Nutrition and Herbal Medicine in Hepatitis: Mechanisms, Clinical Evidence, and Future Directions

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Abstract

Hepatitis is a widespread liver disease with inflammation of the liver and continues to be a significant global health problem. It can result from exposure to toxic chemicals, certain drugs, autoimmune diseases, metabolic disorders, alcohol abuse or viral infections. Untreated chronic liver inflammation can cause liver fibrosis, cirrhosis, liver failure, and liver cancer (hepatocellular carcinoma). While antiviral treatment is the main treatment for viral hepatitis; supportive measures like appropriate nutrition and herbal medicine can positively influence liver health and patient outcomes. A proper diet supplies the necessary nutrients needed for normal liver function, to boost the immune system, to lessen oxidative stress and to promote repair of the damaged liver cells. A nutritious diet with good quality protein, healthy fats, and vitamins, minerals, dietary fibre and foods high in antioxidants can support liver function and slow the progress of disease. The attention is also paid to herbal medicine, as many medicinal plants contain bioactive compounds, possessing antioxidant, anti-inflammatory, antiviral and hepatoprotective properties. In experimental studies, and selected clinical trials, medicinal plants like Silybum marianum, Curcuma longa, Phyllanthus niruri, Glycyrrhiza glabra and Andrographis paniculata have exhibited promising activities of hepatoprotection, anti-inflammatory and antioxidant properties. There are, however, important challenges in their routine clinical use as a result of differences in herbal formulations, lack of standardization, limited high quality clinical evidence and potential herb-drug interactions. This paper reviews the pathogenesis of hepatitis, the importance of nutrition for liver health and the existing scientific evidence of herbal remedies. It also emphasizes safety issues, gaps in existing research, and future directions for evidence-based nutrition and herbal interventions to enhance the care of hepatitis.

Keywords: Hepatitis; Liver health; Nutrition; Herbal medicine; Hepatoprotection

Abbreviations

CLD: Chronic Liver Disease

DNA: Deoxyribonucleic Acid

EGCG: Epigallocatechin-3-gallate

HBV: Hepatitis B Virus

HCC: Hepatocellular Carcinoma
HCV: Hepatitis C Virus
IL-1β: Interleukin-1 Beta
IL-6: Interleukin-6
ROS: Reactive Oxygen Species
TNF-*α*: Tumor Necrosis Factor-Alpha

1. INTRODUCTION

Liver is one of the most crucial organs of the human body with many functions, most of which are related to the metabolism, detoxification of harmful substances, production of bile for digestion, storage of vitamins and minerals and regulation of immune responses. Inflammation of the liver can interfere with these important functions, and cause mild or severe health complications. (1,2) Viral infections, excessive alcohol consumption, certain medications, autoimmune disorders, metabolic diseases and exposure to toxic chemicals are the causes of hepatitis. Of these, viral hepatitis is the most prevalent and involves hepatitis A, B, C, D and E viruses. Most hepatitis A and E infections are acute, but hepatitis B and C infections can be chronic and can lead to liver fibrosis, cirrhosis, if not treated. (3,4)

Hepatitis continues to be a major public health problem worldwide. Every year, millions of people are affected and viral hepatitis is a large contributor to illness and premature death. Many liver related complications and liver cancer are caused by chronic infection of Hepatitis B and C. Despite improvements in vaccination, antiviral therapy, and public health programs, many individuals remain undiagnosed or do not receive timely treatment. Inadequate awareness, access to healthcare, and delayed diagnosis persist to drive up disease burden, especially in low and middle-income countries. Thus, the prevention, early detection and supportive treatment of hepatitis is essential to minimize the burden of hepatitis globally. (5) In addition to medical care, the right diet is essential to liver health and recovery. The balanced diet offers the energy and nutrients used to maintain normal liver function, repair tissues and provide protection. Proteins, vitamins, minerals, dietary fiber and healthy fats help to lower oxidative stress, promote liver cell regeneration and enhance metabolic function. Fruits, vegetables, whole grains, legumes and healthy fats are also an important part of healthy diets and help the liver function properly. Patients with chronic hepatitis may require more nutritional support because malnutrition and nutrient deficiencies may aggravate the disease and decrease the effectiveness of treatment. (6,7)

In recent years, herbal medicine has also gained more popularity as a complementary treatment to support liver health. Medicinal plants have been used to treat liver disease for centuries, as part of traditional medicine practices. (8, 9)

The antioxidants, anti-inflammatory, anti-viral and hepatoprotective effect of many herbs are attributed to the presence of naturally occurring bioactive compounds. (10) Laboratory studies and some clinical trials have provided encouraging results with certain medicinal plants including milk thistle (*Silybum marianum*), turmeric (*Curcuma longa*), licorice (*Glycyrrhiza glabra*), *Phyllanthus niruri* and kalmegh (*Andrographis paniculata*). These plants can be protective to liver cells, anti-inflammatory and improve liver function. The quality, safety, standardization and clinical efficacy of herbal products, however, should be further investigated in well designed clinical studies before being routinely recommended in clinical practice. (11) This review will summarize the effects of liver disease and

liver damage, and focus on the importance of nutritional and herbal management of hepatitis. It highlights the mechanisms by which nutritional strategies and medicinal plants contribute to liver functions, reviews the clinical evidence available, and addresses challenges and future research directions. The review aims to provide updated information which can be helpful for researchers, healthcare professionals, pharmacists and students in order to know the possible benefits and limitations of nutritional and herbal medications in the management of hepatitis.

2. PATHOPHYSIOLOGY OF HEPATITIS

2.1 Mechanisms of Liver Injury

Hepatitis is the inflammation of the liver due to viral infection, alcohol, autoimmune disease, metabolism disorders, some drugs or toxins. Whatever the reason, liver damage starts with the damage of liver cells called hepatocytes. Viral hepatitis is an immune response to infection of hepatocytes by viruses, including hepatitis B virus (HBV) and hepatitis C virus (HCV). The immune system plays an important role in killing the infected cells, but when the immune system is reacting to the infection too strongly or for too long, liver tissue can be damaged as well. (1, 12)

Inflammatory cells such as T lymphocytes, macrophages and natural killer cells move to the liver to regulate the infection. The mediators are useful for the killing of infected cells, but can also damage nearby healthy hepatocytes. Chronic or chronic liver damage can impair the liver's ability to grow back and regenerate normal liver function. This leads to metabolically aberrated patients, decreased detoxification ability, and protein synthesis and bile production defects. (13) Other causes of liver damage to the liver cells include viral infections, alcohol and drugs and metabolic disorders that disrupt the normal metabolic activity of cells and raise the production of harmful molecules. Repeated liver damage causes liver injury, resulting in scarring of the liver tissue and liver disease. (14, 15) The pathophysiological mechanisms of liver injury in hepatitis and the corresponding targets for nutritional and herbal interventions are shown in Figure 1.

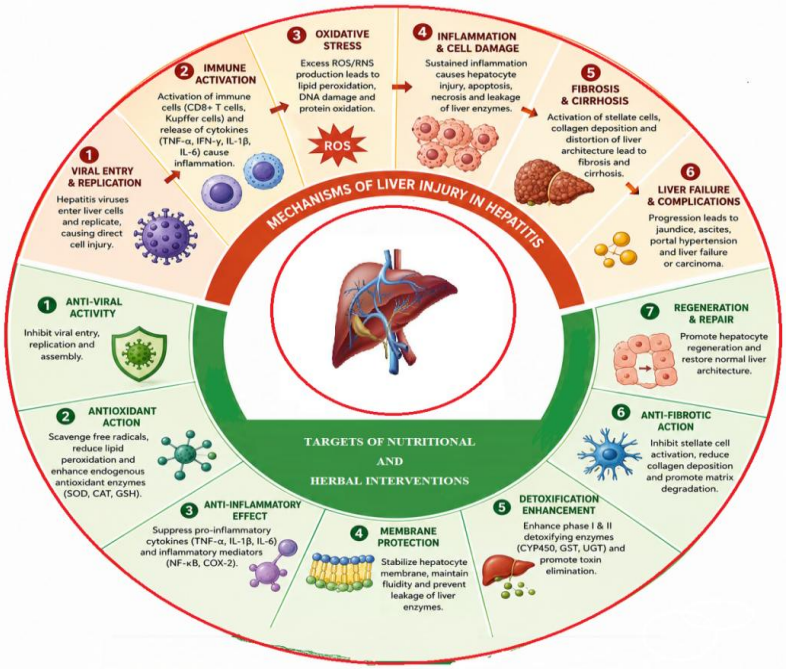


Figure 1: Mechanisms of liver injury in hepatitis and targets of nutritional and herbal interventions.

2.2 Oxidative Stress and Inflammation

Oxidative stress is one of the major factors involved in the development and progression of hepatitis. It is caused by imbalance between the generation of Reactive Oxygen Species (ROS) and the antioxidant defense system. Normally, liver cells are resistant to oxidative damage because of antioxidants like glutathione, superoxide dismutase, and catalase. But, in hepatitis, the production of excess ROS exceeds these protective mechanisms. (16) ROS can damage cellular lipid, protein and DNA and impair cell function leading to cell death. Once damaged, hepatocytes send signals to continue the inflammatory and oxidative damage process. (17) In parallel, inflammatory cytokines like tumor necrosis factor alpha (TNF-α), Interleukin-1 beta (IL-1β) and Interleukin-6 (IL-6) further exacerbate inflammation and cause further liver damage. (18) Oxidative stress also impacts on the function of the mitochondria; less energy becomes available for normal function and liver cells become more susceptible to injury. Chronic inflammation and oxidative stress contribute to the progressive degradation of normal liver tissue and contribute to the progression of the disease. Due to such effects, reducing oxidative stress and controlling inflammation are important therapeutic targets in the treatment of hepatitis. (19)

2.3 Progression to Fibrosis and Cirrhosis

Persistent liver injury disrupts the normal tissue repair process, resulting in excessive deposition of scar tissue and the development of fibrosis. This condition is called "liver fibrosis. Hepatic stellate cells are responsible for most of the fibrosis process, following repeated liver damage; they convert to collagen-producing cells. The activated cells start to make lots of collagen, extracellular matrix proteins that cause progressive scarring in liver tissue.

At the beginning, fibrosis can be reversed, if the cause of liver damage is successfully treated. Persistent inflammation and persistent hepatocyte damage leads to increased scar formation, structural distortion of the liver and diminished blood flow in the liver. Liver function slowly deteriorates with progression of fibrosis. (20, 21) Cirrhosis is the final step in chronic liver damage, when extensive fibrosis results in the loss of normal liver tissue and the development of regenerative nodules. Cirrhosis seriously compromises liver function and can result in complications like portal hypertension, ascites, hepatic encephalopathy, variceal bleeding and liver failure. Hepatocellular carcinoma is also much more common in patients with cirrhosis. (22) Therefore, early diagnosis and timely treatment of hepatitis are important to break the cycle of inflammation, oxidative stress, and fibrosis, and prevent irreversible liver damage. Nutritional support, healthy lifestyle practices, and judicious use of hepatoprotective herbal remedies can help to alleviate oxidative stress and inflammation, complementing antiviral treatment when necessary, and can enhance liver health. (23)

3. ROLE OF NUTRITION IN HEPATITIS

Nutrition is an important part of hepatitis management because it helps maintain normal liver function, supports tissue repair, and improves the body's immune response. The liver plays a central role in the metabolism of carbohydrates, proteins, fats, vitamins, and minerals. During hepatitis, inflammation and liver cell injury can disturb these metabolic processes, increasing the risk of malnutrition and nutrient deficiencies. Poor nutritional status may delay recovery, reduce treatment response, and increase the likelihood of disease progression. (24) Therefore, a balanced and nutrient-rich diet should be considered an essential component of supportive care for patients with hepatitis.

3.1 Macronutrients and Micronutrients

Carbohydrates, proteins and fats are the macronutrients essential in sufficient quantities to maintain energy balance and liver health. Carbohydrates are the main source of energy and aid in the prevention of muscle protein break down for energy production. Fruits, vegetables, legumes and whole grains are good sources of complex carbohydrates, which offer a slower release of energy and are high in dietary fiber that promotes digestive health and helps regulate blood sugar. (25)

Proteins are vital in repairing and renewing damaged liver cells. They are also crucial for the synthesis of enzymes, plasma proteins and immune molecules. Most patients with chronic liver disease are advised to eat quality protein foods like fish, lean poultry, eggs, milk, soy, pulses and legumes. Protein is desirable to help restore muscle tissue and promote recovery. In patients with severe liver disease and/or hepatic encephalopathy, however, protein intake may need to be adjusted on a case by case basis with medical supervision. (26)

Fat in the diet is required for energy production, maintenance of cell membranes and for the absorption of fat soluble vitamins. Omega-3 fatty acids and monounsaturated and polyunsaturated fatty acids are healthy fats that can help decrease inflammation and enhance lipid metabolism. Essential fats come from the foods listed above, while too much saturated fat and trans fat could be harmful to the liver and result in metabolic issues. (27, 28)

Micronutrients play a key role in liver health, too. Vitamins A, C, D and E with B-complex vitamins play a role in immune system, cellular metabolism and tissue repair. Antioxidant defense, enzyme activity, and immune regulation are functions of minerals including zinc, selenium and magnesium. The deficiencies of such nutrients are prevalent in CLD and can be associated with poorer clinical outcomes. These deficiencies can be corrected with nutritional assessment and supplementation as clinically indicated and can improve overall health. (29)

3.2 Antioxidants and Functional Foods

During hepatitis, liver damage is caused by oxidative stress and antioxidant rich foods play a significant role in the dietary management of liver injury. Antioxidants can neutralize ROS, prevent additional hepatocyte injury and decrease cellular damage. Fruits, vegetables, nuts, seeds, and whole grains are a good source of natural antioxidants like vitamin C, vitamin E, carotenoids, polyphenols, and flavonoids. (16)

The food with biological active compounds that is consumed for beneficial effect other than nutrition is called functional food. Fruits like berries, citrus fruits, leafy green vegetables, cruciferous vegetables, tomatoes, garlic, turmeric, ginger, green tea and nuts were found to have positive association with antioxidant status and anti-inflammatory activity when consumed regularly. Probiotic and prebiotic foods, fermented foods (like yoghurt and kefir) can also contribute to a better composition of gut microbiota. The gut-liver axis is a strong connection between the gut and liver, and a healthy intestinal microbiome could have a beneficial effect on the liver. (30, 31)

A number of functional foods exhibit hepatoprotective activity, but should be considered as supportive foods instead of conventional medicine treatment. They are most beneficial as part of a healthy and balanced diet.

3.3 Dietary Recommendations for Liver Health

Treatment of diet depends on the patient's age, nutritional condition, disease activity and the cause of hepatitis. For good liver health, a balanced diet with adequate calories, good quality protein, healthy fats, whole grains, fruits and vegetables and adequate fluids are recommended. Appropriate energy balance and reduced metabolic strain on the liver is achieved by eating regular meals and providing appropriate hydration. (32)

Patients are advised to eat a diverse range of fresh fruits and vegetables, whole grains, legumes, lean proteins, and foods with omega-3 fatty acids; and to avoid processed foods, refined sugars, too much salt, and saturated or trans fats. Alcohol is strongly discouraged as it will promote the progression of liver disease and risk of fibrosing and developing cirrhosis. A healthy body weight is also maintained by a balance diet and regular physical activity which helps to reduce metabolic complications and improves liver functions. (33)

Patients' nutritional requirements can be met by nutritional counseling provided by qualified health professionals, which can lead to better long-term treatment results. Optimal medical management and frequent clinical review will complement evidence based nutritional strategies, which will decrease oxidative stress, promote liver regeneration, optimize immune function and improve quality of life in those with hepatitis. The key nutritional components, dietary recommendations, and their potential benefits in the management of hepatitis are summarized in Table 1.

Table 1: Nutritional recommendations for patients with hepatitis

Nutritional Component	Recommendation	Benefits for Liver Health
Energy Intake	Consume adequate calories based on age, body weight, physical activity, and disease severity.	Prevents malnutrition and supports liver regeneration.
Carbohydrates	Prefer complex carbohydrates such as whole grains, oats, brown rice, fruits, vegetables, and legumes. Limit refined sugars.	Provides sustained energy, maintains blood glucose levels, and prevents muscle breakdown.
Protein	Include high-quality protein sources such as fish, lean poultry, eggs, low-fat dairy, soy products, pulses, and beans.	Promotes repair and regeneration of liver cells and supports immune function.
Dietary Fats	Choose healthy fats from olive oil, nuts, seeds, avocado, and fatty fish. Limit saturated and trans fats.	Reduces inflammation and supports normal lipid metabolism.
Dietary Fiber	Increase intake of fruits, vegetables, whole grains, legumes, and seeds.	Improves digestion, supports gut microbiota, and helps regulate metabolism.
Vitamin A	Consume carrots, spinach, sweet potatoes, and pumpkin in recommended amounts.	Supports immune function and tissue repair.
Vitamin C	Include citrus fruits, guava, kiwi, berries, tomatoes, and bell peppers.	Acts as an antioxidant and protects liver cells from oxidative damage.
Vitamin D	Obtain through sunlight exposure, fortified foods, eggs, and fatty fish; supplement if deficient.	Supports immune regulation and overall liver health.
Vitamin E	Consume almonds, sunflower seeds, spinach, and vegetable oils.	Reduces oxidative stress and protects hepatocytes.
B-Complex Vitamins	Include whole grains, legumes, dairy products, eggs, meat, and green leafy vegetables.	Supports energy metabolism and liver function.
Zinc	Consume seafood, meat, legumes, nuts, and whole grains.	Enhances immune response and tissue repair.
Selenium	Include Brazil nuts (in moderation), fish, eggs, and whole grains.	Strengthens antioxidant defense and reduces oxidative stress.
Omega-3 Fatty Acids	Consume salmon, sardines, mackerel, flaxseed, chia seeds, and walnuts.	Reduces inflammation and supports liver function.
Antioxidant-Rich Foods	Eat colorful fruits, vegetables, green tea, berries, turmeric, garlic, and ginger regularly.	Neutralizes reactive oxygen species and protects hepatocytes.

4. HERBAL MEDICINE IN HEPATITIS

Herbal medicine has been used for centuries in traditional healthcare systems to manage liver disorders. In recent years, there has been growing scientific interest in medicinal plants because many of them contain natural compounds with antioxidant, anti-inflammatory, antiviral, and hepatoprotective properties. (8) These plants may help protect liver cells from damage, reduce inflammation, improve antioxidant defense, and support liver regeneration. Although herbal medicines should not replace standard antiviral therapy for viral hepatitis, they may serve as complementary interventions when used under appropriate medical supervision. Their effectiveness depends on factors such as plant quality, dosage, standardization, and clinical evidence. (34) The major mechanisms underlying the hepatoprotective effects of medicinal herbs are illustrated in Figure 2.

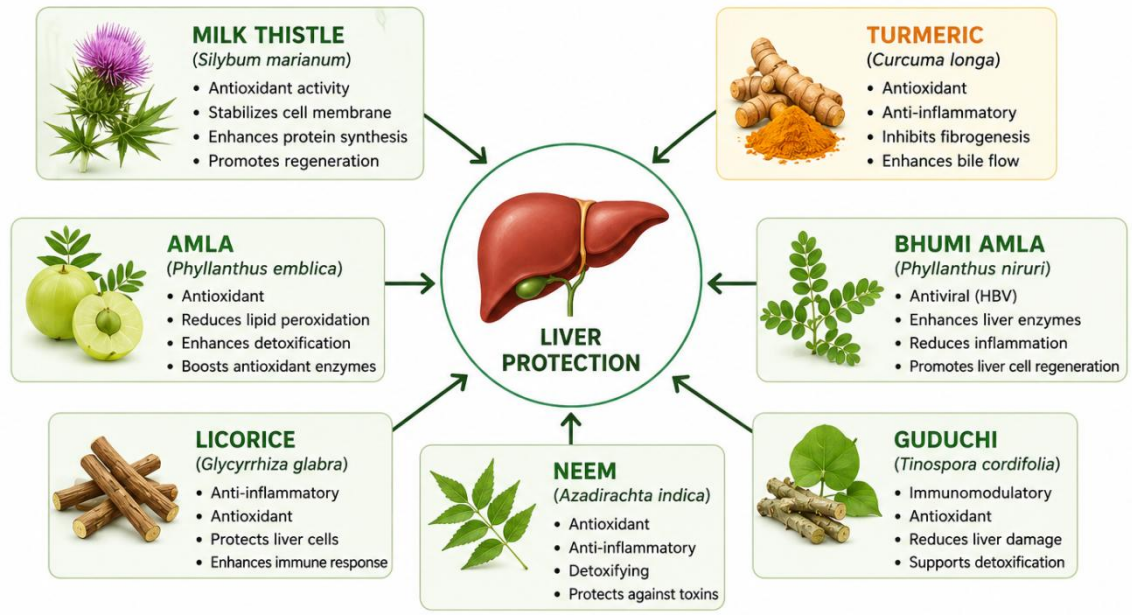


Figure 2: Mechanisms of action of major hepatoprotective herbs.

4.1 Common Hepatoprotective Medicinal Plants

The beneficial effects of several medicinal plants on liver health have been investigated. Of these, one of the most thoroughly studied is milk thistle (*Silybum marianum*). Its active extract, silymarin, has been shown to have antioxidant and membrane stabilizing activity, which could be useful for preventing oxidative damage to hepatocytes and include beneficial effects on liver function. (35)

Turmeric (*Curcuma longa*) has anti-inflammatory and antioxidant properties, owing to the polyphenol curcumin present in it. Curcumin can help to lower inflammatory signaling, oxidative stress, and encourage liver tissue repair. (36) Liquorice (*Glycyrrhiza glabra*) is a plant that contains glycyrrhizin, which is a bioactive compound that is reported to have antiviral, anti-inflammatory and immune-modulatory properties. It has been studied as an adjunctive treatment in chronic viral hepatitis, but has to be monitored for long-term use due to possible adverse effects like hypertension and electrolyte imbalance. (37) *Phyllanthus niruri* is a plant with extensive research on its purported antiviral property against hepatitis B virus (HBV). Experimental research shows that it could help to decrease the number of virus copies and prevent liver cells from getting damaged, but larger clinical trials are required to prove its

clinical efficacy. (38) Kalmegh, *Andrographis paniculata* has a compound called andrographolide, a diterpenoid with anti-inflammatory, antioxidant and immunomodulatory properties. It has been demonstrated to have hepatoprotective activity in various experimental models, through anti-inflammatory and anti-oxidative actions. (39)

There are other medicinal plants that are said to promote liver health with antioxidant activity and anti-inflammatory effects naturally, such as Indian gooseberry (*Phyllanthus emblica*), ginger (*Zingiber officinale*), garlic (*Allium sativum*) and green tea (*Camellia sinensis*). (40) However, the quality of evidence varies among these plants, and additional clinical studies are required before routine therapeutic recommendations can be made.

4.2 Bioactive Phytochemicals

Bioactive phytochemicals are responsible for therapeutic properties of medicinal plants. Their natural substances have several biological effects which support the health of liver. Flavonoids, polyphenols, terpenoids, alkaloids, glycosides, phenolic acids and organosulfur compounds are some of the key categories of phytochemicals. (41)

Flavonoids and polyphenols are well known for their antioxidant properties. They are involved in the elimination of reactive oxygen species, decrease lipid peroxidation, and reduce oxidative damage to cellular constituents. Some of the polyphenolic compounds most widely studied for liver protection include curcumin (from turmeric) and silymarin (from milk thistle). (42) Terpenoids (Andrographolide from *Andrographis paniculata*) show anti-inflammatory and immunomodulatory properties. The antiviral and immune-regulating effect of glycyrrhizin from licorice, and the anti-oxidant and detoxification properties of sulfur compounds contained in garlic have been shown. These phytochemicals work synergistically to maintain normal liver function and help decrease liver damage. (43)

4.3 Mechanisms of Hepatoprotection

Medicinal plants have several complementary mechanisms of protection for the liver. Reduction of oxidative stress is one of the most important mechanisms. Many of the herbs stimulate the activity of the endogenous antioxidant enzymes such as superoxide dismutase, catalase and glutathione peroxidase which help to reduce the damage caused by reactive oxygen species to the cells. Another important mechanism is inhibiting inflammation (44). Herbal phytochemicals help to lower the levels of pro-inflammatory cytokines like tumour necrosis factor alpha (TNF-α), interleukin-1 beta (IL-1 β) and interleukin-6 (IL-6). These inflammatory mediators can be controlled, preventing liver cell damage and promoting tissue repair. (45) A few of the medicinal plants also possess antiviral properties that inhibit the replication process of viruses or increase the immune system's ability to fight the virus. Several phytochemicals also stabilize hepatocyte membranes, maintain mitochondrial function, prevent programmed cell death (apoptosis), and regenerate liver cells that have been damaged. (46)

Other positive effects of herbal medicines include the fact that they can help decrease liver fibrosis. Some phytochemicals inhibit the overproduction of collagen after chronic liver injury, caused by the activation of hepatic stellate cells. These compounds help in preventing collagen deposition and extracellular matrix materials, which slow the fibrosis process and minimize the risk of cirrhosis. (47) Medicinal plants, in general, have hepatoprotective properties via several biological mechanisms, instead of one. They have several promising antioxidant, anti-inflammatory, antiviral, antifibrotic and immunomodulatory properties that suggest they have a potential role in liver health. Their clinical use should be based on scientific evidence, standardized formulations and thorough evaluation

of their safety, including their dosage and product quality and their possible interaction with other drugs. The major mechanisms underlying the hepatoprotective effects of medicinal herbs are illustrated in Figure 2.

Table 2: Major medicinal plants, active constituents, mechanisms of action, and clinical evidence

Medicinal Plant	Common Name	Active Constituents	Mechanism of Hepatoprotection	Clinical Evidence
Silybum marianum	Milk thistle	Silymarin (silibinin, silydianin, silychristin)	Antioxidant, anti-inflammatory, membrane stabilization, promotes liver cell regeneration	Several clinical trials report improvement in liver enzyme levels and oxidative stress; evidence is promising but remains inconsistent.
Curcuma longa	Turmeric	Curcumin	Antioxidant, anti-inflammatory, inhibits inflammatory signaling, reduces oxidative stress	Clinical studies suggest improvement in inflammatory markers and liver function; additional large-scale trials are needed.
Glycyrrhiza glabra	Licorice	Glycyrrhizin, liquiritigenin	Antiviral, anti-inflammatory, immunomodulatory, antioxidant	Reported to improve liver enzyme levels in chronic hepatitis; prolonged use requires monitoring due to possible adverse effects.
Phyllanthus niruri	Stonebreaker	Lignans, flavonoids, phyllanthin, hypophyllanthin	Antiviral, antioxidant, hepatocyte protection, immune modulation	Some studies indicate antiviral activity against hepatitis B virus; overall clinical evidence remains limited.
Andrographis paniculata	Kalmegh	Andrographolide	Antioxidant, anti-inflammatory, immunomodulatory, reduces oxidative damage	Experimental and preliminary clinical studies demonstrate hepatoprotective effects; further clinical validation is required.
Phyllanthus emblica	Indian gooseberry (Amla)	Vitamin C, emblicanin A & B, gallic acid, ellagic acid	Potent antioxidant, anti-inflammatory, reduces lipid peroxidation	Limited clinical studies indicate improvement in antioxidant status and liver function.
Zingiber officinale	Ginger	Gingerols, shogaols, zingerone	Antioxidant, anti-inflammatory, improves lipid metabolism	Preliminary clinical studies suggest beneficial effects on liver function and inflammation; more evidence is needed.
Allium sativum	Garlic	Allicin, S-allyl cysteine, organosulfur compounds	Antioxidant, anti-inflammatory, enhances detoxification enzymes	Clinical studies suggest improvements in oxidative stress and metabolic health; evidence specific to hepatitis is limited.
Camellia sinensis	Green tea	Catechins (EGCG), flavonoids	Antioxidant, anti-inflammatory, protects hepatocytes from oxidative injury	Some clinical studies show improvement in antioxidant capacity; excessive intake of concentrated extracts should be avoided.

Tinospora cordifolia	Guduchi	Tinosporaside, berberine, diterpenoids	Immunomodulatory, antioxidant, anti-inflammatory	Traditional use is well documented; clinical evidence in hepatitis is still limited and requires further investigation.

5. CLINICAL EVIDENCE

The use of nutrition and herbal medicine in hepatitis has gained considerable attention because of their potential to improve liver health and complement conventional treatment. Over the past two decades, several clinical trials have evaluated the effects of dietary interventions, antioxidant supplementation, and herbal medicines in patients with acute and chronic hepatitis. Although many studies have reported encouraging findings, the overall quality of evidence varies due to differences in study design, sample size, treatment duration, and herbal formulations. Therefore, current evidence supports the use of nutritional and herbal interventions as complementary approaches rather than replacements for standard medical therapy. (48)

5.1 Evidence from Clinical Trials

Nutritional management has been demonstrated to enhance the nutritional status, immune function and quality of life of CLD patients in clinical studies. More fruits and vegetables, whole grains, lean protein and healthy fats in a diet have been linked to improved liver function and fewer metabolic complications. Antioxidants, including vitamins C and E, omega-3 fatty acids and zinc, have been found to be useful with certain patient populations in lowering oxidative stress and improving biochemical markers of liver function. The advantages, however, depend on the patient's nutritional status, the severity of the disease and the overall eating habits of the patient. (49)

A number of medicinal plants have also undergone clinical trials. Milk thistle (*Silybum marianum*) has been widely researched as a herbal remedy for liver disease. It has been reported that supplementation with silymarin has resulted in decreasing liver enzymes and oxidative stress. Likewise, curcumin derived from turmeric (*Curcuma longa*) has been shown to have anti-inflammatory and antioxidant properties, and a few clinical trials have indicated mild improvements in liver function markers and inflammatory markers. (50) The study of Licorice (*Glycyrrhiza glabra*) has been conducted primarily in chronic viral hepatitis due to its antiviral and anti-inflammatory effects. Other studies have indicated that glycyrrhizin can help increase levels of liver enzymes and decrease inflammation in the liver. (51) Some clinical studies have revealed phyllanthin (*Phyllanthus niruri*) to possess antiviral activity against hepatitis B virus, but results have been inconsistent. Preliminary clinical studies have revealed hepatoprotective activity for other medicinal plants like Andrographis paniculata, ginger (Zingiber officinale), and Indian gooseberry (Phyllanthus emblica), which need to be subjected to further large scale randomized controlled trials. (38)

In summary, existing clinical data suggest that nutrition and specific herbal drugs have a positive impact on liver function, decrease oxidative stress, and can improve the quality of life in patients receiving treatment. But higher quality evidence is required before these interventions can be routinely recommended in clinical guidelines.

5.2 Benefits and Limitations

In the treatment of hepatitis, there are many potential benefits of nutrition and herbal medicine. A balanced diet will help liver to regenerate, boost immune system function, improve nutritional status and decrease inflammation and oxidative stress. Medicinal plants can also be used as a source of bioactive compounds that exhibit antioxidant, anti-

inflammatory, antiviral and antifibrotic properties, hence may have hepatoprotective and disease modifying effects. (52)

One of the benefits is that many of the medicinal plants are plentiful and are used for a long time. If prepared correctly and administered under the direction of a professional, they can enhance symptom control, quality of life, and be used in conjunction with regular treatment. (53)

However, there are some drawbacks. Several clinical studies have small numbers of subjects, differing study designs, and limited follow up periods, making it hard to compare results from these studies. Herbal medicines have inconsistent clinical effects, as they may contain different amounts of active ingredients and from different plants, under different growing conditions and extraction processes. Many of the studies also only take laboratory markers into account, not longer-term clinical results like prevention of fibrosis, cirrhosis or liver cancer. (54) Thus, large, well designed and multi center clinical studies would be required to determine their long term efficacy and safety with standardized herbal preparations.

5.3 Safety and Herb-Drug Interactions

Herbal medicines are generally perceived as being natural, but they do not always lack side effects. Consuming large amounts of some medicinal plants or from using them for an extended period of time may lead to allergic reactions, gastrointestinal discomfort or changes in blood pressure and electrolyte balance. Safety can also be impacted by the quality of the product, its contamination, adulteration, or improper identification of the plant. (55)

One of the big questions is whether there are any herb-drug interactions. Some herbs can interact with conventional drugs by changing the way they are absorbed, metabolized, or eliminated from the body, such as by interacting with liver enzymes and drug transport proteins. These interactions can decrease the impact of anti-viral drugs, or make them more likely to have a bad side effect. For instance, extended consumption of licorice can cause high blood pressure and low potassium, and some herbals can affect the metabolism of certain drugs. (56)

Antiviral and other medications for associated conditions are often given to patients with hepatitis. Hence, it is advisable to use herbal products only after consulting with the qualified health care professionals. A thorough history of herbal supplement intake should be taken, liver function should be checked on a frequent basis and patients should be counseled on the need for standardized and quality-assured herbal products.

To conclude, there are current clinical findings that indicate potential supportive role of nutrition and selected medicinal plants in the management of hepatitis. However, these interventions should be used in addition to evidence-based medical treatment. (57) Future research is needed to perform well-designed randomized clinical trials, standardize the herbal formulations and increase knowledge about herb-drug interactions to achieve safe and effective use in clinical practice.

6. FUTURE DIRECTIONS

Although significant progress has been made in the management of hepatitis, there is still a need for effective complementary approaches that improve liver health and patient outcomes. Future research should focus on developing evidence-based nutritional strategies and standardized herbal therapies that can be safely integrated with conventional treatment.

Personalized nutrition is a novel therapy where nutrition recommendations are made according to the nutritional status, age, disease stage, metabolic profile and lifestyle of each individual. Rather than implementing a fixed diet for everybody, the nutrition can be individualized to the needs of the patient's clinical condition. This personalized nutrition approach can enhance the effectiveness of treatment, aid liver regrowth, lower inflammation and prevent nutritional deficiencies. Reliable nutritional biomarkers should be identified for future studies to use as guidance to develop personalized nutritional interventions for patients with hepatitis. (58, 59) Advances in pharmaceutical technology have created opportunities to develop safer and more effective herbal products. Standardized phytopharmaceuticals with well characterized bioactive compounds and proved quality, safety and efficacy needs to be focused on future research. New drug delivery technologies like nanoparticles, liposomes and phytosomes could enhance the stability, bioavailability and therapeutic activity of herbal medicines like curcumin and silymarin. Modern formulation techniques like these in conjunction with strict clinical assessment could improve the clinical value of plant based treatments for liver diseases. (60)

Though promising results, there are a number of significant research gaps. Many clinical studies have small numbers of patients, short treatment periods, and use different herbal formulations, which makes it difficult to draw firm conclusions from these studies. Additionally, there are no standardized doses, long term safety information, and extensive herb-drug interaction studies. (61) Randomized controlled trials with large population and multicenter are recommended and it is suggested to use standardized herbal formulations and well established clinical data. The molecular mechanisms of medicinal plants are also an area that needs greater attention and reliable biomarkers for monitoring treatment response should be identified. In summary, future developments in personalized nutrition, the standardized phytopharmaceuticals, and quality clinical studies will contribute to the further development and consolidation of nutrition and herbal medicine as complementary approaches for liver health and hepatitis management.

7. CONCLUSION

Hepatitis continues to be a significant contributor to liver disease in the world and is best managed comprehensively. Aside from conventional medical treatment, a healthy diet and evidence based herbal medicine can be helpful supportive measures for a healthy liver. The essential nutrients, antioxidants and functional foods found in a balanced diet help to minimize oxidative stress, aid in maintaining a healthy immune system, and repair damage to liver cells. Likewise, various medicinal plants such as milk thistle, turmeric, liquorice, *Phyllanthus niruri* and *Andrographis paniculata* are rich in antioxidant, anti-inflammatory, antiviral and hepatoprotective bioactive compounds which can be used as an adjunct to conventional treatment.

Based on available evidence from current clinical trials, there is a possibility of improving liver function with nutrition interventions and selected herbal medicines in the case of patients with hepatitis B or C, resulting in an improvement of the quality of life of patients. Variation in the preparation of herbs, however, and the lack of well designed clinical trials and uncertainty over long term safety and herb-drug interactions, suggest further research is needed. Standardized herbal formulations, personalization of nutrition and well designed multi-center clinical trials are fields that should be investigated in the future to confirm their efficacy and safety. Finally, a combined therapy of balanced nutrition and science based herbal medicine could be a potential complementary treatment of hepatitis. However, these

interventions will need to be optimized and liver health and outcomes will need to be improved through continued research and clinical practice with solid evidence.

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