REVIEW

# Phytochemical and biological activities of *Eremurus spectabilis*: A review

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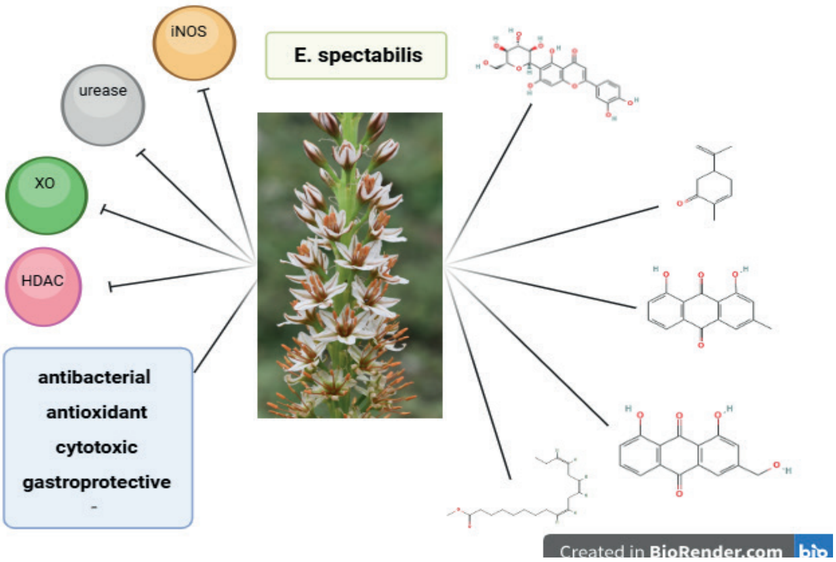
## Abstract

*Eremurus spectabilis M. Bieb*., commonly known as the "foxtail lily," is a plant that is a member of the Xanthorrhoeaceae family. It is found in a variety of locations in Central and Western Asia, such as Afghanistan, Iran, Syria, and Turkey. Traditional medicine has long utilized *E. spectabilis* for its pharmacological properties, including antibacterial, antioxidant, cytotoxic, gastroprotective, and anti-inflammatory effects. Ethnobotanical research has indicated its use in treating dermatitis, diabetes, digestive issues, and inflammatory diseases. This review examines the therapeutic potential and phytochemical profile of *E. spectabilis*. The identification of thirty-five compounds that were isolated from the plant is given particular attention. Phenolic acids, terpenoids, flavonoids, and anthraquinones comprise these compounds. Furthermore, *E. spectabilis* was proven to be a source of essential nutrients, including polysaccharides, vitamins K, C, and D, as well as minerals like potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), and copper (Cu). Despite its promising bioactivities, further research is needed to understand the underlying mechanisms, evaluate its full pharmacological potential, and assess the safety, efficacy, and appropriate dosing for clinical use.

**Keywords**: *Eremurus spectabilis*, foxtail lily, antibacterial activity, antioxidant effect, cytotoxicity, flavonoids




**Graphical abstract** Created in https://BioRender.com

# Introduction

*Eremurus* (*Xanthorrhoeaceae*) is a genus of 62 species native to Central Asia and the Middle East, which has long been valued in traditional medicine. These plants have been used in ethnobotanical practices for various ailments, particularly in the regions where they grow, underscoring their importance in historical and ongoing medicinal applications (*The genus Eremurus.*, 2024; Salehi et al., 2017). One notable species, *Eremurus spectabilis M. Bieb*., known as the "foxtail lily," is also referred to by various local names, including "Çiriş ©," "çireş," "dağ pırasası," "yabani pırasa," "güllük," "kiriş," "sarı çiriş," and "sarı zambak." This species is native to South and Central Asia, encompassing Turkey, Iran, West Pakistan, Afghanistan, Iraq, Palestine, Lebanon, Syria, and the Caucasus. This perennial herbaceous plant can grow up to 1 meter tall and thrives in steppes, open scrublands, limestone rock formations, and scree at altitudes between 1000 and 2750 meters (Murathan et al., 2018).

*E. spectabilis* is historically utilized in traditional medicine due to its phytochemical composition. Phenolic acids, flavonoids, terpenoids, anthraquinones, and other secondary metabolite derivatives are naturally found in plants and fruits. These chemicals have a variety of medicinal properties (Murathan et al., 2018; Prakash & Sagar, 2021). As a medicinal plant, *E. spectabilis* is abundant in these compounds. Ethnobotanical studies indicate its use for treating various ailments, including scabies, diabetes, and intestinal issues (Arıtuluk & Ezer, 2012; Karaman & Kocabas, 2001; Korkmaz & Karakuş, 2015). Furthermore, the plant has demonstrated antibacterial, antioxidant, and cytotoxic activities in various studies (Aykutoğlu et al., 2023; Kanaani & Mohamadi Sani, 2015; Taskin et al., 2012; Tuzcu et al., 2017). Carvone, carvacrol, pentane, ©-caryophyllene, and valencene were discovered to be the primary ingredients of *E. spectabilis'* essential oil (Karaman et al., 2011). Moreover, compounds like inosine, methyl linolenate, chrysophanol, isoorientin, β-sitosterol, and sucrose have been extracted (Karakaya et al., 2017). Previous research also reveals the presence of polysaccharides, vitamins K, C, and D, along with essential minerals such as potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), and copper (Cu), all contributing to its nutritional value (Bircan & Kırbağ, 2015; Cınar et al., 2017; Tosun et al., 2012).

Our literature review indicates a lack of detailed studies specifically focused on *E. spectabilis*. This review aims to compile data on the plant's phytochemical profile, nutritional value, pharmacological applications, and biological activities. Information on *Eremurus* species was gathered from electronic sources spanning the period from 2001 to early 2024.


**Figure 1.** The figure illustrates the different parts of *Eremurus spectabilis*: (a) stem and leaves, (b) root and rhizomes, (c) fruits, and (d) flowers (Tuncer, 2020).

## Traditional uses

Historically, people have used the plant, in both its fresh and dried forms, as a wild edible vegetable, including leaves and roots, as well as a traditional medicinal or folk remedy. Ethnobotanical and ethnopharmacological research has shown its traditional use in alleviating gastrointestinal irritation, liver ailments, cutaneous infections like scabies and syphilis, rheumatism, and different inflammatory conditions (Karaman & Kocabas, 2001; Karaoğlan et al., 2018; Korkmaz & Karakuş, 2015). Traditional medicine extensively employs *E. spectabilis* to remedy jaundice, diabetes, and hyperlipidemia, in addition to addressing dysuria and hypertension (Amiri & Joharchi, 2013; Cınar et al., 2017).

## Phytochemistry profile

*E. spectabilis* was revealed to have various phytochemical compounds, including flavonoids, terpenoids, anthraquinones, and sterols, which all contribute to its bioactivity profile (Karaman et al., 2011; Koldas, 2023; Tegin et al., 2024).

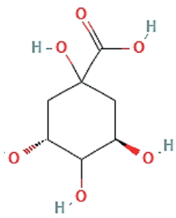
## Carbohydrate composition

In several investigations, *E. spectabilis* revealed the presence of poly-, di-, and monosaccharides. Oligofructose, fructans, and inulin are among the polysaccharides that were identified during the evaluation of the plant's roots (Pourfarzad et al., 2015; Pourfarzad et al., 2014). Additionally, glucomannan was found in another assessment of the plant (Jahanbin & Beigi, 2015). As a disaccharide, sucrose was identified from an investigation conducted on the young leaves (Karakaya et al., 2017). Glucose, fructose, and arabinose are recognized as monosaccharides (Bircan & Kırbağ, 2015).

## Phenolic compounds

*E. spectabilis* yielded several phenolic compounds, primarily from its aerial parts. In an investigation of the plant's aerial parts to analyze its phenolic compounds, LC-MS/MS results of extracts obtained from Soxhlet extraction revealed the presence of various phenolic compounds, including hydroxycinnamic acids (a), hydroxybenzoic acids (b), phenolic acids (c), and flavonoids (d). Hydroxycinnamic acids (a), such as quinic acid (1) and malic acid (2), were the most abundant, highlighting their key roles in the plant's biochemical profile  (Tegin et al., 2024). Another study on the aerial parts identified ferulic acid (3) as one of the prominent compounds (Di Simone et al., 2024). Other hydroxycinnamic acids, such as trans-caffeic acid (4), were also detected at relatively high levels. Hydroxybenzoic acids (b), including trans-aconitic acid (5) and gallic acid (6), were detected. Moreover, phenolic acids (c), like protocatechuic acid (7) and tannic acid (8), were found in moderate concentrations, further contributing to the plant's overall bioactivity. In addition to that, vanillin (9) was identified in smaller quantities, further contributing to the plant's potential role in flavor and bioactivity (Tegin et al., 2024). In another investigation, the methanolic extract of the plant yielded resveratrol (10), which is a polyphenolic compound (Bircan & Kırbağ, 2015).

Different extraction methods identified various flavonoids (d), primarily in the aerial parts of the plant. Isoorientin (11) is one of the flavonoids found in *E. spectabilis*. It has been found in many studies, mostly from the ethyl acetate and MeOH extracts of the leaves (Karakaya et al., 2017; Karaoğlan et al., 2018; Karaoglan et al., 2018). In other research, rutin (12), morin (13), and quercetin (14) were also among the flavonoids detected in the methanol extracts of the plant (Bircan & Kırbağ, 2015). Di Simone et al. (2024) conducted a recent study on the aerial parts, revealing the presence of quercitrin (15), delphinidin 3,5-diglucoside (16), isorhamnetin (17), and isoquercitrin (18) (Di Simone et al., 2024). The aerial parts also yielded the identification of hyperoside (19), a key flavonoid (Di Simone et al., 2024). In a different study done by Tegin et al. in 2024, the aerial parts were also found to contain kaempferol (20), apigenin (21), and luteolin (22) (Tegin et al., 2024).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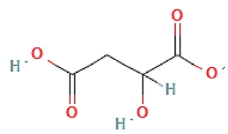
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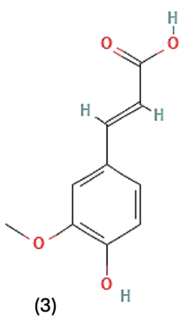
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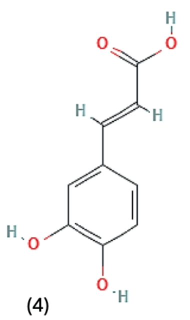
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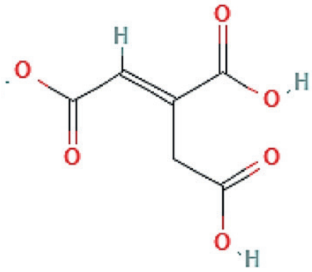
**Figure 2**. Chemical structures of hydroxycinnamic acids (a) isolated from E. spectabilis, including quinic acid (1), malic acid (2), ferulic acid (3), and trans-caffeic acid (4).



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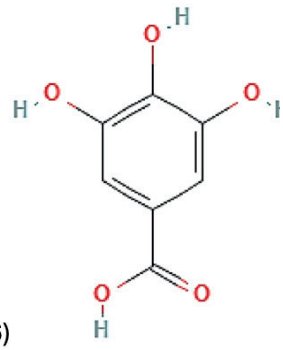

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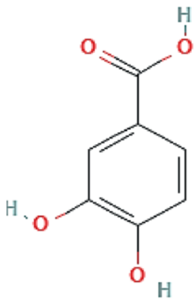
**Figure 3.** The structures of hydroxybenzoic acids (b) isolated from E. spectabilis, including trans-aconitic acid (5) and gallic acid (6).



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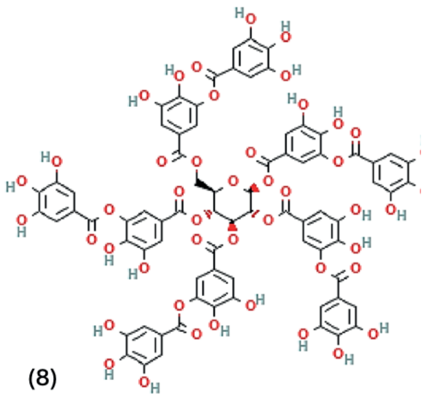

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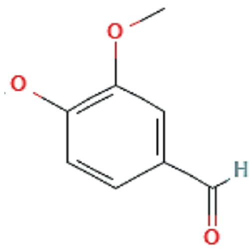

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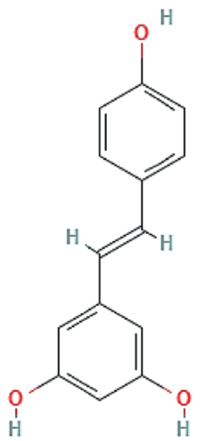

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**Figure 4.** The structures of phenolic acids (c) isolated from E. spectabilis, including protocatechuic acid (7), tannic acid (8), vanillin (9), and resveratrol (10).

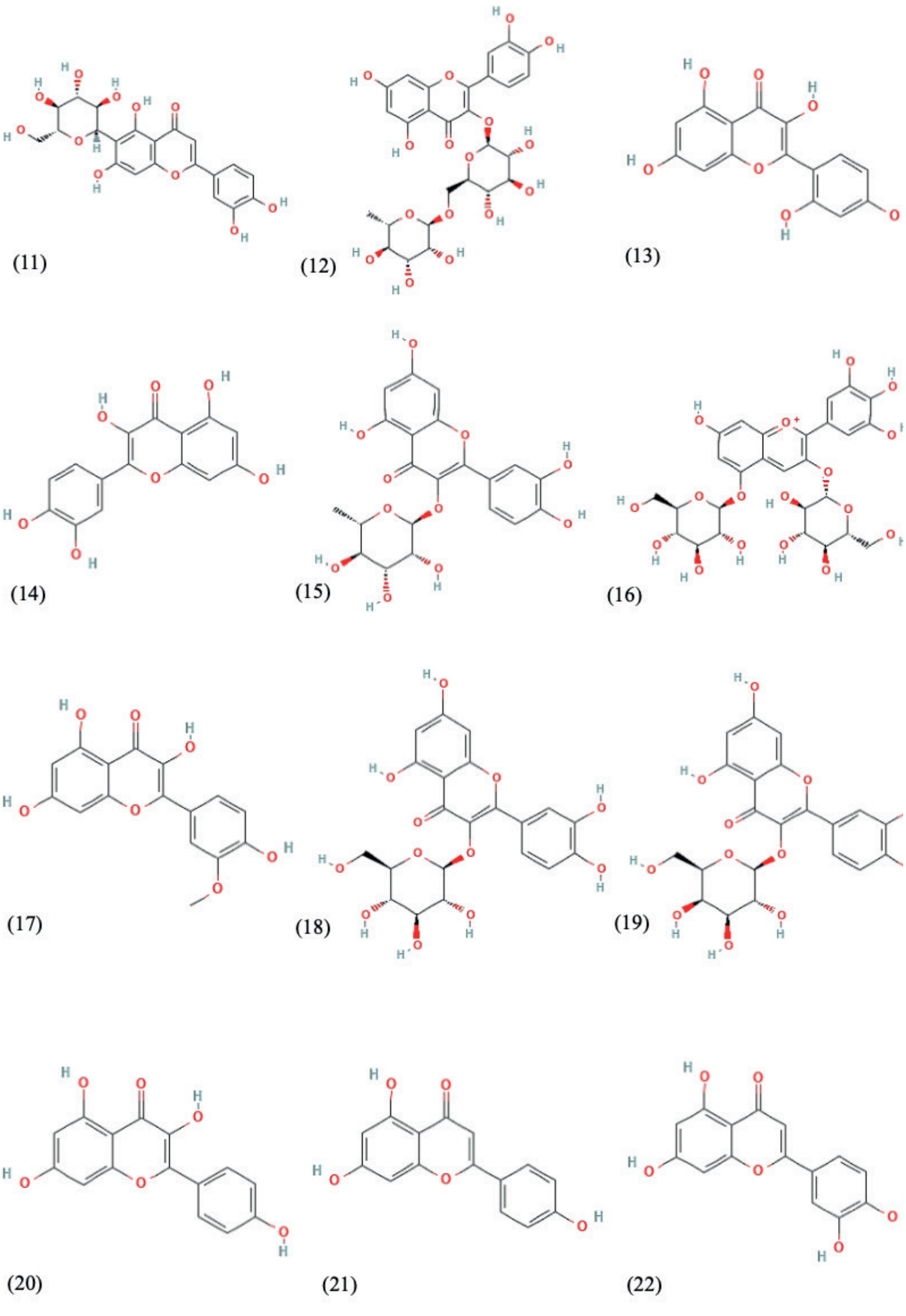



**Figure 5.** The structures of flavonoids (d) identified from the E. spectabilis, including isoorientin (11), rutin (12), morin (13), quercetin (14), quercitrin (15), delphinidin 3,5-diglucoside (16), isorhamnetin (17), isoquercitrin (18), hyperoside (19), kaempferol (20), apigenin (21), and luteolin (22).

## Terpenoids

Carvone (23), carvacrol (24), (E)-caryophyllene (25), valencene (26), and cis-calamenene (27) were the major terpenoids detected from the aerial parts using hexane extraction (Karaman et al., 2011).

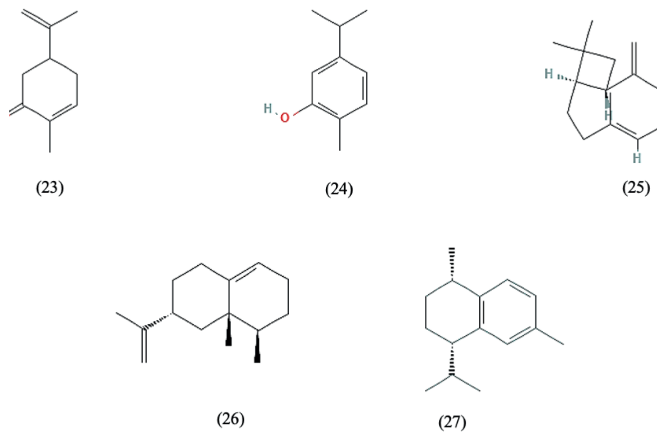



**Figure 6.** The structures of terpenoids identified from the E. spectabilis, including carvone (23), carvacrol (24), (E)-caryophyllene (25), valencene (26), and cis-calamenene (27).

## Anthraquinones

A study by Koldas in 2023 on the aerial parts of *the plant* found that chrysophanol (28), aloe emodin (29), and chrysophanol-8-methyl ether (30) are all anthraquinones, while 7,10-bichrysophanol (31) and chrysalodin (32) are bianthraquinone compounds found in the chloroform extract (Koldas, 2023).

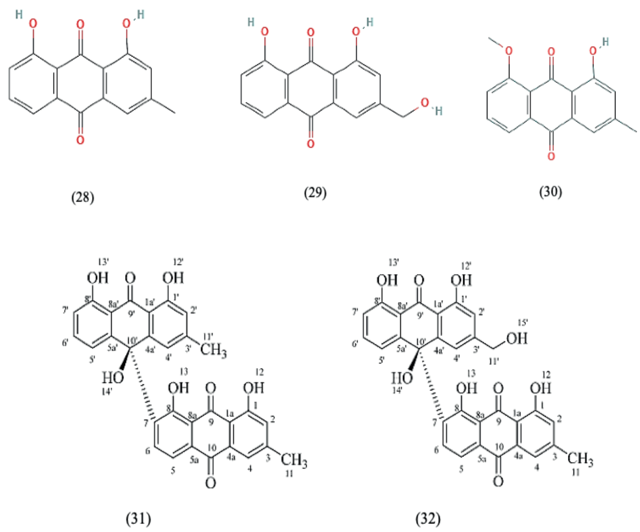
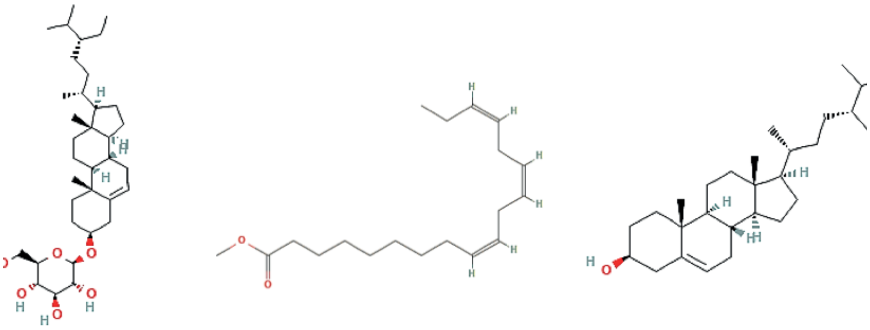



**Figure 7.** Anthraquinones: chrysophanol (28), aloe-emodin (29), and chrysophanol-8-methyl ether (30), and bianthraquinones: 7,10-bichrysophanol (31) and chrysalodin (32).

## Sterols

The chloroform extracts from the aerial parts of *E. spectabilis* identified daucosterol (33) as a major sterol (Koldas, 2023). Methyl linolenate (34) and β-sitosterol (35) were also detected from the hexane extract of the above-ground parts, enhancing the plant's sterol composition (Karakaya et al., 2017).



(33) (34) (35)

**Figure 8.** The structures of sterols identified from the E. spectabilis, including daucosterol (33), methyl linolenate (34), and β-sitosterol (35).

## Nutritional value of *E. spectabilis*

*E. spectabilis* is an exceptional dietary resource due to its remarkable nutritional profile. Its traditional use in local cuisines is substantiated by its minimal calorie and fat content, as well as its beneficial dietary fiber levels. Tosun et al. (2012) reported a protein and ash composition of 1.20% and 0.87%, respectively. However, a subsequent study determined that these levels were below these values (Cınar et al., 2017; Tosun et al., 2012).

Another notable aspect of its profile is its vitamin content; *E. spectabilis* offers a remarkably high amount of vitamin C (129.4 mg/100 g) and vitamin D, which aids in the mitigation of common dietary deficiencies (Bircan & Kırbağ, 2015; Cınar et al., 2017). Vitamin K, α-tocopherol, and ergosterol were also determined (Bircan & Kırbağ, 2015). The plant is also an essential source of macro- and microelement constitution, particularly its high potassium-to-sodium ratio (Cınar et al., 2017). Its high concentration of calcium and magnesium further suggests that it can meet the daily mineral requirements (Tosun et al., 2012). Nevertheless, the concentration of iron has been observed to fluctuate; Tosun et al. (2012) reported 7.1 mg/100 g, while other assessments determined 2.42 mg/100 g (Cınar et al., 2017; Tosun et al., 2012).

## Pharmacological effects

### *Antioxidant activity*

*E. spectabilis* has been the subject of extensive research regarding its antioxidant properties due to its extensive collection of phytochemicals, including flavonoids, hydroxycinnamic acid derivatives, hydroxybenzoic acid derivatives, and organic acids.

A study conducted by Karaman et al. (2011) evaluated the antioxidant and antiradical properties of ethanol, methanol, and aqueous extracts. According to the findings, the methanol extract exhibited the highest antioxidant activity (81.72 mg ascorbic acid/g), and the ethanol extract exhibited the strongest antiradical activity (Karaman et al., 2011). In another study, Falahi et al. (2019) used 2,2-diphenyl-1-picrylhydrazyl (DPPH) and phosphomolybdate methods to examine the activity of five distinct plants from west Iran, showing that *E. spectabilis* had the greatest antioxidant capacity (2.41 μg/mL) of all the species they evaluated (Falahi et al., 2019). Dervişoğlu et al. (2013) also used water extracts from leaves and roots to measure the plant's antioxidant capacity by assessing DPPH and metal chelating activities. The results demonstrated that the antioxidant capacity of root extracts was higher than that of leaf extracts. The hydroxyl radical scavenging activity of both leaf and root extracts was higher than that of ascorbic acid and BHA (Butylated HydroxyAnisole) and BHT (Butylated HydroxyToluene) and comparable to that of α-tocopherol (Dervişoğlu et al.). Moreover, acetone extracts from leaves had the highest antioxidant activity (3703.25 μg ascorbic acid/g) when compared to BHA (Tuzcu et al., 2017). Different extraction techniques demonstrated strong radical scavenging activity (73.89% per mg/mL extract) in a separate study that utilized Density Functional Theory (DFT) methods to analyze the aerial portions of *E. spectabilis*, with a focus on the mechanisms of Hydrogen Atom Transfer (HAT), Single Electron Transfer followed by Proton Transfer (SET-PT), and Sequential Proton Loss Electron Transfer (SPLET) processes (Tegin et al., 2024). Bircan & Kirbağ (2015) revealed that DPPH free radical scavenging activity was effective even at 10 μL, and the reduction of elevated lipid peroxidation (LPO) levels, along with decreased levels of oleic and linoleic acids in the FeCl group, suggested that the flavonoids in methanolic extracts may protect unsaturated fatty acids from free radical attacks (Bircan & Kırbağ, 2015). In other research, the antioxidant effect of eight *E. spectabilis* species from different areas was examined using DPPH radical and β-carotene/linoleic acid assays. *E. spectabilis* showed antioxidant effects in both β-carotene–linoleic acid (inhibition: 94.56%) and DPPH assays (inhibition: 73.69%) (Tosun et al., 2012). Besides that, a significant increase in the expression of the cytochrome c gene was observed in cells exposed to the leaf water extract, with no increase in BAX and BCL-X. Additionally, the assays for superoxide dismutase (SOD), catalase (CAT), and 2,2-diphenyl-1-picrylhydrazyl (DPPH) demonstrated enhanced antioxidant activity in the cells treated with the extracts (Aykutoğlu et al., 2023).

***Antimicrobial effects***

The studies on *E. spectabilis* highlight the variability in antimicrobial activity due to differences in extraction methods, solvent types, bacterial strains, and geographical regions of the plant.

Methanolic extracts of the aerial parts of *E. spectabilis* from Bingöl, Kahramanmaras, and Nakhcevan exhibited significant antibacterial activity against *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Bacillus megaterium*, *Escherichia coli*, and *Enterobacter aerogenes*, with the strongest inhibition observed against *Enterobacter aerogenes* (14.970 mm) from the Nakhcevan sample. Antifungal activity was observed only against *Saccharomyces cerevisiae*, with no effect on other yeast strains (Murathan et al., 2018). However, Kanaani and Sani (2015) found no activity in methanolic root extracts using the agar diffusion method but reported antibacterial effects against *Bacillus cereus*, *Staphylococcus aureus*, *Salmonella enterica*, and *Escherichia coli* using the microdilution broth assay (Kanaani & Mohamadi Sani, 2015). Moreover, Taskin et al. (2012) documented antifungal activity from chloroform and aqueous extracts against *Candida albicans* and antibacterial effects from ethyl acetate and aqueous extracts against *Klebsiella pneumoniae* and *Staphylococcus aureus* (Taskin et al., 2012). In another study, Bircan and Kirbağ (2015) also observed inhibition zones of 12 mm against *Staphylococcus aureus*, 14 mm against *Escherichia coli*, 9 mm against *Candida albicans*, and 8 mm against *Epidermophyton spp.*, indicating broad antimicrobial potential, particularly stronger against bacteria than fungi (Bircan & Kırbağ, 2015). Karaman et al. (2011) found that methanolic, ethanol, and aqueous extracts displayed antimicrobial activity, with the strongest effect from aqueous extracts (10%) against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* (Karaman et al., 2011). In a subsequent study, Tuzcu et al. (2017) revealed that aqueous, acetone, and ethanol extracts demonstrated antimicrobial potential against *Listeria monocytogenes*, *Saccharomyces cerevisiae*, *Staphylococcus aureus*, and *Escherichia coli* using the disk diffusion method (Tuzcu et al., 2017). Furthermore, in a distinct study, the plant exhibited higher antibacterial activity against seven bacteria compared to commercial antibiotics penicillin (10 µg/disc) and amoxicillin-clavulanic acid (30 µg/disc). The above-ground parts were more effective, showing moderate activity against *Bacillus cereus*, *Bacillus subtilis*, *Staphylococcus aureus*, *Enterococcus faecalis*, *Pseudomonas aeruginosa*, and *Escherichia coli*, but low activity against *Salmonella typhimurium*. The underground parts exhibited weaker effects, with the lowest inhibition against *Bacillus subtilis* (7.00 mm) and the highest against *Escherichia coli* (8.33 mm) (Tegin et al., 2024). However, it is observed that at a 1% concentration, no inhibition was found, but increased extract concentrations resulted in stronger inhibition zones, with *Pseudomonas aeruginosa* being more sensitive and *Yersinia enterocolitica* more resistant (Karaman et al., 2011).

***Cytotoxic activity***

The anticancer activity of *E. spectabilis* was investigated in prostate cancer (PC-3) cells using both organic and aqueous extracts from its leaves and roots. A 2017 study by Tuzcu et al. found that acetone, ethanol, and water extracts at concentrations of 250 and 500 µg/mL decreased cell proliferation by up-regulating Bax and caspase-3 mRNA while down-regulating Bcl-2 mRNA (Tuzcu et al., 2017). Additionally, another study showed that aqueous leaf extracts exhibited significant cytotoxic effects, with an $IC_{50\text{ of }250\ \mu g/mL}$ and maximal growth inhibition at 500 µg/mL. The root extract did not induce cell death, while the leaf extract did, as evidenced by increased expression of the cytochrome C gene. Furthermore, the anticancer potential of the leaf extract on PC-3 cells was confirmed by increased lipid peroxidation, indicated by elevated levels of malondialdehyde (MDA) (Aykutoğlu et al., 2023).

Another assessment evaluated the cytotoxic activity of aqueous and hexane-ethanolic extracts of *E. spectabilis* on rhabdomyosarcoma (RD) and Vero cells. The extracts demonstrated dose- and time-dependent inhibition of cell proliferation, with RD cells showing sensitivity to all tested concentrations (10–0.001 µg/ml over 24–72 hours), while Vero cells were resistant at higher concentrations (100 and 10 µg/ml) (Abubaker, 2015). The effects of *E. spectabilis* lyophilized and nanoparticle plant leaf extracts on the cellular and enzymatic immune systems of rats with hepatocellular cancer (HCC) were investigated by Genç and Çelik. In HCC rats, the plant extracts modulated T lymphocyte subsets (CD3+, CD4+, CD8+, and CD4+/CD8+ ratio). CD3+ and CD8+ T cells showed reductions in the groups treated with cancer along with lyophilized plant leaf extract (CLPLE), while CD4+ T cells exhibited a broader decrease across all experimental conditions compared to the normal control. Furthermore, following treatment with lyophilized plant leaf extract (LPLE) and nanoparticle plant leaf extract (NPLE), lung and spleen tissues showed increased levels of the enzymes myeloperoxidase (MPO) and adenosine deaminase (ADA), suggesting improved immunological responses (Genç & Çelik, 2024).

*E. spectabilis*-derived isoorientin exhibits encouraging anticancer efficacy against HT-29 colorectal cancer cells as well as SH-SY5Y neuroblastoma cells. By altering genes linked to the cell cycle and apoptosis, isoorientin efficiently suppresses cell growth, with IC50 values of 250 μM and 125 μM, respectively. It triggers apoptotic pathways by upregulating p53, p21, caspase-3, caspase-8, caspase-9, and ATR and downregulating CCND1, CDK6, Bcl-2, Bax, CHEK1, CHEK2, and ERCC1 (Gundogdu et al., 2018; Karaoğlan et al., 2018). Moreover, various extracts of the plant, particularly the ethanolic and ethyl acetate extracts, exhibit inhibitory effects on histone deacetylase (HDAC), a key regulator of cancer cell proliferation, migration, angiogenesis, immune evasion, and treatment resistance, highlighting the plant's potential as an anti-cancer agent (Bertan & Refiye, 2021; Hai et al., 2022). However, in the study conducted by Karakaya et al., *E. spectabilis* extracts and isolated compounds did not show cytotoxic activity against various cancer cell lines, including HeLa, A-549, MCF-7, mPANC96, U87MG, PC3, and CaCo-2. Nevertheless, the hexane extract exhibited inhibition of inducible nitric oxide synthase (iNOS) in RAW 264.7 murine macrophage cell lines, with an IC50 value of 25 μg/ml, suggesting limited anticancer activity but potential anti-inflammatory properties via iNOS inhibition (Karakaya et al., 2017).

Overall, the cytotoxic activity in the mentioned studies is primarily observed in acetone, ethanol, and aqueous extracts of *E. spectabilis* leaves, which inhibited proliferation in PC-3 and RD cells. Additionally, isoorientin demonstrated cytotoxic effects against HT-29 and SH-SY5Y cells, while root and hexane extracts generally exhibited limited or no cytotoxicity.

***Gastroprotective efficacy***

The gastroprotective activities of the aerial parts of *E. spectabilis* and its major component, isoorientin, were investigated in rats using an indomethacin-induced gastric damage model on rats. Increasing glutathione (GSH) levels and superoxide dismutase (SOD) and lowering lipid peroxidation activity in rat stomach tissue were achieved by all doses of isoorientin and methanol extract. However, the 500 mg/kg dose of methanol extract worked best, similar to the standard drug famotidine, and it counteracted the oxidative stress caused by indomethacin. Researchers attribute the plant's effectiveness to a potential synergistic effect of its components, not just isoorientin, which aligns with its traditional use and highlights *E. spectabilis*'s promise as a natural antiulcer agent (Karaoğlan et al., 2018). In another study, both the ethanolic and ethyl acetate extracts had substantial urease-inhibitory activity, with the ethyl acetate extract exhibiting greater inhibition (Bertan & Refiye, 2021). Blocking urease, which significantly contributes to stomach cancer and peptic ulcers due to excessive ammonia production, aligns with the gastroprotective properties of the plant (Follmer, 2010).

***Antidiabetic activity***

The aqueous extract of fresh *E. spectabilis* leaves was tested for its potential anti-diabetic effects. Compared to acarbose, the extract had strong inhibitory effects on α-glucosidase and α-amylase and an intermediate inhibitory effect on elastase. On the other hand, it had weak inhibitory effects on hyaluronidase and tyrosinase activities compared to their standard inhibitors. This suggests that consuming *E*. spectabilis leaves could potentially help manage postprandial blood glucose levels (Bayrak & Yanardağ, 2021). The plant may also be beneficial in the management of diabetes due to its dominant carbohydrates, glucose, sucrose, and fructose, as well as polysaccharides such as galactomannans. Its traditional uses also support its role in diabetes management (Bircan & Kırbağ, 2015).

***Anti-inflammatory effect***

*E. spectabilis* demonstrated anti-inflammatory properties mostly via the methanol extract, which significantly inhibited lipopolysaccharide (LPS)-induced cyclooxygenase-2 (COX-2) gene expression.

The phytochemicals, such as vanillic and ferulic acids, mitigate oxidative stress and disorders induced by inflammation, especially in the colon (Di Simone et al., 2024). Moreover, the hexane extract exhibited iNOS inhibition with an $IC_{50\ of\ 25\ \mu g/ml}$, indicating potential anti-inflammatory properties (Karakaya et al., 2017). Nonetheless, the plant exhibited no reduction of hPBMC proliferation or TNF-α secretion in vitro (Gaggeri et al., 2015).

***Skin benefits***

Bayrak & Yanardağ (2021) conducted research on the aqueous *E. spectabilis* extract, revealing a moderate inhibitory effect on elastase, which may help with skin problems (Bayrak & Yanardağ, 2021).

**Table 1**. Summary of *E. spectabilis* bioactivity.

| **Bioactivity** | **Plant Part** | **Extract Type** | **MOA\ cell lines\ bacteria types** | **References** |
|---|---|---|---|---|
| Antibacterial | Aerial parts and root | Methanol, aqueous, ethyl acetate, acetone, ethanol | *E. aerogenes, B. cereus, S. aureus, E. coli, K. pneumoniae, L. monocytogenes, S. cerevisiae, B. subtilis, E. faecalis, P. aeruginosa* | (Bircan & Kırbağ, 2015; Karaman et al., 2011; Murathan et al., 2018; Taskin et al., 2012; Tegin et al., 2024; Tuzcu et al., 2017) |
| Antioxidant | Root & Leaves | Methanol, water, acetone, ethanol | Methanol extract exhibited antioxidant activity (81.72 mg ascorbic acid/g); lowering LPO; XO inhibition | (Bertan & Refiye, 2021; Karaman et al., 2011; Tosun et al., 2012) |
| Cytotoxic | leaves and roots | acetone, ethanol, and water | Up-regulating Bax and caspase-3 mRNA; down-regulating Bcl-2 mRNA in PC-3 cells | (Tuzcu et al., 2017) |
| Gastroprotective | leaves | MeOH, ethanolic, and ethyl acetate | Increasing GSH & SOD; lowering lipid peroxidation; blocking urease | (Bertan & Refiye, 2021; Karaoğlan et al., 2018) |
| Antidiabetic | leaves | aqueous | α-glucosidase and α-amylase inhibition | (Bayrak & Yanardağ, 2021) |

# Conclusion

E. spectabilis is a medicinally and nutritionally significant plant with a diverse phytochemical composition, including phenolic acids, flavonoids, terpenoids, and anthraquinones, alongside essential vitamins and minerals. It exhibits antibacterial, antioxidant, cytotoxic, and gastroprotective activities and is traditionally used for scabies, diabetes, and intestinal disorders. Its ethnobotanical significance and potential as a source for novel therapeutic agents highlight the need for further research to fully understand its pharmacological potential.

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## Conflict of interest

The authors declare no conflicts of interest.

## Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## Ethics committee approval

Ethics committee approval is not required for this study.

## Authors' contribution statement

Nour Alhalak and Turgut Şekerler: contributed significantly to the preparation of the manuscript. They guided the overall structure of the review, gathered and analyzed relevant data from various sources, and synthesized the information into a coherent and comprehensive narrative.

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