INFORMATICS JOURNALS

Short Review

Journal of Natural Remedies
DOI: 10.18311/jnr/2026/55273

eISSN: 2320-3358 | Vol 26(10), 2026 | pp. 2655-2671

Some of the Most Important Medicinal Plants with Antihepatotoxic Potential: A Comprehensive Review

Rupinder Kaur[1*], Shruti Saxena[2], Preeti Handa Kakkar[3], Versha Upadhyay[4], Tanuja[5], Simrat Kaur[6] and Manish Chauhan[7]

[1]School of Agriculture, Tulas University, Dehradun – 248001, Uttarakhand, India; roopnarang@gmail.com

[2]SBAS, Shri Guru Ram Rai University, Dehradun – 248001, Uttarakhand, India

[3]School of Agriculture, Dev Bhoomi Uttarakhand University, Dehradun – 248001, Uttarakhand, India

[4]Department of Botany, Maya Devi University, Dehradun – 248001, Uttarakhand, India

[5]Department of Applied Science and Humanities, Tula's Institute, Dehradun – 248001, Uttarakhand, India

[6]Department of Chemistry, Mata Gujri College, Fatehgarh Sahib – 140406, Punjab, India

[7]School of Agriculture, Abhilashi University, Mandi – 175028, Himachal Pradesh, India

Abstract

Background: Medicinal herbs, regarded as a valuable gift from nature, have long been used to enhance, maintain, and preserve human health. Traditional medicinal systems, particularly those practised in Uttarakhand, India, employ numerous plant species for the management of liver disorders. However, a comprehensive evaluation of their hepatoprotective potential is essential to support their therapeutic use. **Aim:** To review and evaluate the hepatoprotective potential of sixteen medicinal plant species from different genera traditionally used in Uttarakhand for the treatment of liver-related disorders, and to identify promising phytoconstituents with hepatoprotective activity. **Methods:** Sixteen medicinal plant species were selected based on their ethnomedical relevance in the treatment of liver diseases. Available scientific literature was critically reviewed to assess experimental evidence of hepatoprotective activity. The studies included various *in vivo* models of hepatotoxicity in rats and mice induced by carbon tetrachloride, mercuric chloride, cumene hydroperoxide, α-naphthyl isothiocyanate, paracetamol, thioacetamide, physical stress, iron overload, β-D-galactosamine, cyclophosphamide, and alcohol. **Results:** All sixteen plant species demonstrated consistent hepatoprotective activity across different experimental models. Three bioactive phytoconstituents-echinocystic acid, schaftoside, and eclalbasaponin II-were identified as particularly promising hepatoprotective compounds. The reviewed evidence supports the therapeutic potential of these medicinal plants in protecting against chemically induced liver injury. **Conclusion:** The medicinal plants traditionally used in Uttarakhand represent promising natural sources of hepatoprotective agents. Further comparative investigations are needed to establish the relative efficacy of these species and to elucidate their mechanisms of action. The identification of bioactive hepatoprotective phytoconstituents and the development of polyherbal formulations from these plants may facilitate the discovery and development of effective hepatoprotective drugs and nutraceuticals.

Major Findings: All sixteen medicinal plant species traditionally used in Uttarakhand demonstrated hepatoprotective activity across diverse experimental models of liver injury. Promising bioactive substances such as echinocystic acid, schaftoside, and eclalbasaponin II have been identified, indicating the potential of these plants for creating new hepatoprotective medications and nutraceuticals.

Keywords: Ethnomedicine, Hepatotoxicity, Oxidative Stress, Polyherbal Formulations, Phytotherapy and Traditional Medicine

(Article Chronicle: Article Received on: 26.03.2026; Revised on: 14.08.2026; Accepted on: 07.09.2026)

*Author for correspondence

1. Introduction

According to reports, 2500 plant species are used by traditional healers in India, and 100 plant species are regularly used as medication[1]. India is known as the botanical garden of the globe and is the world's largest producer of medicinal herbs[2]. Traditional medicine has made use of plants for thousands of years. Interest in researching medicinal plants and their traditional applications around the world has grown over the past few decades[3-5]. The use of medicinal plants to treat a variety of illnesses and the creation of indigenous medicines have significant economic benefits[6,7]. Several plants have been demonstrated to have hepatoprotective properties by enhancing antioxidant status. Therefore, the medication's effectiveness would be passive and preventive in protecting against harm. As the biggest gland in the body, the liver plays a major role in maintaining and coordinating essential physiological processes, which ultimately results in the preservation of homeostasis[8]. For nearly all of the body's metabolic processes, such as the distribution and storage of nutrients and energy, the synthesis and control of hormones and enzymes, the neutralisation of toxins and the processing of xenobiotics, and infections, it acts as the primary physiological centre.

By supplying various digestive enzymes at precise locations and the bile juice in the duodenum, the liver also plays a crucial role in the digestive system, facilitating the digestion of proteins and fats[9]. To aid in the breakdown of fats, the liver produces bile, which is thereafter momentarily held in the gallbladder before being released into the duodenum. The bulk of the biliary fluid is composed of bile salts, which function as a detergent and help the highly hydrophilic and acidified digestive tract dissolve extremely hydrophobic substances including fats, oils, fat-soluble vitamins, and long-chain fatty molecules.

Bile salts also help eliminate cholesterol and other fat-soluble harmful chemicals, including xenobiotics, carcinogens, toxic metabolites, and medicines, by a similar mechanism[10]. Furthermore, hepatic enzymes are required to activate the majority of prodrugs that are supplied in their inactive forms to enhance bioavailability or to decrease toxicity in order for them to exert their respective therapeutic effects[11]. Consequently, balance and optimal health depend on a functioning liver. There are hundreds of etiological events that can infect the liver, including drugs, alcohol, and chemicals (hepatotoxic substances), microorganisms (cytomegalovirus, Epstein-Barr virus, yellow fever viruses, hepatitis viruses), metabolic problems (hemochromatosis, Wilson's disease, obesity related liver disease), and different autoimmune diseases[12]. Numerous hepatotoxic chemicals cause strong free radicals to develop, increasing the oxidative burden and possibly causing cirrhosis, hepatitis, and other liver damage[13]. Since ancient times, natural compounds derived from plants have been used extensively for their healing properties. They are also commonly utilised as nutritional supplements and as food components. Because of their many dietary benefits, including minerals, enzymes, vitamins, phenolics, and antioxidants, plant materials have significantly benefited the food, pharmaceutical, and nutraceutical businesses.

Furthermore, it has been revealed that about 170 phytoconstituents that were extracted from 110 medicinal plants spread across 55 families have hepatoprotective properties. Many herbal products with hepatoprotective effectiveness are sold globally, however, because of their safety and effectiveness profile, only a few numbers of liver friendly herbs and their nutritional formulations are being approved for use in conventional medications[14,15]. These plants' extract may have a protective effect against CCl_4 since it contains phytosterols, alkaloids, terpenoids, coumarins, and polyphenolic chemicals. By boosting the activity of antioxidant enzymes (including CAT, glutathione peroxidase and SOD), polyphenolic substances like flavonoids can shield cells from depleting reduced glutathione. Flavonoids, which act as antioxidant, free radical scavenging are helpful for hepatoprotection. Additionally, by combating free radicals in the environment, these substances with antioxidant qualities might prevent their harmful consequences. Terpenoids with antihepatotoxic properties, like carotenoids, are also referred to as antioxidants. Triterpene ursolic acid may have antihepatotoxic properties. Additionally, sitosterol, silymarin, picroside, kutkoside, neoandrographolide, hypophyllanthin, β-betalain, andrographolide, phyllanthin, curcumin, and glycyrrhizin have been shown to have strong hepatoprotective qualities among

a number of leads derived from plants that contain potential hepatoprotective agents. Alcohol-associated liver disease, cirrhosis, and hepatitis were all much improved by glycyrrhizin and silymarin. β-sitosterol exhibited proliferative, antioxidant, and anti-inflammatory properties. Common medications for a variety of illnesses (such as liver problems, jaundice, malaria, and scanty urine) include betalain. Betalains have anticancer, antiviral, antioxidant, and antiparasitic properties. There is little evidence to support the use of herbal drugs to treat chronic liver illnesses and viral hepatitis, despite promising data regarding the potential for discoveries in the near future. As a result, herbal remedies ought to be suggested in the context of more meticulously carried out clinical investigations.

This thorough review names sixteen important plant species used in ethnomedicine: *Colocasia esculenta* (L.) Schott., *Alstonia scholaris* (L.) R. Br., *Mangifera indica* L., *Hypericum japonicum* Thunb., *Leucas aspera* (Willd.) Link., *Kalanchoe pinnata* (Lam.) Pers., *Litchi chinensis* Sonn., *Andrographis paniculata* (Burm. f.) Nees., *Lawsonia inermis* L. (Henna), *Moringa* (*Moringa oleifera*), *Asparagus racemosus* Willd. *Shatavari*., *Curcuma longa* L. (Turmeric)., *Amaranthus spinosus* L. (*Chaulai*)., *Cassia fistula* L., *Eclipta prostrata* (L.) L., *Hybanthus enneaspermus* (L.) F. Muell. including their hepatoprotective phytoconstituents, ethnomedicinal relevance, and therapeutic potentials in reducing hepatic and oxidative stress (Figures 1 and 2). These substances are frequently used for their antihepatotoxic qualities. Even though a much greater number of plant species have been linked to hepatoprotective properties, the selection process was based on how well they were formulated and then incorporated into contemporary medical systems. With the ultimate goal of identifying these plants as potential sources of novel hepatoprotective herbal medicines, the gathered data was also critically examined to offer insights and suggestions for further research. Furthermore, it has been revealed that about 170 phytoconstituents that were extracted from 110 medicinal plants spread across 55 families have hepatoprotective properties. Additionally, almost 600 commercial herbal products with hepatoprotective effectiveness are sold globally. However, because of their safety and effectiveness profile, only a few hepatoprotective herbs and their

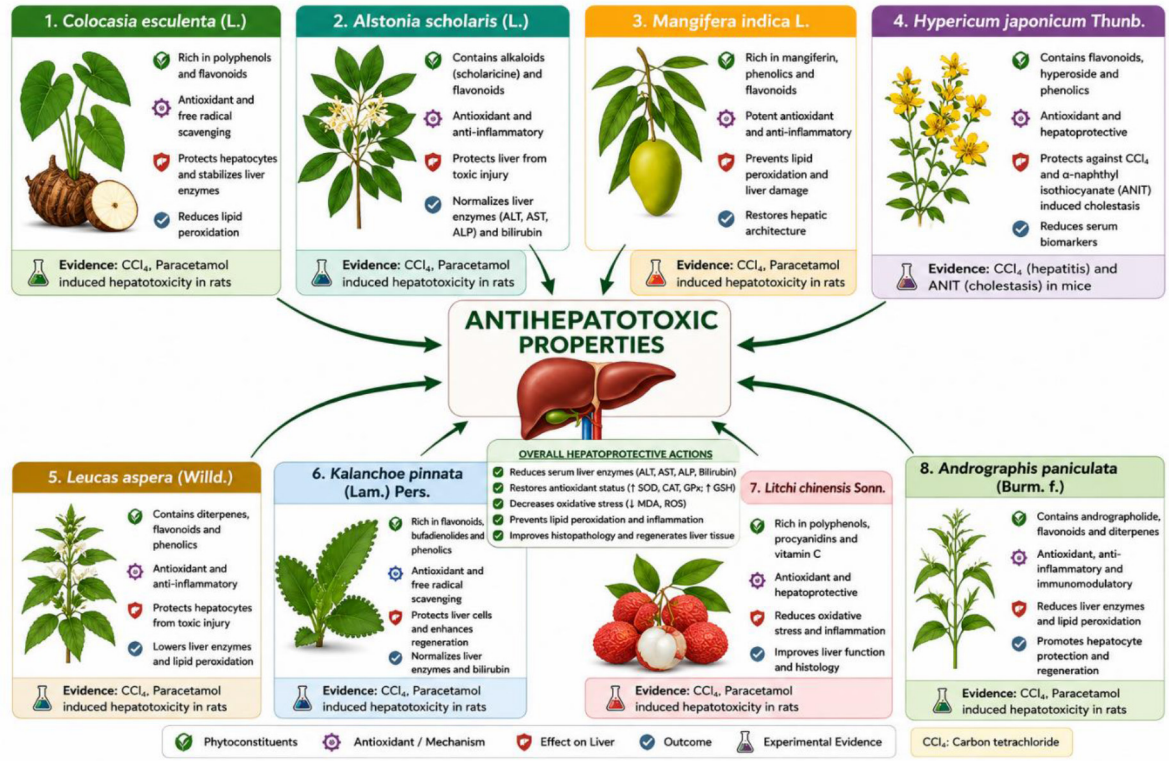


Figure 1. Hepatoprotective phytoconstituents, ethnomedicinal relevance and therapeutic potential of some medicinal plants.

nutritional formulations are being approved for use in conventional medications[14,15].

2. Phytochemistry

The crude extracts used in traditional medical systems are currently being used to identify precise bioactive compounds that contribute to their distinct bioactivities, thanks to the advantages of urbanisation and modern technology. In addition to serving as the primary source of these bioactive compounds, the secondary metabolite pool of plants offers humanity a steady supply of structurally diverse compounds to work with[16]. In turn, these molecules have demonstrated a noteworthy role in the treatment of numerous diseases, either directly as the therapeutic molecule or indirectly as the lead ingredient. Additionally, it has been demonstrated that certain classes of compounds consistently exhibit particular types of pharmacological potentials, such as the antioxidative potential of polyphenols[17], the anti-inflammatory properties of flavonoids, the antiproliferative properties of polyphenols and flavonoids[16], and the hepatoprotective activity of flavonoids, phenolics, and tannins. Alkaloids, glycosides, vitamins, terpenoids, oils and fats, gums, flavonoids, and steroids are just a few of the major phytochemical classes represented by the diverse range of secondary metabolites found in the plants under study. Echinocystic acid, eclalbasaponin II, and schaftoside are the main bioactive metabolites that were separated from these plants and have strong hepatoprotective properties. Additionally, thirteen polyphenolic and flavonoid molecules such as quercetin-7-O-rhamnoside, catechin, kaempferol, epicatechin, quercetin, isoquercitrin, quercitrin, procyanidin A2, anthocyanins, quercetin 3-O-rutinoside-7-O-α-l-rhamnoside, pelargonidin-3-O-glucoside, hyperin and gallic acid, have been chemically identified as the majorchemical constituents of various extracts from these plants that have been shown to exhibit significant antihepatotoxic effects.

The majority of plant-based medications used to treat liver disorders are made with hepatoprotective and antioxidant-related qualities in mind. These are

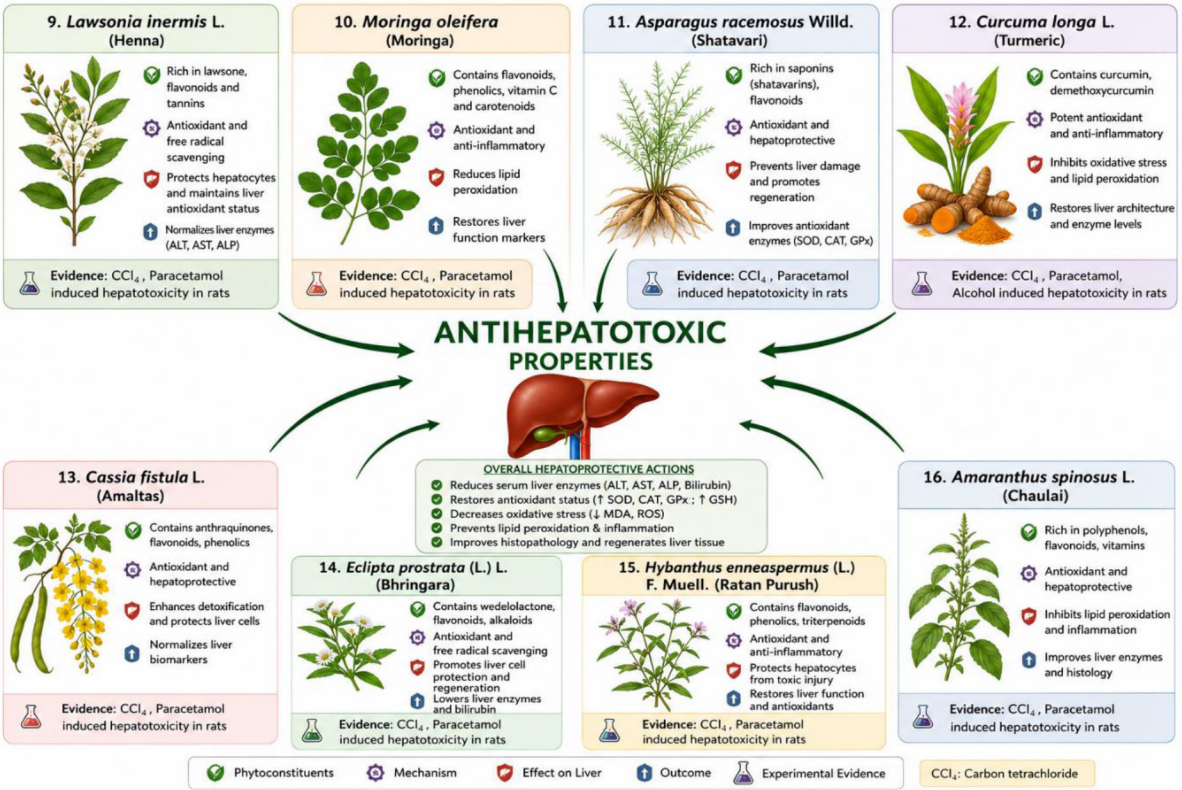


Figure 2. Hepatoprotective phytoconstituents, ethnomedicinal relevance and therapeutic potential of some medicinal plants.

the primary scientific processes that underpin the new medications used to treat liver disorders that have the fewest negative effects on the kidneys. Thus, additional research is required to assess the potential of novel candidate phytochemicals for the synthesis of more potent hepatoprotective medications. Because 50% of individuals in underdeveloped nations who have liver disease or another rely on herbal treatments for treatment, they have drawn attention from all around the world. The majority of herbal extracts that are already on the market have demonstrated great potential in reducing the signs and symptoms of liver illness or injury. To standardise the manufacture and administration of the herbal extracts for efficacy and safety, more studies will be required, particularly in this area, as the scientific validation of the extracts has not yet been established. Similarly, it will be crucial to conduct preclinical research on these herbal products before moving on to clinical trials. The standard dosage schedule established based on clinical studies will also be useful in drug formulation and administration. This will determine the true therapeutic value of these natural herbal items. Additionally, the traditional medicine approach to drug design and discovery can produce a number of essential medications for the treatment of various illnesses.

3. Hepatoprotective Potentials of Some Selected Medicinal Plants

3.1 *Colocasia esculenta* (L.) Schott (Elephant's Ear/Arbi)

The perennial herb *C. esculenta*, also called taro or coco yam, has huge, heart-shaped leaves and a starchy subterranean corm. Grown extensively in Asia, Africa, and the South Pacific, it is a staple crop in the Pacific Islands. The plant is cultivated for its edible corm, which is the primary storage organ, and its leaves[18]. C. *esculenta* is currently acknowledged as a traditional treatment due to its hepatoprotective qualities, which have been further reinforced by pharmacological research. The hepatoprotective activity of the plant's anthocyanin-rich leaf juice was evaluated by administering 5 µl/ml and 10 µl/ml of the extract using the *in vitro* liver slice method. The extract decreased the availability of Alanine Transaminase and Aspartate Transaminase in plasma while increasing their activity in the liver[19].

In Swiss albino mice, the methanol extract of the aerial parts of C. *esculenta* has been demonstrated to have a strong hepatoprotective effect, successfully reversing iron-induced hepatotoxicity. Furthermore, the extract's antihepatotoxic qualities were attributed to its capacity to neutralise iron by chelation and reduction[20]. Interestingly, when seen under a 400× magnification microscope, mouse liver slices stained with haematoxylin and eosin demonstrated a notable reduction in hepatic cell necrosis and an increase in hepatic cells. This also implied that the extract would be helpful in correcting any hepatotoxicity caused by metal overload, which merits more research. But in the event of any chemically caused hepatotoxicity, this logic also calls into question the extract's hepatoprotective qualities.

Schaffoside, found in C. *esculenta*, has been demonstrated to lessen the hepatotoxicity of paracetamol in rats at doses of 40, 80, and 160 mg/kg. According to intracellular research, the medication may activate the hepatocytes' farnesoid X receptor, strengthening the hepatic antioxidant system, activating nuclear factor kappa B (NF-κB) signalling, and lowering the synthesis of pro-inflammatory eicosanoids[21,22].

3.2 *Alstonia scholaris* (L.) R. Br. (Indian Devil Tree)

Alstonia scholaris is an evergreen tree in the *Apocynaceae* family that is often referred to as the scholar tree or blackboard tree. It is spread around the world, including Australia and portions of Africa, although it is indigenous to Southeast Asia and parts of the Indian subcontinent. When hurt, the tree releases its bitter latex, which is its most well-known characteristic. It is a huge tree with tessellated corky gray-white bark that can grow up to 40 meters in height. The fragrant greenish-white or greyish-yellow flowers are surrounded by thick, dark green, whorled leaves. The pharmacological activities of *A. scholaris* are diverse and include antibacterial and synergistic properties[23], anti-inflammatory, anticoagulant, antidepressant properties, antihyperlipidemic and antidiabetic properties[24], anti-proliferative properties[25], anti-asthmatic properties[26], anti-arthritic, and antioxidant properties. The liver toxicity-induced increases in ALT and AST plasma levels in all three mice were decreased by the extract at a dose of 300 mg/kg body weight.

Histopathological study demonstrated that cells treated with *A. scholaris* exhibited reduced cellular necrosis, microvascular cell degeneration, and inflammatory infiltration[27,28]. Similarly, albino rats' plasma concentrations of AST, ALP, ALT, and bilirubin were shown to be suppressed by an ethanol extract of the plant's fruits at a dose of 300 mg/kg body weight by margins of 32.6%, 26.1%, 65.5%, and 50.8%, respectively[29]. In addition to these, this herb has been shown to have strong hepatoprotective properties, which support its ethnomedical claims. In male Wistar rats, a study examined the hepatoprotective effect of *A. scholaris* methanol extract in a hepatotoxic model caused by carbon tetrachloride, β-d-galactosamine, and paracetamol.

3.3 *Mangifera indica* L. (Mango)

A prevalent herb in *Ayurvedic* treatment is *Mangifera indica*. According to studies, mango has cardiotonic, anti-inflammatory, antiviral, antioxidant, and antidiabetic qualities. Many effects have also been investigated, including antitumor, antispasmodic, antifungal, anthelmintic, antiallergic, immunomodulatory, antibacterial, antiparasitic, hypolipidemic, anti-HIV, hepatoprotective, antipyretic, antidiarrheal, antimicrobial, and gastroprotective. *M. indica* is one of the most widely used plants in South Asian rural regions from an ethnomedical perspective because of its hepatoprotective properties[30]. Research has been done on hepatoprotective extracts of different plant sections, including the aerial parts, leaves, stem, fruits, and pulps, against the synthetic substance silymarin[31].

Male Sprague-Dawley rats' oxidative stress-mediated hepatotoxicity caused by cumene hydroperoxide might be reversed by the fruits' aqueous extract. Subsequent biochemical analysis showed reduced levels of lipid peroxidation, hepatocyte lysis, reactive oxygen species production, and intracellular glutathione depletion. The hepatoprotective effects of an aqueous extract of *M. indica* stem bark in male Wistar rats were investigated in another *in vivo* study[32]. In the post-treatment model, the trends for the liver and plasma markers were identical[33]. Using a separate paracetamol-induced hepatotoxic study model in male Wistar albino rats, the aqueous and ethanol extracts from the stem barks demonstrated hepatoprotective properties. At 200 mg/kg body weight, both extracts dramatically increased the liver concentrations of antioxidants, particularly catalase, SOD, and GSH, and reversed the increase in AST, ALT, and ALP brought on by paracetamol[34].

3.4 *Hypericum japonicum* Thunb. (Matted St. John's-wort)

The tiny, annual plant *Hypericum japonicum* Thunb., also referred to as matted St. John's wort, is indigenous to Asia and other parts of the world. It is distinguished by its bright yellow flowers, short, opposite leaves, and prostrate or procumbent growth habit. The plant has persistent, sessile leaves and usually reaches a height of 2 to 5 cm. The species *H. japonicum* is found in regions of Europe and Asia. The herb has been used for ethnomedical purposes for a long time. Numerous bioactive compounds have been identified through phytochemical analyses of this plant, and these have been further described with notable pharmacological potential through relevant research. In the end, specific secondary metabolites have also been linked to the plant's antihepatotoxic qualities[35].

At doses of 0.2, 0.6, and 1.8 g/kg body weight, it was also shown that the plant's ethanol and ethyl acetate extracts inhibited the rise in ALT and AST caused by D-aminogalactose[36]. The hepatoprotective potential of the plant's whole flavonoid extract against carbon tetrachloride-induced liver injury was investigated; it was found to raise the levels of glutathione, malondialdehyde, and superoxide dismutase in hepatic parenchyma. Chromatographic analysis identified kaempferol, quercetin, hypericin, quercitrin, quercetin-7-O-rhamnoside, and isoquercitrin as the main flavonoid constituents of the extract[37]. In Kunming mice, the antihepatotoxic properties of the entire aqueous extract of *H. japonicum* and its various fractions were examined against cholestasis caused by α-naphthyl-isothiocyanate and hepatitis caused by carbon tetrachloride. The study demonstrated that the full aqueous extract and the aqueous fraction, at different doses, reduced several serum markers in both mice in a dose-dependent way[38].

3.5 *Leucas aspera* (Willd.) Link (*Thumbai*)

The annual herb *Leucas aspera*, also called *Thumbai* or *Thumbichittu*, has a square stem and opposing, oblong or linear-oblong lanceolate leaves. It can be found all over

India as well as in places like the Philippines, Java, and Mauritius. The plant is well-known for its agricultural and therapeutic use. It has been demonstrated to have cytotoxic, antifungal, antioxidant, antibacterial, and antinociceptive (pain-relieving) properties. Among the many phytochemicals found in the plant are β-sitosterol, ursolic acid, oleanolic acid, and triterpenoids. *L. aspera*, also referred to as "*Thumbai*", is widely used for hepatoprotection by Southeast Asian ethnomedicinal healers in the Himalayan regions. Scientists have looked into its antihepatotoxic potential in addition to other biological roles[39].

The possible effect of *L. aspera* aqueous extract against d-galactosamine-induced hepatotoxicity was investigated in female Wistar albino rats. The extract stopped the aberrant rise of AST, ALT, ALP, and total bilirubin. Additionally, the extract and the standard decreased the rate of hepatic lipid peroxidation while increasing hepatic antioxidative enzymes such as GPx, catalase, and SOD[40]. In contrast to the group treated with carbon tetrachloride, the pre-treatment animals given the plant sample and reference medication showed signs of enhanced hepatic architectural pattern, suggesting potential protection against carbon tetrachloride-induced liver damage[41].

By dramatically lowering plasma levels of ALT, AST, and ALP in male Wistar rats given carbon tetrachloride at dosages of 100 and 200 mg/kg, another study demonstrated the plant's methanol extract's hepatoprotective qualities. Hepatic antioxidants such as SOD, GST, catalase, GSH, and GPx were also elevated by the extract at both dosages. The potential hepatoprotective benefits of a hydroalcoholic (70:30) extract of *L. aspera* leaves were investigated in male Wistar albino rats administered lead acetate. After 21 days of daily extract treatment, there were significant reductions in plasma ALT, AST, and ALP, which suggested significant antihepatotoxic activity[42].

3.6 *Kalanchoe pinnata* (Lam.) Pers. (*Patharchatta*)

The succulent plant *Kalanchoe pinnata*, also referred to as the "miracle leaf", is prized for both its exceptional capacity for reproduction and its therapeutic qualities. Also referred to as "air plant" or "life plant". It has spread over many tropical and subtropical areas. It is a succulent perennial shrub with smooth, meaty leaves and cylindrical stems that usually reaches a height of 1-2 meters. Throughout the world, it has been used to alleviate headaches and hypertension. Traditional medicine has a long history of using *K. pinnata*. It is also used to treat fevers, cancer, and inflammation. Kidney stones can be treated using the leaves' juice.

In vitro and *in vivo* tests were conducted to examine the hepatoprotective properties of *K. pinnata* leaf ethanol extract and fresh juice against carbon tetrachloride-induced hepatotoxicity. The fresh juice concentrate showed more pronounced hepatoprotective action than the ethanol extract in an *in vitro* study using rat hepatocyte culture, suppressing plasma ALT by 52.7% and 29.3%, respectively, and plasma AST by 34.7% and 22.8%, respectively. The *in vivo* experiment in Wistar albino rats showed a similar pattern, with both samples suppressing serum concentrations of AST, ALT, total bilirubin, and ALP. Furthermore, histological examination of the extract-treated liver cells of rats inebriated with carbon tetrachloride revealed that they were somewhat ambiguous, similar to normal hepatocytes. However, there were many more hepatocytes with a normal nucleus than those injured by carbon tetrachloride[43,44]. According to their respective IC_{50} values of 17.2, 9.3, and 7.1 µg/ml, the methanol extract of *K. pinnata* leaves, together with its ethyl acetate and butanol fractions, exhibited potent antiviral qualities against the hepatitis C virus *in vitro*[45].

3.7 *Litchi chinensis* Sonn. (Lychee)

Litchi chinensis Sonn., a fruit-bearing tree indigenous to subtropical China, is also referred to as litchi or lychee. Because of its edible fruit, this evergreen tree, which is a member of the *Sapindaceae* family, is grown all over the world. The tree's fruits are renowned for their tasty, juicy, and translucent aril (edible flesh), and it has a lengthy growing season with distinct phenophases. Flavan-3-ol monomers and dimers are significant molecules that make up approximately 87% of the moderate levels of polyphenols found in lychees. Hepatotoxicity is one of the many clinical disorders that traditional medicine has traditionally employed the leaves, fruits, and seeds of the well-known South Asian plant *L. chinensis* to treat. Male Sprague-Dawley rats were given doses of 100 and 500 mg/kg body weight of a concentrate of the fresh juice of fruit pulps from two plant species, Gimjeng and Chakapat, to test for possible

hepatoprotective benefits against liver damage caused by carbon tetrachloride. The primary phytochemical components in the concentrates were determined to be pelargonidin-3-O-glucoside, ascorbic acid, and trans-cinnamic acid. Previous research showed that litchi leaf polyphenolic chemicals improve heart and kidney function in 2K1C mice[46].

Following pretreatment with the plant extract, histopathological analysis showed that the animals' livers experienced reduced pathological damage. In rats exposed to carbon tetrachloride, histopathologic changes included centrilobular destruction, which included Kupffer cell hyperplasia. Additionally, in rat livers exposed to carbon tetrachloride, pretreatment with plant extract significantly decreased the degree of apoptosis, increased serum hepatic marker levels, and centrilobular damage[47]. Both dosages were able to dramatically reverse the hepatotoxic elevation of plasma AST, ALT, and ALP levels as well as the rate of hepatic lipid peroxidation following the carbon tetrachloride treatment, in contrast to the standard silymarin (100 mg/kg).

Similar hepatoprotective activity was shown in another study of male Wistar rats fed a high-calorie diet, showing that the aqueous extract of its flowers could reverse the rise of hepatic cytokines, AST and plasma ALT (interleukin-1β, tumour necrosis factor-α, and interleukin-6), as well as plasma concentrations of triacylglycerol and cholesterol[48,49]. Another study demonstrated that the phenolic extract of *L. chinensis* fruit pulp could considerably protect the livers of male Kunming mice from physical stress-induced liver damage. It has been demonstrated that rutin and quercetin both have strong hepatoprotective effects. Remarkably, the increased dosage totally restored the hepatocellular damage brought on by carbon tetrachloride (150 mg/kg)[50].

The extract increased the liver activity of SOD, catalase, GSH, and GPx. The main bioactive components of the phenolic extract were eventually identified as quercetin 3-O-rutinoside-7-O-α-l-rhamnoside, epicatechin and rutin through chromatographic analysis using HPLC. Animal mitochondria examined under a microscope showed that almost all of the mitochondria in the normal control group turned blue-green. Compared to the normal control group, the group under restraint exhibited a significantly lower number of blue-green mitochondria[51]. According to a recent study, the methanol extract of *L. chinensis* fruit pulp improved the *in vitro* cellular viability of BNL hepatocytes (a specific type of liver cell line) more than regular silymarin. Additionally, utilising phytochemical analysis directed by bioactivity, epicatechin and procyanidin A2 were determined to be the extract's main polyphenolic components[52,53].

3.8 *Andrographis paniculata* (Burm. f.) Nees (*Kalmegh*)

Known as *Kalmegh* or the "King of Bitters", *Andrographis paniculata* is an annual herb that is native to tropical Asia and India. Traditional medicine makes extensive use of it to treat a wide range of ailments and is well known for its bitter flavour and therapeutic qualities. This plant has long been used as a remedy for the common cold, diarrhoea, fever from various viral causes, jaundice, and cardiovascular health tonics, and antioxidants. It also helps with sexual dysfunction and serves as a contraceptive. Although the phytoconstituent compositions of this plant vary significantly according to the region, season, and harvest, the active phytochemicals are taken from every portion of the plant. More than 30 flavonoids, 55 diterpenoids, 8 quinic acids, and 4 xanthones are present as phytoconstituents in different parts of the plant.

The prevalence of liver illness is rising, which makes using natural remedies to cure it more appealing. The methanolic extract of *A. paniculata* yielded andrographolide. Many derivatives with pharmacological properties, such as anti-cancer, antiviral, anti-diabetic, antibacterial, anti-feedant, and so on, have recently been synthesised from andrographolide. This study evaluated the hepatoprotective efficacy of andrographolide by derivatising it into 3,19(4-bromobenzylidene). By lowering the levels of SGPT, bilirubin, and SGOT in the *in vivo* experiment, 3,19(4-bromobenzylidene) andrographolide showed a strong hepatoprotective effect. The results are corroborated by the histogram and transaminases. Comparatively speaking, andrographolide was more soluble in this molecule than 3-(4-bromobenzylidene). According to experimental findings, a derivative of 3-(4-bromobenzylidene) has the potential to cure hepatic illness with reduced toxicity and enhanced effectiveness[54].

3.9 *Lawsonia inermis* L. (Henna)

Commonly referred to as henna, *Lawsonia inermis* belongs to the family *Lythraceae*, is a tiny tree or shrub that grows to a height of 2 to 6 meters and has a dense branching habit. Its leaves are the source of a reddish-brown dye, and its bark, seeds, and leaves are all utilised medicinally. Among the many therapeutic benefits of henna are its anti-inflammatory, antibacterial, and wound-healing qualities[55]. The plant has long been used for its therapeutic qualities to treat jaundice, renal lithiases, wounds, and skin inflammation, among other conditions[56,57,58,59]. It is also used in some Nigerian communities to treat poliomyelitis and measles. According to reports, *L. inermis* contains a variety of phytoconstituents, including gallic acid, epicatechin gallate, isoferulic acid, vitexin-2′-o-rhamnoside, catechin gallate, naringenin-7-O-rutinoside, myricetin, catechin, chlorogenic acid, o-coumaric acid, ferulic acid, m-coumaric acid, and quercetin[60].

Lalioside, luteolin-7-O-β-D-glucopyranoside, 1,2,4-trihydroxynaphthalene-1-O-β-D-glucopyranoside, Lawsoniaside, 2,4,6-trihydroxyacetophenone-2-O-β-D-glucopyranoside, and are phytoconstituents that were identified from *L. inermis* leaves[61]. According to a different study, rats given a solution of *L. inermis* leaves (200 mg/kg/day) for 42 days showed no toxicity in tissue sections from the liver, kidney, or spleen[62]. Antihepatotoxic properties of *L. inermis* leaves against liver damage caused by carbon tetrachloride in Wistar albino rats[63]. The hepatoprotective qualities of *L. inermis* aqueous extract against paracetamol-induced liver injury in male albino rats[64].

3.10 *Moringa oleifera* (*Moringa*)

Moringa oleifera Lam., a member of the *Moringaceae* family, is referred to locally as "*Sohanjana*" in Punjabi and "Drumstick tree" in English. There are roughly 33 species in the monogeneric family *Moringaceae*. India, Sri Lanka, Pakistan, South America, Africa, and Mexico are the primary growing regions. Because of their many applications, *Moringa* species have become more significant recently[65]. Skin infections, asthma, arthritis, inflammation, fever, diabetes, diarrhoea, cough, and headaches have all been treated with it for a long time[66]. Gallic acid, quercetin, coumaric acid, kaempferol, and vanillic acid were found and quantified in the plant extracts.

Commonly referred to as "Drumstick," *Moringa oleifera* Lam. (*Moringaceae*) is utilised in Indian traditional medicine to cure a variety of ailments. The hepatoprotective efficacy of an ethanolic extract of *M. oleifera* leaves on liver damage caused by antitubercular medications including isoniazid, rifampicin, and pyrazinamide in rats was also assessed[67]. When taken orally, the extract showed a high protective impact on the levels of bilirubin, lipids, and lipid peroxidation in the liver as well as the levels of glutamic oxaloacetic transaminase, glutamic pyruvic transaminase, and alkaline phosphatase in the serum. Liver segment histopathological examination confirmed this finding. According to the study, silymarin (as a reference) or *M. oleifera* extracts appeared to help patients recover from liver damage brought on by antitubercular medications.

3.11 *Asparagus racemosus* Willd. (*Shatavari*)

Asparagus racemosus, often known as *Shatavari*, is known by its botanical name, *A. racemosus* Willd. *Ayurveda* and other traditional medical systems like *Siddha* and *Unani* use this herb. The presence of numerous phytoconstituents, including isoflavones, saponins, and other compounds, as well as potential liver-protective advantages, are among the plant's many well-known medicinal properties. It is also known as *Satamuli, Satawar*, and *Satavari* in a number of vernacular languages. In India, the plant is typically grown at low elevations. Because it may prevent and treat a variety of illnesses, *A. racemosus* (*Shatavari*), a member of the *Asparagaceae* family, has a unique position in *Ayurvedic* medicine. It is popular among all therapeutic plants because it includes a wide range of bioactive substances, including polyphenols, steroidal glycosides, flavonoids, racemosol, saponins (Shatavarins I, III, IV and II), alkaloids, and vitamins.

The phytopharmaceutical effects of various extracts from the roots, leaves, blossoms, and stems of the shatavari plant have been documented in a data repository. These extracts have been shown to alleviate several ailments, including COVID-19, throat infections, TB, neurological disorders, cough bronchitis, and dyspepsia. The general public consumes a number of commercially available nutraceuticals that are based on shatavari extracts[68].

3.12 *Curcuma longa* L. (Turmeric)

Curcuma longa, the scientific name for turmeric, is a rhizomatous perennial herb that belongs to the ginger family (*Zingiberaceae*). In folk medicine, this rhizomatous herbaceous perennial plant is used to treat, prevent, and manage a number of ailments, including diabetes, cancer, peptic and stomach ulcers, hepatobiliary disorders, arthritis, diarrhoea, inflammation, and psoriasis. Its underground stems, or rhizomes, are the most frequently used part and are valued for their bright yellow colour, distinct aroma, and several medicinal properties.

How curcumin and *C. longa* extract protects against the CCl_4-induced toxicity, it was studied and found that serum ALT and AST levels significantly decreased[69]. The hepatoprotective efficacy of curcumin derived from *C. longa*'s rhizome against ochratoxin A-induced toxicity in white Pekin ducklings was also investigated[70]. Curcumin 400 mg/kg raised liver catalase levels while lowering serum LDL levels. In a related investigation, the hepatoprotective effect of curcumin in rats given Freund's Complete Adjuvant injections was also documented[71]. According to reports, curcumin decreased the levels of AST, bilirubin, ALT, and ALP in the livers of rats in treatment group *C. longa* extract affected rats that were given poisonous CCl_4. When the extract was administered, bilirubin, ALT, and AST levels dropped. Subsequent investigations demonstrated the suppression of morphological alterations, phagocytosis, and nitric oxide release[72].

The antihepatotoxic effects of curcumin in combination with picroliv and ellagic acid on rats that were made toxic by CCl_4[14]. Curcumin was shown to have hepatoprotective effects against STZ-diabetic rats[73]. The liver enzymes ALT and AST were shown to be lower in rats that were administered curcumin combined with yoghurt. By measuring liver enzymes, lower serum levels of ATP, AST, and ALP were discovered. Additionally, curcumin shielded the liver from necrotic damage. Curcumin and *C. longa* extract's medicinal impact against the toxicity generated by mercuric chloride in rats was also investigated[74]. For three days, the rats were given 80 mg/kg of curcumin and 200 mg/kg of *C. longa*. The treatment with extracts reversed the increase in GGT, bilirubin, LDH, ALT, ALP, and AST enzyme activity, and the rats were euthanised after 24 hours.

3.13 *Cassia fistula* L. (*Amaltas*)

The deciduous *Cassia fistula* tree, often called the Golden Shower Tree or *Amaltas*, has a long history of medical use. It's a medium-sized tree with long, rod-shaped fruits and vivid yellow blossoms. The herb has several medicinal properties, including hepatoprotective, wound-healing, and antioxidant properties. The phytochemicals included in *C. fistula* plants include tannins, flavonoids, proteins, carbohydrates, anthraquinone, amino acids and their derivatives, glycosides, rhein, terpenoids, saponins, sugars, mucilage, alkaloids, and many more[75,76]. Antibacterial, antifungal, anti-inflammatory, antioxidant, antitumor, anticancer, anti-yeast, and other skin-related bioactivities are among the many bioactive qualities of this tree[77]. The plant *C. fistula* is noted for having several beneficial properties, including minimal toxicity, good biodegradability, affordability, and ease of availability. These factors help explain why *C. fistula* is used so widely in a range of culinary fields.

The liver must function properly in order to filter out harmful substances that are produced in the body, such as alcohol, carbon tetrachloride, and a variety of medications like paracetamol, antibiotics, and chemotherapy, among others[78]. Rats were given paracetamol to induce hepatotoxicity to examine the hepatoprotective properties of n-heptane extract of *C. fistula* leaves. The extract significantly reduced serum levels of bilirubin, alkaline phosphatase, and transaminases at 400 mg/kg body weight. The outcomes resembled those of a standard hepatoprotective drug[79].

The extract was taken orally at a dose of 400 mg per kilogram of body weight. This dosage showed a notable protective effect by lowering serum levels of bilirubin, glutamic pyruvic transaminase, glutamic oxaloacetic transaminase, and alkaline phosphatase[80]. In another study, it was found that rats given an ethanolic extract of *C. fistula* leaves 500 mg/kg body weight daily for seven days completely reversed the lipid peroxidation, glutathione reductase, and catalase activities in the liver tissues to normal levels[81]. In contrast to the control group, this dosage enhanced the oxidative stress and liver toxicity indicators in the extract-treated rats. The antihepatotoxic potential of the *C. fistula* leaf extract prepared with n-heptane was investigated by causing hepatotoxicity in rats using paracetamol[82].

3.14 *Eclipta prostrata* (L.) L. (*Bhringara*)

Eclipta prostrata, commonly known as False Daisy or Inkweed, is an annual or short-lived perennial herb native to tropical and subtropical regions worldwide. It's part of the *Asteraceae* family and is known for its medicinal properties, particularly in traditional systems like *Ayurveda*. It is a significant ethnomedicine that is mostly used in India's Uttar Pradesh and a few other South Asian nations to cure a variety of illnesses, particularly liver damage and a variety of bacterial infections[83]. In various parts of India, this plant is used extensively to treat various skin conditions, hepatic issues like jaundice, gastrointestinal issues, respiratory issues like asthma, and other symptoms like fever, hair loss and whitening, wounds and cuts, spleen enlargement, etc[84,85]. Hepatitis, itching, bleeding, haematuria, diphtheria, haemoptysis, and diarrhoea symptoms can all be treated with the entire plant[86]. While the shoot juice and mustard oil are used combined to treat diarrhoea and dysentery, when treating infant catarrh, the leaf juice is combined with honey.

In a hepatotoxic model caused by CCl_4, d-galactosamine, and paracetamol, male ICR mice were given the plant's aqueous extract at a concentration of 300 mg/kg body weight. Plasma ALT and AST levels, as well as any ensuing histological alterations, were used to evaluate the hepatoprotective potential. The microscopic pictures demonstrate how *E. prostrata* significantly lessened the severity of the histopathological abnormalities (ballooning degeneration, cellular infiltration in the liver and submassive centrilobular necrosis) in mice that had been given carbon tetrachloride[28].

3.15 *Hybanthus enneaspermus* (L.) F. Muell. (*Ratan Purush*)

Hybanthus enneaspermus (L.) F. Muell., a herb or shrub found throughout the world's tropical and subtropical climates, is a member of the *Violaceae* family and is also referred to as *Ratanpurush* in Hindi. The plant is said to treat "*Kapha*" and "*Pitta*", urinary calculi, urethral discharge, severe diarrhoea, strangury, epilepsy, coughing, mental wandering, burning feeling, blood problems, vomiting, asthma, and breast tone, according to *Ayurvedic* literature. Dipeptide alkaloids, aurantiamide acetate, sugars, steroids, triterpenes, tannins, anthraquinones, isoarborinol, flavonoids, flavones, β-sitosterol, phenols, catachins, and amino acids are among the plant's significant phytochemical constituents. According to pharmacological reports, the plant has hepatoprotective, nephroprotective, antidiabetic, anti-inflammatory, antiplasmodial, anticonvulsant, aphrodisiac and antibacterial properties[87].

In adult male albino rats, the ethanol extract of *H. enneaspermus* leaves was shown to have hepatoprotective qualities against a hepatotoxicity model caused by paracetamol. The extract reduced the plasma concentrations of AST, ALT, and ALP. Furthermore, the extract increased the levels of hepatic antioxidative enzymes SOD (24.4%), GPx (6.7%), catalase (52.7%), glutathione reductase (155.8%), and GST (41.1%), while decreasing hepatic lipid peroxidation by 19.5%. Histological analyses of mice given paracetamol showed severe necrosis with nuclei missing. The experimental animals administered plant extract exhibited a considerable reduction in all of these alterations, principally exhibiting regular hepatocytes with nuclei, normal hepatic central vein, sinusoidal gaps and normal hepatic architecture[88]. In addition to moderate hepatocyte plate disorganisation and lesser interstitial space dilatation, animals treated with an aqueous extract of *H. enneaspermus* and the control group exhibited reduced hepatic vacuolation and improved preservation of normal liver architecture. There were either little or no periportal inflammatory infiltrates in the treated animals' hepatic lobules[89].

3.16 *Amaranthus spinosus* L. (*Chaulai*)

"*Kate Wali Chaulai* (*Kanatabhajii*)" is the Hindi name for *Amaranthus spinosus* Linn. (family-*Amaranthaceae*), a vegetable that is cultivated in many tropical countries, including Sri Lanka and India. Vegetables, such as plants, are rich in antioxidant components[90-92] and high in nutrients because they contain fibre, proteins, and key amino acids, particularly lysine[93]. Tribes in Kerala, India, utilise the juice of *A. spinosus* leaves to avoid stomach bloating, and they are boiled without salt and eaten for two to three days to treat jaundice[94]. It also offers hepatoprotective treatment, according to scientific statements[95].

Numerous vital metabolic processes are regulated by the liver, and hepatic damage is linked to a distortion

of these processes[96]. Therefore, liver illnesses continue to be one of the major health issues. Liver problems continue to rank among the most serious illnesses. Despite the tremendous advances in modern medicine, there aren't many drugs available to address liver issues. To treat liver diseases, the Indian traditional medical system known as "*Ayurveda*" recommends a number of medicinal mixtures. Furthermore, *A. spinosus* is used as an antibacterial, anti-inflammatory, antiviral, antidiuretic, antimicrobial, antimalarial, and for hepatic issues[97,98]. *A. spinosus* whole plants exhibit strong hepatoprotective effects against experimental animals' liver injury caused by carbon tetrachloride. This study suggests that the *A. spinosus*'s phenolic and flavonoid component content, which may be responsible for the hepatoprotective impact, is one possible mechanism of this action[99].

4. Conclusion

Excellent therapeutic options for liver problems may be provided by herbal remedies. Based on their hepatoprotective properties, 16 specific Asian herbs with a wide range of traditional uses were the subject of the current thorough analysis. The lack of adequate acute, sub-acute, and chronic safety reports is the main barrier to using these plants in the creation of hepatoprotective formulations. As a result, significant toxicological research on these plants using cellular, hepatic, and haematological markers is required. Second, a comparative analysis of these plants should be conducted in the same experimental animal model that addresses formulations based on both individual plants and polyherbal formulations. Even though the biochemical level has demonstrated the hepatoprotective qualities of several plant extracts, the data are still lacking since certain plants still have one or more pertinent markers that need to be investigated. A comparative study should enable the assessment of their hepatoprotective qualities using all pertinent markers. It may also result in the creation of a more effective polyherbal formulation that contains individual plants in comparatively small amounts, thereby minimising the toxicities associated with each plant.

Future research must first identify the bioactive compounds found in these plants, and then pharmacologically assess the compounds that show promise for hepatoprotective effects. Since there are now very few modern hepatoprotective medications with practical clinical utility, the discovery of new compounds with comparable potential will undoubtedly support the process of developing newer therapies. Even though we all give our health a lot of thought, health problems have become a social issue. Because of the vital role the liver plays in the body, liver disorders and injuries are now among the most prevalent health problems in the world. The primary causes of liver damage include excessive alcohol use, poor dietary practices, the use of herbal supplements, microbial infections, autoimmune diseases, malignancies, metabolic disorders, and drug abuse. Therefore, it is essential to protect the liver against the aforementioned factors.

Finding new medications that effectively cure liver damage has become crucial in the meantime, particularly since the current medications used to treat the various liver disorders are either insufficient or linked to adverse effects on kidney function. Therefore, the development of novel plant-based hepatoprotective medications is required. The majority of plant-based medications used to treat liver disorders are developed with hepatoprotective and antioxidant-related qualities in mind. These are the primary scientific processes that underpin the new medications used to treat liver disorders that have the fewest negative effects on the kidneys. Thus, additional research is required to assess the potential of novel candidate phytochemicals for the synthesis of more potent hepatoprotective medications. Because 50% of individuals in underdeveloped nations who have liver disease or another rely on herbal treatments for treatment, they have drawn attention from all around the world.

This study makes it abundantly evident that medicinal herbs are essential in the fight against a wide range of illnesses. In animal models, a variety of herbal plants and plant extracts exhibit strong hepatoprotective effects. The presence of flavonoids in all but a few herbal plants is most likely what causes the hepatoprotective action. The study's findings suggest that plant and leaf extracts from some medicinal plants have promising use in the treatment of liver disorders. The mechanism of action of medicinal herbs against experimentally induced hepatotoxicity is explored empirically in this review study. As a result, the review study concludes that the herbal medication has a

hepatoprotective effect, which has been demonstrated by several animal models and provides numerous connections for further research. These results are quite encouraging and imply that more investigation into this herb is required to confirm the results and find additional potential therapeutic advantages.

5. References

1. Pei SJ. Ethnobotanical approaches of traditional medicine studies: some experiences from Asia. Pharma Biol. 2001; 39(Suppl 1):74-79. https://doi.org/10.1076/phbi.39.S1.74.0005
2. Pal SK, Shukla Y. Herbal medicine: current status and the future. Asian Pac J Cancer Prev. 2003; 4(4):281-288. http://journal.waocp.org/article_24328.html
3. Rossato SC, Leitão-Filho HF, Begossi A. Ethnobotany of Caiçaras of the Atlantic Forest Coast (Brazil). Econ Bot. 1999; 53(4):387-395. https://doi.org/10.1007/BF02866716
4. Hanazaki N, Tamashiro JY, Leitão-Filho HF, Begossi A. Diversity of plant uses in two Caiçara communities from the Atlantic Forest coast, Brazil. Biodivers Conserv. 2000; 9(5):597-615. https://doi.org/10.1023/A:1008920301824
5. Gazzaneo LRS, Lucena RFP, Albuquerque UP. Knowledge and use of medicinal plants by local specialists in a region of Atlantic Forest in the state of Pernambuco (Northeastern Brazil). J Ethnobiol Ethnomed. 2005; 1:9. https://doi.org/10.1186/1746-4269-1-9
6. Azaizeh H, Fulder S, Khalil K, Said O. Ethnomedicinal knowledge of local Arab practitioners in the Middle East region. Fitoterapia. 2003; 74(1-2):98-108. https://doi.org/10.1016/S0367-326X(02)00285-X
7. Sivaraj A, Vinoth Kumar P, Devi K, Elumalai EK, Senthil Kumar B. Protective effect of aqueous leaf extract of *Alternanthera sessilis* L. on CCl_4-induced hepatic damage in albino mice. Pharmacologyonline. 2009; 2:692-696. https://pharmacologyonline.silae.it/files/newsletter/2009/vol2/69.Sivaraj.pdf
8. Haque MM, Jahan S, Islam MN, *et al*. Liver physiology and hepatoprotective medicinal plants: a review. J Pharmacogn Phytochem. 2017; 6(5):1234-1242. https://www.phytojournal.com/archives/2017/vol6issue5
9. Kumar V, Abbas AK, Fausto N, Aster JC. Robbins and Cotran pathologic basis of disease. 8th ed. Philadelphia (PA): Elsevier Saunders; 2011. https://www.us.elsevierhealth.com/robbins-and-cotran-pathologic-basis-of-disease-9781416031215
10. Trauner M, Boyer JL. Bile salt transporters: molecular characterization, function, and regulation. Physiol Rev. 2003; 83(2):633-671. https://doi.org/10.1152/physrev.00027.2002
11. Ortiz de Montellano PR. Cytochrome P450: structure, mechanism, and biochemistry. 4th ed. New York (NY): Springer; 2013. https://link.springer.com/book/10.1007/978-1-4614-7480-6
12. Lavanchy D. The global burden of hepatitis C. **Liver Int.** 2009; 29(Suppl 1):74-81. https://doi.org/10.1111/j.1478-3231.2008.01934.x
13. Valko M, Leibfritz D, Moncol J, Cronin MTD, Mazur M, Telser J. Free radicals and antioxidants in normal physiological functions and human disease. Int J Biochem Cell Biol**.** 2007; 39(1):44-84. https://doi.org/10.1016/j.biocel.2006.07.001
14. Girish C, Pradhan SC. Drug development for liver diseases: focus on hepatoprotective medicinal plants. J Ethnopharmacol. 2012; 143(1):22-38. https://doi.org/10.1016/j.jep.2012.06.034
15. Stickel F, Schuppan D. Herbal medicine in the treatment of liver diseases. Dig Liver Dis. 2007; 39(4):293-304. https://doi.org/10.1016/j.dld.2006.11.004
16. Saxena M, Saxena J, Nema R, Singh D, Gupta A. Phytochemistry of medicinal plants. J Pharmacogn Phytochem. 2013; 1(6):168-182. https://www.phytojournal.com/archives/2013/vol1issue6/PartA/26.pdf
17. Zhang H, Tsao R. Dietary polyphenols, oxidative stress and antioxidant and anti-inflammatory effects. Curr Opin Food Sci. 2016; 8:33-42. https://doi.org/10.1016/j.cofs.2016.02.002
18. Chinonyelum AN, Uwadiegwu AP, Nwachukwu OC, Emmanuel O. Evaluation of hepatoprotective activity of *Colocasia esculenta* (L. Schott) leaves on thioacetamide-induced hepatotoxicity in rats. Pak J Pharm Sci. 2015; 28(6 Suppl):2237-2241. PMid: 26687753.
19. Patil BR, Ageely HM. Antihepatotoxic activity of *Colocasia esculenta* leaf juice. Int J Adv Biotechnol Res. 2011; 2(2):296-304. http://www.bipublication.com/files/IJABRv2i22011011.pdf
20. Saikia A, Das M, Saikia Q. Hepatoprotective potential of the methanolic extract of *Colocasia esculenta* on iron overload-induced mice. Medicinal Plants. 2018; 10:243-249. https://doi.org/10.5958/0975-6892.2018.00038.2
21. Guo J, Friedman SL. Toll-like receptor 4 signaling in liver injury and hepatic fibrogenesis. Fibrogenesis Tissue Repair. 2010; 3(1):21. https://doi.org/10.1186/1755-1536-3-21 PMid: 20964825 PMCid: PMC2984459.
22. Liu M, Zhang G, Song M, Wang J, Shen C, Chen Z, *et al*. Activation of Farnesoid X receptor by schaftoside ameliorates acetaminophen-induced hepatotoxicity by modulating oxidative stress and inflammation. Antioxid Redox Signal. 2020; 33(2):87-116. https://doi.org/10.1089/ars.2019.7791 PMid: 32037847.
23. Wang CM, Chen HT, Wu ZY, Jhan YL, Shyu CL, Chou CH. Antibacterial and synergistic activity of pentacyclic triterpenoids isolated from *Alstonia scholaris*. Molecules. 2016; 21(2):139. https://doi.org/10.3390/molecules21020139 PMid: 26821000 PMCid: PMC6273878.
24. Arulmozhi S, Mazumder PM, Lohidasan S, Thakurdesai P. Antidiabetic and antihyperlipidemic activity of leaves of

Alstonia scholaris R. Br. Eur J Integr Med. 2010; 2(1):23-32. https://doi.org/10.1016/j.eujim.2009.12.001

25. Wang CM, Yeh KL, Tsai SJ, Jhan YL, Chou CH. Anti-proliferative activity of triterpenoids and sterols isolated from *Alstonia scholaris* against non-small-cell lung carcinoma cells. **Molecules.** 2017; 22(12):2119. https://doi.org/10.3390/molecules22122119 PMid: 29194373 PMCid: PMC6149710.
26. Shang JH, Cai XH, Zhao YL, Feng T, Luo XD. Pharmacological evaluation of *Alstonia scholaris*: antitussive, anti-asthmatic and expectorant activities. **J Ethnopharmacol.** 2010; 129(3):293-298. https://doi.org/10.1016/j.jep.2010.03.029 PMid: 20381600.
27. Lin SC, Lin CC, Lin YH, Supriyatna S, Pan SL. The protective effect of *Alstonia scholaris* R. Br. on hepatotoxin-induced acute liver damage. Am J Chin Med. 1996(a); 24(2):153-164. https://doi.org/10.1142/S0192415X96000207 PMid: 8874672.
28. Lin SC, Yao CJ, Lin CC, Lin YH. Hepatoprotective activity of Taiwan folk medicine: *Eclipta prostrata* Linn. against various hepatotoxins-induced acute hepatotoxicity. Phytotherapy Research. 1996(b); 10(6):483-490. https://doi.org/10.1002/(SICI)1099-1573(199609)10:6<483::AID-PTR884>3.0.CO;2-2
29. Shankar KR, Rao AL, Kalyani L. Hepatoprotective activity of *Alstonia scholaris* fruits against carbon tetrachloride-induced hepatotoxicity in rats. Asian J Pharm Res Health Care**.** 2012; 4(1):28-32. https://www.researchgate.net/publication/265103150_Hepatoprotective_activity_of_alstonia_scholaris_fruits_against_carbon_tetrachloride-induced_hepatotoxicity_in_rats
30. Shah KA, Patel MB, Patel RJ, Parmar PK. *Mangifera indica* (mango). Pharmacogn Rev. 2010; 4(7):42-48. https://doi.org/10.4103/0973-7847.65325 PMid: 22228940.
31. Ediriweera MK, Tennekoon KH, Samarakoon SR. A review on ethnopharmacological applications, pharmacological activities and bioactive compounds of *Mangifera indica* (mango). Evid Based Complement Alternat Med. 2017; 2017:6949835. https://doi.org/10.1155/2017/6949835 PMid: 29456572 PMCid: PMC5804368.
32. Pourahmad J, Eskandari MR, Shakibaei R, Kamalinejad M. A search for hepatoprotective activity of fruit extract of *Mangifera indica* L. against oxidative stress cytotoxicity. Plant Foods Hum Nutr**.** 2010; 65(1):83-89. https://doi.org/10.1007/s11130-010-0161-9 PMid: 20204522.
33. Adeneye AA, Awodele O, Aiyeola SA, Benebo AS. Modulatory potentials of the aqueous stem bark extract of *Mangifera indica* on carbon tetrachloride-induced hepatotoxicity in rats. J Tradit Complement Med**.** 2015; 5(2):106-115. https://doi.org/10.1016/j.jtcme.2014.11.001 PMid: 26151020 PMCid: PMC4488099.
34. Omotayo MA, Ogundare OC, Oluwafunmilayo A, Longe SA. Hepatoprotective effect of *Mangifera indica* stem bark extracts on paracetamol-induced oxidative stress in albino rats. Eur Sci J. 2015; 11(24). https://eujournal.org/index.php/esj/article/view/6118
35. Liu LS, Liu MH, He JY. *Hypericum japonicum* Thunb. ex-Murray: phytochemistry, pharmacology, quality control and pharmacokinetics of an important herbal medicine. Molecules. 2014; 19(8):10733-10754. https://doi.org/10.3390/molecules190810733 PMid: 25061723 PMCid: PMC6290573.
36. Su D, Zhang R, Zhang C, Huang F, Xiao J, Deng Y, Zhang M. Phenolic-rich lychee (*Litchi chinensis* Sonn.) pulp extracts offer hepatoprotection against restraint stress-induced liver injury in mice by modulating mitochondrial dysfunction. Food Funct. 2016; 7(1):508-515. https://doi.org/10.1039/C5FO00975H PMid: 26569420.
37. Wang N, Wang Y, Li P, Peng W, Xie T, Feng Y, Su W. The bioavailability of hepatoprotective flavonoids in *Hypericum japonicum* extract. Journal Bioanal Biomed. 2009; 1:033-038. https://doi.org/10.4172/1948-593X.1000007
38. Wang N, Li P, Wang Y, Peng W, Wu Z, Tan S, Liang S, Shen X, Su W. Hepatoprotective effect of *Hypericum japonicum* extract and its fractions. J Ethnopharmacol. 2008; 116(1):1-6. https://doi.org/10.1016/j.jep.2007.08.031 PMid: 18178045.
39. Prajapati MS, Patel JB, Modi K, Shah MB. *Leucas aspera*: a review. Phcog Rev. 2010; 4(7):85-87. https://doi.org/10.4103/0973-7847.65331 PMid: 22228944 PMCid: PMC3249905.
40. Banu S, Bhaskar B, Balasekar P. Hepatoprotective and antioxidant activity of *Leucas aspera* against D-galactosamine-induced liver damage in rats. Pharm Biol. 2012; 50(12):1592-1595. https://doi.org/10.3109/13880209.2012.685130 PMid: 22992009.
41. Latha MS, Latha B, Oommen SK, Rajalekshmi R. Hepatoprotective and antioxidant effects of methanolic extract of *Leucas aspera* against carbon tetrachloride-induced oxidative damage in rats. Int J Adv Pharm Res. 2012; 4:1331-1337. http://www.ijapronline.org
42. Thenmozhi M, Dhanalakshmi M, Devi KM, Sushila K, Thenmozhi S. Evaluation of hepatoprotective activity of *Leucas aspera* hydroalcoholic leaf extract during exposure to lead acetate in male albino Wistar rats. Asian J Pharm Clin Res. 2013; 6(1):78-81. https://journals.innovareacademics.in/index.php/ajpcr
43. Adewusi EA, Afolayan AJ. A review of natural products with hepatoprotective activity. J Med Plant Res. 2010; 4(13):1318-1334. https://doi.org/10.5897/jmpr09.472
44. Yadav NP, Dixit VK. Hepatoprotective activity of leaves of *Kalanchoe pinnata* Pers. J Ethnopharmacol. 2003; 86(2-3):197-202. https://doi.org/10.1016/S0378-8741(03)00074-6 PMid: 12738087.

45. Aoki C, Hartati SRI, Santi MR, Firdaus R, Hanafi M, Kardono LBS, Shimizu Y, Sudarmono PP, Hotta H. Isolation and identification of substances with anti-hepatitis C virus activities from *Kalanchoe pinnata*. Int J Pharm Pharm Sci. 2014; 6(2):211-215. https://scholar.ui.ac.id/en/publications/isolation-and-identification-of-substances-with-anti-hepatitis-c-/
46. Mamun F, Rahman MM, Zamila M, Subhan N, Hossain H, Raquibul SMH, Alam MA, Haque MA. Polyphenolic compounds of litchi leaf augment kidney and heart functions in 2K1C rats. J Funct Foods. 2019; 64:103662. https://doi.org/10.1016/j.jff.2019.103662
47. Bhoopat L, Srichairatanakool S, Kanjanapothi D, Taesotikul T, Thananchai H, Bhoopat T. Hepatoprotective effects of lychee (*Litchi chinensis* Sonn.): a combination of antioxidant and anti-apoptotic activities. J Ethnopharmacol. 2011; 136(1):55-66. https://doi.org/10.1016/j.jep.2011.03.061 PMid: 21540102.
48. Wu YS, Chiu CH, Yang DJ, Lin YL, Tseng JK, Chen YC. Inhibitory effects of litchi (*Litchi chinensis* Sonn.) flower-water extracts on lipase activity and diet-induced obesity. J Funct Foods. 2013; 5(2):923-929. https://doi.org/10.1016/j.jff.2013.01.015
49. Park JG, Cheon HJ, Kim YS, Kang SS, Choi JS, Lee SM. Hepatoprotective activities of daidzin, daidzein, genistein and puerarin in primary cultured rat hepatocytes. Yakhak Hoeji. 2007; 51(2):115-125. https://www.koreascience.or.kr/
50. Domitrovic R, Jakovac H, Marchesi VV, Vladimir-Knežević S, Cvijanović O, Tadić Z, Rahelić D. Differential hepatoprotective mechanisms of rutin and quercetin in CCl_4-intoxicated BALB/cN mice. Acta Pharmacol Sin. 2012; 33(10):1260-1270. https://doi.org/10.1038/aps.2012.62 PMid: 22902988 PMCid: PMC4002705.
51. Su CY, Ming QL, Rahman K, Han T, Qin LP. *Lycium chinense* Mill. protects against liver injury by preserving mitochondrial function and reducing oxidative stress in restrained experimental animals. J Ethnopharmacol. 2016; 185:229-238. https://doi.org/10.1016/j.jep.2016.03.050 PMid: 27013097.
52. Chen GL, Chen SG, Zhao YY, Luo CX, Li J, Gao YQ. Phytochemical investigation and hepatoprotective activity of the methanol extract of *Lycium chinense* fruit pulp. Food Chem. 2017; 218:1-8. https://doi.org/10.1016/j.foodchem.2016.09.050 PMid: 27719887.
53. Chen GL, Chen SG, Zhao YY, Luo CX, Li J, Gao YQ. Epicatechin and procyanidin A2 from *Lycium chinense* fruit pulp protect BNL hepatocytes against oxidative injury. J Funct Foods. 2017; 32:208-216. https://doi.org/10.1016/j.jff.2017.02.030
54. Jain K, Majee C. Hepatoprotective activity of andrographolide and its semi-synthetic derivatives. Res J Pharm Technol. 2022; 15(9):4055-4060. https://doi.org/10.52711/0974-360X.2022.00680
55. Kumar M, Kaur P, Chandel M, Singh AP, Jain A, Kaur S. Antioxidant and hepatoprotective potential of *Lawsonia inermis* L. leaves against 2-acetylaminofluorene-induced hepatic damage in male Wistar rats. BMC Complement Altern Med. 2017; 17:56. https://doi.org/10.1186/s12906-017-1567-9 PMid: 28100199 PMCid: PMC5242058.
56. Chopra RN, Nayar SL, Chopra IC. Glossary of Indian Medicinal Plants. New Delhi: Council of Scientific and Industrial Research (CSIR). 1956; pp. 256. https://archive.org/details/in.ernet.dli.2015.126388
57. Kumari P, Joshi GC, Tewari LM. Diversity and status of ethnomedicinal plants of Almora district in Uttarakhand, India. Int J Biodivers Conserv. 2011; 3(7):298-326. https://academicjournals.org/journal/IJBC
58. Bellakhdar J. The traditional Moroccan pharmacopoeia: ancient Arabic medicine and popular knowledge. Paris: Ibis Press; 1997.
59. Sharma J, Gairola S, Gaur RD, Painuli RM. The treatment of jaundice with medicinal plants in indigenous communities of the Sub-Himalayan region of Uttarakhand, India. J Ethnopharmacol. 2012; 143(1):262-291. https://doi.org/10.1016/j.jep.2012.06.034 PMid: 22759701.
60. Guha G, Rajkumar V, Ashok Kumar R, Mathew L. Antioxidant activity of *Lawsonia inermis* extracts inhibits chromium (VI)-induced cellular and DNA toxicity. Evid Based Complement Alternat Med. 2011; 2011:576456. https://doi.org/10.1093/ecam/nep156 PMid: 19875434 PMCid: PMC3136358.
61. Hsouna AB, Trigui M, Culioli G, Blache Y, Jaoua S. Antioxidant constituents from *Lawsonia inermis* leaves: isolation, structure elucidation and antioxidative capacity. Food Chem. 2011; 125(1):193-200. https://doi.org/10.1016/j.foodchem.2010.08.041
62. Alferah MAZ. Toxicity-induced histological changes in selected organs of male Wistar rats by *Lawsonia inermis* leaf extract. Eur J Med Plant. 2012; 2(2):151-158. https://doi.org/10.9734/EJMP/2012/1061
63. Hossain CM, Maji HS, Chakraborty P. Hepatoprotective activity of *Lawsonia inermis* Linn. warm aqueous extract in carbon tetrachloride-induced hepatic injury in Wistar rats. Asian J Pharm Clin Res. 2011; 4(Suppl 1):106-109. https://api.semanticscholar.org/CorpusID:88834970
64. Selvanayaki R, Ananthi T. Hepatoprotective activity of aqueous extract of *Lawsonia inermis* against paracetamol-induced hepatotoxicity in rats. Asian J Pharm Clin Res. 2012; 2(2):75-77. https://anvpublication.org/journal/asian-journal-of-pharmaceutical-research
65. Majali I, Althunibat O, Qaralleh H. Antimicrobial and immunomodulatory activities of *Moringa peregrina*: a mini-review. J Basic Appl Res Biomed. 2015; 1(2):55-61. https://jbarbiomed.com/home/article/view/41
66. Padayachee B, Baijnath H. An overview of the medicinal importance of *Moringaceae*. J Med Plants Res. 2012; 6(48):5831–5839. https://doi.org/10.5897/JMPR12.279

67. Pari L, Kumar NA. Hepatoprotective activity of *Moringa oleifera* on antitubercular drug-induced liver damage in rats. J Med Food. 2002; 5(3):171-177. https://doi.org/10.1089/10966200260398206 PMid: 12495589.
68. Akhtar S, Gupta AK, Naik B, Kumar V, Ranjan R, Jha AK, Rather MA, Rustagi S. Exploring pharmacological properties and food applications of *Asparagus racemosus* (*Shatavari*). Food Chem Adv. 2024; 4:100689. https://doi.org/10.1016/j.focha.2024.100689
69. Lee HY, Kim SW, Lee GH, Choi MK, Chung HW, Lee YC, Kim HR, Kwon HJ, Chae HJ. Curcumin and *Curcuma longa* L. extract ameliorate lipid accumulation through regulation of endoplasmic reticulum redox and ER stress. Scientific Reports. 2017; 7:6513. https://doi.org/10.1038/s41598-017-06872-y PMid: 28747775.
70. Zhai SS, Ruan D, Zhu YW, Li MC, Ye H, Wang WC, Yang L. Protective effect of curcumin on ochratoxin A-induced liver oxidative injury in duck is mediated by modulation of lipid metabolism and intestinal microbiota. Poult Sci. 2020; 99(2):1124-1134. https://doi.org/10.1016/j.psj.2019.10.018 PMid: 32111329 PMCid: PMC7587848.
71. Banji D, Pinnapureddy J, Banji OJF, Saidulu A, Hayath MS. Synergistic activity of curcumin with methotrexate in ameliorating Freund's complete adjuvant-induced arthritis with reduced hepatotoxicity in experimental animals. Eur J Pharmacol. 2011; 668(1-2):293-298. https://doi.org/10.1016/j.ejphar.2011.06.051 PMid: 21763304.
72. Sengupta M, Sharma GD, Chakraborty B. Hepatoprotective and immunomodulatory properties of aqueous extract of *Curcuma longa* in carbon tetrachloride-intoxicated Swiss albino mice. Asian Pac J Trop Biomed. 2011; 1(3):193-199. https://doi.org/10.1016/S2221-1691(11)60026-9 PMid: 23569758 PMCid: PMC3609192.
73. Gutierres VO, Pinheiro CM, Assis RP, Vendramini RC, Pepato MT, Brunetti IL. Curcumin-supplemented yoghurt improves physiological and biochemical markers of experimental diabetes. Br J Nutr. 2012; 108(3):440-448. https://doi.org/10.1017/S0007114511005769 PMid: 22067670.
74. Joshi D, Mittal DK, Shukla S, Srivastav SK, Dixit VA. *Curcuma longa* Linn. extract and curcumin protect CYP2E1 enzymatic activity against mercuric chloride-induced hepatotoxicity and oxidative stress. Exp Toxicol Pathol. 2017; 69(6):373-382. https://doi.org/10.1016/j.etp.2017.03.003 PMid: 28522248.
75. Maqsood A, Munir A, Shahid S. A phytopharmacological evaluation of *Cassia fistula*: a comprehensive review. Int J Pharm Sci Rev Res. 2020; 62(2):45-53. https://globalresearchonline.net/
76. Sharma A, Kumar A, Jaitak V. Pharmacological and chemical potential of *Cassia fistula* L.: a critical review. J Herb Med. 2021; 26:100407. https://doi.org/10.1016/j.hermed.2020.100407
77. Patel JS, Vyas PJ. Phytochemistry of *Cassia fistula* and pharmacological studies of its leaf extracts: a review. Int J Chem Tech Appl. 2016; 5:1-10. http://www.ijcta.com
78. Rotundo L, Pyrsopoulos N. Liver injury induced by paracetamol and challenges associated with intentional and unintentional use. World J Hepatol. 2020;12(4):125-136. https://doi.org/10.4254/wjh.v12.i4.125 PMid: 32685105 PMCid: PMC7336293.
79. Bhakta T, Banerjee S, Mandal SC, Maity TK, Saha BP, Pal M. Hepatoprotective activity of *Cassia fistula* leaf extract. Phytomedicine. 2001; 8(3):220-224. https://doi.org/10.1078/0944-7113-00035 PMid: 11417908.
80. Ali MY, Jannat S, Jung HA, Min BS, Paudel P, Choi JS. Hepatoprotective effect of *Cassia obtusifolia* seed extract and constituents against tert-butyl hydroperoxide-induced oxidative damage in HepG2 cells. J Food Biochem. 2018; 42(1): e12439. https://doi.org/10.1111/jfbc.12439
81. Pradeep K, Mohan CVR, Anand KGV, Karthikeyan S. Effect of pretreatment of *Cassia fistula* Linn. leaf extract against subacute CCl_4-induced hepatotoxicity in rats. Indian J Exp Biol. 2005; 43(6):526-530. https://pubmed.ncbi.nlm.nih.gov/15991578/
82. Paudel P, Jung HA, Choi JS. Anthraquinone and naphthopyrone glycosides from *Cassia obtusifolia* seed mediate hepatoprotection via Nrf2-mediated HO-1 activation and MAPK modulation. Arch Pharm Res. 2018; 41(7):677-689 https://doi.org/10.1007/s12272-018-1040-4 PMid: 29804278.
83. Khan AV, Khan AA. Ethnomedicinal uses of *Eclipta prostrata* Linn. Indian J Tradit Knowl. 2008; 7(2):316-320. https://nopr.niscpr.res.in/bitstream/123456789/1593/1/IJTK%207(2)%20316-320.pdf
84. Jahan R, Al-Nahain A, Majumder S, Rahmatullah M. Ethnopharmacological significance of *Eclipta alba* (L.) Hassk. (*Asteraceae*). ISRN Pharmacol. 2014; 2014:385969. https://doi.org/10.1155/2014/385969 PMid: 27355071 PMCid: PMC4897414.
85. Dalal S, Kataria SK, Sastry KV, Rana SVS. Phytochemical screening of methanolic extract and antibacterial activity of active principles of hepatoprotective herb *Eclipta alba*. Ethnobot Leafl. 2010; 14:248-258. https://opensiuc.lib.siu.edu/ebl/
86. Bakht J, Islam A, Ali H, Tayyab M, Shafi M. Antimicrobial potential of *Eclipta alba* by disc diffusion method. African J Biotechnol. 2011; 10(39):7658-7667. https://psa.pastic.gov.pk/SearchArticleView.aspx?articledetailId=3530&S_id=26819
87. Patel DK, Kumar R, Sairam K, Hemalatha S. *Hybanthus enneaspermus* (L.) F. Muell.: a concise report on its phytopharmacological aspects. Chin J Nat Med. 2013; 11(3):199-206. https://doi.org/10.1016/S1875-5364(13)60017-5 PMid: 23725830.
88. Bhanu SH, Bai M, Chekuri P, Kedam T. Suppression of paracetamol toxicity by antioxidant principles of *Hybanthus*

enneaspermus (L.) F. Muell. in mouse blood and liver. Int J Pharm Pharm Sci. 2011; 3(4):90-94. https://www.researchgate.net/publication/215625230_Suppression_of_paracetamol_toxicity_by_antioxidant_principles_of_Hybanthus_enneaspermus_L_F_Muell_In_mice_blood_and_liver

89. Vuda M, D'Souza R, Upadhya S, Kumar V, Rao N, Kumar V, Boillat C, Mungli P. Hepatoprotective and antioxidant activity of aqueous extract of *Hybanthus enneaspermus* against CCl_4-induced liver injury in rats. Exp Toxicol Pathol. 2012; 64(7-8):855-859. https://doi.org/10.1016/j.etp.2011.03.006 PMid: 21478003.
90. Cao G, Sofic E, Prior RL. Antioxidant capacity of tea and common vegetables. J Agric Food Chem. 1996; 44(11):3426-3431. https://doi.org/10.1021/jf9602535
91. Vinson JA, Hao Y, Su X, Zubik L. Phenol antioxidant quantity and quality in foods: vegetables. J Agric Food Chem. 1998; 46(9):3630-3634. https://doi.org/10.1021/jf980295o
92. Odhav B, Beekrum S, Akula US, Baijnath H. Preliminary assessment of nutritional value of traditional leafy vegetables in KwaZulu-Natal, South Africa. J Food Compos Anal. 2007; 20(5):430-435. https://doi.org/10.1016/j.jfca.2006.04.015
93. Teutonico RA, Knorr D. Amaranth: composition, properties, and applications of a rediscovered food crop. Food Technol. 1985; 39(4):49-60. https://doi.org/10.1021/jf00061a018
94. Hema ES, Sivadasan M, Anil Kumar N. Ethnomedicinal plants used by the Kurichia tribe of Wayanad district, Kerala, India. Ethnobotany. 2006; 18:38-45. https://www.researchgate.net/publication/393901135_Ethnomedicinal_Properties_of_Plants_Used_in_KurchiyasTribe_of_Wayanad_Kerala
95. Rao GM, Rao CV, Pushpangadan P, Shirwaikar A. Hepatoprotective effects of *Amaranthus spinosus* against carbon tetrachloride-induced hepatic damage in rats. J Ethnopharmacol. 2006; 104(1-2):124-128. https://doi.org/10.1016/j.jep.2005.08.064 PMid: 16202548.
96. Wolf PL. Biochemical diagnosis of liver disease. Indian J Clin Biochem. 1999; 14(1):59-90. https://doi.org/10.1007/BF02869152 PMid: 23105203 PMCid: PMC3453559.
97. Olajide OA, Ogunleye BR, Erinle TO. Anti-inflammatory properties of *Amaranthus spinosus* leaf extract. Pharm Biol. 2004; 42(7):521-525. https://doi.org/10.3109/13880200490893285
98. Stintzing FC, Kammerer D, Schieber A, Adama H, Nacoulma OG, Carle R. Betacyanins and antioxidant properties of *Amaranthus* species. J Agric Food Chem. 2004; 52(10):29752981. https://doi.org/10.1021/jf030489q PMid: 14690373 PMCid: PMC11667576.
99. Zeashan H, Amresh G, Rao CV, Singh S. Hepatoprotective activity of *Amaranthus spinosus* in experimental animals. Food Chem Toxicol. 2008; 46(11):3417-3421. https://doi.org/10.1016/j.fct.2008.08.013 PMid: 18783728.

Author Contribution

Rupinder Kaur: Conceptualisation, data curation, methodology, and writing-original draft preparation. Shruti Saxena and Preeti Handa Kakkar: Formal analysis, investigation, and validation. Versha Upadhyaya and Tanuja: Investigation, resources, and supervision. Simrat Kaur and Manish Chauhan: Investigation and data analysis. All authors have read and agreed to the published version of the manuscript.