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Herbal content analysis of ethanol extract of aerial part of Berberis vulgaris plant originating from Artvin (Türkiye)

Artvin (Türkiye) kökenli Berberis vulgaris bitkisinin toprak üstü kısmının etanol ekstraktının bitkisel içerik analizi

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Abstract

Since ancient times, people have used plants in various areas such as nutrition, treatment and industrial purposes. Plants consist of various bioactive compounds and secondary metabolites. These compounds and metabolites are effectively used for various purposes in the pharmaceutical and biotechnological industry. Türkiye has a large number of plant flora that can be used as active pharmaceutical ingredients in terms of plant diversity. One of these plants, *Berberis vulgaris*, is a thorny shrub belonging to the Berberidaceae family that sheds its leaves in winter. The chemical composition of *Berberis vulgaris* is susceptible to considerable variation, contingent upon divergent ecological factors. Consequently, this study was conducted to ascertain the bioactive compounds present in the ethanol extract obtained from the aboveground (leaf and branch) parts of the Berberis vulgaris plant, which is known to be cultivated in the Şavşat district of Artvin province, Türkiye. As a first step to carry out the analysis, ethanol extraction of B. vulgaris leaves and branches was carried out using the maceration method. Gas chromatography-mass spectrometry was used to determine the chemical constituents of B. vulgaris, and 7 compounds were identified in the leaf and 9 compounds in the branch. Octatriacontyl pentafluoropropionate was determined as 59.026% and 41.406% in both extracts, respectively. Other compounds determined in the leaf ethanol extract were 9-octadecenamide (19.639%), heptacosane (6.582%), α-tocopherol (6.344%), diisooctyl phthalate (3.166%), phytol (2.960%), tetraethyl silicate (2.127%); Other compounds determined in the branch ethanol extract were erucamide (27.679%), diisooctyl phthalate (10.174%), 2-hexadecanol (4.527%), 8-octadecenal (4.243%), hexa-t-butyl selenatrisiletane (3.786%), tetraethyl silicate (3.982%), hexadecanoic acid ethyl ester (1.617%), oleic acid, 3-(octadecyloxy)propyl ester (2.585%).

Özet

İnsanlar eski çağlardan beri bitkileri beslenme, tedavi ve endüstriyel amaçlar gibi çeşitli alanlarda kullanmışlardır. Bitkiler çeşitli biyoaktif bileşiklerden ve ikincil metabolitlerden oluşur. Bu bileşikler ve metabolitler, ilaç ve biyoteknoloji endüstrisinde çeşitli amaçlarla etkin bir şekilde kullanılmaktadır. Türkiye, bitki çeşitliliği açısından ilaç etken maddesi olarak kullanılabilecek çok sayıda bitki florasına sahiptir. Bu bitkilerden biri olan *Berberis vulgaris*, kışın yapraklarını döken Berberidaceae ailesine ait dikenli bir çalıdır. *Berberis vulgaris*'in kimyasal içeriği farklı ekolojik koşullarına göre büyük ölçüde değişebilir. Bu nedenle, bu çalışma Türkiye'nin Artvin ili Şavşat ilçesinde yetiştiği bilinen *Berberis vulgaris* bitkisinin toprak üstü (yaprak ve dal) kısımlarından elde edilen etanol ekstraktındaki biyoaktif bileşiklerin belirlenmesi amacıyla gerçekleştirilmiştir**.** Analizin gerçekleştirilmesi için ilk adım olarak, *B. vulgaris* yaprak ve dal etanol ekstraksiyonu maserasyon yöntemi kullanılarak gerçekleştirildi. *B. vulgaris* bitkisinin kimyasal bileşenlerinin belirlenmesi için Gaz Kromatografisi Kütle Spektroskopisi yöntemi kullanılmış ve yaprakta 7, dalda ise 9 bileşik tanımlanmıştır. Oktatriakontil pentafloropropionat her iki özütte sırasıyla %59.026 ve %41.406 olarak belirlendi. Yaprak etanol ekstraktında belirlenen diğer bileşikler 9-oktadekenamid (%19.639), heptakosan (%6.582), α-tokoferol (%6.344), diizooktil ftalat (%3.166), fitol (%2.960), tetraetil silikat (%2.127) iken; Dal etanol ekstraktında belirlenen diğer bileşiklerde; erukamid (%27.679), diizooktil ftalat (%10.174), 2-hekzadekanol (%4.527), 8-oktadekenal (%4.243), hekza-t-bütil selenatrisiletan (%3.786), tetraetil silikat (%3.982), hekzadekanoik asit etil ester (%1.617), oleik asit, 3-(oktadesiloksi)propil ester (%2.585) idi.

GİRİŞ

Medicinal plants have been known among different civilizations for thousands of years and have been used in traditional medicine (especially for the treatment and prevention of chronic diseases) and as supplementary food in most countries since the existence of humanity (Bahmani et al. 2014, Karaköse et al. 2019, Şen et al. 2022).

In recent years and despite the emergence of synthetic drugs, medicinal plants continue to be used in many countries due to their safe use, effectiveness, cultural acceptance and fewer side effects than synthetic drugs (Calixto 2000). Türkiye is considered one of the most important regions in terms of global genetic diversity (Karahan et al. 2020). The main reasons for this are its geographical location, topography and microclimate (Karakose 2022). *Moreover,* there are approximately 11.707 plant taxa, 3.649 of them are endemic, which is 31.82% (Suzen and Atamov 2022).

Berberis L. is an important plant genus belonging to the family *Berberidaceae*, with about 500 plant taxa worldwide (Figure 1). It has important potential applications in the food and pharmaceutical industries (Salehi et al. 2019). *Berberis* spp. are native to central and southern Europe, Asia (including Iran and northern Pakistan), and the northeastern United States. *B. vulgaris* (L.), known as European barberry, common barberry, has a very important role in herbal medicine; its different parts (fruits, leaves, roots, stem, branches, trunk/root bark) have been used in traditional medicine for over 2500 years (Ivan et al. 2024). Different parts of *B. vulgaris* are used in traditional medicine to treat various diseases such as cough, inflammations, fever, hyperglycemia, choleretic, hyperlipidemia, liver disease, depression, bleeding (abnormal uterine bleeding etc.), gastrointestinal system and antidiarrheal (Arayne et al. 2007, Imamshahidi and Hosseinzadeh 2008, JavadiFar and Farhadi 2008, Abd El-Wahab et al. 2013).

B. vulgaris contains isoquinoline alkaloids such as berberine; acanthine, bargustanine (Gorval and Grishkovets 1999). It also includes secondary metabolites such as berbamine, berlambine, palmatine and asculetine, ascorbic acid, caffeic acid, pectin and tannin (Amin *et* al. 1969, Imanshahidi and Hosseinzadeh 2008).

Oxidative stress occurs as a result of the disruption of the balance between the antioxidant defense system and free radicals (non-free radical species such as superoxide anion radicals (O_2•-), singlet oxygen ($^1O_2$), hydroxyl radicals (OH•), and hydrogen peroxide (H_2O_2)) and leads to serious health problems by causing tissue damage (Uguz et al. 2022). Additionally, internal and external factors such as increased glucose levels and UV in the organism also contribute to reactive oxygen production (ROS) (Juan et al. 2021). Polyphenols have important properties such as forming stable chemical complexes by donating hydrogen and neutralizing free radicals by inhibiting enzymes involved in ROS formation, as well as their ability to chelate metals that cause oxidative stress (Demir et al. 2019, Parcheta et al. 2021). This phytochemical profile, which is used very effectively in traditional medicine and is also found in *B. vulgaris*, has been supported by many studies as having antioxidant (Shidfar et al. 2012), acne vulgaris (Fouladi 2012), antidiabetic (Moazezi and Qujeq 2014), dyslipidemic (Derosa et al. 2013), antibacterial (Behravan et al. 2019) properties. Therefore, it has been sufficiently demonstrated that polyphenols control a large number of systems that are beneficial to health.

Figure 1. Aerial parts of Berberis vulgaris

To extract the chemical content in dried *Berberis vulgaris* aerial organs, solvent-related technique was performed for this study. In this case, ethanol was used as the solvent and GC-MS method was used to characterize the chemical components.

MATERIAL AND METHOD

Material

The aboveground parts of the cranberries to be used for analysis were obtained from Şavşat district of Artvin (Türkiye) in august (2023). The location of the plant is 40.28300°N 42.38892°E. Plant samples were collected by Benay Eminağaoğlu and identified by Yusuf Kaya, faculty member of the Biology Department of Atatürk University's Faculty of Science.

Method

Preparation of Ethanol Extract of the Aerial Part of B. vulgaris for Analysis

The leaves and branch of *B. vulgaris* were separated and then washed with distilled water. Then, they were dried separately by spreading them as a thin layer of blotting paper at room temperature without being exposed to direct sunlight. Most of the studies were carried out in the Molecular Biology and Genetics and Organic Chemistry Laboratories of Atatürk University, Faculty of Science.

Ethanol Extract of Aerial Part of B. vulgaris Plant

B. vulgaris plant was dried at room temperature and turned into powder. 100 g of powdered plant material was taken and 1000 ml of ethanol (C_2H_5OH) was added and left to stir for 72 hours at room temperature (25 °C) with a standard heated magnetic stirrer. After the maceration process, the pulp part (waste plant material) in the glass bottle was taken with the help of filter paper and the liquid part was taken into Erlenmeyer. The ethanol in the remaining liquid extract was removed with an evaporator device at 50℃ and 155 rpm. This process was repeated 4 times for the pulp part (Adiguzel et al. 2009, Efe et al. 2021, Aktaş et al. 2022, Palabıyık et al. 2024).

Gas Chromatography-Mass Spectroscopy (GC-MS) Analysis

The chemical composition of *B. vulgaris* aerial extracts in ethanol was determined using the GC-MS method at Atatürk University, Faculty of Pharmacy.

GC-MS System and Chromatographic Conditions

Gas chromatography-mass spectrometry (GC-MS) analysis was performed using an Agilent 7820A gas chromatography system, integrated with a 7673 series autosampler, Chemstation software, and a 5977 70 series mass selective detector. The separation process utilized an HP-5 MS column (30 m × 0.25 mm I.D., USA) with a film thickness of 0.25 µm. The inlet and transfer line temperatures were set at 250°C and 300°C, respectively. The injection parameters were configured as follows: a 1 µL splitless injection mode, helium as the carrier gas with a flow rate of 1 mL/min, and an ionization energy of 70 eV (Mawlid et al. 2023, Rutkowska Discussion 2023).

During the GC-MS procedure, a programmed temperature gradient was applied. Initially, the temperature was increased by 50°C for one minute, followed by a ramp of 20°C per minute up to 100°C, then 10°C per minute up to 180°C, and finally 5°C per minute for an additional minute. The extract's chromatographic peaks and mass spectra were identified by comparing them with reference standard substances.

Identification of Components

In the 2005 version of the National Institute of Standards and Technology (NIST) Library, specifically within the Turbomass 5.2 software, the obscure segment's range was analyzed in comparison to the stored reference section. By evaluating the direct Kovats retention index alongside mass spectra data from the MS library, individual components were effectively distinguished. The NIST database, which contains over 62.000 records, facilitated insights into the GC-MS mass range. The relative concentration of each component was determined by assessing its peak area in proportion to the overall detected areas. This analysis helped identify the test materials, revealing their respective names, molecular weights, and structural compositions.

RESULTS

During the extraction process, the chemical composition of the materials obtained from different parts of the plant (tissues and organs) varies (Doughari et al. 2012) This difference is related to physiological processes such as the synthesis, storage and transportation of primary and secondary metabolites in plants (Wink 2010). The variation in chemical content is not only due to the plant material used; the preferred solvent and the method applied during the extraction process can also affect this change. Plants contain various bioactive components that shape their biological activities (Alawode et al. 2021).

GC-MS analysis was performed to determine the chemical content of ethanol extraction of *B. vulgaris leaf* (E-BVL) and branch (E-BVB). As a result of the analysis, 7 compounds were identified in E-BVL and 9 compounds in E-BVB. These are shown in Table 1 and Table 2.

Table 1. Chemical composition of compounds identified in E-BVL extract

Peak	Retention time (min.)	% of total	Compound	Molecular formula
1	5.302	2.127	Tetraethyl silicate	$C_8H_{20}O_4Si$
2	21.973	2.960	Phytol	$C_{20}H_{40}O$
3	30.944	3.166	Diisooctyl phthalate	$C_{24}H_{38}O_4$
4	32.653	6.582	Heptacosane	$C_{27}H_{56}$
5	33.611	19.639	9-octadecenamide	$C_{18}H_{35}NO$
6	36.501	59.181	Octatriacontyl pentafluoropropionate	$C_{41}H_{77}F_5O_2$
7	36.982	6.344	α-tocopherol	$C_{29}H_{50}O_2$

In the 40 minute GC-MS analysis period, the components began to appear between 5 and 37 minutes. In this period, octa triacontyl pentafluoropropionate (59.181%) was identified as the main component. This component was followed by the following compounds; 9-octadecenamide (19.639%), heptacosane (6.582%), α-tocopherol (6.344%), diisooctyl phthalate (3.166%), phytol (2.960%), tetraethyl silicate (2.127%). Table 1 presents a detailed summary of the bioactive compounds identified by GC-MS analysis in E-BVL extract. In addition, the GC-MS chromatogram of these substances is presented in Fig. 1 and the 3D view in Fig. 3

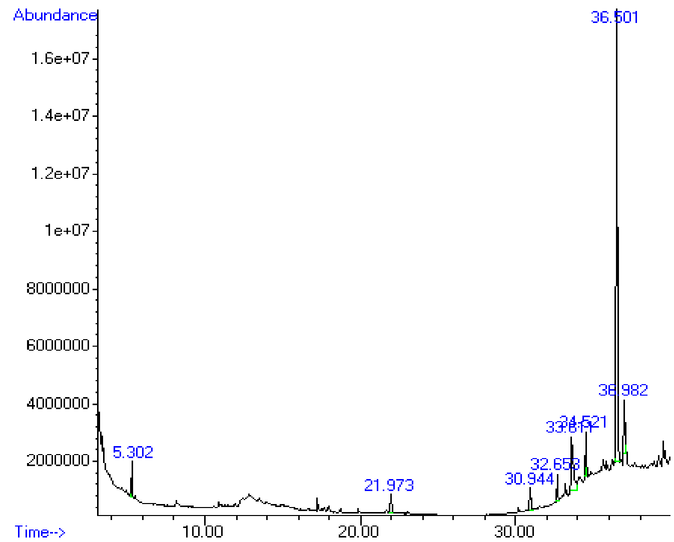

Figure 2. GC-MS chromatogramı of E-BVL

Table 2. Chemical composition of compounds identified in E-BVB extract

Peak	Retention time (min.)	% of total	Compound	Molecular formula
1	5.297	2.127	Tetraethyl silicate	$C_8H_{20}O_4Si$
2	19.921	1.617	Hexadecanoic acid ethyl ester	$C_{18}H_{36}O_2$
3	21.477	4.527	2-hexadecanol	$C_{16}H_{34}O$
4	25.863	4.243	8-octadecenal	$C_{18}H_{34}O$
5	30.953	10.174	Diisooctyl phthalate	$C_{24}H_{38}O_4$
6	33.212	3.786	Hexa-t-butyl selenatrisiletane	$C_{24}H_{54}SeSi_3$
7	33.621	27.679	Erucamide	$C_{18}H_{35}HO$
8	34.526	2.585	Oleic Acid, 3- (octadecyloxy)propyl ester	$C_{39}H_{76}O_3$
9	36.496	41.406	Octatriacontyl pentafluoropropionate	$C_{41}H_{77}F_5O_2$

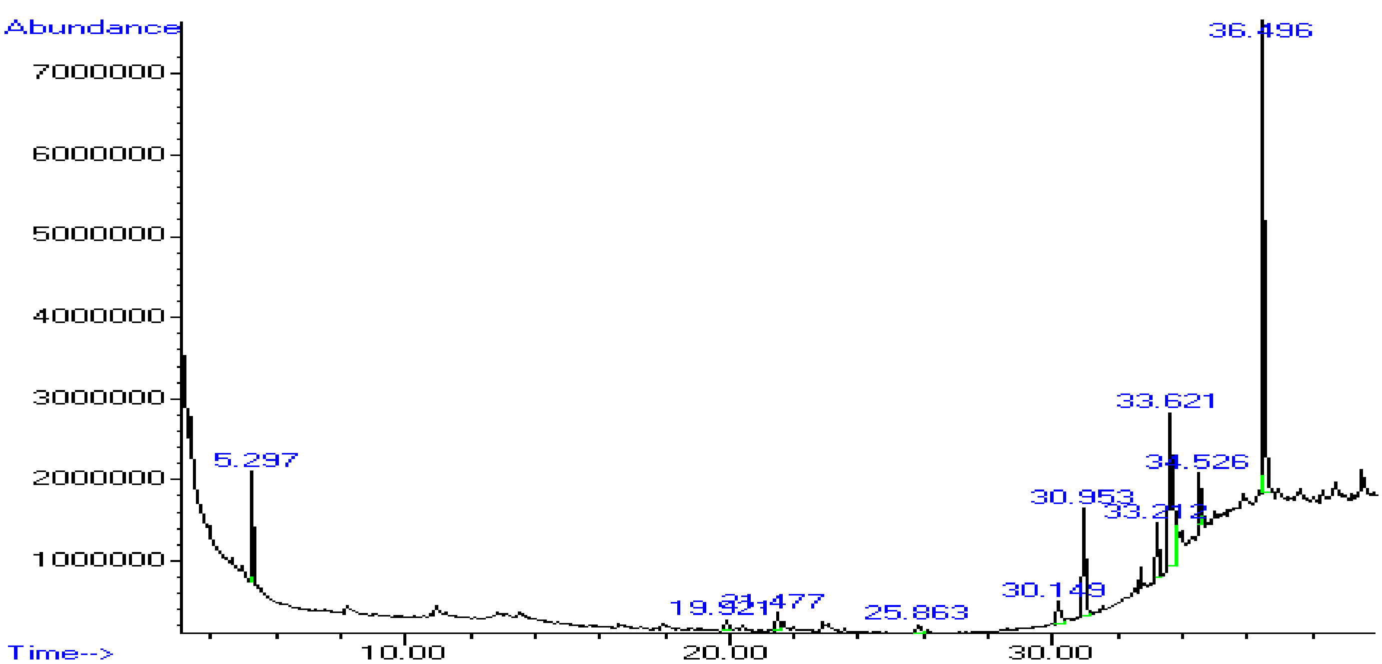

Figure 3. GC-MS chromatogramı of E-BVB

In the 40-minute GC-MS analysis period, the components started to appear between 5 and 37 minutes. In this period, octa triacontyl pentafluoropropionate (41.406%) was determined as the main component. This component was followed by erucamide (27.679%), diisooctyl phthalate (10.174%), 2-hexadecanol (4.527%), 8-octadecenal (4.243%), hexa-t-butyl selenatrisilethane (3.786%), tetraethyl silicate (3.982%), hexadecanoic acid ethyl ester (1.617%), oleic acid, 3-(octadecyloxy)propyl ester (2.585%) compounds, respectively. Table 2 presents a detailed summary of the bioactive compounds identified by GC-MS analysis in E-BVB extract. In addition, the GC-MS chromatogram of these substances is presented in Fig. 2 and the 3D view in Fig. 3.

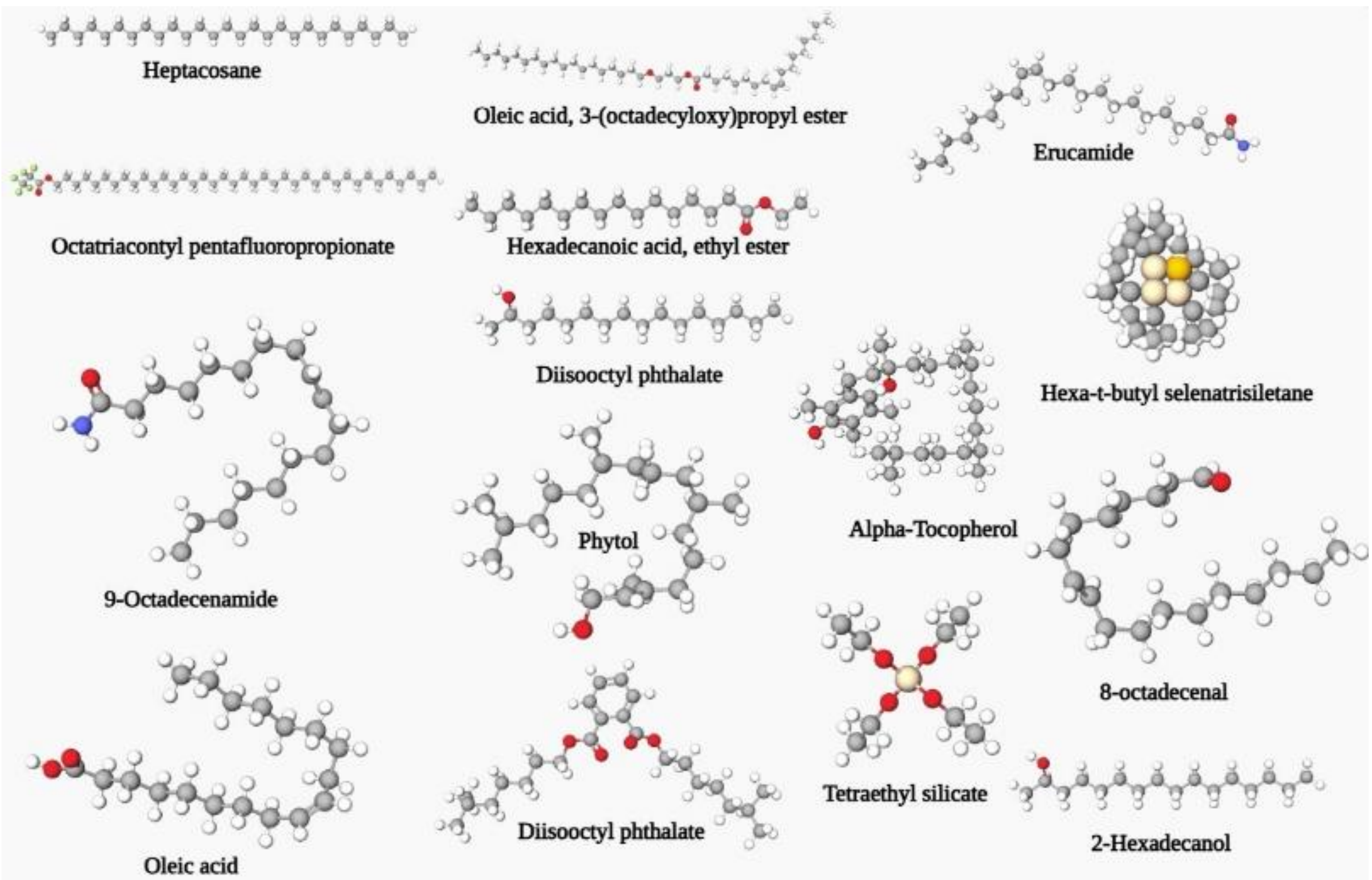

Figure 4. 3D structure visualization of E-BVL and bioactive components of E-BVL (MolView)

DISCUSSION

When the literature on medicinal plants is reviewed, it is possible to say that the most important situation in medicinal plants is the presence of effective, natural and easily accessible therapeutic agents with little or no side effects of the compounds in their structure. Propionate, one of the main compounds identified in our study, is formed as a result of the degradation of propionate fatty acids found in some plants, animals and humans. Octatriacontyl pentafluoropropionate refers to an organic compound containing a long-chain hydrocarbon group (octatriacontyl refers to a 38-carbon straight-chain alkyl group) attached to a pentafluoropropionate moiety. According to studies, pyropionic acid has many properties such as inhibition of lipolysis, antifungal, antibacterial (Sun and Oliver 1994), anti-inflammatory (Curi et al. 1993). In addition, docking analysis of Octatriacontyl pentafluoropropionate found in the structure of corn propolis using computational modeling revealed that it is well oriented within enzyme pockets and binds perfectly, and has an excellent binding pattern with the active site of target macromolecules compared to some broad-spectrum antiviral agents (H Elwakil et al. 2021).

The other component determined in the *B. vulgaris* leaf ethanol extract our study is 9-octadecenamide, a fatty acid amide compound commonly known as oleamide (Abel-Anyebe et al. 2020). This compound is naturally produced by plants and microorganisms (Zulfiqar et al. 2022) According to the studies, it has been determined that this compound, which is naturally found in the brain of humans and animals, is effective in the transition to sleep and in maintaining sleep patterns. In addition, 9-octadecenamide has antibacterial and antifungal properties (Hameed et al. 2016). As a result, it has important applications in the pharmaceutical and cosmetic industries and as a lubricant in the industry (Abel-Anyebe et al. 2020). Heptacosan, one of the other important components determined in the leaf ethanol extract in our study, is a straight-chain alkane containing 27 carbon atoms and is a hydrocarbon compound. It is naturally produced by many plants, animals and insects. According to the results of the literature review, antibacterial activity and antioxidant activity (Witkowska-Banaszczak and Długaszewska 2017) properties were determined. Known as vitamin E, α-tocopherol is a natural antioxidant (Simru 2007). α-tocopherol stabilizes cell membranes and prevents oxidation of skin cells (Tuzcu 2019). It also delays skin aging by preventing collagen cross-linking and lipid peroxidation. According to the literature review, it has been reported that α-tocopherol is used in the healing of sunburn and skin wounds, photo-immune inhibition, prevention of carcinogenesis and as a dermal immune stimulant (Tuzcu 2019). Phthalic acid is a common plasticizer added to polymeric materials to increase their flexibility and processability. Diisooctyl phthalate, one of the phthalic acids, was detected at 52.1% in the methanol extract of *Lilium brownii* Lemoinier (Cheng and Xu 2012) and *Allium fistulosum* L. root exudates (Zhou et al. 2010). In line with of the literature review, diisooctyl phthalate was found to have allelopathic, antimicrobial, and insecticidal properties (Huang et al. 2021, El-Enain et al. 2023). Phytol (PYT; 3,7,11,15-tetramethylhexadec-2-en-1-ol) is a compound produced abundantly in nature by almost all photosynthetic organisms, including algae (de Souza and Nes 1969), plants (Ischebeck et al. 2006), and cyanobacteria (Proteau 1998). It is also formed as an important metabolite during catabolism in ruminant animals. Phytol is considered the most abundant acyclic isoprenoid in the biosphere of our planet (Rontani and Volkman 2003). In accordance with the findings of the literature review, it was observed that phytol has properties such as antimicrobial, antifungal, anti-inflammatory and antioxidant activity (Pejin et al. 2014, İslam et al. 2020). Tetraethyl silicate (TEOS) or tetraethyl orthosilicate is generally used as the main material in the synthesis of silica and the products of ceramic materials (Choudhary et al. 2015.)

Erucamide, commonly used as a slip agent, is a long-chain fatty acid amide (Dulal, 2018). The developments made by Li and his colleagues regarding hypothalamic-pituitary-adrenal fluid loss in mice have been found to eliminate the antidepressant and anxiolytic-like behavioral effects of erucamide, a bioactive fatty acid amide (Li et al. 2017). One of the other parts of *B. vulgaris* branch ethanol extract is 2-hexadecanol, a long-chain fatty alcohol, an organic commonly used as surfactants, emulsifiers and lubricants. It falls into the secondary alcohol class and is generally used for cosmetic, pharmaceutical and industrial purposes. One of the other parts of the E-BVB extract is 2-hexadecanol, a long-chain fatty alcohol that is widely used as an organic surfactant, emulsifier, and lubricant. It falls into the secondary alcohol class and is generally used for cosmetic, pharmaceutical, and industrial purposes. A treatment with *Virgularia gustaviana* found that 2-hexadecanol induced apoptosis in human breast cancer cell MDA-MB-231 and cervical cancer cell Hela (Sharifi et al. 2020). 8-Octadecenal is a long-chain, unsaturated aldehyde, an organic compound used primarily as a sweetener. It belongs to the class of aliphatic aldehydes. Hussein et al. (2016) showed that it has insecticidal properties as a result of the study conducted on *Ammi majus* L. methanol extract. Hexa-tert-butyl selenium trisiletane ($C_{18}H_{54}SeSi_3$) is one of the rare groups belonging to the class of organosilicon-selenium groups. It has a structure in which three silicon (Si) atoms are bonded around one selenium (Se) atom, and each silicon atom is dominated by a large volume of tert-butyl (t-Bu, $C(CH_3)_3$). According to the literature review results, Hexa-t-butyl selenium trisiloxane has sleep disturbance, drowsiness, muscle weakness, anemia, hepatitis, hyperthermic properties (Duraisamy and Selvaraju 2020). Hexadecanoic acid ethyl ester (ethyl ester of palmitic acid) is a long-chain fatty acid ester. It is commonly used as a biodiesel, cosmetic and food additive. It is a natural compound produced from vegetable and animal fats. Hexadecanoic acid ethyl ester is a compound that is frequently investigated for its biological and pharmaceutical properties, showing various potential health benefits and biological activities such as hypocholesterolemic, antioxidant, anti-androgenic activity, hemolytic activity and nematicidal activity (Tyagi and Agarwal 2017). Oleic acid, 3-(octadecyloxy)propyl ester, is an organic product formed by the esterification products of oleic acid and 3-(octadecyloxy)propyl group. This organic is used especially in surfactants, emulsifiers, cosmetic systems and industrial applications. Abubacker and Devi (2014) identified the bioactive compound oleic acid, 3-(octadecyloxy) propyl ester from the plant *Lepidagathis cristata* Willd. and showed that it has antifungal activity (Abubacker and Devi 2014). While the content analysis of *B. vulgaris* from the Artvin region has been successfully carried out, exploring the differences in this species across various global regions would indeed offer a broader perspective. By comparing the plant material from Artvin to samples from other parts of the world, we can potentially uncover regional variations in phytochemical composition, ecological adaptations, and even pharmacological properties. This comparative approach could provide valuable insights into how environmental factors, local climate, or soil conditions might influence the plant's bioactive components. Additionally, it could contribute to a deeper understanding of the global diversity within *B. vulgaris* and its potential applications in different regions. Differences were detected between the *B. vulgaris* plants collected in our study and those collected from other parts of the world in terms of their contents. A good example of these differences is the study conducted by Rahimi-Madiseh and colleagues. The results briefly reveal that *B. vulgaris* contains a large number of phytochemicals, including ascorbic acid, vitamin K, various triterpenoids, more than 10 phenolic compounds and more than 30 alkaloids (Rahimi-Madiseh et al. 2017). Similarly, according to Mokhber-Dezfuli et al. (2014), the crude extract of *B. vulgaris* revealed the presence of alkaloids, tannins and phenolic compounds. The results obtained from different parts of this plant and using different solvents can be summarized as follows. Triterpenes isolated from its fruits: lupeol and oleanolic acid isolated from ethanol extract; sterol obtained from hexane extract: stigmasterol and stigmasterol glucoside obtained from ethyl acetate extract; alkaloids: berberamine, palmatine and berberine. Other important alkaloids are oxyberberine, columbamine, isochoridine, lambertine, magniflorine and bisbenzylsoquinolines (e.g. oxycanthine) reported from this plant.

CONCLUSION

It is extremely important to find or develop a new and powerful drug molecule that can treat diseases that are important factors in the development of many diseases such as cancer, hypocholesterolemia, bacterial and fungal infections, and immunosuppressive diseases. Recent studies on plants have shown progress in this direction. The use of natural products (such as plant sources) since ancient times is also considered a surprising factor in the development of therapeutic agents. In our research, according to the GC-MS analysis results, it was determined that the ethanol extract of the aerial part of *B. vulgaris* plant contained some important chemicals such as octatriactonyl pentafluoropropionate, 9-octadecenamide, heptacosane, α-tocopherol, diisooctyl phthalate, phytol, tetraethyl silicate, diisooctyl phthalate, 2-hexadecanol, 8-octadecenal, hexa-t-butyl selenium trisylethane, tetraethyl silicate, hexadecanoic acid ethyl ester, oleic acid, 3-(octadecyloxy)propyl ester. Accordingly, future studies may reveal that these detected substances are necessary agents in the medical field and may also help in the evaluation of their in vitro and in vivo pharmacological effects.

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REFERENCES

Abd El-Wahab AE, Ghareeb DA, Sarhan EE, Abu-Serie MM, El Demellawy MA (2013) In vitro biological assessment of Berberis vulgaris and its active constituent, berberine: antioxidants, anti-acetylcholinesterase, anti-diabetic and anticancer effects. BMC Complementary and Alternative Medicine, 13: 1-12.

Abel-Anyebe O, Idris N, Keita D, Ekpenyong KI, Yakubu MA (2020) Fatty Amides in Minutes: Direct Formation from Fatty Esters ina Green Synthetic Process. Science, 8(1): 18-28.

Abubacker MN, Devi PK (2014) In Vitro Antifungal Potentials of Bioactive Compound Oleic Acid, 3-(Octadecyloxy) Propyl Ester Isolated from Lepidagathis cristata willd.(Acanthaceae) Inflorescence. Asian Pacific Journal of Tropical Medicine, 7: 190-193.

Adiguzel A, Ozer H, Sokmen M, Gulluce M, Sokmen A, KIlic H, Sahin, Baris O (2009) Antimicrobial and Antioxidant Activity of the Essential Oil and Methanol Extract of Nepeta cataria. Polish Journal of Microbiology, 58: 69–76.

Aktaş KA, Şeker ME, Karaköse M (2022) Determination of Antioxidant Activity of Different Extracts From Bark of Pinus spp. grown in Giresun (Turkey) Province – Phenolic analysis by RP-HPLC-DAD. Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi, 25(1): 10-18.

Alawode TT, Lajide L, Olaleye M, Owolabi B (2021) Stigmasterol and β-sitosterol: antimicrobial compounds in the leaves of Icacina trichantha identified by GC-MS. Beni-Suef University Journal of Basic and Applied Sciences, 10: 1-8.

Amin AH, Subbaiah TV, Abbasi KM (1969) Berberine sulfate: antimicrobial activity, bioassay, and mode of action. Canadian Journal of Microbiology, 15(9): 1067-1076.

Arayne MS, Sultana N, Bahadur SS (2007) The berberis story: *Berberis vulgaris* in therapeutics. Pakistan Journal of Pharmaceutical Sciences, 20(1): 83-92.

Bahmani M, Zargaran A, Rafieian-Kopaei M, Saki K (2014) Ethnobotanical study of medicinal plants used in the management of diabetes mellitus in the Urmia, Northwest Iran. Asian Pacific Journal of Tropical Medicine, 7: S348-S354.

Behravan M, Panahi AH, Naghizadeh A, Ziaee M, Mahdavi R, Mirzapour A (2019) Facile green synthesis of silver nanoparticles using *Berberis vulgaris* leaf and root aqueous extract and its antibacterial activity. International Journal of Biological Macromolecules, 124: 148-154.

Calixto JB (2000) Efficacy, safety, quality control, marketing and regulatory guidelines for herbal medicines (phytotherapeutic agents). Brazilian Journal of Medical and Biological Research, 33: 179-189.

Choudhary R, Koppala S, Swamiappan S (2015) Bioactivity studies of calcium magnesium silicate prepared from eggshell waste by sol–gel combustion synthesis. Journal of Asian Ceramic Societies, 3(2): 173-177.

Curi R, Bond JA, Calder PC, Newsholme EA (1993) Propionate regulates lymphocyte proliferation and metabolism. General Pharmacology, 24(3): 591-597.

de Souza NJ, Nes WR (1969) The presence of phytol in brown and blue-green algae and its relationship to evolution. Phytochemistry, 8(5): 819-822.

Derosa G, Bonaventura A, Bianchi L, Romano D, D'Angelo A, Fogari E, Maffioli P(2013) *Berberis aristata/Silybum marianum* fixed combination on lipid profile and insulin secretion in dyslipidemic patients. Expert Opinion on Biological Therapy, 13(11): 1495-1506.

Doughari JH (2012) Phytochemicals: extraction methods, basic structures and mode of action as potential chemotherapeutic agents (pp. 1-33). Rijeka, Croatia: INTECH Open Access Publisher.

Dulal N (2018) Study on the migration of slip agents on the surface of high-density polyethylene beverage closures (Doctoral dissertation, RMIT University.

Duraisamy M, Selvaraju R (2020) Analysis of chemical compounds by using gas chromatography and mass spectrum analysis, in vitro antioxidant and antibacterial activity of methanolic extracts of seaweed Ulva flexuosa Wulfen (green algae). Aegaeum J., 8: 1438-1454.

El-Enain A, Zeatar A, Zayed A, Elkhawaga M, Mahmoud Y (2023) Diisooctyl phthalate as a secondary metabolite from actinomycete ınhabit animal's dung with promising antimicrobial activity. Egyptian Journal of Chemistry, 66(12): 261-277.

Efe D, Karaköse M, Karaçelik A, Aktaş E, Şeker B, Emin M (2021) GC-MS analyses and bioactivities of essential oil obtained from the roots of *Chrysopogon zizanioides* (L.) Roberty cultivated in Giresun, Turkey. Turkish Journal of Chemistry, 45 (5): Article 19.

Fouladi RF (2012) Aqueous extract of dried fruit of Berberis vulgaris L. in acne vulgaris, a clinical trial. Journal of Dietary Supplements, 9(4): 253-261.

Gorval LM, Grishkovets VI (1999) Alkaloids of some species of the genus Berberis introduced into the Crimea.

Elwakil HB, Shaaban MM, Bekhit AA, El-Naggar MY, Olama ZA (2021) Potential anti-COVID-19 activity of Egyptian propolis using computational modeling. Future Virology, 16(2): 107-116.

Hameed IH, Altameme HJ, Mohammed GJ (2016) Evaluation of antifungal and antibacterial activity and analysis of bioactive phytochemical compounds of *Cinnamomum zeylanicum* (Cinnamon bark) using gas chromatography-mass spectrometry. Oriental Journal of Chemistry, 32(4): 1769.

Huang L, Zhu X, Zhou S, Cheng Z, Shi K, Zhang C, Shao H (2021) Phthalic acid esters: natural sources and biological activities. Toxins, 13(7): 495.

Huang X, Wu H, Jian R, Sun G, Shen J,…. Tao W (2018) The antidepressant effects of α-tocopherol are related to activation of autophagy via the AMPK/mTOR pathway. European Journal of Pharmacology, 833: 1-7.

Hussein HM, Hameed IH, Ubaid JM (2016) Analysis of the secondary metabolite products of Ammi majus and evaluation anti-insect activity. International Journal of Pharmacognosy and Phytochemical Research, 8(8): 1192-1189.

Hussein HM, Ubaid JM and Hameed IH (2016) Insecticidal activity of methanolic seeds extract of *Ricinus communis* on adult of *Callosobruchus maculatus* (coleopteran: brauchidae) and analysis of its phytochemical composition. Int. J. Pharmacog. Phytochem. Res., 8(8): 1385-1397.

Imanshahidi M, Hosseinzadeh H (2008) Pharmacological and therapeutic effects of *Berberis vulgaris* and its active constituent, berberine. Phytotherapy Research, 22(8): 999-1012.

Ischebeck T, Zbierzak AM, Kanwischer M, Dörmann P (2006) A salvage pathway for phytol metabolism in Arabidopsis. Journal of Biological Chemistry, 281(5): 2470-2477.

Islam MT, Ayatollahi SA, Zihad SNK, Sifa N, Khan R, Paul A, ... Sharifi-Rad J (2020) Phytol anti-inflammatory activity: pre-clinical assessment and possible mechanism of action elucidation. Cellular and Molecular Biology, 66(4): 264-269.

Ivan IM, Olaru OT, Popovici V, Chițescu CL, Popescu L, Luță EA, ... Gîrd CE (2024) Antioxidant and cytotoxic properties of *Berberis vulgaris* (L.) stem bark dry extract. Molecules, 29(9): 2053.

JavadiFar K, Farhadi (2008) Effects of *Berberise Vulgaris* fruit extract on blood cholesterol and triglyceride in hyperlipidemic patients. Koomesh, 9(3): 211-216.

Juan CA, Pérez de la Lastra JM, Plou FJ, Pérez-Lebeña E (2021) The chemistry of reactive oxygen species (ROS) revisited: outlining their role in biological macromolecules (DNA, lipids and proteins) and induced pathologies. International Journal of Molecular Sciences, 22(9): 4642.

Karahan F, Ozyigit II, Saracoglu IA, Yalcin IE, Ozyigit AH, Ilcim A (2020) Heavy metal levels and mineral nutrient status in different parts of various medicinal plants collected from eastern Mediterranean region of Turkey. Biological Trace Element Research, 197: 316-329.

Karakose M (2022) Vascular plant diversity of Esenli (Giresun) forest planning unit. Forestist, 72(2): 156-164.

Karaköse, M, Akbulut S, Özkan ZC (2019) Ethnobotanical study of medicinal plants in Torul district, Turkey. Bangladesh Journal of Plant Taxonomy, 2*6*(1): 29–37.

Li MM, Jiang ZE, Song LY, Quan ZS, Yu HL (2017) Antidepressant and anxiolytic-like behavioral effects of erucamide, a bioactive fatty acid amide, involving the hypothalamus–pituitary–adrenal axis in mice. Neuroscience Letters, 640: 6-12

Moazezi Z, Qujeq D (2014) *Berberis* fruit extract and biochemical parameters in patients with type II diabetes. Jundishapur Journal of Natural Pharmaceutical Products, 9(2).

Mokhber-Dezfuli N, Saeidnia S, Gohari AR, Kurepaz-Mahmoodabadi M (2014) Phytochemistry and pharmacology of *Berberis* species. Pharmacogn Rev., 8(15):8-15.

Palabıyık E, Uğuz H, Avcı B, Sulumer AN, Yılmaz B, Aşkın H (2024) Bioactive component analysis of seed coat hexane extract of Ardahan (Turkey) walnut. Frontiers in Life Sciences and Related Technologies (Online), 5 (2).

Parcheta M, Świsłocka R, Orzechowska S, Akimowicz M, Choińska R, Lewandowski W (2021) Recent developments in effective antioxidants: the structure and antioxidant properties. Materials, 14(8): 1984.

Pejin B, Savic A, Sokovic M, Glamoclija J, Ciric A, Nikolic M, ... Mojovic M (2014) Further in vitro evaluation of antiradical and antimicrobial activities of phytol. Natural Product Research, 28(6): 372-376.

Proteau PJ (1998) Biosynthesis of phytol in the cyanobacterium Synechocystis sp. UTEX 2470: utilization of the non-mevalonate pathway. Journal of Natural Products, 61(6): 841-843.

Rahimi-Madiseh M, Lorigoini Z, Zamani-Gharaghoshi H, Rafieian-Kopaei M (2017) *Berberis vulgaris*: specifications and traditional uses. Iran J Basic Med Sci., 20(5):569-587.

Salehi B, Selamoglu Z, Sener B, Kilic M, Kumar Jugran A, de Tommasi NC, Cho W (2019) *Berberis* plants—drifting from farm to food applications, phytotherapy, and phytopharmacology. Foods, 8(10): 522.

Savić S, Petrović S, Barbinta-Patrascu ME, Danilović B, Stanojević L, Savić S, Petronijevic Z (2021) Baobab fruit shell: biophysical investigations of bioactive compounds and minerals. Rom J Phys., 66: 701.

Sharifi S, Mostafavi PG, Tarasi R, Moradi AM, Givianrad MH, Farimani MM, ...Niknejad H (2020) Purified compounds from marine organism sea pen induce apoptosis in human breast cancer cell MDA-MB-231 and cervical cancer cell Hela. European Journal of Pharmacology, 877: 173075.

Shidfar F, Ebrahimi SS, Hosseini S, Heydari I, Shidfar S, Hajhassani G (2012) The effects of *Berberis vulgaris* fruit extract on serum lipoproteins, apoB, apoA-I, homocysteine, glycemic control and total antioxidant capacity in type 2 diabetic patients. Iranian Journal of Pharmaceutical Research: IJPR, 11(2): 643.

Sun Y, Oliver JD (1994) Antimicrobial action of some GRAS compounds against *Vibrio vulnificus*. Food Additives & Contaminants, 11(5): 549–558.

Suzen A, Atamov V (2022) Endemic and rare plant diversity of Ambarlik highland-case study from Çamlihemşin, Türkiye. Plant & Fungal Research, 5(1): 29-33.

Şen G, Akbulut S, Karaköse M (2022) Ethnopharmacological study of medicinal plants in Kastamonu province (Türkiye). Open Chemistry, 20(1): 873-911.

Tuzcu AK (2019) Antioksidanların doğal ve takviye şeklinde kullanımı. Türkiye Klinikleri Kozmetik Dermatoloji Özel Dergisi, 12(2).

Tyagi T, Agarwal M (2017) Phytochemical screening and GC-MS analysis of bioactive constituents in the ethanolic extract of *Pistia stratiotes* L. and *Eichhornia crassipes* (Mart.) solms. Journal of Pharmacognosy and Phytochemistry, 6(1):195-206.

Uguz H, Palabiyik E, Askin H (2022) Free radicals, oxidative stress and biological effects of oxidative stress, antioxidant defense system. In: Onay Derin, D. (ed) International Research in Health Sciences III (1st edition) (pp 7-24). New York: Eğitim Publishing Group, Inc.

Wink M (2010) Introduction: biochemistry, physiology and ecological functions of secondary metabolites, annual plant reviews. Biochemistry of Plant Secondary Metabolism, 40: 1-19.

Zhou BL, Yin YL, Zhang FL, Ye XL (2010) Allelopathic effects of root exudates of grafted eggplants on *Verticillium dahliae* and their constituents' identification. Allelopathy Journal, 25(2): 393-402.

Zulfiqar U, Yasmin A, Fariq A (2022) Metabolites produced by inoculated Vigna radiata during bacterial assisted phytoremediation of Pb, Ni and Cr polluted soil. PLoS One, 17(11): e0277101.