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Antioxidant Activity, Phenolic Composition, and Hormone Content of Wild Edible Vegetables

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Abstract: Wild edible plants have been used since antiquity as folk medicine and as preservatives in foods. This study aimed to determine the antioxidant activities, phenolic compounds, and hormone contents of 12 species of edible wild plants belonging to 9 families, which are consumed as vegetables by the local people at Ergan Mountain in Erzincan in Turkey. *Polygonum cognatum* and *Malva neglecta* were determined to have more antioxidant enzyme activity, more phenolic compounds, and higher hormone content than the other species. The highest catalase (CAT), peroxidase (POD), glutathione reductase (GR), glutathione-s-transferase (GST) values for *P. cognatum* were determined as 45.12, 94.83, 36.76, and 1218.35 EU g^{-1}, respectively. The highest superoxide dismutase (SOD) and ascorbate peroxidase (AxPOD) content for *M. neglecta* were determined as 97.53 EU g^{-1} and 81.93 EU g^{-1}, respectively. *P. cognatum* is the species in which the highest levels of the hormones indolacetic acid (IAA), gibberellic acid (GA), salicylic acid (SA), cytokinin, zeatin and jasmonic acid were detected. The highest levels of caftaric acid (CA), catechin (CAE), ferulic acid (FA), malvidin-3-o-glucoside (MG), myricetin (MYR), rutin (RT), trans-coumaric acid (TPCA), tyrosol (TY), and vanilic acid (VA) compounds were found in *M. neglecta*. It was determined that *Falcaria vulgaris* species had the highest levels of ferulic acid (FA) and quercetin (QUE) phenolics. The results show that edible wild vegetables consumed and studied by the people of the region are an important source of natural antioxidants. The possibilities of using these wild plants as functional foods should be investigated.

Keywords: antioxidant enzyme; erzincan; hormone; phenolic compound; wild edible

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1. Introduction

Wild food resources are gaining more importance all over the world, comprising herbal plants and wild edible horticultural plants such as vegetables, mushrooms, fruits etc. Such plants are well known and have been used for centuries for food and medicinal

purposes in different countries. They are mainly consumed by indigenous or local peoples during their harvest season [1–3].

Turkey, located between Asia and Europe, is considered one of the richest countries for plant biodiversity, including wild edible fruits and vegetables. There are more than 9000 plant species in the flora of Turkey, and some of the edible ones are used for their aromatic and medicinal characteristics [4]. The country has diverse agro-ecological zones and rich forests resources that favor the growth of a wide range of wild edible plants. Different agro-ecological zones have diverse species, which have mainly been used for food and medicine. These natural resources also supply income for rural communities in particular, and they are considered to contribute to future food security and poverty alleviation [5,6].

Wild edible plants, which grow in natural environments, are the cheapest sources of energy in human nutrition, as well as being the sources that meet their daily nutritional needs by rural people in many parts of the world [7]. The healthy nutritional properties of wild edible plants are generally higher than that of cultivated plants [8]. Since these plants tend to be resistant to extreme environmental conditions such as drought, they can be an important food source even in drought periods in future climate change scenarios [9]. Therefore, to combat future food shortage, domestication and intensification of wild food resources (including currently underutilized plants) may become necessary.

In recent years, there has been an increasing interest in wild edible plants by researchers all over the world [10] because they are rich sources of essential nutrients (protein, essential fatty acids, minerals, vitamins, etc.) and bioactive compounds (e.g., antioxidants, phenolic compounds, and secondary metabolites). The natural antioxidant and anthocyanin compounds found in these plants have protective effects against many diseases (such as cancer, diabetes, and cardiovascular diseases) [11–14]. Their antioxidant effects are generally due to the formation of phenolic compounds such as phenolic acids, diterpenes, and tannins. Such dietary bioactive compounds provide biochemical and molecular response mechanisms to reduce free radicals resulting from oxidative stress. Therefore, a continuous supply of polyphenols is essential to provide preventive and defense mechanisms to reduce the risk of chronic disease in humans [15].

The capacity of natural antioxidants to protect from cellular damage caused by oxidative stress has been extensively studied in recent years [16]. Cells often have a complex antioxidant system that includes non-enzymatic antioxidants (such as POD, SOD, CAT, AxPOD, vitamin E, and C) [17].

It is extremely important to identify and quantify antioxidant and phenolic components in plants, which have a significant impact on quality of life and are responsible for controlling diseases. In addition, such information may have importance because it could provide data for researchers involved in genetic resources and biodiversity conservation programs of wild edible plants.

Local peoples living around Ergan Mountain in north-eastern Turkey are familiar with wild plants and use them for food and medicine. However, previous studies on these plants mainly concentrated on the taxonomy of flora [18,19]. Information on potential uses of these flora in the food industry have not been studied.

We aimed to provide sufficient data on antioxidant enzyme activity, phenolic substance, and hormone content of 12 wild edible vegetable species which are most abundant in the Ergan Mountain area and are the most preferred and consumed species of the people of Erzincan province. Determining the content of these plants will be helpful when using these plants for the pharmaceutical, food, and cosmetics industry in future as well.

2. Materials and Methods

2.1. Plant Material

In this study, 12 widely used plant species belonging to 9 different plant families (Amaranthaceae, Apiaceae, Asteraceae, Brassicaceae, Caryophyllaceae, Lamiaceae, Malvaceae, Polygonaceae, and Urticaceae) were collected from Ergan Mountain, Erzincan

province (39°63′13″ N; 39°49′97″ E) in March and May 2021 according to their period of local consumption. Species and family identifications of plants were made in Erzincan Binali Yıldırım University, Department of Botany. Identification of the collected plants was performed according to Davis et al. [20]. General information about the plants is presented in Table 1. The antioxidant enzyme, hormone, and phenolic compound analyses of fresh plant samples were made at Yeditepe University. The edible parts of plants (Table 1) were sampled and analyzed. For example, for *Chenopodium album*, the leaf, fresh stem, and petiole was used. For *Brassica nigra*, only the leaf used.

Table 1. General information on the wild edible plant species investigated in the study.

Family	Species	Local Name	Edible Part
Amaranthaceae	*Chenopodium album* L. subsp. *album* var. *album*	Tel pancarı, Tel otu	Leaf, fresh stem, petiole
Apiaceae	*Falcaria vulgaris* Bernh.	Kazayağı	Leaf, fresh stem
Asteraceae	*Cirsium arvense* (L.) Scop. subsp. *vestitum* (Wimmer and Grab.)	Keğaver	Leaf, fresh stem
	Taraxacum phaleratum G. Hagl. ex Rech.	Karahindiba	Leaf
	Tragopogon buphthalmoides (DC.) Boiss. var. *buphthalmoides*	Yemlik	Leaf
Brassicaceae	*Brassica nigra* (L.) K. Koch	Eşek turpu, Turp otu	Leaf
Caryophyllaceae	*Silene vulgaris* (Moench) Garcke var. *commutata* (Guss.) Coode and Cullen	Gelin parmağı	Leaf
Lamiaceae	*Mentha longifolia* (L.) Hudson subsp. *typhoides* (Briq.) Harley var. *typhoides*	Yarpuz	Leaf, fresh stem
Malvaceae	*Malva neglecta* Wallr.	Ebegümeci	Leaf, petiole
Polygonaceae	*Polygonum cognatum* Meissn.	Madımak	Leaf
	Rumex crispus L.	Evelik	Leaf, fresh stem, petiole
Urticaceae	*Urtica dioica* L.	Isırgan	Leaf, fresh stem, petiole

2.2. Preparation of Plant Samples for Analysis

The edible parts of the plants were separated after collection and washed by distilled water. The edible parts of the plant samples were frozen after weighing. Frozen herbal samples were homogenized by a grinder for extraction.

2.3. Antioxidant Enzyme Analysis

For superoxide dismutase (SOD), peroxidase (POD), catalase (CAT), and ascorbate peroxidase (APX) enzyme analysis, around 500 mg (dry weight base) samples were used for homogenization by adding 3 mL of 50 mM phosphate buffer (pH = 7) solution. Filtered homogenates were centrifuged at 15,000× *g* for 15 min at 4 °C and supernatant was kept at −80 °C. Frozen cell samples powdered in liquid N and extracted with ice-cold 0.1 mM phosphate buffer, pH 7.8, containing 1 mM ethylenediaminetetraacetic acid (EDTA), 1 mM phenylmethanesulfonyl fluoride (PMSF), and 0.5% polyvinylpyrrolidone (PVP). SOD, POD, CAT, and APX activities were determined by spectrophotometry. The absorbance was recorded at 560 nm, and one unit of enzyme reduced the absorbance reading to 50% in comparison with tubes without enzymes [21].

2.4. Hormone Analysis

Gibberellic acid (GA), salicylic acid (SA), indole acetic acid (IAA), and abscisic acid (ABA) extraction and purification were performed by Kuraishi et al. [22] and expressed as ng g^{-1} Dry weight (DW). To obtain supernatants, firstly, 80% methanol at −40 °C was added to 1 g fresh samples and later homogenized for 10 min, and then obtained

supernatants were filtered, dried at 35 °C, and then dissolved in 0.1 M monopotassium phosphate (KH_2PO_4) (pH = 8.0) solution. A Sep-Pak C-18 (Waters) cartridge was used for separation. The hormone was analyzed by HPLC (Agilent Technologies, Santa Clara, CA, USA) with an absorbance of 265 nm in a UV detector [23].

2.5. Total Phenolic Content

For determining total phenolic content, the Folin–Ciocalteu method was used [24]. In brief, 1 mL of extract (100–500 µg/mL) solution was mixed with 2.5 mL of 10% (*w*/*v*) Folin–Ciocalteu reagent. After 5 min, 2.0 mL of Na_2CO_3 (75%) was subsequently added to the mixture and incubated at 50 °C for 10 min. Then, the sample was cooled and the absorbance was measured with a spectrophotometer (Shimadzu UV-1280, Kyoto, Japan) at 765 nm; results are expressed as fresh weight (FW).

2.6. Phenolic Profiles

A HPLC system (Agilent Technologies, Santa Clara, CA, USA) was used to determine the plants' phenolic profiles. A symmetry C18 column was used to separate phenolic compounds. The gradient program was as follows: 0 min, 90% A; 30, min 80% A; 60, min 65% A. The flow rate was 1.0 mL/min [25].

2.7. Statistical Analysis

Statistical analysis of the obtained data was made by variance analysis using the SPSS 22.0 program. Statistical significance of differences between results was determined by Duncan's multiple range tests.

3. Results

3.1. Antioxidant Enzyme and Hormone Contents

Antioxidant enzyme activities of wild plant species from different plant families were examined, and it was determined that the differences between species were statistically significant (Table 2). In terms of CAT enzyme value, the highest activity was determined in *P. cognatum* (45.12 EU g plant^{-1}), while the lowest activity was detected in *T. buphthalmoides* (25.16 EU g plant^{-1}). The highest quantity of POD enzyme activity was determined in *P. cognatum* (94.83 EU g plant^{-1}), while the lowest quantity was determined in *T. buphthalmoides* (54.51 EU g leaf^{-1}). In the examination of SOD enzyme activity, *M. neglecta* had the highest amount (97.53 EU g plant^{-1}), while *T. buphthalmoides* had the lowest value (29.15 EU g plant^{-1}). Ascorbate peroxidase (AxPOD) enzyme was determined to have the highest activity in *M. neglecta* (81.93 EU g plant^{-1}) and the lowest in *C. album* (39.71 EU g plant^{-1}) species. The highest GR was determined in *P. cognatum* (36.76 EU g plant^{-1}), while the lowest quantity was obtained in *T. buphthalmoides* (20.04 EU g plant^{-1}). When examining the amount of GST activity in species, the highest and the lowest GST contents were measured in *P. cognatum* (1218.35 EU g plant^{-1}) and in *T. buphthalmoides* (474.21 EU g plant^{-1}), respectively.

Table 2. Antioxidant enzyme contents of wild edible plant species.

Plant Species	CAT	POD	SOD	AxPOD	GR	GST
	(EU g^{-1} Plant)					
Brassica nigra	35.72 cd	74.97 bcd	68.16 bc	60.49 cde	27.76 cd	801.28 d
Chenopodium album	25.52 g	61.15 ef	65.73 bcd	39.71 g	22.44 ef	634.47 f
Cirsium arvense	28.54 fg	59.89 ef	38.86 de	48.75 efg	23.64 def	667.72 f
Falcaria vulgaris	36.03 cd	65.28 de	46.66 cde	64.76 bcd	26.46 cde	916.64 c
Malva neglecta	44.52 a	93.41 a	97.53 a	81.93 a	34.60 ab	1163.51 a
Mentha longifolia	29.87 f	72.14 cd	56.98 cde	42.91 fg	26.01 de	698.64 ef
Polygonum cognatum	45.12 a	94.83 a	67.00 bcd	69.12 bc	36.76 a	1218.35 a
Rumex crispus	33.87 de	81.15 bc	69.81 bc	51.43 efg	30.43 bc	930.15 bc

Table 2. *Cont.*

Plant Species	CAT	POD	SOD	AxPOD	GR	GST
	(EU g^{-1} Plant)					
Silene vulgaris	31.44 ef	65.45 de	58.96 bcd	54.21 def	24.68 de	782.64 de
Taraxacum phaleratum	38.69 bc	93.44 a	85.79 ab	58.26 cde	33.69 ab	1017.30 b
Tragopogon buphthalmoides	25.16 g	54.51 f	29.15 e	42.54 fg	20.04 f	474.21 g
Urtica dioica	39.79 b	82.83 b	46.14 cde	75.38 ab	33.29 ab	1162.06 a

CAT—catalase; POD—peroxidase; SOD—superoxide dismutase; AxPOD—ascorbate peroxidase; GR—glutathione reductase; GST—glutathione-s-transferase. Values with the same letters in the same column are not significant at the $p \leq 0.01$ level according to Duncan multiple comparison test; means with different letters have statistically significant differences.

The hormone contents of wild plant species from different plant families were examined and it was determined that the differences between species were statistically significant (Table 3). The highest quantity of IAA was determined in *P. cognatum* (2.13 ng mg^{-1} tissue), while the lowest quantity was obtained in *M. longifolia* (0.29 ng g^{-1} DW). The highest quantity of salicylic acid (1.57 ng g^{-1} DW) was obtained in *P. cognatum*, while the lowest amount (0.44 ng g^{-1} DW) was obtained in *M. longifolia*. Abscisic acid (ABA) quantity differed between the plant species; the highest quantity of ABA was measured in *M. longifolia* (16,849.94 ng μL^{-1}), with the lowest in *P. cognatum* (1087.50 ng μL^{-1}).

Table 3. Hormone contents of wild edible plant species.

Plant Species	IAA ng mg^{-1} Tissue	ABA	GA	SA	Cytokinin	Zeatin	Jasmonic Acid
	(ng g^{-1} DW)						
Brassica nigra	0.30 i	15,318.74 b	1.36 k	0.48 gh	1.01 f	0.48 d	4.99 gh
Chenopodium album	0.44 h	13,787.54 c	1.56 j	0.52 g	1.07 f	0.59 bc	6.08 g
Cirsium arvense	1.77 c	4267.93 i	2.86 d	1.26 c	2.32 c	0.63 ab	10.94 d
Falcaria vulgaris	1.87 b	1511.22 kl	3.51 b	1.48 b	2.51 b	0.62 abc	15.15 b
Malva neglecta	1.16 f	9090.07 f	2.11 g	0.94 e	1.51 e	0.63 ab	10.34 de
Mentha longifolia	0.29 i	16,849.94 a	1.26 k	0.44 h	0.87 g	0.44 d	4.31 h
Polygonum cognatum	2.13 a	1087.50 m	3.55 a	1.57 a	2.60 a	0.68 a	16.49 a
Rumex crispus	1.31 e	7031.69 g	2.41 f	1.17 d	2.10 d	0.55 c	9.54 e
Silene vulgaris	0.48 h	12,256.35 d	1.91 i	0.81 f	1.49 e	0.62 abc	7.65 f
Taraxacum phaleratum	0.71 g	10,829.04 e	2.01 gh	0.82 f	1.50 e	0.64 ab	8.00 f
Tragopogon buphthalmoides	1.30 e	2359.67 j	3.25 c	1.42 b	2.48 b	0.59 bc	12.58 c
Urtica dioica	1.51 d	5435.45 h	2.66 e	1.23 cd	2.12 d	0.57 bc	10.32 de

IAA—indole acetic acid; ABA—abscisic acid; GA—gibberellic acid; SA—salicylic acid. Values with the same letters in the same column are not significant at the $p \leq 0.01$ level according to Duncan multiple comparison test; means with different letters have statistically significant differences.

The quantity of gibberellic acid (GA) varied between 1.26 and 3.55 ng g^{-1} DW between the species. The highest quantity of GA was found in *P. cognatum* (3.55 ng g^{-1} DW), while the lowest quantity was in *M. longifolia* (1.26 ng g^{-1} DW). The highest contents of cytokinin, zeatin, and jasmonic acid were found in *P. cognatum* (2.60, 0.68, and 16.49 ng g^{-1} DW, respectively), while the lowest contents of cytokinin, zeatin, and jasmonic acid were in *M. longifolia* (0.87, 0.44, and 4.31 ng g^{-1} DW, respectively) (Table 3).

3.2. Phenolic Content

The phenolic content of wild plant species from different plant families were examined and it was determined that the differences between species were statistically significant (Table 4). The highest (55.14 mg g^{-1} FW) and lowest values (27.37 mg g^{-1} FW) in terms of CA content were determined in *M. neglecta* and *C. album*, respectively. According to the results obtained, the highest CAE content was found in *M. neglecta* (85.00 mg g^{-1} FW), with the lowest content in *T. buphthalmoides* (22.67 mg g^{-1} FW). *M. neglecta* (42.26 mg g^{-1} FW)

had the highest ECAE content, while *T. buphthalmoides* (19.72 mg g^{-1} FW) had the lowest. The highest and lowest FA was measured in *F. vulgaris* (17.89 mg g^{-1} FW) and *T. phaleratum* (11.11 mg g^{-1} FW), respectively. *M. neglecta* had the highest M3G content (84.77 mg g^{-1} FW), while *T. buphthalmoides* had the lowest (41.39 mg g^{-1} FW). The highest MYR content (17.55 mg g^{-1} FW) was determined in *M. neglecta*, while the lowest value was found in *C. album* (7.8 mg g^{-1} FW) (Table 4).

Table 4. Phenolic content of wild edible plant species.

Plant Species	CA	CAE	ECAE	FA	M3G	MYR	RT	TCA	TPCA	TY	QUE	VA
	(mg g^{-1} FW)											
Brassica nigra	44.25 d	59.40 b	29.59 d	16.36 b	64.48 cd	15.31 abc	26.24 cd	25.54 cd	21.15 de	53.80 b	13.98 cd	32.54 de
Chenopodium album	27.37 h	34.41 cde	22.08 fg	12.27 d	42.69 g	7.80 h	17.17 h	17.66 f	15.43 h	32.50 e	11.10 e	21.91 i
Cirsium arvense	35.35 f	26.28 ef	23.00 f	16.83 ab	49.71 f	11.25 efg	20.97 fg	24.24 de	18.27 f	46.46 c	15.64 a	28.10 g
Falcaria vulgaris	45.08 cd	29.13 ef	30.13 d	17.89 a	62.51 d	14.34 bcd	25.28 cde	32.40 b	21.11 de	54.16 b	15.93 a	35.30 c
Malva neglecta	55.14 a	85.00 a	42.26 a	13.96 c	84.77 a	17.55 a	32.71 a	35.83 a	29.11 a	74.05 a	13.25 d	44.79 a
Mentha longifolia	31.72 g	38.39 cd	24.24 ef	12.53 d	50.36 f	9.04 gh	19.89 gh	19.69 f	17.10 g	36.00 e	10.84 e	24.84 h
Polygonum cognatum	47.92 bc	30.09 def	39.99 ab	12.25 d	77.74 b	12.56 cdef	28.42 bc	39.00 a	25.99 b	55.19 b	11.35 e	40.08 b
Rumex crispus	36.32 f	34.66 cde	30.18 d	11.14 e	59.76 de	9.52 fgh	22.78 efg	26.91 cd	21.45 d	45.16 c	10.63 e	30.44 f
Silene vulgaris	39.33 e	51.39 b	26.04 e	16.50 b	56.30 e	13.60 bcde	23.33 def	24.08 de	20.06 e	51.04 b	15.04 ab	30.87 ef
Taraxacum phaleratum	41.08 e	53.59 b	34.80 c	11.11 e	68.81 c	11.70 defg	25.77 cde	28.34 c	24.15 c	50.86 b	10.53 e	34.28 cd
Tragopogon buphthalmoides	29.96 gh	22.67 f	19.72 g	16.19 b	41.39 g	9.53 fgh	17.77 h	21.02 ef	15.94 h	40.54 d	15.48 a	24.52 h
Urtica dioica	49.78 b	40.22 c	38.19 b	14.30 c	75.17 b	15.84 ab	29.52 b	38.44 a	28.24 a	71.83 a	14.59 bc	43.45 a

CA—caftaric acid; CAE—catechin; ECAE—epicatechin; FA—ferulic acid; M3G—malvidin-3-O-glucoside; MYR—myricetin. Values with the same letters in the same column are not significant at the $p \leq 0.01$ level according to Duncan multiple comparison test; means with different letters have statistically significant differences. RT—rutin; TCA—trans-caffeic acid; TPCA—trans-coumaric acid; TY—tyrosol; QUE—quercetin; VA—vanilic acid. Values with the same letters in the same column are not significant at the $p \leq 0.01$ level according to Duncan multiple comparison test; means with different letters have statistically significant differences.

The highest RT content was obtained in *M. neglecta* (32.71mg g^{-1} FW), while the lowest was found in *C. album* and *T. buphthalmoides* (17.17 and 17.77 mg g^{-1} FW, respectively). *P. cognatum* (39.00 mg g^{-1} FW) had the highest TCA content, while *C. album* (17.66 mg g^{-1} FW) had the lowest. The highest and lowest TPCA contents were measured in *M. neglecta* (29.11 mg g^{-1} FW) the *C. album* (15.43 mg g^{-1} FW), respectively. The highest and lowest TY contents were determined in *M. neglecta* (74.05 mg g^{-1} FW) and *C. album* (32.50 mg g^{-1} FW), respectively. The highest QUE was obtained in *F. vulgaris* (15.93 mg g^{-1} FW), while the lowest was found in *T. phaleratum* (10.53 mg g^{-1} FW). The highest VA content was obtained in *M. neglecta* (44.79 mg g^{-1} FW), while the lowest was found in *C. album* (21.91 mg g^{-1} FW) (Table 4).

4. Discussion

The present study revealed for the 12 wild edible plant species investigated, the antioxidant enzyme content was species dependent. *P. cognatum* and *M. neglecta* had higher catalase (CAT) and peroxidase (POD) activity; *M. neglecta* and *T. phaleratum* had higher superoksid dismutase (SOD) activity; *M. neglecta* and *U. dioica* had higher ascorbate peroxidase (AxPOD) activity; *P. cognatum*, *M. neglecta*, *U. dioica*, and *T. phaleratum* had higher glutathione reductase (GR) activity; and *P. cognatum, M. neglecta*, and *U. dioica* had higher glutathione-s-transferase (GST) activity. Kordali et al. [26] carried out antioxidant enzyme analysis of *M. sylvestris* and *A. rosea* plants and reported CAT, POD, SOD, and AxPOD values as 1104–1611, 217–298, 39.34–45.34, and 26.69–39.34 EU g^{-1} plant, respectively. Their CAT and POD values were higher than our results, while their POD and AxPOD values were lower than our results. Alici et al. [27] reported CAT, POD, and SOD values as 38.65, 195.24, and 11.59 EU g^{-1} plant in *R. obtusifolia*, respectively. Their CAT value was comparable with our results; however, they found higher POD values and lower SOD values compared to our samples.

Among these antioxidant enzymes, GST is important in biological systems and act as a defense against oxidative stress [28]. The investigated antioxidant enzymes play significant role in the detoxification of DNA hydroperoxides or by-products of lipid peroxidation [29]. Antioxidants are molecules that prevent damage to the cell by preventing the formation of free radicals or scavenging existing radicals, generally carrying a phenolic function in their

structure. The phenolic compounds found in plants are at the beginning of the compounds that make up the main group of antioxidants of natural origin, and it is known that there is a relationship between the content of these compounds in plants and the antioxidant activity of tissues [17,30–32]. The phenolic content and antioxidant activity of some species were found to be affected by plant species properties and the other factors [33–37]. All physiological processes that take place in living systems involve complex combinations of oxidation and reduction reactions governed by different agents such as enzymes and hormones. Any change that may occur in the redox balance in living things can cause cell and tissue functions to damage. Antioxidants are naturally found in tissues and regulate different oxidation reactions [38]. Reactive oxygen species (ROS) and reactive nitrogen species (RNS) cause cell damage and many diseases by damaging lipids, proteins, enzymes, and nucleic acids. Aerobic organisms and plants respond to this type of oxidative stress caused by ROS and RNS with a defense mechanism consisting of enzymatic and non-enzymatic antioxidants. Enzymatic mechanisms occur with enzymes such as SOD, CAT, GR, and POD. Non-enzymatic mechanisms consist of enzymes such as ascorbic acid, glutathione, flavonoids, carotenoid, alkaloids, and phenolic acids [39]. Free radicals are formed from various metabolic reactions in the body. Enzymatic antioxidant defense systems such as SOD, POD, CAT, and glutathione peroxidase (GPx) play an important and active role in minimizing the harmful effects of free radical compounds on cells and metabolism [40].

In addition, plant hormones or phytohormones (IAA, ABA, GA, SA, etc.) are important substances in the regulation of plant antioxidant enzymatic systems [39]. Therefore, they play critical roles in regulating plant defense mechanisms under stress conditions [41,42]. Antioxidant enzymes and hormones are important for providing an integrative regulatory mechanism that controls the various functions of a plant cell. There is a relationship between the antioxidant activity of plant tissues and the hormone content of plants, and hormones have positive effects on antioxidant content [43]. In addition, earlier studies have shown that phytohormones are also important in human health. Phytohormones such as ABA, SA, and jasmonic acid (JA) have anticancer effects [44]. In addition, another plant hormone, cytokinin, has been reported to delay age-related deformations in human skin fibroblasts [45] and protect DNA and proteins from oxidative damage [46]. Wild plants and functional foods are important sources of antioxidants; therefore, they can help reduce the effects of chronic diseases that may be caused by aging. Antioxidant enzymes are effective compounds in preventing oxidative stress-related diseases. The effects of these compounds on plant tissues are positively affected by phytohormones. Wild plants have significant potential for these compounds [34].

Alaca et al. [36] also found quite variable phenolic compounds in different wild edible plants. Their results showed that wild plants have high contents of different phenolic compounds, comparable with our results.

Many research results have revealed that phenolic compounds protect against many diseases in humans, and that they are essential components of a balanced diet [47]. Polyphenols found in various plants are active substances that regulate the activity of many enzymes and cell receptors. Polyphenols, especially flavonoids (catechin, epicatechin, malvidin-3-o-glucoside, myricetin, rutin, quercetin, etc.), improve learning and memory processes in humans [48,49]. Phenolic compounds with different structures are likely to have different effects [50]. Therefore, it is important to analyze the phenolic compound content in edible plants. Many similar studies have been carried out in different countries on phenolic compounds in different families and different wild plant species belonging to these families [51–53].

The findings obtained in the study showed that the total phenolic compound content and antioxidant activity of the species belonging to different families varied according to the species. In similar studies, it was determined that the natural antioxidant substances contained in wild plant species protect the plants against the damage of free radicals that occur under stress conditions. They have also been stated to have a wide range of effects,

including antimicrobial and antimutagenic effects [54,55]. In another study, it was reported that plant species have different levels of antioxidant activity and that the antioxidant potential of the analyzed plants can be used to prevent cellular destruction caused by oxidative stress and damage [56].

The phenolic content values in this study differed slightly when compared to the values in the literature [15,33,56]. This can be attributed factors such as plant species and genotypes, the time elapsed between harvest and analysis, the geographical and ecological conditions in which the plants were grown, and the extraction method [57–63].

5. Conclusions

In this study, antioxidant enzyme activity, phenolic compound, and hormone contents of species belonging to different plant families were determined for the first time in the literature. Overall, *P. cognatum* and *M. neglecta* are rose to greater prominence than the other species in terms of higher levels of antioxidant enzymes, hormones, and phenolic compounds. The increasing demand for these wild edible plants poses major ecological and social challenges. Thus, their conservation in national gene banks is a priority task. It is thought that the data obtained in this study can provide important contributions of information to practitioners in governmental institutions and NGOs. It is also thought that there is potential for these plants to be used in important sectors such as pharmaceuticals, cosmetics, and food additives for a sustainable future.

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