ISSN: 2456-043X

International Journal of Engineering Science and Generic Research (IJESAR)

Available Online at www.ijesar.in

Volume 11; Issue 4; 2025; Page No. 47-73

Herbal Plants with Hepatoprotective Effects: A Review

Sunil Kumar Malviya[1], Deepak K Birla[2], Manmeet S Saluja[2]

[1]Research Scholars, SunRise University, Alwar, Rajasthan, India
[2]Research Supervisor, SunRise University, Alwar, Rajasthan, India

Article Info: Received: 11-03-2024 / Revised: 22-04-2024 / Accepted: 28-05-2025
Correspondence: Sunil Kumar Malviya
Conflict of interest statement: No conflict of interest

Abstract

The rise of liver diseases has recently surfaced as a major issue in global health. Multiple hazardous substances, including chemotherapeutic medications, thioacetamide, carbon tetrachloride, certain antibiotics, excessive alcohol use, and pathogenic microbes, may induce these disorders. Consequently, keeping the liver healthy is crucial to overall wellness. The downsides of synthetic drugs have outweighed their advantages, notwithstanding progress in pharmacology. Modern medical treatments for liver illness are expensive, associated with dangerous side effects, and ineffective, making them unaffordable for developing countries. Consequently, there seems to have been a worldwide spike in curiosity about studying medicinal plants as possible substitutes for conventional medical treatments. These plants are cheap, easily available, and do not need labor-intensive pharmaceutical production processes. Traditional herbs have been the main emphasis thus far because of their efficacy, low toxicity, and low cost. A literature search using several databases, such as Google Scholar, ISI Web of Knowledge, and PubMed, was conducted and the findings are presented in this study. We combed through every piece of literature on medicinal plants from throughout the world that may provide liver protection. Furthermore, we discussed phytochemical compounds with hepatoprotective effects and wrapped off by showcasing forthcoming studies on the subject.

Keywords: Bioactive compounds, hepatotoxicity, liver diseases, medicinal plant, pharmacology

Introduction

The liver is the most crucial organ because of all the work it does for the body. It is involved in the metabolism of lipids, proteins, and carbohydrates, and it also excretes waste metabolites. Being the first organ in the body to acquire toxins from the intestines, the liver plays a role in their breakdown and elimination, including medications and other foreign chemical substances. Following is a list of the specific functions performed by the liver. Glycogen, minerals, vitamins, and iron are just a few of the many compounds that might be stored in it. When the body's energy demands exceed its blood sugar levels, the liver releases glucose from glycogen reserves. This process eliminates a wide variety of substances from the circulation, including pathogenic organisms, alcohol, chemicals, heavy metals, drugs, and toxic by-products. The liver breaks down a wide variety of substances that end up in the blood, including chemicals, drugs, viruses, bacteria, parasites, fungi, herbicides, alcohol, lipids, food additives, and dead cells. The liver is also known as the biochemical unit of the body since it carries out all of its functions via the skin, lungs, and mouth, among other organs. In the bloodstream, it breaks down substances before distributing them to other parts of the body. The liver's digestive function includes the synthesis of bile, which is necessary for the digestion and emulsification of lipids, oils, and other compounds, including vitamins A, D, E, and K [4]. The proteins it might create include those found in blood, as well as hormones, enzymes, immunological components, and clotting factors. And lastly, when blood sugar levels are low, the liver may make cholesterol, which is a carrier for the energy-supplying lipids needed to make adenosine triphosphate.

Hepatotoxins and Liver Disorders

One of the most critical global health issues is the prevalence of liver diseases in poor countries. Hepatosis without inflammation, hepatitis with inflammation (acute or chronic), and cirrhosis or fibrosis caused by degeneration are all forms of liver disease. They are often brought on by exposure to heavy metals, toxins, malnutrition, or the use of over-the-counter medications that do not have a valid prescription. The aforementioned causes destroy and damage hepatocytes, leading to alcoholic liver disease, hepatitis, jaundice, and fibrosis of the liver. A rise in blood cholesterol levels might be an indication of liver injury or sickness. Having high amounts of triacylglycerols (TAGs) and low-density lipoprotein cholesterol (LDL-C) increases the risk of cardiovascular problems. [5] Hepatic cell overconsumption, toxic substances like thioacetamide (TAA), drug abuse (e.g., paracetamol), chemotherapeutic agents (e.g., carbon tetrachloride, CC14), aflatoxin, microbes, and viral infections (e.g., hepatitis A, B, C, and D) are additional factors that have been demonstrated to cause damage to hepatic cells in previous research. The endoplasmic reticulum and mitochondrial cytochrome P-450 metabolize CC14 from 6 to 8, which generates reactive oxygen species (ROS, $CCl3O^{-}$) and may induce lipid peroxidation. Analgesic and antipyretic properties of PCM make it a common medicine for treating pain and fever. If this medicine is used in excess, it might damage the liver cells, leading to liver disease or injury. [9] Furthermore, when PCM is supplied in excess, it may cause a significant amount of harm to the liver cells, leading to a condition called necrosis. This kind of cell death is characterized by nuclear pyknosis and eosinophilic cytoplasm. The metabolism of PCM in the liver results in the formation of N-acetyl-P-benzoquinoneimine, an oxidative byproduct. Cytochrome P-450 enzymes are among the proteins that these chemical binds to covalently via their sulfhydryl groups. The final cause of this process is the peroxidative degradation of glutathione (GSH) lipids, which leads to hepatocyte necrosis.

Trimethylammonium (TAA) is another substance that damages membranes and prevents RNA from freely passing between the nucleus and cytoplasm. Because of the TAA metabolite, this liver damage occurs. [9] It is possible that TAA reduces the number of hepatocytes and also decreases the frequency of oxygen consumption. More than that, it lowers the bile salt and deoxycholic acid concentrations as well as the total quantity of bile. Abnormal bile excretion, brought on by hepatotoxin-associated liver injury, manifests as an increase in blood toxin levels. [10] This liver must always be able to operate regularly for human health to be maintained. Between the ages of 11 and 13, the liver undergoes incredible regeneration, but it is under continual threat from xenobiotics and chemotherapeutic medications, among other environmental pollutants, which may weaken its defenses and lead to liver damage and malfunction. [14]

In contrast, hepatotoxic chemicals often impair kidney function by damaging hepatocytes, a process that frequently involves oxidative reactions such lipid peroxidation. After liver damage, the antioxidant systems in the body are unable to do their job. Radiation from X-rays, pollutants, ultraviolet light, or metabolic processes inside mitochondria are among the external sources that may generate radon oscillations (ROS). [15] Intracellular ROS concentration is solely dictated by the rate of ROS production and clearance by different endogenous antioxidants, including enzymatic and nonenzymatic pathways. [15]

Extensive research indicates that oxidative stress, brought on by free radicals, leads to hepatocyte degeneration, swelling, necrosis, and apoptosis. Free radicals often injure or harm the liver by lipid peroxidation and covalent binding, which then leads to tissue degeneration. Respiratory oxygen species (ROS) degrade cell membrane lipids, proteins, and nucleic acids; they are linked to a host of age-related diseases and conditions, including diabetes, kidney and lung damage, liver disorders, cancer, inflammatory diseases, cardiovascular diseases, and atherosclerosis. Page 16 and page 17 A process known as lipid peroxidation may damage cell membranes and impair their ability to function. As a result, the cell becomes less efficient in maintaining constant ion gradients and transport. [18] in the liver may also be damaged by chemical exposure and heavy drug use. [14] You can see the proven effects of several medications on the liver in Table 1 and Figure 1.

Lipidic oxidation and free radicals

The process of free radical scavenging is vital in preventing lipid peroxidation that is caused by free radicals. Exposure to ethanol starts a cascade of events that leads to hepatitis and cirrhosis via an enhanced metabolic pathway that produces lipid peroxidation [19]. Hepatoprotective medications made from less harmful plant components have been used over the last several decades. Consequently, a lot of research in this field has been devoted to finding novel hepatoprotective compounds in plants. The importance of regulating the levels of reactive oxygen species (ROS) and antioxidant enzymes such as glutathione peroxidase (GSH-Px), superoxide dismutase (SOD), and catalase (CAT) is emphasized in reference [20]. This is necessary for protecting against oxidative stress and its associated health complications, such as diabetes, kidney and liver damage, cancer, and heart disease. Cu-Zn, Mn-SOD, CAT, and GSH reductase are enzymes that function as natural lipid peroxidation defenses [22]. They stop or slow down this process by eliminating ROS either directly or sequentially. [23] The To prevent lipid peroxidation, it is essential to maintain a high amount of glutathione (GSH), an important cytosolic antioxidant that helps in xenobiotic detoxification and excretion. One xenobiotic that may produce free radicals, namely trichloromethyl radicals, which can cause acute damage to liver cells is CCl_4 [24]. [25] The The Usually, substances that boost the activity of glutathione S-transferase, an enzyme that might potentially convert potentially hazardous chemicals into harmless ones, trigger an ever-increasing defensive mechanism in the liver. Natural commodities, including medicinal plants and their components, may treat and prevent many diseases since they don't interfere with the body's systems as much. citations 26 and 27 There is some evidence that some herbal extracts may help a liver that is already working overtime. 8, 13, and 28

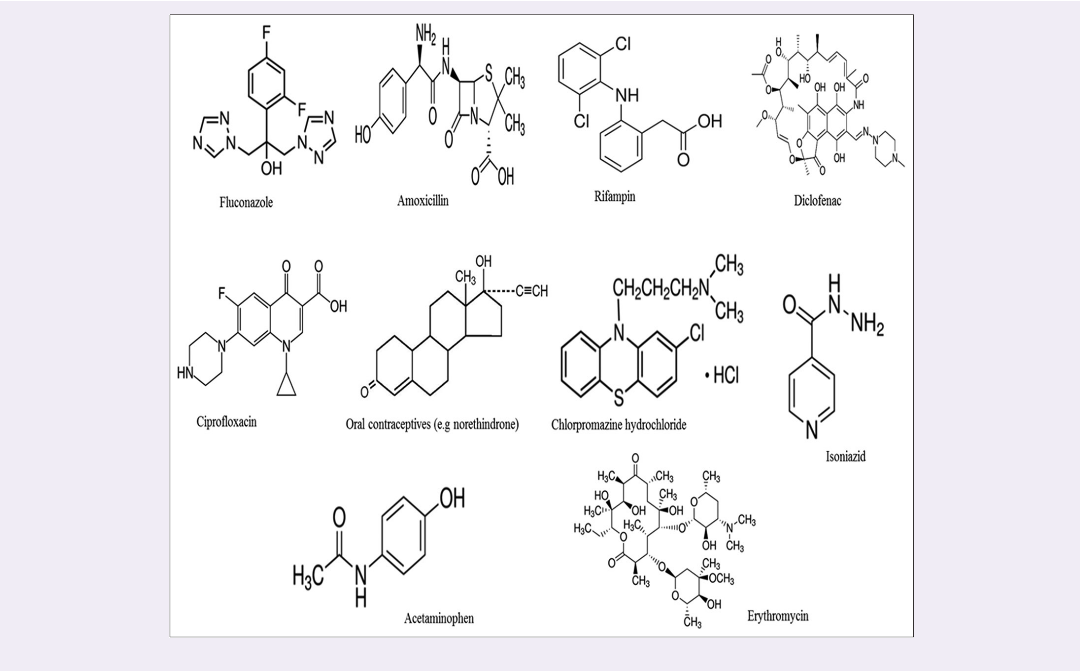
Table 1: Example of some drugs with hepatotoxicity effects

Drugs	Implication
Fluconazole	It leads to hepatitis; it increases the transaminase level, fulminant hepatic failure, and cholestasis
Amoxicillin	It moderates or brings about an increase in SGPT and SGOT levels, hepatic failure such as jaundice, acute cytolytic hepatitis, and hepatic cholestasis
Diclofenac	It elevates AST and ALT levels, jaundice, fulminant hepatitis, and liver necrosis
Rifampin	It leads to hepatitis, hyperbilirubinemia, and cholestasis Ciprofloxacin Elevation of SGOT alkaline phosphatase and SGPT levels occurs from cholestatic jaundice
Oral	Benign neoplasm, hepatic vein occlusion, and jaundice, contraceptives but rarely neoplasm of the liver
Chlorpromazine	It leads to infectious hepatitis with obstructive jaundice as a biomarker
Isoniazid	It elevates the serum transaminase level, severe and fatal hepatitis
Acetaminophen	It makes the cytochrome P-450-2E1 produce a toxic metabolite NAPQI that causes hepatic necrosis Erythromycin. It increases SGPT and SGOT concentration, and it also brings about hepatocellular hepatitis that are sometimes associated with it

SGOT=Serum glutamic oxaloacetic transaminase, ALT=Serum alanine aminotransferase, AST=Aspartate aminotransferase, SGPT=Serum glutamic pyruvic transaminase, NAPQI=N-acetyl-P-benzoquinoneimine

Liver Diseases and Alcoholism

Nowadays, excessive alcohol use is a leading cause of liver problems. [14] Use of ethanol is associated with alcoholic liver disease because the liver is engaged in the metabolism of alcohol, which affects the metabolism of lipoproteins and lipids. In addition, the process of converting ethanol to ROS involves the activation of cytochrome P4502E1. The variables 27 and 30 Figure 2 shows the steps that lead up to oxidative stress in the liver; this stress damages the liver and changes the structural stiffness of the cell membrane, which lets cytosolic enzymes enter the bloodstream. Consequently, the most common biochemical sign of liver damage is increased blood levels of cytosolic enzymes. found in [31] Alanine transaminase (ALT) and aspartate transaminase (AST) levels in the cytoplasm and mitochondria both increase in damaged liver cells. An increase in serum hepatospecific enzymes is caused by a change in the structure of the liver cell membrane, which is caused by membrane leakage. The rate of erythrocyte breakdown is accelerated when blood bilirubin levels are high. Accordingly, human health depends on keeping the liver in good shape. [32] Damage to the liver caused by alcohol is seen in Figure 2.



Medicinal Plants as an Alternative Treatment

A large portion of the global mortality and morbidity burden is attributable to metabolic disorders, which include liver dysfunction. Liver damage remedies have lately gained global attention due to the negative effects of several allopathic drugs on the liver. Folkloric herbs with hepatoprotective effects have so received a great deal of interest from researchers seeking to cure liver disease or injury. The fact that these plants are both medicinal and relatively safe explains a lot. The hepatoprotective properties of many traditional medicines have lately been investigated in animal research. The curative powers of herbs have been known and practised in traditional medicine for a very long time. Researchers have studied the pharmacological and physicochemical properties of several molecule types that have been identified. To accomplish their physiological purpose and manifest their pharmacological effects, chemicals and extracts must be synthesized appropriately. Factors like as low solubility and permeability may affect the absorption and distribution of bioactive substances. [32] It is vital to determine the shelf life of herbal drugs to make sure they remain stable throughout consumption. Light, heat, acidity, humidity, and oxygen all have a role in hastening the breakdown process. There are many different types of chemical components included in herbal treatments. These include carbohydrates, proteins, lipids, metabolites (both primary and secondary), and a host of others. [33]

The negative side effects of synthetic medications have prompted many people to look for alternative hepatoprotective drugs. at the 34th page These days, most hepatoprotective drugs used to treat liver diseases are plant-based, either as single herbs or in complicated mixtures. Traditional medicinal herbs play an important role in the health care systems of rural communities, especially in less developed countries where access to modern medicine is limited. [1] Approximately 70,000 plant species have some kind of therapeutic use. There is a lack of clarity on the science behind the preparation and dose of plants, despite their growing appeal as natural therapy choices. Plants with minimal toxicity should be prioritized, regardless of their usefulness and cost-efficiency. Although there are several herbal medications available, research has shown that only a few numbers of bioactive components really possess the desired antiviral, antioxidant, anticarcinogenic, antifibrotic, and anti-inflammatory properties. [35 & 36]

Investigations on Hepatotoxicity In Vivo and In Vitro

The system's chosen model for hepatic injury is the only determinant of the therapy decision for liver disease. Despite the availability of many models for evaluating the potential hepatoprotective effects of various plant and chemical extracts, the majority of these models have their drawbacks. Accordingly, merging these models will provide optimal outcomes. [37] The pathophysiological damage induced by several chemical substances (such as hypoxia hepatotoxins or anoxia tests in perfused immobilized hepatocytes) was reported in an in vitro investigation by Cerný et al. [38] using hepatocyte cultures and perfused hepatocytes. Table 2 displays a selection of the in vivo models that have been described. Laboratory investigations continue to form the backbone of most research on the hepatoprotective effects of medicinal herbs.

In order to fight free radical species, the majority of organisms have developed their own defensive systems that rely on antioxidants. When the number of free radical species is much higher than the antioxidant that the body produces naturally, the antioxidant system's protective function is inadequate, and external antioxidants play a crucial role. There are a number of plant-based antioxidants that have shown promise in protecting the liver from free radical damage. [39] The phytochemicals found in herbal plants, including phenolics, thiols, and caretonoids, shield the human body from ROS-induced oxidative damage. [17] The focus is now on possible medicinal plants with hepatoprotective properties to treat various liver diseases. The safety and effectiveness of traditional herbal remedies has allowed them to be used for medical purposes since ancient times. A number of herbs have been studied for their hepatoprotective properties, which might help cure various liver ailments. [14] Table 2 shows that many herbal formulations have been successful in treating liver diseases; this study primarily looked at the literature on those that have been shown to have hepatoprotective effects in studies conducted all over the world.

Some Medicinal Plants with Hepatoprotective Activity

Dodonaea viscosa (Sapindaceae)

One species of soapberry is the flowering plant Dodonaea viscosa. Subtropical, warm, and tropical temperate zones in Africa, the Americas, and Australia are just a few places you could find Sapindaceae plants. [47] This herb, which local traditional healers call "Sanatha," has been used for decades to help individuals with diabetes manage their condition. [132] In their investigation, Ahmed et al. [47] documented the hepatoprotective and antihyperlipidemic properties of an aqueous: methanolic (70:30) D. viscosa leaf extract. Alloxan was used to cause diabetes in the rabbits. The findings demonstrated that the experimental group had reduced blood levels of total cholesterol, HDL-CHL, ALT, and AST in comparison to the control group. The extract also markedly increased HDL-CHL, AST, and ALT levels. The hepatoprotective effects of D. viscosa leaf extract are confirmed by these findings.

Phyllanthus muellarianus (Euphorbiaceae)

Senegal, Uganda, Mali, Congo, Togo, South Africa, and the Ivory Coast are just a few of the many African nations where you may find the straggling, monoecious, glabrous, climbing shrub or small tree called Phyllanthus muellarianus. [40] The medicinal uses of this plant's extracts are extensive, including the treatment of paralysis, fever, and bacterial infections, among many others. The presence of phytochemical components that may be responsible for the therapeutic activity, such as furosin, isoquercetin, phaselic acid, corilagin, nitidine, geraniin, and gallic acid, was shown in a phytochemical examination of an extract from P. muellarianus leaf (pages 133 and 134). 3, 5, 13, 136 In 2017, the researchers Ajiboye et al. investigated the effects of a water-based P. muellarianus leaf extract on hepatocellular indices, proinflammatory markers, oxidative stress, and lipid peroxidation in Swiss albino mice with liver injuries caused by b-acetaminophen. [40] This study found that the aqueous leaf extract substantially decreased the acetaminophen-induced increases in ALT, ALP, AST, ALB, and TB ($P < 0.05$). The water-based leaf extract may have antioxidant characteristics since it may reduce the levels of certain liver enzymes that acetaminophen causes, which might mean that it protects the liver from harm caused by acetaminophen. One of the plant extract's phytochemical components, gallic acid, is a well-known antioxidant that may undo acetaminophen-induced liver damage and AST, ALT, and ALP. [137]
In a similar vein, acetaminophen significantly decreased SOD, GSH, CAT, G6PH, and GSH-Px activities in rat liver. Tumor necrosis factor-alpha, malondialdehyde, lipid hydroperoxides, protein carbonyl, and fragmented DNA were significantly attenuated by an aqueous leaf extract of the investigated plant. Additionally, the plant's preventive qualities made it an attractive candidate for potential future usage as a nutritional supplement. [40] **Aquilaria agallocha** (Thymelaeaceae)

The trunk of this enormous tree is three or four feet in diameter, and it may grow to be sixty to eighty feet tall. Southeast Asia is its native home. The bark is papery thin and was sometimes utilized for that purpose, similar to how Betula used it. The leathery, narrow leaves may reach a length of three inches. The fruit is smooth and thin, measuring one to two inches in length, and it is accompanied by white blooms. The plant Aquilaria agallocha has many pharmacological effects, such as reducing fever, pain, inflammation, anxiety, diabetes, diabetes, ulcers, and seizures; and antidiabetic, antihistaminic, antipyretic, laxative, antidiarrheal, sedative, antibacterial, and antimicrobial properties, among many others. [138] Alam et al. [72] demonstrated that Sprague-Dawley (SD) rats' livers were protected against PCM-induced hepatotoxicity by using an ethanolic extract of A. agallocha (AAE) leaves at a concentration of 400 mg/ml. The results showed that AAE leaves are hepatoprotective, as they decreased TB, AST, ALP, ALT, LDH, and CHL in SD rats, and they enhanced ALB and total protein content. They also protected PCM-induced histological alterations in the liver. [72]

Table 2: Medicinal plants with hepatoprotective potentials

Family	Name of the plant	Plant parts used	Extract used	Oral dose (mg/kg)	Hepatotoxicity inducing agents	Biochemical and histopathological parameter studied	Reference
Euphorbiacea e Scrophulariac eae Fabaceae Rubiaceae Cannaceae Moraceae Zingibera ceae Sapindac eae Asteraceae Cyatheaceae Araceae Nyctaginacea e Apocynaceae Asclepiadoide ae Arecaceae Asteraceae Cactaceae	*Phyllanthus muellarianus Picrorhiza kurroa Bauhi nia varieg ata Galium aparine Canna indica Ficus cordata Curcuma longa Dodonaea viscosa Eclipta prostrata Cyathea gigantea Alocasia macrorrhizo s Boerhavia diffusa Leptadenia pyrotechnica*	Leaves Roots rhizom es Stem barks Who le plan t Aerial parts Roots Rhizo me Leave s Fresh leaves Leaves Leave and tuber Roots Who le plan t Leav	Aqueous Etha nol Alco hol Alcohol Methanol Methanol/et hyl acetate Ethanol Methanol Methanol Methanol Ethanol and aqueous Ethanol Methano l, petroleu m ether, chlorofo rm, acetone, and aqueous Methano l Methanol Ethanol	400 mg/kg 2.60 ml/kg 100 and 200 mg/kg 2 ml/kg 100 and 200 mg/kg 400 mg/kg 600 mg/kg 500 mg/kg 10 80 mg/kg 100 and 200 mg/kg 200 mg/kg 200 and 400 mg/kg 150 ml/kg 200 and 300	Acetaminophen CC l4 CC l4 CC l4 CC l4 CC l4 PC M Alloxan CC l4 PC M CC l4 Country-made liquor PCM CC	ALP, ALT, AST, ALB, TB, CAT, SOD, GSH-Px, GSH SGOT, SGPT, ALP, CHL, TB, and TP AST, ALP, GGT, ALT, TBARS, and liver protein ALT, AST, and ALP SGPT, SGOT, TB, CAT, GSH, LPO LDH ALT, ALP, and AST AST, LDLC, ALT, HDL STG, and TC ALT, AST, and serum bilirubin SGPT, SGOT, ALP, TB, TP Serum ALT and AST SGPT, SAP, TGs, and total lipid levels SGPT, TB, ALP, and SGOT SGPT, ALP, SGOT, and bilirubin content TBAST, ALT,	[40] [41] [42] [43] [44] [45] [46] [47] [48] [49] [17] [50] [7] [51] [52] [53] [54] [55]

Rutaceae *Apiace* *ae* *Cactac* *eae* *Rosaceae* *Vitaceae* *Polygonaceae* *Pandanaceae* *Rhamnaceae*	*Tylophora* *Phoenix dactylife ra* *Tridax procum bens* *Opuntia ficus-indica* *Clausena lansium* *Apium graveolens* *Opuntia ficus-indica* *Agrimon ia eupatori a Vitis vinifera* *Rheum palmatum* *Panda nus odorif er* *Ziziphus oenoplia*	es Fruit Aerial parts Leaves Stem bark See ds Ste m Aerial part Leaves Aerial part Roo ts Roo ts	Aqueous Methanol Methanol Aqueous Aqueous Alco hol N/A Etha nol Alco hol	mg/kg 300 mg/kg 300 mg/kg 2, mL/kg 100 and 200 mg/Kg 250 mg/Kg 1500 mg/kg 100 and 300 mg/kg 125 mg/kg 25 and 100 mg/kg 200 and 400 mg/kg 150 and 300 mg/kg	l4 TA A d-GalN/LPS CC l4 CC l4 CC l4 CP F Etha nol $CCl4$ CCl_4/ethanol PCM INH and RIF	and ALP AST, LDH, ALT, ALP, GGT, TB, and TBARS AST, ALT, creatinine, urea, and uric acid Reduction in phenobarbitone , sleeping time and serum liver protein, serum AST, ALT, and ATP. SGOT, SGPT, SALP, TP, TA, and GSH ALAT, ASAT, ALP, LDH, CHL, and albumin AST and ALT AST and ALT N/A SGOT, SALP, SGPT, TB, and TGA SGOT, SGPT, SALP, SB, SOD, CAT, GST, and GPx	[56] [57] [58] [59] [60] [61] [62]

Table 2: Contd..

Family	Name of the plant	Plant parts used	Extract used	Oral dose (mg/kg)	Hepatotoxicity inducing agents	Biochemical and histopathological parameter studied	Reference
Astera *ceae* *Betula* *ceae* *Laura* *ceae* *Apiaceae* *Anacardiace* *ae* *Lythraceae* *Rosaceae* *Cucurbit* *aceae* *Muntingi* *aceae* *Thymelae* *aceae* *Berberid*	*Cichor* *ium* *intybu* *s* *Corylus* *avellana* *Cinnamom* *um cassia* *Anethum* *graveolens* *Pistacia* *lentiscus* *Punica* *granatum* *Rosa* *damascena* mill *Cucurbita* *maxima* *Muntingia* *calabura* *Aquilaria* *malaccensi* *s* *Coptidis* *rhizoma* *Cynara* *scolym* *us L.* *Calend* *ula* *officina* *lis*	Lea ves Lea ves Bar k Seeds Gums Edible portion (seed coats and juice) Flower Aerial parts Fruits Leaves NA Root Wh ole	Ethan ol Aque ous Ethan ol N A N A Acetone Aqueous Metha nol Metha nol Ethan ol	50, and 100 mg/kg NA 40 mg/kg 500 and 1000 l/kg NA 400mg/ kg 250, 500 and 1000 mg/kg 250 and 500 mg/kg 50, 250, and 500 mg/kg 400 mg/kg 120 mg/kg 900 mg/kg	CCl_4 CCl_4 and acetaminophen Dimethylnitros amine C Cl 4 C Cl 4 INH and RIF Acetaminophen CCl_4 Acetamino phen PCM C Cl 4 C Cl 4 Acetaminophen	ALT, AST, and ALP GPT and GOT TP, albumin, TB, direct bilirubin, GOT, GPT, and ALP SGPT, SGOT, and ALP AST, ALT and MDA, GSH, GPx, GST, GR, SOD, and CAT AST, ALT, and LDH AST, ALT, ALP, LDH, ALBTB, urea and creatinine, TBARS, and GSH SGPT, SGOT, ALP, TP, and TB AST, ALT, and ALP AST, ALT, LDH, ALP, bilirubin, CHL, TP, and ALB ALT, AST,	[63] [64] [65] [66] [67] [68] [69] [70] [71] [72] [73] [74] [75] [76] [77] [78] [79]

aceae *Apiaceae* *Asteraceae* *Asteraceae* *Asteraceae* *Euphorbiaceae* *Fabaceae* *Euphorbiaceae* *Fabaceae* *Rutaceae* *Acanthaceae* *Asteraceae* *Fabaceae*	*Taraxacum officinale* *Tragopogon porrifolius* *Baliospermum montanum* *Tephrosia purpurea* *Alchornea cordifolia* *Trigonella foenum-graecum* L. *Glycosmis pentaphylla* Corr. *Andrographis lineata* Nees *Wedelia chinensis* L. *Cassia fistula*	plant Roots Edible root and shoot Root Aerial parts leaves Leaves Leaves, bark Leaves Leaves Seeds	NA Hydroalcohol Methanol Hydroalcoholic acid Methanol Methanol Ethanol Methanol Ethanol Methanol Methanol Ethanol Methanol	500 mg/kg 250 mg/kg 250 mg/kg 2000 mg/kg 500 mg/kg 300 mg/kg 100 mg/kg 500 mg/kg 845 mg/kg 200 mg/kg 200 and 400 mg/kg	/CCl_4 Ethanol CCl_4 TAA TAA CCl_4 H_2O_2; CCl_4 CCl_4 CCl_4 CCl_4 PCM	and SOD ALT, ALP, AST, GSH, and CAT ALT, AST, and LDH TBARS, GST, GSH, SOD, CAT, GR, and GPx CAT, SOD and GSTAST, ALT, and LDH GOT, GPT, ALP, TB, TC, TB, and albumin AST, GSH, ALT, ALP, TB, GGT, and MDA SGOT/AST, SGPT/ALT, ALP, and TB ALT, AST, ALP, and GGT ALT/SGPT, AST/SGOT, CHL, bilirubin, and glucose SGOT, SGPT, and ALP AST, ALT, ALP, protein, and bilirubin SGOT, SGPT, ALP, and bilirubin	[80] [81] [82] [83] [84] [85]

Table 2: Contd...

Family	Name of the plant	Plant parts used	Extract used	Oral dose (mg/kg)	Hepatotoxicity inducing agents	Biochemical and histopathological parameter studied	Reference
Fabaceae	*Bauhinia racemosa* Lam.	Bark	Methanol	NA	CCl_4 and	SGPT, SGOT, SOD, GSH, and TBARS	[86]
Fabaceae	*Bauhinia variegata* L.	Stem bark	Methanol	100 and 200 mg/kg	PCM	AST, ALT, ALP, and GGT	[87]
Scrophulariaceae	*Scrophularia hypericifolia*	Aerial parts	Ethanol	250 and 500 mg/kg	CCl_4	ALT, GGT, AST, and ALP	[88]
Phyllanthaceae	*Phyllanthus urinaria*	Whole plant	Methanol	200 mg/kg	PCM	Cytochrome P450	[89]
Phyllanthaceae	*Phyllanthus emblica*	Fruits	NA		Acetaminophen CCl_4	CYP2E1 protein GSH	[90]
Liliaceae	*Allium cepa*	Fresh bulbs	Aqueous	100 mg/kg	Ethanol		[91]
Moraceae	*Ficus carica*	Leaves, fruit, and roots	Petroleum ether extract, aqueous extract, and methanolic extract	100, 300 and 600 mg/kg	Rifampicin	ALT, ALP, AST, and TB	[92]
Rhamnaceae	*Ziziphus mucronata*	Leaves	Methanol	NA	Dimethoate	NA	[93]
Lamiaceae	*Salvia miltiorrhiza*	Dried pulverized roots	Ethanol	200 mg/kg	CCl_4	SGOT, TBARS, SGPT, GSH, SOD, tocopherol,	[94]
Malvaceae	*Hibiscus rosasinensis*	Flower	Aqueous	50 mg/kg	Mixture of cholesterol and cholic acid with coconut oil	HDL, LDL, CHOL, TL, TGA	[95]
Loranthaceae	*Dendrophthoe falcata*	Leaves	Aqueous and ethanol	80, 160 and 240 mg/kg	CCl_4	Induce apoptosis of hepatic stellate cells (HSCs)	[15]
Asteraceae	*Bidens pilosa*	Dried aerial parts	Ethanol	100 mg/kg	CCl_4	AST, ALT, ALP	[96]
Fomitopsis Deae	*Antrodia cinnamomea*	Fruiting	Aqueous extract and ethanol	15 mg/kg	CCl_4	AST, TP	[97]
			Methanol	1250		ALP, and ALT, TB	[98] [99]
						AST, ALT, and	[100]

Cyperaceae *Malvaceae* *Polygona* *ceae* *Araceae* *Apiaceae* *Lorantha* *ceae* *Fabaceae* *Fabaceae* *Oxalidaceae* *Fabaceae* *Malvaceae*	*Cyperus rotundus* *Hibiscus sabdariffa* *Rheum palmatum* *Amorphopha llus paeoniifoliu s* *Petroselinu m crispum* *Loranthus parasiticus* *Trigonella foenum-grae cum* *Tephrosia purpurea* Oxalis corniculata *Indigof era tinctori a* *Alcea rosea*	bodies and mycelia Leaves Aqueou s extract Dried root Tubers Leaves Leaves Dried seeds Root Wh ole plan ts Leav es Aerial parts	Aqueous Ethanol Aqueous Aqueous and methanol Ethanol Etha nol Etha nol Ethanol Methanol Aqueous methanol	mg/kg 200 mg/kg NA 400 mg/kg 300 mg/kg 200 mg/kg 100 mg/kg 20-100 mg/kg 50-200 mg/k g 100 mg/kg 75, 150, 300 mg/kg 200 mg/kg	CC l4 CC l4 CC l4 PC M ST Z D-galactosamine and CCl4 TAA CCl4 PC M PC M PC M	LDH induced elevation of expression of hepatic mRNAs, i.e., MMP-9, TNF-α, KLF-6, and TGF-β1 levels SGOT, SGPT, ALP ALT, AST, and ALP ALT, AST, HA, and laminin (LN) sGPT, serum glutamic ALP, TBARS, and GS H SG PT ALP and GGT Induce apoptosis of hepatic stellate cells (HSCs) SGOT, SGPT, and ALP TBARS, SOD, CAT, and GSH TB, DB, ALP, and AST	[101] [102] [103] [104] [94] [105] [106] [107]

Table 2: Contd...

Family	Name of the plant	Plant parts used	Extract used	Oral dose (mg/kg)	Hepatotoxicity inducing agents	Biochemical and histopathological parameter studied	Reference
Fabaceae	*Cajanus cajan*	Whole plant	Methanol	NA	CCl_4	SGOT, CHL, and SGPT	[108]
Solanaceae	*Cestrum nocturnum*	Leav es	Aqueo us	250 and 500 mg/kg	PC	SGOT, SGPT, ALP, AST, ALT,	[109]
Convolvula	*Convolvulus arvensis*	Who	ethano l	200 and 500 mg/kg 2 mg/kg	M	and LDH ALP, ALP, AST, and TB	[110]
ceae	*Glycyrrh iza*	le plant	Ethan ol		PC	SOD, GST, CAT, GSH, and	[111]
Fabaceae	*glabra Ipomoea*	Root s		200 mg/kg	M	GSH-Px	[28]
Convolvula	*staphylina*		Aqueous	250 and 500	CCl	ALP, SGOT, AST, CHL,	
ceae	*Malva parviflora*	Leaves	Hydroalco	mg/kg NA	4	ALT, SGPT ALT, TP, AST, and	[112]
Malvaceae	*Nigella sativa*	Who le	hol		CCl	ALP	[113]
Ranunculac		plant	Methanol	100 and 500 mg/kg	4	ALP, ALT, TB, AST, and TP	[114]
eae	*Fraxinus rhynchophy lla Rumex*	Seed s	Alcohol	250 and 500 mg/kg	PC	GOT, GPT, CAT, SOD, and	[115]
Oleaceae	*dentatus*	Who le	Ethanol	500 and 750 mg/kg	M	GPx ALP, ALT, TB, and AST	[116]
Polygonace	*Suaeda fruticosa*	plant Who le	Aqueo us/ methan	250 and 500 mg/kg 400 mg/kg	Galactosamine/ lipopolysacchari de CCl_4	SGPT, ALP, ALT, SGOT, AST, TP, and TB	
ae		plant	ol		PC	SGOT, ALT,	[117]
Amarantha ceae	*Thymus linearis*	Leav es	Aqueo us/ methanol	200 mg/kg	M	SGPT, TB, ALP, and AST GSH, ALP,	[118]
	Trichodesm a	Leaves	Aqueous/ethe	100 mg/kg	PC	SOD, AST, CAT, TB,	[119]
Lamiaceae	*sedgwickian um*	Leaves	r Ethanol	40 mg/kg	M	ALT, and TP SGPT, SGOT, ALP, and TB	[120]
Boraginaceae	*Vitis vinifera*	Roo	Ethan	50 and 250 mg/kg	PCM and	MDA, GSH,	[121]
Vitaceae	*Hygrophila auriculata*	ts	ol	300 mg/kg	CCl_4 CCl_4	protein, bilirubin, SGOT, ALP, and	[122]
Acanthaceae	*Ocimum gratissimum*	Roo ts	Aqueo us	150 mg/kg	CC l4	SGPT ALT, AST, and ALP	[123]
Lamiaceae	*Bauhinia purpurea*				CC	ALT, ALP, and AST TB,	[29]
Fabaceae	*Plumbago zeylanica*	Fresh	Methanol		l4	SGPT, SGOT, and ALP	
Plumbaginace	*Salix caprea*	leaves	Ethanol	100 and 200 mg/kg	CCl	ALT, AST, ALP, albumin, TB,	[108]
ae Salicaceae		Leaves	Methanol		4	TG, urea, creatinine, TB,	
	Tecome lla	Aerial	Ethanol	NA	PC	TBARS, and GSH AST,	[124]
Bignoniaceae	*undulat a*	parts			M	GSH, SGOT, SOD, SPGT,	[125]
			Aqueous/	500 and 1000	PC	CAT,	

Anacardiaceae *Scrophulariaceae* *Verbenaceae* *Lamiaceae* *Mimosaceae* *Rubiaceae* *Cupressaceae* *Oleaceae*	*Pistacia integerrima* *Scoparia dulcis* *Stachytarpheta jamaicensis* *Ocimum tenuiflorum* *Mimosa pudica* *Kohautia grandiflora* *Juniperus communis* *Fraxinus rhynchophylla*	Flowers Aerial parts Bark Leaves Whole plant Leaves Leaves Leaves Fruits Stem barks	ethanol Ethyl acetate Ethanol Ethanol Alcohol Methanol Aqueous Ethanol Ethyl alcohol	mg/kg 200 mg/kg 200 mg/kg 200 mg/kg 300 mg/kg 200 mg/kg 400 mg/kg	M CCl_4 PCM PCM CCl_4 CCl_4 PCM CCl_4 PCM PCM and azithromycin CCl_4	GSH-Px, GST, ALP, and ALT, ALP, ALT, and AST SGPT, TB, ALT, ALP, SGOT, and AST SGPT, TB, ALP, SGOT, AST, TP, CHL, and ALT ALP, ALT, SGOT, AST, and SGPT AST, SGOT, ALT, SGPT, TP ALP, and TB TP ALP, TB, ALT, and AST SGOT, TB, SGPT, and ALP ALT, AST, MDA, SOD, GSH, and GSH-Px	[126] [127] [128] [129] [130] [13]

Table 2: Contd...

Family	Name of the plant	Plant parts used	Extract used	Oral dose (mg/kg)	Hepatotoxicity inducing agents	Biochemical and histopathological parameter studied	Reference
Saururaceae	*Saurus chinensis*	Whole plant	Ethanol	70 mg/kg	CCl_4	AST, ALT, ALP, CHL, SOD, CAT, MDA, and GSH	[131]

SGOT=Serum glutamic oxaloacetic transaminase, SB=Serum bilirubin, SOD=Superoxide dismutase, GST=Glutathione S-transferase, ALP=Alkaline phosphatase, GPT=Glutamic pyruvic transaminase, ALT=Serum alanine aminotransferase, AST=Aspartate aminotransferase, SALP=Serum alkaline phosphatase, MDA=Malondialdehyde content, GSH=Glutathione, GSH-Px=Glutathione peroxidase, TG=Triglycerides, GPT=Glutamic pyruvic transaminase, TB=Total bilirubin, TBARS=Lipid peroxidation (thiobarbituric acid reactive substance), GSH=Reduced glutathione, ALB=Albumin, GR=Glutathione reductase, SALP=Serum alkaline phosphatase, GGT=Gamma glutamyl transferase, SALT=Serum aspartate amino transaminase, GPx=Glutathione peroxidase,
GR=Glutathione reductase, CHL=Cholesterol, LDH=Lactate dehydrogenase, SGPT=Serum glutamate pyruvate transaminase, TP=Total

protein, GOT=Glutamic oxaloacetic transaminase, CAT – catalase, TB=Total bilirubin, NA=Not applicable, CPF=Organophosphorous insecticide chlorpyrifos, TAA=Thioacetamide, d-GalN/LPS=d-galactosamine/lipopolysaccharide, INH=Isoniazid, RIF=Rifampicin, N/A=Not available

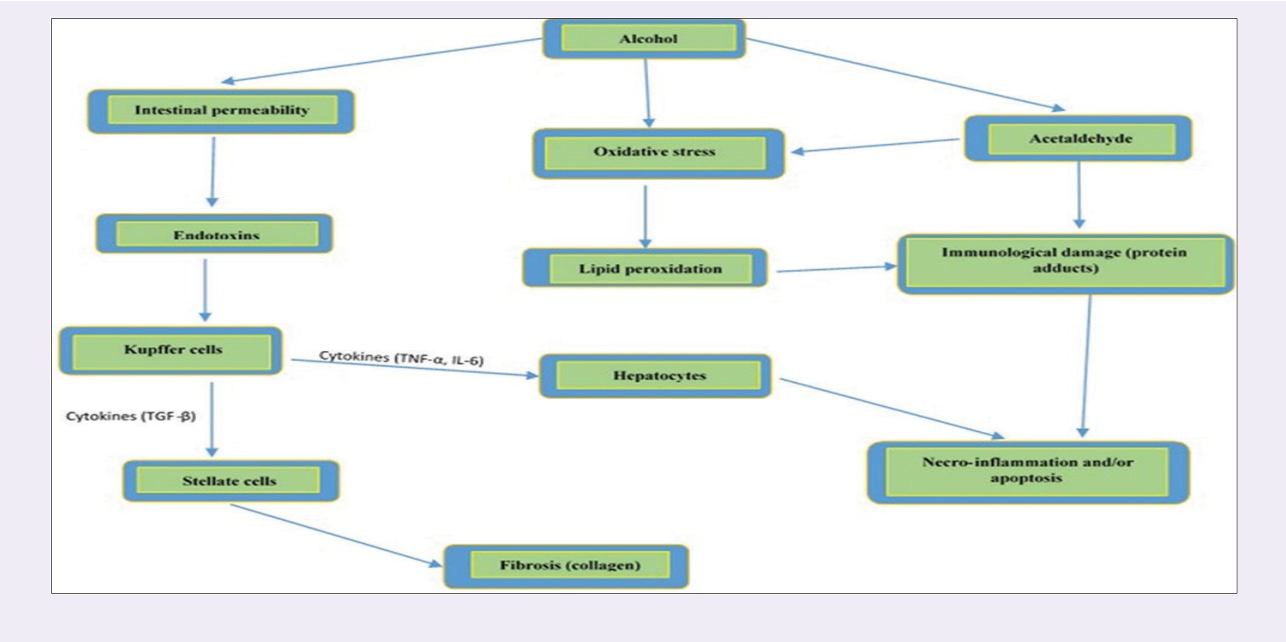


Figure 2: Mechanism of alcohol-induced hepatotoxicity [2]

Salix caprea (Salicaceae)

One of Salix caprea's family names is Salicaceae. [29] This tree, which is also called big sallow, pussy willow, or goat willow, is among the most widespread varieties of willow in Europe, Western Asia, and Central Asia. Antioxidant, anti-inflammatory, and anti-inflammatories are only a few of the biological potentials shown by the plant in previous studies. 47,139 people have relied on S. caprea as a remedy for various human and animal ailments. Common complaints that it helps with include fever, headaches, stomachaches, and constipation. [29] Qualitative examination revealed that the plant extract contained bioactive components, namely flavonoids and phenolic acids. There were flavonoids such as quercetin and luteolin-7-glucoside as well as phenolic compounds such as salignin and catechins.

Wahid et al. tested the hepatoprotective effects of an ethanolic Salix subserrata Willd floral extract in CCl4-induced liver injury. [29] There was a significant decrease in blood enzyme levels after administering this plant's ethanolic extract, which may indicate that it might mitigate CCl4-induced liver tissue damage or restore plasma membrane integrity. The hepatoprotective effect of this plant extract likely accounted for its antioxidant activity; it protected liver cells against CCl4 free radical metabolites by halting their damage cascade that began with lipid peroxidation and ended with cell death.

Caesalpinia crista (Fabaceae)

Caesalpinia crista, a perennial climbing shrub belonging to the Fabaceae family, is prevalent throughout India in plains, deserts, coastal areas, and hills up to 1000 meters in elevation. In Hindi, it is often referred to as Karanja. [141] C. crista contains bioactive compounds such as glycosides, alkaloids, saponins, and flavonoids. This plant has medicinal characteristics that combat inflammation, malaria, jaundice, helminthiasis, diabetes, periodontal disease, and fever. Mishra et al. assessed the hepatoprotective effects of ethanolic extracts from C. crista leaves in rats experiencing PCM-induced hepatotoxicity, as detailed in references [61,142]. The positive control group exhibited no changes in TB levels, serum marker enzymes, or TGA after treatment with ethanolic extract at dosages of 200 or 400 mg/kg. Conversely, the treated group exhibited a substantial decrease in these levels. The ethanolic extracts of C. crista leaves had significant hepatoprotective benefits against PCM-induced hepatic injury in rats, as shown by these findings. [61]

Alocasia indica (Araceae)

Alocasia indica is extensively cultivated in the tropical and subtropical regions of Southern India, West Bengal, Assam, and Maharashtra. This herbaceous perennial attains a height of around 5 meters. [17] The edible tuber of the A. indica plant is often consumed as a common vegetable due to its affordability and widespread availability. Traditional medicine use A. indica for the treatment of ailments related to the spleen and abdomen. While their research concentrates on the inedible leaf portion of the plant, the edible tuber is widely used as a vegetable by the Indian populace. Pal et al. [14] evaluated the hepatoprotective efficacy of both ethanolic and aqueous extracts of A. indica tubers against CCl4-induced hepatic injury in male Albino Wistar rats. Their findings indicated that biochemical analysis of both water and ethanolic extracts revealed several pharmacological constituents, including tannins, flavonoids, alkaloids, glycosides, and saponins. The ethanolic extract exhibited superior antioxidant potential and elevated levels of flavonoids and phenolics in comparison to the aqueous extract. In an in vivo trial, both the aqueous and alcoholic extracts exhibited significant hepatoprotective benefits. The outcomes of this research indicate that this plant extract may serve as an antioxidant in the formulation of treatments for liver diseases.

Opuntia ficus-indica (Cactaceae)

Opuntia ficus-indica, a domesticated crop vital to agricultural economies in arid and semiarid locations worldwide, is a cactus species used mostly for fruit production and is a member of the Cactaceae family. The probable point of origin is Mexico. In the absence of herbaceous plants and water, it is customary to use it as a vegetable feed resource for cattle. [143] Rather of examining the fruit, the majority of scientific medical research concentrates on the leaves (cladodes). The efficacy of a 2 mL/kg aqueous extract from cactus cladodes in safeguarding the liver against CCl4-induced toxicity in male Wistar rats was examined. [54] The The findings indicated that, in contrast to the CCl4-treated group exhibiting hepatotoxicity, the group administered the aqueous extract of O. ficus-indica shown markedly reduced levels of AST and ALT

Cyathea gigantea (Cyatheaceae)

The tree fern Cyathea gigantea (Wall. ex. Hook.) is indigenous to moist, open environments in Nepal, Western Java, Northeastern to Southern India, and Sri Lanka. The plant's highest height may attain is 20 meters. A total of 144 Kiran et al. [49] demonstrated the hepatoprotective effect of a methanolic extract of C. gigantean leaves against PCM-induced toxicity in Wistar Albino rats. Histological and biochemical hepatic damage was seen in the experimental rats after PCM intoxication. The liver damage was ameliorated by reinstating the structural integrity of the plasma membrane, leading to a reduction in elevated levels of ALP, serum glutamic oxaloacetic transaminase, TB, and serum glutamate-pyruvate transaminase following treatment with methanolic C. gigantean leaf extract. The phytochemical screening findings indicate that C. gigantean leaf extract comprises phenols, triterpenes, saponins, sterols, and flavonoids. The hepatoprotective action may be attributed to these bioactive components. The rat PCM-induced hepatotoxicity model was used to assess the hepatoprotective properties of C. gigantean.

Phoenix dactylifera (Arecaceae)

In the northern areas of Nigeria, Middle Eastern nations, and Arabian countries, the date palm, or Phoenix dactylifera, is often used to treat liver ailments and associated symptoms, such as jaundice. [52] Previous study indicates that the fruit extract protects the liver from detrimental chemicals, including alcohol. [145] Okwuosa et al. [52] investigated the potential hepatoprotective effects of date palm (P. dactylifera) fruit extracts in TAA-induced toxicity in male rats. The researchers determined that the plant's methanolic fruit extract had significant hepatoprotective properties, since the levels of hepatocellular enzymes were lower in the test groups than in the TAA-induced group. The extract may possess the capacity to reverse plasma membrane damage by mitigating the elevation of serum bilirubin and alkaline phosphatase (ALP) induced by TAA. [52] Qualitative screening revealed that plant extracts include tannins, flavonoids, saponins, terpenoids, carbohydrates, steroids, proteins, and glycosides. Reports indicate that flavonoids may stabilize the cell membrane. [146] The flavonoid content of P. dactylifera extract is likely responsible for its membrane stabilizing effect. This study did not investigate the biochemical mechanism by which P. dactylifera demonstrates its hepatoprotective properties. The bioactive compound N-sitosterol in the fruit extract was believed to be responsible for its action. [147] The hepatoprotective properties of flavonoids were believed to stem from their capacity to inhibit cytochrome P450 aromatase. [148] Similarly, Al-Qarawi et al. [149] established that extracts from the pulp and seeds of dates (P. dactylifera L.) exhibited hepatoprotective properties against CCl4-induced toxicity in rats.

Convolvulus arvensis (Convolvulaceae)

The invasive plant Convolvulus arvensis originates from Asia. The numeral 150 This plant belongs to the family Convolvulaceae. When not climbing, the plant may proliferate into dense mats 5 cm thick; it is often used as a laxative. Dermatological disorders, coughs, jaundice, and influenza may all get advantages from the botanical extract. Moreover, it has the capacity to reduce inflammation, edema, and joint pain. Ali et al. [110] recently shown the hepatoprotective effect of an ethanolic extract of C. arvensis at dosages of 200 and 500 mg/kg in rats exposed to PCM-induced toxicity. The heightened levels of TB and hepatic enzymes were markedly reduced ($P < 0.05$) in rats administered with PCM-induced ethanolic extract of C. arvensis. Quercetin and kaempferol were the principal phytochemical constituents of C. arvensis. Quercetin is a flavonoid with established hepatoprotective effects. [151]

Bioactive Molecules with Hepatoprotective Potentials

Previous study has resulted in the identification of many plant biomolecules exhibiting notable hepatoprotective effects. Humans have not yet undergone extensive clinical investigations with these pure compounds. Biomolecules including resveratrol, curcumin, silymarin, glycyrrhizin, and quercetin confer diverse biological properties to certain bioactive compounds, encompassing antiviral, antioxidant, anticancer, antiaging, antifibrotic, antidiabetic, and anti-inflammatory capabilities (Table 3).

Table 3: Examples of reported phytochemical compounds with hepatoprotective potential

Phytochemical compounds	Plants
Glycyrrhizin	Glycyrrhiza glabra
Resveratrol	Hygrophila auriculata
Curcumin	Curcuma spp.
Colchicine	Colchicum autumnale
Silymarin (silybin)	Silybum marianum
Quercetin	Hibiscus vitifolius
Fumaric acid	Sida cordifolia
Coumarins	Artemisia abrotanum
Schizantherin A	Schisandra chinensis
Kutkoside	Picrorhiza kurroa
Catechin	Anacardium occidentalis
Papyriogenin	Tetrapanax papyrifer
Cronin	Gardenia jasminoides
Syringopicroside	Syringa oblata
Piceid	Polygonum cuspidatum
Gomishins	Schisandra chinensis

Saikosaponin	Bupleurum falcatum
Cosmosiin	Cupressus sempervirens L.
Patuletin	Ficus ingens

Conclusions and Future Prospects

Despite widespread concern for health, health issues have emerged as a significant challenge in our culture. Liver illnesses and injuries are among the most common medical issues globally, despite the liver's essential function in the body. Liver damage may result from several factors, mostly poor dietary practices, excessive alcohol use, herbal supplements, microbial infections, autoimmune disorders, malignancies, metabolic diseases, and substance addiction. Consequently, it is important to protect the liver against the aforementioned hazards.

Nevertheless, considering that existing treatments for numerous hepatic disorders are either inadequate or associated with adverse effects on renal function, the need for the identification of novel therapeutics that efficiently rectify liver damage has grown pressing. Therefore, the creation of new hepatoprotective pharmaceuticals sourced from plants is essential. Their antioxidant properties and hepatoprotective effects underpin the majority of phytotherapeutics used in the treatment of liver ailments. To address liver diseases with novel therapeutics that exhibit minimal renal side effects, the following fundamental scientific concepts are established. Consequently, more investigation is necessary to evaluate the potential for creating more potent hepatoprotective agents from new candidate phytochemicals. Given that a significant portion of the population in impoverished countries depends on herbal remedies for liver ailments, these treatments have gained global prominence. The majority of commercially available herbal extracts have shown promising efficacy in mitigating the signs and symptoms of hepatic injury or disease. To far, there is no evidence supporting the scientific validity of herbal extracts; thus, further research is necessary, especially in this domain, to establish protocols for the safe and effective production and administration of herbal extracts. Moreover, it is essential to subject these herbal medicines to preclinical testing prior to initiating clinical trials. The therapeutic effectiveness of these all-natural herbal medicines may be evaluated, and the established dosage regimen from clinical studies may guide future pharmaceutical development and administration. Furthermore, several essential pharmaceuticals for addressing diverse illnesses may be made available using the traditional medical approach to drug discovery and creation. Isolating active principles and converting them into pharmaceuticals requires substantial effort and financial investment. The prioritization of plant-based drugs, namely those generated from singular or composite plant extracts, is essential in the treatment of liver diseases, especially those focused on restoring the structural integrity of the hepatic cell membrane. In general, a singular plant extract cannot remedy all types of liver ailments. Consequently, it may be necessary to formulate a herbal amalgamation of extracts from many plants to enhance the treatment's efficacy. Moreover, additional research, namely toxicity assessments, must be undertaken to ensure the safety of the plant combination. This is likely due to the possibility that one of the plant extracts might be toxic, so compromising the efficacy of the other extracts in the combination. Furthermore, traditional healers in underdeveloped countries need education on appropriate hygienic methods for processing plant materials, given that most plant extracts are used by economically disadvantaged rural populations. Contamination must be avoided or eradicated during the preparation of herbal extracts.

In conclusion, more investigation into the structural modifications of beneficial compounds derived from herbal extracts via computational chemistry techniques is necessary to create more effective plant-based hepatoprotective pharmaceuticals.

References

1. Abhilash G, Maheswari YJ, Gopal A, Chanda D. Review on some medicinal

plants with hepato-protective activities. Res Rev J Pharmacogn Phytochem 2014;22:33.
2. Rane J, Jadhao R, Bakal RL. Liver diseases and herbal drugs: A review. J Innov Pharm Biol Sci 2016;3:24-36.
3. Akinloye OA, Olaniyi MO. Hepato-protective effect of Cajanus cajan on tissue defense system in D-galactosamine-induced hepatitis in rats. Turk J Biochem 2011;36:237-41.
4. Nayak SS, Jain R, Sahoo AK. Hepatoprotective activity of Glycosmis pentaphylla against paracetamol-induced hepatotoxicity in Swiss albino mice. Pharm Biol 2011;49:111-7.
5. Dominiczak MH. Lipids and Lipo proteins. In: Baynes JW, Dominiczak MH, editors. Medical Biochemistry. Philadephia: Elsevier Mosby; 2005. p. 234-42.
6. Sathesh Kumar S, Ravi Kumar B, Krishna Mohan G. Hepatoprotective effect of Trichosanthes cucumerina var cucumerina L. on carbon tetrachloride induced liver damage in rats. J Ethnopharmacol 2009;123:347-50.
7. Partap S, Tewari U, Sharma K, Jha KK. Hepatoprotective activity of whole plant extract of Leptadenia pyrotechnica against paracetamol induced damage in rats. J Drug Deliv 2014;4:36-9.
8. Ajboye TO, Yakubu MT, Salau AK, Oladiji AT, Akanji MA, Okogun JI, et al. Antioxidant and drug detoxification potential of aqueous extract of Annona senegalensis leaves in carbon tetrachloride-induced hepatocellular damage. Pharm Biol 2010;48:1361-70.
9. Jannu V, Baddam PG, Boorgula AK, Jambula SR. A review on hepatoprotective plants. Int J Drug Dev Res 2012;4:1-8.
10. Zeashan H, Amresh G, Singh S, Rao CV. Hepatoprotective activity of Amaranthus spinosus in experimental animals. Food Chem Toxicol 2008;46:3417-21.
11. Pradhan SC, Girish C. Hepatoprotective herbal drug, silymarin from experimental pharmacology to clinical medicine. Indian J Med Res 2006;124:491-504.
12. Haidry M, Malik AT. Hepatoprotective and antioxidative effects of Terminalia arjuna against cadmium provoked toxicity in albino rats (Ratus norvigicus). Biochem Pharmacol 2014;3:1.
13. Guo S, Guo T, Cheng N, Liu Q, Zhang Y, Bai L, et al. Hepatoprotective standardized EtOH-water extract from the seeds of Fraxinus rhynchophylla hance. J Tradit Complement Med 2017;7:158-64.
14. Ali MI, Kumar M. A recent update on hepatoprotective potential of herbal plant. Int J Env Sci Technol 2015;1:25-49.
15. Haque A, Tahmina, Afsana SK, Sarker IR, Hossain M, Islam S, et al. Antioxidant and hepatoprotective effects of aqueous and ethanol extracts of Dendrophthoe falcate Linnleaves. Archives 2014;1:90-101.
16. Singh N, Kamath V, Narasimhamurthy K, Rajini PS. Protective effect of potato peel extract against carbon tetrachloride-induced liver injury in rats. Environ Toxicol Pharmacol 2008;26:241-6.
17. Pal S, Bhattacharjee A, Mukherjee S, Bhattacharya K, Khowala S. Antioxidant and hepatoprotective activity of ethanolic extract of Alocasia indica tuber. Am J Phytomed Clin Ther 2014;2:191-208.
18. Madkour FF, Abdel-Daim MM. Hepatoprotective and antioxidant activity of Dunaliella salina in paracetamol-induced acute toxicity in rats. Indian J Pharm Sci 2013;75:642-8.
19. Constantin M, Bromont C, Fickat R, Massingham R. Studies on the activity of bepridil as a scavenger of free radicals. Biochem Pharmacol 1990;40:1615-22.
20. Afaf I, Abuelgasim, Nuha HS, Mohammed AH. Hepatoprotective effect of Eclipta alba against carbon tetrachloride-induced damage in rats. Res J Anim Vet Sci 2008;3:20-3.
21. Jaeschke H. Reactive oxygen and mechanisms of inflammatory liver injury: Present concepts. J Gastroenterol Hepatol 2011;26 Suppl 1:173-9.
22. Yen FL, Wu TH, Lin LT, Lin CC. Hepatoprotective and antioxidant effects of Cuscuta chinensis against acetaminophen-induced hepatotoxicity in rats. J Ethnopharmacol 2007;111:123-8.
23. Hiraganahalli BD, Chinampudur VC, Dethe S, Mundkinajeddu D, Pandre MK, Balachandran J, et al. Hepatoprotective and

antioxidant activity of standardized herbal extracts. Pharmacogn Mag 2012;8:116-23.
24. Elberry AA, Harraz FM, Ghareib SA, Nagy AA, Gabr SA, Suliaman MI, et al. Antihepatotoxic effect of Marrubium vulgare and Withania somnifera extracts on carbon tetrachloride-induced hepatotoxicity in rats. J Basic Clin Pharm 2010;1:247-54.
25. Poli G. Pathogenesis of liver fibrosis: Role of oxidative stress. Mol Aspects Med 2000;21:49-98.
26. Gholamian-Dehkordi N, Luther T, Asadi-Samani M, Mahmoudian-Sani MR. An overview on natural antioxidants for oxidative stress reduction in cancers; a systematic review. Immunopathol Persat 2017;3:12.
27. Mahmoudian-Sani M, Luther T, Asadi-Samani M, Saeedi-Boroujeni A, Gholamian N. A new approach for treatment of type 1 diabetes: Phytotherapy and phytopharmacology of regulatory T cells. J Renal Inj Prev 2017;6:158-63.
28. Bag AK, Mumtaz SM. Hepatoprotective and nephroprotective activity of hydroalcoholic extract of Ipomoea staphylina leaves. Bangladesh J Pharmacol 2013;8:263-8.
29. Wahid A, Hamed AN, Eltahir HM, Abouzied MM. Hepatoprotective activity of ethanolic extract of Salix subserrata against CCl4-induced chronic hepatotoxicity in rats. BMC Complement Altern Med 2016;16:263.
30. Lu Y, Cederbaum AI. CYP2E1 and oxidative liver injury by alcohol. Free Radic Biol Med 2008;44:723-38.
31. Ramaiah SK. A toxicologist guide to the diagnostic interpretation of hepatic biochemical parameters. Food Chem Toxicol 2007;45:1551-7.
32. Fang Z, Bhandari B. Effect of spray drying and storage on the stability of bayberry polyphenols. Food Chem 2011;129:1139-47.
33. Bott RF, Labuza TP, Oliveira WP. Stability testing of spray- and spouted bed-dried extracts of Passiflora alata. Dry Technol 2010;28:1255-65.
34. Mamat SS, Kamarolzaman MF, Yahya F, Mahmood ND, Shahril MS, Jakius KF, et al. Methanol extract of melastoma malabathricum leaves exerted antioxidant and liver protective activity in rats. BMC Complement Altern Med 2013;13:326.
35. Olakunle Ajiboye T. In vivo antioxidant potentials of Piliostigma thonningii (Schum) leaves: Studies on hepatic marker enzyme, antioxidant system, drug detoxifying enzyme and lipid peroxidation. Hum Exp Toxicol 2011;30:55-62.
36. Oloyede HO, Ajiboye TO, Komolafe YO. Polyphenolic extract of Blighia sapida arilli prevents N-nitrosodiethylamine-mediated oxidative onslaught on microsomal protein, lipid and DNA. Food Biosci 2013;1:48-56.
37. Muriel P. Some experimental models in liver damage. In: Sahu SC, editor. Hepatotoxicity: From Genomics to In Vitro and In Vivo Models. 1st ed. London, UK: John Wiley and Sons Inc.; 2008. p. 119-37.
38. Cerný D, Canová NK, Martínek J, Horínek A, Kmonícková E, Zídek Z, et al. Effects of resveratrol pretreatment on tert-butylhydroperoxide induced hepatocyte toxicity in immobilized perifused hepatocytes: Involvement of inducible nitric oxide synthase and hemoxygenase-1. Nitric Oxide 2009;20:1-8.
39. Ajiboye TO, Yakubu MT, Oladiji AT. Lophirones B and C extenuate AFB1-mediated oxidative onslaught on cellular proteins, lipids, and DNA through nrf-2 expression. J Biochem Mol Toxicol 2014;28:558-67.
40. Ajiboye TO, Ahmad FM, Daisi AO, Yahaya AA, Ibitoye OB, Muritala HF, et al. Hepatoprotective potential of Phyllanthus muellarianus leaf extract: Studies on hepatic, oxidative stress and inflammatory biomarkers. Pharm Biol 2017;55:1662-70.
41. Arsul VA, Wagh SR, Mayee RV. Hepatoprotective activity of livergen, a polyherbal formulation against carbon tetrachloride induced hepatotoxicity in rats. Int J Pharm Pharm Sci 2011;3:228-31.
42. Ajay KG, Neelam M. Hepatoprotective activity of aqueous and ethanolic extract of Boerhaavia erecta. in carbontetrachloride intoxicated albino rats. Am J Pharmacol Toxicol 2006;1:17-20.
43. Khan MU, Rohilla A, Bhatt D, Afrin S, Rohilla S, Ansari SH. Diverse belongings of

Calendula officinalis: An overview. Int J Pharm Sci Drug Res 2011;3:173-7.

44. Arulkumaran KS, Rajasekaran A, Ramasamy A, Jegadeesan M, Kavimani S, Somasundaram A. Amaranthus spinosus. seeds protect liver against toxic effects of ethanol and carbon tetrachloride in rats. Int J Pharm Tech Res 2009;1:273-46.
45. Donfack HJ, Kengap RT, Ngameni B, Chuisseu P, Tchana AN, Buonocore D, et al. Ficus cordata Thunb (Moraceae) is a potential source of some hepatoprotective and antioxidant compounds. Pharmacologia 2011;2:137-45.
46. Hsieh CC, Fang HL, Lina WC. Inhibitory effect of Solanum nigrum on thioacetamide-induced liver fibrosis in mice. J Ethnopharmacol 2008;119:117-21.
47. Ahmed A, Shah WA, Akbar S, Kumar D, Kumar V, Younis M. In-vitro antiinflammatory activity of Salix caprea Linn. (goat willow) by HRBC membrane stabilization method. J Pharm Res 2011;4:1067-8.
48. Hui Mei L, Hsien Chun T, Chau Jong W, Jin-Jin L, Chia Wen L, Fen-Pi C. Hepatoprotective effects of Cassia fistula Linn extract against CCl4 induced oxidative damage in rats. Chem Biol Interact 2008;171:283-93.
49. Kiran PM, Raju AV, Rao BG. Investigation of hepatoprotective activity of Cyathea gigantea (Wall. EX. Hook.) leaves against paracetamol-induced hepatotoxicity in rats. Asian Pac J Trop Biomed 2012;2:352-6.
50. Mishra G, Khosa RT, Singh P, Jha KK. Hepatoprotective potential of ethanolic extract of Caesalpenia crista leaves against paracetamol induced hepatotoxicity in rats. J Coastal Life Med 2014;2:575-79.
51. Mujeeb M, Aeri V, Bagri P, Khan SA. Hepatoprotective activity of methanolic extract of Tylophora indica (Burm. F,) Merill. leaves. Int J Green Pharm 2010;3:125-7.
52. Okwuosa CN, Udeani TK, Umeifekwem JE, Onuba AC, Anioke IC, Madubueze RE. Hepatoprotective effect of methanolic fruit extracts of Phoenix dactylifera (Arecaceae) on thioacetamide induced liver damage in rats. Am J Phytomed Clin Ther 2014;2:290-300.
53. Meena B, Ezhilan RA, Rajesh R, Hussain KS, Ganesan B, Anandan R. Antihepatotoxic potential of Tridax procumbens on antioxidant defense status in D-galactosamine-induced hepatitis in rats. Afr J Biochem Res 2008;2:51-5.
54. Djerrou Z, Maameri Z, Halmi S, Djaalab H, Riachi F, Benmaiza L, et al. Hepatoprotective effect of Opuntia ficus-indica aqueous extract against carbon tetrachloride-induced toxicity in rats. Online J Biol Sci 2015;15:36-41.
55. Adebajo AC, Iwalewa EO, Obuotor EM, Ibikunle GF, Omisore NO, Adewunmi CO, et al. Pharmacological properties of the extract and some isolated compounds of Clausena lansium stem bark: Anti-trichomonal, antidiabetic, anti-inflammatory, hepatoprotective and antioxidant effects. J Ethnopharmacol 2009;122:10-9.
56. Ahmed B, Alam T, Varshney M, Khan SA. Hepatoprotective activity of two plants belonging to the Apiaceae and the Euphorbiaceae family. J Ethnopharmacol 2002;79:313-6.
57. Ncibi S, Ben Othman M, Akacha A, Krifi MN, Zourgui L. Opuntia ficus indica extract protects against chlorpyrifos-induced damage on mice liver. Food Chem Toxicol 2008;46:797-802.
58. Yoon SJ, Koh EJ, Kim CS, Zee OP, Kwak JH, Jeong WJ, et al. Agrimonia eupatoria protects against chronic ethanol-induced liver injury in rats. Food Chem Toxicol 2012;50:2335-41.
59. Orhan DD, Orhan N, Ergun E, Ergun F. Hepatoprotective effect of Vitis vinifera L. Leaves on carbon tetrachloride-induced acute liver damage in rats. J Ethnopharmacol 2007;112:145-51.
60. Guo MZ, Li XS, Xu HR, Mei ZC, Shen W, Ye XF, et al. Rhein inhibits liver fibrosis induced by carbon tetrachloride in rats. Acta Pharmacol Sin 2002;23:739-44.
61. Mishra G, Khosa RL, Singh P, Jha KK. Hepatoprotective potential of ethanolic extract of Pandanus odoratissimus root against paracetamol-induced hepatotoxicity in rats. J Pharm Bioallied Sci 2015;7:45-8.
62. Rao CV, Rawat AK, Singh AP, Singh A, Verma N. Hepatoprotective potential of

ethanolic extract of Ziziphus oenoplia (L.) mill roots against antitubercular drugs induced hepatotoxicity in experimental models. Asian Pac J Trop Med 2012;5:283-8.

63. Jamshidzadeh A, Khoshnood MJ, Dehghani Z, Niknahad H. Hepatoprotective activity of Cichorium intybus L. leaves extract against carbon tetrachloride induced toxicity. Iran J Pharm Res 2006;1:41-6.
64. Rusu MA, Bucur N, Puică C, Tămaş M. Effects of Corylus avellana in acetaminophen and CCl4 induced toxicosis. Phytother Res 1999;13:120-3.
65. Lim CS, Kim EY, Lee HS, Soh Y, Sohn Y, Kim SY, et al. Protective effects of Cinnamomum cassia blume in the fibrogenesis of activated HSC-T6 cells and dimethylnitrosamine-induced acute liver injury in SD rats. Biosci Biotechnol Biochem 2010;74:477-83.
66. Taher M, Ghannadi A, Karmiyan R. Effects of volatile oil extracts of Anethum graveolens L. and Apium graveolens L. seeds on activity of liver enzymes in rat. J Qazvin Univ Med Sci 2007;11:8-12.
67. Mavridis SK, Gortzi O, Lalas S, Paraschos S, Skaltsounis AL, Pappas IS. Hepatoprotective effect of Pistacia lentiscus var. chia total extract against carbon tetrachloride-induced liver damage in rats. Planta Med 2008; 74 - PA339. DOI: 10.1055/s-0028-1084336.
68. Yogeeta S, Ragavender HR, Devaki T. Antihepatotoxic effect of Punica granatum. acetone extract against isoniazid- and rifampicin-induced hepatotoxicity. Pharm Biol 2007;45:631-7.
69. Saxena M, Shakya AK, Sharma N, Shrivastava S, Shukla S. Therapeutic efficacy of Rosa damascena mill. on acetaminophen-induced oxidative stress in albino rats. J Environ Pathol Toxicol Oncol 2012;31:193-201.
70. Saha P, Mazumder UK, Haldar PK, Bala A, Kar B, Naskar S. Evaluation of hepatoprotective activity of Cucurbita maxima aerial parts. J Herb Med Toxicol 2011;5:17-22.
71. Mahmood ND, Mamat SS, Kamisan FH,Yahya F, Kamarolzaman MF, Nasir N, et al. Amelioration of paracetamol-induced hepatotoxicity in rat by the administration of methanol extract of Muntingia calabura L. Leaves. Biomed Res Int 2014; DOI:.org/10.1155/2014/695678.
72. Alam J, Mujahid M, Badruddeen, Jahan Y, Bagga P, Rahman MA, et al. Hepatoprotective potential of ethanolic extract of Aquilaria agallocha leaves against paracetamol induced hepatotoxicity in SD rats. J Tradit Complement Med 2017;7:9-13.
73. Feng Y, Siu KY, Ye X, Wang N, Yuen MF, Leung CH, et al. Hepatoprotective effects of berberine on carbon tetrachloride-induced acute hepatotoxicity in rats. Chin Med 2010;5:33.
74. Fallah Huseini H, Zareei Mahmoudabady A, Ziai SA, Mehrazma M, Alavian SM, Mehdizadeh M, et al. The effects of Cynara scolymus L. leaf and Cichorium intybus L. root extracts on carbon tetrachloride induced liver toxicity in rats. J Med Plants 2011;10:33-40.
75. Singh MK, Sahu P, Nagori K, Dewangan D, Kumar T, Alexander A, et al. Organoleptic properties in vitro and in vivo pharmacological activities of Calendula officinalis Linn: An over review. J Chem Pharm Res 2011;3:655-63.
76. Das SK, Mukherjee S. Biochemical and immunological basis of silymarin effect, a milk thistle (Silybum marianum) against ethanol-induced oxidative damage. Toxicol Mech Methods 2012;22:409-13.
77. Mroueh M, Daher C, El Sibai M, Tenkerian C. Antioxidant and hepatoprotective activity of Tragopogon porrifolius methanolic extract. Planta Med Planta Med 2011;77-PF72. DOI: 10.1055/s-0031-1282460.
78. Kumar SV, Mishra SH. Hepatoprotective effect of Baliospermum montanum (Willd) Muell.-arg against thioacetamide induced toxicity. Int J Compreh Pharm 2012;9:1-4.
79. Khatri A, Garg A, Agrawal SS. Evaluation of hepatoprotective activity of aerial parts of Tephrosia purpurea L. and stem bark of Tecomella undulata. J Ethnopharmacol 2009;122:1-5.
80. Osadebe PO, Okoye FB, Uzor PF, Nnamani NR, Adiele IE, Obiano NC, et al. Phytochemical analysis, hepatoprotective

and antioxidant activity of Alchornea cordifolia methanol leaf extract on carbon tetrachloride-induced hepatic damage in rats. Asian Pac J Trop Med 2012;5:289-93.
81. Meera R, Devi P, Kameswari B, Madhumitha B, Merlin NJ. Antioxidant and hepatoprotective activities of Ocimum basilicum linn. and Trigonella foenum-graecum linn. against H2O2 and CCL4 induced hepatotoxicity in goat liver. Indian J Exp Biol 2009;47:584-90.
82. Ahsan MR, Islam KM, Bulbul IJ. Hepatoprotective activity of methanol extract of some medicinal plants against carbon tetrachloride-induced hepatotoxicity in rats. Eur J Sci Res 2009;37:302-10.
83. Sangameswaran B, Reddy TC, Jayakar B. Hepatoprotective effect of leaf extracts of Andrographis lineata nees on liver damage caused by carbon tetrachloride in rats. Phytother Res 2008;22:124-6.
84. Murugaian P, Ramamurthy V, Karmegam N. Hepatoprotective activity of Wedelia calendulacea L. against acute hepatotoxicity in rats. Res J Agr Biol Sci 2008;4:685-7.
85. Chaudhari NB, Chittam KP, Patil VR. Hepatoprotective activity of Cassia fistula seeds against paracetamol-induced hepatic injury in rats. Arch Pharm Sci Res 2009;1:218-21.
86. Gupta M, Mazumder KU, Kumar ST, Gomathi P, Kumar RS. Antioxidant and hepatoprotective effects of Bauhinia racemose against paracetamol and carbontetrachloride induced liver damage in rats. Int J Pharm Technol 2004;3:12-20.
87. Bodakhe SH, Ram A. Hepatoprotective properties of Bauhinia variegata bark extract. Yakugaku Zasshi 2007;127:1503-7.
88. Alqasoumi SI. Evaluation of the hepatroprotective and nephroprotective activities of Scrophularia hypericifolia growing in Saudi Arabia. Saudi Pharm J 2014;22:258-63.
89. Hau DK, Gambari R, Wong RS, Yuen MC, Cheng GY, Tong CS, et al. Phyllanthus urinaria extract attenuates acetaminophen induced hepatotoxicity: Involvement of cytochrome P450 CYP2E1. Phytomedicine 2009;16:751-60.
90. Haque R, Bin-Hafeez B, Ahmad I, Parvez S, Pandey S, Raisuddin S, et al. Protective effects of Emblica officinalis Gaertn. in cyclophosphamide-treated mice. Hum Exp Toxicol 2001;20:643-50.
91. Kumar K, Eswar KN, Sudheer HV, Nelli GB. In vitro antioxidant activity and in vivo hepatoprotective activity of aqueous extract of Allium cepa bulb in ethanol induced liver damage in wistar rats. Food Sci Hum Wellness 2013;2:132-8.
92. Mawa S, Husain K, Jantan I. Ficus carica L. (Moraceae): Phytochemistry, traditional uses and biological activities. Evid Based Complement Alternat Med 2013;2013:974256.
93. Kwape TE, Chaturvedi P, Kamau JM, George S. Hepato-protective potential of methanol extract of leaf of Ziziphus mucronata (ZMLM) against dimethoate toxicity: Biochemical and histological approach. Ghana Med J 2013;47:112-20.
94. Parajuli DR, Park EJ, Che XH, Jiang WY, Kim YC, Sohn DH, et al. PF2401-SF, standardized fraction of Salvia miltiorrhiza, induces apoptosis of activated hepatic stellate cells in vitro and in vivo. Molecules 2013;18:2122-34.
95. Biswas A, D'Souza UJ, Bhat S, Damodar D. The hepatoprotective effect of Hibiscus rosa sinensis flower extract on diet- induced hypercholesterolemia in male albino wister rats. Int J Med Pharm Sci 2014;4:1-10.
96. Kviecinski MR, Felipe KB, Correia JF, Ferreira EA, Rossi MH, de Moura Gatti F, et al. Brazilian Bidens pilosa linné yields fraction containing quercetin-derived flavonoid with free radical scavenger activity and hepatoprotective effects. Libyan J Med 2011;6:5651-8.
97. Liu YW, Lu KH, Ho CT, Sheen LY. Protective effects of Antrodia cinnamomea against liver injury. J Tradit Complement Med 2012;2:284-94.
98. Rao YN, Rao MP, Rao VR, Suresh K, Rafi M, Rao TN, et al. Prelimeinary phytochemical screening and hepatoprotective activity of methanolic leaves extract of Cyperus rotundus in CCl4 induced hepetotoxicity in albino wistar rats. World J Pharm Pharm Sci 2014;3:787-95.
99. Da-Costa-Rocha I, Bonnlaender B, Sievers H, Pischel I, Heinrich M. Hibiscus sabdariffa L. – A phytochemical and

pharmacological review. Food Chem 2014;165:424-43.
100. Wang JB, Zhao HP, Zhao YL, Jin C, Liu DJ, Kong WJ, et al. Hepatotoxicity or hepatoprotection? Pattern recognition for the paradoxical effect of the Chinese herb Rheum palmatum L. in treating rat liver injury. PLoS One 2011;6:e24498.
101. Hurkadale PJ, Shelar PA, Palled SG, Mandavkar YD, Khedkar AS. Hepatoprotective activity of Amorphophallus paeoniifolius tubers against paracetamol-induced liver damage in rats. Asian Pac J Trop Biomed 2012;2:S238-42.
102. Farzaei MH, Abbasabadi Z, Ardekani MR, Rahimi R, Farzaei F. Parsley: A review of ethnopharmacology, phytochemistry and biological activities. J Tradit Chin Med 2013;33:815-26.
103. Moghadamtousi SZ, Kamarudin MN, Chan CK, Goh BH, Kadir HA. Phytochemistry and biology of Loranthus parasiticus merr, a commonly used herbal medicine. Am J Chin Med 2014;42:23-35.
104. Zargar S. Protective effect of Trigonella foenum-graecum on thioacetamide induced hepatotoxicity in rats. Saudi J Biol Sci 2014;21:139-45.
105. Sreejith G, Jayasree M, Latha PG, Suja SR, Shyamal S, Shine VJ, et al. Hepatoprotective activity of Oxalis corniculata L. ethanolic extract against paracetamol induced hepatotoxicity in wistar rats and its in vitro antioxidant effects. Indian J Exp Biol 2014;52:147-52.
106. Felicia FA, Muthulingam M. Renal antioxidant and lipid peroxidative role of Indigofera tinctoria (Linn.) against paracetamol induced hepatotoxicity in rats. Int J Pure Appl Zool 2013;1:37-42.
107. Hussain L, Akash MS, Tahir M, Rehman K, Ahmed KZ. Hepatoprotective effects of methanolic extract of Alcea rosea against acetaminophen-induced hepatotoxicity in mice. Bangladesh J Pharmacol 2014;9:322-7.
108. Singh D, Gupta RS. Hepatoprotective activity of methanol extract of Tecomella undulate against alcohol and paracetamol induced hepatotoxicity in rats. Life Sci Med Res 2011;26:1-6.
109. Qadir MI, Murad MS, Ali M, Saleem M, Farooqi AA. Hepatoprotective effect of leaves of aqueous ethanol extract of Cestrum nocturnum against paracetamol-induced hepatotoxicity. Bangladesh J Pharmacol 2014;9:167-70.
110. Ali M, Qadir MI, Saleem M, Janbaz KH, Gul H, Hussain L, et al. Hepatoprotective potential of Convolvulus arvensis against paracetamol-induced hepatotoxicity. Bangladesh J Pharmacol 2013;8:300-4.
111. Al-Razzuqi R, Al-Jawad F, Al- Hussaini J, Al-Jeboori A. Hepatoprotective effect of Glycyrrhiza glabra in carbon tetrachloride-induced model of acute liver injury. J Phys Pharm Adv 2012;2:259-63.
112. Mallhi TH, Abbas K, Ali M, Qadir MI, Saleem M, Khan YH. Hepatoprotective activity of methanolic extract of Malva parviflora against paracetamol-induced hepatotoxicity in mice. Bangladesh J Pharmacol 2014;9:342-6.
113. Gani SM, John SA. Evalution of hepatoprotective effect of Nigella sativa L. Int J Pharm Pharm Sci 2013;5:12-9.
114. Peng WH,Tien YC, Huang CY, Huang TH, Liao JC, Kuo CL, et al. Fraxinus rhynchophylla ethanol extract attenuates carbon tetrachloride-induced liver fibrosis in rats via down-regulating the expressions of uPA, MMP-2, MMP-9 and TIMP-1. J Ethnopharmacol 2010;127:606-13.
115. Saleem M, Ahmed B, Karim M, Ahmed S, Ahmad M, Qadir MI, et al. Hepatoprotective effect of aqeous methanolic extract of Rumex dentatus in paracetamol induced hepatotoxicity in mice. Bangladesh J Pharmacol 2014;9:284-9.
116. Rehman JU, Saqib NU, Akhtar N, Jamshaid M, Asif HM, Sultana S, et al. Hepatoprotective activity of aqueous-methanolic extract of Suaeda fruticosa in paracetamol-induced hepatotoxicity in rabbits. Bangladesh J Pharmacol 2013;8:378-81.
117. Alamgeer, Nawaz M, Ahmad T, Mushtaq MN, Batool A. Hepatoprotective activity of Thymus linearis against paracetamol and carbon tetrachloride-induced hepatotoxicity in albino mice. Bangladesh J Pharmacol 2014;9:230-4.

118. Saboo SS, Tapadiya G, Farooqui IA, Khadabadi SS. Free radical scavenging, in vivo antioxidant and hepatoprotective activity of folk medicine Trichodesma sedgwickianum. Bangladesh J Pharmacol 2013;8:58-64.
119. Sharma SK, Suman N, Vasudeva N. Hepatoprotective activity of Vitis vinifera root extract against carbon tetrachlorideinduced liver damage in rats. Acta Pol Pharm 2012;69:933-7.
120. Dhanaraj TS, Gowthami R, Rajlakshmi S, Murugaiah K. Antihepatotoxicity of Hygrophila auriculata on CCl4 induced hepatotoxicity in rats. Asian J Res Pharm Sci 2012;2:140-2.
121. Friday UO, Ifeanyi E, Emmanuel AI, Godwin C, Emeka J. Analgesic and hepatoprotective activity of methanoilc leaf extract of Ocimum gratissimum. Res J Med Plant 2012;6:108-19.
122. Yahya F, Mamat SS, Kamarolzaman MF, Seyedan AA, Jakius KF, Mahmood ND, et al. Hepatoprotective activity of methanolic extract of Bauhinia purpurea leaves against paracetamol-induced hepatic damage in rats. Evid Based Complement Alternat Med 2013;2013:636580.
123. Kanchana N, Sadiq AM. Hepatoprotective effect of Plumbago zeylanica on paracetamol induced liver toxicity in rats. Int J Pharm Pharm Sci 2011;3:32-9.
124. Joshi UP, Mishra SH. In vitro antioxidant and hepatoprotective activity of isolated compounds from Pistacia integerrima. Aust J Med Herbalism 2010;22:22-34.
125. Tsai JC, Peng WH, Chiu TH, Huang SC, Huang TH, Lai SC, et al. Hepatoprotective effect of Scoparia dulcis on carbon tetrachloride induced acute liver injury in mice. Am J Chin Med 2010;38:761-75.
126. Joshi V, Sutar P, Karigar A, Patil S, Gopalakrishna B, Sureban R. Screening of ethanolic extract of Stachytarpheta indica L. (vahl) leaves for hepatoprotective activity. Int J Res Ayurveda Pharm 2010;1:174-9.
127. Lahon K, Das S. Hepatoprotective activity of Ocimum sanctum alcoholic leaf extract against paracetamol-induced liver damage in albino rats. Pharmacognosy Res 2011;3:13-8.
128. Rajendran R, Hemalatha S, Akasakalai K, Madhu Krishna CH, Sohil B, Sundaram M. Hepatoprotective activity of Mimosa pudica leaves against carbon tetrachloride induced toxicity. J Nat Prod 2009;2:116-22.
129. Garba SH, Sambo N, Bala U. The effect of the aqueous extract of Kohautia grandiflora on paracetamol-induced liver damage in albino rats. Niger J Physiol Sci 2009;24:17-23.
130. Singh H, Prakash A, Kalia AN, Majeed AB. Synergistic hepatoprotective potential of ethanolic extract of Solanum xanthocarpum and Juniperus communis against paracetamol and azithromycin induced liver injury in rats. J Tradit Complement Med 2016;6:370-6.
131. Wang L, Cheng D, Wang H, Di L, Zhou X, Xu T, et al. The hepatoprotective and antifibrotic effects of Saururus chinensis against carbon tetrachloride induced hepatic fibrosis in rats. J Ethnopharmacol 2009;126:487-91.
132. Ahmad M, Khan MA, Arshad M, Zafar M. Ethnophytotherapical approaches for the treatment of diabetes tract by the local inhabitants of district Attock (Pakistan). Ethnobotanical Leaf 2006;10:41-8.
133. Onocha P, Opegbemi A, Kadri A, Ajayi K, Okorie D. Antimicrobial evaluation of Nigerian euphorbiaceae plants: Phyllanthus amarus and Phyllanthus muellarianus leaf extracts. Niger J Nat Prod Med 2004;7:9-12.
134. Brusotti G, Cesari I, Frassà G, Grisoli P, Dacarro C, Caccialanza G, et al. Antimicrobial properties of stem bark extracts from Phyllanthus muellerianus (Kuntze) excell. J Ethnopharmacol 2011;135:797-800.
135. Agyare C, Lechtenberg M, Deters A, Petereit F, Hensel A. Ellagitannins from Phyllanthus muellerianus (Kuntze) exell: Geraniin and furosin stimulate cellular activity, differentiation and collagen synthesis of human skin keratinocytes and dermal fibroblasts. Phytomedicine 2011;18:617-24.
136. Cesari I, Grisoli P, Paolillo M, Milanese C, Massolini G, Brusotti G, et al. Isolation and characterization of the alkaloid nitidine responsible for the traditional use of

Phyllanthus muellerianus (Kuntze) excell stem bark against bacterial infections. J Pharm Biomed Anal 2015;105:115-20.
137. Rasool MK, Sabina EP, Ramya SR, Preety P, Patel S, Mandal N, et al. Hepatoprotective and antioxidant effects of gallic acid in paracetamol-induced liver damage in mice. J Pharm Pharmacol 2010;62:638-43.
138. Alam J, Mujahid M, Rahman M, Akhtar J, Khalid M, Jahan Y, et al. An insight of pharmacognostic study and phytopharmacology of Aquilaria agallocha. J Appl Pharm Sci 2015;5:173-81.
139. Enayat S, Ceyhan MŞ, Başaran AA, Gürsel M, Banerjee S. Anticarcinogenic effects of the ethanolic extract of Salix aegyptiaca in colon cancer cells: Involvement of Akt/PKB and MAPK pathways. Nutr Cancer 2013;65:1045-58.
140. Hussain HB, Elshazly A, Elsayed A, Krohn K, Riaz M, Schulz B. Chemical constituents and antimicrobial activity of Salix subserrata. Rec Nat Prod 2011;5:133-7.
141. Gupta AK, Tandon N, Sharma M. Quality Standards of Indian Medicinal Plants. Vol. 29. New Delhi: Indian Council of Medical Research; 2005. p. 25-6.
142. Kannur DM, Hukkeri VI, Akki KS. Adaptogenic activity of Caesalpinia bonduc seed extracts in rats. J Ethnopharmacol 2006;108:327-31.
143. Felker P, Paterson A, Jenderek M. Forage potential of opuntia clones maintained by the USDA, National Plant Germplasm System (NPGS) collection. Crop Sci 2006;46:2161-8.
144. Large MF, Braggins JE. Tree Ferns. Portland, Oregon: Timber Press; 2004. p. 136.
145. Barh D, Mazumdar BC. Comparative traditional medicine of the nutritive values of palm saps before and after their partial fermentation and effective use of wild date. (Phoenix sylvestris Roxb.) Sap in treatment of anemia. Res J Med Med Sci 2008;3:173-6.
146. Middleton E Jr. Kandaswami C, Theoharides TC. The effects of plant flavonoids on mammalian cells: Implications for inflammation, heart disease, and cancer. Pharmacol Rev 2000;52:673-751.
147. Lin CN, Tome WP. Antihepatotoxic principles of Sambucus formosana. Planta Med 1988;54:223-4.
148. Kowalska MT, Brandt ME, Puett D. Inhibition of cytochrome P 450 aromatase activity by plant extracts. Planta Med 1990;56:675-7.
149. Al-Qarawi AA, Mousa HM, Ali BE, Abdel-Rahman H, El-Mougy SA. Protective effect of extracts from dates (Phoenix dactylifera L.) on carbon tetrachloride-induced hepatotoxicity in rats. Int J Appl Res Vet Med 2004;2:176-80.
150. Kaur M, Kalia A. Convolvulus arvensis: A useful weed. Int J Pharm Pharm Sci 2012;4:38-40.
151. Pavanato A, Tuñón MJ, Sánchez-Campos S, Marroni CA, Llesuy S, González-Gallego J, et al. Effects of quercetin on liver damage in rats with carbon tetrachloride-induced cirrhosis. Dig Dis Sci 2003;48:824-9.
152. Abenavoli L, Capasso R, Milic N, Capasso F. Milk thistle in liver diseases: Past, present, future. Phytother Res 2010;24:1423-32.
153. Chirumbolo S. The role of quercetin, flavonols and flavones in modulating inflammatory cell function. Inflamm Allergy Drug Targets 2010;9:263-85.
154. Glauert HP, Calfee-Mason K, Stemm DN, Tharappel JC, Spear BT. Dietary antioxidants in the prevention of hepatocarcinogenesis: A review. Mol Nutr Food Res 2010;54:875-96.
155. Ni YF, Kuai JK, Lu ZF, Yang GD, Fu HY, Wang J, et al. Glycyrrhizin treatment is associated with attenuation of lipopolysaccharide-induced acute lung injury by inhibiting cyclooxygenase-2 and inducible nitric oxide synthase expression. J Surg Res 2011;165:e29-35.
156. Zhao L, Wu J, Yang J, Wei J, Gao W, Guo C, et al. Dietary quercetin supplementation increases serum antioxidant capacity and alters hepatic gene expression profile in rats. Exp Biol Med (Maywood) 2011;236:701-6.

157. Timmers S, Auwerx J, Schrauwen P. The journey of resveratrol from yeast to human. Aging (Albany NY) 2012;4:146-58.
158. Lekić N, Canová NK, Hořínek A, Farghali H. The involvement of heme oxygenase 1 but not nitric oxide synthase 2 in a hepatoprotective action of quercetin in lipopolysaccharide-induced hepatotoxicity of D-galactosamine sensitized rats. Fitoterapia 2013;87:20-6.
159. Gupta SC, Kismali G, Aggarwal BB. Curcumin, a component of turmeric: From farm to pharmacy. Biofactors 2013;39:2-13.
160. Zhang A, Sun H, Wang X. Recent advances in natural products from plants for treatment of liver diseases. Eur J Med Chem 2013;63:570-7.
161. Li L, Hai J, Li Z, Zhang Y, Peng H, Li K, et al. Resveratrol modulates autophagy and NF-□B activity in a murine model for treating non-alcoholic fatty liver disease. Food Chem Toxicol 2014;63:166-73.