Journal of Horticultural Science and Technology 2(2): 34-40 (2019)
ISSN: 2617-3220 (Print), 2664-9489 (Online)
http://www.pshsciences.org

Review Article

Licorice a Supernatural Herb for Healthy Life: Bioactive Phytochemicals and Biological activities – A Review

Rozina Aslam[a], Misbah Aslam[a], Shawana Abdullah[a] and Muhammad Sarwar Yaqub[b]*
[a]Department of Chemistry, The Islamia University of Bahawalpur, Pakistan
[b]Department of Horticultural Sciences, The Islamia University of Bahawalpur, Pakistan

ABSTRACT

Licorice, a medicinal herb, has been found to contain various phytochemicals including flavonoids, phenolic compounds, saponins, sapogenins, pterocarpenes, coumestan derivatives, 2-arylobenzofuran derivatives, chemopreventive agents, acidic constituents and glycyrrhizin having different biological activities. Licorice is used in medical for treatment of various diseases like atherosclerosis, osteoporosis and Alzheimer's disease. It is used as anti-inflammation, anti-ulcer, anti-cancer, anti-virus and in many other problems. It is also used as additive for flavoring candies, chewing gum and toothpaste. The roots of this plant are majorly used for extracting different phytochemicals. Various licorice species: *Glycyrrhiza glabra, G. uralensis, G. inflata, G. lepidota,* and *G. pallidiflora* contain various phytochemicals with different type of biological activities. This paper provides a brief of the bioactive constituents and biological functions of different licorice species in details.

Keywords: *Antioxidants, flavonoids, gan cao, Glycyrrhiza species, medicinal plant, saponin.*

Article History: *Received 02 April 2019; Revised 02 June 2019; Accepted 16 June 2019; Published 30 June 2019.*

INTRODUCTION

Licorice is an herb from *Glycyrrhiza* genus of Leguminosae family. The word *Glycyrrhiza* has been derived from Greek word, glykos rhiza meaning 'sweet root'. Chinese called the licorice as 'gan cao' which means sweet grass (Wang et al., 2015). The genus *Glycyrrhiza* consists of about 30 species. Roots and stolons of some *Glycyrrhiza* species (*G. glabra, G. uralensis, G. inflata, G. eurycarpa, G. aspera, and G. korshinskyi*) are the economic parts because of sweet taste, which have been used for medicinal purpose for at least 4000 years. In pharmacy, term *Succus liquiritae* is used for licorice extract (Fenwick et al., 1990). Many isoprenoids substituted flavonoids are extracted from these plants. Kampo which is traditional Japanese medicine also contain licorice (Hayashi and Sudo, 2009). In Chinese pharmacopoeia, three species of *Glycyrrhiza* (*G. uralensis, G. glabra, G. inflata*) are most commonly used in medicinal prescriptions. In different provinces of China i.e. Inner Mongolia, Gansu, Heilongjiang, Ningxia and Qinghaiit, it is used as a medicinal plant (Yan et al., 2002). Licorice extract can be modified enzymatically in order to improve its sweetness by addition of cyclodextrin glucanotransferase. Several constituents isolated from this enzymatically modified licorice extract (EMLE) were glycyrrhizin, 3-O-[α-D-glucuronopyranosyl-(1f2)-α-D-glucuronopyranosyl]- liquiritic acid (2), and their derivatives glucosylated at the C-4 position of the terminal glucuronopyranose with additional one (3 and 4, respectively) and two (5 and 6, respectively) glucose moieties (Hong et al., 2000). Chinese Herbal Constituents Database (CHCD) and Bioactive Plant Compound Database (BPCD) contain information about classification of phytochemicals and chemical constituents isolated from various herbs and their different uses (Ehrman et al., 2007). Flavonoids/phenolics extracted from different herbs including licorice are found to be associated with antioxidant activity and used as remedy in cardiovascular diseases (Liao et al., 2008). The biologically important compounds found in licorice are triterpenoid saponins, flavonoids, polyamines and polysaccharides. These compounds are biologically active in different species of *Glycyrrhiza*.

ORIGIN AND MORPHOLOGY

Licorice plant is widely distributed all over the world. The extract from roots of *G. glabra* is inhabited in various countries like Greece, Turkey, Spain, Iraq, Caucasian, Transcaspian Russia, India, Italy, Iran and northern China (Lucas,1976; Lakshami and Geetha, 2011). The foliage of the plant has 3-8 leaflets. It is a perennial plant and leaves come out every year (Lakshami and Geetha, 2011).

BIOACTIVE PHYTOCHEMICALS OF LICORICE

Glycyrrhizin

Glycyrrhizin, extracted from dried roots and stolons of *G. glabra* is used in agricultural, pharmaceutical and confectionery industries (Fenwick et al., 1990; Kinghorn and Compadre, 2001). Sweetness of glycyrrhizin is 200 times more than sucrose and it

Corresponding author
E-mail: citsykk@yahoo.com (M.S. Yaqub)

is long lasting (Mizutani et al., 1994). A natural sweetener, mono-ammonium glycyrrhizate (MAG) is made from licorice by using pressurized hot water extraction (PHWE) (Mamata and Panja, 2008). In glycyrrhizin, oleanane-type triterpene saponin is responsible for sweet flavor of this plant (Hayashi and Sudo, 2009). In Japan, it is used as additive for flavoring and sweetening tobacco, candies, chewing gum and toothpaste. Ammonium glycyrrhizinate is used as flavoring and foaming agent and generally regarded as safe. Previous phytochemical studies on licorice has shown that two structurally important secondary metabolites are present i.e. triterpenoids (glycyrrhizic acid) and phenolic derivatives (e.g. liquiritigenin) (Kitagawa, 2009; Nomura et al., 2002). Various biological effects are associated with these chemical constituents, such as anti-microbial (Mitscher et al., 1980), anti-oxidant (Vaya et al., 1997), anti-inflammatory, anti-ulcer (Aly et al., 2005), anti-hepatotoxic (Dhiman and Chawla, 2005), cytoprotective and cytotoxic activities (Young et al., 2007).

Chemopreventive agents

Licorice contains chemopreventive agents like chalcone derivative (Wang and Nixon, 2001) and a novel group neolignan lipid esters (Kinghorn and Compadre, 2001). Several chemopreventive agents have been found in root of *Glycyrrhiza uralensis* which can inhibit proliferation of human breast cancer cell. Extract of licorice was modulated with the expression of Bcl-2/Bax family of apoptotic family regulators against human breast cancer (Eun-Hye et al., 2004).

Flavonoids

Five flavonoid compounds from the air-dried roots of *G. glabra* L. collected from Xinjiang province of China include glucoliquiritin apioside (a flavonone bisdesmoside), prenyllicoflavone (a bisprenylflavone) (Kitagawa et al., 1993), shinflavanone (a prenylated pyranoflavanone), shinptercarpin (Fukai et al., 1998), and 1-methoxyphaseolline (both pyranopterocarpans). Yenesew et al. (2000) extracted eleven flavonoids, eight known saponins and seven flavonoid glycosides from *Erythrina*. Underground parts of *G. uralensis* also contain three minor flavonoids namely, licofuranocoumarin, isotrifoliol and glisoflavanone (Hatano et al., 2000). Flavonoids are found to be associated with various biological activities. Mainly, plants of Leguminosae family (e.g. beans and peas) have these flavonoids. Although the tendency of these compounds is weak but to some extent can suppress diverse diseases like, atherosclerosis, osteoporosis and Alzheimer's disease (Shi et al., 2001; Nomura et al., 2002). Five flavonoids were isolated by purification of *G. uralensis* extract i.e. liquiritin, liquiritigenin, isoliquiritigenin, 7,4-dihydroxyflavone and isoononin (Bolleddula et al., 2009). Some compounds of flavonoids have weaker anti-*Helicobacter pylori* activity. These include glycyrin, gancaonin I, formononetin, 6,8-diprenylorobol, dihydrolicoisoflavone A, isolicoflavonol, glyasperin D, and gancaonol B (Fukai et al., 2002). Hatano et al. (1988) isolated two new flavonoids namely, glycyrrhisoflavanone and glycyrrhisoflavone. Their structure was also elucidated, that is 7,8- dihydroxy-2-2-dimethyl-5-methoxy{3,6-bi-2*H*-1-benzopyran}4-3H-one, and 3-[3,4-dihydroxy-5-(3-methyl-2-butenyl) phenyl]-5,7-dihydroxy-4*H*-1-benzopyran-4-one. Licoricidin is an isoflavan derivative. Its chemical formula is $C_{25} H_{32} O_5$ and melting point 161 °C and structure is 3, 6-diisopentenyl-2,4,5-trihydroxy-7-methoxyisoflavan (Shibata and Saito, 1968). *G. aspera* contains flavonoid compounds like: glucoisoliquiritin apioside, 7-O-apioglucosyl, 4-dihydroxyflavone, dihydroglyasperin C, asperopterocarpin and 1-methoxyphaseollidin (Kitagawa et al., 1988). Wang et al. (2004) isolated seven compounds from cultivated licorice for the first time including isoliquiritigentin, enchinatin, licochalcone B, liquiritigenin, 4,7- dihydroxyflavone, liquiritin and isoliquiritin. Multistep chromatographic fractionation from licorice of *G. uralensis* and *G. inflata* contained five flavonoids which include liquiritin, licuraside, isoliquiritin, liquiritigenin, and licochalcone A. These compounds were investigated for anti-tyrosinase activity for applications in food and cosmetic industries (Boqiang et al., 2005). Four known isoflavonoids; 5-*O*-methylglycryol, isoglycyrol, 6, 8-di-isoprenyl-5,7,4-tri-hydroxyisoflavone and gancaonin extracted from *G. uralensis* found to have anti-bacterial activity (Jian et al., 2006). The main flavonoid of *G. uralensis* Fisch. is licoricidin. The hydroxyl groups of flavonoids conjugate with glucuronyl by the action of UDP-glucuronosyltransferase (UGT). Licoricidin incubation with uridine 5'-diphosphoglucuronic acid and NADPH in the microsomes of human liver yields a metabolite monoglucuronyl licoricidin by UGT1A9. Formation of this metabolite in human liver microsomes (HLMs) may be used as a substrate *in vitro* to measure the efficiency of UGT1A9 (Cho et al., 2019).

Phenolic compounds

Licorice contain phenolic compounds like formononetin, glabridin, hemileiocarpin, hispaglabridin B, isoliquiritigenin (Kinghorn and Copadre, 2001), 4-O-methylglabridin, and pratocarpin B (Nomura et al., 2002). Shua et al. (2016) has reported 20 flavonoid glycosides compounds from roots and rhizomes of *G. uralensis.*

Saponins

G. Aspera contains four known saponins (Kitagawa et al., 1988). From dried roots of *G. uralensis* Fisch., a triterpene oligoglycoside named licorice-saponin L3 and a chalcone oligoglycoside (isoliquiritin apioside) were isolated along with licorice-saponins A3, E2, G2, and H2 (Kitagawa et al., 1993). Licorice roots, taken from different origin found to contain 15 types of saponins (Kitagawa et al., 1988). From *G. lepidota* (American licorice) two known saponins are licorice-saponin H2 and macedonoside A (Hayashi et al., 2005).

Sapogenins

G. uralensis roots contain seven triterpene sapogenins; methyl glycyrrhetate, glabrolide, methyl 3β, 24-dihydroxyolean-11, 13(18)-diene-30-oate, methyl 24-hydroxyglycyrrhetate and 24-hydroxyglabrolide (Shu et al., 1985).

Pterocarpenes

By bioassay-guided fractionation methods two new pterocarpenes; glycyrrhizol A and glycyrrhizol B were isolated from roots of *G. uralensis* (Jian et al., 2006).

Coumestan derivatives

Structures of coumestan derivatives, 2-glycyrol, 5-O-methoxyglycerol and isoglycerol were known half century ago (Saito and Shibata, 1969). Glycyrol coumestan has been extracted from *G. uralensis* (Li et al., 2010; Nehybova et al., 2014).

2-Arylobenzofuran derivative

From xibei (seihoku kanzo) which is a commercial licorice, 2-arylbenzofuran derivative named licocoumarone was isolated. 3-arylcoumarin derivative, glycycoumarin was also derived from xibei licorice. By spectroscopic and chemical studies, structure of licocoumarone was determined. Licocoumarone had both antimicrobial and antioxidant activity while glycycoumarin had only antimicrobial activity (Demizu et al., 1988).

Acidic constituents

Zuo et al. (1994) has reported 42 compounds isolated from *G. pallidiflora* by using various separation methods. For the first time, three new compounds homopterocarpin, soyasapogenol B and glypallidifloric acid (2β-hydroxy-oleana-11, 13(18)-diene-30-dioic acid) were isolated by spectroscopic and chemical methods. Yong et al. (2009) has extracted licorice content using simultaneous distillation extraction and analyzed with gas chromatography-mass spectrometry (GC-MS). Total 128 volatile components were separated. 108 components constituted 92.2% of total and among these 30.6% was caproic acid, 13.55% hexadecanoic acid, 3.99% ethyl hexanoate, 3.93% ethyl linoleate, 2.84% 11-hexadecanal, 2.09% 3-methyl-cyclopentol, 1.82% 2-pentnyl-furan and 1.76% 1-hexanol. Licorice extract was also investigated to reduce the irritation of cigarette smoke. These components were found useful and sweetness of smoke was improved.

MECHANISM OF ACTION

Licorice has proper mechanism of action for the prevention of diseases. In liver, glycyrrhizic acid can inhibit the metabolism of aldosterone, and suppress the activity of 5-(beta)-reductase which is responsible for pseudoaldosterone syndrome. It can perform the functions of mineralocorticoid and glucocorticoid due to the structural similarity (Armanini et al., 1983). Licorice can inhibit phospholipase A2 enzyme (which is responsible for inflammation) because it has steroid like anti-inflammatory action. Glycyrrhizic acid can inhibit all the inflammatory processes and enzymes like cyclooxygenase, and prostaglandin, it can inhibit the platelet aggregation also (Okimasu et al., 1983). It can inhibit the growth of DNA and RNA bacteria, which are responsible for herpes zoster (Baba and Shigeta, 1987), Hepatitis A (Crance et al., 1990), and Hepatitis C (Rossum et al., 1999). Licorice can lower the lipid peroxide value in liver of rat by the help of licorice isoflavones, hispaglabridin (Nagai et al., 1991). At the site of inflammation, Glycyrrhizin and glabridin can inhibit the production of reactive oxygen species (ROS) by the help of neutrophils (Akamatsu et al., 1991; Wang and Nixon, 2001). Licorice is used for inhibiting DNA gyrase in *H. pylori* which stop its growth and replication (Chatterji et al., 2001).

BIOLOGICAL ACTIVITIES

Licorice from Russian and Xinjiang origin has been investigated for anti-microbial and anti-oxidant activity. Glabrene, glabridin, and licochalcones A and B were found to be active ingrediants (Okada et al., 1989). The biologically important components of licorice have anti-viral, anti-bacterial, anti-inflammatory, anti-oxidative, anti-allergy, anti-cancer, anti-depressive, anti-diabetic and cardioprotective effects (Asl and Hosseinzadeh, 2008; Fiore et al., 2008). It is used for tonifying stomach, eliminating phlegm, relieving cough, removing heat, detoxifying, peptic ulcer, hepatic disease, cancer, and for viral infections (Li et al., 2011; Qiao et al., 2014).

Anti-ulcer and anti-*Helicobacter pylori* activity

Helicobacter pylori is the gram negative S shaped flagellated bacterium which has infected half of mankind worldwide and is considered causative agent of peptic ulcer (Gorden et al., 1994; Hunt et al., 2011; Mannanthendil et al., 2013). Extract of licorice has been used for the treatment of peptic ulcer. Flavonoids from licorice were expected to show more anti-*H. pylori* activity because kaempferol (4',5,7- trihydroxyflavonol) exhibited antibacterial action in *H. pylori*-infected Mongolian gerbils (Kataoka et al., 2001). Among the flavonoids, licoricone, 1-methoxyphaseollidin, vestitol and gancaonol C also show anti-*H. pylori* activity against clarithromycin amoxicillin-resistant and sensitive strains. Ethanol extract of *G. uralensis* contains three isoflavonoids (3-arylocoumarin, pterocarpan, isoflavan) and 15 known flavonoid compounds. In *H. pylori*-infected individuals, these compounds may prove as effective chemopreventive agents of gastric and peptic ulcer (Fukai et al., 2002). Licorice also has anti-ulcer agent glycyrrhizinic acid, which is responsible for raising the prostaglandin concentration that increase rate of mucous secretion and cell proliferation in stomach. *In vitro* activity of some components of licorice [Extractum liquiritiae (EL), Glycyrrhizic acid (GL), glycyrrhetinic acid (GA), novel lipophilic derivative of glycyrrhetinic acid monoglucuronide (GAMG), and acetylated GAMG (aGAMG)] against 29 *H. pylori* strains has been studies. The minimum inhibitory concentration (MIC) of each compound was measured through agar dilution method, and brain heart infusion method was used for measuring the killing kinetics (Dhiman and Chawla, 2005). GA can inhibited 79.3% of the strains and found as a most potent component of licorice against ulcer bacterium (Kim et al., 2009; Tsai and Chen, 1991). Licorice root extract contain polysaccharide which inhibit *H. pylori* adhesion with gastric mucosa (Wittschier et al., 2009). In 2012, antibiotic resistance of clarithromycin and amoxicillin increased in *H. pylori* (An et al., 2013). Licorice is used for production of secretin for protection of mucosal cells (Hajiaghamohammadi et al., 2016).

Hepatoprotective and anti-hepatitis activity

Licorice protect liver by resisting the change in cell membrane permeability, and inhibit the phospholipase A2 (Dhiman and Chawla, 2005; Kim et al., 2009). Glycyrrhizin have components which are active against hepatitis B and C. It decreases the serum alanine aminotransferase concentration which give stability to virus, and also inhibit the replication of HCV (Hepatitis C virus) RNA genome (Van Rossum et., 1999; Orlent et al., 2006; Stickel and Schuppan, 2007; Manns et al., 2012). *G. uralensis* and *G. glabra* also inhibit HCV genome replication, and is used in folk medicine to treat liver diseases (Asl and Hosseinzadeh, 2008; Sekine-Osajima et al., 2009; Wang et al., 2013). Real-time PCR is used for analyzing the effects of *Glycyrrhiza* species on HCV RNA genome (Deng et al., 2011; Wahyuni et al., 2013). The component of *G. uralensis* like glabridin, liquiritigenin, glycycoumarin, glycyrin and glycyrol; all of these are potent agents against hepatitis C (Adianti et al., 2014).

Anti-inflammatory activity

Triterpen glycyrrhizin is the most potent anti-inflammatory agent extracted from licorice (Kiso et al., 1984). Glycyrrhizin is not only the scavenger of ROS (reactive oxygen species) but it also inhibits formation of ROS by neutrophils (Akamatsu et al., 1991). Licorice can resist formation of ROS and inhibit peroxidation of lipid in cell membrane. It increases formation of natural antioxidants in the body like super oxide dismutase (Rackova et al., 2007). Several workers have reported that *G. glabra* has anti-inflammatory effect (Aly et al., 2005; Dong et al., 2007; Zore et al., 2008).

Anti-tumor activity

Licorice root extract contain beta-hydroxy-DHP component that induce apoptosis and arrest G2/M cell cycle in breast and prostate cancer (Rafi et al., 2002). *G. uralensis* extract of root in DMSO (Dimethyle sulfoxide) is used in treating estrogen related breast cancer. However, this depends on the extract of root and its specific concentration. It arrests cell cycle at moderate concentration, otherwise it increases cell proliferation (Hu et al., 2009). *G. uralensis* components have anti-tumor characteristics (Miraj, 2016). Glycyrrhizin can increase immune response by increasing anti-tumor cytokine-IL-7 proliferation and maturation which is important in cancer diagnosis (Ayeka et al., 2016). Ethanolic extract of *G. aspera* has anti-tumor property against N-methyl-N-nitrosourea (MNU) showing direct anti-tumor effect against DNA alkylation (Inami et al., 2017).

Anti-hyperlipidemic and anti-cardiovascular toxin activity

Triterpenoid components of licorice are effective in reducing triglycerides and cholesterol level in blood and give protection against cardiovascular disease and atherosclerosis (Jiao et al., 2007). Glycyrrhizic acid is similar in structure with mineralocrticoids and glucocorticoids. So, it can be used as analogue in steroid metabolism. It prevents the action of LOX (lipid peroxidase) and COX (cytochrome oxidase) and decrease the level of VLDL (very low density lipoprotein) in plasma and prevent heart from various diseases (Churchill, 2013).

Anti-stroke activity

Glabridin is the component of licorice extract which has property against stroke formation and prevents brain by inhibiting super oxide production in cortical neuron (Yu et al., 2008).

Anti-cough and immunomodulator activity

Licorice is an efficient compound used for treatment of cough and cold. It has various components that are glycyrrhizin, glycyrrhetinic acid, flavonoids, isoflavonoids and chalcones. Glycyrrhetinic acid increases INFγ (interferon gamma) and IgE (immunoglobulin E) which improve rate of immunity in individuals (Gulati et al., 2016). Aqueous extract of roots of licorice is used as immunomodulator. It increases cellular immune response by increasing antibody concentration in body (Salarzaei et al., 2017).

Anti-herpes activity

Glycyrrhizic component of licorice can be used in the form of gel on lesions which entrap DNA, RNA of virus and reduce the recurrence of herpes (Pizzorno et al., 2016).

Anti-plasmodial activity

Root extract of *G. glabra* is used for production of resistance for all malarial diseases. Attempts have been made to use total root extract for creating new anti-malarial drug from plant source (Sangian et al., 2013; Haddad et al., 2017; Ramazani et al., 2018).

Anti-hypermineralocorticoid activity

Licorice with the aid of intact adrenals leads to hypertension, as it causes sodium retention. One of its components, glycyrrhetinic acid was suggested to cure Addison's disease as it causes hyperaldosteronism, because the activity and structure of this constituent are similar to steroid hormones cortisol and aldosterone (Conn et al., 1968; Elizabeth and Morris, 1991). Glycyrrhizic acid component of licorice can be used in steroid metabolism to stop the production of mineralocorticoid, but this property requires fixed concentration of licorice intake. Otherwise it can oppose this effect (Isbrucker and Burdock, 2006).

CONCLUSION

Licorice is a medicinal herb which has fewer side effects and more potency to treat diseases by controlling their natural pathways; for example, in cancer it modifies immune system to destroy abnormal cells, in ulcer it decreases ammonia coat around bacterium to facilitate its killing, it increases natural antioxidant to prevent free radical formation. So, it has importance due to less side effect and fast response. Main phytochemical which was found in licorice extract was flavonoid. Root extract of *G. uralensis* is being investigated as breast cancer inhibitor. The genus *Glycyrrhiza* consists of about 30 species, including *G. pallidiflora*, *G. lepidota*, *G. aspera*, *G. uralensis, G. glabra, G. inflata, G. eurycarpa, and G. korshinskyi*. These have been investigated for their biochemical constituents and biological activities by different investigators and found effective against numerous diseases from digestive problems to cancers. There is need to explore the biochemical constituents and biological activities of the remaining twenty-two species of the magical *Glycyrrhiza* herb and there are chances that the remaining species could be effective against some other diseases. It is also suggested to investigate the antimicrobial activity of licorice for the treatment of animal and plant diseases.

REFERENCES

Adianti, M., Aoki, C., Komoto, M., Deng, L., Shoji, I., Wahyuni, T.S., Lusida, M.I., Soetjipto, Fuchino, H., Kawahara, N. and Hotta, H. 2014. Anti-hepatitis C virus compounds obtained from *Glycyrrhiza uralensis* and other *Glycyrrhiza* species. *Microbiology and Immunology*, 58: 180-187.

Akamatsu, H., Komura, J., Asada, Y. and Niwa, Y. 1991. Mechanism of anti-inflammatory action of glycyrrhizin: effect on neutrophil functions including reactive oxygen species generation. *Planta Medica*, 57: 119-121.

Aly, A.M., Al-Alousi, L. and Salem, H.A. 2005. Licorice: a possible anti-inflammatory and anti-ulcer drug. *AAPS PharmSciTech,* 6: E74-E82.

An, B., Moon, B.S., Kim, H., Lim, H.C., Lee, Y.C., Lee, G., Kim, Sa-H., Park, M. and Kim, J.B. 2013. Antibiotic resistance in *Helicobacter pylori* strains and its effect on *H. pylori* eradication rates in a single center in Korea. *Annals of Laboratory Medicine,* 33: 415-419.

Armanini, D., Karbowiak, I. and Funder, J.W. 1983. Affinity of liquorice derivatives for mineralocorticoid and glucocorticoid receptors. *Clinical Endocrinology*, 19: 609-612.

Asl, M.N. and Hosseinzadeh, H. 2008. Review of pharmacological effects of *Glycyrrhiza* sp. and its bioactive compounds. *Phytotherapy Research*, 22: 709-724.

Ayeka, P.A., Bian, Y., Mwitari, P.G., Chu, X., Zhang, Y., Uzayisenga, R. and Otachi, E.O. 2016. Immunomodulatory and anticancer potential of Gan cao (*Glycyrrhiza uralensis* Fisch.) polysaccharides by CT-26 colon carcinoma cell growth inhibition and cytokine IL-7 upregulation *in vitro*. *BMC Complementary and Alternative Medicine*, 16: 206.

Baba, M. and Shigeta, S. 1987. Antiviral activity of glycyrrhizin against varicella-zoster virus *in vitro*. *Antivirus Research,* 7: 99-107.

Bolleddula, J., Doddaga, S., Wang, R., Holmes, D., Goldfarb, J. and Li Xiu-min. 2009. Licorice flavonoids inhibit eotaxin-1 secretion by human fetal lung fibroblasta *in vitro*. *Journal of Agricultural and Food Chemistry*, 57: 820-825.

Boqiang, F., Li, H., Wang, X., Lee, F.S.C. and Cui, S. 2005. Isolation and identification of flavonoids in licorice and study of their inhibitory effects on tyrosinase. *Journal of Agricultural and Food Chemistry*, 53: 7408-7414.

Chatterji, M., Unniraman, S., Mahadevan, S. and Nagaraja, V. 2001. Effect of different classes of inhibitors on DNA gyrase from Mycobacterium smegmatis. *Journal of Antimicrobial Chemotherapy,* 48: 479-485.

Cho, P.J., Kim, J.H., Lee, H.S., Kim, J.A. and Lee, S. 2019. Identification of specific UGT1A9-mediated glucuronidation of licoricidin in human liver microsomes. *Biopharmaceutical & Drug Disposition,* 40(2): 94-98.

Churchill, L.O. 2013. Epidemiology of ischaemic heart disease in sub-Saharan Africa. *Cardiovascular Journal of Africa,* 24(2): 34-42.

Conn, J.W., Rower, D.R. and Cohen, E.L. 1968. *Glycyrrhiza glabra*. *Journal of the American Medical Association,* 205: 80-84.

Crance, J., Biziagos. E., Passagot, J., van Cuyck-Gandre, H. and Deloince, R. 1990. Inhibition of hepatitis A virus replication *in vitro* by antiviral compounds. *Journal of Medical Virology,* 31: 155-160.

Demizu, S., Kajiyama, K., Hiraga, Y., Yamamoto, S., Tamura, Y.O. and Kinoshita, T. 1988. Antioxidant and antimicrobial constituents of licorice: Isolation and structure elucidation of a new benzofuran derivative. *Chemical and Pharmaceutical Bulletin,* 36: 3474-3479.

Deng, L., Shoji, I., Ogawa, W., Kaneda, S., Soga, T., Jiang, D.P., Ide, Y.H. and Hotta, H., 2011. Hepatitis C virus infection promotes hepatic gluconeogenesis through an NS5A-mediated, FoxO1-dependent pathway. *Journal of Virology*, 85(17): 8556-8568.

Dhiman, R.K. and Chawla, Y.K. 2005. Herbal medicines for liver diseases. *Digestive Diseases and Science,* 50: 1807-1812.

Dong, S., Inoue, A., Zhu, Y., Tanji, M. and Kiyama, R. 2007. Activation of rapid signaling pathways and the subsequent transcriptional regulation for the proliferation of breast cancer MCF-7 cells by the treatment with an extract of *Glycyrrhiza glabra* root. *Food and Chemical Toxicology,* 45: 2470-2478.

Ehrman, T.M., Barlow, D.J. and Hylands, P.J. 2007. Phytochemical informatics of traditional Chinese medicine and therapeutic relevance. *Journal of Chemical Information Model*, 47: 2316-2334.

Elizabeth, A.D. and Morris, D.J. 1991. Medicinal uses of licorice through the millennia: the good and plenty of it (review). *Molecular and Cellular Endocrinology,* 78: 1-6.

Eun-Hye, J., Hong, H.D., Ahn, N.C., Jung, J.W., Yang, S.R., Park, J.S., Kim, S.H., Lee, Y.S. and Kang, K.S. 2004. Modulations of the Bcl-2/Bax family were involved in the chemopreventive effects of licorice root (*Glycyrrhiza uralensis* Fisch.) in MCF-7 human breast cancer cell. *Journal of Agricultural and Food Chemistry,* 52: 1715-1719.

Fenwick, G.R., Lutomski, J. and Nieman, C. 1990. Liquorice, *Glycyrrhiza glabra* L. composition, uses and analysis. *Food Chemistry,* 38: 119-143.

Fiore, C., Eisenhut, M., Krausse, R., Ragazzi, E., Pellati, D., Armanini, D. and Bielenberg, J. 2008. Antiviral effects of *Glycyrrhiza* species. *Phytotherapy Research*, 22: 141-148.

Fukai, T., Cai, B.S., Maruno, K., Miyakawa, Y., Konishi, M. and Nomura, T. 1998. An isoprenylated flavanone from *Glycyrrhiza glabra* and rec-assay of licorice phenols. *Phytochemistry*, 49: 2005-2013.

Fukai, T., Marumo, A., Kaitou, K., Kanda, T., Terada, S. and Nomura, T. 2002. Anti-*Helicobacter pylori* flavonoids from licorice extract*. Life Sciences,* 71: 1449-1463.

Gorden, P., Ferguson, J.H. and Fauci, A.S. 1994. Conference sponsors, *Helicobacter pylori* in peptic ulcer disease. *NIH Consensus Statement,* 12: 1-23.

Gulati, K., Rai, N., Chaudhary, S. and Ray, A. 2016. Nutraceuticals in respiratory disorders. In: Gupta, R.C. (ed.). Nutraceuticals: Efficacy, Safety and Toxicity. Academic Press, Elsevier, Amsterdam, pp. 75-86.

Haddad, M.H.F., Mahbodfar, H., Zamani, Z. and Ramazani, A. 2017. Antimalarial evaluation of selected medicinal plant extracts used in Iranian traditional medicine. *Irani Journal of Basic Medical Science*, 20: 415-422.

Hajiaghamohammadi, A.A., Zargar, A., Oveisi, S., Samimi, R. and Reisian, S. 2016. To evaluate of the effect of adding licorice to the standard treatment regimen of *Helicobacter pylori*. *The Brazilian Journal of Infectioius Diseases,* 20: 534-538.

Hatano, T., Aga, Y., Shintani, Y., Ito, H., Okuda, T. and Yoshida, T. 2000. Minor flavonoids from licorice. *Phytochemistry*, 55: 959-963.

Hatano, T., Kagawa, H., Yasuhara, T. and Okuda, T. 1988. Two new flavonoids and other constituents in licorice root: Their relative astringency and radical scavanging effects. *Chemical and Pharmaceutical Bulletin,* 36: 2090-2097.

Hayashi, H., Miwa, E. and Inoue, K. 2005. Phylogenetic relationship of *Glycyrrhiza lepidota* (American licorice), in genus *Glycyrrhiza* based on rbcL sequences and chemical constituents. *Biology and Pharmaceutical Bulletin,* 28: 161-164.

Hayashi, H. and Sudo, H. 2009. Economic importance of licorice. *Plant Biotechnology*, 26: 101-104.

Hong, M.L., Sugimoto, N., Akiyama, T. and Maitani, T. 2000. Constituents and their sweetness of food additive enzymatically modified licorice extract. *Journal of Agricultural and Food Chemistry,* 48: 6044-6047.

Hu, C., Liu, H., Du, J., Mo, B., Qi, H., Wang, X., Ye, S. and Li, Z. 2009. Estrogenic activities of extracts of Chinese licorice (*Glycyrrhiza uralensis*) root in MCF-7 breast cancer cells. *The Journal of Steroid Biochemistry and Molecular Biology,* 113: 209-216.

Hunt, R., Xiao, S.D., Megraud, F., Leon-Barua, R., Bazzoli, F., van der Merwe, S., Vaz Coelho, L.G., Fock, M., Fedail, S., Cohen, H., Malfertheiner, P., Vakil, N., Hamid, S., Goh, K.L., Wong, B.C., Krabshuis, J. and Le Mair, A. 2011. *Helicobacter pylori* in developing countries. World Gastroenterology Organization Global Guideline. *Journal of Gastrointestinal and Liver Diseases,* 20: 299-304.

Inami, K., Mine, Y., Tat, J., Mori, C. and Mochizuki, M. 2017. Antimutagenic components in *Glycyrrhiza* against N-methyl-N-nitrosourea in the

Ames assay. *Natural Products Research,* 31: 691-695.

Isbrucker, R. and Burdock, G. 2006. Risk and safety assessment on the consumption of licorice root *(Glycyrrhiza* sp.), its extract and powder as a food ingredient, with emphasis on the pharmacology and toxicology of glycyrrhizin. *Regulatory and Toxicological Pharmacology,* 46: 167-192.

Jian, H., Chen, L., Heber, D., Shi, W. and Lu, Q.Y. 2006. Antibacterial compounds from *Glycyrrhiza uralensi*s. *Journal of Natural Products,* 69: 121-124.

Jiao, J., Zhang, Y., Lou, D., Wu, X. and Zhang, Y. 2007. Antihyperlipidemic and antihypertensive effect of a triterpenoid-rich extract from bamboo shavings and vasodilator effect of friedelin on phenylephrine-induced vasoconstriction in thoracic aortas of rats. *Phytotherapy Research,* 21: 1135-1141.

Kataoka, M., Hirata, K., Kunikata, T., Ushio, S., Iwaki, K., Ohashi, K., Ikeda, M. and Kurimoto, M. 2001. Antibacterial action of tryptanthrin and kaempferol, isolated from the indigo plant (*Polygonum tinctorium* Lour.) against *Helicobacter pylori*-infected Mongolian gerbils. *Journal of Gastroenterology*, 36: 5-9.

Kim, Y.W., Kang, H.E., Lee, M.G., Hwang, S.J., Kim, S.C. and Lee, C.H. 2009. Liquiritigenin, a flavonoid aglycone from licorice, has a choleretic effect and the ability to induce hepatic transporters and phase-II enzymes. *American Journal of Physiology- Gastrointestinal and Liver Physiology*, 296: 372-381.

Kinghorn, A.D. and Compadre, C.M. 2001. Less common high-potency sweetners. In: O'Brien-Nabors, L. (ed.). Alternative Sweeteners, Third Ed. Marcel Dekker, New York, pp. 209-231.

Kiso, Y., Tohkin, M. and Hikino, H. 1984. Mechanism of antihepatotoxic activity of glycyrrhizin, I: Effect on free radical generation and lipid peroxidation. *Planta Medica,* 50: 298-302.

Kitagawa, I. 2009. Licorice root. A natural sweetener and an important ingredient in Chinese medicines. *Pure and Applied Chemistry,* 74: 1189-1198.

Kitagawa, I., Chen, W.Z., Hori, K., Kobayashi, M. and Ren, J. 1988. Chemical studies of Chinese licorice-roots. II. Five new flavonoid constituents from the roots of *Glycyrrhiza aspera* PALL. collected in Xinjiang. *Chemical and Pharmaceutical Bulletin,* 46: 1511-1517.

Kitagawa, I., Hori, K., Uchida, E., Chen, W.Z., Yoshikawa, M. and Ren, J. 1993. Saponin and Sapogenol. L. On the constituents of the roots of *Glycyrrhiza uralensis* Fischer from Xinjiang, China. Chemical structures of licorice-saponin L3 and isoliquiritin apioside. *Chemical and Pharmaceutical Bulletin,* 41: 1567-1572.

Lakshmi, T. and Geetha, R. 2011. *Glycyrrhiza glabra* Linn. commonly known as licorice: a therapeutic review. *International Journal of Pharmaceutical and Pharmacological Sciences*, 3: 20-25.

Li, J., Tu, Y., Tong, L., Zhang, W., Zheng, J. and Wei, Q. 2010. Immunosuppressive activity on the murine immune responses of glycyrol from *Glycyrrhiza uralensis* via inhibition of calcineurin activity. *Pharmacology and Biology,* 48: 1177-1784.

Li, Y.J., Chen, J., Li, Y., Li, Q., Zheng, Y.F., Fu, Y. and Li, P. 2011. Screening and characterization of natural antioxidants in four *Glycyrrhiza* species by liquid chromatography coupled with electrospray ionization quadrupole time-of-flight tandem mass spectrometry. *Journal of Chromatography A,* 1218: 8181-8191.

Liao, H., Banbury, L.K. and Leach, D.N. 2008. Antioxidant activity of 45 Chinese herbs and the relationship with their TCM characteristics. *Evidence Based Complementary and Alternative Medicine,* 5: 429-434.

Lucas, R. 1976. Nature's Medicines. Melvin Powers/Wilshire Book Company New York, pp. 89-94.

Mamata, M. and Panja, P. 2008. A novel process for extraction of natural sweetener from licorice (*Glycyrrhiza glabra*) roots. *Separation and Purification Technology,* 63: 539-545.

Mannanthendil, K.A., Debraj, D., Prashanth, D., Edwin, J.R., Srikanth, H.S., Muruganantham, N., Dethe, S.M., Anirban, B., Jaya, B., Deepak, M. and Agarwal, A. 2013. *In vitro* anti-*Helicobacter pylori* activity of a flavonoid rich extract of *Glycyrrhiza glabra* and its probable mechanisms of action. *Journal of Ethnopharmacology,* 145: 581-586.

Manns, M.P., Wedemeyer, H., Singer, A., Khomutjanskaja, N., Dienes, H.P., Roskams, T., Goldin, R., Hehnke, U. and Inoue, H. 2012. Glycyrrhizin in patients who failed previous interferon alpha-based therapies: biochemical and histological effects after 52 weeks. *Journal of Viral Hepatitis,*19: 537-546.

Miraj, S. 2016. Anti-cancer and anti-tumor activity of *Glycyrrhiza uralensis* Fisch. *Der Pharmacological Lettre,* 8: 417-420.

Mitscher, L.A., Park, Y.H., Clark, D. and Jack Beal, L. 1980. Anti-microbial agents from higher plants. Anti-microbial isoflavonoids and related substances from *Glycyrrhiza glabra* L. var. typica. *Journal of Natural Products,* 43: 259-269.

Mizutani, K., Kuramoto, T., Tamura, Y., Ohtake, N., Doi, S., Nakaura, M. and Tanka, O. 1994. Sweetness of glycyrrhetinic acid 3-O-mono-b-D-glucuronide and related glycosides. *Bioscience, Biotechnology and Biochemistry,* 58: 554-555.

Nagai, T., Egashira, T., Yamanaka, Y. and Kohno, M. 1991. The protective effect of glycyrrhizin against injury of the liver caused by ischemia-reperfusion. *Archives of Environmental Contamination and Toxicology,* 20: 432-436.

Nehybova, T., Smarda, J. and Benes, P. 2014. Plant coumestans: Recent advances and future perspectives in cancer therapy. *Anti -Cancer Agents in Medical Chemistry,*14: 1-12.

Nomura, T., Fukai, T. and Akiyama, T. 2002. Chemistry of phenolic compounds of licorice (*Glycyrrhiza* species) and their estrogenic and cytotoxic activities. *Pure and Applied Chemistry,* 74: 1199-1206.

Okada, K., Tamura, Y., Yamamoto, M., Inoue, Y., Takagaki, R., Kunio, T., Demizu, S., Kajiyama, K., Hiraga, Y. and Kinoshita, T. 1989. Identification of antimicrobial and antioxidant constituents from licorice of Russian and Xinjiang Origin. *Chemical and Pharmaceutical Bulletin,* 37: 2528-2530.

Okimasu, E., Moromizato, Y., Watanabe, S., Sasaki, J., Shiraishi, N., Morimoto, Y.M., Miyahara, M. and Utsumi, K. 1983. Inhibition of phospholipase A2 and platelet aggregation by glycyrrhizin, an antiinflammation drug. *Acta Medica Okayama,* 37: 385-391.

Orlent, H., Hansen, B.E., Willems, M., Brouwer, J.T., Huber, R., Kullak-Ublick, G.A., Gerken, G., Zeuzem, S., Nevens, F., Tielemans, W.C.M., Zondervan, P.E., Lagging, M., Westin, J. and Schalm, S.W. 2006. Biochemical and histological effects of 26 weeks of glycyrrhizin treatment in chronic hepatitis C: a randomized phase II trial. *Journal of Hepatology*, 45: 539-546.

Pizzorno, J.E., Murray, M.T. and Joiner-Bay, H. 2016. The Clinician's Handbook of Natural Medicine (3rd Ed.). Elsevier Health Sciences Ltd., Amsterdam.

Qiao, X., Liu, C.F., Ji, S., Lin, X.H., Guo, D.A. and Ye, M. 2014. Simultaneous determination of five minor coumarins and flavonoids in *Glycyrrhiza uralensis* by solid-phase extraction and high-performance liquid chromatography/electrospray ionization tandem mass spectrometry. *Planta Medica,* 80: 237-242.

Rackova, L., Jancinova, V., Petríkova, M., Drabikova, K., Nosal, R., Stefek, M., Kostalova, D., Pronayova, N. and Kovacova, M. 2007. Mechanism of anti-inflammatory action of liquorice extract and glycyrrhizin. *Natural Products Research,* 21: 1234-1241.

Rafi, M.M., Vastano, B.C., Zhu, N., Ho, C.T., Ghai, G., Rosen, R.T., Gallo, M.A. and DiPaola, R.S. 2002. Novel polyphenol molecule isolated from licorice root (*Glycrrhiza glabra*) induces apoptosis, G2/M cell cycle arrest, and Bcl-2 phosphorylation in tumor cell lines. *Journal of Agricultural and Food Chemistry,* 50: 677-684.

Ramazani, A., Tavakolizadeh, M., Ramazani, S., Kheiri-Manjili, H. and Eskandari, M. 2018. Antiplasmodial property of *Glycyrrhiza glabra* traditionally used for malaria in Iran: Promising activity with high selectivity index for malaria. *Journal of Arthropod-Borne Diseases,* 12(2): 135-140.

Saito, T. and Shibata, S. 1969. Chemical studies on oriental plant drugs. XXII. Some new constituents of licorice root. (2). Glycyrol, 5-O-methylglycyrol and isoglycyrol. *Chemical and Pharmaceutical Bulletin,*17: 729-734.

Salarzaei, M., Saravani, S., Heydari, M., Aali, H., Malekzadegan, A., Soofi, D., Movaghar, E.R., Mir, S. and Parooei, F. 2017. Prevalence of urinary tract infection in children with nephrotic syndrome.

International Journal of Pharmaceutical Science and Research, 8: 1346-1350.

Sangian, H., Faramarzi, H., Yazdinezhad, A., Mousavi, S.J., Zamani, Z., Noubarani, M. and Ramazani, A. 2013. Antiplasmodial activity of ethanolic extracts of some selected medicinal plants from the northwest of Iran. *Parasitology Research,* 112: 3697-3701.

Sekine-Osajima, Y., Sakamoto, N., Nakagawa, M., Itsui, Y., Tasaka, M., Nishimura-Sakurai, Y., Chen, C.H., Suda, G., Mishima, K., Onuki, Y., Yamamoto, M., Maekawa, S., Enomoto, N., Kanai, T., Tsuchiya, K. and Watanabe, M. 2009. Two flavonoids extracts from Glycyrrhizae radix inhibit *in vitro* hepatitis C virus replication. *Hepatology Research,* 39: 60-69.

Shi, Y.Q., Fukai, T., Sakagami, H., Kudora, J., Miyaoka, R., Tamura, M., Yoshida, N. and Nomura, T. 2001. Cytotoxic and DNA damage-inducing activities of low molecular weight phenols from rhubarb. *Anticancer Research,* 21: 2847-2853.

Shibata, S. and Saito, T. 1968. The chemical studies on oriental plant drugs. XIX. Some new constituents of licorice root. 1. The structure of licoricidin. *Chemical and Pharmaceutical Bulletin,*16: 1932-1936.

Shu, Y.H., Zhao, Y.Y. and Zhang, R.Y. 1985. Isolation and identification of triterpene sapogenins from *Glycyrrhiza uralensis* Fisch. *Acta Pharmaceutica Sinica,*20(3): 193-197.

Shua, J., Li, Z., Song, W., Wang, Y., Liang, W., Li, K., Tang, S., Wang, Q., Qiao, X., Zhou, D., Yu, S. and Ye, M. 2016. Bioactive constituents of *Glycyrrhiza uralensis* (licorice): Discovery of the effective components of the traditional herbal medicine. *Journal of Natural Products,* 79: 281–292.

Stickel, F. and Schuppan, D. 2007. Herbal medicine in the treatment of liver diseases. *Digestive and Liver Diseases,* 39: 293-304.

Tsai, T.H. and Chen, C.F. 1991. High-performance liquid chromatographic determination of 18α-glycyrrhetinic acid and 18β-glycyrrhetinic acid in rat plasma: application to pharmacokinetic study. *Journal of Chromatography. B*: *Biomed Science and Applications*, 567: 405-414.

Rossum, T.G.V, Vulto, A.G., Hop, W.C., Brouwer, J.T., Niesters, H.G. and Schalm, S.W. 1999. Intravenous glycyrrhizin for the treatment of chronic hepatitis C: a double-blind, randomized, placebo-controlled phase I/II trial. *Journal of Gastroenterology and Hepatology,* 14: 1093-1099.

Vaya, J., Belinky, P.A. and Aviram, M. 1997. Antioxidant constituents from licorice roots: isolation, structure elucidation and antioxidative capacity toward LDL oxidation. *Free Radical Biology and Medicines*, 23: 302-313.

Wahyuni, T.S., Tumewu, L., Permanasari, A.A., Apriani, E., Adianti, M., Rahman, A., Widyawaruyanti, A., Lusida, M.I., Fuad, A., Soetjipto, Nasronudin, Fuchino, H., Kawahara, N., Shoji, I., Deng, L., Aoki, C. and Hotta, H. 2013. Antiviral activities of Indonesian medicinal plants in the East Java region against hepatitis C virus. *Virology Journal*, 10: 259.

Wang, J., Chen, X., Wang, W., Zhang, Y., Yang, Z., Jin, Y., Ge, H.M., Li, E. and Yang, G. 2013. Glycyrrhizic acid as the antiviral component of *Glycyrrhiza uralensis* Fisch. against coxsackievirus A16 and enterovirus 71 of hand foot and mouth disease. *Journal of Ethnopharmacology*, 147: 114-121.

Wang, L., Yang, R., Yuan, B., Liu, Y. and Liu, C. 2015. The antiviral and antimicrobial activities of licorice, a widely-used Chinese herb. *Acta Pharmaceutica Sinica B*, 5: 310-315.

Wang, Y., Bai, H., Dou, D., Pei, Y., Chen, Y., Li, W., Koike, K., Xing, S. and Nikaido, T. 2004. Study on the flavonoids constituents of cultivated licorice. *Northweset Pharmaceutical Journal,* 6: 1-4.

Wang, Z.Y. and Nixon, D.W. 2001. Licorice and cancer. *Nutrition and Cancer*, 39: 1-11.

Wittschier, N., Faller, G. and Hensel, A. 2009. Aqueous extracts and polysaccharides from liquorice roots (*Glycyrrhiza glabra* L.) inhibit adhesion of *Helicobacter pylori* to human gastric mucosa. *Journal of Ethnopharmacology,* 125: 218-223.

Yan, G.H., Dong, G.L. and Hua, Y.J. 2002. Measurement and comparison of glycyrrhizic acid contents in roots of licorice (*Glycyrrhiza uralensis* Fisch.) from different cultivating areas. *Journal of Forest Research,*13: 141-143.

Yenesew, A., Midiwo, J.O., Heydenreich, M., Schanzenbach, D. and Peter, M.G. 2000. Two isoflavanones from the stem bark of *Erythrina sacleuxii*. *Phytochemistry,* 55: 457-459.

Yong, X., Neng-jun, X. and Nai-ding, W. 2009. Analysis of chemical constituents of licorice extract: volatile compounds by GC-MS. *Applied Chemical Industry,*38(11): 1683-1687.

Young, W.C., Jung, H.A., Liu, Y., Su, B.N., Castoro, J.A., Kellar, W.J., Pereira, M.A. and Kinghorn, A.D. 2007. Anti-oxidant constituents of the roots and stolons of licorice (*Glycyrrhiza glabra*). *Agricultural and Food Chemistry*, 55: 4691–4697.

Yu, X.Q., Xue, C.C., Zhou, Z.W., Li, C.G., Du, Y.M., Liang, J. and Zhou, S.F. 2008. *In vitro* and *in vivo* neuroprotective effect and mechanisms of glabridin, a major active isoflavan from *Glycyrrhiza glabra* (licorice). *Life Sciences,* 82: 68-78.

Zore, G.B., Winston, U.B., Surwase, B.S., Meshram, N.S., Sangle, V.D., Kulkarni, S.S. and Mohan, K.S. 2008. Chemoprofile and bioactivities of *Taverniera cuneifolia* (Roth) Arn.: A wild relative and possible substitute of *Glycyrrhiza glabra* L. *Phytomedicine,* 15: 292-300.

Zuo, Z., Zhao, H., Liu, X., Zhu, Y., Xia, R., Zhu, Y., Zhang, Y. and Lin, M. 1994. Studies on the chemical constituents of prickly fruit licorice (*Glycyrrhiza pallidiflora*). *Chinese Traditional and Herbal Drugs,* 25: 3-6.