

Review on herbal drugs used in liver disorders

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Abstract:

Liver disorders represent a significant global health burden due to the central role of the liver in metabolism, detoxification, and maintenance of physiological balance. A wide range of factors, including viral infections, excessive alcohol consumption, metabolic disturbances, drug toxicity, and environmental pollutants, contribute to liver damage, leading to conditions such as hepatitis, fatty liver disease, fibrosis, cirrhosis, and hepatocellular carcinoma. Although modern medical therapies are available, their effectiveness is often limited by adverse effects, high cost, drug resistance, and lack of complete recovery in chronic conditions.

In recent years, herbal medicines have gained considerable attention as alternative and complementary therapeutic options for liver disorders. Medicinal plants such as *Silybum marianum*, *Phyllanthus niruri*, *Picrorhiza kurroa*, *Andrographis paniculata*, *Boerhavia diffusa*, *Glycyrrhiza glabra*, *Curcuma longa*, *Tinospora cordifolia*, *Eclipta alba*, and *Embllica officinalis* have been widely studied for their hepatoprotective properties. These plants contain bioactive compounds that exert therapeutic effects through multiple mechanisms, including antioxidant activity, anti-inflammatory action, inhibition of fibrosis, enhancement of detoxification, and promotion of hepatocyte regeneration.

This review provides a comprehensive overview of liver disorders, their pathophysiology, and the role of herbal medicines in liver protection. It also discusses the mechanisms of action, polyherbal formulations, traditional preparations, safety considerations, toxicity evaluation, and quality control measures of herbal drugs. Furthermore, recent advances such as nanotechnology-based delivery systems and the concept of personalized herbal medicine are highlighted. Overall, herbal medicines offer a promising, cost-effective, and holistic approach for the management of liver diseases, although further scientific validation and standardization are essential for their integration into modern healthcare systems.

Keywords:

Liver disorders, Hepatoprotection, Herbal medicine, Medicinal plants; Antioxidant activity, Anti-inflammatory effects, Liver fibrosis, Hepatocyte regeneration, Phytochemicals, Polyherbal formulations, Liver cirrhosis, Hepatitis; Fatty liver disease.

1. Introduction:

The liver is the largest internal organ and performs many vital metabolic, exocrine, and endocrine functions. Its main jobs include producing and secreting bile, processing nutrients and food components, and detoxifying substances from both inside and outside the body. The liver also helps regulate glucose by making and storing glycogen. Additionally, it supports stable blood conditions by producing clotting factors and important serum proteins, especially albumin (Zorn, 2008).

over 5,000 distinct bodily functions, such as helping with blood clotting, cleaning the blood, turning food into nutrients, regulating hormone levels, fighting infections and diseases, healing after injuries, and breaking down cholesterol, glucose, and iron while keeping their levels balanced (Sivakrishnan, 2019).

2. Functions and importance of liver:

The liver is the largest solid internal visceral organ of the human body and performs a wide range of vital physiological functions. Historically, it has been regarded as a central organ associated with vitality and various mental and emotional activities. Physiologically, the liver serves as a major metabolic center, participating in numerous biochemical and regulatory processes essential for maintaining homeostasis. It also functions as an accessory organ of the gastrointestinal system.

The liver's primary roles include the metabolism of nutrients and the excretion of metabolic waste products. It is actively involved in carbohydrate, lipid, and protein metabolism, and plays a crucial role in maintaining blood glucose balance through glycogen storage and release. In addition, the liver is responsible for the detoxification and metabolism of drugs and toxic substances, thereby protecting the body from harmful compounds (Mohajan, 2025).

3. Overview of liver disorders:

Chronic liver diseases constitute a significant global health challenge and contribute substantially to the growing burden of disease worldwide. Among these disorders, liver cirrhosis, which results from prolonged and progressive liver injury, is recognized as a major cause of morbidity and mortality across the globe. According to Cheemerla and Balakrishnan, liver cirrhosis was responsible for approximately 1.32 million deaths worldwide in 2017. Furthermore, cirrhosis ranks 11th among the leading causes of death globally and is also a major contributor to long-term disability, thereby imposing a considerable burden on healthcare systems and affected populations (Kumar et al., 2023).

4. Causes of liver diseases:

Liver diseases can arise from a wide range of etiological factors, including infections, metabolic disturbances, and exposure to toxins, autoimmune conditions, and genetic abnormalities. Among these, viral infections represent one of the most common causes, particularly those caused by hepatitis viruses such as hepatitis A, B, C, D, and E, which may lead to acute or chronic inflammation of the liver. Another major cause is excessive alcohol consumption, which can result in progressive liver disorders including alcoholic fatty liver disease, alcoholic hepatitis, and eventually liver cirrhosis due to sustained hepatocellular damage.

In recent years, non-alcoholic fatty liver disease (NAFLD) has become increasingly prevalent and is closely linked with obesity, diabetes mellitus, and metabolic syndrome. Liver injury may also occur due to drug-induced toxicity or exposure to harmful chemicals, as certain medications and environmental toxins can damage hepatocytes. Moreover, autoimmune disorders, such as autoimmune hepatitis, develop when the immune system mistakenly attacks healthy liver cells. In addition, genetic and metabolic conditions, including Wilson's disease and hemochromatosis, can disrupt normal liver function by causing the abnormal accumulation of metals or metabolic products within liver tissues (Kumar et al., 2021).

5. Limitations of modern therapy:

Modern pharmacological and interventional approaches have significantly improved the management of liver diseases such as hepatitis, cirrhosis, non-alcoholic fatty liver disease (NAFLD), and hepatocellular carcinoma. Despite these advances, several important limitations remain, which continue to affect treatment outcomes and patient quality of life.

5.1. Limited curative potential:

Many chronic liver diseases, particularly cirrhosis and advanced fibrosis, cannot be completely reversed with currently available therapies. Most treatment strategies primarily aim to slow disease progression and reduce complications rather than provide a definitive cure.

5.2. Adverse drug reactions:

Drugs commonly used in the treatment of liver disorders, including antiviral agents and immunosuppressive drugs, may produce significant side effects such as nephrotoxicity, metabolic abnormalities, and drug-induced hepatotoxicity. These adverse effects may limit long-term use and reduce patient adherence to therapy.

5.3. Delayed diagnosis:

Liver diseases often remain asymptomatic in the early stages, making early detection difficult. As a result, many patients are diagnosed only after significant structural and functional damage to the liver has already occurred, which reduces the effectiveness of available treatments.

5.4. High cost of therapy:

Advanced treatment options such as direct-acting antiviral drugs for hepatitis C, biological therapies, and liver transplantation are often expensive.

This high cost restricts accessibility, particularly in low- and middle-income countries, where healthcare resources may be limited.

5.5. Development of drug resistance:

Long-term use of antiviral medications, especially in chronic infections such as hepatitis B and hepatitis C, may lead to the development of drug resistance, thereby reducing therapeutic effectiveness and complicating disease management.

5.6. Limited availability of donor organs:

Liver transplantation remains the only definitive treatment option for end-stage liver disease. However, the shortage of suitable donor organs significantly limits the number of patients who can benefit from this life-saving procedure.

5.7. Complex pathophysiology of liver diseases:

Liver disorders involve multiple pathological mechanisms, including inflammation, oxidative stress, fibrosis, immune dysregulation, and metabolic disturbances. Because of this complexity, treatment with a single drug is often insufficient to effectively target all underlying disease pathways (Asrani et al., 2019).

6. Role of herbal drugs in liver protection:

The liver is the largest internal organ of the human body and performs a wide range of vital functions, including metabolism, detoxification, digestion, and storage of essential nutrients. It plays an important role in eliminating harmful substances such as toxins, drugs, and alcohol, thereby protecting the body from chemical damage. Continuous exposure to toxic substances, infectious agents, excessive alcohol intake, and unhealthy lifestyle habits can injure liver cells and may lead to the development of liver disorders such as hepatitis, cirrhosis, fatty liver disease, and liver cancer.

Although modern pharmacological therapies are available for the treatment of liver diseases, they possess certain limitations, including adverse effects, high treatment cost, and limited effectiveness in chronic conditions. Due to these limitations, herbal medicines are increasingly being used as alternative or supportive approaches for liver protection. Medicinal plants contain various natural bioactive compounds that may help in preventing liver damage, promoting regeneration of liver cells, and improving overall liver function (Kshirsagar & Mohite, 2008).

7. Liver disorders:

Liver disorders comprise a wide range of diseases and pathological conditions that affect the normal structure and physiological functioning of the liver. The liver is an essential organ responsible for several vital functions, including the metabolism of carbohydrates, proteins, and lipids; detoxification of harmful substances such as drugs, alcohol, and environmental toxins; synthesis of plasma proteins and clotting factors; storage of glycogen, vitamins, and minerals; and production of bile necessary for digestion and absorption of fats. Disruption of these critical functions due to infections, toxic exposures, metabolic disturbances, autoimmune reactions, genetic abnormalities, or unhealthy lifestyle factors may result in the development of liver diseases. Liver disorders may be classified as acute or chronic depending on the duration and progression of the disease. Acute liver disorders develop rapidly within a short period, often as a result of viral infections, drug toxicity, or exposure to toxic chemicals. In contrast, chronic liver diseases progress gradually over months or years and may lead to continuous damage to liver cells. Persistent injury to hepatic tissue can cause inflammation, fibrosis, cirrhosis, liver failure, and hepatocellular carcinoma. Common examples of liver disorders include hepatitis (viral and non-viral), alcoholic and non-alcoholic fatty liver disease, liver fibrosis, cirrhosis, cholestasis, and liver cancer. Because the liver plays a central role in maintaining metabolic balance and removing harmful substances from the body, impairment of liver function can significantly influence overall health.

The global incidence of liver disorders has increased due to factors such as unhealthy dietary patterns, excessive alcohol intake, sedentary lifestyle, exposure to environmental toxins, and drug-induced liver toxicity. Early diagnosis and appropriate therapeutic intervention are essential to prevent disease progression and related complications. Therefore, a clear understanding of liver disorders is necessary for the development of effective

preventive and therapeutic approaches aimed at improving liver health and reducing disease burden (Kumar et al., 2021).

8. Classification of liver disorders:

Liver disorders can be classified according to their cause, duration, structural changes, and functional abnormalities. The liver is an essential organ responsible for performing numerous vital activities such as metabolism of carbohydrates, proteins, and lipids, detoxification of harmful substances, synthesis of important proteins, and production of bile required for digestion of fats. Any alteration in the normal structure or functioning of the liver may lead to various hepatic diseases. Proper classification of liver disorders is important because it helps in accurate diagnosis, effective treatment planning, and understanding the severity and progression of disease.

8.1. Based on duration of disease:

8.1.1. Acute liver disorders:

Acute liver disorders occur suddenly and progress rapidly within a short period of time. These conditions are commonly caused by viral infections, toxic substances, drug overdose, or chemical poisoning. Acute liver damage may significantly reduce liver function in a short duration and therefore requires timely medical management.

Examples:

- Acute hepatitis
- Acute liver failure

8.1.2. Chronic liver disorders:

Chronic liver disorders develop slowly and continue for a long period, usually more than six months. Persistent injury to liver tissue over time may result in permanent structural damage and gradual decline in liver function.

- Examples:
- Chronic hepatitis
- Cirrhosis
- Chronic fatty liver disease

8.2. Based on etiology (cause):

8.2.1. Infectious liver disorders:

Infectious liver diseases are caused by microorganisms such as viruses, bacteria, or parasites that invade liver tissue and produce inflammation or cellular damage. Viral infections are among the leading causes of liver disorders worldwide.

Examples:

- Viral hepatitis (Hepatitis A, B, C, D, E)

8.2.2. Alcoholic liver disease:

Alcoholic liver disease develops due to prolonged and excessive intake of alcohol, which gradually damages liver cells and impairs normal liver function.

Examples:

- Alcoholic fatty liver
- Alcoholic hepatitis
- Alcoholic cirrhosis

8.2.3. Non-alcoholic fatty liver disease (NAFLD):

Non-alcoholic fatty liver disease occurs when excess fat accumulates in liver cells in individuals who consume little or no alcohol. It is commonly associated with conditions such as obesity, diabetes mellitus, insulin resistance, and metabolic syndrome.

8.2.4. Drug-induced liver disorders:

Some medications and chemical substances can produce harmful effects on liver tissue, resulting in liver injury or impairment of liver function. The severity of liver damage depends on factors such as dosage, duration of use, and individual sensitivity.

Examples:

- Paracetamol toxicity
- Hepatotoxicity caused by anti-tubercular drugs

8.2.5. Autoimmune liver disorders:

Autoimmune liver disorders occur when the body's immune system mistakenly attacks its own liver cells, leading to inflammation and progressive liver damage.

Examples:

- Autoimmune hepatitis
- Primary biliary cholangitis

8.2.6. Genetic or metabolic liver disorders:

These liver diseases arise due to inherited metabolic defects that interfere with normal biochemical processes of the liver, resulting in accumulation of harmful substances within liver tissue.

Examples:

- Wilson's disease
- Hemochromatosis

8.3. Based on pathological changes:**8.3.1. Hepatitis:**

Hepatitis refers to inflammation of liver cells caused by viral infections, alcohol consumption, drugs, toxins, or autoimmune reactions.

8.3.2. Fatty liver (Steatosis):

Fatty liver disease is characterized by excessive accumulation of fat inside liver cells, which affects normal metabolic and physiological functions of the liver.

8.3.3. Fibrosis:

Fibrosis occurs due to excessive formation of fibrous connective tissue in response to long-term liver injury, gradually disturbing normal liver structure.

8.3.4. Cirrhosis:

Cirrhosis represents an advanced stage of chronic liver disease characterized by permanent scarring, distortion of liver architecture, and progressive loss of liver function.

8.3.5. Liver cancer (Hepatocellular Carcinoma):

Liver cancer is a malignant condition that develops from liver cells, often associated with chronic liver disorders such as cirrhosis or prolonged viral hepatitis infection.

8.4. Based on functional disturbance:**8.4.1. Cholestatic disorders:**

Cholestatic liver disorders occur due to impaired production or obstruction of bile flow, leading to accumulation of bile components within the liver and bloodstream.

Examples:

- Cholestasis
- Biliary obstruction

8.4.2. Hepatocellular disorders:

Hepatocellular disorders mainly affect hepatocytes (liver cells), resulting in impairment of metabolic, synthetic, and detoxification functions of the liver.

Examples:

- Viral hepatitis
- Drug-induced liver injury (Kumar et al., 2020)

9. Hepatitis:

Hepatitis is a medical condition characterized by inflammation of the liver, which interferes with its normal physiological functions such as metabolism of nutrients, detoxification of harmful substances, synthesis of proteins, and production of bile necessary for digestion. The disease may present as acute (short-term) or chronic (long-term), depending on the duration and extent of liver injury. Hepatitis may develop due to various causes including viral infections, excessive alcohol consumption, autoimmune reactions, or exposure to hepatotoxic drugs and toxic chemicals. Inflammation of liver tissue results in damage to hepatocytes (liver cells), and if left untreated, it may progress to more serious complications such as fibrosis, cirrhosis, or liver failure (Kumar et al., 2020).

Viral infections are considered the most common cause of hepatitis, particularly infections caused by Hepatitis A, B, C, D, and E viruses. Hepatitis A and Hepatitis E are usually transmitted through contaminated food or water and are often associated with poor sanitation conditions. In contrast, Hepatitis B, Hepatitis C, and Hepatitis D are primarily transmitted through infected blood, use of unsterilized needles, unsafe blood transfusions, sexual contact, or transmission from an infected mother to her child. In addition to viral causes, long-term alcohol consumption, misuse or overdose of certain medications such as paracetamol, and autoimmune conditions in which the immune system attacks liver cells may also lead to inflammation of the liver (World Health Organization, 2023).

The symptoms of hepatitis may vary depending on severity and stage of the disease. Common clinical manifestations include fatigue, loss of appetite, nausea, vomiting, abdominal discomfort, dark-colored urine, pale stools, and jaundice, which is characterized by yellow discoloration of the skin and eyes. In early stages, some individuals may not experience noticeable symptoms, making early detection difficult. Diagnosis of hepatitis is generally based on liver function tests, detection of viral markers in blood, and imaging techniques such as ultrasound. Early diagnosis, proper medical treatment, balanced nutrition, avoidance of alcohol, and healthy lifestyle practices play an important role in preventing disease progression and maintaining normal liver function (Schiff et al., 2017).

10. Fatty liver disease:

Alcoholic liver disease (ALD) and non-alcoholic fatty liver disease (NAFLD) are among the most common causes of chronic liver disorders worldwide and represent a major burden on public health. Both conditions are characterized by similar structural changes in liver tissue, especially the abnormal accumulation of fat within liver cells, a condition known as steatosis. If the disease progresses, both ALD and NAFLD may lead to serious complications such as fibrosis, cirrhosis, and hepatocellular carcinoma. Although these disorders share certain pathological similarities, they differ mainly in their underlying causes, and careful examination of histological patterns can assist in differentiating between the two conditions.

Alcoholic liver disease occurs primarily due to prolonged and excessive consumption of alcohol, which gradually damages liver cells and interferes with normal liver function. Over time, continued alcohol intake may lead to progressive stages of liver injury, including alcoholic fatty liver, alcoholic hepatitis, and alcoholic cirrhosis, which may eventually result in end-stage liver disease. In contrast, non-alcoholic fatty liver disease develops in individuals who consume little or no alcohol and is commonly associated with metabolic conditions such as obesity, type 2 diabetes mellitus, insulin resistance, and abnormal lipid metabolism. In many cases of NAFLD, simple fat accumulation in the liver may not immediately lead to severe damage; however, the presence of non-alcoholic steatohepatitis (NASH), characterized by inflammation and cellular injury, indicates a greater likelihood of progressive liver disease and possible development of cirrhosis.

NAFLD observed in children and adolescents shows certain differences in clinical presentation and tissue changes when compared with adult forms of the disease, suggesting that pediatric NAFLD may represent a distinct clinical entity. Furthermore, the global increase in obesity and metabolic syndrome has contributed to a higher incidence of both non-cancerous and cancerous liver tumors. To better understand disease severity and monitor therapeutic response, several histological scoring systems have been developed for ALD and NAFLD. These scoring methods are useful in clinical research and practice, as they help evaluate disease progression and assist healthcare professionals in selecting appropriate treatment strategies (Sung et al., 2014).

11. Cirrhosis:

Cirrhosis is a long-standing liver disease that develops due to persistent injury to liver tissue caused by various harmful factors such as chronic infections, excessive alcohol consumption, metabolic disorders, or toxic substances. Continuous damage to hepatocytes results in ongoing inflammation and activation of fibrotic processes, leading to excessive deposition of connective tissue within the liver. Microscopically, cirrhosis is characterized by the formation of regenerative nodules of liver cells that are enclosed by thick fibrous septa. These structural alterations progressively disrupt the normal architecture of the liver, resulting in loss of healthy liver tissue and collapse of normal hepatic organization. Consequently, the normal vascular structure of the liver becomes markedly altered.

The distortion of hepatic blood vessels increases resistance to blood flow through the portal circulation, leading to portal hypertension. At the same time, the ability of the liver to carry out essential synthetic functions, including the production of albumin, clotting factors, and other vital proteins, becomes significantly impaired. From a clinical perspective, cirrhosis is regarded as an advanced and largely irreversible stage of chronic liver disease that may lead to severe complications and increased risk of mortality if not appropriately managed. In cases of end-stage cirrhosis, liver transplantation is often considered the most effective treatment option. Preventive strategies and clinical management commonly include regular screening for complications such as esophageal varices and hepatocellular carcinoma, which are frequently associated with severe liver damage (Tsochatzis et al., 2014).

12. Liver fibrosis:

Liver fibrosis is a pathological condition that occurs as a result of long-term or repeated injury to liver tissue and is characterized by excessive deposition of extracellular matrix (ECM) components, particularly collagen. This condition is commonly observed in many chronic liver diseases and represents an important intermediate stage in the progression of liver damage. The most common causes of liver fibrosis in developed countries include chronic infection with hepatitis C virus (HCV), long-term alcohol abuse, and non-alcoholic steatohepatitis (NASH). Continuous accumulation of ECM proteins gradually alters the normal structure of the liver by forming fibrous scar tissue. With ongoing injury, fibrotic tissue may lead to the formation of regenerative nodules of hepatocytes, ultimately progressing to cirrhosis. Cirrhosis is associated with significant impairment of liver function and increased resistance to intrahepatic blood flow, which can result in complications such as portal hypertension and hepatic insufficiency.

Previously, liver fibrosis was believed to be a passive and irreversible process resulting from destruction of normal liver tissue and its replacement with dense collagen-rich material. However, current scientific understanding describes liver fibrosis as an active and regulated biological response similar to wound healing that occurs following chronic liver injury. Early clinical studies conducted in the 1970s suggested that even advanced stages of fibrosis might be partially reversible if the underlying cause of liver injury is removed or effectively treated. Interest in the cellular mechanisms of liver fibrosis increased during the 1980s when hepatic stellate cells (HSCs), also known as Ito cells or perisinusoidal cells, were identified as the primary cells responsible for producing collagen and other ECM components in the liver. These cells, originally described by von Kupffer in the nineteenth century, undergo activation in response to chronic liver damage and acquire fibrogenic characteristics that contribute to progression of fibrosis. Later, improved laboratory techniques enabled isolation of hepatic stellate cells from both animal and human liver tissue, facilitating detailed study of their biological behavior. Cultured hepatic stellate cells became a valuable experimental model for understanding cellular activation processes and mechanisms involved in the development and progression of liver fibrosis (Bataller & Brenner, 2005).

13. Jaundice:

Jaundice is a medical condition characterized by a yellowish discoloration of the skin, sclera (the white portion of the eyes), and mucous membranes due to the accumulation of the bile pigment bilirubin in body tissues. Bilirubin is a naturally occurring pigment produced during the normal breakdown of heme, an essential component of hemoglobin found in red blood cells. Under normal physiological conditions, bilirubin is processed by the liver and excreted through bile. However, when bilirubin levels increase excessively in the bloodstream, it may accumulate in tissues and produce the characteristic yellow coloration. Elevated bilirubin levels can be particularly harmful in newborn infants, as excessive bilirubin may affect the central nervous system and lead to serious complications if not treated promptly. The term “jaundice” originates from the French word *jaune*, meaning yellow, which describes the typical appearance of affected individuals.

Jaundice is an indication of hyperbilirubinemia, a condition in which the concentration of bilirubin in the blood rises above normal limits. The increased bilirubin level may occur in either conjugated (water-soluble) or

unconjugated (water-insoluble) form, depending on the underlying cause of the disorder. Clinical symptoms of jaundice usually become noticeable when the serum bilirubin concentration exceeds approximately 2 mg/dL (34.2 μ mol/L). Bilirubin is mainly produced from the degradation of the hemoglobin component. The heme molecule is broken down by the enzyme heme oxygenase at the alpha-methene bridge, resulting in the formation of biliverdin along with the release of iron and carbon monoxide. Biliverdin is then converted into bilirubin by the enzyme biliverdin reductase. After its formation, bilirubin is transported to the liver, where it undergoes further metabolic processing to facilitate its elimination from the body through bile (Abbas et al., 2016).

14. Drug-induced liver injury:

Drug-induced liver injury (DILI) is a significant medical concern because many commonly prescribed medications and chemical substances have the potential to adversely affect liver function. Identifying liver injury caused by drugs can be difficult, as a wide variety of medications are capable of producing liver damage, and the clinical manifestations often vary from mild abnormalities to severe liver failure. In many cases, there are no specific symptoms that clearly confirm drug-related hepatotoxicity, which makes diagnosis more complex. A large number of pharmaceutical agents have been reported to cause liver injury, and adverse hepatic effects remain one of the leading reasons for discontinuation or withdrawal of approved drugs from clinical use. Drug-induced liver injury also contributes substantially to cases of acute liver failure globally.

Among the various drugs associated with hepatotoxicity, paracetamol (acetaminophen) is recognized as one of the most common causes of acute liver failure, particularly when taken in excessive doses. Clinical observations over the years have indicated an increase in the proportion of acute liver failure cases linked to paracetamol toxicity. However, it is uncertain whether this apparent increase represents a true rise in paracetamol-related liver injury or a relative decrease in other causes of acute liver failure, such as viral hepatitis. Apart from paracetamol, several other medications have also been associated with liver damage, particularly antibacterial agents. Anti-tubercular drugs are considered one of the most important classes of medications responsible for non-paracetamol-related hepatotoxicity.

Despite growing awareness, the actual frequency and severity of drug-induced liver injury are often underestimated in the general population. Clinical studies suggest that a proportion of hospitalized patients may develop liver injury during treatment due to adverse drug reactions. Early detection of drug-related hepatotoxicity is therefore essential to prevent serious complications and improve patient outcomes. A better understanding of the mechanisms responsible for liver injury, along with careful monitoring of medication use and patient response, plays an important role in minimizing the risk of liver damage and ensuring safer therapeutic practices (Kaplowitz, 2004).

15. Hepatocellular carcinoma:

Hepatocellular carcinoma (HCC) is the most frequently occurring primary malignancy of the liver and is considered a major contributor to cancer-related deaths worldwide. It ranks among the leading causes of mortality associated with malignant diseases affecting humans. Even though significant progress has been made in preventive strategies, screening techniques, and the development of advanced diagnostic and therapeutic approaches, the global incidence as well as mortality associated with HCC continues to increase. Liver cirrhosis is recognized as the most important predisposing factor for the development of hepatocellular carcinoma, irrespective of the underlying cause of liver damage. Chronic infection with hepatitis B virus (HBV) and hepatitis C virus (HCV) significantly increases the risk of cirrhosis and consequently contributes to the development of HCC. Long-term alcohol consumption is also considered a major risk factor, as alcohol-induced liver injury increases the probability of progression to cirrhosis and eventually liver cancer.

The diagnosis of hepatocellular carcinoma is usually established through a combination of clinical evaluation, imaging techniques, and laboratory investigations, and histopathological confirmation is not always required. Individuals at high risk, particularly those suffering from cirrhosis or chronic viral hepatitis, are advised to undergo regular screening for early detection of the disease. Common screening methods include imaging procedures such as ultrasonography, computed tomography (CT), and magnetic resonance imaging (MRI), along with measurement of serum biomarkers such as alpha-fetoprotein (AFP). These investigations are generally performed at intervals of approximately six months in order to identify the disease at an early stage. Various therapeutic options are available for the management of hepatocellular carcinoma; however, surgical resection and orthotopic liver transplantation (OLT) are considered the most effective curative approaches depending on the stage and extent of disease progression (Balogh et al., 2016).

16. Pathophysiology of liver damage:

Liver damage occurs when hepatocytes (liver cells) are exposed to harmful agents such as viral infections, excessive alcohol intake, toxic chemicals, certain medications, metabolic abnormalities, or autoimmune reactions. The liver is an essential organ responsible for several important physiological functions, including metabolism of nutrients, detoxification of harmful substances, production of bile for digestion, and synthesis of vital proteins. Therefore, any injury to the structure or function of liver cells can disturb normal metabolic processes and adversely affect overall health. The pathophysiological process of liver damage involves a series of interconnected cellular and biochemical events such as inflammation, oxidative stress, cellular injury, and formation of fibrotic tissue, which may eventually progress to cirrhosis or liver failure if not appropriately treated (Kumar et al., 2020).

The initial stage of liver injury generally begins with damage to hepatocytes caused by exposure to toxic substances, viral infections, or long-term alcohol consumption. This cellular damage leads to the generation of reactive oxygen species (ROS) and free radicals, resulting in oxidative stress. Oxidative stress disrupts normal cellular function by damaging important cellular components such as lipids, proteins, and DNA. In response to liver injury, immune cells release inflammatory mediators including tumor necrosis factor-alpha (TNF- α) and various interleukins, which contribute to the inflammatory response and further aggravate tissue injury. Persistent inflammation results in degeneration and death of liver cells through processes such as necrosis or apoptosis (Jaeschke, 2006).

When liver injury continues for an extended period, hepatic stellate cells become activated and begin to produce increased amounts of collagen and other extracellular matrix proteins. Excessive accumulation of these structural proteins leads to fibrosis, which is characterized by formation of scar tissue within the liver. Gradual progression of fibrosis disturbs normal liver architecture and impairs blood circulation within hepatic tissue, ultimately leading to cirrhosis, which represents an advanced and irreversible stage of liver disease associated with severe impairment of liver function. Advanced liver damage may further result in complications such as portal hypertension, jaundice, fluid accumulation in the abdominal cavity (ascites), and hepatic failure. Therefore, early diagnosis and proper management of liver injury are essential to prevent progression of disease and preserve normal liver function (Friedman, 2003).

17. Mechanism of liver injury:

Liver injury develops when hepatocytes (liver cells) are exposed to harmful substances such as toxins, drugs, excessive alcohol, infectious agents, or metabolic disturbances. One of the key processes involved in liver damage is oxidative stress, which occurs when harmful agents increase the production of reactive oxygen species (ROS). These highly reactive molecules damage vital cellular structures including lipids, proteins, and DNA, thereby impairing normal cellular function and reducing the liver's ability to perform essential metabolic and detoxification activities (Jaeschke, 2006).

Damage to liver cells stimulates an inflammatory response in which immune cells release various inflammatory mediators such as cytokines, including tumor necrosis factor-alpha (TNF- α) and different interleukins. These substances intensify cellular injury and contribute to degeneration and death of hepatocytes through processes such as necrosis or apoptosis. Continuous inflammation not only aggravates tissue injury but also promotes progressive structural alterations within liver tissue (Friedman, 2003).

With persistent exposure to harmful stimuli, hepatic stellate cells become activated and begin producing excessive amounts of collagen and other extracellular matrix components. This leads to the development of fibrosis, a condition characterized by abnormal accumulation of fibrous connective tissue that disturbs the normal architecture of the liver. If the injury continues over time, fibrosis may progress to cirrhosis, which is an advanced and irreversible stage of liver disease associated with severe structural distortion, impaired liver function, and an increased risk of liver failure (Kumar et al., 2020).

18. Oxidative stress:

Oxidative stress occurs when the production of reactive oxygen species (ROS) becomes greater than the ability of the body's antioxidant defense system to neutralize them. High levels of ROS can cause damage to important cellular components including lipids, proteins, and DNA, which interferes with normal cellular functions. In organs such as the liver and brain, oxidative stress plays an important role in the development and progression of several disorders, including liver diseases and depression. Prolonged oxidative damage may weaken cellular structure and negatively affect normal physiological processes (Halliwell & Gutteridge, 2015).

19. Inflammation:

Excessive oxidative stress can stimulate inflammatory pathways, leading to the release of inflammatory mediators such as tumor necrosis factor-alpha (TNF- α), interleukins (IL-1, IL-6), and prostaglandins. These inflammatory substances contribute to tissue injury, disrupt metabolic activities, and increase the production of free radicals, thereby worsening cellular damage. Chronic inflammation is closely linked with the progression of many health conditions, including neurodegenerative disorders and liver injury, as continuous inflammatory responses gradually impair normal protective mechanisms of the body (Reuter et al., 2010).

20. Role of antioxidants:

Antioxidants are important protective substances that help neutralize reactive oxygen species and reduce cellular damage caused by oxidative stress. Natural antioxidants such as flavonoids, polyphenols, vitamin C, vitamin E, and carotenoids act by scavenging free radicals and preventing lipid peroxidation within cell membranes. By decreasing oxidative stress and limiting inflammatory reactions, antioxidants help preserve normal cellular structure and function, thereby playing a beneficial role in the prevention and supportive management of various diseases associated with oxidative damage (Lobo et al., 2010).

21. Herbal medicines – Basic concept:

The use of medicinal plants, plant components, and isolated phytochemical substances for the prevention and treatment of various diseases has been practiced since ancient times. Plant-derived natural products continue to contribute significantly to modern healthcare and drug development. It has been estimated that nearly one-fourth of prescribed medicines across the world originate directly or indirectly from plant sources, and more than one hundred active compounds obtained from plants are currently utilized in medical practice. According to the World Health Organization (WHO), around 11% of the medicines included in the essential drug list are derived exclusively from plant origin. In many developing countries, particularly in regions of Africa and Asia, approximately 80% of the population depends on traditional medicine as a primary form of healthcare. Likewise, in India, a substantial portion of the rural population relies on herbal remedies and indigenous systems of medicine for managing various health conditions.

India is known for its rich diversity of medicinal plant species, many of which are widely used in the herbal pharmaceutical industry. A large number of plant species are utilized for the preparation of herbal formulations, and several important medicinal plants are produced on a large scale to meet industrial demand. The herbal medicine sector in India has experienced steady growth due to increasing public awareness about natural treatment options and the perception of comparatively fewer side effects. The rising global demand for plant-based therapies has also encouraged expansion of the herbal industry and contributed to increased export of herbal products.

On the basis of the nature of active chemical constituents, herbal drugs may be categorized into three main groups. The first group includes crude plant materials such as dried leaves, roots, bark, seeds, or powders that are directly used in traditional medicinal preparations. The second group consists of extracts obtained from plants in which active constituents are isolated and purified; these compounds generally show stronger pharmacological activity due to their defined chemical composition. The third group includes standardized herbal formulations for which scientific evaluation and safety information, including acute and chronic toxicity data from experimental studies, are available. This classification supports better understanding of the therapeutic importance, safety considerations, and scientific validation of herbal medicines in contemporary healthcare practice (Sahoo et al., 2010).

22. History and traditional systems:

Herbal medicines have been used for thousands of years in the prevention and management of various diseases. Early human societies relied heavily on plants for both nutritional and medicinal purposes, gradually developing knowledge through observation, practical experience, and traditional wisdom. Ancient civilizations such as India, China, Egypt, and Greece carefully documented the healing properties of medicinal plants and established organized systems of treatment based on natural remedies. One of the earliest classical texts describing herbal medicine is the Ayurvedic scripture Charaka Samhita (around 1000 BC), which provides detailed information about numerous medicinal plants and their therapeutic applications. Likewise, ancient Chinese literature such as Shennong Bencao Jing also recorded the medicinal value of plant-based substances. These early scientific observations formed the basis for the evolution of pharmacology and the development of modern medicines derived from natural sources (Aggarwal et al., 2013).

Traditional medical systems including Ayurveda, Unani, Siddha, and Traditional Chinese Medicine (TCM) place great importance on the use of medicinal plants for promoting health and treating diseases. Ayurveda,

which originated in India, focuses on maintaining balance among the three fundamental physiological principles known as Vata, Pitta, and Kapha through the use of herbal formulations such as Ashwagandha, Brahmi, and Turmeric. Unani medicine, influenced by the teachings of Greek and Arab physicians, utilizes plant-based remedies to restore balance within the body according to humoral theory. In Traditional Chinese Medicine, herbs such as Ginseng and Ginkgo are commonly used to improve vitality, mental performance, and overall health. These traditional healthcare systems consider herbal medicines as holistic therapies that help maintain general well-being instead of only relieving disease symptoms (Mukherjee, 2007).

Even in modern times, herbal medicines continue to play an important role in primary healthcare, particularly in developing countries where medicinal plants are easily accessible, economical, and culturally accepted. Global health data indicate that a large portion of the world's population still depends on plant-based remedies for basic medical needs. Scientific investigations in recent decades have confirmed the therapeutic potential of many medicinal plants and have contributed to the development of several modern drugs derived from natural sources. Thus, traditional knowledge regarding medicinal plants remains highly relevant and continues to support progress in modern medicine, pharmaceutical research, and the discovery of safer and more effective therapeutic agents (World Health Organization, 2013).

23. Advantages and limitations:

23.1. Advantages:

Herbal medicines offer several advantages because they are derived from natural sources and have been used for centuries in traditional healthcare practices. When taken in proper doses, they are usually considered safe and are generally well tolerated by patients. Medicinal plants contain multiple active chemical constituents that act on different biological pathways, producing beneficial effects such as antioxidant, anti-inflammatory, and immune-supporting activities. Another important benefit of herbal medicines is their affordability, as many medicinal plants are easily available and cost-effective, particularly in developing countries. In addition, herbal therapies are widely accepted culturally and are commonly used in traditional medical systems such as Ayurveda and Unani. These systems adopt a holistic approach, focusing on improving overall health and maintaining balance in the body rather than only treating specific symptoms (Mukherjee, 2007).

23.2. Limitations:

Despite their benefits, herbal medicines also have certain limitations that need careful consideration. One major concern is the lack of uniform standardization, which may result in variation in the concentration of active constituents and differences in therapeutic effectiveness. Some herbal preparations may also interact with modern pharmaceutical drugs, potentially affecting their safety and clinical outcome. Moreover, insufficient scientific evidence and limited large-scale clinical trials for certain medicinal plants restrict their wider acceptance in modern evidence-based medical practice. Quality-related problems such as adulteration, contamination, substitution of plant materials, and incorrect identification of herbs may also influence the safety and reliability of herbal products. Therefore, proper standardization, quality assurance, and scientific evaluation are essential to ensure the safe and effective use of herbal medicines (Bent, 2008).

23.3. WHO guidelines:

The World Health Organization (WHO) has developed detailed guidelines to maintain the quality, safety, and effectiveness of herbal medicines. These recommendations are intended to regulate the use of medicinal plants and encourage their safe integration into modern healthcare practices. WHO emphasizes accurate identification of plant materials, proper standardization of herbal preparations, and scientific assessment through pharmacological and clinical research. The main objective of these guidelines is to ensure that herbal products are consistent in quality and free from problems such as contamination, adulteration, or variation in the levels of active constituents (World Health Organization, 2003).

According to WHO guidance, herbal medicines should be evaluated using specific quality control measures, including proper authentication of plant species, assessment of purity, testing for stability, and identification of important bioactive phytochemicals. WHO also recommends following Good Agricultural and Collection Practices (GACP) and Good Manufacturing Practices (GMP) to ensure uniformity and reliability of herbal products. In addition, the organization highlights the importance of toxicity evaluation, appropriate dose determination, and clinical evidence to confirm both the safety and therapeutic benefits of herbal medicines (World Health Organization, 2011).

WHO also supports preservation and documentation of traditional medicinal knowledge and encourages scientific validation of herbal drugs through systematic research. Proper labeling of products, suitable storage

conditions, and continuous monitoring of possible adverse effects are important components of quality assurance. These recommendations help ensure that herbal medicines remain safe, effective, and consistent in quality, thereby promoting their responsible use in healthcare systems (World Health Organization, 2013).

24. Herbal drugs used in liver disorders:

Chronic liver diseases represent a major public health problem worldwide, and liver cirrhosis is considered one of the important causes of death in many regions, especially in Western countries. Common chronic liver disorders include viral hepatitis B and C, alcoholic liver disease, non-alcoholic fatty liver disease, and hepatocellular carcinoma. Although modern medical science has made significant progress in diagnosis and treatment, many challenges still exist in achieving fully effective management of these conditions. Conventional therapies, while helpful, may sometimes provide limited clinical benefit, may produce undesirable side effects, and are often expensive, making them less accessible for patients in developing nations.

Due to these limitations, plant-based therapeutic compounds have gained increasing interest as alternative or supportive options for the treatment of liver diseases. Herbal medicines are generally easier to obtain, comparatively affordable, and do not require complicated chemical synthesis procedures. In recent years, the use of phytomedicine has increased considerably, not only among healthcare professionals but also among the general population in developed countries. Various surveys conducted in Europe and the United States have shown a noticeable rise in the use of herbal preparations, with many patients suffering from liver disorders incorporating plant-derived products into their treatment regimen. Similar patterns have been observed in European countries, where significant financial expenditure has been reported for herbal products such as silymarin, a widely used plant-based preparation for the management of chronic liver diseases (Chan & Graham, 2006).

24.1. Milk thistle:

Silybum marianum (L.) Gaertn., also referred to as *Cardus marianum* L., is an annual or biennial herb that belongs to the Asteraceae family and typically grows up to about 1.5 meters in height. The name *Silybum* was originally used by the ancient Greek physician Dioscorides to describe edible thistle-like plants, while the term *marianum* originates from a traditional legend. According to this legend, the characteristic white veins present on the leaves were believed to have formed from drops of milk from the Virgin Mary. It is said that during the journey from Egypt, Mary found shelter beneath the protective thorny leaves of this plant while nursing the infant Jesus. This historical and cultural association gave rise to the common name Milk Thistle, and contributed to its long-standing use in traditional medicine for various therapeutic purposes.



Figure.1: Milk Thistle

These compounds have been shown to possess several important pharmacological properties, including hepatoprotective, antioxidant, anti-inflammatory, and anti-fibrotic activities. Furthermore, they may enhance protein synthesis and support the regeneration of liver cells, which contributes to restoration of normal liver function. Some of these bioactive substances have also been reported to promote lactation and exhibit immunomodulatory effects, thereby helping regulate immune system activity. The following section provides a summarized overview of selected scientific studies related to these therapeutic properties (Butterweck & Schmidt, 2007).

24.2. *Phyllanthus niruri*:

Phyllanthus niruri (P. niruri) is an important medicinal herb widely used in traditional healthcare systems such as Ayurveda, Traditional Chinese Medicine, and Indonesian Jamu. The whole plant is commonly employed in

the treatment of various health problems including dysentery, influenza, vaginitis, tumors, diabetes, kidney stones, jaundice, and digestive disturbances such as dyspepsia. It has also been traditionally used as a diuretic and for managing infections caused by bacterial and viral agents. Furthermore, this plant is known for its protective effects on the liver and has been used in conditions such as hepatotoxicity and hepatitis B, as well as for regulating elevated blood glucose levels.

In Ayurvedic medicine, *Phyllanthus niruri* has been utilized for more than two thousand years for the treatment of disorders such as jaundice, gonorrhea, menstrual irregularities, and diabetes. The plant is also widely used in Jamu, a well-known Indonesian traditional herbal medicine system, where it is valued for its antiviral and hepatoprotective activities. Because of its diverse pharmacological properties, *P. niruri* is considered a significant medicinal plant for maintaining liver health and managing various metabolic and infectious diseases.

Phyllanthus is a large plant genus that belongs to the family Euphorbiaceae, consisting of shrubs, small trees, and some herbaceous species. This genus includes more than 600 species that are widely distributed in tropical and subtropical regions of the world. Several important species such as *P. acuminatus*, *P. amarus*, *P. pulcher*, *P. niruroides*, *P. anisobolus*, *P. orbiculatus*, *P. emblica*, *P. oxyphyllus*, *P. flexuosus*, *P. reticulatus*, *P. fraternus*, *P. simplex*, *P. mullerianus*, *P. urinaria*, *P. myrtifolius*, *P. virgatus*, *P. niruri*, and *P. watsonii* have been investigated extensively for their phytochemical constituents and pharmacological activities.



Figure.2: *Phyllanthus niruri*

Species of the *Phyllanthus* genus are commonly found in warm climatic regions including parts of Asia, Africa, and South America. Many of these plants are well recognized for their medicinal importance and have been traditionally used in the treatment of various health conditions, particularly liver disorders, infections, and metabolic diseases. The therapeutic value of these plants is mainly attributed to the presence of diverse bioactive compounds such as alkaloids, flavonoids, lignans, and tannins. Because of these biologically active constituents, *Phyllanthus* species have gained considerable scientific attention for their potential use in the development of natural therapeutic agents (Bagalkotkar et al., 2006).

24.3. *Picrorhiza kurroa*:

Picrorhiza kurroa Royle ex Benth. Is a well-known medicinal herb valued for its diverse pharmacological properties, including antimicrobial, hepatoprotective, antioxidant, antibacterial, antimutagenic, and anticancer activities. The rhizomes of this plant have been widely investigated and are known to contain several bioactive constituents responsible for its therapeutic effects. Phytochemical studies of the rhizomes have identified important compounds such as sterols, glycosides, phenolic compounds, iridoid glycosides, and cucurbitacins, which belong to the triterpenoid group and are associated with multiple biological functions.



Figure.3: *Picrorhiza kurroa*

Various experimental investigations, including chemical evaluation and thin-layer chromatography (TLC) analysis, have confirmed the presence of these active constituents in extracts of *Picrorhiza kurroa*. Both aqueous and methanolic extracts of the rhizomes have been tested for antimicrobial activity against different

pathogenic microorganisms. These include fungal organisms such as *Candida albicans* and *Aspergillus niger*, as well as bacterial strains such as *Staphylococcus aureus*, *Bacillus subtilis*, *Micrococcus luteus*, *Escherichia coli*, and *Pseudomonas aeruginosa*. Research findings indicate that methanolic extracts generally show stronger antimicrobial activity than aqueous extracts, particularly against *Pseudomonas aeruginosa* and *Staphylococcus aureus*. In comparison, aqueous extracts demonstrated relatively weaker antimicrobial effects and limited activity against fungal species.

Although the antimicrobial effectiveness of *Picrorhiza kurroa* extracts may be lower than that of standard antibiotics such as ciprofloxacin, the plant remains therapeutically important because of its natural origin and multiple beneficial properties. Its hepatoprotective and antioxidant activities, combined with moderate antimicrobial potential, make it a valuable medicinal plant for supporting liver health and managing certain infections (Masood et al., 2015).

24.4. *Andrographis paniculata*:

Andrographis paniculata is a well-recognized medicinal herb that has been extensively used in traditional Asian medical systems for several centuries. It is widely known for its traditional “blood purifying” properties, which has led to its use in conditions believed to arise from impurities in the blood, including skin disorders, boils, scabies, and persistent or recurrent fevers. The aerial parts of the plant are commonly utilized for medicinal purposes and contain numerous bioactive constituents such as lactones, diterpenoids, diterpene glycosides, flavonoids, and flavonoid glycosides, which are responsible for its therapeutic potential.

Scientific studies, including controlled clinical trials, have demonstrated that *Andrographis paniculata* can be safely used to help reduce symptoms associated with uncomplicated upper respiratory tract infections. Since many of the conditions traditionally treated with this plant may resolve naturally over time, further scientific research is required to clearly establish and confirm its therapeutic efficacy. Pharmacological investigations have reported that *A. paniculata* possesses several biological activities, including antibacterial, antifungal, antiviral, choleric, hypoglycemic, hypocholesterolemic, and adaptogenic effects.



Figure.4: *Andrographis paniculata*

In the Unani system of medicine, *Andrographis paniculata* is regarded as a medicinal plant with multiple therapeutic properties such as aperient, anti-inflammatory, emollient, astringent, diuretic, emmenagogue, stomachic, liver tonic, carminative, antihelmintic, and antipyretic actions. Because of its traditional role in purifying the blood, the plant has been recommended for managing conditions such as leprosy, gonorrhea, scabies, skin eruptions, boils, and chronic or seasonal fevers. Owing to its diverse pharmacological properties, *Andrographis paniculata* continues to be an important subject of scientific study for its (Akbar, 2011).

24.5. *Boerhavia diffusa*:

Historical records show that medicinal plants have been used for many centuries as natural remedies for relieving pain and treating various health disorders. The investigation of plant-derived chemical constituents through pharmacological and phytochemical studies has provided a strong scientific basis for the discovery of new therapeutic molecules. Natural products continue to play an important role in modern drug development, as researchers focus on identifying bioactive compounds that are effective, safe, and associated with minimal toxic effects. The study of plant-based compounds offers significant potential for developing new medicines for the treatment and management of various diseases.

Traditional knowledge systems, especially those preserved by tribal communities, have greatly contributed to the use of medicinal plants in healthcare. These communities have relied on plants as therapeutic agents through observation, practical experience, and knowledge passed down across generations. The long-standing use of medicinal plants through traditional practices highlights their importance as valuable healing resources since the early stages of human civilization.



Figure. 5: *Boerhavia diffusa*

Consequently, medicinal plants have become important subjects of study in both classical botany and modern plant sciences, contributing substantially to the progress of natural product research and the development of new pharmaceutical agents (Raviraj et al., 2012).

24.6. *Glycyrrhiza glabra*:

Since ancient times, different civilizations have depended on natural resources, particularly medicinal plants, for maintaining health and treating various diseases. Even today, a significant proportion of the global population, especially in developing nations, relies on plant-based remedies to meet primary healthcare needs. The use of medicinal plants is believed to extend back thousands of years, with historical records suggesting their application in traditional healing practices for more than 3000 years. Over time, many plant species have been scientifically investigated and reported to possess diverse biological and therapeutic activities.

An important example of such a medicinal plant is licorice (*Glycyrrhiza glabra*), which is recognized for its wide range of pharmacological properties including anti-inflammatory, expectorant, and hormone-regulating effects. Traditionally, licorice has been used to relieve cough, improve respiratory function, and support liver health by assisting detoxification processes. It has also been used internally in the management of conditions such as Addison's disease, asthma, bronchitis, peptic ulcer, arthritis, allergic disorders, and during steroid therapy. When applied externally, licorice preparations have been used in the treatment of certain skin conditions such as eczema, herpes, and shingles.



Figure.6: *Glycyrrhiza glabra*

Scientific studies have shown that licorice may influence hormonal balance, including lowering serum testosterone levels in women, and may provide therapeutic benefit in certain blood-related conditions such as aplastic anemia. In addition, licorice extracts have been used in autoimmune disorders and have shown potential benefits in immune deficiency conditions such as AIDS. The active constituents present in licorice root exhibit both estrogenic and anti-estrogenic activities, which contribute to its wide range of pharmacological effects and support its traditional importance as a medicinal plant (Kaur et al., 2013).

24.7. *Curcuma longa* (Turmeric):

Turmeric (*Curcuma longa*) is a perennial medicinal plant belonging to the family Zingiberaceae and has been used for centuries in traditional systems of medicine such as Ayurveda, Unani, and Siddha. Its medicinal use dates back nearly 4000 years to the Vedic period in India, where it was valued not only as a healing herb but also as an important part of daily food and religious practices. In Ayurveda, turmeric is regarded as a highly beneficial herb because of its combined nutritional and medicinal importance. Owing to its wide range of therapeutic benefits, turmeric has gained worldwide recognition and continues to attract scientific attention for its potential role in disease prevention and treatment.

Turmeric is obtained from the rhizomes of *Curcuma longa*, which are brownish-yellow in color and contain the major active compound curcumin. The plant has a short stem, large oblong leaves, and branched rhizomes that are commonly used as a spice, natural coloring agent, and preservative in many Asian countries. It is native to South-East Asia and is cultivated in several tropical regions including India, China, Sri Lanka, Bangladesh, Myanmar, Nigeria, Australia, and parts of the Caribbean and Latin America.



Figure.7: Turmeric (*Curcuma longa*)

India is the largest producer, consumer, and exporter of turmeric, contributing a major share of global production. Turmeric is also considered auspicious in Indian culture and is widely used in traditional rituals and ceremonies.

Traditionally, turmeric has been used as a household remedy for many health conditions. In classical Indian medicine, it has been applied in the treatment of sprains, swelling, wounds, and inflammatory disorders. It has also been used for digestive problems, liver disorders, cough, cold, sinusitis, diabetes, rheumatism, and other chronic ailments. Because of its anti-inflammatory, antioxidant, antimicrobial, and hepatoprotective properties, turmeric continues to be widely studied as a valuable natural therapeutic agent for promoting overall health and supporting the management of various diseases (Prasad et al., 2011).

25. Conclusion:

Liver disorders remain a major global health concern due to their increasing prevalence and their profound impact on human health. Conditions such as hepatitis, fatty liver disease, fibrosis, cirrhosis, drug-induced liver injury, and hepatocellular carcinoma continue to contribute significantly to morbidity and mortality worldwide. Although modern therapeutic approaches have improved disease management, limitations including adverse effects, high treatment costs, limited curative potential, and accessibility issues highlight the need for alternative and complementary treatment strategies.

Herbal medicines have emerged as promising hepatoprotective agents because of their diverse pharmacological activities, including antioxidant, anti-inflammatory, antifibrotic, immunomodulatory, and regenerative effects. Medicinal plants such as *Silybum marianum*, *Phyllanthus niruri*, *Picrorhiza kurroa*, *Andrographis paniculata*, *Boerhavia diffusa*, *Glycyrrhiza glabra*, and *Curcuma longa* have demonstrated considerable potential in protecting liver tissues against various forms of injury and supporting liver function. Their therapeutic actions are primarily attributed to the presence of bioactive phytochemicals capable of targeting multiple pathways involved in liver damage.

Despite the growing scientific evidence supporting the efficacy of herbal drugs, challenges related to standardization, quality control, safety assessment, dosage optimization, and clinical validation remain significant. Therefore, rigorous pharmacological studies, well-designed clinical trials, and adherence to international quality guidelines are essential to ensure the safe and effective use of herbal medicines. Future research integrating traditional knowledge with modern scientific approaches may facilitate the development of novel hepatoprotective therapies and improve the management of liver diseases.

In conclusion, herbal medicines represent a valuable and cost-effective therapeutic resource for the prevention and management of liver disorders. With continued scientific validation, standardization, and regulatory oversight, herbal drugs have the potential to play an increasingly important role in modern hepatology and integrative healthcare.

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