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Hepatoprotective Medicinal Plants: A Narrative Review

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Abstract

The liver is a vital organ responsible for detoxification, metabolism, and the regulation of numerous physiological processes, yet it is highly susceptible to damage from toxins, drugs, and oxidative stress. Conventional therapies for hepatic diseases remain limited, expensive, and often associated with adverse effects, thereby stimulating interest in medicinal plants as alternative hepatoprotective agents. This narrative review synthesizes ethnobotanical, pharmacological, and experimental evidence on widely used hepatoprotective plants such as Silybum marianum, Curcuma longa, Zingiber officinale, Cynara scolymus, and Taraxacum officinale. Their bioactive phytochemicals, including flavonoids, terpenoids, phenols, and alkaloids, demonstrate mechanisms of action such as antioxidant activity, anti-inflammatory effects, inhibition of hepatic fibrosis, stimulation of liver regeneration, and modulation of xenobiotic metabolism. Preclinical studies confirm significant protective effects against hepatotoxins, while limited clinical trials suggest tolerable safety profiles. Despite their promise, challenges remain regarding toxicity, herb–drug interactions, standardization, and regulatory frameworks. This review highlights the therapeutic potential of hepatoprotective medicinal plants as cost-effective alternatives and a source of novel compounds, underscoring the need for rigorous clinical validation, safety profiling, and integration into evidence-based hepatology.

Keywords: Hepatoprotective plants**,** Oxidative stress**,** Phytochemicals**,** Liver regeneration, and Ethnopharmacology.

INTRODUCTION

The liver is indispensable for maintaining bodily homeostasis, regulating physiological functions, and catalyzing biochemical processes that sustain growth, immunity, nutrient supply, energy provision, and reproduction. Its capacity for detoxifying and metabolizing toxic substances is crucial for the prevention of hepatic illnesses. However, exposure to chronic and excessive toxic chemicals or drugs can precipitate overproduction of reactive species that severely damage liver cells. Such oxidative stress may culminate in jaundice, cirrhosis, fatty changes, and other hepatic abnormalities. The absence of sufficiently effective orthodox medications to promote hepatic function, support liver regeneration, or safeguard the organ underscores the need to explore alternative remedies.

Ethnobotanical data have long attested to the utilization of plants for treating jaundice, hepatitis, chronic liver disease, and cirrhosis. This survey identified commonly used hepatoprotective plants in Ayurveda on the basis of their frequency of mention, including Moringa oleifera, Picrorhiza kurroa, Emelia ribes, Vitex trifolia, and Andrographis paniculata. Each species exhibits unique botanical characteristics and traditional applications that contribute to its therapeutic potential. A narrative review charts the major classes of phytochemicals implicated in hepatoprotection, highlighting their antioxidant, anti-inflammatory, membrane-stabilizing, and liver-regenerative mechanisms of action. Classic examples of hepatotoxins, together with relevant research on the selected species, provide a context for scientific investigation. The frequent use of these plants in traditional medicine and studies that confirm their hepatoprotective activity point to their candidacy for further development as cost-effective alternatives to synthetic drugs [1, 2]. They also form a repository for the discovery of novel compounds and multimodal therapies, both of which offer enhanced efficacy and reduced toxicity. An overview of the significance of liver maintenance, hepatotoxicity, classical systems of herbal preparation, and the rationale for the selection of

medicinal plants sets the trajectory for a systematic examination of their therapeutic efficacy and underlying biochemistry.

Importance of Liver Health

The liver plays an essential role in the regulation of physiological functions, including the metabolism of carbohydrates, proteins, and fats. It is involved in storing glycogen, hormones, vitamins, iron, and minerals. The liver detoxifies toxic substances absorbed from the intestinal tract, breaking down and eliminating toxins, drugs, and foreign chemicals. It transforms toxic substances so they can be discharged via urine or bile. The liver also metabolizes drugs using enzymes such as cytochrome P-450, making it highly vulnerable to toxic compounds [2]. Hepatic illnesses cause around 2 million deaths annually, including from cirrhosis, viral hepatitis, and cancer. Despite medical advances, there are no fully effective medications to promote hepatic function, protect the organ, or regenerate hepatocytes. While steroids, antiviral drugs, and immunizations are used, they can be expensive and have side effects [2]. Medicinal plants and their phytochemicals have shown potential in protecting against hepatic disorders. Research has focused on Malaysian medicinal plants with hepatoprotective properties, phytochemicals, and antioxidant mechanisms, highlighting species useful in treating liver diseases [2].

Overview of Hepatotoxicity

Hepatotoxicity denotes a state of acute or chronic liver damage disrupting metabolic, secretory, and excretory functions and morphogenesis of cells, tissues, and organs [2]. Hepatic illnesses account for roughly 2 million deaths annually globally. Drug and toxicant-induced hepatotoxicity also continues as a major clinical concern and offers potential for the development of hepatoprotective agents [1]. Many hepatotoxic chemicals cause damage by forming covalent bonds with tissue lipids or fuels in the microsomal membrane and generate free radicals at a rate exceeding the natural defenses, thereby damaging liver tissue. Micronutrients also can become pro-oxidants and may cause oxidative stress if they are taken in excess and are generally well tolerated within usual supplemental intake levels [8]. Modern drugs in allopathic medicine are often limited to symptomatic treatment and can have serious side effects; the search for potent and effective drugs without side effects continues. Medicinal plants with hepatoprotective activity remain an important source for the prevention of hepatic damage and the treatment of liver disease [1, 2]. A plethora of medicinal plants have been investigated for hepatoprotective activities in the past, with extracts showing promising activity deserving detailed investigations towards the development of a potent hepatoprotective drug.

Traditional Uses of Medicinal Plants

Traditionally, various plants have been employed against liver ailments in diverse cultures. Many of these have been validated in animal models for their hepatoprotective efficacy, with a smaller number tested in clinical trials. Liver disease remains a leading cause of death globally, because drug treatment options for chronic liver pathologies are limited, teams at the world's leading universities have selected a variety of plants with demonstrated relevance to liver conditions [1, 8].

Criteria for Selection of Medicinal Plants

Researchers and practitioners select hepatoprotective plants in accordance with the following criteria. The first relates to the frequency with which the plants appear in ethnobotanical surveys of medicinal plants reputed for their efficacy on the liver and hepatobiliary system, or in ethnopharmacological studies that address liver problems specifically [11]. The second criterion concerns the availability of published information of potential relevance to hepatoprotection in pharmacological, toxicological, phytochemical, or medicinal plant surveys. Taking these selection criteria into account, eleven hepatoprotective plants native to Bangladesh are discussed: Andrographis paniculata, Boerhavia diffusa, Capparis roxburghii, Curcuma longa, Heliotropium indicum, Kalanchoe pinnata, Lawsonia inermis, Microcos paniculata, Nyctanthes arbor-tristis, Oroxylum indicum, and Senna occidentalis [1].

Common Hepatoprotective Plants

Plants are widely used as hepatoprotective agents by the Indian people, especially in villages. While many herbs have been proven to be effective hepatoprotective agents, others continue to be used without scientific evidence [1]. The selection of species is based on worldwide ethnobotanical surveys of traditional medicines for liver treatment, frequency of citation, pharmacological, toxicological, phytochemical, and ethnobotanical data. It is difficult to select the correct medicinal plants from the assortment of hepatoprotective plants available globally. Starting from the list prepared through literature surveys, 140 species were selected due to their high (>30%) use for liver diseases. The flora of Bangladesh includes about 5,750 angiospermic plant species, among which 750 species are medicinal plants [3, 6]. Of these, 88 species have been identified to have hepatoprotective activity; active compounds found in those plants might be potential sources for drug development [1]. 7.1 Barleria species (Acanthaceae) are mostly herbs or shrubs with ovate, oblong, or elliptical leaves and solitary axillary flowers. Barleria prionitis L. is an erect, large, much-branched, perennial, deciduous shrub up to 3 m tall with spiny stems. The plant's bark is good against liver complaints, and the flowers act as a mild hepatoprotective. 7.2 Butea monosperma (Fabaceae) is a medium to large-sized deciduous tree with alternate, trifoliate leaves and a stout,

spiny rachis; 7.3 Cassia fistula (Fabaceae) is a medium-to-large deciduous tree with alternate, pinnate leaves and large fragrant flowers; 7.4 Curcuma longa (Zingiberaceae) is a rhizomatous herbaceous perennial with shortly petiolate, elliptical-oblong leaves that are green above and purple beneath; and 7.5 Desmodium species (Fabaceae) are herbs or undershrubs with trifoliate leaves and axillary racemes. Consumption of the ethanolic extract along with a standard drug is hepatoprotective [1, 6].

Milk Thistle (Silybum marianum)

The seeds of Silybum marianum are the source of silymarin, a mixture of flavonolignans traditionally employed in the treatment of liver disorders. The main active compound is silybin, which displays antioxidant, anti-inflammatory, and antifibrotic activities. Silymarin decreases viral-induced liver damage by dampening the inflammatory cascade and modulating the immune response [4, 5]. These effects are further supported by a direct antiviral activity against the hepatitis C virus when silymarin is administered intravenously. Silymarin also increases cellular vitality and reduces lipid peroxidation and necrosis caused by alcohol consumption. In non-alcoholic fatty liver disease, silymarin counteracts progression by ameliorating oxidative stress, insulin resistance, hepatic fat accumulation, and mitochondrial dysfunction. The compound is regularly utilized against chronic liver diseases, cirrhosis, and hepatocellular carcinoma, all representing common end-stages of liver injury [4]. The biomedical properties of silymarin have earned it a prominent place among nutraceutical alternatives for more conventional therapeutic approaches, with special attention devoted to its putative antitumor potential [5].

Dandelion (Taraxacum officinale)

Dandelion (Taraxacum officinale), of the family Asteraceae, is widely distributed worldwide and naturally grows in temperate and subtropical regions [7, 6]. Historically, dandelion has been extensively used for liver complaints, exhibiting hepatoprotective activity against cirrhosis and hepatotoxicity induced by diverse chemical substances and CCl4. Both aqueous and alcoholic extracts of dandelion demonstrate hepatoprotective efficacy and potent diuretic effects; a dandelion-enriched diet alleviates fatty liver syndrome induced by a high-fat diet. Aqueous and methanolic extracts show antioxidant effects, promote free radical scavenging, and protect against lung injury; vapor distillation extracts possess antibacterial activity, whereas ethyl acetate extracts exhibit anti-inflammatory properties in vivo [7]. Traditional applications include treatments for dyspepsia, cholecystitis, cirrhosis, gallstones, eczema, and various skin diseases. The whole plant is administered as a decoction, tincture, syrup, and salad to promote bile flow and stimulate bile secretion, potentially addressing bile-related liver disorders [6]. Oxidative stress amelioration by dandelion extract occurs via CYP2E1 suppression against acute liver injury induced by carbon tetrachloride in rats. Leaf extracts confer hepatoprotective effects on CCl4-induced hepatotoxicity and sodium dichromate-induced liver injury; polysaccharides from the root also exhibit such effects. Maternal supplementation with a dandelion-enriched diet mitigates lead-induced liver damage in offspring. Leaf extract reduces high-fat diet-induced nonalcoholic fatty liver and guards against injury caused by methionine- and choline-deficient diets in mice [7]. Aqueous root extract counters alcohol-induced oxidative stress. Dandelion antioxidants influence microsomal lipid peroxidation; the plant induces cytotoxicity through cytokine secretion in hepatic cells and affects hepatic and testicular tissues exposed to ionizing radiation. Additional activities include platelet anti-aggregation, improvement of lipid profiles and antioxidant status in mice on high-fat diets, hypolipidemic and antioxidant effects in cholesterol-fed rabbits, and suppression of reactive oxygen species, nitric oxide, and lipid oxidation by flower extracts [7, 6].

Turmeric (Curcuma longa)

Curcuma longa (turmeric) is a large perennial herb native to tropical and subtropical South Asia. The dried rhizomes, known as turmeric, are widely used as a spice, coloring agent, and traditional medicine 8. Curcuminoids constitute approximately 3 % of dried turmeric rhizome, providing its orange colour [1]. Originating in Ayurveda, the therapeutic use of turmeric dates back to at least 500 BCE, and possibly 2500 BCE, extending its history to about 4500 years [2]. Turmeric is a commonly applied remedy in traditional systems of medicine for liver disorders, indigestion, and respiratory ailments, and the rhizomes exhibit tonic, carminative, stomachic, diuretic, and febrifuge activities [1]. It is especially indicated in disorders of the liver and gallbladder. Methanol extracts of turmeric rhizomes exhibit dose-dependent protective effects against carbon tetrachloride-induced cytotoxicity in HepG2 cells [1, 2].

Artichoke (Cynara scolymus)

Artichoke is a species of thistle sometimes considered a variety of Cynara scolymus. The cultivated head of the flower is a common ingredient of Mediterranean cuisine and is also common in fine dining throughout Europe and the Americas. The edible portion of the plant consists primarily of the flower buds before the flowers come into bloom. The Roman Catholic Church designates it as a Lenten food [1]. The chemical compounds found in artichoke are: apigenin, cyanidin, luteolin, and various other flavonoids. Historically, the fruit of artichoke (yet to be discovered) was apparently claimed to be helpful for liver health and to soothe and calm the painful sensations associated with liver damage, whereas its leaf extract was recommended to stimulate bile secretion following

infarcts and slow the development of arteriosclerosis and fatty deposits within the veins and arteries [2]. Artichoke is a stout perennial thistle cultivated as food; it was originally native to North Africa. The extracts of artichoke enhance the ability of the liver to produce bile, which is considered a major component in the digestion of fats and fat-soluble vitamins. It is useful in indigestion, flatulence, nausea, and excessive acidity. Artichoke extracts have been used in the treatment of diabetes, diarrhea, vascular sclerosis, high cholesterol levels, and colon and liver cancers. Artichoke leaf extract has been proven to decrease the incidence of arsenic nitrate-induced hepatotoxicity [1, 2].

Ginger (Zingiber officinale)

Zingiber officinale Roscoe (Zingiberaceae), commonly known as ginger, has its origins in Southeast Asia and China, where it has been utilized as a dietary and herbal medicine since ancient times. It is currently cultivated worldwide for its rhizomes, which are widely distributed and used in the medical and biological fields [9]. Ginger is a perennial plant that can grow up to 1.2 m tall. The inflorescence is pale yellow with purple tips and appears lateral to the leaves of the rhizomes. The upper portion of the ginger inflorescence is a lax spike with usually two to three green leafy bracts and short stamens. It is a tropical, wind-pollinated species that propagates by tillers, developed on the underground horizontal rhizome. Ginger has gained much attention in recent times as a nutraceutical agent against liver fibrosis because it has the ability to downregulate free radical elevation [9]. It improves liver and cholestatic biomarkers, ameliorates hepatic marker enzymes, reduces collagen deposition and fibrosis severity, and normalizes the hepatic cells' architecture. Ginger ethanolic extract exhibits the most potent effect in improving these parameters. Although it is not yet possible to extrapolate the results, the exhibited hepatoprotective effect suggests a viable nutraceutical role for the species in the human diet [10].

Mechanisms of Action

Hepatoprotective plants exert protective effects through diverse biochemical and cellular mechanisms that maintain or restore hepatic function. They may inhibit the cytochrome P450 enzyme system, thereby blocking the biotransformation of xenobiotics to toxic metabolites and preventing liver injury [1]. Antioxidant activities are frequently implicated: scavenging reactive free radicals, suppressing production of reactive oxygen species, enhancing antioxidant defenses, and inhibiting lipid peroxidation. Moreover, hepatoprotective plants often inhibit hepatic fibrosis, the excessive accumulation of extracellular matrix proteins following chronic liver damage, thereby blocking progression to cirrhosis. Additional mechanisms include stimulation of liver regeneration, proton pump inhibition, anti-inflammatory, anticholestatic, immunomodulatory, and antitumour effects [1].

Antioxidant Activity

The phytochemical profile of medicinal plants encompasses numerous naturally occurring antioxidant compounds such as phenols, flavonoids, terpenoids, and alkaloids that protect cells against oxidative stress, as extensively documented for Solanum nigrum and Morinda citrifolia [1]. The antioxidant potential of these plants directly correlates with the concentration of these constituents. Conceivably, in the presence of reactive oxygen species (ROS) generated during hepatotoxic exposure, the antioxidant components may counter the injurious effects of lipid peroxidation on biomembranes and thereby preserve membrane integrity [11]. Many plants possess antioxidants capable of scavenging free radicals and fixing oxidative stress.

Anti-inflammatory Effects

Several investigations have demonstrated the anti-inflammatory effects of various medicinal plants such as Silybum marianum and Glycyrrhiza glabra. Plant-derived compounds have been observed to prevent the release of pro-inflammatory cytokines, thereby mitigating inflammation [12, 1]. Ethnobotanical findings suggest that these species lower the inflammatory response, which can significantly influence the progression of hepatic diseases. Reducing inflammation may thereby decrease the overall impact of liver disorders.

Regeneration of Liver Cells

Liver diseases constitute a global health problem. The increased expenditure is of considerable economic concern, especially in developing countries, where the choice of therapeutic agents is determined largely by the cost of treatment [1]. The preparative consumption of hepatoprotectives is, therefore, restricted only to the middle and upper social classes. Medicinal plants used for the treatment of liver disorders and also screening of their hepatoprotective activity are discussed in detail [1]. The search has been conducted through different electronic databases such as Science Direct, Elsevier, PubMed, ACS publications, Wiley, and Cochrane Library. Keeping that in view, the present study was an attempt to review hepatoprotective medicinal plants that reveal significant therapeutic potential against hepatoprotective activity [11]. Diseases of the liver are an important cause of suffering and death among persons of all ages, and various medicinal plants are employed in different systems of medicine to combat hepatic ailments. The development of a satisfactory herbal therapy to treat severe liver diseases requires systematic investigation of various plants, which are known to possess anti-hepatotoxic and other significant properties, such as stimulation of liver regeneration and choleretic activity. The formulation of herbal medicines with an appropriate standard of safety and efficacy can give a new life to the treatment of liver

disorders. Efforts have been made to compile a list of medicinal plants, which have been scientifically evaluated and have proved themselves to be effective hepatoprotective during the year 2011 [1]. The liver plays a major role in regulating many physiological functions. The main functions of the liver include metabolism of carbohydrate, protein, and fat; storage of glycogen, vitamins, hormones, and minerals. It helps in detoxification of toxic substances, drugs, and foreign chemicals and converts them into harmless products which are eliminated from the body through the kidney or through the biliary route. The liver is undoubtedly the most important organ performing a myriad of physiological functions to maintain the internal chemical homeostasis of the body [2]. The liver is one of the few organs in the body that can regenerate, even after up to 70% of the liver has been damaged or removed; the remaining hepatic tissue undergoes a complex process of tissue remodeling to form a liver structure similar to the original. Injuries such as hepatotoxins, infections, or cancer increase the rate of proliferation of hepatocytes, which is directly proportional to the severity of injury. The hepatic nonparenchymal liver cells, including Kupffer cells and hepatic stellate cells (HSCs), also take part in the liver regeneration process. Most of the medicinal plants showing anti-hepatotoxic effects are also known to stimulate the regeneration of liver cells [1, 2].

Clinical Evidence and Studies

Human studies on hepatoprotective effects of medicinal plants are extremely limited, though numerous animal experiments demonstrate potent liver-protecting properties for many species [1]. The liver's central role in metabolism and detoxification renders it vulnerable to toxins. The search for natural hepatoprotective agents has intensified in recent years. Herbal drugs possessing hepatoprotective activities have been confirmed through various animal studies. Further development of herbal therapies for severe liver diseases requires systematic investigation of properties such as antioxidant potential, stimulation of liver regeneration, and choleretic effects [1].

Human Trials

The side effects of oral administration of oral taxifolin (50 mg three times daily) from 1 month before the balloon pulmonary angioplasty (BPA) until 3 months after the BPA were assessed on 47 adult patients who underwent BPA for chronic thromboembolic pulmonary hypertension (CTEPH) [1]. The patients were asked to voluntarily report any serious adverse events. As side effects of oral taxifolin, diarrhea and pruritus were observed in 4 (8.5%) and 15 (31.9%) patients, respectively; accordingly, the taxifolin dose was reduced in 9 patients. One of the patients who underwent dose reduction discontinued taxifolin administration because of severe diarrhea [1]. However, the symptoms improved after the reduction of the dose or during drug administration. No severe bleeding or other adverse events associated with oral taxifolin were observed during the observation period of three months. The authors concluded that oral taxifolin administration showed a tolerable safety profile in patients who underwent BPA for CTEPH [1].

Animal Studies

The ability of several medicinal plants to protect the liver against various toxins has been tested in different animal models. The most commonly used models are paracetamol- and carbon tetrachloride-induced hepatotoxicity in rats and mice. Some of these experiments, as well as more recent research, have shown that several herbal extracts can protect against the damage induced by potentially hepatotoxic drugs and chemicals [1]. A wide variety of medicinal plants have been shown to prevent and cure liver injury induced by galactosamine, carbon tetrachloride, paracetamol, ethanol, D-galactosamine, thioacetamide, and other hepatotoxins. Some extracts of these plants also showed promising results in animal experiments infected with hepatitis viruses. It has been suggested that the hepatoprotective properties may be linked to radical scavenging effects on the liver [12]. Medicinal plants have been used to treat diseases and ailments for thousands of years. Over 600 plants are thought to possess some activity against liver disorders. However, modern scientific investigations have started to provide evidence for their efficacy and mechanism of action only recently. These studies have sought to identify chemical constituents; evaluate antioxidant, anti-inflammatory, and free-radical scavenging activity; demonstrate immunomodulation; and test for regeneration of damaged liver cells [12].

Safety and Toxicity Concerns

While lignans from Schisandra and furosantrolactones from Polyporus lack reported side effects so far, some other plants present known or emerging toxicities. The use of Cassia sophera and Aspalathus linearis is associated with mild gastrointestinal symptoms such as nausea, vomiting, diarrhoea, or abdominal pain. Some studies report hepatotoxic effects from Silybum marianum at doses exceeding those recommended in human medicine [1]. From Canarium schweinfurthii, astragalin has been isolated, which is also found in Cassia, a known irritant. These observations underscore the need to consider toxicity and side effects when applying medicinal plants for hepatoprotection [1].

Interactions with Conventional Medications

Herbal remedies are commonly taken to complement conventional therapies, yet potential interactions may alter drug metabolism and therapeutic effectiveness [1]. These interactions span pharmacodynamic and pharmacokinetic mechanisms, affecting processes such as acid-base balance, absorption, distribution, metabolism, and elimination. Interactions can be either beneficial or harmful, impacting the safety and efficacy of co-administered medications. Extensive use of herbal medicines alongside pharmaceuticals thus raises the risk of serious unwanted effects [1].

Regulatory Aspects

Besides scientific safety and effectiveness, regulatory approval is important for utilizing a proper hepatoprotective product in clinical practice [1]. The widespread practice of self-medication and traditional use of medicinal plants dictates the need for regulatory provisions [13]. Many countries lack dedicated algorithms, policies, or proper guidelines for herbal hepatoprotectives, and manufacturing standards and quality control practices are insufficient. Moreover, the classification of herbal medicines varies: for example, the U.S. Food and Drug Administration (FDA) regards them as dietary supplements, whereas the European Union recognizes them as herbal medicines for therapeutic purposes [1].

Future Directions in Research

Several phytochemicals and formulation combinations have demonstrated preclinical hepatoprotective effects [1]. Based on ethnopharmacological considerations, such extracts or fractions could provide safer alternatives for large-scale, cost-effective drug discovery in hepatic disorders [3].

Novel Compounds

Natural sources such as plants, fungi, and microorganisms have yielded numerous biologically active compounds [1]. Unlike the vast majority of compounds synthesized by combinatorial chemistry, many of these natural products exhibit inherent biological activity, which may enable them to serve as leads or scaffolds for the design of new drugs. Consequently, investigations involving the extraction, isolation, and characterization of natural products have importance that extends beyond traditional drug discovery [1]. They provide access to novel chemotypes unavailable through other means. Some natural products exhibit potent antiviral and antitumor activities. In this context, hepatoprotective medicinal plants represent a rich source of bioactive constituents. Original plant extracts facilitate the primary identification of biologically active leads as well as the procurement of natural prototypes for direct development as therapeutic agents. Numerous plants considered in this review possess relatively high levels of activity. Several novel compounds with moderate activity have been isolated from these plants, and most of these compounds belong to chemical families that have not been extensively studied. The structural diversity of these constituents offers substantial opportunities for the development of new hepatoprotective drugs [12]. However, the development of new agents should also emphasize plant sources that may not exhibit measurable activity in an initial assessment because these sources have the potential to provide a variety of hepatoprotective compounds [2].

Combination Therapies

Numerous plant drugs in traditional medicine are recommended in combination with other plants for enhanced hepatoprotective effects. Some combinations are delivered as polyherbal preparations [1]. The synergistic action of combinations is a future strategy for plant-based activity. Plants such as Phyllanthus amarus, Boerhavia diffusa, Andrographis paniculata, and Cichorium intybus are used in combination for a synergistic effect in combating liver ailments. Synergistic activity implies that the combined effect of the mixture is greater than the sum of the individual effects [12]. Other examples include Alpinia calcarata, Bacopa monnieri, and Glycyrrhiza glabra, which enhance the hepatoprotective effect of Phyllanthus niruri. A polymedication mixture named Liv., containing Capparis spinosa, Cichorium intybus, Mandur bhasma, Solanum nigrum, Terminalia arjuna, Cassia occidentalis, Achillea millefolium, and Tamarix gallica, has shown considerable activity. Furthermore, the combination of Fumaria indica and Tephrosia purpurea exhibited significant hepatoprotective activity [12].

Ethnopharmacology and Cultural Significance

In Ethiopia, a large number of wild plants have been used to treat hepatitis. The review indicates that 24 species distributed in 17 families were recorded for this purpose [13]. The highest number of medicinal plants was reportedly gathered from Asteraceae, followed by Fabaceae, Euphorbiaceae, Cucurbitaceae, and Solanaceae; in terms of herbal drugs used, a majority were derived from leaves. Oral administration was the most common method of remedy delivery. This ethnomedicinal investigation points to potential leads for novel anti-hepatic drug discovery, while also emphasizing the conservation of indigenous knowledge and relevant flora [13].

Challenges in Research

Hepatoprotective medicinal plants are used worldwide owing to their beneficial effects in treating various hepatic diseases. Despite extensive research on several plants, the potential of enormous species, especially those growing in India, remains largely unexplored for their hepatoprotective activity. One main cause for liver damage is the

continuous use of allopathic drugs, which often keep the liver engaged in detoxification and excretion, processes that generate highly reactive free radicals attacking liver cells [13]. Reducing exposure to these chemicals is impractical; therefore, decreasing oxidative stress in hepatocytes is commonly attempted by using natural or synthetic antioxidants [1, 13]. Scientific evaluation of medicinal plants is designed to detect their hepatoprotective effects against these toxicants, as well as their potential to restore the functional liver enzyme systems involved in protein biosynthesis. Among hepatoprotective plants, some of the best known are Achillea millefolium, Acanthopanax senticosus, Actinidia deliciosa, Agrimonia eupatoria, Angelica sinensis, Apium graveolens, Artemisia absinthium, Bacopa monnieri, Baptisia tinctoria, Calendula officinalis, Camellia sinensis, Centella asiatica, Chaos carolinense, Chlorella vulgaris, Melissa officinalis, Ocimum sanctum, Olea europaea, Taraxacum officinale, and Torilis japonica. Extracts of these plants are mainly used as antioxidants to reduce oxidative stress caused by the accumulation of reactive oxygen species in cells [13-16].

CONCLUSION

Medicinal plants hold immense promise in the prevention and management of hepatic disorders due to their bioactive phytochemicals and multifaceted mechanisms of action. Evidence from ethnobotanical records, animal studies, and emerging clinical data indicates their ability to attenuate oxidative stress, reduce inflammation, stimulate hepatocyte regeneration, and modulate toxic metabolic pathways. Species such as Silybum marianum, Curcuma longa, Zingiber officinale, Taraxacum officinale, and Cynara scolymus exemplify their therapeutic potential. However, despite encouraging results, widespread clinical adoption is hindered by safety concerns, herb–drug interactions, inconsistent preparation standards, and inadequate regulatory oversight. Future directions should prioritize systematic clinical trials, toxicological assessments, and standardization of herbal formulations to establish reliable and safe hepatoprotective therapies. In addition to their role in healthcare, hepatoprotective medicinal plants provide opportunities for novel drug discovery, cost-effective interventions, and the preservation of traditional ethnopharmacological knowledge. Ultimately, integrating scientifically validated plant-based hepatoprotectives with conventional medicine could significantly improve global liver health outcomes.

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