MEDICINAL LICORICE (GLYCYRRHIZA GLABRA L.) AND ITS CHEMICAL COMPOSITION: PHYTOCHEMICAL CONSTITUENTS AND PHARMACOLOGICAL SIGNIFICANCE

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ABSTRACT

Glycyrrhiza glabra L., commonly known as licorice, is one of the oldest medicinal plants widely used in traditional and modern medicine due to its diverse pharmacological properties. The plant has attracted significant scientific attention because of its rich chemical composition and broad spectrum of biological activities. The roots and rhizomes of licorice contain numerous bioactive compounds, including triterpenoid saponins, flavonoids, coumarins, polysaccharides, phenolic acids, essential oils, and other secondary metabolites that contribute to its therapeutic potential. Glycyrrhizin, the principal triterpenoid saponin, is considered the major active constituent responsible for many pharmacological effects such as anti-inflammatory, antiviral, hepatoprotective, antioxidant, antimicrobial, immunomodulatory, and anticancer activities.

Recent phytochemical studies have identified more than 400 chemical compounds in G. glabra, making it one of the most extensively studied medicinal plants. Advances in chromatographic and spectroscopic techniques have enabled detailed characterization of these constituents and their biological functions. The pharmacological properties of licorice have been confirmed through numerous in vitro, in vivo, and clinical studies, supporting its application in treating respiratory disorders, gastrointestinal diseases, liver dysfunction, skin diseases, and viral infections.

This review summarizes the botanical characteristics, chemical composition, extraction methods, pharmacological activities, medicinal applications, safety considerations, and future perspectives of Glycyrrhiza glabra. Understanding the relationship between its phytochemical constituents and biological

activities may contribute to the development of novel pharmaceutical products and functional foods derived from licorice.

1. Introduction. Medicinal plants have served as an important source of therapeutic agents for thousands of years. According to the World Health Organization (WHO), approximately 80% of the world's population relies partly on traditional herbal medicine for primary healthcare. Natural products continue to provide valuable compounds for the development of pharmaceutical drugs, dietary supplements, and functional foods. Among these medicinal plants, *Glycyrrhiza glabra* L., commonly known as licorice, occupies a prominent position because of its remarkable therapeutic properties and long history of medicinal use.

Licorice belongs to the family Fabaceae and is a perennial herbaceous plant native to Southern Europe, Central Asia, and the Mediterranean region. It is extensively cultivated in countries such as China, India, Iran, Turkey, Uzbekistan, Kazakhstan, and Russia. The plant is characterized by deep-rooted rhizomes that accumulate numerous biologically active compounds. The dried roots are widely utilized in pharmaceutical, cosmetic, and food industries due to their sweet taste and medicinal value.

Historical records indicate that licorice has been used for more than 4,000 years in ancient Egyptian, Greek, Roman, Chinese, Persian, and Ayurvedic medicine. Ancient physicians prescribed licorice preparations for treating cough, asthma, gastric ulcers, liver diseases, and inflammatory disorders. Modern scientific investigations have confirmed many of these traditional applications through pharmacological and clinical studies.

The therapeutic value of *Glycyrrhiza glabra* is primarily attributed to its rich phytochemical composition. More than 400 bioactive compounds have been identified, including triterpenoid saponins, flavonoids, chalcones, coumarins, isoflavonoids, polysaccharides, amino acids, sterols, volatile oils, tannins, and phenolic acids. Among these constituents, glycyrrhizin is recognized as the principal active compound responsible for the characteristic sweet taste and many pharmacological activities. Glycyrrhizin is approximately 30–50 times sweeter than sucrose and possesses significant anti-inflammatory, antiviral, antioxidant, hepatoprotective, and immunomodulatory effects.

Flavonoids constitute another important group of phytochemicals found in licorice roots. Major flavonoids include liquiritin, liquiritigenin, isoliquiritigenin, glabridin, glabrene, and licochalcone A. These compounds exhibit potent antioxidant activities by scavenging free radicals and protecting cells from oxidative stress. Numerous studies have demonstrated that flavonoids also possess antimicrobial, anticancer, neuroprotective, and cardioprotective properties.

Modern analytical techniques such as high-performance liquid chromatography (HPLC), gas chromatography–mass spectrometry (GC–MS), liquid chromatography–mass spectrometry (LC–MS), and nuclear magnetic resonance (NMR) spectroscopy have significantly improved the identification and quantification of licorice phytochemicals. These technologies have enabled researchers to establish relationships between chemical constituents and biological activities, facilitating the development of standardized herbal medicines.

Pharmacological investigations have shown that licorice extracts exert multiple biological effects. These include anti-inflammatory, antiviral, antibacterial, antifungal, antioxidant, hepatoprotective, gastroprotective, immunomodulatory, antidiabetic, anticancer, neuroprotective, and cardioprotective activities. Consequently, licorice has become an important raw material for pharmaceutical preparations, herbal medicines, nutraceuticals, and cosmetic products.

Despite its numerous therapeutic benefits, excessive consumption of licorice may produce adverse effects due to glycyrrhizin-induced inhibition of 11β-hydroxysteroid dehydrogenase type 2. Long-term intake of large quantities may result in hypertension, hypokalemia, edema, and pseudoaldosteronism. Therefore, appropriate dosage and standardized preparations are essential to ensure safe clinical application.

The objective of this review is to summarize current knowledge regarding the botanical characteristics, phytochemical composition, extraction methods, pharmacological properties, medicinal applications, toxicological aspects, and future research directions of *Glycyrrhiza glabra*. Understanding the relationship between its chemical constituents and therapeutic activities may facilitate the development of innovative plant-based medicines and functional products.

2. Materials and Methods.

2.1. Study Design. This study was conducted as a comprehensive literature review following the IMRAD structure to evaluate the phytochemical composition and pharmacological significance of *Glycyrrhiza glabra* L. Relevant scientific publications were critically analyzed to summarize current knowledge regarding the medicinal properties, chemical constituents, extraction methods, biological activities, and therapeutic applications of licorice.

2.2. Data Sources. Scientific information was collected from internationally recognized electronic databases, including **PubMed**, **Scopus**, **Web of Science**, **ScienceDirect**, **SpringerLink**, **Google Scholar**, and **Wiley Online Library**. Additional information was obtained from books, review articles, pharmacopoeias, and reports published by international health organizations.

2.3. Statistical Analysis

Since this study is based on a literature review rather than experimental research, no original statistical analysis was performed. Data reported in previously published studies were compared descriptively, and similarities or differences among research findings were discussed qualitatively. The reliability of conclusions was assessed based on the consistency of evidence obtained from multiple independent investigations.

3. Results. 3.1 Phytochemical Composition of *Glycyrrhiza glabra.*

The literature analysis demonstrated that *Glycyrrhiza glabra* is one of the richest medicinal plants in terms of phytochemical diversity. More than **400 bioactive compounds** have been identified in its roots, rhizomes, leaves, and seeds. These compounds belong to several major classes, including triterpenoid saponins, flavonoids, chalcones, coumarins, polysaccharides, phenolic acids, essential oils, sterols, amino acids, and volatile compounds.

Among these constituents, **glycyrrhizin** is the predominant triterpenoid saponin and represents approximately **2–15%** of the dry weight of licorice roots, depending on

geographical origin, cultivation conditions, and harvesting time. Glycyrrhizin is hydrolyzed into glycyrrhetinic acid, which is largely responsible for the plant's pharmacological effects.

3.2. Major Chemical Constituents

The principal phytochemicals identified in *Glycyrrhiza glabra* are summarized below.

Chemical Group	Representative Compounds	Main Biological Activities
Triterpenoid saponins	Glycyrrhizin, Glycyrrhetinic acid	Anti-inflammatory, antiviral, hepatoprotective
Flavonoids	Liquiritin, Liquiritigenin, Glabridin, Isoliquiritigenin	Antioxidant, antimicrobial, anticancer
Chalcones	Licochalcone A, Licochalcone B	Antibacterial, antioxidant
Coumarins	Herniarin, Umbelliferone	Anti-inflammatory
Polysaccharides	Licorice polysaccharides	Immunomodulatory
Phenolic acids	Ferulic acid, Caffeic acid	Antioxidant
Sterols	β-Sitosterol, Stigmasterol	Cholesterol-lowering activity
Essential oils	Various terpenes	Antimicrobial

These compounds collectively contribute to the therapeutic potential of licorice through synergistic biological effects.

3.3. Glycyrrhizin. Glycyrrhizin is the most abundant and pharmacologically important constituent of licorice root. Chemically, it is a triterpenoid glycoside composed of glycyrrhetinic acid linked to two molecules of glucuronic acid. Several studies demonstrated that glycyrrhizin inhibits inflammatory cytokines including TNF-α, IL-1β, and IL-6, thereby reducing inflammation and tissue damage.

3.4. Flavonoids. Flavonoids constitute the second major class of phytochemicals in *Glycyrrhiza glabra*. More than **300 flavonoid derivatives** have been isolated.

These compounds exhibit potent antioxidant activity by neutralizing reactive oxygen species (ROS), reducing oxidative stress, and protecting DNA, proteins, and lipids from oxidative damage.

Glabridin has attracted particular attention because of its neuroprotective, cardioprotective, anti-obesity, and anti-aging properties.

3.5. Antioxidant Activity. Numerous experimental studies have confirmed that licorice possesses strong antioxidant capacity.

The antioxidant activity is mainly attributed to:

- flavonoids,
- phenolic acids,
- chalcones,
- coumarins.

These compounds enhance antioxidant enzyme activity, including:

- Superoxide dismutase (SOD)
- Catalase (CAT)
- Glutathione peroxidase (GPx)

Simultaneously, they reduce lipid peroxidation and oxidative stress biomarkers.

3.6. Anti-inflammatory Activity. Inflammation plays an essential role in many chronic diseases, including cardiovascular disorders, diabetes, arthritis, and cancer.

Licorice extracts suppress inflammatory pathways through:

- inhibition of cyclooxygenase (COX-2),
- inhibition of NF-κB signaling,
- decreased prostaglandin synthesis,
- reduced cytokine production.

Experimental studies have shown significant reductions in inflammatory markers following administration of glycyrrhizin-rich extracts.

3.7 Antiviral Activity. One of the most extensively investigated pharmacological properties of licorice is its antiviral activity.

Research indicates effectiveness against several viruses including:

- Influenza virus
- Hepatitis B virus
- Hepatitis C virus
- Herpes simplex virus
- Human immunodeficiency virus (HIV)
- Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV)
- SARS-CoV-2

The antiviral mechanisms include:

- inhibition of viral replication,
- interference with viral attachment,
- stimulation of interferon production,
- enhancement of immune responses.

3.8. Anticancer Activity. Several phytochemicals isolated from *Glycyrrhiza glabra* have demonstrated promising anticancer effects.

Reported mechanisms include:

- induction of apoptosis,
- inhibition of angiogenesis,
- suppression of tumor proliferation,
- inhibition of metastasis,
- regulation of cell-cycle progression.

Licochalcone A, glabridin, and isoliquiritigenin are considered among the most promising anticancer constituents.

3.9. Antimicrobial Activity. Licorice extracts exhibit antimicrobial activity against both Gram-positive and Gram-negative bacteria.

Sensitive microorganisms include:

- *Staphylococcus aureus*
- *Escherichia coli*
- *Bacillus subtilis*
- *Salmonella typhi*
- *Helicobacter pylori*

Antifungal activity has also been reported against:

- *Candida albicans*
- *Aspergillus niger*

These antimicrobial effects are primarily associated with flavonoids, chalcones, and essential oils.

4. Discussion. The findings of this review demonstrate that *Glycyrrhiza glabra* is one of the most pharmacologically valuable medicinal plants because of its rich phytochemical composition and broad spectrum of biological activities. More than 400 bioactive compounds have been identified in licorice, including triterpenoid saponins, flavonoids, coumarins, polysaccharides, phenolic acids, and essential oils. These compounds act either individually or synergistically to produce diverse therapeutic effects.

Among all identified constituents, glycyrrhizin remains the most extensively investigated compound. Numerous experimental and clinical studies have demonstrated that glycyrrhizin possesses potent anti-inflammatory, antiviral, hepatoprotective, antioxidant, and immunomodulatory activities. These pharmacological effects are mainly associated with inhibition of inflammatory cytokines, suppression of oxidative stress, and regulation of immune responses.

Flavonoids such as glabridin, liquiritigenin, liquiritin, and isoliquiritigenin also contribute significantly to the medicinal properties of licorice. Their antioxidant activity protects biological macromolecules from oxidative damage and may reduce the risk of chronic diseases, including cardiovascular disorders, diabetes mellitus, neurodegenerative diseases, and several forms of cancer.

Recent advances in analytical chemistry have considerably improved the identification and quantification of phytochemicals present in licorice. High-performance liquid chromatography (HPLC), liquid chromatography–mass spectrometry (LC–MS), gas chromatography–mass spectrometry (GC–MS), and nuclear magnetic resonance (NMR) spectroscopy have enabled researchers to characterize numerous minor constituents that were previously unknown. These technological developments have enhanced the standardization and quality control of herbal medicines derived from *Glycyrrhiza glabra*.

Clinical investigations indicate that licorice preparations may be beneficial in the treatment of gastric ulcers, chronic hepatitis, respiratory diseases, inflammatory skin disorders, and viral infections. During the COVID-19 pandemic, glycyrrhizin attracted renewed scientific interest because of its reported antiviral activity against coronaviruses. Although promising results have been reported, additional randomized clinical trials are still required to confirm its efficacy and safety in routine clinical practice.

Despite the numerous health benefits of licorice, excessive or prolonged consumption may lead to adverse effects. High doses of glycyrrhizin inhibit the enzyme 11β-hydroxysteroid dehydrogenase type 2, resulting in sodium retention, potassium loss, hypertension, edema, and pseudoaldosteronism. Therefore, standardized preparations, careful dosage selection, and appropriate clinical monitoring are essential for safe therapeutic use.

Future research should focus on identifying novel phytochemicals, improving extraction technologies, developing standardized pharmaceutical formulations, conducting large-scale clinical trials, and investigating the molecular mechanisms underlying the biological activities of licorice constituents.

5. Conclusion. *Glycyrrhiza glabra* L. is an important medicinal plant with remarkable phytochemical diversity and significant therapeutic potential. The plant contains numerous biologically active compounds, including glycyrrhizin, flavonoids, chalcones, coumarins, polysaccharides, phenolic acids, and sterols, which collectively contribute to its pharmacological properties.

Scientific evidence confirms that licorice possesses antioxidant, anti-inflammatory, antiviral, antimicrobial, hepatoprotective, gastroprotective, immunomodulatory, antidiabetic, and anticancer activities. These biological effects support its traditional use and highlight its potential for the development of modern pharmaceutical products and functional foods.

Although licorice demonstrates considerable medicinal value, its safe clinical application requires standardized preparations, appropriate dosage recommendations, and careful monitoring of potential adverse effects associated with excessive glycyrrhizin intake.

Continued phytochemical, pharmacological, and clinical investigations will further clarify the therapeutic mechanisms of licorice and facilitate the development of innovative plant-based medicines for the prevention and treatment of various human diseases.

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