. Asghari and Houshfar (2001) identified that Elemicin is the main chemical compound in the *Pycnocycla spinosa* var spinosa. The concentration of Elemicin in *Pycnocycla spinosa* was 60.1% (Mahboubi *et al.*, 2016). Among identified compounds E-isoelimicin with an amount of (26.1%) was only found in seed sample in the first year. Spathulenol (8.64%) and *β*-eudesmol (9.27%) indicated high amount of concentration in SL in the second year. Spathulenol was also reported in *Pycnocycla caespitosa* by (Asgarpanah *et al.*, 2014) and *Pycnocycla nodiflora* (Nasr & Asgarpanah, 2014). *β*-eudesmol was observed in *Pycnocycla caespitosa* (Asgarpanah *et al.*, 2014).

Sefidkon & Emami Bistgani (2021) showed that chemical variation in essential oil can be explained by the following factors: 1) genetic variation in the population; 2) diversity among different parts of each plant and growth stages; 3) environmental factors. Furthermore, it was reported that the medicinal plant substances, especially secondary metabolites, are the reflection of environmental factors, growth stage and plant genetic background (Liu *et al.*, 2015). Weather factors including temperature, precipitation and soil can affect oil content and composition in many aromatic plants (Moghaddam & Farhadi, 2015).

In the most studies it was indicated that essential oil content and chemical composition were influenced by harvest time and climate condition such as *Achillea millefolium* (Aziz *et al.*, 2018) *Ocimum minimum* L. (Figueredo *et al.*, 2017), *Salvia officinalis* (Zawiślak *et al.*, 2014), and *Thymbra spicata* (İnan *et al.*, 2011). Evaluations have shown that in addition to the role of genetic factors and environment in the production and quantitative and qualitative diversity of

the essential oil compounds, other factors such as organs of the plant and the stage of the growth in which the plant is located are very effective. Different organs of aromatic plants have a different capacity for production of essential oils and to achieve maximum performance of essential oil and information from plant organs with high percentage of essential oil is very necessary (Reddy, 2019). This issue can be considered for medicinal plants breeder as a purpose of breeding in the dry matter yield of the organs and also for use in pharmaceutical, food and cosmetic industries (Heidarpour, 2013).

Periodic fluctuations in the composition and function of plant essential oils can be justified by various arguments. Simultaneously as plant developments, cell structure and its textures change and chemical compositions change, all of the items can be affected by chemicals components behavior (Morshedloo *et al.*, 2017; Emami Bistgani *et al.*, 2019; Emami Bistgani *et al.*, 2017b; Emami Bistgani *et al.*, 2018). Differences in the composition of essential oils can be partly due to structures glandular trichomes in the leaves. Volatile plant compounds are produced and stored in the specific glandular to minimize the own toxicity and the existence of higher levels of these compounds make it possible as a defense factor in the herb (Jamzad, 2009).

In conclusion, p-cymene and α-phellandrene were found in SL and seed samples during two years. Concerning the fact that these kinds of aroma have biological activities which are related to type of their structures and their relative percentages, such variation in the chemical composition of the studied species assisted the collection of those with higher qualification bioactive constituents for use in relevant industries. On the other hand, Elemicin, E-isoelemicin, spathulenol and b-eudesmol content varied according to year and plant organ. According to obtained results, variation in main chemical compounds can be due to the effect of various organs and ecological, edaphic and climatic factors. The results also demonstrated that determination of this variation is helpful for identification of new components in the species and other species of this genus. Finally, the *Pycnocycla aucherana* species with high bioactive compounds may be recommended for different applications. For instance, it can provide characteristic aroma and biological properties to the essential oils and are important flavoring and fragrance agents in food products, beverages, cosmetics, and pharmaceuticals.

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Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research and publishing ethics. The scientific and legal responsibility for manuscripts published in IJSM belongs to the authors.

Authorship Contribution Statement

Fatemeh Askari: Design the experiment, extration of essential oil, collected valuable data. **Fatemeh Sefidkon:** Phytochemistry analysis, **Zohreh Emami Bistgani:** Formal analysis and writing the manuscript, **Mohamad-Amin Soltanipour:** Collected the seeds.

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