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A Recent Update on Hepatoprotective Potential of Herbal Plant

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Abstracts

Liver damage is an epidemic and metabolic disorder which is the most important cause of mortality and morbidity globally. Liver injury treatments are important issue of today's research domain, because of many allopathic drugs and their toxic influence lead to liver damage. Therefore attention is drawn to the potentials of medicinal plants that have the hepatoprotective ability to reduce or cure liver disorder. The use of herbal plants or their primary and secondary metabolites for curing diseases has long being in continuation since ancient times due to its therapeutic efficacy and safety. Various herbal plants have been investigated for their hepatoprotective potential to treat different types of liver disorder. Numerous herbal plants and formulations are effective in treatment of liver disorder. This systemic review mainly is focused on herbal plants as hepatoprotective in various traditional medicines and explores the herbal plant, isolated active constituent and formulation with hepatoprotective activity.

Keywords: *Hepatoprotective activity; Herbal plant; Liver disease*

Introduction

Liver is the largest glandular organ of the body which plays a pivotal role to regulate whole metabolic process and homeostasis of the body. It is the most important site of intermediary metabolism and accountable for detoxifying any foreign material and other xenobiotics by converting and excreting waste and toxin. It is considered as one of the most vital organs due to the handling the metabolism of carbohydrates, lipid, protein, secretion of bile, storage of vitamins and production of a variety of coagulation factors. Thus the maintenance of healthy liver is imperative for human health (Pradhan and Girish 2006, Haidry and Malik 2014). In spite of its extensive regenerative capacity, continuous various exposures to environmental pollutants, xenobiotics, and chemotherapeutic agents could repress and overcome the natural protective ability of the liver, leading to liver malfunction and later if it is not treated properly leads to liver injury.

Today, alcohol misuse is one of the major health problems globally. There is a close relationship between ethanol intake and alcoholic liver disease because of 80% of consumed alcohol is metabolized in the liver consequently profound effect on the metabolism of lipids and lipoproteins. Moreover, ethanol is metabolized into cytotoxic acetaldehyde by enzyme alcohol dehydrogenase and acetaldehyde is oxidized to acetate by aldehyde oxidase or xanthine

oxidase in the liver, giving rise to reactive oxygen species (ROS) via cytochrome P450 2E1 (Lu and Cederbaum 2008). This leads to oxidative stress in the hepatic cells which is the most striking initial expression of alcohol-induced liver injury ultimately damage to the liver cell membrane and the cytosolic enzymes are leaked into the blood stream. Therefore, the elevation of these cytosolic enzymes in the blood stream serves as a quantitative marker of hepatic damage (Ramaiah 2007).

It has been reported that the free radicals induced oxidative stress is a main cause of liver disorder such as swelling, necrosis, degeneration and apoptosis of hepatic cells. Liver may be damaged by free radicals via mechanisms of lipid peroxidation and covalent binding with consequent tissue injury. Reactive oxygen species (ROS) such as superoxide, hydroxyl, peroxyl, and alkoxy radicals cause damage to nucleic acid, proteins, and membrane lipids and have been associated with many aging related problems together with atherosclerosis, liver disorders, lung, kidney damage, diabetes mellitus, cancer inflammatory diseases and cardiovascular diseases (Singh et al. 2008, Pal et al. 2014). Lipid peroxidation damage to cell membranes subsequent affects the integrity and function of the cell membrane which affects the cell's ability to maintain ion gradients and transport. On the other hand liver disorders are mainly caused by chemicals and drugs when taken in very high doses (Ekaidem et al. 2012).

In case of liver damages the capacity of natural antioxidant system is impaired. ROS are generated by environmental factors such as ultraviolet radiation, pollutants, x-rays, or by normal metabolic process in mitochondria. The intracellular concentration of ROS depends on both their generation by endogenous or exogenous factors and removal by various endogenous antioxidants including both enzymatic and nonenzymatic processes (Haque et al. 2014)

Liver diseases are major global health problem prevalent in developing countries. Liver disease classified as hepatosis (non-inflammatory), acute or chronic hepatitis (inflammatory) and cirrhosis or fibrosis (degenerative). It is frequently abused by the environmental toxins, heavy metals, poor eating habits, alcohol, prescription and the counter drug use thus it is damaged and weakened ultimately leads to the hepatitis, jaundice, liver fibrosis and alcoholic liver disease. Liver disease may results in elevated levels of plasma total cholesterol, Low density lipoprotein cholesterol (LDL-C), and Triacylglycerols (TGs) are associated with high risk of atherosclerosis and cardiovascular disease (Dominiczak, 2005, Ekaidem et al. 2012).

Almost all organisms possess antioxidant defence and repair systems which reduce the production of free radical species, but these protective systems are insufficient to entirely prevent the damage when there is increased oxidant radical generation. Various antioxidant agents of herbal plant have been found to protect human liver from free radicals damage (Ekaidem et al. 2012). The presence of a wide

range of phytoconstituents such as phenolics thiols and caretonoids in herbal plants protects the human body against oxidative damage by ROS (Pal et al. 2014).

Although the notable progresses in conventional medical therapy in the last 20 years, drugs available for the treatment of hepatic diseases were limited in efficacy and could have prompted various unwanted side effects when compared to other medical therapies for hepatic diseases which were difficult to handle. In addition, some of these modern hepatoprotective drugs did not protect liver against injury. In response to these factors that limit the use of conventional drugs and efforts were continuously made to identify new sources of agents with hepatoprotective potential (Mamat et al. 2013).

Interestingly, over the last few decades the reputation of use complementary and alternative medicines has increased worldwide due to its therapeutic efficiency and safety, particularly herbal/plant-based therapies, to cure various diseases, efforts are increasingly being carried out by scientists to investigate the hepatoprotective potential of various medicinal plants (Mamat et al. 2013).The plant kingdom is a valuable source of new herbal medicinal agents. In recent years numerous traditional medicinal plants were tested for their hepatoprotective potential in the experimental animals. Traditional medicines and prescriptions with beneficial effects against various pathological conditions have recently paying attention as alternative therapies (Biswas et al. 2014). Several studies have proved the beneficial outcomes of herbal medicine for human health. A variety of molecules have been isolated and their physicochemical and pharmacological properties have been studied.

However, compounds and extracts need to be appropriately formulated to facilitate their physiological target and pharmacological activity. Factors such as low permeability and solubility could affect the absorption and delivery of bioactive molecules (Fang and Bhandari, 2011). On the other hand the shelf-life of herbal medicine should be evaluated in order to assurance the stability during the period of use. Degradation reactions are enhanced by temperature, humidity, pH, oxygen and light. Herbal medicines are complex mixtures of different classes of chemical compounds, such as carbohydrates, lipids, proteins, and secondary metabolites (Bott et al. 2010).

In present study an effort has been made to review the most prospective herbal plants having pharmacologically most reputable hepatoprotective potential.

Herbal plant with reported hepatoprotective potential

Allium cepa

Allium cepa (Family: Liliaceae) commonly known as garden onion. *A. cepa* is a bulbous plant extensively cultivated in China, India and United States. It is rich in carbohydrates, potassium, sodium and phosphorus. Traditionally onion has been used to treat

intestinal infections, ear ache, eye infections, headaches associated with drowsiness, urinary tract burning, ulcers on heels and cough resulted from inspiration of cold air (Price et al. 1997).

Phytochemical screening revealed that aqueous extract of bulbs of *A. cepa* contains abundant a group of polyphenolic compounds tannins, saponins, flavanoids. organosulphur compounds like dipropyl disulphide, methyl-1-propenyl trisulphide and propyl-1-propenyl trisulphide (Teyssier et al. 2001). Approximately 20 types of flavonols were detected, with the two main flavonols representing up to 80–85% of the total flavonoid content i.e. quercetin conjugates:quercetin-m 3, 40-O-diglucoside (QDG) and quercetin-40-O-monoglucoside (QMG) (Price et al. 1997).

Many reports revealed that onion was found to have antibacterial, antiviral, antiparasitic, antihyperlipidemic, antifungal, anti-inflammatory antihypertensive, anti-hypoglycemic, antithrombotic, and antioxidant activities (Griffiths et al. 2002). In recent decades, the extracts of various parts of the *A. cepa* have been extensively studied for their anti-diabetic (Kook et al. 2009), anti-tumor (Dorant et al. 1996), hepatoprotective (Obioha et al. 2009), and anti-nephrotoxicity (Ige et al. 2011)activities. The antioxidant activity in *A. cepa* bulb is mainly due to the existence of flavonoids, selenium, vitamin C and amino acids (Zielinska et al. 2003, Elhassaneen et al. 2009). *A. cepa* also shows effective antioxidant activity.

A. cepa aqueous bulb extract had showed hepatoprotective activity against ethanol-induced hepatotoxicity in adult male albino wistar rats which might be due to its antioxidant potential against DPPH (2,2-diphenyl-1-picrylhydrazyl), hydroxyl and superoxide radicals which quench ROS and regenerate membrane-bound antioxidants at both preventive and curative doses and significantly restored the elevated levels of Serum aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and total bilirubin (TB) (Kumar et al. 2013).

Alocasia indica

Alocasia indica (Family: Araceae) is extensively cultivated in tropical and sub-tropical regions, such as West Bengal, Maharashtra Assam, and Southern India. In local languages of West Bengal, it is popular as '*Mannkochu*'. The plant is a perennial herb frequently attaining heights of 5 meters. The tuber part of the *A. indica* plant is edible and is also used as a common vegetable available easily and cheap among common people (Pal et al. 2014). Since last few decades *A. indica* is used in the treatment of abdomen and spleen related disorders. The non-edible part of the plant, like leaves, has been used for the treatment of various inflammatory diseases including bruises and rheumatism (Pal et al. 2014).

It was also revealed that the ehanolic extract of the leaves of the plant contained free radical scavenging activity, hepatoprotective activities

(Mulla et al. 2009), antioxidant, antinociceptive, anti-inflammatory, antimicrobial activities (Mulla et al 2010), antidiarrheal and antiprotozoal activities (Mulla et al. 2011).

Phytochemical screening of both the ehanolic and aqueous extract revealed the presence of alkaloids, flavonoids, tannins, glycosides and phenolics as found in several plant extract (Vulgaris et al. 2013).

It has been reported that phenolic compounds like flavonoids, phenolic acid, proanthocyanidins, diterpenes and tannins are derived from several medicinal plants and exhibit antioxidant activity by inactivating free radicals or by preventing the decomposition of hydroperoxides into free radicals. Flavonoids have free radical scavenging activity, inhibition of hydrolytic and oxidative enzyme activity as well as antinociceptive and anti-inflammatory activities (Akinpelu et al 2010, Pal et al. 2014).

In vivo antioxidant activity was done by hepatoprotection against liver injury induced by carbon tetrachloride (CCl_4) in rats which has been extensively and successfully reported by many investigators. CCl_4 is metabolized by cytochrome P-450 in endoplasmic reticulum and mitochondria with the formation of CCl_3O^-, a ROS which initiates lipid peroxidation and enhanced marker enzymes such as ALT, ALP and AST (Shahjahan et al. 2004). Malonaldehyde (MDA), marker of lipid peroxidation, was noticeably increased in ethanol-attenuated liver. Reduced glutathione (GSH) is normally present in hepatocytes for detoxification of free radicals. GSH depletion increases the sensitivity of cells to various aggressions leading to tissue disorder and injury (Meagher et al. 1999, Pal et al. 2014).

Histopathological study of CCl_4 induced liver section shows severe necrotic changes and substantial changes such as microvesicular steatosis, increase in sinusoidal space, inflammatory infiltration of lymphocytes, dilation of central vein and increase in fat droplet (Shi et al 1998).

Ethanolic extract of *A. indica* tuber recover the changes by showing the normal pattern of the central vein, radiating pattern of cell plates and absence of fat droplets. Serum marker ALT, ALP, AST, MDA, GSH were significantly reversed by ethanolic extract of *A. indica* tuber (Pal et al. 2014).

Antrodia Cinnamomea

Antrodia cinnamomea (Family: Polyporaceae) is a medicinal mushrooms and parasitic fungus can be mostly found in Taiwan. *A. Cinnamomea* is used to treat liver diseases, abdominal pain, hypertension, diarrhea, and other diseases (Ao et al. 2009). Historically, indigenous Taiwanese people have used to treat liver disorders from excessive alcohol consumption. However, it is difficult to collect wild *A. cinnamomea* fruiting bodies (Liu et al. 2012).

Several reports have been published on the chemical components of *A. cinnamomea.* Phytochemical constituents isolated from *A.*

cinnamomea, such as flavonoids, benzenoids, polyphenols, maleic/succinic acid derivatives, diterpenes, triterpenoids, steroids, and polysaccharides, have been reported to exhibit therapeutic activities (Lu et al. 2007 and 2011, Huang et al. 2010a, Kumar et al. 2011, Wu et al. 2011).

A. Cinnamomea fruiting bodies were reported to show the hepatoprotective potential against ethanol induced acute liver injury in Sprague Dawley (SD) rats (Chiang et al., 2010). Huang et al. investigated the effects of *A. cinnamomea* fruiting bodies against chronic alcohol consumption in rats and found that the gene expression of SREBP-1c, acetyl-CoA carboxylase, 3-hydroxy-3-methoxyglutaryl-CoA reductase, fatty acid synthase and malic enzyme was downward regulated. The results of histopathological examination also revealed that the alcohol induced liver injuries i.e. hepatocyte necrosis and inflammatory cell infiltration, were prevented by ethanolic extract *A. cinnamomea* fruiting body (Huang et al. 2010a).

Wu et al. investigated the hepatoprotective potential of *A. cinnamomea* fruiting bodies against ethanol induced liver fibrosis and found that the expression of hepatic mRNAs, i.e., matrix metalloproteinase (MMP)-9, tumor necrosis factor (TNF)-α, Kruppel-like factor (KLF)-6 and transforming growth factor (TGF)-β1, were downward regulated by ethanolic extract *A. cinnamomea* (Wu et al. 2011).

Lu et al. reported the effects of *A. cinnamomea* mycelia against ethanol induced liver injury in male SD rats and found the suppression of elevated levels of AST, ALT, ALP, and TB in rats by orally administration of *A. cinnamomea*. Lu et al. (2011) further reported that a triterpenoid enriched fraction of the ethanolic extract of *A. cinnamomea* mycelia showed the greatest effectiveness in preventing ethanol induced acute liver injury and free radical generation in rats (Lu et al. 2007).

Hsiao et al. examined the hepatoprotective potential of the water extract of fruiting bodies against CCl_4 induced liver injury in mice and found that the level of plasma transaminases, i.e., AST and ALT, were significantly decline in the group of mice orally administered with the aqueous extract of *A. cinnamomea* (Hsiao et al. 2003). Hseu et al., reported that the activities of hepatic superoxide dismutase (SOD) and catalase (CAT) were enhanced by treatment with the water extract of *A. cinnamomea*. The water extract of *A. cinnamomea* fruiting bodies exhibits an ability to scavenge 1,1-diphenyl-2-picrylhydrazyl radicals in an in vitro study (Hseu et al., 2008).

Bidens pilosa

Bidens. pilosa (Family: Asteraceae) is an erect, perennial herb widely distributed from temperate and tropical regions (Alcaraz et al. 1998) and traditionally medicine used for several purposes including the treatment of antitumor, anti-inflammatory, antidiabetic and antihyperglycemic, antioxidant, immunomodulatory, antimalarial, antibacterial,

antifungal, antihypertensive, vasodilatory, hepatoprotective and antiulcerative activities. (Yuan et al. 2008, Arlene et al. 2013).

B. pilosa is an extraordinary source of phytochemicals and 201 compounds have so far been identified from this plant, including 70 aliphatics (36 polyynes), 60 flavonoids, 25 terpenoids, 19 phenylpropanoids, 13 aromatics, 8 porphyrins, and 6 other compounds (Silva et al 2011).

All parts of the plant are used in the medicinal preparations, which are mainly water and alcohol macerations in bottles or herbal teas used orally or topically. Kviecinski et al. evaluated free radical scavenging activity of *B. pilosa*, which exert a beneficial action in preventing liver damage induced by CCl_4 and significant decrease serum enzymatic activities of AST, ALT, and lactate dehydrogenase (LDH) (Kviecinski et al. 2011).

Boerhavia diffusa

Boerhavia diffusa (Family: Nyctaginaceae) is a well known medicinal plant in traditional Indian medicine as well as Southern American and African continent. Its various parts and especially roots have been used for gastrointestinal, hepatoprotective, and gynecological indications, immunomodulation, antifibrinolysis, anticancer activity, antidiabetic activity, anti-inflammation, and diuresis. *B. diffusa* has been widely studied for its phytochemical constituents and therapeutic activities. The roots are the source of a novel class of isoflavonoids known as rotenoids, flavonoids, flavonoid glycosides, xanthones, purine nucleoside, lignans, ecdysteroids, and steroids (Mishra et al. 2014a).

Miralles et al. reported 15 amino acids (6 essential) in the whole plant and 14 amino acids (7 essential) in the roots along with isopalmitate acetate, behenic acid, arachidic acid (6.3%), and saturated fatty acids (38%) (Miralles et al. 1988). Ujowundu et al. (2008) accounted the presence of vitamins C, B3, and B2 (44.80, 97.00mg, and 22.00mg) along with calcium (174.09mg) in roots. *B. diffusa* contains various categories of secondary metabolites, i.e. flavonoid glycosides, isoflavonoids (rotenoids), steroids (ecdysteroid), alkaloids, and phenolic and lignin glycosides (Bairwa et al. 2014).

Venkatalakshmi et al. accounted for protection against paracetamol induced hepatotoxicity for *B. diffusa* extracts (Venkatalakshmi, 2011). Olaleye et al. evaluated the aqueous and ethanolic extracts of fresh leaves for antioxidant activity *in vitro* and *in vivo* assays. Antioxidative evaluation of the ethanolic extract has shown appreciable quantities of phenolic and flavonoid content along with vitamins C and E. It also contained selenium and zinc. Pretreatment with *B. diffusa* aqueous and ethanolic extracts decline enzymatic activities and serum bilirubin caused by acetaminophen.The increase in ALP was reduced by almost 50% by aqueous and ethanolic extracts (both 400mg/Kg, orally for 7 days) whereas the increase in ALT and AST was decreased by more than 70% and serum

LDH level was also restored (Olaleye et al. 2010).

Caesalpenia crista

Caesalpinia crista (Family: Febaceae), commonly known as karanja, is an extensive shrub perennial climber distributed throughout India on waste land and coastal areas (Gupta et al. 2005). Phytochemical screening of ethanolic extract of *C. crista* revealed the presence of various phyto-constituents such as alkaloids, saponin glycosides, phenolic, flavonoids and carbohydrate. The seeds of the plant contain arginine, aspartic acid, citroline and diterpine δ-caesalpin.

C. crista have been used for treatment of anti-inflammatory, jaundice, antihelmintic, antimalarial, stomachic, various liver disorders antidiabeti and antiperiodic, antipyretic (Kannur et al. 2006).

The ethanolic extract of *C. crista* (200 and 400 mg/kg) significantly reversed the levels of serum glutamic pyruvates transaminase (SGPT) and serum glutamic oxaloacetate transaminase (SGOT) and ALP and total bilirubin and triglycerides against paracetamol induced liver toxicity in rats.

Chelidonium majus

Chelidonium majus L. (family: Papaveraceae) is a plant highly admire for its therapeutic potential in western phytotherapy and traditional Chinese medicine (TCM). The plant contains, as major phytochemicals i.e. isoquinoline, flavonoids, phenolic acids and alkaloids such as sanguinarine, chelidonine, chelerythrine, berberine, protopine and coptisine. Both crude extracts of *C. majus* and purified compounds derived from it exhibit a wide variety of biological activities i.e. anti-inflammatory, antimicrobial, immunomodulatory, antitumoral, choleretic, hepatoprotective, analgesic (Gilcaa et al. 2010).

The ethanolic extract of whole plant exerted marked hepatoprotection against CCl_4 toxicity in rats and p-dimethylaminoazobenzene-induced hepatocarcinogenesis in mice, indicated by a reduction in the number of necrotic cells, a prevention of fibrotic changes, and decreased activities of transaminases and bilirubin (Biswas etal. 2008).

Cyperus rotundus

Cyperus rotundus L. (Family: Cyperaceae), also known as purple nutsedge or nutgrass, is a common perennial weed with slender, scaly creeping rhizomes, bulbous at the base and arising singly from the tubers which are about 1-3 cm long (Uddin et al. 2006).

Different phytochemical studies on *C.rotundus* revealed the presence of alkaloids, flavonoids, tannins, starch, glycosides, furochromones, monoterpenes, sesquiterpenes, sitosterol, glycerol, linolenic, myristic and stearic acids. The major phytochemicals isolated from essential oil and the extracts of *C. rotundus* rhizome are Alpha-cyperone, Alpha-rotunol, Beta-cyperone, Beta-pinene, Beta-rotunol, Beta-selinene, Calcium, Camphene, Copaene,

Cyperene, Cyperenone, Cyperol, Cyperolone Cyperotundone D-copadiene, D-epoxyguaiene, D-fructose, D-glucose, Flavonoids, Gamma-cymene, Isocyperol, Isokobusone, Kobusone, Limonene, Linoleic-acid, Linolenic-acid, Magnesium, Manganese, C. rotunduskone, Myristic-acid, Oleanolic-acid, Oleanolic-acid-3-o-neohesperidoside, Oleic-acid, P-cymol, Patchoulenone, Pectin, Polyphenols, Rotundene, Rotundenol, Rotundone, Selinatriene, Sitosterol, Stearic-acid, Sugeonol, Sugetriol [Sivapalan 2013].

C.rotundus contains an essential oil that provides for the characteristic odour and taste of the herb, comprised mostly sesquiterpene hydrocarbons, epoxides, ketones, monoterpenes and aliphatic alcohols. Sesquiterpenes include selinene, isocurcumenol, nootkatone, aristolone, isorotundene, cypera-2,4(15)-diene, and norrotundene, as well as the sesquiterpene alkaloids rotundines A-C. Other constituents include the ketone cyperadione, and the monoterpenes cineole, camphene and limonene. *C.rotundus* has also been shown to contain miscellaneous triterpenes including oleanolic acid and sitosterol, as well as flavonoids, sugars and minerals (Jeong et al. 2000, Kilani et al. 2008).

A number of pharmacological and biological activities including anti-inflammatory, antidiabetic, antidiarrhoeal, cytoprotective, antimutagenic, antimicrobial, antibacterial, antioxidant, cytotoxic, apoptotic, anti-pyretic and analgesic activities have been reported for this plant [Sivapalan 2013].

The ether extract of the rhizomes of *C. rotundus* (100 mg/kg) exhibited significant hepatoprotective effect by lowering serum levels of glutamic oxaloacetic transaminase, glutamic pyruvic transaminase, alkaline phosphatase and total bilirubin in rats by inducing liver damage by carbon tetrachloride. The ethyl acetate extract (100 mg/kg) exhibited hepatoprotective activity supplemented by histopathological examination of liver sections [Kumar et al. 2005, Sivapalan 2013].

The methanolic extract of leaves of *c. rotundus* (200mg/kg) evaluated for the hepatoprotective effect against CCl_4 induced liver damage in wistar albino rats which shows significant ($p<0.05$) hepatoprotective effect by lowering the SGOT, SGPT and ALP (Rao et al. 2014).

Dendrophthoe falcate

Dendrophthoe falcate (Family: Loranthaceae) is used extensively in traditional system of medicine as cooling, bitter, aphrodisiac, epilepsy, astringent, narcotic, diuretic, pulmonary tuberculosis, asthma, menstrual disorders, swellings, wounds, ulcers, renal, vesical calculi and skin diseases. The decoction of whole plant is used to treat joint pains and leaf juice is used for relief from chest pain. *D. falcate* is also reported to have cytotoxic, immunomodulatory activities, and wound healing potentials (Haque et al 2014).

Leaves of *D. falcate* contain L- Threonine dehydratase, hexokinase, Glucanphosphatase. It has also been reported several possible active chemical constituents such as β-

amyrinacetate, β-sitostirol, stigmasterol, oleanolic acid, kaempferol, quercetin, quercetin–3-O-rhamnoside, rutin, myricetin and their glycosides, catechin, leucocyanidin, kaempferol-3-O-α-L-rhamnopyranoside and quercetin-3-O-α-Lrhamnopyranoside. *D. falcate* also contains tannins comprising of gallic acid, chebulinic acid, ellagicacid, quercetinand and cardiac glycosides such as strospeside, odoroside F and neritaloside were isolated from the leaves of *D. falcate*. Pentacyclic triterpenes: 3β-acetoxy-1β-(2-hydroxy-2-propoxy)-11α-hydroxy-olean-12-ene, kaempferol-3-O-α-L-rhamnopyranoside, quercetin-3-O-α-L-rhamnopyranosidewere also reported in the plant (Haque et al 2014).

The study revealed that the phenolic compounds and flavonoids in the ethanolic extract of leaves of *D. falcata* are responsible for the hepatoprotective activity of both ethanol and aqueous extracts significantly reduced AST, ALT, ALP, TB levels and increased the total protein (TP) and total albumin (TA) levels. The liver histology of the ethanolic extract treated group showed microfatty changes with a dense collection of lymphoid cells suggesting evidence of very little necrosis or degeneration (Pattanayak and Priyashree 2008).

Haque et al reported ethanolic and aqueous extract shows hepatoprotective activity against CCl_4 toxicity in rats indicated by a reduction AST, ALT, ALP, TP and TB (Haque et al 2014).

Ficus carica

Ficus carica L. (Family: Moraceae) is ordinarily deciduous tree and commonly known as “fig” and inhabited to southwest Asia and the eastern Mediterranean. The dried fruits of *F. carica* have been reported as source of vitamins, minerals, carbohydrates, sugars, fiber, organic acids, and phenolic compounds such as proanthocyanidins. Its fruit, root, and leaves are used in traditional medicine to treat various ailments such as gastrointestinal (i.e. colic, indigestion, loss of appetite and diarrhea), respiratory (i.e. sore throats, coughs, and bronchial problems), and cardiovascular disorders and as anti-inflammatory and antispasmodic remedy (Mawa et al. 2013).

Phytochemical studies on *F. carica* revealed the presence of various bioactive compounds such as phenolic compounds, phytosterols, organic acids, anthocyanin, triterpenoids, coumarins, and volatile compounds such as hydrocarbons, aliphatic alcohols (Oliveira et al. 2009).

The ethanolic extract of *F. carica* leaf (200 mg/kg) exhibited hepatoprotective activity against CCl_4 induced hepatotoxicity in mice model and observed that enhanced protection against CCl4 induced hepatic damage (Aghel et al. 2011).

Petroleum ether extracts of Shade dried leaves of *Ficus carica* indicating promising antihepatotoxic activity against rifampicin induced liver toxicity in rats and there was significant reversal of biochemical, histological and functional changes i.e. SGOT,

SGPT, TB and histological changes in liver (Gond and Khadabadi 2008).

The ethanolic extract of *F. carica* leaves exhibited hepatoprotective and antioxidant activity in hepatotoxic Albino rats induced via CCl_4 and significantly decline biochemical parameters such as SGOT, SGPT, TP, TA, ALP and TB. The extract in addition reduced CCl_4 induced lipid peroxidation i*n-vivo* and *in-vitro* **(Mohd).**

Hibiscus rosasinensis

Hibiscus rosasinensis flower extract is commonly used to treat symptoms related to blood circulation deficiencies, and is well known to reduce blood and plasma viscosity and thus improve microcirculation. In addition, it has received much attention due to its numerous biological activities, such as inhibition of platelet aggregation, suppression of hypertension and anti-aging (Biswas et al. 2014).

Phytochemical analysis of the crude extract of *H. rosasinensis* showed the presence of alkaloids, saponins, tannins, phenolics and flavonoids. Flower extract of *H. rosasinensis* exhibits hepatoprotective potential against hypercholesterolaemic rats and significantly decreased the levels of AST, ALT, ALP enzymes in the serum and significantly increased in TP levels (Biswas et al. 2014).

Hibiscus sabdariffa

Hibiscus sabdariffa L., also known as roselle, is an ideal crop for developing countries and can be used as food and fibre. In China the seeds are used for their oil and the plant is used for its medicinal properties, while in West Africa the leaves and powdered seeds are used in meals. Additionally, it is used in the pharmaceutical and food industries (Da-Costa-Rocha et al. 2014).

The main phytochemicals of *H. sabdariffa* are organic acids, anthocyanins, polysaccharides and flavonoids. Methanolic and aqueous extracts of *H. sabdariffa* (100-800 mg/Kg) showed hepatoprotective effects in a range of models based on toxin-induced hepatitis including, *tert*-butylhydroperoxide, lipopolysaccharides, azathioprine, carbon tetrachloride, cadmium, ammonium chloride, acetaminophen and irradiation (Da-Costa-Rocha et al. 2014).

The hepatoprotective and antioxidant potential investigation showed that Polyphenol Rich Extract of *H. sabdariffa* (50 and 100 mg/kg) was able to scavenge the ABTS and DPPH radicals and significantly decline serum ALT, AST, ALP, LDH GSH, SOD, CAT and TBARS levels against CCl_4 induced liver toxicity in rats (Adetutu and Owoade 2013).

Leptadenia pyrotechnica

Leptadenia pyrotechnica (Family: Asclepiadaceae) is a plant wild growing in the Sharm El-Sheikh region, southern Sinai, Egypt. The leaves and bark of the plant are used in folk medicine to prepare antispasmodic, anti-inflammatory, antihistaminic, antibacterial diuretic, urolith

expulsion, expectorant, gout, and rheumatism remedies (Amal et al. 2009).

The main phycoconstituents of *L. pyrotechnica* are phenolic compounds, flavonoids, quercetin-3-*O*-galactoside, alkaloids, pregnane glycosides, amino acids, sterols, sitosterol, triterpenoids, taraxerol, fernenol, and leptadenol, fatty acids, and fatty alcohols (Amal et al. 2009).

The methanolic extract of whole plant of *Leptadenia pyrotechnica* exhibited hepatoprotective activity against hepatic damage in rats and marked reduction in the elevated activities of the hepatic enzymes i.e. SGOT, SGPT, ALP and TB levels (Partap et al. 2014).

Loranthus parasiticus

Loranthus parasiticus (Family: Loranthaceae) is aerial hemiparasitic plants. *L. parasiticus* contains pronounced levels of crude 82.28% of fiber, 2.70% of crude protein, 0.77% of crude fat and 2.60% of other components (Chen et al., 2003). Coriaria lactone is a mixture of compounds isolated from *L. parasiticus* includes sesquiterpene lactones such as coriamyrtin, tutin, corianin and coriatin. These sesquiterpenes were isolated from the ethanol extract of L. parasiticus leaves. Aqueous fraction of L. parasiticus contains two known proanthocyanidins of AC trimer and (β)-catechin (Wong et al., 2012b).

The ethanol extract of *L. parasiticus* stem shows hepatoprotective potential against CCl_4 damage in rat liver and caused 50% inhibition on SGPT (Moghadamtousi et al. 2014).

Melastoma malabathricum

Melastoma malabathricum L. (family: Melastomaceae) is known to the "*Senduduk*" and has been used to treat various diseases. The leaves of *M. malabathricum* have been proven to possess various pharmacological activities, including antioxidant activity, antibacterial, antiviral, antiparasitic, cytotoxicity, anticoagulant, platelet-activating factor inhibitory, wound healing, antiulcer, antidiarrheal, antivenom, antiinflammatory, antinociceptive and antipyretic and hepatoprotective activity (Yahya et al. 2012).

Various phytochemical have been isolated from ethanolic extracts of *M. malabathricum* i.e. isoquercitrin 6"-O-gallate, malabathrin- A, -B, -C, -D, -E and -F, 1,4,6-tri-O-galloyl-β-D-glucoside, 1,2,4,6-tetra-O-galloyl-β-D-glucoside, strictinin, casuarictin, pedunculagin, nobotanin-B, -D, -G, -H and -J, pterocarinin C, new complex tannins in which an ellagitannin and a flavan-3-ol are bound by a C-glycosidic linkage belonging to type II + tannins, casuarinin, (−)-epicatechin gallate, (−)-epicatechin, stachyurin, procyanidin-B2 and -B5, stenophyllanins A and B, alienanin B, and brevifolincarboxylic acid. The methanol extract of *M. malabathricum* contains ursolic acid, 2-hydroxyursolic acid and asiatic acid, as well as glycerol-1,2-dilinolenyl- 3-O-β-Dgalactopyranoside and glycerol 1,2-dilinolenyl- 3-O- (4,6-di-O-isopropylidene)-β-D-galactopyranoside, 2,5,6-trihydroxynaphtoic

carbonic acid, methyl-2,5,6-trihydroxynaphtalene carbonate, flavonol glycoside derivative quercitrin and kaempferol-3-O-(2',6'-di-O-p-trans-coumaroyl)- β-glucosid. The hexane fraction of methanol extract *M. malabathricum* contains β-sitosterol, α-amyrin, uvaol, quercetin, quercitrin, rutin, and sitosterol-3-O-β-D-glucopyranoside; iv) 90% aqueous methanolic extract – ursolic acid, 2α-hydroxyursolic acid and asiatic acid, β-sitosterol 3- O-β-Dglucopyranoside, glycerol 1,2-dilinolenyl-3-O-β-D-galactopyranoside and glycerol 1,2-dilinolenyl-3-O-(4,6-O-isopropylidene)-β- D-galactopyranoside. The ethyl acetate extract *M. malabathricum* contains 2,5,6-trihydroxynaphtoic carbonic acid, methyl-2,5,6-trihydroxynaphtalene carbonate, and flavonol glycoside derivative, quercetin and quercitrin. The hexane extract *M. malabathricum* contains 2,5,6-trihydroxynaphtoic carbonic acid, methyl-2,5,6-trihydroxynaphtalene carbonate, and flavonol glycoside derivative, α-amyrin, patriscabatrine and auranamide (Mamat et al. 2013).

Mamat et al. reported hepatoprotective activity of the methanolic extract of *M. malabathricum* against the paracetamol induced hepatotoxic model in rats (Mamat et al. 2013)

Oxalis corniculata

Oxalis corniculata L.,(Family: Oxalidaceae) is a subtropical, delicate-appearing, low growing, herbaceous plant being native of India abundantly distributed in damp shady places, roadsides, plantations, lawns, nearly all regions throughout the warmer parts of India, especially in the Himalayas and commonly known as creeping woodsorrel. Traditionally the plant reported to possess varsatile medicinal uses likely treatment for relieve the intoxication produced by *Datura*, as a refrigerant. decoction of roots is useful for worms, giddiness, diarrhea and dysentery. The leaves *O. corniculata* are useful for cough, cold, fever, antihelmintic, stomach ache and stop bleeding from wounds.

Phytochemical investigations methanolic and ethanolic extracts of of *O. corniculata* have revealed the presence of tannins, palmitic acid, fiber, tannin oleic, linoleic, linolenic, stearic acids, carbohydrate, glycosides, phytosterols, phenolic compounds, flavanoids, proteins, amino acids volatile oil, tartaric acid, citric acids, calcium oxalate and flavones (Das et al. 2012).

The ethanolic extract of *O. corniculata* exhibited significant hepatoprotective effects against the paracetamol induced hepatotoxicity in rat model and decline the serum levels of various biochemical parameters such as SGOT, SGPT and ALP (Sreejith et al. 2014).

Petroselinum crispum

Petroselinum crispum (family: Umbelliferae), locally known as Baqdunis and have been employed in the food, pharmaceutical, perfume, and cosmetics industries and serve as vegetable or condiment in cookery. Parsley has been claimed in Arab Traditional Medicine to

possess variety of properties including laxative, diuretic and antiurolithiatic. The leaves are used against inflammatory condition, aphrodisiac, mastitis, haematomata, constipation, flatulence, jaundice, colic, edema, rheumatism, diseases of prostate and liver ailments, antimicrobial, antianemic, hemorrhagic, anticoagulant, antihyperlipidemic, antihep-atotoxic lumbago, blood pressure regulator, eczema, knee, ache, impotence nose bleed and laxative. Parsley seed are also used as a diuretic and the hypoglycemic activity. Jassim reported antihepatotoxic potential and protective activity on kidney damage induced by valoproic acid (Jassim 2013). The Phytochemical screening *P. crispum* revealed the presence of ascorbic acid, carotenoids, coumarins, apiole, various terpenoic compounds, phenyl propanoids, phthalides, furano coumarins, and tocopherol, flavonoids, tannins, sterols and or triterpenes (Al-Howiriny et al. 2003, Jassim 2013).

An ethanolic extract of *P. crispum* exhibited significant potential of anti-inflammatory and anti-hepatotoxic activities against inflammation induced by carrageenan and cotton pellet granuloma and hepatic damage induced by CCl_4 in rats. (Al-Howiriny et al. 2003).

Farzaei et al., reported hepatoprotective activity of ethanolic extract of *P. crispum* against CCl_4 induced oxidative stress mice (Farzaei et al. 2013).

Rheum palmatum

Rheum palmatum found among the oldest and best known herbal medicines. They are present in Chinese Pharmacopeia and used as laxative, antiphlogistic and treatment of indigestion. *R. palmatum* herb is also applied to stimulate gastric juice and bile excretion. Rhubarb roots have an antibacterial, anticancer activity, antioxidant activity, antiviral and hepatoprotective. The most important phytoconstituents of roots are antrachinons (2–8%) such as chrysophanic acid, emodin, aloe-emodin, rhein and physcion, with their O-glycosides such asglucorhein, chrysophanein, glucoemodin; sennosides AE, reidin C and others, their glycosides, bianthrones, hydrolysable and condensed tannins (5–10%), mainly catechin, stilbenes (resveratrol, rhapontigenin), volatile oil (containing paeonol, di-isobutyl phaltate, cinnamic aldehyde, methyl eugenol); rutin, fatty acids, calcium oxalate and phenolic constituent such as flavonoids, stilbenes and anthraquinones (Akinpelu et al. 2010).

In addition to the clinical evidence of the effectiveness of rhubarb in treating chronic hepatic diseases, many experiments at the animal, cellular and molecular levels have revealed that rhubarb and its anthraquinone constituents exert hepatoprotective effect against hepatic injury against CCl_4 induced elevation of ALT, AST, hyaluronic acid (HA) and laminin (LN) levels in rats and mice (Wang et al 2011).

Salvia miltiorrhiza

Salvia miltiorrhiza, (Family: Labiatae) is a deciduous perennial flowering plant in the genus *Salvia*, highly valued for its roots in traditional Chinese medicine and commonly known as Danshen and found in China and Japan, preferring grassy places in forests, hillsides, and along stream banks in the west and southwest provinces of China. Danshen is the dried root of *S. miltiorrhiza* and is one of the most versatile Chinese herbal drugs. Danshen was used infrequently in ancient Chinese's medicine, yet it has become an important herb in modern Chinese clinical practice and used clinically to treat and prevent cardio-vascular disease, hyperlipidemia, and cerebro-cardiac, vascular disorders such as atherosclerosis (Cheng 2007).

The main phyto-constituents of *S. miltiorrhiza* can be divided into two groups, hydrophilic compounds such as salvianolic acids, and lipophilic chemicals, including diterpenoid and tanshinones and the second group of components, labelled tanshinone I, tanshinone II, cryptotanshinone. More recently, nearly 40 variants of the basic tanshinone structures have been found in the roots. The tanshinones are unique chemical constituents, and similar compounds are not found in other Chinese herbs. The total tanshinone content of the roots is about 1%, with tanshinone I and II and cryptotanshinone being present in the largest amount. In one recent study, the concentration of *S. miltiorrhiza* yielded tanshinone II 0.29%, cryptotanshinone 0.23% and tanshinone I 0.11%. Among the tanshinones, tanshinone I, tanshinone IIA and cryptotanshinone are the major bioactive constituents and have various kinds of pharmacological effects including anti-inflammatory, antibacterial, hepato-protective, antioxidant, antitumor activities, prevention of angina pectoris and myocardial infarction (Wang 2010).

S. miltiorrhiza has been widely used for the treatment of various liver diseases in different experimental models. Parajuli et al. reported hepatoprotective potential of purified extract isolated from *S. miltiorrhiza* enriched with tanshinone I, tanshinone IIA and cryptotanshinone on hepatocyte injury induced by CCl_4 *in vitro* and *in vivo* (Parajuli et al. 2013).

Tephrosia purpurea

Tehrosia purpurea (Family: Fabaceae) is common known as wild indigo in Tamil 'Kolanji' and widely distributed in tropical, sub-tropical and arid regions of the world. It is an important component of some preparations such as Tephroli and Yakrifit used for liver disorders. Traditionally drug is used as liver tonic, treatment of jaundice, dyspepsia, diarrhoea, rheumatism, asthma and urinary disorders (Dalwadi et al. 2014).

The crystalline compounds were isolated from petrol soluble fraction of $CHCI_3$ extract of *T. purpurea* along with isolonchocarpin, pongamol, lanceolatin B and lanceolatin A, isopentenyl. Phytochemical investigation also revealed the presence of flavonoids, glycosides, rotenoids, isoflavones, flavanones, chalcones, flavanols and sterols. (Dalwadi et al. 2014).

The ethanolic extract of the root of *T. purpurea* exhibits hepatoprotective activity against CCl_4 induced oxidative damage and dysfunction in the liver of rats and decline hepatospecific enzymes such as AST, ALT, acid phosphatase (ACP), ALP, LDH and 5' nucleotidase (5'NT) and serum levels of TB and total cholesterol (TC) whereas TP, TA, total glycogen (TG) and hepatospecific enzymes were significantly increased (Dalwadi et al. 2014).

Gora and Baxla reported hepatoprotective potential of *T. purpurea* extracts (500 mg/kg) against arsenic induced toxicity in wistar albino rats and observed reduced serum ALT , AST, ALP activity and increased TP and reduced necrosis and inflammation in liver **(Gora and Baxla).**

Aerial parts of *T. purpurea* evaluated for its efficacy in rats by inducing hepatotoxicity with D-galactosamine HCl (acute) and carbon tetrachloride (chronic). The ethanolic extract of *T. purpurea* leaves were evaluated for hepatoprotective activity in rats by inducing hepatotoxicity with CCl_4 and conclude that the hepatoprotective activity was more in ethanolic extract of leaves (Chaudhari et al. 2012).

Terminalia arjuna

Terminalia arjuna (Family: Combretaceae) is a deciduous and ever green tree, standing 20-30m above ground level and found in Uttar Pradesh, South Bihar, Madhya Pradesh, Delhi and Deccan region near ponds and livers. Stem bark *T. arjuna* possesses glycosides, large quantities of flavonoids, tannins and minerals. Flavonoids have been detected to antioxidant, anti inflammatory and lipid lowering effects while glycosides are cardiotonic (Doorika and Ananthi 2012).

The aqueous extract of *T. arjuna* (200mg/kg) bark exhibits hepatoprotective effect against isoniazid induced acute liver damage on albino rats and significantly reduced the elevated levels of biochemical markers i.e. ALT, AST and ALP and increased the level of SOD and GSH (Doorika and Ananthi 2012).

The extract of bark of *Terminalia arjuna* reported for its hepatoprotective and antioxidative effects on cadmium induced toxicity in albino rats and significantly decline the serum levels of following biomarkers ALT, AST, ALP, and MDA and enhance the protein and antioxidant enzymes i.e. SOD, CAT, and GSH (Haidry and Malik 2014).

Trigonella foenum-graecum

Trigonella foenum-graecum L. (Family: leguminosae) is commonly known as fenugreek. *T. foenum-graecum* with common name Methi in India is used in medicine to tonify kidneys, disperse cold and alleviate pain, hernia and pain (Sharma et al., 1996). *T. foenum-graecum* have therapeutic effect against anti ulcer, wound healing, CNS stimulant, immunomodulatory, antioxidant, antidiabetic, anti-neoplastic, anti-inflammatory and anti-pyretic drugs (Zargar 2014).

The extract prepared from the dried seeds of *T. foenum-graecum* exhibits hepatoprotective

potential against rat model induced liver cirrhosis by thioacetamide. After the administration of extract the oxidative stress and lipid peroxidation were reversed and the elevated levels of ALP, c-glutamyl transferase and selected biochemical markers of liver cirrhosis including drug metabolizing enzymes were also reversed (Zargar 2014).

Ziziphus mucronata

Ziziphus mucronata (Family: Ramnaceae) medicinal plants are used traditionally to treat various ailments in Africa and grows throughout Upper Egypt, Sinai and in the Mediterranean region, Africa, Australia, and tropical America.. Zizyphus has a common name ‘‘Nabka”. The roots, bark and leaves are used in the treatment of arthritis, chest pains digestive disorders, weakness, liver complaints, obesity, urinary troubles, diabetes, skin infections, loss of appetite, fever, pharyngitis, bronchitis, anemia, diarrhea, and insomnia (Koeven 2001). Other medicinal properties of *Z. mucronata* are hypoglycemic, hypotensive anti-inflammatory, antimicrobial, antioxidant, antitumour and Hepatoprotective, antioxidant and as an immune system stimulant (Yossef et al. 2011)**.**

Phytochemical studies show the presence of cyclopeptide alkaloids, flavonoids, sterols, tannins, and triterpenoid saponins and peptide, cyclopeptide betulinic acid (Yossef et al. 2011)**.**

The methanol leaf extract of *Z. mucronatai* exhibits the hepatoprotective activity against dimethoate induced liver toxicity and oxidative stress in male albino Sprague Dawley rats by maintaining normal reduced GSH, vitamin C and E, SOD, CAT, cholineasterase and lipid profiles and significant decline activities of SGOT, SGPT and ALP (Kwape et al. 2013a).

Conclusion

The above mentioned herbal plants reviewed in detailed for hepatoprotective potential. In traditional systems of medicine herbal plants and their formulations are used to cure liver diseases. Despite the availability of extensive information concluded that herbal remedies are effective alternatives for management of hepatic diseases. A single drug cannot be effective against all types of liver disorders therefore effective formulations have to be developed using indigenous herbal plants, with proper pharmacological experiments and clinical trials.

Table: 1- List of harbal plants showing Hepatoprotective activity

S. N.	Name of plant	Plant Part used	Plant Extract	Active constituent	Experimental Model	Hepatoprotective activity/study outcome	Reference
1	*Allium cepa*	Fresh bulbs	Aqueous extract	Proteins, carbohydrates, polyphenolic compounds tannins, saponins, flavanoids	Ethanol induced liver damage in male rats	AST, ALT, ALP and TB, were significantly decreased	Kumar et al. 2013
2	*Alocasia indica*	Tuber	Ethanolic (80%) and Aqueous extract	Alkaloids, flavonoids, glycosides, saponin and tannins	CCl_4 induced hepatic injuries in male Albino Wister rats	Recovery percentage of serum ALT by 65.32% and AST by 77.36%	Pal et al. 2014
3	*Antrodia Cinnamomea*	Fruiting bodies and Mycelia	Aqueous extract and Ethanolic extract (90%)	Benzenoids, diterpenes, triterpenoids, steroids, maleic/succinic acid derivatives,	CCl_4 induced liver injury and ethanol induced liver injury in rats	Suppression of ethanol and CCl_4 induced elevation of expression of hepatic mRNAs, i.e. MMP-9, TNF-α, KLF-6, and TGF-β1 levels	Liu et al. 2012
4	*Bidens pilosa*	Dried aerial parts	Ethanolic extracts (90%)	Flavonoids and polyacetylenes	CCl_4 induced liver injury in Male Balb-c mice.	Significant decrease serum enzymatic activities of AST, ALT, and LDH	Kvieci nski et al. 2011
5	*Boerhavia diffusa*	Roots	ethanolic extract (95%)	Flavonoid glycosides, isoflavonoids, steroids, alkaloids, and phenolic and lignan glycosides	Hepatotoxicity induced by country made liquor in rats	Reduced the increment in serum parameters like SGPT, SAP, TGs, and total lipid levels	Mishra et al. 2014a
6	*Caesalpenia crista*	Leaves	Ethanolic extract (90%)	Carbohydrate, alkaloids, glycosides and phenolic compounds	Paracetamol induced hepatotoxicity in rats.	Reversed the levels of SGPT, SGOT, ALP, TB and TGs	Mishra et al. 2014
7	*Chelidonium majus*	Whole plant	Ethanolic extract	Benzyl isoquinoline alkaloids viz. protoberberine, protopine, benzophenanthredine	p-dimethyl aminoazobenzene (p-DAB) induced hepatocarcinogenesis in mice	Biochemical assay of some toxicity marker enzymes and histology of liver sections suggest hepatoprotective effects	Biswas et al. 2008
8	*Cyperus rotundus*	Leaves	Methanolic extract	Flavonoids and alkaloids	CCl_4 induced liver damage in wistar albino rats	Lowering the serum levels of various biochemical parameters such as serum SGOT, SGPT, ALP	Rao et al 2014
9	*Dendrophtho e falcate*	Leaves	Aqueous and Ethanolic extracts	Phenol and flavonoids	Liver damage was induced by intraperitonial administration of 25% CCl_4 in olive oil in rats	Reduced the increment in serum parameters like AST, ALT, ALP, TP and TB	Haque et al. 2014
10	*Ficus carica*	Leaves, Fruit and Roots	Petroleum ether extract, Aqueous extract and Methanolic extract	Phenolics organic acids and volatile compounds	Rifampicin induced liver damage in male rats	Significant reversal of biochemical, histological, and functional changes induced by rifampicin on rats indicated potential hepatoprotective activity	Mawa et al. 2013
11	*Hibiscus rosa sinensis*	Flower	Aqueous extract	Saponins, flavonoids, tannins, phenols, sterols, alkaloids, and anthocyanins.	Induced hypercholesterolemia by feeding pure cholesterol and cholic acid orally mixing with coconut oil in rats	Decreased the levels of AST, ALT, ALP enzymes in the serum	Biswas et al. 2014
12	*Hibiscus sabdariffa*	Seeds, Leaves and Shoots	Aqueous extracts	Phenolic acids, organic acid and anthocyanins	CCl_4 induced oxidative damage of rat liver	Significantly reduced serum activities of ALT, AST, and ALP	Da-Costa-Rocha et al. 2014
13	*Leptadenia pyrotechnica*	Whole plant	Methanolic, petroleum ether, chloroform, acetone and aqueous extract	flavonoids and polyphenolic compounds	Paracetamol induced liver damage in wistar rats	A marked reduction in the elevated activities of the hepatic enzymes i.e. SGOT, SGPT, ALP and TB levels	Partap et al. 2014
14	*Loranthus parasiticus*	Leaves	Ethanolic extract	Sesquiterpene lactones (coriamyrtin, tutin, corianin and coriatin)	D-galactosamine and CCl_4 damage in rat liver cells	50% inhibition on SGPT	Mogha damtou si et al. 2014

15	*Melastoma malabathricum*	Leaves	Methanolic extract	Flavonoids	Paracetamol induced liver toxicity in rats	Serum liver enzymes ALT, ALP and AST as well as the microscopic observations and microscopic scoring supported the hepatoprotective potential	Mamat et al. 2013
16	*Oxalis corniculata*	Whole plants	Ethanolic extract (95%)	Flavonoids, phenols and tocopherols	Paracetamole induced hepatotoxicity in wistar rats	Lowering the serum levels of various biochemical parameters such as SGOT, SGPT and ALP,	Sreejith et al. 2014
17	*Petroselinum crispum*	Leaves	Aqueous extract	Flavonoids, phenolic compounds and ascorbic acid	STZ- induced diabetic rats	Significant decrease in blood glucose, ALP, sialic acid, uric acid, potassium and sodium levels, liver lipid peroxidation and non-enzymatic glycosylation and increase in liver glutathione	Farzaei et al. 2013
18	*Rheum palmatum*	Dried root	Ethanolic extract (90%)	Anthraquinone derivatives and tanninrelated compound	CCl_4 induced liver injury in rats	Elevation of ALT, AST, HA and laminin (LN) levels were reversed	Wang et al 2011
19	*Salvia miltiorrhiza*	Dried pulverized roots	Ethanolic extract (95.6%)	Salvianolic acids, tanshinone, cryptotanshinone	CCl_4 induced liver injury in rats	Induce apoptosis of hepatic stellate cells (HSCs)	Parajuli et al. 2013
20	*Tephrosia purpurea*	Root	Ethanolic extract	Isolonchocarpin, purpurenone, purpurin, dehydrolsodericin, maackiain, purpurin, semiglabrin and pseudosemiglabrin	CCl_4 induced oxidative damage and resultant dysfunction in the liver of rats.	Decreasing the serum levels of AST, ALT, ACP, ALP, LDH and 5' NT	Dalwadi et al. 2014
21	*Terminalia arjuna*	Bark	Aqueous extract	Flavonoids, tannins and oligomeric proanthocyanidins	Cadmium induced toxicity in Albino Rats	Significantly reversed the elevated the serum levels of following biomarkers ALT, AST, ALP, and MDA	Haidry and Malik 2014
22	*Trigonella foenum-graecum*	Dried seeds	Ethanolic extract	β-carotein, saponins, coumarin, nicotinic acid, phytic acid, scopolatin, trigonelline	Thioacetamide induced liver cirrhosis in rats	The elevated levels of alkaline phosphatase, c-glutamyl transferase and selected biochemical markers of liver cirrhosis were reversed.	Zargar 2014
23	*Ziziphus mucronata*	Leaves	Methanolic extract (70%)	Phenols	Dimethoate induced liver damage in rats	A significant decline serum marker enzymes SGOT, SGPT and ALP	Kwape et al. 2013

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