Cumhuriyet Sci. J., 46(4) (2025) 735-740
DOI: https://doi.org/10.17776/csj.1786038

Cumhuriyet Science Journal

| csj.cumhuriyet.edu.tr | Founded: 2002 ISSN: 2587-2680 e-ISSN: 2587-246X Publisher: Sivas Cumhuriyet University

Polyphenolic Content and Antioxidant Activity of Aerial Parts of Four Turkish Medicinal Plants

Ayşe Hanbeyoğlu [1,a,*]

[1] *Chemistry and Chemical Prosses Technology, Gemerek Vocational School, Sivas Cumhuriyet University, Sivas, Türkiye*

**Corresponding author*

Research Article

History
Received: 18/09/2025
Accepted: 16/12/2025

ABSTRACT

The objective of this study was to investigate the total phenolic and flavonoid content, antioxidant capacity, and radical scavenging activity of endemic plants: *Allium scorodoprasum* L. subsp. *rotundum* (L.) Stearn, *Consolida Orientalis* (J. Gay) Schrödinger*, Fibigia clypeata* (L.) Medik, *Silene compacta* Fischer. Total antioxidant capacity was evaluated using the CUPRAC method. The radical scavenging effect was examined by looking at the scavenging activity of DPPH and H_2O_2 radicals. The total phenolic content (53.83 ± 2.63 mg GAE/g sample) and total flavonoid content (2.89 ± 0.13 mg QUE/g sample) were found to be higher in *S. compacta* compared to the other plants. In total antioxidant capacity analyses, the highest value was once again achieved in *S. compacta* (41.93 ± 0.95 mg TRXE/g sample), in accordance with its phenolic content. Radical scavenging activities exhibited a concentration-dependent response; all the extracts demonstrated significant scavenging activities against DPPH and H_2O_2 radicals. Consequently, the examined plants exhibited significant antioxidant activities due to the presence of specific phytochemicals. The plants under scrutiny, most notably *S. compacta*, are considered to be significant sources of natural substances, with potential for utilisation in the development of novel phytopharmaceuticals.

Keywords: Antioxidant, DPPH, CUPRAC, Total phenolic, Total flavonoid

[a] *hanbeyogluayse@gmail.com* *https://orcid.org/0000-0002-9256-5046*

Introduction

Free radicals, such as reactive oxygen species (ROS) and reactive nitrogen species (RNS), have been shown to induce oxidative stress (OS) when present in high concentrations within living organisms [1]. The deleterious effects of these species can be mitigated by antioxidant compounds, which have been shown to delay or prevent the induction of oxidative stress [2]. Antioxidants have been shown to exert their activity by (i) preventing the formation and derivation of free radicals, (ii) interfering with the radical oxidation process, and (iii) creating inert free radical derivation reactions [3]. Natural antioxidants (vitamins A, C, and E, carotenoids, phenols, flavonoids, anthocyanins, etc.) are increasingly attracting attention as powerful antidotes to free radicals [4], [5].

Antioxidants, found in varying amounts in different plant species, have been reported to be quite effective in preventing oxidative stress-related aging, cardiovascular diseases, diabetes, and cancers [6]. For instance, plants of the *Consolida* genus are rich in phenolic acids, phytosterols, fatty acids, and other volatile components, and these components can be used as a potential medicinal resource for drug discovery [7]. It has been documented that *Silene compacta* species are rich in quinic acid, malic acid, protocatechuic acid, p-coumaric acid, and hesperidin, and have been shown to possess significant antibacterial properties [8]. It has been established that *Allium scorodoprasum* species contain dietary fibre, sugars, flavonoids, and essential oils, as well as certain volatile sulfur compounds. In addition to these properties, the plant material exhibits a range of biological activities, including antimicrobial, antioxidant, diuretic, antihypertensive, anti-obesity, hepatoprotective (liver-protective), and antitumor properties [9].

It has been documented that members of the *Fibigia* species have been observed to demonstrate significant enzyme inhibitory activity and antioxidant potential. Furthermore, analysis has revealed the presence of compounds such as caffeic acid-O-hexoside, caffeoyl alcohol O-glucopyranoside, and ferulic acid [10]. In recent years, interest in the study of antioxidant compounds derived from plant sources has increased due to the rise in demand for foods and nutritional supplements obtained entirely from natural sources [11]. The use of plant derivatives – such as flower, leaf, or root extracts – that are rich in antioxidant components has become pervasive in the food industry, where they are used as diverse food additives and functional food ingredients. Market research studies show that the market value of synthetic and natural antioxidants increases every year [12]. Therefore, evaluating the bioactive properties of plants is important.

For this purpose, this study evaluated the bioactive properties of *Allium scorodoprasum* L. subsp. *rotundum* (L.) Stearn, *Consolida Orientalis* (J. Gay) Schrödinger, *Fibigia clypeata* (L.) Medik, and *Silene compacta* Fischer plants that grow naturally in Sivas Province, Turkey. Due to the complex structure of phytochemicals, the evaluation of the bioactive properties of plants cannot be accurately performed using a single method [13]. Therefore, the total phenolic content, total flavonoid content, total antioxidant capacity, DPPH radical scavenging activity, and H_2O_2 radical scavenging activity of the methanol extract of the plants were evaluated. The data obtained from this study are expected to provide valuable and comprehensive scientific information, forming the basis for future, detailed research.

Material and Method

Preparation of Plant Material

The plants used in the study were collected in June 2022 from Sızır village, Sivas, Türkiye (39°18′21″N 35°56′48″E). Sivas Cumhuriyet University member Asst. Prof. Alper ZÖNGÜR made the taxonomic description of the collected samples. Following the harvesting of the plants, the aerial parts were subjected to a drying process at ambient temperature and in the absence of sunlight. The flowering parts of allium, consolida and silene plants were extracted, as were the aerial parts of the fibiga plant (stem, leaves, seeds and flowers). Thereafter, the plants were ground in a mill.

The extraction stage was conducted utilising the maceration technique with methanol. For this purpose, plant material samples (10 g) were mixed with 100 mL of solvent at room temperature for 24 hours. Subsequently, the extracts were filtered, and solvent was added to the residue once more, which was then subjected to maceration for a period of 24 hours. This process was repeated on three occasions. The collected extracts were then combined and dried in an oven at 40°C. The extraction yield was calculated by dividing the dry extracts obtained by the initial amount of plant material extracted. Accordingly, the extraction yields of A. scoropsadum, C. orientalis, F. clypeata, and S. compacta are 9.67%, 17.13%, 7.7%, and 11.48%, respectively. All extracts were stored at +4°C until analysis.

Absorbance measurements were performed using a Thermo Fisher Scientific Evolution 201 UV-Vis spectrophotometer at the Advanced Technology Research and Application Center Laboratory of Sivas Cumhuriyet University.

Determination of Antioxidant Potential of the Extracts

Determination of total phenolic content

The Total phenolic content was determined using the Folin-Ciocalteu method with modifications [14]. A solution of extract was prepared by dissolving 20 mg of plant extracts in 10 mL of methanol. A quantity of 0.2 mL of standard/extract solution and 0.3 mL of Folin-Ciocalteu reagent (10-fold diluted) were mixed and subsequently incubated at room temperature for a period of 10 minutes. Subsequently, 2 mL of Na_2CO_3 (7.5%) was added to the mixture. The mixture was then subjected to incubation in conditions of darkness and ambient temperature for a period of 60 minutes. Absorbance was measured at a wavelength of 650nm, employing a UV-Vis spectrophotometer. The total phenolic content was calculated based on gallic acid equivalents (GAE). A calibration curve was created using standard gallic acid solutions at concentrations ranging from 10 to 1000 μg/ml.

Determination of total flavonoid content

The total flavonoid content assay was carried out as described previously by Do et al with slight modifications [15]. A solution of extract was prepared by dissolving 20 mg of plant extracts in 10 mL of methanol. A volume of 1.5 millilitres of standard (at at varying concentrations)/extract solution and 1.5 millilitres of 2% $AlCl_3$ were mixed and incubated at room temperature for 15 minutes. Absorbance was measured at a wavelength of 435nm. The total flavonoid content was calculated based on quercetin equivalents (QUE). A calibration curve was created using standard quercetin solutions at concentrations ranging from 62.5 to 1000 μg/ml.

Total antioxidant capacity

The total antioxidant capacity was determined by means of the CUPRAC method [16]. The CUPRAC reagent was prepared by combining 5 mL of $CuCl_2$ ($1x10^{-2}$ M), 5 mL of neocuproine ($7.5x10^{-3}$ M), and 5 mL of ammonium acetate buffer (1 M, pH 7). A solution of extract was prepared by dissolving 20 mg of plant extracts in 10 mL of methanol. A volume of 0.7 mL of standard/plant extract solution at varying concentrations and 2.1 mL of CUPRAC reagent were mixed and incubated at room temperature for 30 minutes. Absorbance was measured at a wavelength of 450nm. The total antioxidant capacity was calculated on the basis of trolox equivalents (TRXE). A calibration curve was created using standard trolox solutions at concentrations ranging from 6.5 to 400 mg/ml.

Radical Scavenging Activity

DPPH radical scavenging activity

The DPPH free radical scavenging assay was carried out as described previously by Sethi et al. with slight modifications [17]. A quantity of 0.2 millilitres of gallic acid standard or extract was mixed with 1.8 millilitres of DPPH (0.1 mM) reagent. The standard GA and plant extract concentrations range from 0.05 to 2 mg/ml. The mixture was then left to incubate for a period of 30 minutes in conditions of darkness and at a temperature that was ambient temperature. The calculation of inhibition percentages, IC_{50} values, and relative potency (RP) values was performed on the basis of the absorbance values obtained at 517 nm. Gallic acid (GA) was utilised as a positive control.

H_2O_2 radical scavenging activity

The H_2O_2 radical scavenging activity was estimated by the Ruch Figure method [18]. A volume of 0.7 mL of standard/extract and 2.1 mL of a 40 mM H_2O_2 solution, prepared using a pH 7.4 phosphate buffer, were mixed. The standard and plant extract concentrations range from

0.008 to 0.13 mg/ml. The mixture was left to stand at room temperature for 10 minutes, after which the absorbance was measured at 230 nm. Butylated hydroxytoluene (BHT) was utilised as a positive control.

Statistical Analysis

All statistical analyses were performed using SPSS 23 software. The results were presented as mean ± standard deviation (SD), based on triplicate measurements (n = 3). The assessment of normality was conducted through the utilisation of the Shapiro–Wilk test, while the evaluation of homogeneity of variances was facilitated by Levene's test. In order to evaluate the differences among the four plant species in terms of Total Phenolic Content, Total Flavonoid Content, Total Antioxidant Capacity, and antioxidant activity parameters (DPPH and H_2O_2 radical scavenging assays), one-way ANOVA was applied.

Results and Discussion

Total Antioxidant Contents

It has been determined that certain phytonutrients – including phenolics, flavonoids, tannins and saponins – possess potent antioxidant activity and the capacity to scavenge free radicals [19]. The total phenolic and flavonoid compounds, as well as the total antioxidant capacities, of various plant extracts obtained from different parts of *A. scorodoprasum, C. orientalis, F. clypeata,* and *S. compacta* are presented in Table 1. The results indicated that the total phenolic content of the methanol extract of *S. compacta* (53.83 mg GAE/g sample) was statistically significantly higher than that of other plants, followed by the methanol extracts of *F. clypeata* (34.07 mg GAE/g sample) and *C. orientalis* (31.00 mg GAE/g). Concerning flavonoid content, the extract of S. compacta, among the plants examined, exhibited the highest flavonoid concentration (2.89 mg QUE/g sample). The lowest flavonoid concentration was measured in the extracts of *A. scorodoprasum* examined. The total antioxidant content of the extracts was examined using the CUPRAC method. The quantitative analysis results of total antioxidant levels showed that they were higher in *S. compacta* extracts, consistent with their total phenolic and flavonoid content. Additionally, the total contents of phenolic compounds, flavonoids and antioxidants have generally decreased in the following order: *S. compacta>F. clypeata>C. orientalis> A.scorodoprasum.* The results of the analysis of variance (ANOVA) indicated statistically significant differences among species for all measured parameters (TPC: $F = 55.00$, $p = 1.10\times10^{-5}$; TFC: $F = 727.32$, $p = 4.38\times10^{-10}$; TAC: $F = 590.76$, $p = 1.00\times10^{-9}$). Tukey's HSD test confirmed that *S. compacta* differ significantly from other species in terms of TAC parameters.

Table 1. Total phenolic contents, total flavonoid contents and total antioxidant capacity of plant extracts (p<0.001).

Total Phenolic Content (mg GAE/g sample)			
A.scorodoprasum	*C. orientalis*	*F. clypeata*	*S. compacta*
26.96±2.06	31.00±2.63	34.07±3.62	53.83±2.63
Total Flavonoid Content (mg QUE/g sample)			
A.scorodoprasum	*C. orientalis*	*F. clypeata*	*S. compacta*
0.28±0.0059	0.54±0.038	1.31±0.067	2.89±0.13
Total Antioxidant Capacity (CUPRAC. mg TRXE/g sample)			
A.scorodoprasum	*C. orientalis*	*F. clypeata*	*S. compacta*
16.42±0.56	31.12±1.02	25.2±0.26	41.93±0.95

A study examining the antioxidant potential of *C. orientalis* found that the methanol extract had a total phenolic content of 23.05 ± 1.57 mg GAE/g extract and a total flavonoid content of 29.83 ± 0.63 mg rutin/g extract [20]. The total phenolic and flavonoid content of the methanol extract of *S. compacta* was found to be 108.94 µg pyrocatechol/mg extract and 55.88 µg QUE/mg extract in the bull study [21]. Sarikurkcu demonstrated that the methanol extract of *S. compacta* exhibits high levels of both total phenolic content (30.88 mg GAE/g) and flavonoid content (50.19 mg rutin/g) [22]. Taşcı et al. determined the natural antioxidant content and capacity of *A. scorodoprasum* plants growing in seven different locations across three provinces of Turkey (Samsun, Nevşehir and Tokat). The total phenolic compound values in the onion and leaf parts of the samples were found to be 254.51-927.81 and 1929.05-19645.24 mg GAE/kg sample, respectively [23]. Mollica et al. investigated the antioxidant and phenolic composition of flower, stem, and bulb extracts of *A. scorodoprasum*, employing in vitro bioassays. The analysis revealed that the flower extract exhibited a high phenolic content (27.69 mg GAE/g extract), while the root extract demonstrated a substantial flavonoid content (14.95 mg rutin/g extract). The results have demonstrated that different parts of *A. scorodoprasum* possess divergent biological activities and can be utilised as medicinal food plants for specific therapeutic applications [24]. In a study examining the pharmacological properties of the methanolic extract of *Fibigia eriocarpa*, the total phenolic and flavonoid content of the plant was found to be 35.42 mg GAE/g extract and 24.31 mg rutin/g extract, respectively [25]. In a further analogous study, the total phenolic content of *Fibigia clypeata* was determined to be 33.42 mg GAE/g extract, while the total flavonoid content was ascertained to be 21.58 mg rutin/g extract [10]. The results of F. clypeata in our study are consistent with the existing literature and indicate that F. clypeata is rich in phenolic content. Unver and colleagues found a total of 8.04 g kg-1 of individual phenolic compounds in the water extract of F. clypeata, including 3.66 g kg-1 of fumaric acid and 1.73 g kg-1 of ferulic acid [26]. In a study examining the phytochemical composition of different *Consolida* species, the antioxidant properties were evaluated using the CUPRAC method, yielding results ranging from 29.47 to 78.36 mg TRXE/g extract [27]. In their study, Zengin et al. examined the phytochemical profile of various *Silene* species and determined their antioxidant activities using the CUPRAC method. The study revealed that the antioxidant activities ranged from 92 to 154 mg TRXE/g extract [8]. Dordevski et al. determined the antioxidant capacity of the ethanol extract of the plant *A. scrodoprasum* to be 55.35 mg TRXE/g using the CUPRAC method. Concurrently, the study identified rutin and kaempferol flavonoids, as well as kaempferol-3-O-glucoside, in the extracts under investigation. Furthermore, it was reported that flavonoids exhibited a greater dominant compared to phenolic acids [28]. In a study examining the methanol extract of *F. eriocarpa*, the total antioxidant activity was determined using the CUPRAC method and found to be 181.63 mg TRXE/g extract [25].

Free Radical Scavenging Activities

The free radical scavenging abilities of the examined plants were investigated using DPPH and H_2O_2 scavenging activity tests. Gallic acid was utilised as the positive control in DPPH scavenging activity, while BHT was employed as the positive control in H_2O_2 scavenging activity. The results were evaluated by calculating the IC_{50} and RP values of the extracts and positive controls. The IC_{50} value, representing the concentration of an antioxidant required to reduce the initial radical concentration by 50%, is a crucial metric for evaluating antioxidant capacity [29]. This is typically determined through a comparison with standard antioxidants, which serve as reference points for evaluating antioxidant activity. The RP value is indicative of the strength or weakness of the antioxidant effect of a given sample in comparison to a predetermined positive control. The higher the RP value, the lower the antioxidant effect, and the lower the RP value, the stronger the antioxidant effect. If RP is less than 0.1, the antioxidant is very strong; if RP is less than 1, it is strong; if RP is less than 10, it is moderately strong; if RP is less than 100, it is weak; if RP is more than 100, it is inactive [30].

The DPPH free radical's effectiveness is diminished by the incorporation of an electron into its structure from an antioxidant or a free radical ion [31]. Consequently, the DPPH radical can be quenched in any environment where an antioxidant is effective. In the DPPH test, *S. compacta* extracts (0.63±0.01 mg/mL) demonstrated superior scavenging activity in comparison to the other plants examined, with *C. orientalis* and *F. clypeata* exhibiting comparatively weaker activity. The lowest DPPH scavenging activity was observed in the *A. scorodoprasum* extract, with an IC_{50} value of 3.63±1.16 mg/mL. A thorough examination of the RP values revealed that the extracts of *S. compacta*, *C. orientalis*, and *F. clypeata* exhibited moderate antioxidant activity, while the extract of *A. scorodoprasum* exhibited weak antioxidant activity. It was observed that the extract of *S. compacta* at a concentration of 2 mg/mL exhibited a sweeping effect that was 87.60% more active than the positive control (Table 2.). The higher DPPH radical scavenging activity of *S. compacta* extract can be explained by the higher concentration of total phenolic, flavonoid, and antioxidant content found in these extracts compared to other plants studied.

The ANOVA results indicated statistically significant differences among species for all measured parameters (DPPH: $F = 784.92$, $p = 3.23\times10^{-10}$; H_2O_2: $F = 18.33$, $p = 0.000607$). Pearson correlation analysis was performed to determine the contribution of TPC, TFC, and TAC to antioxidant activity. A strong negative correlation was observed between the phenolic/flavonoid content and the DPPH IC50 (TPC: $r = –0.717$; TFC: $r = –0.718$). Even stronger correlations were found for H2O2 radical scavenging activity (TPC: $r = –0.921$; TFC: $r = –0.889$). TAC exhibited the highest correlation with both antioxidant parameters (DPPH: $r = –0.900$; H2O2: $r = –0.993$). The findings indicate that phenolic compounds, flavonoids, and overall antioxidant capacity contribute substantially to the observed antioxidant activities, with *S. compacta* being the most potent species in terms of statistical analysis.

Table 2. Radical scavenging activities of plant extracts ($p<0.001$).

DPPH Radical Scavenging Activity (%)		
	IC_{50} (mg/mL)	RP
A. scorodoprasum	3.63±1.16	23.86±1.68
C. orientalis	1.24±0.02	8.12±0.29
F. clypeata	1.40±0.01	9.21±0.26
S. compacta	0.63±0.01	4.12±0.15
GA	0.15±0.0044	
H_2O_2 Radical Scavenging Activity (%)		
	IC_{50} (mg/mL)	RP
A. scorodoprasum	0.198±0.038	2.87±0.082
C. orientalis	0.140±0.015	2.03±0.089
F. clypeata	0.152 ±0.015	2.20±0.087
S. compacta	0.086±0.0078	1.24±0.21
BHT	0.069±0.014	

A study was conducted to examine the antioxidant activity of *C. orientalis*. The results of this study indicated that the ethanol extract of *C. orientalis* exhibited low-moderate antioxidant activity (IC_{50} (µg/ml)=4.8), as determined by the DPPH radical scavenging activity [32]. This is a comparatively low concentration in relation to the results of the present study. In another study, the DPPH radical inhibition rates of the ethanol extract of *C. orientalis* were found to be consistent with our current study (8.97 ± 0.77%, 19.59 ± 1.79%, and 38.11 ± 1.02% for concentrations of 0.2, 0.5, and 1 mg/mL, respectively) [20]. In a study examining the DPPH free radical scavenging effect of the methanol extract of *S. compacta*, the IC_{50} value was found to be 56.78 µg/mL [21]. Sarikurkcu, on the other hand, stated that *S. compacta* exhibited superior antioxidant activity with a DPPH radical scavenging activity of 45.82 mg TRXE/g [22]. In another study, the DPPH free radical scavenging effect of the bulb and leaf parts of *A. scorodoprasum* plants collected from seven different locations was determined to be 0.99-9.02 and 36.61-241.06 µmol TRXE/g. It was stated that the leaves of the *A. scorodoprasum* plant are rich in antioxidants [23]. Zengin et al. determined the DPPH radical scavenging activity of the methanol extract of *F. Eriocarpa* to be 69.30 mg TRXE/g extract [25].

As illustrated in Table 2, the plant extracts exhibiting inhibition percentages are characterised by lower H_2O_2 scavenging activity. At the highest concentration of 0.13 mg/mL, the activity of *S. compacta* was the only parameter to exceed 50%. Concurrently, *S. compacta* exhibited the most pronounced scavenging activity, with an IC_{50} value of 0.086±0.0078 mg/mL. According to the RP values, all plant extracts exhibited moderate efficacy in terms of H_2O_2 scavenging activity. Han et al. reported that the H_2O_2 scavenging activity of an *A. monanthum* extract was 65.29 ± 0.68% [33]. In a study examining different parts of the Allium ursinum plant (leaves, fresh roots, fresh flowers, and fresh bulbs), it was observed that fresh roots possess a strong H_2O_2 scavenging capacity (9.55±0.32%) [34].

In conclusion, there are statistically significant differences at a very high level ($p < 0.001$) among plants in all parameters. TPC, TFC, and TAC are the main determinants of antioxidant activity. The negative correlations between antioxidant activity and TPC/TFC/TAC indicate that these components significantly increase the activity. In the DPPH and H_2O_2 tests, S. compacta is the most potent antioxidant species with the lowest IC_{50} values. Among the plants examined in this study, *S. compacta* have the highest phytochemical content and, accordingly, exhibits high antioxidant activity and radical scavenging activity. S. compacta is statistically significantly higher than other species in all parameters. This phenomenon can be attributed to the fact that the antioxidant and free radical scavenging capabilities of plants are largely derived from phytochemical compounds. A recent study has demonstrated that S. compacta methanol extract is characterized by a high concentration of flavonoids, flavonoid glycosides, phenolic acids, phenolic aldehydes, and coumarins. In the present study, the high antioxidant activity of S. compacta extracts can be attributed to the components of its structure [21]. The phytochemical contents and antioxidant activities identified in this study and in previous studies may vary considerably. The rationale behind this phenomenon is attributable to the substantial variation in the phytochemical composition of plants and, consequently, their antioxidant activity, which is contingent on the specific plant parts and their geographical location [23]. The antioxidant capacity of plants is influenced by a number of factors, including the region in which they are cultivated, as well as their age and growth stage [35]. In this case, the discrepancies observed between previous studies and the present one may be attributable to the fact that plant materials are cultivated in disparate locations and under varying conditions. At the same time, these phenomena can also be affected to varying degrees by other variables such as different pre-processing and extraction methodologies, harvest time, plant age, and growth stage [30].

Conclusions

The findings of this study demonstrated that the methanol extracts of *A. scorodoprasum, C. orientalis, F. clypeata,* and *S. compacta* exhibited significant biological activities. The extracts were found to possess noteworthy antioxidant capacities and are considered to warrant further investigation for their cosmetic potential. The results indicate that S. compacta is a valuable natural source of bioactive compounds due to its high antioxidant and radical scavenging activities. Future studies will focus on isolating and characterizing pure compounds from the most active extracts. The plant is therefore a promising candidate for use in the development of new phytopharmaceuticals. However, further studies are required to elucidate the mechanisms of enzyme inhibition, anti-cancer properties, and toxicity of the plants mentioned in the study, thereby supporting existing research.

Conflicts of interest

There are no conflicts of interest in this work.

Acknowledgment

This work received financial support from the Sivas Cumhuriyet University of Scientific Research Project (GMYO-2022-003).

References

[1] Mateș L., Banc R., Zaharie F.A., Rusu M.E., Popa D.S., Mechanistic Insights into the Biological Effects and Antioxidant Activity of Walnut (Juglans regia L.) Ellagitannins: A Systematic Review, *Antioxidants*, 13 (2024) 974.

[2] Guo Q., Li F., Duan Y., Wen C., Wang W., Zhang L., Huang R., Yin Y., Oxidative stress, nutritional antioxidants and beyond, *Science China Life Sciences*, 63 (2020) 866–874.

[3] Mirończuk-Chodakowska I., Witkowska A.M., Zujko M.E., Endogenous non-enzymatic antioxidants in the human body, *Advances in Medical Sciences*, 63 (2018) 68–78.

[4] Effiong M.E., Umeokwochi C.P., Afolabi I.S., Chinedu S.N., Comparative antioxidant activity and phytochemical content of five extracts of Pleurotus ostreatus (oyster mushroom), *Scientific Reports*, 14 (2024) 3794.

[5] Enoma D.O., Larbie C.E., Dzogbefia V.P., Obafemi Y.D., Evaluation of the antioxidant activities of some wild edible indigenous Ghanaian mushrooms, *IOP Conference Series: Earth and Environmental Science*, 210 (2018) 012010.

[6] Kim Y., Kim Y.J., Shin Y., Comparative Analysis of Polyphenol Content and Antioxidant Activity of Different Parts of Five Onion Cultivars Harvested in Korea, *Antioxidants*, 13 (2024) 197.

[7] Yin T., Cai L., Ding Z., A systematic review on the chemical constituents of the genus Consolida (Ranunculaceae) and their biological activities, *RSC Advances*, 10 (2020) 35072–35089.

[8] Zengin G., Mahomoodally M.F., Aktumsek A., Ceylan R., Uysal S., Mocan A., et al., Functional constituents of six wild edible Silene species: A focus on their phytochemical profiles and bioactive properties, *Food Bioscience*, 23 (2018) 75–82.

[9] Demir T., Akpınar Ö., Kara H., Güngör H., Phenolic profile and investigation of biological activities of Allium scorodoprasum L. subsp. rotundum, *Food Bioscience*, 46 (2022) 101548.

[10] Zengin G., Mahomoodally M.F., Rocchetti G., Lucini L., Sieniawska E., et al., Chemical Characterization and Bioactive Properties of Different Extracts from Fibigia clypeata, an Unexplored Plant Food, *Foods*, 9 (2020) 705.

[11] Ma Y.L., Sun P., Feng J., Yuan J., Wang Y., Shang Y.F., et al., Solvent effect on phenolics and antioxidant activity of Huangshan Gongju (Dendranthema morifolium (Ramat) Tzvel. cv. Gongju) extract, *Food and Chemical Toxicology*, 147 (2021) 111875.

[12] Kotha R.R., Tareq F.S., Yildiz E., Luthria D.L., Oxidative Stress and Antioxidants—A Critical Review on In Vitro Antioxidant Assays, *Antioxidants*, 11 (2022) 2388.

[13] Du G., Li M., Ma F., Liang D., Antioxidant capacity and the relationship with polyphenol and Vitamin C in Actinidia fruits, *Food Chemistry*, 113 (2009) 557–562.

[14] Hu Y., Pan Z.J., Liao W., Li J., Gruget P., Kitts D.D., Lu X., Determination of antioxidant capacity and phenolic content of chocolate by attenuated total reflectance-Fourier transformed-infrared spectroscopy, *Food Chemistry*, 202 (2016) 254-261.

[15] Do Q.D., Angkawijaya A.E., Tran-Nguyen P.L., Huynh L.H., Soetaredjo F.E., Ismadji S., Ju Y.-H., Effect of extraction solvent on total phenol content, total flavonoid content, and antioxidant activity of Limnophila aromatica, *Journal of Food and Drug Analysis*, 22(3) (2014) 296-302.

[16] Apak R., Güçlü K., Demirata B., Özyürek M., Çelik S.E., et al., Comparative Evaluation of Various Total Antioxidant Capacity Assays Applied to Phenolic Compounds with the CUPRAC Assay, *Molecules*, 12(7) (2007) 1496-1547.

[17] Sethi S., Joshi A., Arora B., et al., Significance of FRAP, DPPH, and CUPRAC assays for antioxidant activity determination in apple fruit extracts, *European Food Research and Technology*, 246 (2020) 591–598.

[18] Ruch R.J., Cheng S.-j., Klaunig J.E., Prevention of cytotoxicity and inhibition of intercellular communication by antioxidant catechins isolated from Chinese green tea, *Carcinogenesis*, 10(6) (1989) 1003–1008.

[19] Zengin G., Aktumsek A., Investigation of antioxidant potentials of solvent extracts from different anatomical parts of Asphodeline anatolica E. Tuzlaci: An endemic plant to Turkey, *African Journal of Traditional, Complementary and Alternative Medicines*, 11 (2014) 481.

[20] Zengin G., Mahomoodally M.F., Picot-Allain C.M.N., Cakmak Y.S., Uysal S., Aktumsek A., In vitro tyrosinase inhibitory and antioxidant potential of Consolida orientalis, Onosma isauricum and Spartium junceum from Turkey, *South African Journal of Botany*, 120 (2019) 119–123.

[21] Boğa M., Chemical Constituents, Cytotoxic, Antioxidant and Cholinesterases Inhibitory Activities of Silene compacta (Fischer) Extracts, *Marmara Pharmaceutical Journal*, 21 (2017) 445.

[22] Sarıkürkcü C., Unlocking the therapeutic potential of Silene compacta: A comparative study of antioxidant and enzyme inhibitory activities across solvent extracts, *Selçuk Üniversitesi Fen Fakültesi Fen Dergisi*, 51 (2025) 7–17.

[23] Taşcı B., Kütük H., Koca İ., Antioxidant Activity of Allium scorodoprasum L. subsp. rotundum (L.) STEARN Plant Grown in Turkey, *Turkish Journal of Agriculture - Food Science and Technology*, 7 (2019) 1561–1567.

[24] Mollica A., Zengin G., Locatelli M., Picot-Allain C.M.N., Mahomoodally M.F., Multidirectional investigations on different parts of Allium scorodoprasum L. subsp. rotundum (L.) Stearn: Phenolic components, in vitro biological, and in silico propensities, *Food Research International*, 108 (2018) 641–649.

[25] Zengin G., Lobine D., Mollica A., Locatelli M., Carradori S., Mahomoodally M.F., Multiple pharmacological approaches on Fibigia eriocarpa extracts by in vitro and computational assays, *Fundamental & Clinical Pharmacology*, 32 (2018) 400–413.

[26] Unver T., Uzuner U., Akcora-Yildiz D., Gurhan I., Arkan C., Ozdemir Z., Multidirectional in silico and in vitro research for the pharmaceutical potential of Fibigia clypeata (L.) Medik: Phytochemical, Antimicrobial, and Antimyeloma Properties, *ChemistryOpen*, (2025) 1-13.

[27] Rocchetti G., Zengin G., Cakmak Y.S., Mahomoodally M.F., Kaya M.F., et al., A UHPLC-QTOF-MS screening provides new insights into the phytochemical composition and biological properties of six Consolida species from Turkey, *Industrial Crops and Products*, 158 (2020) 112966.

[28] Đorđevski N., Uba A.I., Zengin G., Božunović J., Gašić U., Ristanović E., et al., Chemical and Biological Investigations of Allium scorodoprasum L. Flower Extracts, *Pharmaceuticals*, 16 (2022) 21.

[29] Martinez-Morales F., Alonso-Castro A.J., Zapata-Morales J.R., Carranza-Álvarez C., Aragon-Martinez O.H., Use of standardized units for a correct interpretation of IC50 values obtained from the inhibition of the DPPH radical by natural antioxidants, *Chemical Papers*, 74 (2020) 3325–3334.

[30] Ancuceanu R., Anghel A.I., Hovaneț M.V., Ciobanu A.M., Lascu B.E., Dinu M., Antioxidant Activity of Essential Oils from Pinaceae Species, *Antioxidants*, 13 (2024) 286.

[31] Wang L., Wang Z., Li X., Preliminary phytochemical and biological activities study of solvent extracts from a cold-field fruit—Malus baccata (Linn.) Borkh, *Industrial Crops and Products*, 47 (2013) 20–28.

[32] Sönmez Gürer E., Karadağ A.E., Baydar R., Demirel M., Investigation of the chemical composition, antioxidant and anticholinesterase activities of Consolida orientalis, *Journal of Health Sciences and Medicine*, 7 (2024) 691–695.

[33] Han H.S., Jung J.S., Jeong Y.-I., Choi K.C., Biological Synthesis of Copper Nanoparticles Using Edible Plant Allium monanthum: Characterization of Antibacterial, Antioxidant, and Anti-Inflammatory Properties Using In Silico Molecular Docking Analysis, *Materials*, 16(20) (2023) 6669.

[34] Lupoae M., Bounegru A.V., Dinica R.M., Cârâc G., Exploring In Vitro Antioxidant Activity of Allium ursinum and Alliaria petiolata Through Various Analytical Methods, *Revue Roumaine de Chimie*, 70(3–4) (2025) 223–233.

[35] Djerrad Z., Djouahri A., Kadik L., Variability of Pinus halepensis Mill. Essential Oils and Their Antioxidant Activities Depending on the Stage of Growth During Vegetative Cycle, *Chemistry & Biodiversity*, 14 (2017).