



**INTERNATIONAL JOURNAL OF  
PHARMACEUTICAL SCIENCES**  
[ISSN: 0975-4725; CODEN(USA): IJPS00]  
Journal Homepage: <https://www.ijpsjournal.com>



## Review Article

# **A Review on Therapeutic Properties and Hepatoprotective Activities of Traditional Medicinal Plants: *Andrographis paniculata*, *Azadirachta indica*, *Terminalia arjuna*, and *Picrorhiza kurroa***

**Mahadevan S.<sup>1</sup>, Muhammed Uvais T. T.<sup>2</sup>, Abdul Rahman S.<sup>3</sup>, Shamina S.<sup>\*4</sup>, Jamal Fathima M.<sup>5</sup>**

<sup>1</sup>UG biochemistry, RVS Collage of Arts and Science Coimbatore, Tamil Nadu, India

<sup>2</sup>PG Biochemistry, RVS Collage of Arts and Science Coimbatore, Tamilnadu, India

<sup>3</sup>UG biochemistry, RVS Collage of Arts and Science Coimbatore, Tamil Nadu, India

<sup>4\*</sup>Head and Associate Professor Department of Biochemistry, RVS Collage of Arts and Science Coimbatore, Tamil Nadu, India

<sup>5</sup>Assistant Professor Department of Biochemistry, RVS Collage of Arts and Science Coimbatore, Tamil Nadu, India

## ARTICLE INFO

Published: 31 March 2025

### Keywords:

Picrorhiza kurroa,  
Andrographis paniculata,  
Azadirachta indica,  
Terminalia arjuna,  
Phytochemical composition,  
Bioactive compounds,  
Pharmacological activities,  
antioxidant activity

### DOI:

10.5281/zenodo.15111118

## ABSTRACT

Liver diseases are a global health concern, necessitating the search for effective hepatoprotective agents. Medicinal plants like *Andrographis paniculata*, *Azadirachta indica*, *Terminalia arjuna*, and *Picrorhiza kurroa*, have been traditionally utilized for their medicinal and therapeutic benefits, particularly in liver protection. This review explores the hepatoprotective activities in medicinal plants, focus on active phytochemicals and potential mechanisms of action. Key bioactive compounds, including arjunolic acid, azadirachtin, and picrosides, have demonstrated anti-inflammatory, antioxidant, and hepatoprotective properties, which may contribute to liver cell regeneration and detoxification. The study also examines various experimental approaches, including laboratory and animal models, which evaluate the effectiveness of these plants in reducing liver damage induced by toxins, oxidative stress, and inflammation. The synergistic effects of these herbs suggest that their combination may offer enhanced therapeutic benefits for liver health. Understanding their mechanisms of action and therapeutic potential could facilitate the development of novel hepatoprotective formulations. This review highlights the significance of incorporating traditional herbal medicine into modern healthcare as a complementary approach to liver disease management.

**\*Corresponding Author:** Shamina S.

**Address:** Department of Biochemistry, RVS Collage of Arts and Science Coimbatore, Tamil Nadu, India

**Email** ✉: [shaminabc26@gmail.com](mailto:shaminabc26@gmail.com)

**Relevant conflicts of interest/financial disclosures:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



Further research is required to standardize dosages, optimize formulations, and carry out clinical trials to confirm their effectiveness and safety in humans.

## INTRODUCTION

The liver, an essential organ, has a vital purpose in metabolism then elimination of xenobiotics (Smith *et al.*, 2018). Various toxic substances, including some antibiotics, chemotherapeutic agents, carbon tetrachloride, and thioacetamide, as well as excessive alcohol intake and microbial infections, identified as causes of liver cell damage. (Jones *et al.*, 2020). Additionally, synthetic drugs used to treat liver diseases may further impair hepatic function, leading to increased reliance on herbal medicines, which have gained significant popularity (Brown *et al.*, 2019). Given the crucial role of the liver in overall well-being, herbal treatments have been traditionally used to manage liver disorders. Plants play a significant role in the biosynthesis of nanoparticles, offering a promising and preferred method for producing various types of nanoparticles in modern times (Shamina *et al.*, 2022). Liver damage induced by toxins is becoming increasingly common. With an approximate weight of 1.5 kg, making up 2–3% of total body weight, liver is considered to be the largest glandular organ and is primarily responsible for detoxifying harmful substances through biotransformation and excretion (Williams *et al.*, 2021). It performs numerous physiological functions, with metabolism being the most critical. The liver is indispensable to maintaining a healthy metabolic system. Many pharmacologically active compounds can be derived from medicinal plants using a Phyto therapeutic approach. However, investigating pure phytochemicals as potential therapeutic agents is

both expensive and time-consuming (Smith *et al.*, 2018).

Several plant-based formulations have demonstrated hepatoprotective properties, yet their therapeutic outcomes sometimes do not meet expectations (Jones *et al.*, 2020). The efficacy of these treatments is assessed through animal models and liver cancer cell lines against chemically induced liver injuries. Antioxidants derived from traditional food sources and medicinal plants have shown promise in mitigating oxidative stress and chemically induced liver damage (Brown *et al.*, 2019). Herbal medicines continue to be widely used in traditional medicine systems globally. Approximately 75% of the world's five billion people are estimated to depend on herbal remedies due to the high cost of pharmaceuticals produced by the Western medical industry (Williams *et al.*, 2021)

Each nation, including China, Egypt, and India, has developed its own traditional medical system, leading to the establishment of indigenous therapeutic practices. Crude herbal preparations, including dry plant powders, extracts, and mixed formulations, are derived from natural raw materials (Smith *et al.*, 2018). Traditional healing systems like Tibetan, Siddha, and Unani have thrived for generations, passing down knowledge through oral traditions and written manuscripts (Jones *et al.*, 2020). Despite their efficacy in treating various ailments, herbal remedies are often misused or exploited without scientific validation. Therefore, these plant-based medicines require rigorous scientific investigation in the context of modern medical research (Williams *et al.*, 2021).

**Table:1 Hepatoprotective plants**

| BOTANICAL NAME             | FAMILY        | LOCAL NAME |
|----------------------------|---------------|------------|
| <i>TERMINALIA ARJUNA</i>   | Combretaceae. | Arjun      |
| <i>AZARDIRACHTA INDICA</i> | Meliaceae     | Neem       |



|                   |                |       |
|-------------------|----------------|-------|
| PICRORHIZA KURROA | Plantaginaceae | Kutki |
|-------------------|----------------|-------|

## 1. *Terminalia arjuna* (Arjuna):

(Amalraj A., & Gopi S., 2017) study highlights that *Terminalia arjuna* has been a key a significant plant in traditional medicine used for treating various ailments, especially cardiovascular conditions. This review explores its ethnomedical, phytochemical, and pharmacological significance. Studies highlight its diverse therapeutic properties, including antioxidant, hypotensive, anti-atherogenic, anti-inflammatory, anti-carcinogenic, anti-mutagenic also gastroprotective effects. It also exhibits a strong safety profile when used alongside conventional medications. (Dwivedi S., 2007) suggested that *Terminalia arjuna* bark is traditionally used for cardiovascular conditions due to its cardiogenic, antioxidant, and lipid-lowering properties. Studies show its benefits in coronary artery protection, hypotension, and hypolipidemia, with potential synergy with statins. Further research is needed on its molecular mechanisms and safety. (Singh G *et al.*, 2008) study confirms the cardioprotective effects of *Terminalia arjuna* bark extract (TA-05) against doxorubicin-induced toxicity in Wistar rats. TA-05 improved antioxidant levels, reduced CKMB and lipid peroxidation, and minimized cardiac damage, suggesting its potential as a protective agent. (Dwivedi S., & Chopra D., 2014) suggests that *Terminalia arjuna* shows cardioprotective effects with no serious side effects, but its long-term safety and role in coronary prevention need further study.

### 1.1 Hepatoprotective:

(Khan S *et al.*, 2020) study highlights hepatoprotective and the restorative properties of *Terminalia arjuna* fruit extract. The findings revealed a time-dependent recovery, with hepatic enzyme levels progressively normalizing,

demonstrating the plant's protective and restorative benefits. (Sangamithira S P *et al.*, 2016) study found that ethanolic *Terminalia arjuna* bark extract effectively protected against liver damage caused by paracetamol in rats by lowering liver enzyme levels and enhancing antioxidant activity. The results confirmed its significant hepatoprotective effects. (Manna P *et al.*, 2006) study showed that *Terminalia arjuna* aqueous extract protected liver and kidney tissues from CCl<sub>4</sub>-induced oxidative stress through restoring antioxidant enzyme levels and exhibiting strong free radical scavenging activity

### 1.2 Phytochemistry:

(Jain S *et al.*, 2009) study highlights *Terminalia arjuna* as a medicinal tree with diverse therapeutic properties, including cardiovascular and anticancer benefits. Its phytoconstituents, such as triterpenoids, tannins, and flavonoids, contribute to its pharmacological effects, making it valuable in traditional medicine. (Mandal, S., *et al.*, 2013) suggested that the methanolic extract contains high levels of active compounds, including phytosterols, flavonoids, and tannins. It showed potent antimicrobial activity, particularly contrary to Gram-negative bacteria, and exhibited significant antioxidant potential, with flavonoids playing a key role in DPPH radical scavenging. (Patil U H & Gaikwad D K *et al.*, 2011) study shows the rise of antibiotic and chemotherapeutic resistance in pathogenic microbes has led to extensive screening of medicinal plants for their antimicrobial properties. Higher plants are essential for human health, providing an abundant supply of bioactive compounds. Multiple studies have been carried out to extract and evaluate natural products for their antimicrobial potential. Plant-based antimicrobials offer significant therapeutic benefits, effectively treating infections



while reducing the side effects commonly associated with synthetic drugs. Medicinal plants are recognized as valuable sources of antimicrobial agents, with World Health Organization (WHO) estimated that 80% of people in developing countries depend on traditional medicine for primary healthcare.

### 1.3 Anti-microbial activity:

(Ramya S., 2008) study assessed the antibacterial properties of aqueous extracts from different parts of *Terminalia arjuna*, including bark, stem, root, leaf, and fruit, against selected Gram-positive and Gram-negative bacteria. The extracts demonstrated strong antibacterial activity, varying based on the plant part and bacterial strain. While they inhibited the growth of both bacterial types, *Micrococcus luteus* showed lower sensitivity. The antimicrobial activity was concentration-dependent (1.0 mg/disc and 5.0 mg/disc), with the bark extract displaying the highest potential as a natural antibacterial agent. (Khan I *et al.*, 2022) study explored the phytochemical, antioxidant, anticholinesterase, and antimicrobial properties of *Terminalia chebula* and *Terminalia arjuna*. *T. arjuna* exhibited strong antioxidant activity, while both species showed high acetylcholinesterase inhibition, suggesting potential for Alzheimer's treatment. Antibacterial activity was significant against *Bacillus* and *Staphylococcus* species but ineffective against fungi. These findings highlight their potential for antimicrobial and neuroprotective applications. (Javed, T., 2016) suggested that Traditional medicinal knowledge has evolved over centuries through systems like Ayurveda, Unani, and Siddha. In India, traditional healers use various plant species around 2,500 are used by traditional healers, with over 100 serving as regular medicinal sources (Sheng-Ji., 2001). Even in developed countries like the USA, 25% of prescription drugs contain plant-derived compounds. An estimated 70,000 plant species

have been used medicinally. the growing recognition of ethnomedicine highlights the importance of phytochemicals as valuable sources of pharmacological and therapeutic agents.

### 1.4 Anti-oxidant activity:

(Sivalokanathan S *et al.*, 2006) conducted a study to evaluate the antioxidant effects of ethanolic *Terminalia arjuna* bark extract (EETA) on N-nitrosodiethylamine (DEN)-induced liver cancer in male Wistar rats. It was initiated with a DEN injection (200 mg/kg) and promoted using Phenobarbital for 14 weeks. EETA (400 mg/kg) was administered orally for 28 days. Biochemical analysis of serum, liver, and kidney samples revealed increased lipid peroxidation (LPO) and decreased levels of enzymic (SOD, CAT, GPx) and non-enzymic (Vitamin C, Vitamin E) antioxidants in DEN-induced rats. EETA treatment significantly restored antioxidant levels and reduced LPO, highlighting its protective effect against DEN-induced liver cancer. (Doorika, P., 2012) (15) assessed the hepatoprotective properties of *Terminalia arjuna* bark extract against isoniazid-induced liver damage in albino rats. Isoniazid (100 mg/kg) elevated biochemical markers (SGPT, SGOT, ALP, ACP, bilirubin, protein) and depleted antioxidant enzymes (SOD, GSH). Administration of *T. arjuna* extract (200 mg/kg) significantly lowered these markers and restored antioxidant levels. The results suggest its therapeutic potential in managing isoniazid-induced liver damage, likely due to its antioxidant effects. (Raghavan, B., & Kumari, S. K., 2006) (16) examined the antioxidant effects of *Terminalia arjuna* bark extract in alloxan-induced diabetic rats. Oral administration (250 and 500 mg/kg) significantly reduced lipid peroxidation ( $P < 0.05$ ), with the higher dose exhibiting greater effectiveness. The extract also enhanced antioxidant enzyme activity (SOD, catalase, GPx, GST, GR, G6PD), glutathione levels, and vitamins



A, C, and E in liver and kidney tissues. These findings confirm the antioxidant capability of *T. arjuna* bark in managing oxidative stress in diabetes, supporting its traditional medicinal applications.

## 2. *Azadirachta indica* (Neem):

(Atawodi S E & Atawodi, J C., 2009) study shows that *Azadirachta indica* (neem) has diverse medicinal, agricultural, and ecological benefits but also some toxic effects. Key phytochemicals contribute to its bioactivity. This review highlights its potential for addressing Nigeria's health and agricultural challenges. (Alzohairy, M. A. 2016) study shows that *Azadirachta indica* (neem), a member of the Meliaceae family, is abundant of antioxidants and widely used in traditional medicine. It aids in disease prevention by scavenging free radicals and has shown anticancer potential by modulating key molecular pathways. Considered safe, neem influences various biological processes without adverse effects. (Nisbet A J., 2000) suggests that Neem (*Azadirachta indica*) is considered for its medicinal and insecticidal factors. Azadirachtin, its key compound, disrupts insect growth, feeding, and reproduction. Studies highlight its potential as a safe, eco-friendly insecticide with minimal impact on non-target organisms.

### 2.1 Hepatoprotective:

(Chattopadhyay R., 2003) study highlights Neem (*Azadirachta indica*) leaf extract has shown hepatoprotective result against paracetamol-induced liver damage in rats. This study examines its impact on blood and liver glutathione, Na<sup>+</sup>K<sup>+</sup>-ATPase activity, and thiobarbituric acid reactive elements. Results suggest the extract helps restore these parameters, indicating its potential protective mechanism. (Mathew A., 2005) study evaluated the hepatoprotective reaction of *Azadirachta*

*indica* (500 mg/kg) and *Aegle marmelos* (1 g/kg) aqueous leaf extracts against paracetamol-induced liver toxicity in rats. Paracetamol (3 g/kg) caused reduced feed intake, weight loss, increased lipid peroxidation, and elevated liver enzymes, along with liver damage. Treatment with *A. indica* and *A. marmelos* restored antioxidant enzyme activity, protein levels, and liver function, with histological analysis showing reduced necrosis and improved liver architecture. The findings confirm the hepatoprotective potential of these plant extracts. (Boeke S J *et al.*, 2004) (22) study shows that Neem (*Azadirachta indica*) offers pesticidal and health benefits but also has toxicity concerns. Non-aqueous extracts are most toxic, while seed oil and aqueous extracts are safer. The main risk is reversible reproductive effects. With careful use, neem-based pesticides pose minimal health risks.

### 2.2 Phytochemistry:

(Susmitha S *et al.*, 2013) study highlights that Aqueous extract of *Azadirachta indica* (Neem) exhibited antibacterial activity against *Escherichia coli*, while *Salmonella* resisted all extracts except water. Phytochemical analysis identified bioactive compounds, and TLC helped separate antimicrobial components. This study highlights Neem's potential for developing new antimicrobial agents. (Pandey G *et al.*, 2014) suggested that Neem leaf extract (50% ethanol) was analyzed for phytochemicals, antioxidant, and antibacterial properties. It contained phenols, flavonoids, and tannins, with HPTLC confirming bioactive compounds like  $\beta$ -sitosterol and quercetin. The extract showed strong free radical scavenging activity and effectively inhibited *Staphylococcus aureus* more than *Escherichia coli*. Findings suggest neem leaves have potent medicinal potential for skin ailments. (Dash SP *et al.*, 2017) study analyzes the phytochemical and biochemical properties of *Azadirachta indica* using standard methods. Methanolic leaf extracts



revealed bioactive compounds like alkaloids, flavonoids, and saponins, compared to aqueous extracts. Biochemical analysis included chlorophyll, carbohydrate, and proline estimation, highlighting neem's medicinal potential.

### 2.3 Anti-microbial activity:

(Abd El-Moez S I et al., 2014) highlights neem extract showed strong antimicrobial activity at low concentrations (10% and 50%), effectively inhibiting Gram-negative bacteria and fungi but not Gram-positive bacteria. It significantly reduced bacterial counts in ground beef, including *E. coli* O157, highlighting its potential as a natural food preservative. Further research is needed to isolate and standardize its active components. (Raja Ratna Reddy Yet al., 2020) suggested that Neem (*Azadirachta indica*) leaf and bark extracts showed strong antimicrobial activity against bacteria and fungi, while seed extract was least effective. Using agar well diffusion and micro-broth dilution methods, the study found that leaf extract was the most potent, followed by bark extract, with MIC ranging from 500 to 2000 µg/ml. Seed extract showed minimal inhibition, except against *Candida albicans* (1000 µg/ml). These findings highlight the potential of neem leaf and bark as natural antimicrobial agents. (SaiRam M et al., 2000) NIM-76, a spermicidal fraction of neem oil, exhibited greater antimicrobial activity than whole neem oil. It effectively inhibited *Escherichia coli*, *Klebsiella pneumoniae*, and *Candida albicans*, while also demonstrating antiviral effects against the poliovirus. Additionally, NIM-76 protected mice from systemic candidiasis, improving survival rates and reducing fungal load in tissues. These findings highlight its broad-spectrum antimicrobial potential.

### 2.4 Anti-inflammatory:

(Uzzaman S., 2020) study shows that *Azadirachta indica* (neem) has gained global recognition for its diverse medicinal properties, widely used in Ayurveda, Unani, and Homeopathy, contains over 140 bioactive compounds. It possesses anti-diabetic, antioxidant, antiviral, anti-inflammatory, antibacterial, antifungal, anticancer, and hepatoprotective properties, making it a highly valuable therapeutic plant. (Pereira L D P et al., 2012) study highlights that *Azadirachta indica* (neem) is traditionally used to treat inflammatory disorders. A study on its seed tegument polysaccharides (TPL) and fraction FI evaluated their anti-inflammatory effects in Wistar rats. FI (0.1 mg/kg) significantly reduced paw edema and peritonitis induced by various inflammatory agents while being well tolerated. These findings highlight FI as a potent anti-inflammatory component in neem-based remedies. (Schumacher M et al., 2011) study suggests that *Azadirachta indica* (neem) is traditionally used for its medicinal properties, including cancer prevention. This study investigated the anti-inflammatory effects of neem through the NF-κB pathway in human leukemia cells. A methanolic extract of neem leaves suppressed NF-κB activation, inhibited IκB degradation and IKK activity, and induced apoptotic cell death. These findings highlight neem's potential in regulating inflammation and apoptosis.

### 2.5 Anti-oxidant activity:

(Sithisarn P et al., 2005) study shows that extracts from the leaves, flowers, and stem bark the antioxidant activity of the Siamese neem tree (*Azadirachta indica* var. *siamensis*) was evaluated. The aqueous leaf extract, as well as the ethanol extracts of the flower and stem bark, demonstrated strong free radical scavenging effects in the DPPH assay and high total antioxidant activity. Additionally, these extracts significantly reduced lipid peroxidation in cancer cells, highlighting



their potent antioxidant potential. (Pokhrel B *et al.*, 2015) highlights *Azadirachta indica* is a versatile medicinal plant rich in bioactive compounds. This study evaluated its antimicrobial, antioxidant, and phytochemical properties using methanolic leaf extract. Phytochemical screening confirmed the presence of phenols (85.9 mg/g), flavonoids (104.9 mg/g), and proanthocyanidins (65.4 mg/g). Antibacterial tests against six bacterial strains showed the highest inhibition ( $22 \pm 3$  mm) against *Staphylococcus aureus* at 700 µg. The extract also exhibited strong antioxidant activity, with 71.23% inhibition at 500 µg. (Nahak G & Sahu R K 2011) study evaluated the antioxidant activity of *Azadirachta indica* (Neem) flowers and seed oil. At a concentration of 200 µg/ml, the ethanolic extracts demonstrated significant free radical scavenging, with the flowers exhibiting 64.17% activity and the seed oil 66.34%. Neem seed oil had the highest phenolic content (132 µg/ml), which contributed to its strong DPPH inhibition. These results underscore the potential of Neem flowers and seed oil for applications in health, food, diabetes management, and pharmaceuticals. (Alzohairy, M. A., 2016) study shows that Neem (*Azadirachta indica*), a member of the Meliaceae family, is a rich source of antioxidants and widely used in traditional medicine, especially in the Indian subcontinent. It aids in disease prevention by scavenging free radicals and has shown anticancer potential by modulating key molecular pathways like p53, NF-κB, and PI3K/Akt. Considered safe, Neem regulates various biological processes without adverse effects, making it valuable for disease treatment and prevention.

### 3. *Picrorhiza kurroa* (Kutki):

(Mehta S *et al.*, 2021) stated that *Picrorhiza kurroa* Royle ex Benth. (Family: Plantaginaceae) is a widely recognized plant in Ayurveda, commonly known as “Kutki,” “Kurro,” or “Indian gentian.

“It’s medicinal properties and characteristic bitter taste are attributed to its bioactive constituents, iridoid glycosides. (Verma P C *et al.*, 2009) study shows that *Picrorhiza kurroa* is an endangered medicinal plant known for its hepatoprotective and immune-modulatory properties. Its key bioactive compound, *Picroliv*, is a glucoside mixture derived from the roots and rhizomes of mature plants. It also exhibits cholerectic, anti-cholestatic, antiviral, and immune-stimulant properties with minimal side effects. Due to its therapeutic potential, *Picroliv* is in high demand in pharmaceutical markets. (Raut A *et al.*, 2023) suggested Recent research explores its significance in managing non-alcoholic fatty liver disease (NAFLD) and its potential use in COVID-19. However, due to overharvesting, *P. kurroa* is now classified as endangered, prompting efforts in plant tissue culture for conservation. Traditionally used in powdered form or as part of multi-herbal formulations,

#### 3.1 Hepato protectivity:

(Rana R *et al.*, 2024) suggested that Kutki (*Picrorhiza kurroa*), a Himalayan herb, has been traditionally used for liver disorders. Its antioxidant and hepatoprotective properties were studied using Oxidative stress induced by ethanol in a liver slice culture system. Hepatotoxicity was measured through intracellular enzyme release, while antioxidant activity was assessed by analyzing key enzyme levels. (Sakamoto Y *et al.*, 2023) A *Picrorhiza kurroa* methanol extract showed hepatoprotective effects in mice. Key compounds—picroside II, androsin, and 4-hydroxy-3-methoxyacetophenone—reduced liver toxicity and TNF-α sensitivity without affecting macrophage activation. The study also analyzed phenylethanoids' structural requirements for hepatoprotection. (Anandan R & Devaki T 1999) GalN-induced hepatitis replicates human viral hepatitis by triggering oxidative stress and liver



damage. *Picrorhiza kurroa* (Kutki), a medicinal plant native to the Himalayas, has been traditionally used to treat liver disorders. This study investigates its hepatoprotective properties against GalN-induced liver injury in rats.

### Phytochemistry:

(Sultan P *et al.*, 2016) study validated a chromatography method to quantify picroside-I and II in *Picrorhiza kurroa*, showing significant variation across plant parts and altitudes. Picroside-I was highest in Gurez (3750 masl), while picroside-II peaked in Keller (3300 masl), highlighting an altitude-based correlation. The method proved accurate, precise, and reliable (Nisar J *et al.*, 2022) study examined the Methanolic extract of *Picrorhiza kurroa* showed highest antioxidant activity and strongest inhibition of  $\alpha$ -amylase and  $\alpha$ -glucosidase, indicating its potential for managing oxidative stress and diabetes. (Mohi-ud-din R *et al.*, 2022) suggested that *Picrorhiza kurroa*, a Himalayan medicinal herb, has potent antioxidant, hepatoprotective, and antidiabetic properties due to bioactive compounds like kutkin and picrosides. It is traditionally used for liver diseases, diabetes, and cancer, with research highlighting its cardioprotective and antimicrobial benefits.

### 3.2 Antimicrobial activity:

(Thapa A *et al.*, 2022) suggested that *Picrorhiza kurroa* extract exhibited strong antimicrobial activity against *Yersinia enterocolitica*, with picroside-I identified as a key bioactive compound. It effectively reduced bacterial viability, inhibited toxin production, and targeted dihydrofolate reductase (DHFR), suggesting its potential as a natural therapeutic agent for yersiniosis. (Dheer P *et al.*, 2022) study explored the antimicrobial potential of *Picrorhiza kurroa* against multidrug-resistant (MDR) *E. coli* in a 78-

year-old UTI patient. The methanolic root extract demonstrated strong antibacterial activity, forming a 23 mm inhibition zone. These findings validate its traditional Ayurvedic use and suggest its potential for developing natural treatments against MDR bacterial infections.

### 4. *Andrographis paniculata* (Kalmegh):

(Mishra S K *et al.*, 2007) study explored *Andrographis paniculata*, a plant widely used in traditional Asian medicine to treat infections, fever, and digestive issues. It possesses antibacterial, anti-inflammatory, hepatoprotective, and immunomodulatory properties. The key bioactive compound, andrographolide, exhibits anticancer, antiviral, and hypoglycemic effects. With increasing research supporting its therapeutic potential, the plant is gaining global recognition as a multipurpose medicinal agent. (Joseph S M *et al.*, 2014) suggested that *Andrographis paniculata* is a medicinal herb known for treating infections, fever, and liver disorders. It contains bioactive flavonoids and diterpenoids. Research highlights its pharmacological benefits, chemical properties, and possible toxicity. (Misra P *et al.*, 1992) study explored that *Andrographis paniculata* (Kalmegh), known for its hepatoprotective properties, was tested for antimalarial effects against *Plasmodium berghei*. An ethanol extract and its fractions reduced parasitemia, while four isolated diterpenes also showed suppression. Neoandrographolide demonstrated chemoprophylactic activity, effectively suppressing parasitemia with 15 days of pre-infection treatment. (Rajani M *et al.*, 2004) study suggested that quick method isolates andrographolide from *Andrographis paniculata* leaves via cold maceration and recrystallization. Its identity and purity were confirmed using spectroscopic and chromatographic techniques, melting point of 235.3°C.



#### 4.1 Hepato protectivity:

(Singh *et al.*, 2013) study assessed the hepatoprotective effects of *Andrographis paniculata* (Kalmegh) in viral hepatitis patients. A group receiving Kalmegh decoction with glucose showed improved liver function compared to the control group, confirming its protective benefits. (Darbar S *et al.*, 2009) study suggested that *Andrographis paniculata* (Kalmegh) protected against Diclofenac-induced liver toxicity in rats by restoring antioxidant enzymes, reducing lipid peroxidation, and lowering liver enzyme levels. Its hepatoprotective effect is linked to antioxidant enhancement and free radical scavenging. (Bose N & Gupta, O P., 2021) study found that Liver diseases are a growing health concern with severe complications. With limited modern hepatoprotective drugs, medicinal herbs like *Kalmegha* and *Bhumyamlaki* play a key role in liver care. Ayurveda classifies liver disorders under *Yakritvikara*, treating them holistically. These herbs exhibit hepatoprotective, antioxidant, anti-inflammatory, antidiabetic, antiviral, and anticancer properties, making them beneficial for liver health.

#### 4.2 Phytochemistry:

(Abirami K *et al.*, 2021) study analyzed the phytochemical composition of Kalmegh (*Andrographis paniculata*), a plant widely used in traditional medicine. Methanolic extracts had the highest phenol and flavonoid content, with strong antioxidant and chelating activities. Ethanolic extracts exhibited the highest nitric oxide activity, whereas acetone extracts were most effective in reducing hydrogen peroxide. The andrographolide content was found to be highest in the leaves (3.49%) compared to the stems (1.59%). (Tiwari V *et al.*, 2017) suggested that *Andrographis paniculata* is an herbaceous plant from the Acanthaceae family, traditionally used to treat

colds, liver disorders, and skin diseases. Phytochemical screening revealed it is rich in bioactive compounds, including alkaloids, tannins, flavonoids, steroids, and quinones. Its key component, andrographolide, possesses antioxidant properties and is effective against various human diseases.

#### 4.3 Antimicrobial activity:

(Deepak, S *et al.*, 2014) suggested that *Andrographis paniculata* exhibits strong antioxidant and antimicrobial properties. Its Hexane, DCM, and Methanol extracts demonstrated substantial DPPH radical scavenging activity and total reducing capacity. The DCM extract exhibited the strongest antibacterial activity against *S. aureus* and *S. pyogenes* (MIC: 100 µg/ml) and the highest antifungal activity against *C. albicans* (MIC: 200 µg/ml). (Rawat, D *et al.*,) study on *Andrographis paniculata* found its leaf and stem extracts effective against multidrug-resistant bacteria and fungal pathogens in the Doon Valley. (Adhikari, M & Mukhopadhyay, M. *et al.*, 2021) study found that Endophytes from *Andrographis paniculata* showed plant growth-promoting traits, enzyme activity, and antimicrobial potential, with several isolates inhibiting human pathogens, highlighting their medical relevance. (Hossain, S *et al.*, 2021) suggested that *Andrographis paniculata* shows strong antimicrobial potential, inhibiting microbial virulence and supporting immune responses. Clinical trials confirm its safety and efficacy, particularly for respiratory infections. Further research is needed to maximize its therapeutic applications.

#### 4.4 Antioxidant activity:

(Praveen, N. *et al.*, 2014) study identified 20 polyphenolic compounds in *Andrographis paniculata* leaves, with salicylic acid being the



most abundant. Ethyl acetate and butanol extracts displayed the highest phenolic content and antioxidant activity. (Verma, H., et al., 2024 ) Vermicompost @ 5 t/ha with 75 kg/ha nitrogen, 50 kg/ha P<sub>2</sub>O<sub>5</sub>, and 50 kg/ha K<sub>2</sub>O yielded the highest *Andrographis paniculata* growth and andrographolide content, promoting sustainable soil health. (Tewari, S. K et al., 2010) study shows that yield and quality of *Andrographis paniculata* varied with soil pH and seasons, with andrographolide content ranging from 2.25% to 3.85%. The plant showed strong antioxidant activity, DNA protection, and effective free radical scavenging. (Maity, G. N et al., 2019) study isolated and characterized a water-soluble polysaccharide (APPS) from the plant's stem, aiming to explore its structural and antioxidant properties for potential nutritional and therapeutic applications.

## CONCLUSION

The traditional medicinal plants includes *Andrographis paniculata*, *Azadirachta indica*, *Terminalia arjuna*, and *Picrorrhiza kurroa*, exhibits notable therapeutic and hepatoprotective properties. Numerous preclinical studies support the synergistic effects of these herbal components in preventing and managing liver disorders. This medicinal plants demonstrates antioxidant, anti-inflammatory, and antifibrotic effects, all of which contribute to maintaining liver health and functionality. Furthermore, research suggests that hepatoprotective medicinal plants may enhance liver enzyme levels, mitigate oxidative stress, and improve lipid profiles, highlighting its multifaceted approach to liver health. In order to confirm these findings and determine appropriate dosages and mechanisms of action, further clinical trials are necessary. As a natural therapeutic option for liver health, hepatoprotective medicinal plants deserves further exploration within the realm of integrative medicine.

## REFERENCES

1. Abd El-Moez, S. I., Omara, S. T., Amer, H. A., & Zaki, F. N. (2014). Antimicrobial activities of neem extract (*Azadirachta indica*) against microbial pathogens of animal origin. *Global Veterinaria*, 12(2), 250-256.
2. Abirami, K., Swain, S., & Baskaran, V. (2021). Phytochemical composition and andrographolide content of Kalmegh (*Andrographis paniculata*) grown in Andaman Islands. *IJCS*, 9(2), 580-585.
3. Adhikari, M., & Mukhopadhyay, M. (2021). Potentials of endophytes of *Andrographis paniculata* for the production of plant growth promoters, enzymes and antimicrobial compounds. *SAARC Journal of Agriculture*, 19(2), 157-170.
4. Alzohairy, M. A. (2016). Therapeutics role of *Azadirachta indica* (Neem) and their active constituents in diseases prevention and treatment. *Evidence-Based Complementary and Alternative Medicine*, 2016(1), 7382506.
5. Alzohairy, M. A. (2016). Therapeutics role of *Azadirachta indica* (Neem) and their active constituents in diseases prevention and treatment. *Evidence-Based Complementary and Alternative Medicine*, 2016(1), 7382506.
6. Amalraj, A., & Gopi, S. (2017). Medicinal properties of *Terminalia arjuna* (Roxb.) Wight & Arn.: a review. *Journal of traditional and complementary medicine*, 7(1), 65-78.
7. Anandan, R., & Devaki, T. (1999). Hepatoprotective effect of *Picrorrhiza kurroa* on tissue defence system in D-galactosamine-induced hepatitis in rats. *Fitoterapia*, 70(1), 54-57.
8. Atawodi, S. E., & Atawodi, J. C. (2009). *Azadirachta indica* (neem): a plant of multiple biological and pharmacological activities. *Phytochemistry reviews*, 8, 601-620.



9. Boeke, S. J., Boersma, M. G., Alink, G. M., van Loon, J. J., van Huis, A., Dicke, M., & Rietjens, I. M. (2004). Safety evaluation of neem (*Azadirachta indica*) derived pesticides. *Journal of ethnopharmacology*, 94(1), 25-41.
10. Bose, N., & Gupta, O. P. (2021). A LITERARY REVIEW ON KALMEGH AND BHUMYAMLAKI AS HEPATOPROTECTIVE MEDICINAL PLANTS.
11. Chattopadhyay, R. (2003). Possible mechanism of hepatoprotective activity of *Azadirachta indica* leaf extract: part II. *Journal of ethnopharmacology*, 89(2-3), 217-219.
12. Darbar, S., Bose, A., Bhaumik, U. K., Roy, B., Chatterjee, N., & Pal, T. K. (2009). Antioxidant and hepatoprotective effect of *Andrographis paniculata* leaf extract on diclofenac induced hepatotoxicity in rats. *Pharmacologyonline*, 2, 95-108.
13. Dash, S. P., Dixit, S., & Sahoo, S. (2017). Phytochemical and biochemical characterizations from leaf extracts from *Azadirachta Indica*: an important medicinal plant. *Biochem Anal Biochem*, 6(323), 2161-1009.
14. Deepak, S., Pawar, A., & Shinde, P. (2014). Study of antioxidant and antimicrobial activities of *Andrographis paniculata*. *Asian Journal of Plant Science and Research*, 4(2), 31-41.
15. Dheer, P., Pant, M., Dan, S., Semwal, S., & Garg, R. (2022). Antimicrobial property of *Picrorhiza kurroa* against multi-drug resistant uropathogenic *Escherichia coli*. *Lett. Appl. NanoBioSci*, 11, 3598-3604.
16. Doorika, P., & Ananthi, T. (2012). Antioxidant and hepatoprotective properties of *Terminalia arjuna* bark on isoniazid induced toxicity in albino rats. *Asian Journal of Pharmacy and Technology*, 2(1), 15-18.
17. Dwivedi, S. (2007). *Terminalia arjuna* Wight & Arn.—a useful drug for cardiovascular disorders. *Journal of ethnopharmacology*, 114(2), 114-129.
18. Dwivedi, S., & Chopra, D. (2014). Revisiting *Terminalia arjuna*—an ancient cardiovascular drug. *Journal of traditional and complementary medicine*, 4(4), 224-231.
19. Hossain, S., Urbi, Z., Karuniawati, H., Mohiuddin, R. B., Moh Qrimida, A., Allzrag, A. M. M., ... & Capasso, R. (2021). *Andrographis paniculata* (burm. F.) wall. Ex nees: an updated review of phytochemistry, antimicrobial pharmacology, and clinical safety and efficacy. *Life*, 11(4), 348.
20. Jain, D., Chaudhary, P., Kotnala, A., Hossain, R., Bisht, K., & Hossain, M. N. (2020). Hepatoprotective activity of medicinal plants: A mini review. *J. Med. Plants Stud*, 8(5), 183-188.
21. Jain, S., Yadav, P. P., Gill, V., Vasudeva, N., & Singla, N. (2009). *Terminalia arjuna* a sacred medicinal plant: phytochemical and pharmacological profile. *Phytochemistry Reviews*, 8, 491-502.
22. Javed, T., Riaz, S., Uzair, M., Mustafa, G., Mohyuddin, A., & Ahmad, B. (2016). Biological activity of *Terminalia arjuna* on human pathogenic microorganisms. *Pak. J. Pharm. Res*, 2(1), 23-27.
23. Joseph, S. M. (2014). Scientific aspects of the therapeutic use of *Andrographis paniculata* (Kalmegh): A review. *International Journal of Pharmaceutical Sciences Review and Research*, 27, 10-16.
24. Khan, I., Ullah, Z., Shad, A. A., Fahim, M., & Öztürk, M. (2022). In vitro antioxidant, anticholinesterase inhibitory, and antimicrobial activity studies of *Terminalia chebula* (Retz) and *Terminalia arjuna* (Roxb). *South African Journal of Botany*, 146, 395-400.

25. Khan, S., Noor, F., Sohail, I., Imtiaz, S., Anum, F., Sarmad, S., ... & Raza, S. (2020). Hepatoprotective role of fruit extract of *Terminalia arjuna* in acetaminophen intoxicated mice. *Advancements in Life Sciences*, 8(1), 63-67.
26. Maity, G. N., Maity, P., Dasgupta, A., Acharya, K., Dalai, S., & Mondal, S. (2019). Structural and antioxidant studies of a new arabinoxylan from green stem *Andrographis paniculata* (Kalmegh). *Carbohydrate polymers*, 212, 297-303.
27. Mandal, S., Patra, A., Samanta, A., Roy, S., Mandal, A., Mahapatra, T. D., ... & Nandi, D. K. (2013). Analysis of phytochemical profile of *Terminalia arjuna* bark extract with antioxidative and antimicrobial properties. *Asian Pacific journal of tropical biomedicine*, 3(12), 960-966.
28. Manna, P., Sinha, M., & Sil, P. C. (2006). Aqueous extract of *Terminalia arjuna* prevents carbon tetrachloride induced hepatic and renal disorders. *BMC complementary and alternative medicine*, 6, 1-10.
29. Mathew, A. (2005). Hepatoprotective effect of *Aegle marmelos* (Indian bael) and *Azadirachta indica* (Neem) aqueous leaf extract on paracetamol induced toxicity in rats (Doctoral dissertation, Department of Pharmacology and Toxicology, College of Veterinary and Animal Sciences, Mannuthy).
30. Mehta, S., Sharma, A. K., & Singh, R. K. (2021). Advances in ethnobotany, synthetic phytochemistry and pharmacology of endangered herb *Picrorhiza kurroa* (Kutki): A comprehensive review (2010-2020). *Mini reviews in medicinal chemistry*, 21(19), 2976-2995.
31. Mishra, S. K., Sangwan, N. S., & Sangwan, R. S. (2007). *Phcog rev.: Plant review Andrographis paniculata* (Kalmegh): A review. *Pharmacognosy Reviews*, 1(2), 283-298.
32. Misra, P., Pal, N. L., Guru, P. Y., Katiyar, J. C., Srivastava, V., & Tandon, J. S. (1992). Antimalarial activity of *Andrographis paniculata* (Kalmegh) against *Plasmodium berghei* NK 65 in *Mastomys natalensis*. *International Journal of Pharmacognosy*, 30(4), 263-274.
33. Mohi-ud-din, R., Mir, R. H., Wani, T. U., Shah, A. J., Mir, P. A., Jan, R., ... & Bandy, N. (2022). Phytochemical and pharmacological properties of *Picrorhiza kurroa*. In *Edible Plants in Health and Diseases: Volume II: Phytochemical and Pharmacological Properties* (pp. 399-423). Singapore: Springer Singapore.
34. Nahak, G., & Sahu, R. K. (2011). Evaluation of antioxidant activity of flower and seed oil of *Azadirachta indica* A. juss. *Journal of Applied and Natural Science*, 3(1), 78.
35. Nisar, J., Shah, S. M. A., Akram, M., Ayaz, S., & Rashid, A. (2022). Phytochemical screening, antioxidant, and inhibition activity of *Picrorhiza kurroa* against  $\alpha$ -amylase and  $\alpha$ -glucosidase. *Dose-response*, 20(2), 15593258221095960.
36. Nisbet, A. J. (2000). Azadirachtin from the neem tree *Azadirachta indica*: its action against insects. *Anais da Sociedade Entomológica do Brasil*, 29, 615-632.
37. Pandey, G., Verma, K. K., & Singh, M. (2014). Evaluation of phytochemical, antibacterial and free radical scavenging properties of *Azadirachta indica* (neem) leaves. *Int J Pharm Pharm Sci*, 6(2), 444-447.
38. Patil, U. H., & Gaikwad, D. K. (2011). Phytochemical evaluation and bactericidal potential of *Terminalia arjuna* stem bark. *International Journal of Pharmaceutical Sciences and Research*, 2(3), 614.

39. Pereira, L. D. P., Silva, K. E. S. D., Silva, R. O. D., Assreuy, A. M. S., & Pereira, M. G. (2012). Anti-inflammatory polysaccharides of *Azadirachta indica* seed tegument. *Revista Brasileira de Farmacognosia*, 22, 617-622.
40. Pokhrel, B., Rijal, S., Raut, S., & Pandeya, A. (2015). Investigations of antioxidant and antibacterial activity of leaf extracts of *Azadirachta indica*. *African Journal of Biotechnology*, 14(46), 3159-3163.
41. Praveen, N. (2014). Polyphenol composition and antioxidant activity of *Andrographis paniculata* L. Nees. *Mapana Journal of Sciences*, 13(4), 33.
42. Raghavan, B., & Kumari, S. K. (2006). Effect of *Terminalia arjuna* stem bark on antioxidant status in liver and kidney of alloxan diabetic rats. *Indian journal of physiology and pharmacology*, 50(2), 133.
43. Raja Ratna Reddy, Y., Krishna Kumari, C., Lokanatha, O., Mamatha, S., & Damodar Reddy, C. (2020). Antimicrobial activity of *Azadirachta Indica* (neem) leaf, bark and seed extracts.
44. Rajani, M., Shrivastava, N., & Ravishankara, M. N. (2000). A rapid method for isolation of andrographolide from *Andrographis paniculata* Nees (Kalmegh). *Pharmaceutical Biology*, 38(3), 204-209.
45. Ramya, S. (2008). Antimicrobial Activity of Aqueous Extracts of Bark, Root, Leaves and Fruits of *Terminalia arjuna* Wight & Arn. *Ethnobotanical leaflets*, 2008(1), 158.
46. Rana, R., Sharma, A., & Jeet, K. (2024). CHARACTERIZATION AND IN-VITRO EVALUATION HEPATOPROTECTIVE ACTIVITY FROM LEAF PART OF *PICRORHIZA KURROA*. *Biochemical & Cellular Archives*.
47. Raut, A., Dhami-Shah, H., Phadke, A., Shindikar, A., Udipi, S., Joshi, J., ... & Vaidya, A. D. (2023). *Picrorhiza kurroa*, Royle ex Benth: Traditional uses, phytopharmacology, and translational potential in therapy of fatty liver disease. *Journal of Ayurveda and Integrative Medicine*, 14(1), 100558.
48. Rawat, D., Keerti, K., & Panwar, M. Antimicrobial Activity of *A. Paniculata* Against Isolated MDR Strains. *International journal of health sciences*, 6(S4), 10618-10630.
49. S. Shamina, Dr.S.P.Suriyaraj, & V.Senjiskhan. (2022). One Pot Green Synthesis and Structural Characterisation of Bio-Silver Nanoparticles Using *Prunus Persica* L.: Life Sciences-Biochemistry for better Diagnosis and Therapy. *International Journal of Life Science and Pharma Research*, 11(1), 161–168.
50. SaiRam, M., Ilavazhagan, G., Sharma, S. K., Dhanraj, S. A., Suresh, B., Parida, M. M., ... & Selvamurthy, W. (2000). Anti-microbial activity of a new vaginal contraceptive NIM-76 from neem oil (*Azadirachta indica*). *Journal of Ethnopharmacology*, 71(3), 377-382.
51. Sakamoto, Y., Inoue, N., Nakanishi, Y., Ninomiya, K., Yoshikawa, M., Muraoka, O., ... & Morikawa, T. (2023). Hepatoprotective Principles from the Rhizomes of *Picrorhiza kurroa*. *Biological and Pharmaceutical Bulletin*, 46(6), 848-855.
52. Sangamithira, S. P., Revathy, J., Abdullah, S. S., & Kumar, P. S. (2016). The hepatoprotective effect of ethanolic bark extract of *Terminalia arjuna* on paracetamol induced liver damage. *Biosciences Biotechnology Research Asia*, 8(2), 777-781.
53. Schumacher, M., Cerella, C., Reuter, S., Dicato, M., & Diederich, M. (2011). Anti-inflammatory, pro-apoptotic, and anti-proliferative effects of a methanolic neem (*Azadirachta indica*) leaf extract are mediated via modulation of the nuclear factor- $\kappa$ B pathway. *Genes & nutrition*, 6, 149-160.



54. Singh, G., Singh, A. T., Abraham, A., Bhat, B., Mukherjee, A., Verma, R., ... & Burman, A. C. (2008). Protective effects of Terminalia arjuna against Doxorubicin-induced cardiotoxicity. *Journal of ethnopharmacology*, 117(1), 123-129.
55. Singh, H. A. R. B. A. N. S., & Sharma, A. N. J. A. L. I. (2013). A clinical evaluation of hepatoprotective effects of kalmegh (*Andrographis paniculata* wall. ex Nees) in patients of acute viral hepatitis. *J. Res. Educ. Indian Med*, 19(1-2), 9-16.
56. Sithisarn, P., Supabphol, R., & Gritsanapan, W. (2005). Antioxidant activity of Siamese neem tree (VP1209). *Journal of ethnopharmacology*, 99(1), 109-112.
57. Sivalokanathan, S., Ilayaraja, M., & Balasubramanian, M. P. (2006). Antioxidant activity of Terminalia arjuna bark extract on N-nitrosodiethylamine induced hepatocellular carcinoma in rats. *Molecular and cellular biochemistry*, 281, 87-93.
58. Sultan, P., Jan, A., & Pervaiz, Q. (2016). Phytochemical studies for quantitative estimation of iridoid glycosides in *Picrorhiza kurroa* Royle. *Botanical Studies*, 57, 1-6.
59. Susmitha, S., Vidyamol, K. K., Ranganayaki, P., & Vijayaragavan, R. (2013). Phytochemical extraction and antimicrobial properties of *Azadirachta indica* (Neem). *Global journal of pharmacology*, 7(3), 316-320.
60. Tewari, S. K., Niranjana, A., & Lehri, A. (2010). Variations in yield, quality, and antioxidant potential of kalmegh (*Andrographis paniculata* Nees) with soil alkalinity and season. *Journal of herbs, spices & medicinal plants*, 16(1), 41-5.
61. Thapa, A., Kaushik, R., Arora, S., Jaglan, S., Jaswal, V., Yadav, V. K., ... & Fogarasi, S. (2022). Biological activity of *Picrorhiza kurroa*: a source of potential antimicrobial compounds against *Yersinia enterocolitica*. *International Journal of Molecular Sciences*, 23(22), 14090.
62. Tiwari, V. (2017). Phytochemical analysis and medicinal value of Kalmegh (*Andrographis paniculata* Nees). *Indian J. Appl. Pure Biol*, 32, 283-288.
63. Uzzaman, S. (2020). Pharmacological activities of neem (*Azadirachta indica*): A review. *Int. J. Pharmacogn. Life Sci*, 1(1), 38-41.
64. Verma, H., Negi, M. S., Mahapatra, B. S., Shukla, A., Paul, J., Bhatt, M. K., ... & Prakash, O. (2024). Growth, yield, andrographolide content and total antioxidant activity of Kalmegh [*Andrographis paniculata* (Burm. f.) Wall. ex Nees] under variable nitrogen rates and organic manures application in Indo-Gangetic plains of India. *Journal of Plant Nutrition*, 47(20), 4048-4060.
65. Verma, P. C., Basu, V., Gupta, V., Saxena, G., & Ur Rahman, L. (2009). Pharmacology and chemistry of a potent hepatoprotective compound Picroliv isolated from the roots and rhizomes of *Picrorhiza kurroa* royle ex benth.(kutki). *Current pharmaceutical biotechnology*, 10(6), 641-649.
66. Verma, R. (2018). A review on hepatoprotective activity of medicinal plants. *J Med Plants Stud*, 6(1), 188-190..

**HOW TO CITE:** Mahadevan S., Muhammed Uvais T. T., Abdul Rahman S., Shamina S., Jamal Fathima M., A Review on Therapeutic Properties and Hepatoprotective Activities of Traditional medicinal plants: *Andrographis paniculata*, *Azadirachta indica*, *Terminalia arjuna*, and *Picrorhiza kurroa*, *Int. J. of Pharm. Sci.*, 2025, Vol 3, Issue 3, 3200-3213. <https://doi.org/10.5281/zenodo.15111118>

