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## REVIEW ARTICLE

# A REVIEW ON CONSTITUENTS, PHARMACOLOGICAL ACTIVITIES AND MEDICINAL USES OF *GLYCYRRHIZA GLABRA*

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### ABSTRACT

Plants have been one of the important sources of medicines for human being and animals since the ancient time. At present scenario there is an increasing demand for herbal medicines, health products and pharmaceuticals products. Herbal medicines have attained popularity at global level to replace the synthetic chemicals as they have shown less adverse reactions.

*Glycyrrhiza glabra* Linn is a commonly used herb for different diseases. Present review article deals with chemical constituents present in various parts of *Glycyrrhiza glabra* and pharmacological activities. Present article aim to comply all the updated information on its phytochemical and pharmacological activities, which were performed by widely different methods. *Glycyrrhiza glabra* Linn possesses antibacterial, antioxidant, antimalarial, antispasmodic, anti-inflammatory and anti-hyper glycemc properties. Various other effects like antiulcer, antiviral, antifungal have also been discussed. This article may be useful for many researchers in discovering potential therapeutic effects and developing new formulations.

**Keywords:** Antibacterial, anti malarial, antioxidant, *Glycyrrhiza glabra*, glycyrrhizin.

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### INTRODUCTION

Human beings have used plants for medicinal purposes for centuries. It has been estimated that such use of medicinal plants possibly go back in time to around 3000 years. Today, a great percentage of the world population, particular in developing countries, uses plants for facing primary needs of medical assistance<sup>1</sup>. Modern drugs like aspirin, atropine, ephedrine, digoxin, morphine, quinine, reserpine and tubocurarine are examples, which were originally discovered through observations of traditional cure methods of indigenous people<sup>2</sup>. *Glycyrrhiza glabra* has been known in pharmacy for thousands of years. In old Chinese pharmacy, it was considered to belong to drugs of the first class and to it was ascribed the rejuvenating property when consumed for long periods<sup>3</sup>. In ancient Egypt, Greece and Rome licorice was frequently used. The earliest record of its use in medicine is found in "code Humnubari" (2100 BC)<sup>4</sup>. It was also one of the important plants mentioned in Assyrian herbal (2000 BC). Hippocrates (400 BC) mentioned its use as a remedy of ulcers and quenching of thirds. The drug was also mentioned by Theophrastus and Dioscorides. In traditional Siddha

system of medicine, liquorice is used as a demulcent, expectorant, anti-tussive, laxative and sweetener<sup>5</sup>.

### Distribution/ habitat

This plant is cultivated in Russia, UK, USA, Italy, France, Germany, Spain, China and Northern India (Punjab and Sub-Himalayan tracts). It is distributed in Southern Europe, Syria, Iran, Afghanistan, Russia, China, Pakistan and Northern India. Large scale commercial cultivation is seen in Spain, Sicily and England<sup>10</sup>.

**Table 1: Classification**

Kingdom	Plantae
Subkingdom	Tracheobionta-Vascular plants <sup>6</sup>
Super division	Spermatophyta-Seed plants
Division	Magnoliophyta
Class	Magnoliopsida <sup>7</sup>
Subclass	Rosidae
Order	Fabales <sup>8</sup>
Family	Fabaceae-Pea family
Genus	<i>Glycyrrhiza</i> licorice <sup>9</sup>
Species	<i>Glycyrrhiza glabra</i> L



Figure 1: Leaves, flower, root and powder of *Glycyrrhiza glabra*

### Cultivation

It is a perennial herb/ sub shrub for subtropical and temperate zone. Young pieces of stolons having 2-3 buds of aerial shoot are used for propagation. Three to four feet deep soil having light, loamy, stone-free texture is needed for the plant<sup>11</sup>. It is usually grown continuously on the same land. Licorice enjoys fertile, sandy or clay soil near a river or stream where enough water is available for the plant to flourish in the wild, or under cultivation where it can be irrigated. The pieces of stolons are planted in March at 2' by 3' distance. The plant attains a maximum height up to 2 m. The underground stem grow horizontally up to 2 m length, highly branched consisting of short taproot with large number of rhizomes<sup>12</sup>. The roots are harvested 3-4 years after planting when they show sufficient growth. Dry conditions at planting time and for the next two months give best chance for a good crop. A yield of two tons of roots per acre for bailing, plus 3-4 cwt of trimmings or offal is considered satisfactory. Rhizomes and roots are dug up in October, from the plants which have not borne the fruits. Drug is washed after removal of buds and rootlets. Some pieces are peeled and divided into small pieces. The drug is dried first under sun and then in shades, during which it loses about 50 per cent of its weight<sup>13</sup>.

### Morphology

**Leaves-** are compound, imparipinnate, alternate, having 4-7 pairs of oblong, elliptical or lanceolate leaflets covered with soft hairs on underside.

**Flowers-** are narrow, typically papilionaceous, axillary spikes, lavender to violet in color. The calyx is short, campanulate, with lanceolate tips and bearing glandular hairs<sup>14</sup>.

**Fruit-** is a compressed legume or pod, up to 1.5 cm long, erect, glabrous, somewhat reticulately pitted, and usually contains, 3-5 brown, reniform seeds<sup>15</sup>.

**Root-** is approximately 1.5 cm long and subdivides into subsidiary roots, about 1.25 cm long, from which the horizontal woody stolons arise. They may reach 8 m and when dried and cut, together with the root, constitute commercial licorice. It may be found peeled or unpeeled. The pieces of root break with a fibrous fracture, revealing the yellowish interior with a characteristic odor and sweet taste<sup>16</sup>.

### Chemical constituents

Flavonoid rich fractions include liquiritin, isoliquertin, liquiritigenin and rhamnoliquiritin and five new flavonoids-glucoliquiritin apioside, prenyllicoflavone A, shinflavanone, shintpaterocarpin and 1-methoxyphas-eolin isolated from dried roots. The roots of *Glycyrrhiza glabra* Linn contain glycyrrhizin, which is a saponin that is 60 times sweeter than cane sugar. Both glycyrrhizin and glycyrrhetic acid can exist in the 18 $\alpha$  and 18 $\beta$  stereoisomers<sup>17</sup>. Isolation and structure determination of licopyranocoumarin, licoarylcoumarin, glisoflavone together with a new coumarin-GU-12 are also reported. Four new isoprenoid-substituted phenolic constituents-semilicoisoflavone B, 1-methoxyficifolinol, isoangustone A, and licoriphenone had isolated from roots<sup>18</sup>. Also a new prenylated isoflavan derivative, kanzonol R was also isolated<sup>19</sup>.

The presence of many volatile components such as pentanol, hexanol, linalool oxide A and B, tetramethyl pyrazine, terpinen-4-ol,  $\alpha$ -terpineol, geraniol and others in the roots are also reported. In addition presence of propionic acid, benzoic acid, ethyl linoleate, methyl ethyl ketone, 2, 3-butanediol, furfuraldehyde, furfuryl formate, 1-methyl-2-formyl pyrrole, trimethyl pyrazine, maltol and other compounds are also isolated from the essential oil.

Table 2: Quantitative standards

Total ash	Not more than 4.5 %
Acid insoluble ash	Not more than 1.5%
Water soluble ash <sup>20</sup>	Not more than 1%
Aqueous extractive value	Not less than 20%
Ethanol extractive value	Not less than 15%
Chloroform extractive value <sup>21</sup>	Not less than 5%
Water soluble extractive	Not less than 20%
Moisture content <sup>22</sup>	Not more than 7.45%

### Pharmacology

After oral administration of licorice in humans, the main constituent, glycyrrhizic acid, is hydrolyzed to glycyrrhetic acid by intestinal bacteria possessing a specialized  $\beta$ -glucuronidase. Glycyrrhetic acid is 200-1,000 times more potent an inhibitor of 11- $\beta$ -hydroxysteroid dehydrogenase (involved in corticosteroid metabolism) than glycyrrhizic acid<sup>23</sup>.

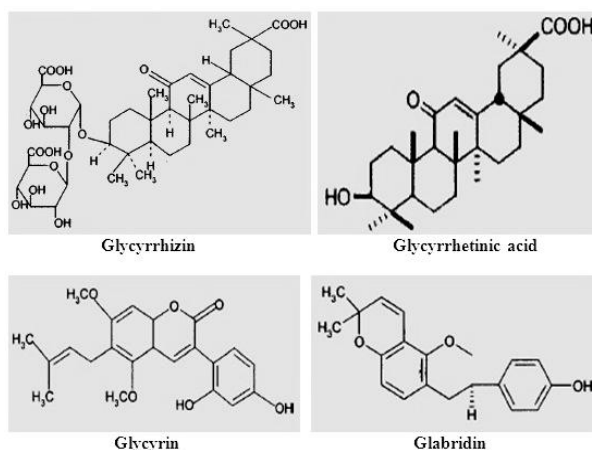


Figure 2: Chemical structure of some active constituents of *Glycyrrhiza glabra*

After oral dosing, glycyrrhetic acid is rapidly absorbed and transported via carrier molecules to the liver. In the liver it is metabolized to glucuronide and sulfate conjugates, which are subsequently rehydrolyzed to glycyrrhetic acid<sup>24</sup>. Glycyrrhetic acid is then reabsorbed, resulting in a significant delay in terminal clearance from plasma. In the 24-hour period after oral administration, glycyrrhizin was found in the urine, indicates it's partly absorption as an intact molecule<sup>25</sup>.

#### Traditional uses

1. A decoction of madhuka or its powder is generally prescribed with honey in anemia.
2. After mixing with cow's milk it is used for promoting lactation<sup>26</sup>.
3. 10g powder of it mixed with 10g sugar, pounded with rice water is commonly prescribed in menorrhagia.
4. A confection of rice milk, prepared with Yashtimadhu, is used treatment of hoarseness of voice.
5. Charaka prescribed 10 g madhuka powder mixed with honey, followed by intake of milk, as an aphrodisiac and as an intellect-promoting tonic<sup>27</sup>.
6. Charaka prescribed paste of licorice and *Picirrhiza kurroa* with sugar water as a cardio-tonic.
7. Charaka prescribed Yashtimadhu and *Santalum album*, powdered with milk in haematemesis.
8. Sushrata prescribed the paste of Yashti madhu 10g in intrinsic haemorrhage<sup>28</sup>.
9. In oedema, paste of licorice and *Sesamum indicum*, milk mixed with butter is used.
10. Warm clarified butter mixed with licorice, is used topically on wounds, bruises and burns.
11. A decoction of madhuka is used on erysipelas.
12. A decoction of the root is a good wash for falling and greying of hair<sup>29</sup>.

## PHARMACOLOGICAL ACTIVITIES

### 1. Anti-tussive and Antidemulcent activity

The licorice powder and extract were found to be effective in the treatment of sore throat, cough and bronchial catarrh. Licorice has been shown to work as efficiently as codeine in sore throat. It decreases irritation and produces expectorant effects. Carbenoxolone (a semi synthetic compound derived

from *Glycyrrhiza*) stimulates gastric mucus secretion. Glycyrrhizin is responsible for demulcent action of liquorice. Liquiritin apioside, an active compound present in the methanolic extract of liquorice which inhibits capsaicin induced cough<sup>30</sup>.

### 2. Antioxidant activity

*Glycyrrhiza* have a significant free-radical quenching effect. Licorice flavonoids have exceptionally strong antioxidant activity. Antioxidant activity of licorice flavonoids was found to be over 100 times stronger than that of antioxidant activity of vitamin E. Thus, licorice extract can be efficiently used to formulate cosmetic products for the protection of skin and hair against oxidative damage<sup>31,32</sup>.

### 3. Anti-malarial activity

Licochalcone A (a chalcone) present in liquorice is responsible for antimalarial activity. A previous reported study against *P. yoelii* in mice with oral doses of 1000 mg kg<sup>-1</sup> have shown to eradicate malaria parasite completely<sup>33</sup>.

### 4. Anti-fungal activity

*Glycyrrhiza glabra* possess good anti fungal activity. In a previous reported study of screening for antifungal compounds from various plant materials, licorice extract with 80% methanol (oil-based extract of licorice; OEL) was found to possess high fungicidal effect against *Arthrimum sacchari* M001 and *Chaetomium funicola* M002 and its active compound was identified as glabridin<sup>34</sup>. Thus, licorice extract has a great potential in formulating cosmetic products with antiseptic activities.

### 5. Immunostimulatory activity

A studies proved that *Glycyrrhiza glabra* at 100µg/ml concentration, possess immunostimulatory effects. It increases production of TCD69 lymphocytes and macrophages from human granulocytes. In a previous reported study, licorice root extract was found to prevent the rise in the amount of immune-complexes related to autoimmune diseases like systemic lupus erythematosus<sup>35</sup>.

### 6. Anti ulcer activity

Glycyrrhizic acid, a major component of licorice, has antiulcer effect by raising the local concentration of prostaglandins that promote mucous secretion and cell proliferation in the stomach. In a previous reported study activity of *Extractum liquiritiae* (EL),

glycyrrhizic acid, glycyrrhetic acid and a novel lipophilic derivative of glycyrrhetic acid monoglucuronide (GAMG), acetylated GAMG (aGAMG), were active against 29 *Helicobacter pylori* strains. The potent *in vitro* activity of glycyrrhizic acid against *H. pylori* concludes its beneficial effect on peptic ulcers<sup>36</sup>.

#### 7. Anti dyslipidaemic effect

In a previous reported study ethanolic (95%) extract of root of *Glycyrrhiza glabra* and its fractions were investigated for its antidyslipidaemic activity on dyslipidaemic hamsters. The reduction in LDL-cholesterol level by ethanolic extract, ethyl acetate soluble fraction and water soluble fraction were 43.9, 31.0, 33.4 and 24.6%, respectively. The treatment with *Glycyrrhiza glabra* root ethanolic extract and its fractions significantly brought down LDL and VLDL in the HFD fed hamsters to various degrees<sup>37</sup>.

#### 8. Anti-bacterial Activity

Secondary metabolites such as; saponins, alkaloids and flavonoids present in hydro-methanolic root extract of *Glycyrrhiza glabra*, possess potent antibacterial activity against *Staphylococcus aureus*. Moreover various studies on aqueous and ethanolic extracts of liquorice proved its inhibitory activity on cultures of *Staphylococcus aureus* and *Streptococcus pyogenes*<sup>38</sup>.

#### 9. Anti-viral effects

It is reported that liquorice extract inhibits the growth of viruses, including herpes simplex, Varicella zoster, Japanese encephalitis, influenza virus, vesicular stomatitis virus and type A influenza virus. Glycyrrhizin does not allow the virus cell binding. Thus, it is found to have a prominent antiviral activity<sup>39</sup>.

#### 10. Antithrombotic effect

In a previous reported study the *in-vivo* effects *Glycyrrhiza glabra* extract and combined effect with Vitamin K and Heparin were evaluated in Sprague Dawley Rats. It is found that extract of *G. glabra* increased the bleeding time when given in the doses of 180 mg/kg and 360 mg/kg. Blood loss was evaluated 60 minute later as a function of absorbance at 540 nm due to hemoglobin content in water solution. Altogether data indicates that *Glycyrrhiza glabra* is an effective anti thrombotic agent<sup>40</sup>.

#### 11. Hair growth stimulation

Liquorice has a significant hair growth activity and it can be safely used in herbal formulations in treatment of various types of Alopecia. In a previous reported study hydro-alcoholic extract of liquorice showed good hair growth promoting activity. Comparison between liquorice extract and the standard drug used (Minoxidil 2%) showed that, 2% concentration of liquorice extract showed better hair growth stimulatory activity than 2% Minoxidil<sup>41</sup>.

#### 12. Skin lightening activity

The extract of liquorice is reported to be an effective pigment lightening agent. Glabridin in the hydrophobic fraction of liquorice extract inhibits tyrosinase activity in cultured B16 murine melanoma cells. Some other active compounds in liquorice extract like glabrene, Licochalcone A, Isoliquiritin are also responsible for inhibition of tyrosinase activity. Liquiritin present in

liquorice extract disperse melanin, thereby inducing skin lightening<sup>42</sup>.

#### 13. Anti-inflammatory activity

It is reported that glycyrrhetic acid in liquorice extract gives anti-inflammatory effect similar to glucocorticoids and mineralocorticoids. Liquorice root (*Glycyrrhiza*) extract promotes the healing of ulcers of the stomach and mouth and this fact was known for over 2000 years. According to studies, glycyrrhizic acid inhibits all factors responsible for inflammation. It inhibits cyclooxygenase activity and prostaglandin formation. It is also responsible for indirectly inhibiting platelet aggregation<sup>43</sup>.

#### 14. Anti-diabetic activity

In a previous study Kuroda M *et al.*, reported that ethyl acetate extract of licorice exhibited a significant PPAR- $\gamma$  (peroxisome proliferator-activated receptors) that function as transcription factors regulating the expression of genes involved in glucose and lipid metabolism binding activity. Finally reduces the blood glucose level in knockout diabetic mice<sup>44</sup>.

#### 15. Hepatoprotective activity

Glycyrrhizin induced a significant reduction in serum aminotransferases and improved the liver histology<sup>45</sup>. It has also been implicated that long-term usage of glycyrrhizin prevents development of hepatocellular carcinoma in chronic hepatitis C. *In vitro* studies have indicated that glycyrrhizin modifies the intracellular transport and suppresses hepatitis B virus (HBV) surface antigen (HbsAg)<sup>46</sup>.

#### 16. Anticancer activity

*G. glabra* extract has been used in herbal formulations for combating cancers like PC-SPEs, a polyherbal composition used for prostate cancer. The licorice extract induced the BCl<sub>2</sub> phosphorylation and G2/M cycle arrest in tumour cell lines.

### CONCLUSION

At present scenario there has been an increase in demand for the phytopharmaceuticals all over the world because of the fact that the allopathic drugs have more side effects. This forms a basis for the selection of plant for further phytochemical and pharmacological investigation. The pharmacological activities reported in the present review confirm the therapeutic value of *Glycyrrhiza glabra*. The plant has been used since centuries for asthma, bronchitis, ulcers, and an anti-inflammatory. It is reported to contain essential oil, coumarins, alkaloids and flavonoids. Extract of root can be found in various herbal preparations that are in market today. Presence of chemical compounds indicates that the plant could serve as "lead" for development of novel agents for disorders in the coming years.

In this regard, further studies need to be carried out to explore *Glycyrrhiza glabra* Linn for its potential in preventing and treating diseases. So, the present review gives a direction for future investigators to carry out research on the plant so that they could get some medicinally important drugs or may design new dosage form of active constituents.

## REFERENCES

- Mazumdar PM, Patnayak SP, Parwani H. Evaluation of immunomodulatory activity of *Glycyrrhiza glabra* roots in combination with zinc. *As Pac J Trop Med* 2012; S15-S20. [https://doi.org/10.1016/S2221-1691\(12\)60122-1](https://doi.org/10.1016/S2221-1691(12)60122-1)
- Sowmya M, Kumar S. Anti-stress property of *Glycyrrhiza glabra* on stress induced *Drosophila melanogaster*. *J Str Phys Bioch* 2010; 6: 18-27.
- Jatav VS, Singh SK, Sharma AK. Recent Pharmacological trends in *Glycyrrhiza glabra*. *Int J Pharm Fron Res* 2011; 1: 170-85. [https://doi.org/10.13040/IJPSR.0975-8232.4\(7\).2470-77](https://doi.org/10.13040/IJPSR.0975-8232.4(7).2470-77)
- Lakshmi T, Geetha RV. *Glycyrrhiza glabra* commonly known as licorice- a therapeutic review. *Int J Pharm Pharm Sci* 2011; 3: 20-25.
- Kumar A, Dora J. Review on *Glycyrrhiza glabra*: licorice. *J Pharm Scient Innov.* 2012, 1: 1-4.
- Ramar PS, Peter NP, Ponnampalam G. A compilation of bioactive compounds from Ayurveda; Biomedical Informatics Publishing Group 2008; 3(3), 100-110. <https://doi.org/10.6026/97320630003100>
- Karahana F, Avsarb C, Ilker IO, Berber I. Antimicrobial and antioxidant activities of medicinal plant *Glycyrrhiza glabra* var. glandulifera from different habitats, *Biotech Biotechnological Equip* 2016;1-8. <https://doi.org/10.1080/13102818.2016.1179590>
- Tene V, Malago O, Finzi PV, Vidari G. An ethnobotanical survey of medicinal plants used in Loja and Zamora chinchipi. *Equador J Ethnopharm* 2007; 111: 63-81. <https://doi.org/10.1016/j.jep.2006.10.032>
- Kalaarasi P, Pugalendi KV. Antihyperglycemic effect of 18 beta glycyrrhetic acid, aglycone of glycyrrhizin on streptozotocin diabetic rats. *Europ J Pharm* 2009; 1: 269-73. <https://doi.org/10.1016/j.ejphar.2008.12.057>
- Mukherjee PK, Wahile A. Integrated approaches towards drug development from Ayurveda and other Indian system of medicines. *J Ethnopharm* 2006; 103, 25-35. <https://doi.org/10.1016/j.jep.2005.09.024>
- Al Razzuqii RAM., Al-Hussaini JA. Hepatoprotective effect of *Glycyrrhiza glabra* in CCl4 induced model in acute liver injury. *J Phys Pharm Adv* 2012; 2: 259-63. <https://doi.org/10.3390/ijms12106529>
- Cooper H, Bhattacharya B, Verma V. Licorice and Soy sauce, a life-saving concoction in a patient with addisons disease. *Ann Clin Biochem* 2007; 44: 397-9. <https://doi.org/10.1258/000456307780945624>
- Kamei J, Nakamura R, Ichiki H, Kubo M. Antitussive principles of *Glycyrrhiza radix*, a main component of Kampo preparations Bakumondo-to (Mai-men-dongtang). *E. J. Pharm.* 2003; 69:159-163. <https://doi.org/10.1016/j.ejphar.2004.11.042>
- Nitalikar M, Munde KC, Dhore BV. Studies of antibacterial activities of *Glycyrrhiza glabra* root extract. *Int J Pharm Tech Res* 2010; 2: 899-901.
- Dhingra D, Parle M, Kulkarni SK. Memory enhancing activity of *Glycyrrhiza glabra* Linn in mice. *J Ethnoph* 2004; 91(2-3):361-365. <https://doi.org/10.1016/j.jep.2004.01.016>
- Takii H, Kometani T, Nishimura T, NakaeT, Okada S and Fushiki T. Anti-diabetic effect of Glycyrrhizin in genetically diabetic KK-Ay mice. *Biol Pharm Bull* 2000; 24:484-487. <https://doi.org/10.1248/bpb.24.484>
- Trivedi R, Sharma K. Hydroalcoholic extract of *Glycyrrhiza glabra* attenuates chronic fatigue stress induced behavioral alterations in mice. *Int J Pharm Biolog Sci* 2011; 2: 996-1001. [https://doi.org/10.13040/IJPSR.0975-8232.4\(7\).2470-77](https://doi.org/10.13040/IJPSR.0975-8232.4(7).2470-77)
- Kalaigandhi V, Poovendran P. Antimicrobial activity of *Glycyrrhiza glabra* against peptic ulcer produced *Helicobacter pylori*. *Int J Curr Pharm Res* 2011; 3: 93-95. PMID: 26664383
- Latif M., Iqbal L., Fatima N. Evaluation of antioxidant and urease inhibition activity of roots of *Glycyrrhiza glabra*. *Pakistan J Pharm Sci* 2012; 25: 99-102.
- Gupta VK, Fatima A, Faridi U. Antimicrobial potential of *Glycyrrhiza glabra* roots. *Elsevier J Ethnopharmacol* 2008; 116:377-380. <https://doi.org/10.1016/j.jep.2007.11.037>
- Sofia H, Walter TM. Review of *Glycyrrhiza glabra* L. siddha papers. *Med J* 2009; 2:1-7. PMID: 27731836
- Jahan Y, Siddique HH. Study of antitussive potential of *Glycyrrhiza glabra* and *Adhatoda vasica* using a cough model induced by SO<sub>2</sub> gas in mice. *Int J Pharm Sci Res* 2012; 3: 1668-74. [https://doi.org/10.13040/IJPSR.0975-8232.3\(6\).1668-74](https://doi.org/10.13040/IJPSR.0975-8232.3(6).1668-74)
- Visavadiya NP, Soni B, Dalwadi N. Evaluation of antioxidant and anti-atherogenic properties of *Glycyrrhiza glabra* root using *in vitro* models. *Int J Food Sci Nut* 2009; 60(2):135-149. <https://doi.org/10.1080/09637480902877998>
- Chakravarthi KK., Avadhani R. Effect of *Glycyrrhiza glabra* root extract on learning and memory in Wistar albino rats. *Drug Inv Today* 2012; 4: 387-90. <https://doi.org/10.4103/0976-9668.117025>
- Yazdi A, Sardari S, Sayyah Md. Evaluation of anticonvulsant activity of leaves of *Glycyrrhiza glabra* grown in Iran as a possible renewable source for anticonvulsant compounds. *Iran J Pharm Res* 2011; 10(1), 75-82. PMID: 24363684
- Gupta N, Belemkar S, Gupta PK, Jain A. Study of *Glycyrrhiza glabra* on glucose uptake mechanism in rats, *Int J drug Disc Herbal Res* 2011; 1(2): 50-51.
- Mirmala P, Selvaraj T. Anti-inflammatory and antibacterial activities of *Glycyrrhiza glabra*. *J Agri Techn* 2011; 7: 815-23. <https://doi.org/10.1016/j.apsb.2015.05.005>
- Chowdhury B, Bhattamisra SB, Das MC. Anti-convulsant action and amelioration of oxidative stress by *Glycyrrhiza glabra* root extract in pentylenetetrazole- induced seizure in albino rats. *Indian J Pharmacol* 2013; 45(1): 40-43. <https://doi.org/10.4103/0253-7613.106433>
- Lee CK, Park KK, Lim SS. Effects of licorice extracts against tumor growth and cisplatin induced toxicity in a mouse xenograft model of colon cancer. *Biol Pharm Bulletin* 2007; 30: 2191-5.
- Xu-ying W, Ming L, Xiao-dong L and Ping H. Hepatoprotective and anti hepatocarcinogenic effects of glycyrrhizin and matrine. *J Chemico-Biological Interac.* 2009; 181(1):15-19. <https://doi.org/10.1016/j.cbi.2009.04.013>
- Kiso Y, Tohkin M, Hikino H. Mechanism of antihepatotoxic activity of glycyrrhizin, I: Effect on free radical generation and lipid peroxidation. *Planta Medica* 1984; 50:298-302. <https://doi.org/10.1055/s-2007-969714>
- Demizu S, Kajiyama K, Takahashi Y, Hiraga S, Yamamoto Y, Tamura K, Kinoshita T. Antioxidant and antimicrobial constituents of licorice: isolation and structure elucidation of a new benzofuran derivative. *Chem Pharm Bull* 1988; 36:3474-3479. <https://doi.org/10.1248/cpb.36.3474>
- Sianne S, Fanie RVH. Antimalarial activity of plant metabolites. *Nat Prod Rep* 2002; 19:675-692. <https://doi.org/10.3390/ijms19051382>
- Hojoa H, Satob J. Antifungal Activity of Licorice (*Glycyrrhiza glabra*) and potential applications in beverage foods. *Food Ingredients J Japan* 2002; 203. <https://doi.org/10.1016/j.apsb.2015.05.005>
- Ju HS, Li XJ, Zhao BL, Han ZW, Xin WJ. Effects of Glycyrrhiza Flavonoids on lipid peroxidation and active oxygen radicals. *Acta Pharm Sinica.* 1989; 24(11):807-812.
- Krausse R, Bielenberg J, Blaschek W, Ullmann U. In and anti- *Helicobacter pylori* activity of *Extractum liquiritiae*, glycyrrhizin and its metabolites. *J Antimicrob Chemother* 2004; 54(1): 243-246.
- Kim YW, Kang HE, Lee MG, Hwang SJ, Kim SC, Lee CH. Liquiritigenin, a flavonoid aglycone from licorice, has a choleric effect and the ability to induce hepatic transporters and phase-II enzymes. *Am J Physiol Gastrointest Liver Physiol* 2009; 296(2):372-381. <https://doi.org/10.1152/ajpgi.90524.2008>
- Sharma V, Agrawal RC, Pandey S. Phytochemical screening and determination of anti-bacterial and

- antioxidant potential of *Glycyrrhiza glabra* root extracts. J Environ Res Develop 2013; 7(4A):1552-1558.
39. Pompei R, Pani A, Flore O, Marcialis MA, Loddò B. Antiviral activity of glycyrrhizic acid. Experientia 1980; 36:304. <https://doi.org/10.1021/jm0493008>
40. Mendes-Silva W, Assafim M, Ruta B, Monteiro RQ, Guimaraes JA, Zingali RB. Antithrombotic effect of Glycyrrhizin, a plant-derived thrombin inhibitor. Thromb Res 2003; 112:93-98. <https://doi.org/10.1016/j.thromres.2003.10.014>
41. Roy SD, Karmakar PR, Dash S, Chakraborty J, Das B. Hair growth stimulating effect and phytochemical evaluation of hydro-alcoholic extract of *Glycyrrhiza glabra*. Global J Res Med PLants Indigen Med 2014; 3(2):40-47.
42. Cronin H, Draelos ZD. Top 10 botanical ingredients in 2010 anti-aging creams. J Cosm Derm 2010; 9(3):218-225. <https://doi.org/10.1111/j.1473-2165.2010.00516.x>
43. Ohuchi K, Tsurufuji A. A study of the anti-inflammatory mechanism of glycyrrhizin. Mino Med Rev 1982; 27:188-193.
44. Kuroda M, Mimaki Y, Sashida Y, Mae T, Kishida H, Nishiyama H, Tsukagawa M, Konishi E, Takahashi K, Kawada T, Nakagawa K and Kitahara M. Phenolics with PPAR-Ligand-binding activity obtained from Licorice (*Glycyrrhiza uralensis* roots) and ameliorative effects of Glycyrin on genetically diabetic KK-Ay mice. Bioorg Med Chem Lett 2004; 55-61. <https://doi.org/10.1016/j.bmcl.2003.09.052>
45. Sato H, Goto W, Yamamura J, Kurokawa M, Kageyama S, Takahara T, Watanabe A, Shiraki K. Therapeutic basis of Glycyrrhizin on chronic hepatitis B. Antiviral Res 1996; 30: 171-177. [https://doi.org/10.1016/0166-3542\(96\)00942-4](https://doi.org/10.1016/0166-3542(96)00942-4)
46. Van Rossum TG, Vulto AG, De Man RA, Brouwer JT, Schalm SW. Glycyrrhizin as a potential treatment of chronic hepatitis C. Aliment Pharmacol Ther 1998; 12: 199-205. <https://doi.org/10.1046/j.1365-2036.1998.00309.x>
47. Wagner H and Jurcic K. Immunological studies of Revitonil: a phytopharmaceuticals containing *Echinacea purpurea* and *Glycyrrhiza glabra* root extract. Phytomedicine 2002; 9 (5): 390-397. <https://doi.org/10.1078/09447110260571616>