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Review Paper

A Comprehensive Review on the Biological Activities, Usage Areas, Chemical and Phenolic Compositions of *Lycium barbarum* Used in Traditional Medicine Practices

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Abstract

Plants are organic substances extensively utilized in conventional medicinal procedures. We conducted a comprehensive review of the literature to assemble information on the biological activities, areas of use, total phenolic and flavonoid concentrations, as well as the chemical and phenolic compositions of *Lycium barbarum* L. The literature investigation revealed that *Lycium barbarum* has been extensively studied for its antioxidant, antibacterial, and anticancer properties. Furthermore, it was observed that various components of the plant, including the fruit, leaves, flower, root, and bark, were utilized for distinct purposes. Furthermore, it was observed that the chemical and phenolic compositions documented in it exhibited variations depending on the specific parts that were utilized. Chlorogenic acid, *p*-coumaric acid and ferulic acid are common compounds found in the leaves, flowers and fruit parts of the plant. It is thought that it will be an important material in future studies because it is a source of phenolic compounds reported in the plant. Therefore, *L. barbarum* is believed to have significant potential as a natural resource in the development of pharmacological strategies.

Keywords

Anticancer, Antimicrobial, Antioxidant, Chinese Wolfberry, Goji Berry, Phenolics

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1. INTRODUCTION

Throughout history, humans have utilized numerous natural substances for their advantageous properties. Natural goods encompass several taxa, including fungi, flora, and fauna, that are widely distributed in the natural environment (Ahmad et al., 2023). Of all these options, plants are the predominant natural resources utilized for various purposes. Humans utilize plants for several functions including sustenance, protection, warmth, tools, and disease management (Korkmaz et al., 2018). Currently, plants hold the highest priority in people's dietary preferences. They encompass essential vitamins, minerals, and other elements that are necessary for human nourishment (Mohammed et al., 2024). Furthermore, plants possess significant value as natural resources in the field of medicine. Numerous research have provided evidence that plants have a wide range of biological activities, encompassing anticancer, antibacterial, antioxidant, anti-inflammatory, antiproliferative, antiaging, antiallergic, hepatoprotective, and DNA protective roles (Mohammed et al., 2021; Dogan et al., 2023; Kalkan et al., 2023; El-Chaghaby et al., 2024; Kahraman and Calıskan, 2024; Latifani et al., 2024; Özcandır et al., 2024; Sholikhah et al., 2024; Segmenoglu and Sevindik, 2024; Widyastuti et al., 2024). It is crucial to examine the biological activities of plants in this particular situation (Mohammed et al., 2022). We combined the stated biological activity, utilization areas, total phenolic and flavonoid contents, as well as the chemical and phenolic compositions of *Lycium barbarum* from the existing literature in our study.

Lycium barbarum (Solanaceae) is known by various names including "Chinese wolfberry, goji berry, wolfberry, barbary matrimony vine, red medlar, and matrimony vine". China is its country of origin. The Chinese term for it is Ningxia gouqi. Nevertheless, it is prevalent in numerous diverse locations. *L. barbarum* has been cultivated in China for over six centuries. At now, it is widely cultivated in the Ningxia Hui Autonomous Region situated in the north-central region of China. The fruits of the plant are utilized by Chinese medicine practitioners and are referred to be high grade. Additionally, it is cultivated to mitigate erosion and protect irrigated regions from desertification. The plant is a deciduous shrub with a woody structure that reaches a height ranging from 1 to 3 meters. The leaves of the plant are lanceolate and can be arranged either alternately or in groups of up to three. The flowers are arranged in clusters of one to three in the leaf axils. The goji berry fruit has a vibrant orange-red color and has an ellipsoid form (Potterat, 2010; Amagase and Farnsworth, 2011; Qian et al., 2017; Kwok et al., 2019; Tian et al., 2019; Ma et al., 2023).

2. THERAPEUTIC POTENTIALS

A compilation was made of the documented usage areas of *Lycium barbarum* in the literature. The results are displayed in Table 1 and Figure 1.

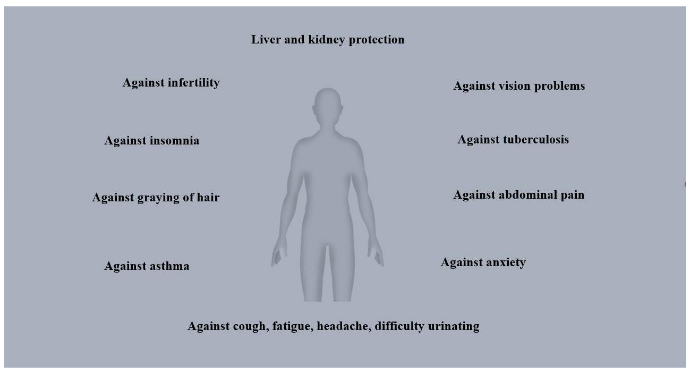

Figure 1. Therapeutic Potentials of *Lycium barbarum*

Scientific literature on *L. barbarum* reveals that investigations have been carried out on several plant parts, such as the fruit, flower, leaves, root, and bark. This fruit is employed for its hepatoprotective and renal properties, as well as in other forms including fresh fruit, dehydrated fruit, fruit juice, and sauces. Furthermore, it finds application in the manufacturing of wine and tea. The fruit is thought to provide advantages for visual impairments, inhibiting early graying of hair, management of infertility, relief from abdominal pain, cough, weariness, headache, and urinary retention (Potterat, 2010; Amagase and Farnsworth, 2011; Yao et al., 2018; Byambasuren et al., 2019). The leaves of this plant have been documented to be beneficial for liver protection, eyesight issues, cough, dizziness, and fever (Dong et al., 2011; Byambasuren et al., 2019; Lei et al., 2022; Yao et al., 2018). The flower component has been shown to be utilized in the management of lanosterol regulation, eye therapy, and cholesterol regulation (Byambasuren et al., 2019). Various ailments such as fever, hypertension, cough, diabetes, dizziness, gynecomastia, lower back pain, claudication, leukorrhea, headache, amnesia, agrypnia, asthma, tuberculosis, anxiety, gynecological disorders, night sweats, kidney pain, palpitations, insomnia, tears, and spermatorrhea are often treated with the root and bark of this plant (Potterat, 2010; Yao et al., 2018; Byambasuren et al., 2019). Furthermore, upon examination of the studies, it has been seen that the fruit component is favored to a greater extent compared to other components in terms of usage.

3. BIOLOGICAL ACTIVITIES

Plants are known to display many biological functions (Mohammed et al., 2023). We collated the existing literature on the biological activity studies of *L. barbarum* in our study. The research findings indicated that several extracts of the plant, including methanol, ethanol, polysaccharides, oligosaccharides, ethyl acetate, water, polyphenols, hexane, and acetone, were utilized. The table presented in Table 2 and Figure 2 displays the results of the biological activity investigations conducted on *L. barbarum*.

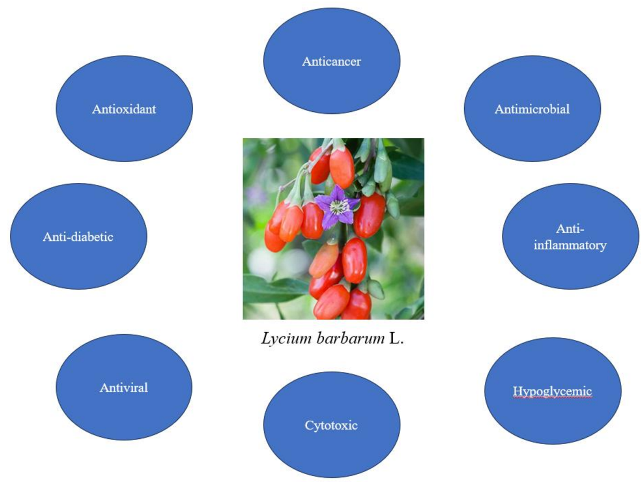

Figure 2. Biological Activities of *Lycium barbarum*

4. ANTIOXIDANT ACTIVITY

Free radicals are generated during normal physiological processes. Although these chemicals are not dangerous at low concentrations, their quantities can lead to significant damage (Sevindik et al., 2018; Korkmaz et al., 2021). In order to mitigate or eliminate the harmful consequences induced by free radicals, the antioxidant defense mechanism is activated (Krupodorova and Sevindik, 2020). In certain cases, the antioxidant defense mechanism is insufficient in effectively neutralizing increased levels of free radicals. Under these circumstances, there is the presence of oxidative stress. Chronic oxidative stress is the fundamental factor responsible for the development of several diseases including cancer, cardiovascular disorders, neurological disorders, and diabetes (Sevindik et al., 2017; Bal et al., 2019; Eraslan et al., 2021; Krupodorova et al., 2024). Additional antioxidants can be employed to counteract the detrimental effects of oxidative stress (Sevindik et al., 2024). In this specific scenario, plants prove to be highly valuable natural resources. For our study, we collected the previously documented antioxidant activity data of *L. barbarum* from the available literature. An investigation conducted in Taiwan revealed that the flavonoid component of the methanol extract obtained from *L. barbarum* exhibited effectiveness in removing detrimental free radicals, binding metal ions, and

Table 1. Therapeutic Potentials of *Lycium barbarum* L.

Therapeutic Potentials	Used Parts	References
Liver and kidney protection, vision problems, against premature graying of hair, infertility, abdominal pain, cough, fatigue, headache, difficulty urinating	Fruit	(Potterat, 2010; Amagase and Farnsworth, 2011) (Yao et al., 2018; Byambasuren et al., 2019)
Liver protection, vision problems, cough, dizziness, fever	Leaves	(Dong et al., 2011; Yao et al., 2018) (Byambasuren et al., 2019; Lei et al., 2022)
Controlling lanosterol, eye treatment, cholesterol control	Flower	(Byambasuren et al., 2019)
Fever, hypertension, cough, diabetes, dizziness, gynecomastia, lower back pain and claudication, leukorrhea, headache, amnesia, agrypnia, asthma, tuberculosis, anxiety, gynecological diseases, night sweats, pain in the kidneys, palpitations, insomnia, tears, spermatorrhea	Root, bark	(Potterat, 2010; Yao et al., 2018) (Byambasuren et al., 2019)

Table 2. Biological Activity of *Lycium barbarum*

Biological Activities	Extractions	References
Anticancer, antitumor, cytotoxic	Polysaccharides, water	(Mao et al., 2011; Georgiev et al., 2019)
Anti-diabetic, hypoglycemic	Polysaccharides	(Ma et al., 2022; Zhou et al., 2022)
Anti-inflammatory,	Ethanol	(Lee et al., 2020)
Antimicrobial	Ethanol, methanol, water	(Fıt et al., 2013; Mocan et al., 2014) (Xiao Ning et al., 2015; Skenderidis et al., 2019b) (Ilic et al., 2020)
Antioxidant	Ethanol, methanol, polysaccharides, oligosaccharides, ethyl acetate, water, polyphenols, hexane, acetone	(Wang et al., 2010; Jabbar et al., 2014; Jiang, 2014) (Zhang et al., 2014; Mocan et al., 2014) (Mocan et al., 2015b; Magiera and Zarȩba, 2015) (Lu et al., 2019; Ilic et al., 2020; Shang et al., 2022) (Benchennouf et al., 2017; Skenderidis et al., 2019a)
Antiviral	polysaccharides	(Li et al., 2023)

exerting a reducing effect, as evidenced by the outcomes of the DPPH and ABTS tests. Moreover, it was noted that the zeaxanthin fraction had the most significant effect in removing hydroxy free radicals, whereas polysaccharides showed a con-

Table 3. Chemical Contents of *Lycium barbarum*

Essential oil content (%)	References
Acetic acid (48.33), hexadecanoic acid (47.5), ethyl lactate (12.97), 3-hydroxy-2- butanone (9.99), linoleic acid (9.1), 1-methoxy-2-propanone (8.84), β-elemene (5.4), myristic acid (4.2), ethyl hexadecanoate (4.0), hexanal, (E)-2-hexenal, nonanal, isoamylol, 1-hexanol, 1-octen-3-ol, hexyl acetate, methyl salicylate, ethyl octanoate, o-cymene, d-limonene, linalool, β-cyclocitral, 2-pentylfuran	(Altintas et al., 2006) (Chen et al., 2015) (Lu et al., 2017)

Table 4. Phenolic Contents of *Lycium barbarum*

Used Parts	Phenolic Contents (mg/g)	References
Leaves	Caffeic acid (<0.00002), chlorogenic acid (<0.00002-5.89929), *p*-coumaric acid (<0.00002-0.03029), ferulic acid (0.10719), isoquercitrin (0.01275-0.02508), gensitic acid (< 0.00002), kaempferol (0.79-7.63), rutin (5.25-15.839), salicylic acid (0.23902), sinapic acid (0.00236), syringic acid (0.00076), quercitrin (0.013), quercetin (0.00559-7.57), vanilic acid (0.00946), vanilin (0.00862)	(Dong et al., 2011; Mocan et al., 2014) (Mocan et al., 2015a; Pollini et al., 2020)
Flower	Chlorogenic acid (0.21691), *p*-coumaric acid (0.01284), ferulic acid (0.04248), isoquercitrin (0.02046), rutin (0.06053), quercitrin (0.01113)	(Mocan et al., 2015a)
Fruit	Caffeic acid (0.00906-0.918), fumaric acid (0.126-0.338), pyrogallol (0.00897), *p*-coumaric acid (0.07038-0.974), gallic acid (0.00295), chlorogenic acid (0.05556-11.23), quercetin (0.00212-0.04132), isoquercetin (0.00290-0.02154), epicatechin (0.00863-0.01828), epigallocatechin (0.00066-0.00537), epigallocatechin gallate (0.00523), luteolin-7-O-glucoside (0.00889), kaempferol-3-O-rutinoside (0.01337-0.02512), pelargonin chloride (0.00335-0.01952), cyanidin chloride (0.00153-0.0114), cyanidin-3-O-glucoside (1.11225), pelargonidin-3-O-glucoside (0.1196), rutin (0.09859-0.12538), ferulic acid (0.06201-0.9455), isorhamnetin-3-glucoside (0.01756-0.2113), isorhamnetin-3-O-rutinoside (0.01534-0.1817), isorhamnetin (0.01159-0.1530)	(Donno et al., 2015; Protti et al., 2017) (Ozkan et al., 2018; Nzeuwa et al., 2022)

siderable advantage in scavenging superoxide anions (Wang et al., 2010). A study conducted in Romania examined the antioxidant status of the ethanol extract produced from *L. barbarum* using DPPH and FRAP tests. The study reported the DPPH inhibitory concentration (IC_{50}) value as 124.06 μg/mL and the IC_{50} value from the FRAP test as 1344 μmol/100 mL (Mocan et al., 2015b)). A study carried out in Greece assessed the antioxidant capacity of the methanol extract derived from *L. barbarum* using DPPH and ABTS tests. The study showed that the IC_{50} value of the DPPH test result was 830-1150 μg/mL, while the IC_{50} value of the ABTS test result was 195-397 μg/mL (Skenderidis et al., 2019a). A study conducted in China found that the polysaccharides extract derived from *L. barbarum* had an IC_{50} value of 1.98-4.96 mg/mL in the DPPH test and an IC_{50} value of 0.20-2.25 mg/mL in the ABTS test (Zhang et al., 2014). A separate investigation was carried out in Greece to examine the antioxidant properties of ethyl acetate and water extracts derived from *L. barbarum*. This was done using FRAP, DPPH, and chemiluminescence tests. The study indicated that the ethyl acetate extract exhibited the strongest scavenging capabilities, with a half maximum effective concentration (EC_{50}) value of 4.73 mg/mL and an IC_{50} value of 0.47 mg/mL, as determined by DPPH and chemiluminescence studies (Benchennouf et al., 2017). A study conducted in Romania indicated that the ethanol extract derived from *L. barbarum* has a DPPH test result of 29.30 μg/mg (Mocan et al., 2014). A study carried out in Poland examined the antioxidant activity of the methanol extract derived from *L. barbarum* using the DPPH test. The study indicated a range of 40.5-54.9 for the DPPH inhibition percentage (Magiera and Zaręba, 2015). A separate investigation carried out in China examined the antioxidant properties of the polyphenols extract derived from *L. barbarum* using DPPH, ABTS, OH, and Fe^{2+} chelating activity tests. The study provided IC_{50} values of the tests as follows: 1751.1-2351.78 μg/mL, 322.07-373.65 μg/mL, 3689.07-4742.99 μg/mL, and 1969.16-2701.50 μg/mL, respectively (Shang et al., 2022). A separate study carried out in China examined the antioxidant properties of methanol and ethyl acetate extracts derived from *L. barbarum*. The investigation involved the use of DPPH, reducing power, superoxide, hydroxyl radical, and lipid peroxidation tests. The study revealed the EC_{50} values of the tests utilized as follows: 38.96-198.30 μg/mL, 99.89-246.23 μg/mL, 69.56-321.53 μg/mL, 56.23-168.45 μg/mL, and 46.48-135.46 μg/mL, respectively (Jabbar et al., 2014). A study conducted in Serbia examined the antioxidant properties of the methanol extract derived from *L. barbarum*. This investigation utilized FRAP, CUPRAC, DPPH, ABTS, and beta-carotene bleaching tests. The study provided the test values as follows: 532.4-1943.9 μmol TE/100 g, 616.7-1057.4 μmol TE/100 g, 443.6-1022.5 μmol TE/100 g, 12.9-28.4 mmol TE/100 g, and 15.9-22.0%, respectively (Ilic et al., 2020). A separate study conducted in China examined the antioxidant properties of an extract of *L. barbarum* generated using hexane, acetone, and ethanol, as well as extracts formed only using ethanol. The antioxidant status was evaluated using DPPH, ABTS, and FRAP tests. The study indicated that the EC_{50} value for the DPPH test was between 2.278-26.12 mg/mL, the EC_{50} value for the ABTS test was between 0.057-2.557 mg/mL, and the EC_{50} value for the FRAP test was between 11.45-94.75 μmol Fe^{2+}/g (Lu et al., 2019). A study conducted in China indicated that the hydroxyl radical scavenging activity of the oligosaccharides extract derived from *L. barbarum* was 86.46% (Jiang, 2014). Within this particular context, based on information from literature sources, it has been noted that *L. barbarum* exhibits a noteworthy capacity for antioxidation. Consequently, it was concluded that *L. barbarum* has the potential to serve as a natural source of antioxidants.

5. ANTIMICROBIAL ACTIVITY

Antimicrobial medications are employed by humans to combat microbial infections (Mohammed et al., 2019). Nevertheless, the current impact of antimicrobial medicines is inadequate. The rise in the prevalence of drug-resistant microbes resulting from inadvertent drug usage has prompted researchers to explore novel antimicrobial medications (Mohammed et al., 2020; Krupodorova et al., 2022). Scientists have prioritized the exploration of naturally occurring antimicrobial medications as a result of the potential adverse effects associated with manmade antibiotics (Baba et al., 2020). Plants hold significant value as natural resources in this particular context. We collated the antibacterial activity findings of *L. barbarum* reported in the literature for our study. In this particular investigation carried out in Romania, the researchers examined the antibacterial properties of an ethanol extract derived from *L. barbarum* against various types of bacteria including *Bacillus subtilis, Escherichia coli, Listeria monocytogenes, Staphylococcus aureus*, and *Salmonella typhimurium*. The study indicated that the range of inhibition zone values was 12.3-17.2 mm (Mocan et al., 2014). A study conducted in Greece investigated the antimicrobial potential of water and ethanol extracts obtained from *L. barbarum* against various bacteria and fungi including *Salmonella typhimurium, Clostridium perfringens, Escherichia coli, Staphylococcus aureus, Listeria monocytogenes, Campylobacter jejuni, Rhodotorula mucilaginosa, Penicillium expansum, Yarrowia lipolytica, Fusarium oxysporum, Metschnikowia fructicola, Aspergillus niger*, and *Rhizoctonia solani*. The study reported a range of 10-200 mg/mL for the minimal inhibitory concentration (MIC) value and the minimum bactericidal concentration (MBC) value (Skenderidis et al., 2019b). A study conducted in China found that *L. barbarum* shown substantial antibiotic activity against *Colletotrichum nigrum*, *Bacillus* sp., and *Exserohilum turcica*, while displaying a weaker inhibitory impact against *Escherichia coli* and *Staphylococcus aureus* (Xiao Ning et al., 2015). A study conducted in Serbia investigated the antimicrobial properties of methanol extract derived from *L. barbarum* against various microorganisms including *Staphylococcus aureus* subsp. *aureus*, *S. epidermidis*, *Enterococcus faecalis*, *Escherichia coli*, *Salmonella enterica* subsp. *enterica serovar*., *Klebsiella pneumoniae* subsp. *pneumoniae*, *Pseudomonas aeruginosa*, and *Candida albicans*. The study indicated a range of 0.001-16 μg/mL for the minimum inhibitory concentration (MIC) values (Ilic et al., 2020). A separate study conducted in Romania examined the impact of an aqueous extract derived from *L. barbarum* on *Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa*, and *Candida albicans*. The study indicated an inhibitory zone ranging of 8-25 mm (Fıt et al., 2013). Based on literature data, it has been observed that *L. barbarum* exhibits antibacterial properties against the described strains in this particular environment. Consequently, *L. barbarum* is believed to possess natural antibacterial properties.

6. OTHER ACTIVITIES

Prior research has observed that *L. barbarum* demonstrates several biological actions, apart from its characteristic antioxidant and antibacterial behavior. In a study was reported out in South Korea to examine the anti-inflammatory properties of the ethanol extract obtained from *L. barbarum* in the given circumstances. The work evaluated the influence of endoplasmic reticulum stress pathway and pro-inflammatory cytokines on MEF-knockout cell lines and the intestines of mice that were given a high-fat diet and subjected to inflammation produced by lipopolysaccharide. The study revealed that it reduced the generation of nitric oxide (NO), irrespective of the existence or non-existence of inflammation. Additionally, it was observed that it suppressed endoplasmic reticulum stress and inflammation in laboratory conditions using IRE1a and XBP1, as well as in the inflamed intestines of mice (Lee et al., 2020). A separate study conducted in China examined the antidiabetic properties of a polysaccharides extract derived from *L. barbarum*. The research revealed that the oral administration of medicine to mice with diabetes produced by a high-fat diet and streptozotocin for a duration of six weeks led to a significant decrease of 13.51% in overnight blood glucose levels. In addition, the diabetic mice showed an enhancement in glycated hemoglobin and beta cell activity (Zhou et al., 2022). An independent study carried out in China investigated the impact of *L. barbarum* polysaccharide (LBP) treatment on the management of type 2 diabetes by modulating the composition of gut microbiota. In diabetic mice that were fed a high-fat diet (HFD) and treated with streptozotocin (STZ) to produce diabetes, the study discovered that LBP significantly decreased hyperglycemia, hyperlipidemia, and insulin resistance. Moreover, there have been findings suggesting that higher doses of LBP have demonstrated more effective hypoglycemic effects in comparison to lower and moderate doses. Moreover, research has shown that large dosages of LBP significantly augment the functions of CAT, SOD, and GSH-Px in diabetic patients, while concurrently decreasing inflammation (Ma et al., 2022). An independent investigation conducted in China investigated the influence of *L. barbarum* glycopeptide (LbGp) on viral pneumonia produced by H1N1. LbGp is a composite of five intricate polysaccharide-protein interactions (LbGp1-5) purified from the fruit of *L. barbarum*. The results of the study shown that the administration of LbGp significantly enhanced the survival rate and body weight of mice challenged with H1N1, while concurrently decreasing the lung index (Li et al., 2023). A separate study conducted in China examined the impact of *L. barbarum* on the proliferation of human colon cancer cells (SW480 and Caco-2) and explored the potential processes involved. The subjects were administered *L. barbarum* at concentrations ranging from 100 to 1,000 mg/L for a duration of 1 to 8 days. The investigation revealed that treatment with *L. barbarum* effectively suppressed the growth of both colon cancer cell lines in a manner that depended on the dosage. Furthermore, it was observed that the proliferation of SW480 cells was strongly decreased at concentrations ranging from 400 to 1,000 mg/L. Additionally, it was shown that the proliferation of Caco-2 cells was greatly suppressed at doses ranging from 200 to 1,000 mg/L (Mao et al., 2011). An investigation conducted in Bulgaria assessed the cytotoxic effects of the extract obtained from *L. barbarum* on MCF-7 and MDA-MB-231 breast cancer cells. The investigation revealed an IC_{50} value of 0.07 μM for MCF-7 cells and 0.79 μM for MDA-MB-231 cells (Georgiev et al., 2019). After reviewing the existing studies, it was determined that *L. barbarum* exhibits significant biological activities.

7. CHEMICAL AND PHENOLIC CONTENTS

Plants produce several chemical substances internally through synthesis. We collated the chemical contents detected in the fruit of *L. barbarum* as described in the literature in our investigation. The results are displayed in Table 3 and major compounds in Figure 3.

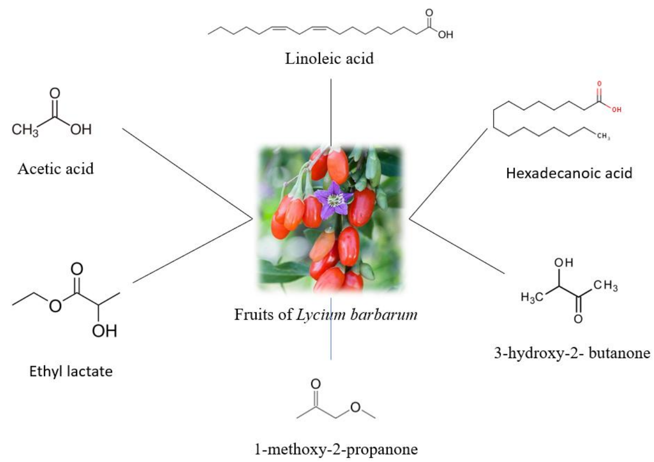

Figure 3. Major compounds of *Lycium barbarum*

It has been reported that *L. barbarum* fruit contains acetic acid, hexadecanoic acid, ethyl lactate, 3-hydroxy-2- butanone, linoleic acid, 1-methoxy-2-propanone, β-elemene, myristic acid, ethyl hexadecanoate, hexanal, (E)-2-hexenal, nonanal, isoamylol, 1-hexanol, 1-octen-3-ol, hexyl acetate, methyl salicylate, ethyl octanoate, o-cymene, d-limonene, linalool, β-cyclocitral, 2-pentylfuran (Altintas et al., 2006; Chen et al., 2015; Lu et al., 2017).

Secondary metabolites are compounds that have no nutritional properties but are very important in terms of medicine (Karalti et al., 2022). In this study, the phenolic contents of *L. barbarum* reported in the literature are shown in Table 4 as mg/g.

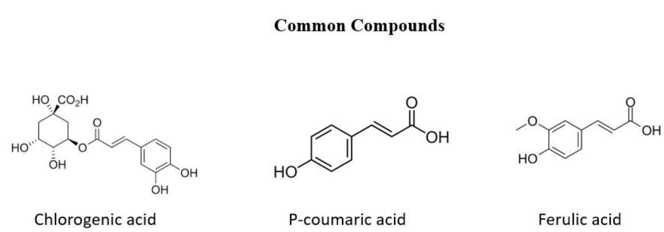

Figure 4. Common Compounds of *Lycium barbarum*

According to literature data, phenolic contents of leaves, flower and fruit parts of *L. barbarum* were analyzed. Caffeic acid, chlorogenic acid, *p*-coumaric acid, ferulic acid, isoquercitrin, gensitic acid, kaempferol, rutin, salicylic acid, sinapic acid, syringic acid, quercitrin, quercetin, vanilic acid, vanilin were reported in the leaves part (Dogan et al., 2023; Mocan et al., 2014, 2015a; Pollini et al., 2020). *p*-coumaric acid, ferulic acid, chlorogenic acid, isoquercitrin, rutin and quercitrin were reported in the flower part (Mocan et al., 2015a). It has been reported that pyrogallol, *p*-coumaric acid, fumaric acid, chlorogenic acid, quercetin, isoquercetin, gallic acid, epicatechin,

Table 5. Total Phenolic and Flavonoid Contents of *Lycium barbarum* L.

Used Parts	Total Phenolic Values (mg/100g)	Total Flavonoid Values (mg/100g)	References
Fruit, leaves	14-3000	–	(Wang et al., 2010; Mocan et al., 2014; Donno et al., 2015) (Nardi et al., 2016; Benchennouf et al., 2017; Islam et al., 2017) (Kafkaletou et al., 2018; Mocan et al., 2018; Wojdyło et al., 2018) (Mocan et al., 2019; Yossa Nzeuwa et al., 2019; Ilic et al., 2020) (Taneva and Zlatev, 2020; Magalhaes et al., 2022; Nzeuwa et al., 2022) (Xu et al., 2022)
	–	20-2480	(Wang et al., 2010; Mocan et al., 2014; Nardi et al., 2016) (Islam et al., 2017; Mocan et al., 2018, 2019) (Ilic et al., 2020; Magalhaes et al., 2022; Xu et al., 2022)

luteolin-7-O-glucoside, kaempferol-3-O-rutinoside, pelargon in chloride, cyanidin chloride, epigallocatechin, epigallocatechin gallate, cyanidin-3-O-glucoside, ferulic acid, pelargonidin-3-O-glucoside, rutin, isorhamnetin-3-O-rutinoside, isorhamne tin-3-glucoside, isorhamnetin and caffeic acid are present in the fruit part (Donno et al., 2015; Protti et al., 2017; Ozkan et al., 2018; Nzeuwa et al., 2022; Ju et al., 2023).

8. TOTAL PHENOLIC AND FLAVONOID CONTENTS

Total phenolic and flavonoid contents of *L. barbarum* reported in the literature are shown in Table 5.

Total phenolic contents of *L. barbarum* fruit and leaves have been reported to be between 14-3000 mg/100g (Wang et al., 2010; Mocan et al., 2014; Donno et al., 2015; Nardi et al., 2016; Benchennouf et al., 2017; Islam et al., 2017; Kafkaletou et al., 2018; Mocan et al., 2018; Wojdyło et al., 2018; Mocan et al., 2019; Yossa Nzeuwa et al., 2019; Ilic et al., 2020; Taneva and Zlatev, 2020; Magalhaes et al., 2022; Nzeuwa et al., 2022; Xu et al., 2022). Total flavonoid contents have been reported to be between 20-2480 mg/100g (Wang et al., 2010; Mocan et al., 2014; Nardi et al., 2016; Islam et al., 2017; Mocan et al., 2018, 2019; Ilic et al., 2020; Magalhaes et al., 2022; Xu et al., 2022).

9. CONCLUSIONS

Lycium barbarum, originating from China and now distributed globally, serves various purposes. We compiled the documented biological activities, chemical and phenolic compositions, utilization areas, total phenolic and flavonoid contents of *L. barbarum* in our study. The analyses revealed that there has been extensive research on the antioxidant, antibacterial, and anticancer properties of *L. barbarum*. Within this context, it has been observed that the plant possesses the ability to serve as a natural agent in combating diseases. Additionally, it can function as an additional antioxidant and antibacterial agent in food products. Furthermore, it is believed that the plant might serve as a significant natural resource in the development of pharmacological designs due to the presence of various chemical and phenolic substances in its distinct components. Therefore, it is believed that *L. barbarum* can serve as a potential natural resource for future investigations on various biological activities, as well as for isolating and investigating the effects of known bioactive chemicals.

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