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The Evaluation of Essential Oils Compositions, Mineral and Heavy Metal Content of *Xanthium strumarium* L. Grown in Cultural Conditions

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Abstract: *The aim of this study was to investigated the chemical composition of essential oils from different organs (fruits, leaves, and stems) and determined the heavy metal and nutrient elements in leaves of Xanthium strumarium cultivated in culture conditions. The essential oils of the plant parts dried in the shade isolated by hydrodistillation and the essential oils extracted by using Clevenger apparatus analyzed by GC-MS. Nutrients and heavy metals (aluminum, cadmium, cobalt, chromium, nickel, phosphorus, potassium, calcium, sulfur, iron, copper, zinc, manganese, boron, and sodium) in the leaves using an iCAP-Qc ICP-MS spectrometer detected. While the main components in the fruit essential oil were 6-epi-shyobunol (17.13%), α-bisabolene epoxide (12.34%), α-cadinol (10.28 %), and tau-cadinol (10.06%),the main components of leaves essential oil were recorded as α-cadinol (12.40%) and caryophyllene oxide (11.88%), while borneol (9.24%), isoaromadendrene epoxide (8.74%), cubedol (8.62%), hexahydrofarnesyl acetone (8.06%), tau-cadinol (6.79%), 2,2,6-trimethyl- 1-(3-methylbuta-1,3-dienyl)-7-oxabicyclo[4.1.0]heptan-3-ol (5.01%), and α-bisabolene epoxide (5.00%) were recorded abundantly. Duraldehyde formed 79.92% of the stem essential oil. Other important components in this essential oil were mesitol with 8.89% and mesitioic acid with 4.49%. Among the three macro minerals (Ca, K and P) in the dried leaves of X. strumarium evaluated in the study, K had the highest value. The microelement content of the leaves varied between 0.305±0.002(Zn)-3.235±0.062 (Fe) ppm. The mineral content of the plant, whose fresh leaves are consumed as a vegetable by the local people, was found to be low. Generally, X. strumarium is a rich source of essential oil components. In this study, fruit essential oil was for the first time. The findings from this study can be useful for future studies.*

Keywords*: Xanthium strumarium L., essential oil, 6-epi-shyobunol, α-cadinol, mineral*

1. Introduction

People all over the world pick herbs from natural areas and traditionally have them used in the treatment of diseases since ancient times. Depending on the progress of science and pharmacy techniques, the purification of the therapeutic active substances from herbs has been ensured and most of them have been obtained synthetically in the 19th and 20th centuries [1]. Recently, treatment with plants has become popular again due to serious side effects caused by synthetic drugs.

Cocklebur (*Xanthium strumarium* L.) belonging to the Asteraceae family is an invasive weed in many parts of the world. The plant can be up to 1 m tall. There are purple spots on the thick, hairy, and spineless stem of the plant. The leaves are light and bright green, 4-12 cm long, usually 3-lobed and irregularly toothed. The plant blooms in June-July and matures in September-October. There are 2 seeds in each of the 1-3.5 cm long, egg-shaped fruit with needle-like projections on them [2]. In addition to being a weed, cocklebur, a valuable medicinal plant, is cultivated for vegetable purposes in China. [3,4]. It has been recorded that the young flower tops and the bottom two leaves of the plant are boiled in water and consumed as a vegetable in India and China [3,5]. Especially fruits and roots of this plant are used to prepare remedies for appetizing, diaphoretic, diuretic, etc. in folk medicine [3]. The fruits are collected when ripe and dried for use in decoctions. Its use was first mentioned in Chinese medicine. It is a common ingredient of Chinese patent remedies and is used to adulterate *Datura stramonium* [1].

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The plant is used internally for allergic rhinitis, sinusitis, catarrh, rheumatism, rheumatoid arthritis, lumbago, leprosy, and externally for pruritus [5]. Sesquiterpenoids, coumarins, thiazides, phenyl-propanoids, lignanoids, steroids, glycosides, flavonoids, anthraquinones, and naphthoquinones have been detected in the main chemical composition of the aerial parts of *X. strumarium* [6,7]. Among these compounds, there are those that have important medical activities such as hypoglycemic, diuretic, antiulcerogenic, anthelmintic, antifungal, anti-inflammatory, antidiabetic, and anticancer [8-10]. Similarly, thiazolidinediones found in the fruits of the plant exhibited cytotoxic activity against SK-LU-1, MCF-7, HepG2, and SK-Mel-2 cell lines [11]. It had been determined that the extracts obtained from the plant exhibited activity against *Proteus vulgaris*, *Staphylococcus aureus*, *Bacillus subtilis*, *Candida albicans*, and *C. pseudotropicalis*. It has been emphasized that this activity is the role of xanthol, a sesquiterpene found in the plant [12]. Also, the aerial parts of the plant contain essential oil characterized by monoterpenes and sesquiterpenes. This essential oil is comprised of cis-β-guaiene, limonene, and borneol as major components [3,13].

Edible wild plants of different species have played an important role throughout human history. Although these plants are used as food, they are mostly consumed fresh and processed into foods such as salads and meals. In addition, it is traditionally used in the treatment of some diseases and forms the raw material of many drugs used for human and animal health [14]. Edible wild vegetables contribute to an important part of the human diet with their basic biochemicals (such as carbohydrates, proteins, and lipids). On the other hand, these plants also act as additional sources of vitamins and minerals [15,16]. Foods in the vegetable group are generally not energy sources, and in human nutrition mainly mineral substances Ca, Fe, F, Mg, P, K, Na, Zn, etc.), vitamins (A, B, and C), dietary fiber, protein and They are a source of phytochemicals (such as phenolic compounds, sterols) [14]. Calcium, phosphorus, potassium, sulfur, sodium, chlorine, and magnesium are major nutrients, while iron, cobalt, copper, zinc, manganese, iodine, bromine, and selenium are minor nutrients [17]. These essential nutrients, which are essential for the healthy production of plants, are also necessary for the growth and development of all living things. As it is known, minerals that make up 4-6% of the human body have very important functions in nutrition [18].

The genus *Xanthium* is represented by 6 taxa, 3 species (*X. orientale*, *X. spinosum*, and *X. strumarium*), and 3 subspecies (*X. orientale* subsp. *italicum*, *X. strumarium* subsp. *brasilicum*, and *X. strumarium* subsp. *strumarium*) in Turkey Flora [19]. The aim of this study was to investigate the chemical composition of essential oils from different organs (fruits, leaves, and stems) and determined the heavy metal and nutrient elements in leaves of *X. strumarium* cultivated in culture conditions.

2. Materials and methods

2.1. Plant material

Cocklebur seeds were collected from an altitude of 1440 m in Yozgat province /Turkey in 2014. These seeds were sown at a distance of 60x20 cm on a sandy loam soil at the experimental field of Yozgat Bozok University/Turkey, (39.753722 N, 34.802738 E, altitude 1267 m), during the spring season in 2015. After sowing, nitrogen fertilizer (150 kg ha^{-1}) was given when the plants were in the 3-4 leaf stage. After fertilization, the trial area was irrigated. During the vegetation period, weed control was carried out with hoe in the experimental area. The sowing, seedling emergence, and harvesting dates were recorded as 31 March, 20 May, and 29 September, respectively. Harvest was done by hand when the fruits were greenish-yellow. After the fruits, leaves, and stems of the harvested plants were separated, they were dried in the shade at room temperature (Figure 1).

The soil structure of the experimental area is clayey, neutral, salt-free, high in lime, sufficient organic matter, high phosphorus content, and very high potassium content (Table 1).

The experimental area generally has a semi-arid climate. In 2015, monthly temperature values recorded in August and September were 1.6°C and 4.6°C higher, respectively, compared to long years (1960-2015). The precipitation recorded in May, June, and September was also higher (66.6 mm, 50.9mm, and 6.9 mm, respectively) than the average of long years. Especially in May and June, approximately twice the precipitation of long years was recorded. The relative humidity values recorded in the year the experiment was carried out showed parallelism with the data for long years (Figure 2) [19].

2.2. Essential oil extraction

The fruits, leaves, and stems of cocklebur were dried at temperature and powdered using a mechanical grinder (LAVIONHC-200). The essential oils were extracted from 50 g of sample in 500 mL of water for 3 h in a Clevenger-type apparatus. The essential oil content of the herbal samples was determined as (%, v w^{-1}) on dry matter (essential oil volume/sample weight in g). The samples of essential oils were taken into dark-colored flasks and stocked at 4^{o}C in a refrigerator until they were analyzed [20].

2.3. Identification of the essential oil components

The chemical components of the essential oil samples from fruits, leaves, and stems were defined by gas chromatography-mass spectrometry (GC/MS) analyses (GC/MS-QP2010 Ultra, Shimadzu, Japon). The 0.1 mL oil sample was dissolved in 10 mL n-hexane and shaken vigorously. It was kept in the dark for 1-2 h. The sample was taken into vials and given to the device. The information about the chromatographic method is given below:

Column: RXI-5MS (0.25 um x 30 m x 0.25 mm); Scan range: 35-600 m z-1; Split ratio: 30; Oven temperature: 60^{o}C for 1 min followed by a temperature rise at a 4^{o}C min^{-1} rate to 250^{o}C (held for 4 min); Flow rate: 1.50 mL min^{-1}. The essential oil components were identified by comparing their mass spectra, retention times, and relative to C_5-C_{40} n-alkanes, the FFNSC 1.2 and W9N11.1 mass spectral library, and the literature [22].

2.3. Determination of nutrient elements and heavy metal content in leaf samples

1 g of leaf sample dried in the shade was weighed and placed in a porcelain crucible. This sample was burned at a maximum temperature of 550°C in the ash oven (NABERTHERM B180) until gray ash was obtained. 3N HCl was added to the burnt sample. Then, distilled water was added to the sample filtered through Whatman No.1 filter paper, with a final volume of 10mL [23]. Nutrients and heavy metals (aluminum, cadmium, cobalt, chromium, nickel, phosphorus, potassium, calcium, sulfur, iron, copper, zinc, manganese, boron, and sodium) in the sample using an iCAP-Qc ICP-MS spectrometer (Thermo Scientific) detected. Analyzes were carried out at the Science and Technology Application and Research Center (Yozgat Bozok University, Turkey).

ICP-MS conditions are as follows: microflow PFA nebulizer,1550 W plasma power, quartz cyclonic, Peltier cooled spray chamber, 2.5 mm quartz injector; monitoring of 197Au; argon as nebulizer gas at 0.98 L min^{-1}; argon as auxiliary gas at 0.80 L min^{-1}; argon as a refrigerant at 14.00 L min^{-1}; and an analysis time of 60 s. The numerical data calculated considering the dry weight of the plant are the mean of three replicates and are presented as the mean ± SD. A total of 11 points are drawn between 1 ppb and 1 ppm for the calibration curve [24,25]. The weighings were made using an analytical balance (RADWAG AS 220 R2). All chemicals used in the analyses were of analytical grade and were obtained from Sigma-Aldrich.

3. Results and discussions

In the present study, the essential oil yields were determined as 0.095% (v w^{-1}) for fruits, 0.06% (v w^{-1}) for leaves, and 0.02% (v w^{-1}) for stems. The essential oil content of the leaf was recorded as lower less than the ones reported by Taher et al. [26] (0.12%) and Parveen et al. [27] (0.13%). The percentage composition of the essential oils from leaves, fruits, and *X. strumarium* is shown in Table 2.

According to Table 2, the leaves, fruits, and stems essential oils were different both quantitatively and qualitatively. The fruit and leaf essential oils were composed largely of oxygenated sesquiterpene, while the stem essential oil was characterized by oxygenated monoterpenes (Figure 3). Twenty-seven components were identified in fruit essential oil, representing 99.97% of whole essential oil composition. The main components were 6-epi-shyobunol (17.13%), α-bisabolene epoxide (12.34%), α-cadinol (10.28 %), and tau-cadinol (10.06%). The other significant components were diepicedrene-1-oxide (7.67%) and humulene (5.18%). There is no research on the essential oil content and composition in the fruit of the plant. In the leaf essential oil, eighteen components were recorded, representing 98.31% of the whole essential oil composition. The main components were α-cadinol (12.40%) and caryophyllene oxide (11.88%), while borneol (9.24%), isoaromadendrene epoxide (8.74%), cubedol (8.62%), hexahydro-farnesyl acetone (8.06%), tau-cadinol (6.79%), 2,2,6-trimethyl-1-(3-methylbuta-1,3-dienyl)-7-oxa-bicyclo[4.1.0]heptan-3-ol (5.01%), and α-bisabolene epoxide (5.00%) were recorded abundantly. In the essential oil obtained from the stems, 9 components representing 82.02% of the oil were determined. Duraldehyde formed 79.92% of the stem essential oil. Other important components in this essential oil were mesitol with 8.89% and mesitioic acid with 4.49%.

The results of the studies on the essential oil composition of the plant are summarized in Table 3. Potential uses of the main components of the essential oil from *X. strumarium* are given in Table 4.

There are differences between the findings we obtained and those of the researchers listed in Table 3. As known, the chemical composition of essential oils obtained from plants is affected by many factors such as environmental conditions, collection or harvest time, methods of analysis, genetic variation, part of plant utilized, postharvest drying and storage, etc. [28, 29].

The basic nutrients, some toxic heavy metals, and Al content of *X. strumarium* leaves are presented in Table 5. The mineral content of some wild plants whose leaves are consumed as vegetables is given in Table 6. Among the three macro minerals (Ca, K and P) in the dried leaves of *X. strumarium* evaluated in the study, K had the highest value. The microelement content of the leaves varied between 0.305±0.002 (Zn)-3.235±0.062 (Fe) ppm. It was reported that there is a wide variation in nutritional elements among plant species [30]. This situation is also observed in Table 6. When the data obtained from previous studies are examined, it is seen that *X. strumarium* leaves have very low values in terms of both macro and micronutrients compared to some wild plants whose leaves are consumed as vegetables (Table 6). Especially in India, the fresh leaves of *X. strumarium* collected from the natural environment are boiled and eaten [30,31]. In our study, the plants were collected when the fruits were in the green-yellow period and the mineral content of the green leaves in this period was determined. This may be the reason for the low mineral composition of the leaves. In addition, the nutritional content of vegetables is affected by numerous factors such as genotype, environmental conditions (salinity, drought, temperature, light, etc.), cultivation techniques (fertilization, irrigation, harvesting, etc.), and maturity level [32,33].

The negative effects of wild plants on human nutrition are due to the toxicity of the compounds they contain, and the sources of toxic substances in their plants are diverse. Plants absorb toxic compounds such as nitrate, heavy metals, and pesticide residues from the outside, which have a negative effect on human nutrition, store in the plant, and adversely affect human nutrition [34]. Therefore, analytical detection of heavy metals in the used parts of medicinal and aromatic plants collected from the natural environment is among the most important quality parameters in determining the purity, safety, and effectiveness of these plants [35]. According to the analysis results, the heavy metal content of the leaves was found in order: Co > Al > Cd > Cr > Hg> Ni. The limit values for Cd, Cr, and Ni determined by WHO/FDA are 0.3, 0.02, and 1.63 ppm, respectively [36]. The amounts of three metals detected in *X. strumarium* leaves were lower than the maximum allowable values determined by WHO/FDA.

Table 1. Soil analysis results of the experimental area

Texture (%)	Total salt (mS cm^{-1})	*p*H	$CaCO_3$ (%)	Organic matter (%)	P_2O_5 (ppm)	K_2O (ppm)
78.65	0.12	7.27	21.72	3.8	11.29	268.02

Table 2. Comparative percentage composition of the essential oils from the stem and fruit, leaf of *X. strumarium*

Compound	Empirical Formula	RT[a]	RI[b]	Relative Percentage		
				Fruit	Leaf	Stem
Borneol	$C_{10}H_{18}O$	19.769	1148	0.88	9.24	-[c]
Bicyclo[3.1.1]hept-2-en-4-ol, 2,6,6-Trimethyl-, acetate	$C_{12}H_{18}O$	22.884	1238	-	-	2.37
Bicyclo[3.3.0]octan-2-one, 7-Isopropylidene-	$C_{11}H_{16}O$	23.212	1247	-	-	1.50
Bornyl acetate	$C_{12}H_{20}O_2$	23.769	1264	1.17	2.06	-
Mesitol	$C_9H_{12}O$	24.548	1286	-	-	8.89
Duraldehyde	$C_{10}H_{12}O$	26.876	1357	-	-	79.92
β-Cubebene	$C_{15}H_{24}$	27.237	1368	-	1.20	-
Pentanoic acid, 1,1-Dimethylpropyl ester	$C_8H_{16}O_2$	27.640	1380	0.84	-	-
Caryophyllene	$C_{15}H_{24}$	28.336	1401	0.45	-	-
γ-Elemene	$C_{15}H_{24}$	28.581	1409	3.54	-	-
2,4,6-Trimethylbenzyl alcohol	$C_{10}H_{14}O$	29.262	1432	-	-	0.54
Humulene	$C_{15}H_{24}$	29.436	1438	5.18	-	-
Cyclotridecanone	$C_{13}H_{24}O$	29.819	1450	0.56	-	-
2-Tridecanone	$C_{13}H_{26}O$	30.190	1462	0.81	-	-
2,2,6-Trimethyl-1-(3-methylbuta-1,3-dienyl)-7-oxabicyclo [4.1.0] heptan-3-ol	$C_{14}H_{22}O_2$	30.392	1468	-	5.01	-
3-Methylpentan-3-yl 2-Methylbutanoate	$C_{11}H_{22}O_2$	30.435	1470	1.83	-	-
Cubedol	$C_{15}H_{26}O$	30.631	1476	2.92	8.62	-
γ-Cadinene	$C_{15}H_{24}$	31.164	1492	2.05	-	-
Mesitoic acid	$C_{10}H_{12}O_2$	31.275	1496	-	-	4.49
4-epi-Cubedol	$C_{15}H_{26}O$	31.320	1497	-	1.93	-
6-epi-Shyobunol	$C_{15}H_{26}O$	31.411	1500	17.13	-	-
2,4,6-Trimethylbenzyl alcohol	$C_{10}H_{14}O$	31.612	1507	-	-	1.56
Caryophyllene oxide	$C_{15}H_{24}O$	31.842	1515	2.94	11.88	-
1,5-Dimethyltetraline	$C_{12}H_{16}$	32.278	1530	-	3.58	-
Acetylcyclododecane	$C_{14}H_{26}O$	32.715	1545	0.87	-	-
Spathulenol	$C_{15}H_{24}O$	33.176	1561	3.01	2.69	-
Globulol	$C_{15}H_{26}O$	33.943	1587	-	3.20	-
Humulene epoxide	$C_{15}H_{24}O$	34.165	1594	4.40	-	-
Ledene oxide	$C_{15}H_{24}O$	34.477	1605	0.93	4.70	-
Isoaromadendrene epoxide	$C_{15}H_{24}O$	34.510	1606	4.75	8.74	-
Tau-cadinol	$C_{15}H_{26}O$	34.939	1622	10.06	6.79	-
2-(4a,8-dimethyl-1,2,3,4,4a,5,6,7-octahydro-naphthalen-2-yl)-prop-2-en-1-ol	$C_{15}H_{24}O$	35.143	1629	0.75	-	-
α-Cadinol	$C_{15}H_{26}O$	35.360	1637	10.28	12.40	-
Bicyclo[4.4.0]dec-2-ene-4-ol, 2-methyl-9-(prop-1-en-3-ol-2-yl)-	$C_{15}H_{24}O_2$	35.605	1646	-	1.18	-
3-Methyl-2-butenoic acid, 2,6-dimethylnon-1-en-3-yn-5-yl ester	$C_{16}H_{24}O_2$	36.619	1682	-	-	0.88
(1,5,5,8-tetramethyl-bicyclo[4.2.1]non-9-yl)-acetic acid	$C_{15}H_{26}O_2$	37.615	1718	1.66	-	-
Benzyl Benzoate	$C_{14}H_{12}O_2$	38.167	1739	-	-	0.39
Diepicedrene-1-oxide	$C_{15}H_{24}O$	38.427	1749	7.67	-	-
Murolan-3,9(11)-diene-10-peroxy	$C_{15}H_{24}O_2$	39.332	1782	0.70	-	-
Hexahydrofarnesyl acetone	$C_{18}H_{36}O$	39.794	1799	-	8.06	-
α-Bisabolene epoxide	$C_{15}H_{24}O$	39.839	1801	12.34	5.00	-
Platambin	$C_{15}H_{26}O_2$	41.365	1863	1.58	-	-
Murolan-3,9(11)-diene-10-peroxy	$C_{15}H_{24}O_2$	41.625	1873	0.67	-	-
2,4,6-Trimethylmandelic acid	$C_{11}H_{14}O$	42.316	1900	-	2.03	-
Oxygenated monoterpene				0.88	9.24	82.02
Sesquiterpene				11.22	6.21	-
Oxygenated sesquiterpene				77.18	72.16	-
Alcohols				1.68	10.09	12.46
Others				9.01	0.61	5.52
TOTAL				99.97	98.31	100.00
Essential oil (%)				0.095±0.007a[d]	0.06±0.014b	0.02±0.00c

[a]RT: Retention Time, [b]RI: Retention Index, [c]Not detected, [d] *$P<0.01$*

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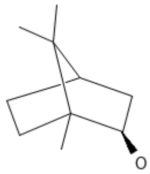
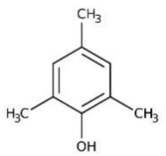
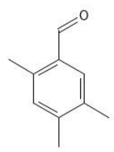
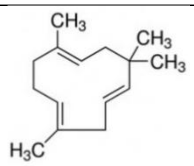
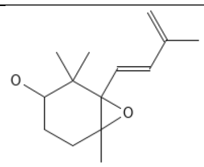
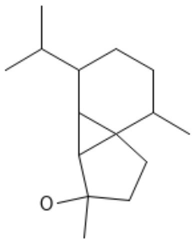
Table 3. The research findings on the major components of the essential oil from *X. strumarium*

Plant parts	The major component of the essential oil	Reference
aerial parts	Limonene (43.6%)	[21]
Leaf	limonene (24.7%), borneol (10.6%)	[11]
Stem	limonene (15.0%), bornyl acetate (19.5%), *β*-selinene (10.1%)	
Leaf	*β*-guaiene (79.6%)	[32]
Leaf	cis-β-guaiene (34.2%), limonene (20.3%), borneol (11.6%)	[8]
Leaf	*β*-caryophyllene (17.53%)	[22]

Table 4. Potential uses of the main components of the essential oil from *X. strumarium*

Compound name	Chemical structure	Molecular weight (g mol^{-1})	Potential for use in medicine, food, cosmetics, etc.	References
Borneol		154.25	Repairing damaged cells Treatment of cardiovascular and cerebrovascular diseases	[37,38]
Mesitol		340.70	Production of pesticides, rubber, pharmaceuticals, varnishes, and dyestuffs	[39]
Duraldehyde		148.20	Additives for resins, pharmaceutical and agricultural intermediates, Flavor and fragrance	[40]
Humulene		204.35	Food additive Treatment of inflammatory diseases, antitumor and anticancer, malaria treatment, weight loss, antihistamine and antibacterial, and pesticide	[41,42]
2,2,6-trimethyl-1-(3-methylbuta-1,3-dienyl)-7-oxabicyclo[4.1.0] heptan-3-ol		222.32	Oligosaccharide provider	[43]
Cubedol		222.37	a food-flavoring agent and perfumery	[44]

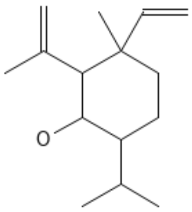
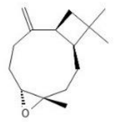
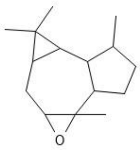
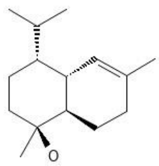
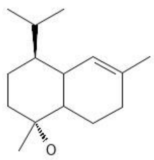
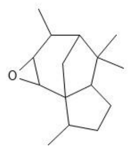
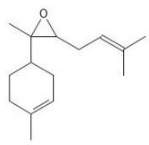
6-epi-shyobunol		222.37	Anti-inflammatory, Antiinociceptive and antipyretic	[45]
Caryophyllene oxide		220.35	Preservatives in food and cosmetics, anticarcinogenic, anti-inflammatory, skin healer, and flavoring	[46-48]
Isoaromadendrene epoxide		220.35	antimicrobial, antioxidant and anti-inflammatory	[49]
Tau-cadinol		222.37	Anticancer	[50]
α-cadinol		222.37	anti-inflammatory and antimite	[31,51]
Diepicedrene-1-oxide		220.35	Nitric oxide synthase inhibitor	[52]
α-bisabolene epoxide		220.35	sweetener and food additive biofuel	[53]

Table 5. Essential plant nutrients and heavy metal content of *X. strumarium* leaves

Macro nutrients (ppm)		Micro nutrients (ppm)		Heavy metals (ppm)	
Ca	1.183±0.007	Fe	3.235±0.062	Al	0.518±0.004
K	142.724±1.838	Mn	0.180±0.000	Ni	0.014±0.000
P	14.244±0.2	Zn	0.305±0.002	(ppb)	
		Cu	0.157±0.001	Cd	0.201±0.007
		B	1.183±0.007	Co	0.969±0.010
		Na	1.122±0.018	Cr	0.145±0.001
				Hg	0.015±0.001

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Table 6. The nutritional content of some wild plants whose leaves are consumed as vegetables (ppm)

Species	Ca	K	P	Fe	Mn	Zn	Cu	Na	References
Malva neglecta	-	5 000	428.75	-	4.6	69.5	1.15	108	[54
Chenopodium album subsp. *album* var. *album*	2 590	6 180	374.6	-	4.8	64.5	0.8	90.5	
Tussilago farfara	1 845	5 255	537.1	-	2.15	12.5	1.2	83	
Ipomoea aquatica Forssk.	5 983	4 406	-	144	12	42	6 338	840	[55]
Amarantus viridis L.	5 736	3 316	-	415	19	19	1 860	104	
Caltha polypetola	2 799	15.71	3 236.7	110.6	42.7	22.8	9.4	262.4	[56]
Bellevalia forniculata	-	8 929.3	3384.7	116.4	25.6	33.6	11.3	263.9	
Urtica dioica L.	11 500	13 200	4 700	182.57	29.26	33.38	-	-	[57]

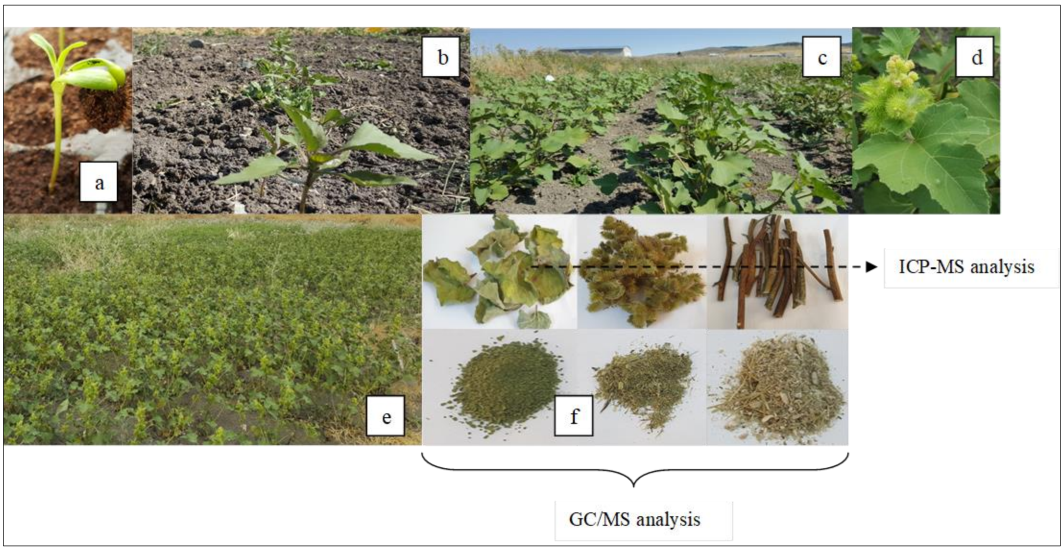

Figure 1. Production stages of plant material (a-emergence, b- the period with 3-4 leaves, c-the pre-bloom period, d-the fruit formation period, e-maturation, f-the leaf, fruit, stem separation in harvested plants and their ground samples)

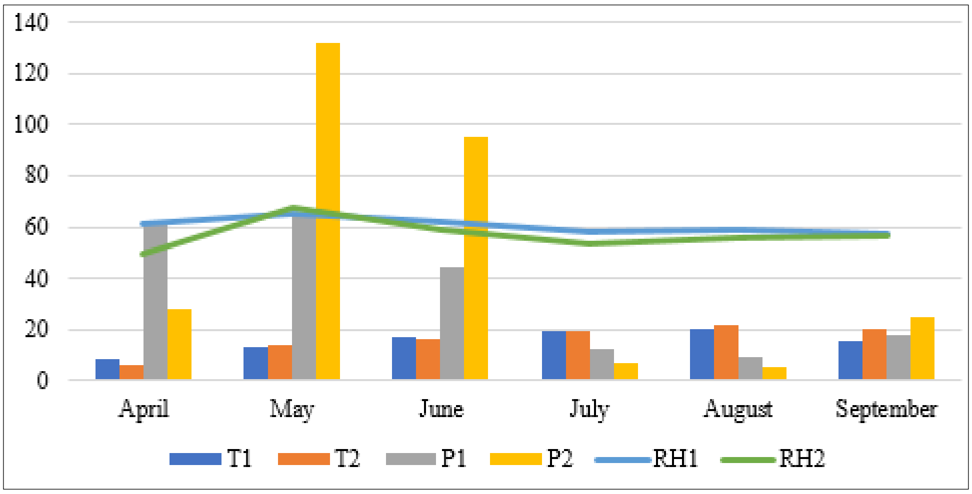

Figure 2. Some climatic data recorded in the experimental area during vegetation (T1: Temperature for long years (°C), T2: Temperature for 2015 year (°C), P1: Precipitation (mm) for long years, Precipitation (mm) for 2015 year, RH1: Relative humidity for long years, RH2: Relative humidity for 2015 year)

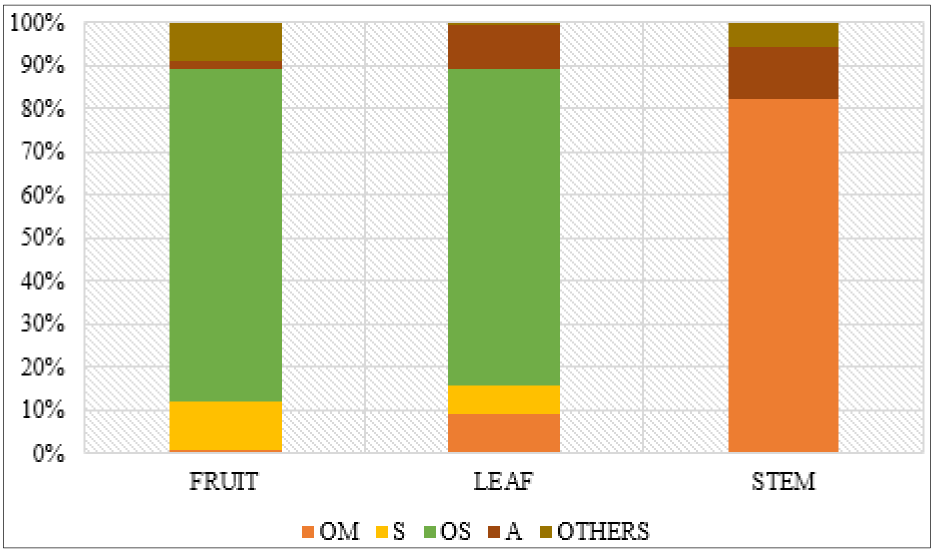

Figure 3. Functional grouping of essential oils from the different organs of *X. strumarium* (OM: Oxygenated Monoterpene; S: Sesquiterpene; OS: Oxygenated Sesquiterpene; A: Alcohols)

4. Conclusions

In summary, this study analyzed the essential oil compositions of stems and fruits, and leaves of *X. strumarium* L. grown in the experimental area. The essential oil content of the fruits was higher than the essential oil content of the leaves and stems. Both the amount and chemical composition of the essential oil obtained from the fruit, leaf and stem parts of *X. strumarium* differed. 4 components (6-epi-shyobunol, α-bisabolene epoxide, α-cadinol, and tau-cadinol) constituting 51.93% of the oil in fruit essential oil, 6 components (borneol, cubedol, caryophyllene oxide, isoaromadendrene epoxide, α-cadinol, and hexahydrofarnesyl acetone) constituting 58.94% of the oil in leaf essential oil, and 2 components (duraldehyde and mesitol) constituting 88.81% of the oil in stem essential oil had been had the highest values. In addition, the essential oil from the leaf with the essential oils from fruit and leaf were characterized by oxygenated monoterpene compounds and oxygenated sesquiterpene compounds, respectively. This plant is a rich source of essential oil components. The chemical composition of fruit essential oil from this plant was investigated for the first time. The findings from this study can be useful for future studies. On the other hand, it was determined that the nutrient content of the leaves of the plants we used in the study was low when compared with the literature data (other wild plants whose leaves are consumed as vegetables). It is known that foods are affected by many factors such as nutrient composition, genetic structure, ecological conditions, agricultural practices, and maturity stage and growth period. Therefore, detailed studies are needed to determine the nutritional properties of *X. strumarium* L.

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