



## HEPATOPROTECTIVE ACTIVITY OF ANDROGRAPHIS PANICULATA

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### ABSTRACT

Liver diseases remain a major global health concern and are often associated with excessive alcohol consumption, viral infections, drug toxicity, and metabolic disorders. Conventional therapies used for the management of liver diseases may produce adverse effects and are sometimes inadequate in preventing liver damage. Therefore, the search for safe and effective hepatoprotective agents from natural sources has gained significant attention. Among medicinal plants, *Andrographis paniculata* (commonly known as Kalmegh or King of Bitters) has been widely used in traditional systems of medicine such as Ayurveda and Chinese medicine for the treatment of various ailments, particularly liver disorders. The plant contains several bioactive phytochemicals, including diterpenoid lactones, flavonoids, and polyphenols, with andrographolide identified as the major active constituent responsible for many of its pharmacological activities. Numerous experimental studies have demonstrated that extracts of *Andrographis paniculata* exhibit significant hepatoprotective activity against chemically induced liver damage. The hepatoprotective effects are mainly attributed to its antioxidant, anti-inflammatory, and free-radical scavenging properties, which help in reducing oxidative stress and preventing cellular damage in liver tissues. Additionally, the plant has shown the ability to normalize liver enzyme levels and improve overall liver function in various experimental models. This review aims to summarize the botanical characteristics, phytochemical constituents, pharmacological properties, and mechanisms underlying the hepatoprotective activity of *Andrographis paniculata*. The compiled information highlights the therapeutic potential of this medicinal plant as a natural hepatoprotective agent and emphasizes the need for further clinical studies to validate its efficacy and safety in the treatment of liver diseases.

**KEYWORDS:** *Andrographis paniculata*, Hepatoprotective activity, Andrographolide, Phytochemicals, Antioxidant activity, Herbal medicine, Liver protection.

### INTRODUCTION

The liver is one of the most important organs in the human body and plays a crucial role in maintaining metabolic homeostasis. It performs several vital functions including detoxification of harmful substances, metabolism of carbohydrates, proteins, and lipids, synthesis of plasma proteins, and storage of essential nutrients.<sup>[1]</sup> Due to its central role in metabolism and detoxification, the liver is highly susceptible to damage caused by toxins, alcohol consumption, viral infections, drugs, and environmental pollutants.<sup>[2]</sup> Liver diseases such as hepatitis, cirrhosis, fatty liver disease, and drug-induced liver injury are major global health problems that contribute significantly to morbidity and mortality

worldwide. Although modern medicine provides several therapeutic options for the management of liver disorders, many of these treatments are associated with side effects and limited effectiveness. Therefore, the search for safer and more effective hepatoprotective agents has become an important area of research. Medicinal plants have been widely used in traditional systems of medicine such as Ayurveda, Siddha, and Traditional Chinese Medicine for the treatment and prevention of liver diseases.<sup>[3]</sup> Herbal medicines are considered valuable due to their natural origin, therapeutic effectiveness, and relatively fewer side effects. Several plant species have been reported to possess hepatoprotective properties, including those

containing bioactive compounds with antioxidant, anti-inflammatory, and free radical scavenging activities that help protect liver cells from damage. Among these medicinal plants, *Andrographis paniculata*, commonly known as Kalmegh or “King of Bitters,” has gained considerable attention for its potential hepatoprotective activity. This plant belongs to the family Acanthaceae and is widely distributed in India, Sri Lanka, China, and other tropical and subtropical regions of Asia. It has been traditionally used for the treatment of fever, infections, digestive disorders, and liver diseases. The therapeutic potential of *Andrographis paniculata* is mainly attributed to its rich phytochemical composition, particularly diterpenoid lactones such as andrographolide, which is considered the major bioactive compound responsible for many of its pharmacological effects. Recent pharmacological and experimental studies have demonstrated that extracts of *Andrographis paniculata* exhibit significant hepatoprotective effects against chemically induced liver damage. These effects are mainly due to its antioxidant, anti-inflammatory, and hepatocellular protective properties. Therefore, the present review aims to summarize the botanical characteristics, phytochemical constituents, and pharmacological mechanisms underlying the hepatoprotective activity of *Andrographis paniculata*, highlighting its potential as a natural therapeutic agent for the management of liver disorders.



#### LIVER AND LIVER DISORDERS:

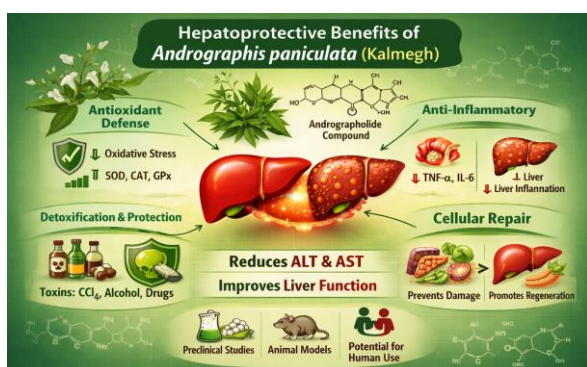
The liver is the largest internal organ in the human body and plays a vital role in maintaining metabolic balance. It is responsible for various physiological functions such as detoxification of harmful substances, metabolism of

carbohydrates, proteins and lipids, synthesis of plasma proteins, and storage of vitamins and minerals. Because of its central role in detoxification and metabolism, the liver is highly vulnerable to damage caused by toxins, alcohol, drugs, viral infections, and environmental pollutants. Liver disorders are among the most common health problems worldwide and include conditions such as hepatitis, fatty liver disease, cirrhosis, and hepatocellular carcinoma. Viral hepatitis caused by hepatitis viruses (A, B, C, D, and E) is a major cause of liver inflammation and can lead to chronic liver disease if untreated. Excessive alcohol consumption and prolonged use of certain drugs may also lead to liver injury and impaired liver function. In addition, metabolic disorders such as non-alcoholic fatty liver disease (NAFLD) have become increasingly prevalent due to modern lifestyle factors including poor diet and lack of physical activity. Damage to liver cells often results in elevated levels of liver enzymes such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP). Since conventional treatments for liver diseases are limited and sometimes associated with adverse effects, there is a growing interest in identifying natural hepatoprotective agents from medicinal plants that can help prevent or reduce liver damage.

#### IMPORTANCE OF HEPATOPROTECTIVE MEDICINAL PLANTS

The liver is often referred to as the body's natural detoxification center, continuously working to neutralize harmful chemicals, drugs, toxins, and metabolic waste products. Because of this crucial role, the liver is highly vulnerable to damage caused by alcohol consumption, viral infections, environmental pollutants, and long-term use of certain medications.<sup>[4]</sup> In recent years, the incidence of liver diseases such as hepatitis, cirrhosis, and fatty liver disease has increased significantly, creating an urgent need for effective hepatoprotective therapies. Although several synthetic drugs are available for managing liver disorders, many of them show limited effectiveness and may produce undesirable side effects during prolonged use. As a result, there has been growing scientific interest in identifying safer and more effective alternatives derived from natural sources. Medicinal plants have played an essential role in traditional healthcare systems for thousands of years. In systems such as Ayurveda, Siddha, and Traditional Chinese Medicine, numerous herbal formulations have been used to treat liver-related ailments.<sup>[5]</sup> These plants contain diverse phytochemicals such as flavonoids, terpenoids, alkaloids, phenolic compounds, and glycosides that contribute to their therapeutic properties. Many of these compounds exhibit strong antioxidant and anti-inflammatory activities, which help protect liver cells from oxidative stress and cellular damage. Hepatoprotective medicinal plants function through various mechanisms, including reducing lipid peroxidation, enhancing antioxidant enzyme activity, stabilizing hepatocyte membranes, and promoting the

regeneration of damaged liver tissues. In addition, herbal remedies are often considered more accessible, cost-effective, and relatively safe when used appropriately. Plants such as *Andrographis paniculata*, *Phyllanthus niruri*, and *Silybum marianum* have been widely investigated for their hepatoprotective properties. Among these, *Andrographis paniculata* has attracted considerable attention due to the presence of the bioactive compound andrographolide, which has demonstrated significant protective effects against chemically induced liver injury.<sup>[6]</sup> Therefore, medicinal plants continue to be an important source for the discovery of novel hepatoprotective agents and offer promising potential for the development of safer therapies for liver diseases.



### OVERVIEW OF ANDROGRAPHIS PANICULATA

*Andrographis paniculata* is a well-known medicinal herb widely used in traditional medicine for the treatment of various diseases, particularly liver disorders. It belongs to the family Acanthaceae and is commonly known as Kalmegh or the “King of Bitters” due to its extremely bitter taste. The plant is an annual herb that grows abundantly in tropical and subtropical regions of Asia, especially in countries like India, Sri Lanka, China, and Thailand. The plant has been used for centuries in traditional systems of medicine such as Ayurveda, Siddha, and Traditional Chinese Medicine.<sup>[7]</sup> It is traditionally used to treat fever, infections, digestive disorders, and liver-related diseases such as jaundice and hepatitis. Different parts of the plant, particularly the leaves and aerial parts, are used for medicinal purposes because they contain several biologically active compounds. The therapeutic value of *Andrographis paniculata* is mainly attributed to its rich phytochemical composition. The plant contains important bioactive constituents such as diterpenoid lactones, flavonoids, and polyphenolic compounds. Among these compounds, Andrographolide is considered the most important active constituent responsible for many of the plant’s pharmacological activities.<sup>[8]</sup> Scientific studies have shown that this compound exhibits antioxidant, anti-inflammatory, antimicrobial, and hepatoprotective properties. Because of its wide range of medicinal benefits, *Andrographis paniculata* has gained considerable attention in modern pharmacological research. Several experimental studies have demonstrated that extracts of this plant can protect liver

cells from damage caused by toxic chemicals and oxidative stress. As a result, it is considered a promising natural source for the development of hepatoprotective drugs and herbal formulations used in the management of liver diseases.

### BOTANICAL DESCRIPTION

*Andrographis paniculata* is a small, erect, annual herb widely recognized for its medicinal value. The plant belongs to the family Acanthaceae and typically grows to a height of about 30–110 cm. It thrives well in warm and humid climatic conditions and is commonly found in tropical and subtropical regions.<sup>[9]</sup> The plant is characterized by its slender green stems and extremely bitter taste, which is why it is popularly known as the “King of Bitters.” The stem of *Andrographis paniculata* is dark green, quadrangular, and smooth. The leaves are simple, opposite, and lanceolate in shape with a pointed tip. They are dark green in color and measure approximately 2–8 cm in length. These leaves contain a high concentration of active phytochemicals responsible for the plant’s therapeutic properties. The flowers of the plant are small and white with purple or pink spots on the petals.<sup>[10]</sup> They are arranged in loose spreading racemes or panicles, which give the plant its species name *paniculata*. Flowering usually occurs during the rainy season. The fruit of the plant is a narrow, linear capsule about 1–2 cm long, containing numerous small yellowish-brown seeds. Different parts of the plant, especially the aerial parts such as leaves and stems, are widely used for medicinal purposes. These parts contain important bioactive compounds that contribute to its pharmacological activities, including hepatoprotective, anti-inflammatory, antioxidant, and antimicrobial effects.<sup>[11]</sup> Due to these beneficial properties, *Andrographis paniculata* has gained considerable importance in both traditional herbal medicine and modern pharmacological research.

### TAXONOMICAL CLASSIFICATION

The scientific classification of *Andrographis paniculata* helps in understanding its systematic position in the plant kingdom. Taxonomy is the branch of botany that deals with the identification, naming, and classification of plants based on their morphological and genetic characteristics. Proper taxonomical classification is important for accurate identification of medicinal plants, especially those widely used in traditional and modern medicine.<sup>[12]</sup> *Andrographis paniculata* belongs to the family Acanthaceae, which consists of many tropical herbs and shrubs known for their medicinal value. The plant is classified under the division of flowering plants and shows characteristic features such as opposite leaves, small tubular flowers, and capsule-type fruits.

### The taxonomical hierarchy of *Andrographis paniculata* is presented as follows

Kingdom: Plantae  
 Division: Magnoliophyta (Angiosperms)  
 Class: Magnoliopsida (Dicotyledons)

Order: Lamiales  
 Family: Acanthaceae  
 Genus: *Andrographis*  
 Species: *Andrographis paniculata*

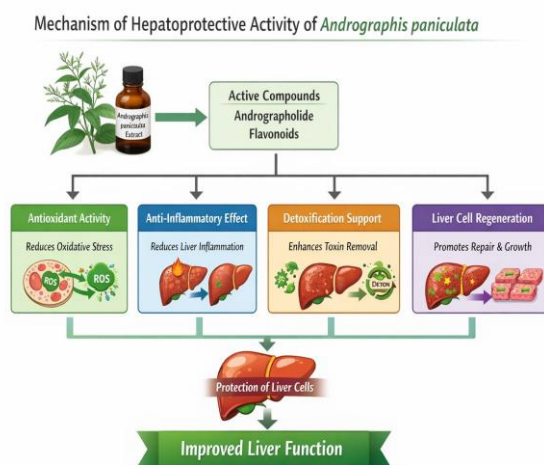
Plants belonging to the genus *Andrographis* are generally known for their bitter taste and medicinal importance. Among them, *Andrographis paniculata* is the most widely studied species due to its significant pharmacological properties. It has been traditionally used in herbal medicine systems such as Ayurveda and Traditional Chinese Medicine for treating infections, fever, and liver-related disorders.<sup>[13]</sup> The correct taxonomical identification of *Andrographis paniculata* is essential in pharmacognosy and herbal drug research to ensure the authenticity, quality, and safety of plant-based medicines used for therapeutic purposes.

### PHYTOCHEMICAL CONSTITUENTS

*Andrographis paniculata* is well known for its rich phytochemical composition, which is responsible for its wide range of pharmacological activities. Phytochemicals are naturally occurring chemical compounds present in plants that contribute to their medicinal and therapeutic properties.<sup>[14]</sup> Numerous scientific studies have reported that *Andrographis paniculata* contains a variety of biologically active compounds, including diterpenoid lactones, flavonoids, polyphenols, alkaloids, and glycosides. These compounds play a significant role in providing antioxidant, anti-inflammatory, antimicrobial, and hepatoprotective effects. Among the various phytoconstituents, Andrographolide is considered the most important and active compound present in the plant. It is mainly responsible for many of the plant's pharmacological properties, particularly its hepatoprotective and anti-inflammatory activities.<sup>[15]</sup> Andrographolide has been widely studied for its ability to protect liver cells from damage caused by toxins, drugs, and oxidative stress. In addition to andrographolide, the plant also contains other diterpenoid compounds such as Neoandrographolide, Deoxyandrographolide, and Andrographanin, which also contribute to its medicinal value. The leaves and aerial parts of the plant are particularly rich in these bioactive constituents. Flavonoids and phenolic compounds present in the plant act as powerful antioxidants that help neutralize harmful free radicals in the body. By reducing oxidative stress, these compounds help protect liver cells from damage and support normal liver function. Furthermore, the presence of various phytochemicals in *Andrographis paniculata* contributes to its multiple pharmacological activities such as hepatoprotective, antidiabetic, antiviral, anti-inflammatory, and immunomodulatory effects.<sup>[16]</sup> Because of this diverse chemical composition, the plant has gained considerable attention in modern pharmacological and phytochemical research. Scientists continue to investigate these compounds to better understand their mechanisms of

action and to develop effective herbal formulations for the treatment of liver disorders and other diseases.

### MECHANISM OF HEPATOPROTECTIVE ACTIVITY

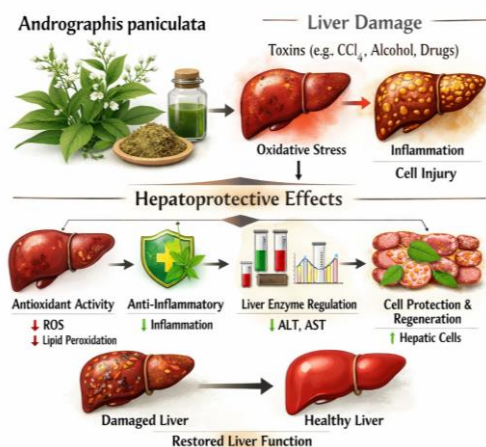


The hepatoprotective effect of *Andrographis paniculata* is mainly attributed to its bioactive compound Andrographolide, along with other phytochemicals such as flavonoids and phenolic compounds. These constituents protect the liver through several biological mechanisms that help prevent or reduce liver damage.<sup>[17]</sup> One of the major mechanisms is antioxidant activity. The plant extract helps neutralize harmful free radicals and reduces oxidative stress, which is one of the primary causes of liver cell damage. By preventing lipid peroxidation in liver tissues, it helps maintain the structural integrity of hepatocytes (liver cells). Another important mechanism is its anti-inflammatory effect. The phytochemicals present in the plant reduce the production of inflammatory mediators and cytokines that contribute to liver inflammation. This helps in reducing tissue injury and supports the healing process of damaged liver cells. In addition, *Andrographis paniculata* also promotes detoxification and regeneration of liver cells.<sup>[18]</sup> It enhances the activity of natural antioxidant enzymes such as superoxide dismutase (SOD), catalase, and glutathione, which play a crucial role in protecting the liver from toxic substances. These actions collectively help in restoring normal liver function and protecting the liver from chemically induced damage. Therefore, through antioxidant, anti-inflammatory, and hepatocellular protective mechanisms, *Andrographis paniculata* acts as an effective natural hepatoprotective agent.<sup>[19]</sup>

### EXPERIMENTAL STUDIES ON HEPATOPROTECTIVE EFFECT

Several experimental studies have demonstrated the hepatoprotective potential of *Andrographis paniculata* against chemically induced liver damage. Researchers have widely used different animal models to evaluate the protective effects of this medicinal plant on liver tissues.<sup>[20]</sup> In many studies, liver injury is artificially

induced in laboratory animals using toxic chemicals such as carbon tetrachloride (CCl<sub>4</sub>), paracetamol, alcohol, or other hepatotoxic agents. These chemicals cause oxidative stress and cellular damage in liver tissues, leading to increased levels of liver enzymes in the blood.<sup>[21]</sup> Administration of extracts obtained from *Andrographis paniculata*, particularly from its leaves and aerial parts, has shown significant protective effects in these experimental models. The plant extract has been reported to reduce elevated liver enzyme levels such as serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), and alkaline phosphatase (ALP). These enzymes are commonly used as biochemical markers for assessing liver function, and their reduction indicates improvement in liver health. The hepatoprotective activity of the plant is mainly attributed to the presence of the bioactive compound Andrographolide along with other phytochemicals such as flavonoids and phenolic compounds. These constituents help reduce oxidative stress, inhibit lipid peroxidation, and protect hepatocytes from toxin-induced damage. Histopathological examinations of liver tissues in experimental animals have also shown that treatment with *Andrographis paniculata* extract helps restore normal liver architecture and reduces inflammation and necrosis. These findings strongly support the potential use of this plant as a natural hepatoprotective agent. Therefore, experimental research plays an important role in validating the traditional medicinal use of *Andrographis paniculata* for the prevention and treatment of liver disorders.<sup>[22]</sup>



#### OTHER PHARMACOLOGICAL ACTIVITIES:

*Andrographis paniculata* is widely recognized not only for its hepatoprotective properties but also for its diverse pharmacological activities. The therapeutic potential of this plant is mainly attributed to its rich phytochemical composition, particularly the presence of bioactive compounds such as Andrographolide, flavonoids, and other diterpenoid lactones. These compounds contribute to a variety of biological effects that have been extensively studied in modern pharmacological research.<sup>[23]</sup> One of the important pharmacological properties of *Andrographis paniculata* is its anti-

inflammatory activity. The plant extract has been reported to reduce inflammation by inhibiting the production of inflammatory mediators and cytokines in the body. This property makes it useful in the management of inflammatory conditions and infections. In addition, the plant exhibits significant antioxidant activity, which helps neutralize harmful free radicals and protect cells from oxidative damage. Another important activity is its antimicrobial effect. Studies have shown that extracts of *Andrographis paniculata* possess antibacterial, antiviral, and antifungal properties. Because of these effects, the plant has traditionally been used to treat respiratory infections, fever, and gastrointestinal disorders. The plant also demonstrates immunomodulatory activity, which helps strengthen the immune system and improves the body's defense mechanisms against various pathogens. Furthermore, *Andrographis paniculata* has shown promising antidiabetic activity by helping regulate blood glucose levels and improving insulin sensitivity in experimental studies. It has also been reported to exhibit anticancer and cardioprotective properties, which further highlight its medicinal importance. Due to these wide-ranging pharmacological activities, *Andrographis paniculata* has gained significant attention in pharmaceutical and biomedical research. Its multiple therapeutic effects make it a valuable medicinal plant for the development of herbal drugs and natural health products aimed at treating various human diseases.<sup>[24]</sup>

#### SAFETY AND TOXICITY

The safety and toxicity profile of *Andrographis paniculata* has been widely evaluated through various experimental and clinical studies. In traditional medicine systems such as Ayurveda and Siddha, this plant has been used for many years to treat fever, infections, digestive disorders, and liver diseases. Generally, when used in appropriate doses, *Andrographis paniculata* is considered safe and well tolerated. Toxicological studies conducted on experimental animals have shown that extracts of *Andrographis paniculata* exhibit low toxicity and do not produce significant harmful effects at therapeutic doses. Acute and sub-chronic toxicity studies indicate that the plant extract does not cause severe damage to major organs such as the liver, kidney, or heart when administered within recommended limits. The safety of the plant is mainly attributed to its natural bioactive constituents, particularly Andrographolide, which has been extensively studied for its pharmacological activities. However, excessive consumption or prolonged use of high doses may sometimes lead to mild side effects such as gastrointestinal discomfort, nausea, headache, or allergic reactions in sensitive individuals. In some cases, very high doses may affect appetite or cause mild digestive disturbances.<sup>[25]</sup> Therefore, proper dosage and medical supervision are recommended when using herbal preparations containing *Andrographis paniculata*. Pregnant and breastfeeding women are generally advised to avoid the use of this herb without medical consultation, as sufficient clinical safety data are not

available. Overall, available scientific evidence suggests that *Andrographis paniculata* is relatively safe when used appropriately, but further clinical studies are required to fully establish its long-term safety and therapeutic dosage in humans.

### FUTURE PERSPECTIVES

The growing incidence of liver diseases worldwide has increased the need for safer and more effective therapeutic agents. Medicinal plants have gained considerable attention in recent years due to their natural origin, therapeutic potential, and relatively fewer side effects compared to synthetic drugs. Among these plants, *Andrographis paniculata* has emerged as a promising source of hepatoprotective compounds and has attracted significant interest from researchers in the fields of pharmacology and herbal medicine.<sup>[26]</sup> Although numerous experimental studies have demonstrated the hepatoprotective effects of *Andrographis paniculata*, further research is required to fully understand its clinical applications. Future studies should focus on detailed investigations of its bioactive constituents, particularly Andrographolide, to determine their exact mechanisms of action at the molecular level. Advanced techniques such as molecular pharmacology, biotechnology, and drug delivery systems may help improve the therapeutic effectiveness of these compounds. In addition, well-designed clinical trials are necessary to evaluate the safety, efficacy, and optimal dosage of *Andrographis paniculata* in human patients suffering from liver disorders. Standardization of herbal extracts and quality control of plant materials are also important aspects that need to be addressed in future research. This will help ensure consistency, safety, and effectiveness in herbal formulations. Furthermore, the development of novel pharmaceutical formulations such as capsules, tablets, and nano-formulations containing standardized extracts of *Andrographis paniculata* may enhance its therapeutic potential. Overall, continued scientific research and clinical evaluation will play a crucial role in establishing this medicinal plant as a reliable natural hepatoprotective agent for the management of liver diseases.

### CONCLUSION

*Andrographis paniculata* is a medicinal plant known for its liver -protective (hepatoprotective) activity. Its main bioactive compound andrographolide helps protect the liver from toxic substances like paracetamol and carbon tetrachloride. The plant has strong antioxidant, anti-inflammatory, and detoxifying protective. It helps reduce elevated liver enzyme (SGOT, SGPT, ALP) and bilirubin, which indicate liver damage. It also increases antioxidant enzymes such as SOD, catalase, and glutathione, protecting liver cells from oxidative stress. Phytochemical like flavonoids, phenolic compounds, and diterpenoids support liver structure and regeneration. Overall, it shows promising potential for preventing and treating liver disorders.

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