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Investigation of Nutrient Element Content, Physicochemical and Biochemical Properties of Evening Primrose (*Oenothera biennis* L.)

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ABSTRACT

Oenothera biennis L., also known by names such as "evening primrose, calliopsis and sundrops," is a biennial plant species belonging to the Onagraceae family. The oil present in both its leaves and seeds is utilized in pharmacology and the food industry. *O. biennis* L., an important medicinal plant, the total ash content determined as 21.24%, dry matter content as 91.45%, total antioxidant activity as 200.59 µmol TE/g, total phenolic matter as 204.22 mg GAE/g and flavonoid content as 14.86 mg QE/100 g. Additionally, the amounts of a macro and micronutrient elements (Mg, K, Ca, Fe, Mn, Zn, Cu Ni), as well as heavy metals (As, Cd, Co, Cr, Pb), have been determined. Based on the obtained results, it can be concluded that the species is rich in nutrient elements and biochemical content. By introducing this species into cultivation, it can be classified as a vegetable and provide a source of raw material for the pharmaceutical industry. Considering the examined parameters, it is believed that the cultivation and commercial production of this species are feasible.

Ezan Çiçeğinin (*Oenothera biennis* L.) Besin Elementi İçeriği, Fizikokimyasal ve Biyokimyasal Özelliklerinin Araştırılması

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ÖZ

"Ezan çiçeği, çuha çiçeği ve akşam sefası" gibi isimlerle de bilinen *Oenothera biennis* L., Onagraceae familyasına ait iki yıllık bir bitki türüdür. Hem yapraklarında hem de tohumlarında bulunan yağ, farmakolojide ve gıda endüstrisinde kullanılmaktadır. Önemli bir tıbbi bitki olan *O. biennis* L.'nin toplam kül içeriği %21.24, kuru madde içeriği %91.45, toplam antioksidan aktivite 200.59 µmol TE/g, toplam fenolik madde 204.22 mg GAE/g ve flavonoid içeriği 14.86 mg QE/100 g olarak belirlenmiştir. Ayrıca, makro ve mikro besin elementlerinin (Mg, K, Ca, Fe, Mn, Zn, Cu Ni) yanı sıra ağır metallerin (As, Cd, Co, Cr, Pb) miktarları da belirlenmiştir. Elde edilen sonuçlara dayanarak, türün besin elementleri ve biyokimyasal içerik açısından zengin olduğu sonucuna varılabilir. Bu türün kültüre alınmasıyla, sebze olarak sınıflandırılabilir ve ilaç endüstrisi için bir hammadde kaynağı sağlayabilir. İncelenen parametreler göz önünde bulundurulduğunda, bu türün yetiştirilmesinin ve ticari üretiminin mümkün olduğu düşünülmektedir.

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1. Introduction

Evening Primrose (*Oenothera biennis* L.) is a tall and abundantly leafy plant from the Onagraceae family. The length of its leaves varies between 5 to 20 cm, with a width of 1 to 2.5 cm. It is a biennial herbaceous plant, and its flowering period lasts until late autumn. *O. biennis* L. has long been cultivated as an ornamental plant and has become naturalized in temperate regions of both hemispheres (Palmer, 1985). It is primarily found as a wild plant in North America. The mature seeds of Evening Primrose contain around 7-10% gamma-linolenic acid (GLA) in the fixed oil extracted from them. *O. biennis* L. is an edible plant; its young leaves can be consumed raw in salads, and its taproots can be cooked and eaten (Peterson, 1977; Szczawinski and Turner, 1978). The seed oil is widely used for reducing pain associated with premenstrual syndrome (PMS) in women and for promoting skin health (Ghasemnezhad and Honermeier, 2008; Sekeroglu, 2010; Mokhtari, 2016). Plants belonging to this genus are considered a valuable source of medicine for treating neurodegenerative disorders, diarrhea, immune disorders, and kidney problems. Additionally, their crude extracts have shown a wide range of pharmacological effects, including antimicrobial, antioxidant and anti-inflammatory properties, among others, in various in vivo and in vitro studies (Timoszuk et al., 2018).

Plants are rich sources of bioactive compounds. Due to the presence of these compounds in many plant structures, they are used in the production of medicines. Additionally, the plants themselves or their pure herbal components with medicinal properties are used for therapeutic or protective purposes. Substances such as terpenes, alkaloids, phenylpropanoids and flavonoids found in plants are referred to as secondary metabolites, and many of them are utilized as drugs (Hendrawati, 2011).

Plant nutrients are elements that are essential for the growth and normal development of plants and, cannot be replaced by any other chemical element in terms of their functions (Gezgin and Hamurcu, 2006). Many factors, including the plant's genetic profile, growing environment, soil composition, availability of water and growing season, affect a plant's nutrient content. Therefore, it has been emphasized that there are significant variations in the mineral compositions and different parts of plants (Yıldırım et al., 2001; Tunçtürk et al., 2019). Medicinal and aromatic plants may not always be reliable, due to the presence of toxic elements, they contain (Teschke et al., 2013). Some metals, such as zinc, iron, copper, chromium and cobalt become toxic at high concentrations for essential nutrients. On the other hand, metals like lead and cadmium have no beneficial properties and are solely toxic. The medicinal, nutritional and toxic properties of plants are related to their chemical compositions containing metal ions.

In this study, the biochemical content, nutritional values, macro and micronutrients and heavy metal contents of *O. biennis* L. which is a member of the Onagraceae family were investigated.

2. Material and Methods

2.1. Plant material

The study material consists of *O. biennis* L. grown in the Medicinal and Aromatic Plants Garden of Van Yüzüncü Yıl University, Faculty of Agriculture, Department of Field Crops. This garden is located in 1680m altitude (38º33'46.21" N, 43º17'51.29" E). The soil properties of the area where the plant was cultivated were texture sandy-loamy, pH 7.65, total salt 8.8 µS/cm, organic matter 0.94. Samples were taken in the first week of August in the second year after planting. The samples of the plant materials were shade dried. The dried samples were then cut into smaller pieces and grounded into moderately coarse powder.

2.2. Determination of ash, dry matter, heavy metal and nutrient contents

The total ash, dry matter and minerals (including macro elements: K, Ca and Mg; micro elements: Fe, Zn, Cu and Mn) and some heavy metals (As, Cd, Co, Ni, Cr and Pb) were determined. Dry matter was determined by-drying of the samples at 105 ºC for 24 hours in oven. For the total ash (inorganic matter) determination, an Electrical Muffle furnace set at 550 ºC was used. The mineral constituents of the plant samples were investigated as follows: Dried samples were ashed in a furnace with hydrochloric acid and nitric acid (AR) (AOAC 2000). Then, distilled water (50 ml) were added to samples in a volumetric flask. All assays were performed triplicate and the standard materials were being utilized for chemical analyses. Atomic Absorption Spectrometry (AAS) was used to estimate the K, Ca, Mg, Fe. ICP-OES (Inductively coupled plazma-Optical emission spectrometer) was used to determinate for other micro element and heavy metals constituents (Mn, Zn, Cu, Ni, As, Cd, Co, Cr and Pb). The results and standard deviations (Sd) of chemical analyses have been shown in Table 2.

2.3. Total antioxidant, total phenolic and total flavonoids content.

Total phenolic compounds content was measured according to Obanda, Owuor (1997) method. The antioxidant activity was also performed based on the Antioxidant Power (Iron (III) antioxidant power reduction, FRAP) method (Benzie, Strain 1996) followed by readings the absorbance at 593 nm, and antioxidant activity values were recorded as Trolox equivalent (TE)/mg. The total flavonoids content was determinated with some modifications according to the method developed by Quettier-Deleu et al. (2000). The total amount of flavonoid was measured at 415 nm and calculated in mg quercetin equivalent (QE) 100 g-1 DM.

2.4. Determination of Nitrogen balance index, cholorophyll, flavonol and anthocyanin

The Nitrogen balance index (NBI), chlorophyll, flavonol and anthocyanin content were measured on the leaf non-destructively using and in real time the Dualex scientific+ (FORCE-A, France) device before harvesting.

3. Results and Discussion

The study investigated some nutritional values, mineral and heavy metal contents, as well as biochemical and physiological contents of *O. biennis* L. the analysis results are presented in Table 1 and Table 2. The total ash content and dry matter ratio of *O. biennis* L. were found to be 21.24% and 91.45%, respectively, as shown in Table 1. The ash content of *Oenothera paradoxa* reported as 16.8% (Peiretti et al. 2004), which was lower than our findings. The ash content was higher than that reported by Tunçtürk et al. (2018) for *Cichorium intybus* L. (6.21%), and Bukhsh et al. (2007) for *Plantago ovata* species (8.6%). Additionally, it was higher than the values reported by Demir (2006) for measles (9.48%), fodder (11.79%), and wild leek (3.44%).

In the study, the dualeks values were determined as follows: NBI 12.86 dx, chlorophyll 25.20 dx, flavonol 1.97 dx, and anthocyanin 0.03 dx for *O. biennis* L. (Table 1.). On the other hand, Uçar et al. (2022) conducted a study on *Salvia officinalis* L., where different bacterial applications resulted in varying values for NBI, chlorophyll, flavonol and anthocyanin, ranging from 26.32 to 45.98 dx, 21.32 to 25.44 dx, 0.54 to 0.71 dx, and 0.050 to 0.074, respectively. In comparison, the study found that, except for the NBI value, the other parameters were similar or higher in the *O. biennis* L. compared to *Salvia officinalis* L.

In the biochemical content analysis, the total antioxidant activity was found to be 200.59 μmol TE/g, the total phenolic content was 204.22 mg GAE/g, and the total flavonoid content was 14.86 mg QE/100 g. In a previous study, while hydroalcoholic extract of *O. biennis* antioxidant activity and total phenolic content reported as 7258.67 μmol TE/g and 631.49 μg GAE/mL (Fecker et al., 2020), total phenolic and flavonoid content of *Oenothera rosea* reported 135.29 GAE/g and 22.03 QE/g, respectively (Márquez-Flores et al., 2018). As can be seen from these results obtained from Oenothera, the phenolic profile may vary with genetics, environment and extraction method. Murathan (2018) reported that the total phenolic content in *Allcemilla sericata* was 80.7 mg/100g and in *Rumex crispus* was 427.2 mg/100g in their study on plant extracts. Demir et al. (2014) determined the total phenolic content in *Primula veris* ethanol extracts to be 122.8 μg/g. Rudhani et al. (2017) reported that different *Primula veris* extracts had total phenolic content ranging from 5.10 to 17.30 mg/g and total flavonoid content ranging from 12.15 to 31.43 mg/g. In another literature, Olaruve et al. (2016) found the total phenolic content and total flavonoid content in dried *Anthriscus sylvestris* leaves ethanol extracts to be 41.63 mg/g and 25.76 mg/g, respectively. Regarding the total antioxidant values, Murathan (2018) obtained the lowest value from *Rumex crispus* (178.4 μmol Fe (II)/g) and the highest value of 770.8 μmol Fe (II)/g from *Allcemilla sericata*. The findings from the study were consistent with the relevant literature.

Table 1. Biochemical and physicochemical content of *O. biennis* L.

	Mean		S.D.
Total Ash (%)	21.24	±	0.47
Dry matter(%)	91.45	±	0.58
Total Flavonoid Content (mg QE/100 g)	14.86	±	7.28
Total Antioksidant Activity (µmol TE/g)	200.59	±	10.96
Total Phenolik Content (mg GAE/g)	204.22	±	4.53
Nitrogen Balance Index (NBI)	12.86	±	2.43
Cholorophyll	25.20	±	3.29
Flavonol	1.97	±	0.20
Anthocyanin	0.09	±	0.03

(Xmean ± SD), N = 3

The macro and micro-nutrient elements, as well as heavy metal contents in the plant samples, are given in Table 2. According to the obtained results, the concentrations of these elements are as follows: Magnesium (Mg) 4.25 g/kg, Potassium (K) 19.70 g/kg, Calcium (Ca) 26.53 g/kg, Manganese (Mn) 71.03 mg/kg, Iron (Fe) 808.16 mg/kg, Copper (Cu) 6.22 mg/kg, Nickel (Ni) 4.93 mg/kg, Zinc (Zn) 20.29 mg/kg, Arsenic (As) 3.68 mg/kg, Chromium (Cr) 3.86 mg/kg, Cadmium (Cd) 0.04 mg/kg, Cobalt (Co) 0.39 mg/kg and Lead (Pb) 0.88 mg/kg.

The concentration values of the nutrient elements in some medicinal plants have been reported to range from 1.17 to 86.43 g/kg for Mg (Akgünlü, 2012). Wild edible plants consumed as vegetables have been found to vary in K content from 4.34 to 557.91 g/kg (Akgünlü, 2012; Tunçtürk et al., 2017; Tunçtürk et al., 2017a; Tunçtürk et al., 2017b; Tunçtürk et al., 2017c). Ca concentrations have been shown to vary widely in the range of 0.03 to 777.52 g/kg (Koca et al., 2009; Kayalar et al., 2014; Tunçtürk et al., 2017). Our findings are consistent with the research on macro element concentrations in some medicinal and wild edible plants.

Low concentrations of micronutrients have been found to be essential for the health of humans and animals, and their deficiency can lead to abnormalities causing infections (Maiti et al., 2016). According to Maiti et al. (2016), the analysis of micronutrient content in 44 traditionally used medicinal plant species revealed concentrations of Fe, Cu and Zn ranging from 98.28 to 3973.55 mg/kg, 4.17 to 33.88 mg/kg and 9.49 to 216.31 mg/kg, respectively. The study concluded that the data obtained align with relevant literature and indicate the species' suitability in terms of micronutrient content.

When toxic heavy metal consumption exceeds tolerance limits in ecosystems, it leads to adverse effects in humans, plants and animals. Metal ion accumulation in plants from the soil disrupts the food chain (Yaashikaa et al., 2022). In the conducted study, concentrations of certain harmful heavy metals with detrimental effects on living organisms, such as Cr, Cd, Co and Pb, were determined. The concentrations of these heavy metals in various medicinal plants were reported as follows: Cr ranging

from 0.65 to 19.10 mg/kg, Cd from 0.012 to 0.440 mg/kg, Co from 0.047 to 1.69 mg/kg and Pb from 0.04 to 1.40 mg/kg (Başgel and Erdemoğlu, 2006; Koca et al., 2008; Koca et al., 2009; Akgünlü, 2012; Şekeroğlu et al., 2012; Tunçtürk et al., 2015). It was found that, our results are consistent with previous studies of heavy metal concentrations in certain wild and medicinal plants.

Table 2. Macro-micro nutrients element and heavy metal content of *O. biennis* L.

	Mean		S.D.
Mg(g/kg)	4.25	±	0.50
K(g/kg)	19.70	±	4.00
Ca(g/kg)	26.53	±	4.98
Fe (mg/kg)	808.16	±	37.72
Mn (mg/kg)	71.03	±	10.87
Zn (mg/kg)	26.69	±	4.09
Cu (mg/kg)	6.22	±	1.11
Ni (mg/kg)	4.93	±	1.09
As (mg/kg)	3.68	±	2.37
Cd (mg/kg)	0.04	±	0.01
Co (mg/kg)	0.39	±	0.0004
Cr (mg/kg)	3.86	±	0.71
Pb (mg/kg)	0.88	±	0.06

(Xmean ± SD), N = 3

4. Conclusion

As a result, the conducted study revealed that *O. biennis* L. species is rich in macro and micronutrients while having low levels of heavy metal content. The biochemical and physicochemical analysis results indicated that the examined parameters are at ideal levels.

Due to limited awareness of *O. biennis* L. as an edible plant, this characteristic remains overlooked. The research findings suggest that the high nutritional and biochemical content of this species could be a driving factor for its cultivation. Conducting further studies to extensively investigate the nutritional content, and pharmacological use of *O. biennis* L. is essential for its widespread adoption.

Statement of Conflict of Interest

The authors declare that there is no conflict of interest between them.

Author's Contributions

The authors declare that, they have contributed equally to the article.

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