PHYTOCHEMICAL AND PHARMACOLOGICAL REVIEW OF LICORICE (*Glycyrrhiza sp.*) - A TRADITIONAL LOCAL HERB FOR THE FUTURE OF MEDICINE

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ABSTRACT

The genus Glycyrrhiza (Fabaceae), with over 30 species, includes plants with abundant medicinal properties that have been prevalently used for a long time in traditional medicine. Today, along with the rapid development of modern medicine, this traditional medicine still plays an important role in the research and development of many new drugs. This report emphasized the contribution of some major components of Cam thao (Licorice), one of the species with multifaceted pharmacological effects and used to produce new drugs. Numerous studies have discovered that Licorice contains important substances that affect the physiological activities of living organisms, such as liquirtin, rhamnoliquirilin, liquiritigenin, prenyllicoflavone A, glucoliquiritin apioside, 1-metho-xyphaseolin, shinpterocarpine, shinflavanone, licopyranocoumarin, isoflavone, licoarylcoumarin, glycyrrhizin, and manifold components. In this review, the most recent research results within the last 5 years on the pharmacological effects of Licorice are systemized according to the role of Licorice on nervous, respiratory, digestive, immune, reproductive systems (both male *and female) and metabolism. It is predicted that Licorice (Fabaceae) will certainly continue to be the subject of manifold scientific works in the future. The effects that have been interesting in the scientific community recently are: oxidation prevention, memory impairment prevention, weight loss, reproductive function improvement in obese men, and immune system function enhancement in many types of cancer. In addition, previous and ongoing studies have shown that Glycyrrhizin, an active ingredient found in Licorice, is effective against Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) because of its antiviral activity. As a result, Licorice can be considered a promising future herbal medicine vital to individual and community health.*

Keywords: *Cam thao, Licorice, Glycyrrhiza uralensis, Glycyrrhiza glabra, Glycyrrhiza inflata.*

I. INTRODUCTION

From ancient times, mankind has used many types of medicinal herbs for ailments in traditional folk remedies from Eastern to Western countries. Today, along with the rapid development of modern medicine, traditional medicine still plays an important role in the research and development of many new drugs.

For thousands of years, Licorice has represented one of the most crucial traditional herbal medicines in Ayurvedic medicine. Anti-cancer, anti-atherosclerotic, anti-diabetic, anti-asthmatic effects and various pharmacological actions have all been discovered [8]. Licorice was also recognized for its ability to fight against certain viruses (HIV, HBV, HCV, HPV, Influenza virus…). Among them, SARS-CoV-2 was one of the most notable viruses found in December 2019. This was the respiratory virus, which originated in Wuhan city, China, and triggered a worldwide epidemic [14]. Licorice inhibits the virus's binding to the angiotensin-converting enzyme 2 (ACE-2) receptor both before and after it enters the body. Besides, glyasperin A, found in Licorice's composition, restrains the replication process by limiting viral replication in the body [6]. With the applications that have been investigated, Licorice will be one of the immensely potential medicinal herbs in the research of new drugs. This article will provide information related to Licorice, a legume with numerous noteworthy pharmacological activities in botanical traits, chemical composition, and new effects discovered worldwide in the last five years.

In the present review, we present a comprehensive description of the current knowledge of Licorice, including the botanical characteristics, chemical composition, and some results of new studies on the effects of Licorice on organ systems. It means anti-inflammatory effects on the nervous system, cough treatment, asthma, anti-SARS-CoV-2 virus, immunomodulatory activities, the effect of reducing colitis on the digestive system, the effect of improving menopausal symptoms, and the effect of improving semen parameters infection, and the effect of reducing BMI will be provided.

II. CONTENT

2.1. Botanical characteristics

Licorice is a precious medicinal plant prepared from the rhizomes and roots of several species of Kingdom: Plantae, Division: Angiospermae, Class: Dicotyledoneae, Order: Rosales, Family: Fabaceae, Genus: Glycyrrhiza with Greek origin 'glykos' meaning sweet and 'rhiza' meaning root. The genus Glycyrrhiza contains about 30 species worldwide, most of which are found in Asia [5]. The parts of Licorice plant are shown in **Figure 1**.

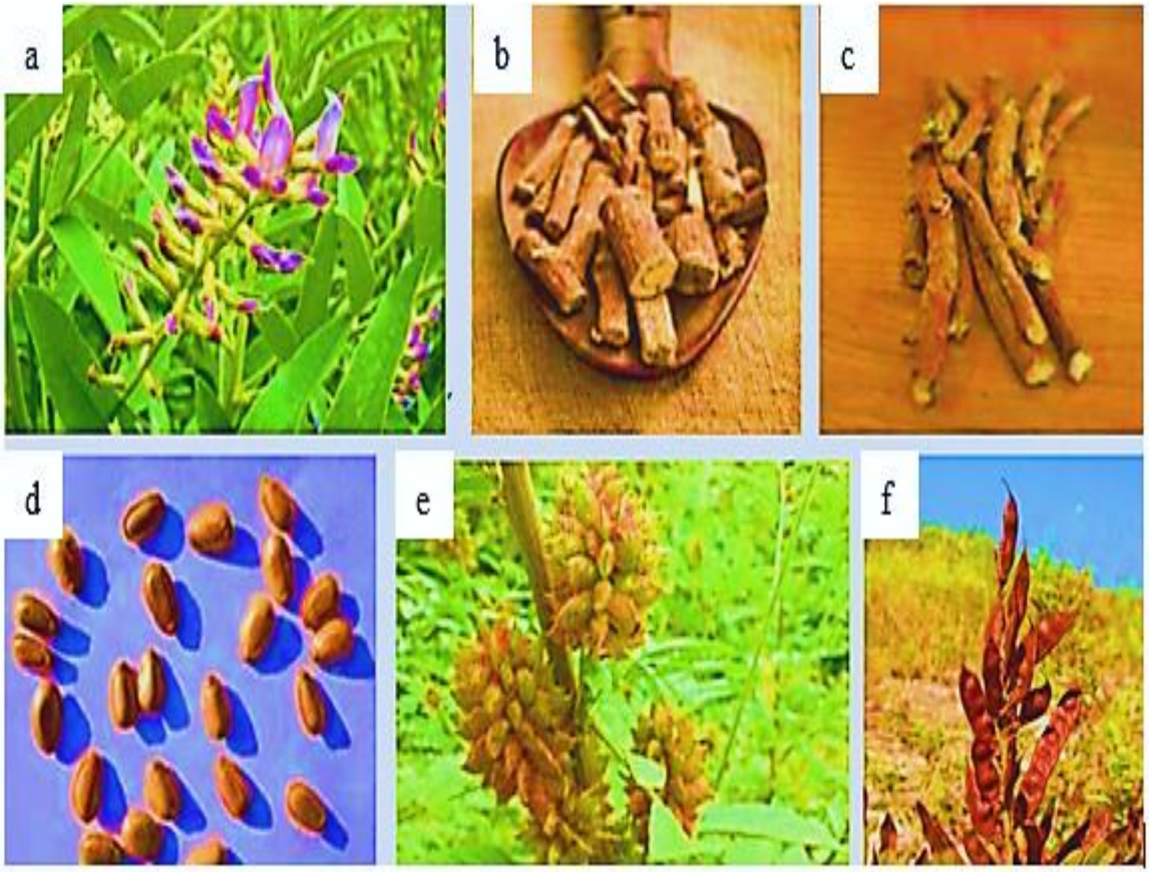

Figure 1. Parts of Licorice plant (*Glycyrrhiza Glabra*):
a) flower; b) dry stem; c) dry root; d) seed; e) fresh fruit; f) dried fruit [8].

Licorice is a perennial plant that comes in three varieties: *Glycyrrhiza uralensis* Fisch, *Glycyrrhiza glabra* L., and *Glycyrrhiza inflata* Batal [10]. Due to the same genus, it is frequently hard to distinguish the morphological characteristics of these three plants. Botanical studies frequently concentrate on the parts of these species used as roots and rhizomes. The roots of wild and cultivated Licorice have distinct characteristics [12]. In Vietnam, Licorice is used in various preventive and supportive treatments for acute respiratory infections caused by SARS-CoV-2, which is also related to the three species mentioned above [11].

2.2. Chemical composition

Licorice contains flavonoids, triterpene saponins, coumarin polysaccharides, and other phenols [10]. Among them, prominent ingredients are liquirtin, rhamnoliquirilin, liquiritigenin, prenyllicoflavone A, glucoliquiritin apioside, 1-metho-xyphaseolin, shinpterocarpine, shinflavanone, licopyranocoumarin, isoflavone, licoarylcoumarin, glycyrrhizin, and manifold components that are presented in **Table 1**.

Table 1. International Union of Pure and Applied Chemistry (IUPAC) name and chemical formula of bioactive molecules isolated from *Glycyrrhiza* [4].

No.	Compound	IUPAC name	Chemical formula
A	18-β-Glycyrrhetinic acid	(2R,4aS,6aS,6bR,8aR,10S,12aS,14bR)-10-hydroxy-2,4a,6a,6b,9,9,12a-heptamethyl-13-oxo-3,4,5,6,6a,7,8,8a,10,11,12,14bdode cahydro-1H-picene-2-carboxylic acid	$C_{30}H_{46}O_4$
B	1-Methoxyficifolinol	(6aR,11aR)-1-methoxy-2,8-bis(3-methylbut -2-enyl)-6a,11a-dihydro-6H-[1]benzofuro [3,2-c]chromene-3,9-diol	$C_{26}H_{30}O_5$
C	2,3-Butanediol	Butane-2,3-diol	$C_4H_{10}O_2$
D	Furfuraldehyde	Furan-2-carbaldehyde	$C_5H_4O_2$
E	Glabrene	8-(7-hydroxy-2H-chromen-3-yl)-2,2-di methylchromen-5-ol	$C_{20}H_{18}O_4$
F	Glabridin	4-[(3R)-8,8-Dimethyl-3,4-dihydro-2H,8H-pyrano[2,3-f]chromen-3-yl]-1,3-benzene diol	$C_{20}H_{20}O_4$
G	Glisoflavone	3-[3,4-dihydroxy-5-(3-methylbut-2-enyl) phenyl]-7-hydroxy-5-methoxychromen-4-one	$C_{21}H_{20}O_6$
H	Glycyrrhizic acid	(2S,3S,4S,5R,6R)-6-[(2S,3R,4S,5S, 6S)-2-[[(3S,4aR,6aR,6bS,8aS,11S,12aR,14aR, 14bS)-11-carboxy-4,4,6a,6b,8a,11,14b-heptamethyl-14-oxo-2,3,4a,5,6,7,8,9,10,12, 12a,14a-dodecahydro-1H-picen-3-yl]oxy]-6-carboxy-4,5-dihydroxyoxan-3-yl]oxy-3, 4,5-trihydroxyoxane-2-carboxylic acid	$C_{42}H_{62}O_{16}$
I	Glycyrrhizin	(3β,20β)-20-carboxy-11-oxo-30-norolean-12-en-3-yl-2-O-β-D-glucopyranuronosyl-α-D-glucopyranosiduronic acid	$C_{42}H_{62}O_{16}$
J	Isoangustone A	3-[3,4-dihydroxy-5-(3-methylbut-2-enyl) phenyl]-5,7-dihydroxy-6-(3-methylbut-2-enyl) chromen-4-one	$C_{25}H_{26}O_6$
K	Isoliquiritigenin	(E)-1-(2,4-Dihydroxyphenyl)-3-(4-hydroxy phenyl)prop-2-en-1-one	$C_{15}H_{12}O_4$
L	Kanzonol R	3-[2-hydroxy-4-methoxy-3-(3-methylbut-2-enyl)phenyl]-5-methoxy-3,4-dihydro-2H-chromen-7-ol	$C_{22}H_{26}O_5$
M	Licoarylcoumarin	3-(2,4-dihydroxyphenyl)-7-hydroxy-5-methoxy-8-(2-methylbut-3-en-2-yl)chro men-2-one	$C_{21}H_{20}O_6$
N	Licochalcone A	(E)-3-[4-Hydroxy-2-methoxy-5-(2-methyl but-3-en-2-yl)phenyl]-1-(4-hydroxyphenyl) prop-2-en-1-one	$C_{21}H_{22}O_4$
O	Licocoumarin A	3-[2,4-dihydroxy-3-(3-methylbut-2-enyl) phenyl]-7-hydroxy-8-(3-methylbut -2-enyl) chromen-2-one	$C_{25}H_{26}O_5$

No.	Compound	IUPAC name	Chemical formula
P	Licopyrano-coumarin	7-(2,4-dihydroxyphenyl)-2-(hydroxymethyl) -5-methoxy-2-methyl-3,4-dihydropyrano[3, 2-g]chromen-8-one	$C_{21}H_{20}O_7$
Q	Licoriphenone	1-(2,4-dihydroxyphenyl)-2-[6-hydroxy-2,4 -dimethoxy-3-(3-methylbut-2-enyl) phenyl]ethanone	$C_{21}H_{24}O_6$
R	Liquiritigenin	(2S)-7-Hydroxy-2-(4-hydroxyphenyl)-2,3-dihydro-4H-chromen-4-one	$C_{15}H_{12}O_4$
S	Liquiritin	(2S)-7-hydroxy-2-[4-[(2S,3R,4S,5S,6R)-3, 4,5-trihydroxy-6-(hydroxymethyl)-oxan-2-yl]oxyphenyl]-2,3-dihydrochromen-4-one	$C_{21}H_{22}O_9$
T	Prenyllicoflavone A	7-Hydroxy-2-[4-hydroxy-3-(3-methyl-2-buten-1-yl)phenyl]-6-(3-methyl-2-buten -1-yl)-4H-1-benzopyran-4-one	$C_{25}H_{26}O_4$
U	Semilicoisoflavone B	5,7-dihydroxy-3-(8-hydroxy-2,2-dimethyl chromen-6-yl) chromen-4-one	$C_{20}H_{16}O_6$
V	Shinpterocarpin	(2R,10R)-17,17-dimethyl-3,12,18-trioxa pentacyclo[11.8.0.02,10.04,9.014,19] henicosa-1(13),4(9),5,7,14(19),15,20-heptaen-6-ol	$C_{20}H_{18}O_4$
W	Tetramethyl pyrazine	Tetramethylpyrazine-2,3,5,6-tetracarboxy late	$C_{12}H_{12}N_2O_8$
X	α-Terpineol	2-(4-Methylcyclohex-3-en-1-yl)propan-2-ol	$C_{10}H_{18}O$

Table 1 shows that the majority of Licorice's components are flavonoids and saponins.

2.3. Pharmacological effects

Licorice was a medicinal herb prevalently used in traditional Chinese medicine to treat hepatitis, influenza flu, and stomach ulcers [10]. It has pharmacological activities on various systems such as the central nervous system and endocrine system; liver, renal, and pancreatic protection function; anti-ulcer, anti-inflammatory, anti-allergic, anti-viral, antibacterial, and immune system boosting effects, antioxidant, anti-diabetic and memory impairment prevention [16]. In addition, Licorice also has effects on reducing cough, reducing spasms, loosening phlegm, and eliminating agents that cause upper respiratory tract obstruction due to the effect of increasing mucus secretion in the trachea. These effects are displayed in **Figure 2**.

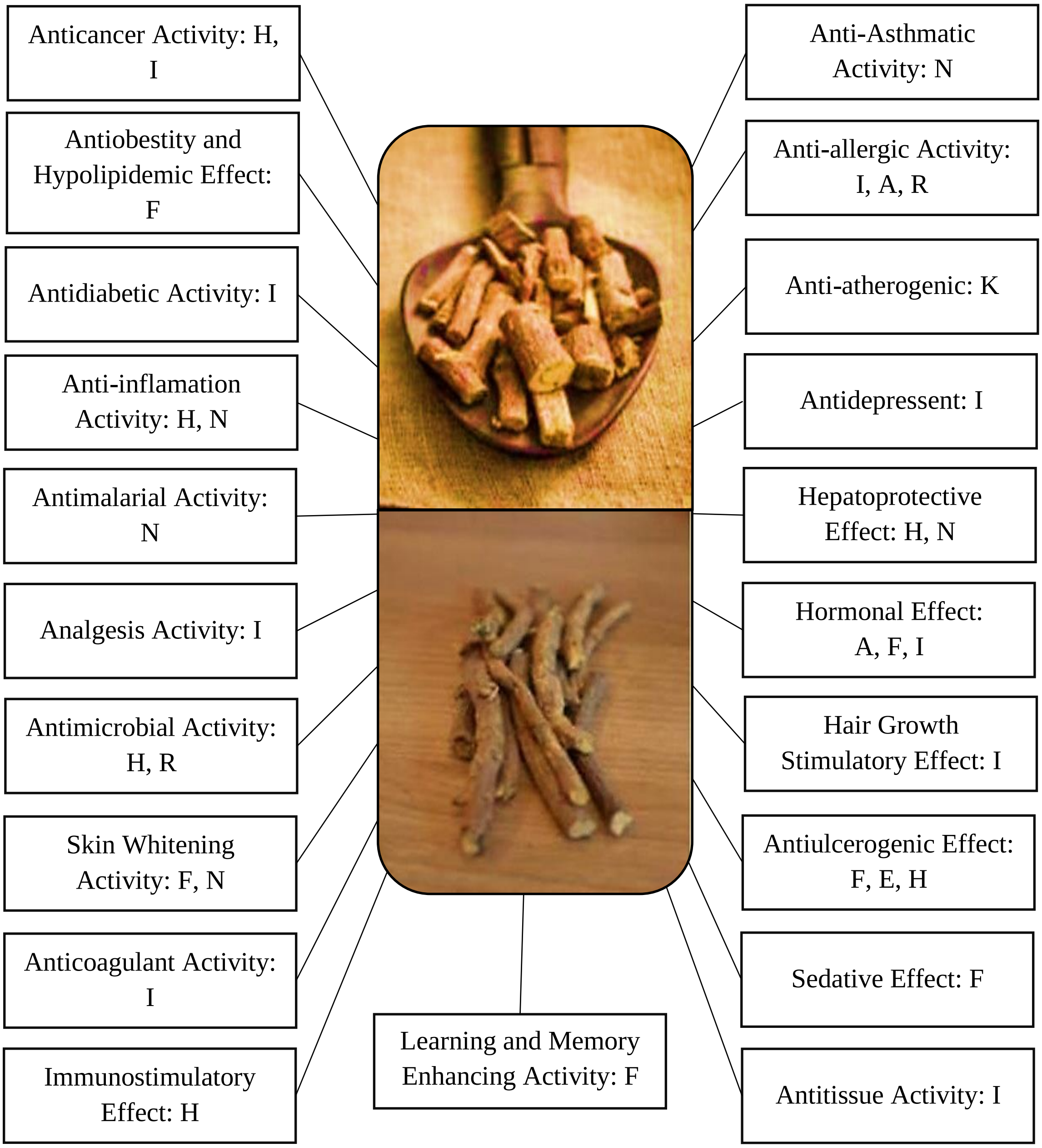

Figure 2. List of Bioactive compounds being available in Licorice and their role in alleviating different physiological ailments [8].

2.3.1. Effects on the nervous system

In vitro testing revealed the anti-inflammatory effect of Licorice (*Glycyrrhiza uralensis*) in a study on its neuroprotective activity. The anti-neuroinflammatory potential of Licorice was evaluated through the inhibition of nitric oxide (NO) production of lipopolysaccharide (LPS) in murine microglial BV-2 cells by Griess reaction, and the results are summarized in **Table 2** [13]. In this way, the anti-inflammatory effect of LPS was evaluated *in vitro*, promising in reducing the incidence of neurological disorders such as Parkinson's and Alzheimer's disease.

Table 2. IC_{50} values of compounds 1-14 inhibiting NO production in BV-2 Cells [13].

Compound	IC_{50} (µg/mL)	Compound	IC_{50} (µg/mL)
(2R)-liquiritigenin-7-O-β-D-glucopyranosyl-(2→1)-O-β-D-apiofuranoside	>50	Licuraside	>50
(2S)-liquiritigenin-7-O-β-D-glucopyranosyl-(2→1)-O-β-D-apiofuranoside	>50	Liquiritigenin-7,4'-di-O-β-D-glucopyranoside	>50
18β-glycyrrhetinic acid-3-O-D-glucuronide	>50	Liquiritin	>50
3,4-dihydroxyquinoline 4-O-β-D-glucopyranoside	48.6±1.7	Liquiritin apioside	>50
Isoliquiritigenin-4,4'-di-O-β-D-glucopyranoside	>50	Neoisoliquiritin	47.1±1.7
Isoliquiritin	39.8±1.6	Neoliquiritin	30.8±1.5
Isoliquiritin apioside	>50	Ononin	>50
Curcumin*	1.9±0.3	*Curcumin was used as a positive control.	

According to IC_{50} values, four compounds with IC_{50} values less than 50g/mL increase the inhibitory activities of LPS-stimulated NO production in BV-2 cells.

2.3.2. Effects on the respiratory system

Licorice powder and extracts are effective in treating upper respiratory tract infections. Glycyrrhizin, in particular, is a chemical that acts as an expectorant, reduces secretions, aids in reducing upper respiratory tract blockage, and increases mucus secretion in the bronchi. Capsaicin, which causes cough, can be inhibited by liquiritinapioside. In addition, ethanolic extract of Licorice has been shown to prevent sulfur dioxide induced cough in mice. Licorice soothes irritation and works similarly to codeine to cure sore throats [8]. Because of its antiviral action against SARS-CoV, glycyrrhizin is a promising active ingredient with the potential effect against SARS-CoV-2. Furthermore, the strong structural and genetic similarity of SARS-CoV and SARS-CoV-2 underlines Licorice's potential against SARS-CoV-2. SARS-CoV-2 infection is largely reliant on the ACE2 receptor. The glycyrrhizin's hydrophobicity allows it to attach to the hydrophobic portion of ACE2 and prevents the SARS-CoV-2 from binding. The nasal epithelium had the highest level of ACE2 of all respiratory epithelial cells, followed by the oral epithelium, suggesting that the nose and mouth were the first places SARS-CoV-2 invaded [6]. Based on the findings, topical glycyrrhizin administration in the nose and oral cavity would be the body's first line of defense against-SARS-CoV-2’s invasion.

2.3.3. Effects on the digestive system

The recovery effect of peptic ulcers has been a conventional use of Licorice, but there are still interesting new studies on this effect of Licorice that have been conducted. In a study on the reduction of Irinotecan (CPT-11)-induced colitis of total flavonoid of *Glycyrrhiza uralensis* (TFGU) by altering the intestinal and fecal microbiota, it was shown that TFGU reduces significantly reduced body weight and shortened colon length induced by CPT-11. Mice were orally administered TFGU at a dose of 135mg/kg, and were intraperitoneally injected with CPT-11 40mg/kg to induce colitis the day after. After 10 days, fresh stools were collected, colon tissue removed, and cecum and colon length measured.

Histopathological analysis showed that TFGU significantly reduced inflammatory cell infiltration and partially rescued tissue structures destroyed by CPT-11. On the other hand, TFGU also altered the structure and function of the gut microbiota, as examined through fecal metabolism in treated mice [15]. In conclusion, the study has shown the remarkable efficacy of TFGU in treating CPT-11-induced colitis.

2.3.4. Effects on the immune system

Licorice has been shown in numerous studies to have immunoregulatory effects on experimental malignancies. A study of the immunomodulatory action of Licorice *(Glycyrrhiza uralensis Fisch)* polysaccharide in tumor-bearing CT-26 mice showed substantial changes in the tumor as well as immunological organs such as the thymus and spleen ($p<0.05$) and enhanced the general health of mice. Increases the index of immunological organs while inhibiting tumor growth. Polysaccharides also significantly impacted cytokine production, raising the levels of interleukin 2 (IL-2), IL-6, and IL-7, while decreasing tumor necrosis factor (TFN) levels. The polysaccharide extracts (A, B, and C, each with 20 animals) were administered orally to mice at a dose of 500 mg/kg per day for 14 days. Extraction B (with final alcohol concentration after precipitation with 95% alcohol was 57-82%) had the most change compared with extracts A and C (A: 57%, C: 82%) [3]. Another investigation on the immunostimulatory activity of the polysaccharide of Licorice *(Glycyrrhiza uralensis)* also revealed that the polysaccharide extracted from Licorice dramatically raised the percentage of immune cells in the spleen, including CD3+, CD11c+, CD11b+, CD19+…. Simultaneously, the ratio and activation (CD44+) of CD8+ T cells were significantly improved. In addition, the study also showed that Licorice increased serum IL-12 levels and not TFNα. The mouse model of immunosuppression by subjecting BALB/c mice to cyclophosphamide 80mg/kg intraperitoneally daily for 3 days. On day 4, mice were treated intraperitoneally with 20mg/kg of extracted polysaccharide (93% polysaccharide content) daily for 7 days with 5 samples [2]. A study on the lung cancer growth inhibitory effect of Licorice *(Glycyrrhiza uralensis Fisch)* demonstrated that Licorice induces G0/G1 phase cell cycle arrest by upregulating the cyclin-dependent kinase 4 (CDK4) - Cyclin D1 complex on tumor cells through *in vivo* and *in vitro* assays. In the *in vivo* test, the group of mice administered Licorice with anti-PD-L1 antibody reduced the tumor volume by 54.7%. Meanwhile, *in vitro* test was performed and Licorice treatment markedly decreased CDK4 and Cyclin D1 abundance and resulted in significant PD-L1 accumulation. On the other hand, Licorice boosted antigen-presenting gene expression and CD8+ T cell infiltration in the tumor microenvironment (TME) [17]. In conclusion, the preceding research outcomes show that Licorice has a considerable impact on immune function in cancer treatment. It is a prospective medicinal plant for supporting and replacing chemotherapy and radiation in cancer treatment.

2.3.5. Effects on the genitourinary system

The effects on the reproductive system are probably less well known regarding Licorice. Nevertheless, studies on the effects of Licorice on the reproductive system in both men and women continue to be conducted.

Female genital system

Research on the improvement of menopausal symptoms of Licorice *(Glycyrrhiza uralensis)* using bioconversion with *Monascus albidulus* has shown that *Monascus*-fermented Licorice contains high levels of liquiritigenin and monacolin K, at the same time can exhibit high estrogen receptor beta (ERβ)-selective binding activity. The fermented Licorice in this study exhibited estrogen receptor (ER)-binding activity, specifically binding to ERβ (82.5%). This suggests that fermented Licorice may have an advantage in alleviating menopausal symptoms over other phytoestrogens with low side effects [9]. As a result, Licorice is a potential therapeutic herb that can be used to prevent and treat menopausal symptoms, especially given the current demand for natural medicine.

Male genital system

In a 16-week study on the improving effects of Licorice *(Glycyrrhiza glabra)* on sperm parameters in rats fed a high-fat diet (HFD), a significant increase in sperm motility was observed. Licorice at the dose regimen of 50mg/kg (GC50) and 100mg/kg (GC100) were 52.9±2.86 and 55.94±3.71, respectively, compared with the HFD group (p=0.01 and p=0.000, respectively) as well as improved sperm count and abnormal morphology compared with HFD rats. The sperm count in the GC100 group also rose noticeably ($6.62\times10^6\pm0.55$) compared with the control group ($3.75\times10^6\pm0.61$), p=0.01. Although GC100 treatment significantly reduced abnormal sperm morphology compared with the HFD group (p=0.02), there was still a dramatic increase compared with the control group (p=0.000) [7]. Through the results of the above study, we found a remarkable effect of Licorice in improving sperm parameters in HFD rats.

2.3.6. Effects on metabolic function

In another study of rats that were fed an HFD diet for 16 weeks, rats were given Licorice at doses of 50mg/kg (GC50), and 100mg/kg (GC100) had a significant reduction in BMI compared to the HFD group (p=0.04). Simultaneously, the GC50 and GC100 groups drastically reduced fat weight compared to the HFD group (p=0.04). GC50, on the other hand, greatly decreased triglyceride and leptin levels in rats on the HFD regimen (p=0.02) [7]. It was discovered that Licorice had a significant impact on rat metabolic function, particularly lipid metabolism.

III. RESULTS

From the analysis of the results of research works in the last half-decade, Licorice (Fabaceae) will certainly continue to be the subject of manifold scientific works in the future. Indeed, experimental studies are immensely useful for testing pharmacological action and finding new therapeutic drugs containing Licorice. The effects that have been interesting in the scientific community recently are: oxidation prevention, memory impairment prevention, weight loss, reproductive function improvement in obese men, and immune system function enhancement in many types of cancer. In addition, the effect of preventing the entry of viruses to the host cells, including the causative agent of Coronavirus disease (COVID-19), SARS-CoV-2, also requires more research results to have enough scientific evidence about the antiviral effect or activity of Licorice.

IV. CONCLUSIONS

Licorice (Fabaceae) contains the main components, including flavonoids, triterpene saponins, coumarin polysaccharides, and other phenols. Those active compounds are potential effects in neuroprotection, upper respiratory tract disorder treatment, immune improvement for cancer patients, blood fat reduction, weight loss, endocrine and reproductive function improvement, especially SARS-CoV-2 entry inhibition ability.

REFERENCES

1. Abraham J. and Florentine S. (2021), "Licorice (Glycyrrhiza glabra) extracts-suitable pharmacological interventions for COVID-19? A review", Plants, 10(12), 2600.
2. Aipire A., Mahabati M., Cai S., Wei X., Yuan P., et al. (2020), "The immunostimulatory activity of polysaccharides from Glycyrrhiza uralensis", PeerJ, 8, e8294.
3. Ayeka P. A., Bian Y., Githaiga P. M., and Zhao Y. (2017), "The immunomodulatory activities of Licorice polysaccharides (Glycyrrhiza uralensis Fisch) in CT 26 tumor-bearing mice", BMC Complementary and Alternative Medicine, 17(1), pp. 1-9.
4. Batiha G. E. S., Beshbishy A. M., El-Mleeh A., Abdel-Daim M. M., and Devkota H. P. (2020), "Traditional uses, bioactive chemical constituents, and pharmacological and toxicological activities of Glycyrrhiza glabra L.(Fabaceae)", Biomolecules, 10(3).
5. Bisht D., Rashid M., Arya R. K. K., Kumar D., Chaudhary S. K., et al. (2021), "Revisiting Liquorice (Glycyrrhiza glabra L.) as anti-inflammatory, antivirals and immunomodulators: potential pharmacological applications with mechanistic insight", Phytomedicine Plus, 100206.
6. Chrzanowski J., Chrzanowska A., and Graboń W. (2021), "Glycyrrhizin: An old weapon against a novel coronavirus", Phytotherapy Research, 35(2), pp. 629-636.
7. Ghorbanlou M., Rostamkhani S., Shokri S., Mahmazi S., Fallah R., et al. (2020), "Possible ameliorating effects of Glycyrrhiza glabra (Licorice) on the sperm parameters in rats under high fat diet", Endocrine regulations, 54(1), pp. 22-30.
8. Hasan M. K., Ara I., Mondal M. S. A., and Kabir Y. (2021), "Phytochemistry, pharmacological activity, and potential health benefits of Glycyrrhiza glabra", Heliyon, 7(6), e07240.
9. Kim K. U., Lee S. J., and Lee I. (2020), "Development of an Improved Menopausal Symptom - Alleviating Licorice (Glycyrrhiza uralensis) by Biotransformation Using Monascus albidulus", J. Microbiol. Biotechnol, 30:178-186.
10. Li F., Liu B., Li T., Wu Q., Xu Z., et al. (2020), "Review of constituents and biological activities of triterpene saponins from Glycyrrhizae Radix et Rhizoma and its solubilization characteristics", Molecules, 25(17), 3904.
11. National Institute of Medicinal Materials (2020), "A number of medicinal herbs, traditional herbs and medicinal plants are used in the prevention and treatment of acute respiratory infections caused by SARS-CoV-2".
12. Wang H., Song W., Tao W., Zhang J., Zhang X., et al. (2021), "Identification wild and cultivated licorice by multidimensional analysis", Food Chemistry, 339, 128111.
13. Wei G., Da H., Zhang K., Zhang J., Fang J., and Yang Z. (2021), "Glycoside compounds from Glycyrrhiza uralensis and their neuroprotective activities", Natural Product Communications, 16(2), 1934578X21992988.
14. Wu D., Wu T., Liu Q., and Yang Z. (2020), "The SARS-CoV-2 outbreak: what we know", International Journal of Infectious Diseases, 94, pp. 44-48.
15. Yue S. J., Qin Y. F., Kang A., Tao H. J., Zhou G. S., et al. (2021), "Total flavonoids of Glycyrrhiza uralensis alleviates irinotecan-induced colitis via modification of gut microbiota and fecal metabolism", Frontiers in immunology, 12, 1588.
16. Zhao S., Yan X., Zhao Y., Wen J., Zhao Z., and Liu H. (2018), "Dihydroisocoumarins from Radix Glycyrrhizae", Chemistry Central Journal, 12(1), pp. 1-6.
17. Zhu J., Huang R., Yang R., Xiao Y., Yan J., et al. (2021), "Licorice extract inhibits the growth of non-small cell lung cancer by down-regulating CDK4-Cyclin D1 complex and increasing CD8+ T cell infiltration", Cancer cell international, 21(1), pp. 1-18.

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