HERBAL MEDICINE IN VIRAL HEPATITIS: EVIDENCE-BASED THERAPEUTIC POTENTIAL, MOLECULAR MECHANISMS, AND CLINICAL PERSPECTIVES.

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ABSTRACT

Viral hepatitis is a serious worldwide health problem as it leads to high morbidity due to chronic liver inflammation, cirrhosis, and other complications. Fortunately, there is a wide range of traditional medicinal herbs that can help in the treatment of the disease. Bioactive compounds isolated from medicinal plants, such as silymarin, glycyrrhizin, phyllanthin, curcumin, and andrographolide, have shown good antiviral activity against various hepatitis viruses. Mechanistically, these compounds are able to inhibit various stages of the viral replication cycle, including viral entry, DNA and RNA polymerization, and viral protein processing. They also possess potent antioxidant (by upregulating Nrf2-mediated SOD, catalase, glutathione, and downregulating reactive oxygen species and lipid peroxidation) and anti-inflammatory activities (by inhibiting NF-κB, COX-2, TNF-α, IL-1β, IL-6, and TGF-β/Smad pathways) and prevent hepatic stellate cell activation. Thus, herbal extracts are promising therapeutics for the treatment of viral hepatitis, as they effectively reduce serum ALT and AST levels, decrease the viral load, and improve general well-being with minimal side effects. However, there is a need for clinical trials to comprehensively evaluate the effectiveness and safety of herbal extracts in patients with viral hepatitis. Therefore, the combination of standard antiviral drugs with herbal extracts could be an optimal solution to fight the disease.

KEYWORDS

Viral hepatitis, Medicinal plants, Antiviral activity, Hepatoprotection, Phytochemicals, Clinical evidence.

INTRODUCTION

Viral hepatitis is spreading at an extremely rapid pace worldwide. The condition usually affects the parenchyma of the liver, mostly by way of five different viruses [1]. More than 1.1 million deaths are caused by the disease every year [2]. Chronic Hepatitis B and C viruses are particularly dangerous, as the infection is recurring in about 254 million and 50 million people worldwide, respectively, and it is the leading cause of cirrhosis and hepatocellular carcinoma [3,4]. Moreover, the hepatitis D virus (HDV) can chronically infect about 12 million people as either a coinfection or a superinfection with the hepatitis B virus (HBV). Such cases are exceptionally severe because they often lead to hepatic failure [5]. Finally, the hepatitis A and E viruses (HAV, HEV) are known to cause sporadic outbreaks of acute food- and water-borne illness, which are especially prevalent in developing countries and result in more than 50000 deaths from fulminant liver failure every year [6].

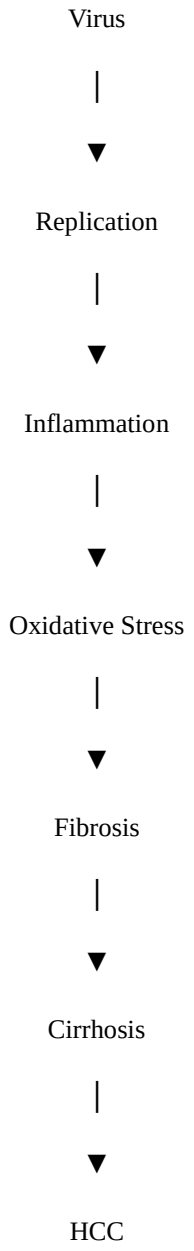
In response to this unacceptable mortality toll, WHO has set ambitious global elimination targets by 2030, including a 90% reduction in the incidence of chronic infection and a 65% reduction in hepatitis-related deaths compared to 2015 levels [7]. Nevertheless, it is essential to recognize that the attainment of these targets is significantly hindered by the current limitations of conventional therapeutics [8]. Chronic hepatitis B virus (HBV) infections require long-term nucleos(t)ide analogue (NUC) suppression, which is associated with an inevitable risk for viral resistance, thereby undermining treatment efficacy [9]. Moreover, while pan-genotypic direct-acting antivirals (DAAs) are undeniably potent in treating hepatitis C virus (HCV) infections, their worldwide application is impeded by prohibitively high costs and insufficient accessibility in low- and middle-income countries [10]. Additionally, conventional interferon-based regimens for HCV are limited by severe adverse effects, including pronounced cytopenias, depression, and overall immunosuppression [11].

To counter these pharmacological limitations, there is an emerging need to develop herbal medicine and natural compounds as adjunctive treatments for hepatic diseases [12]. However, non-standardized botanicals may pose an even greater risk for severe drug-induced liver injury; thus, evidence-based phytotherapy is of utmost essence [13]. Double-blind randomized clinical trials are needed to standardize the doses and establish the safety profile of herbal remedies and to identify the bioactive components targeting viral and fibrotic pathways [14].

PATHOGENESIS OF VIRAL HEPATITIS

The major causes of viral hepatitis are caused by 5 different hepatotropic viruses: HAV, HBV, HCV, HDV and HEV [15], whose difference in structure and replication mechanisms is reflected in the ways of their damaging effect on the liver [16].

Viral entry into the host hepatocyte is determined by specific cell receptors, among which are NTCP for HBV/HDV and CD81 for HCV [8]. After their entry into the cell, viruses can replicate either in the nucleus (for HBV, using stable cccDNA templates) or in the cytoplasm in the form of membrane-associated RCs (for HCV, HEV, and HAV) [4]. However, HDV causes a direct cytopathic effect, while the destruction of hepatocytes for the other three viruses is mainly immune-mediated [19]. For example, antigen-presenting cells recruit cytotoxic CD8+ T-cells and NKs that cause massive apoptosis and necrosis of infected cells [20].



When viral clearance fails (particularly in HBV, HCV, and HDV), persistent active replication causes chronic inflammation [11]. Activated intrahepatic Kupffer cells continuously release pro-inflammatory cytokines such as TNF-α and IL-6 [22]. This ongoing inflammatory state induces intracellular oxidative stress, generating excessive reactive oxygen species (ROS) that induce severe mitochondrial dysfunction and lipid peroxidation [23]. ROS and pro-inflammatory signaling cascades activate quiescent hepatic stellate cells (HSCs) into collagen-producing myofibroblasts [14].

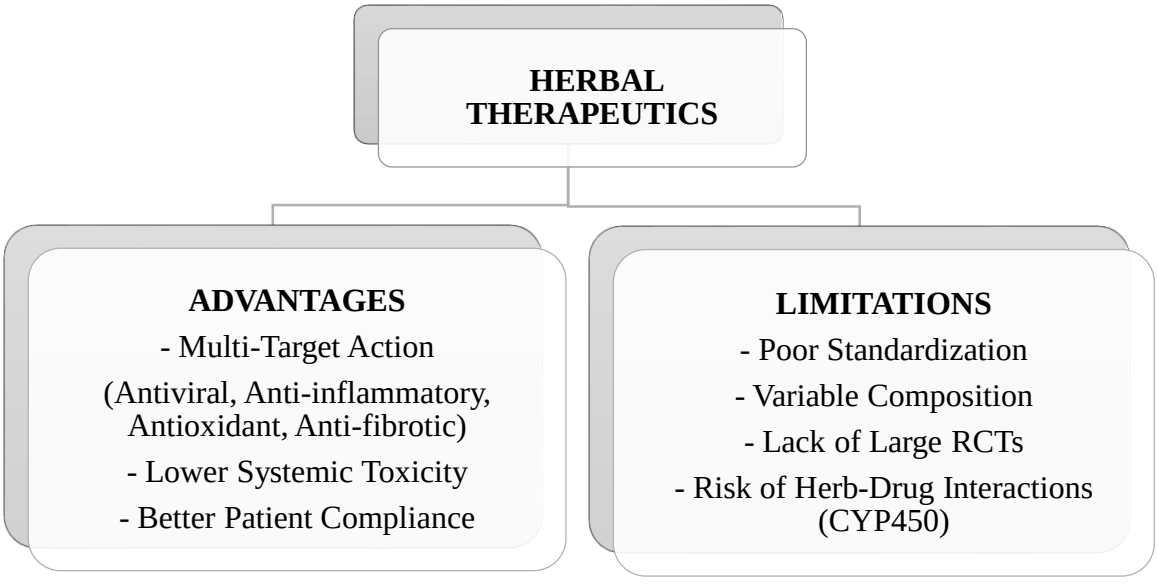
Pathological extracellular matrix deposition plays a pivotal role in liver fibrosis progression [21]. Subsequently, the disrupted hepatic architecture is replaced by distorted tissue, resulting in cirrhosis with regenerate nodules and impaired vascularization [13]. Consequently, enhanced cell turnover, oxidative stress-mediated DNA damage, and altered oncogenic signaling cascades contribute to genomic instability, culminating in hepatocellular carcinoma [22].

NEED FOR HERBAL MEDICINES IN VIRAL HEPATITIS

Herbal medicines are presented as promising treatment alternatives or complements for patients with complex forms of liver disease [14]. Their main advantage is the multi-target nature of their action [13]. In contrast to single compound drugs, herbal medicines contain a combination of bioactive substances, which act synergistically on several targets, including antiviral, anti-inflammatory, antioxidant, immunomodulatory, and anti-fibrotic [12].Phytochemicals directly suppress viral replication, scavenge reactive oxygen species (ROS), inhibit nuclear factor-kappa B (NF-κB) pathways, regulate host immune responses, and suppress hepatic stellate cell (HSC) activation [17]. Furthermore, plant-derived therapies generally offer lower intrinsic toxicity and improved long-term patient compliance compared to synthetic antiviral regimens [3].

Despite the apparent benefits, there are considerable limitations to the current state of herbal medicines that impede their widespread acceptance by the scientific community in the field of hepatology [8]. These include the challenge of standardizing preparations from one batch to another due to the variable composition of phytochemicals resulting in inconsistent clinical outcomes [11]. Besides, many herbal treatments lack robust clinical evidence from randomized controlled trials to establish their safety profiles, optimal doses, and mechanisms of action [19]. Lastly, inappropriate administration may result in serious adverse effects through interactions with other drugs by causing induction or inhibition of metabolic enzymes and transporters [21].

Figure 1: Advantages and limitations of herbal therapeutics



MEDICINAL PLANTS USED IN VIRAL HEPATITIS

Traditional medicinal plants are a significant source of hepatoprotective and antiviral compounds [14]. Active ingredients isolated from these plants can affect different stages of the viral replication cycle and reduce liver inflammationmediated signalization pathways [13].

Table 1: Comparative Analysis of Medicinal Plants

Plant	Major Compounds	Mechanism	Evidence
Silybum marianum	Silymarin (Silybin A/B)	Antioxidant, membrane stabilization, anti-fibrotic	Clinical
Glycyrrhiza glabra	Glycyrrhizin, Glycyrrhizic acid	Anti-HBV, surface antigen suppression, anti-inflammatory	Clinical
Phyllanthus amarus	Lignans (Phyllanthin, Hypophyllanthin)	Anti-HBV polymerases, HBsAg/HBeAg inhibition	Clinical
Andrographis paniculata	Andrographolide	NF-κB inhibition, immunomodulatory, anti-apoptotic	Preclinical
Curcuma longa	Curcumin	NF-κB inhibition, downregulates HBV transcription	Clinical
Picrorhiza kurroa	Picrosides (Picroside I & II)	Hepatoprotective, lipid peroxidation inhibition	Clinical
Eclipta alba	Wedelolactone	Anti-inflammatory, 5-lipoxygenase inhibition	Experimental
Boerhavia diffusa	Punarnavine	Antioxidant, free radical scavenging, anti-fibrotic	Animal
Tinospora cordifolia	Tinosporaside	Immunomodulatory, macrophage activation	Experimental
Camellia sinensis	EGCG (Epigallocatechin gallate)	Anti-HCV, viral entry & assembly inhibition	Experimental

Botanical Profiles

1. Silybum marianum (Milk Thistle)

- Active Constituents: Silymarin, a standardized mixture of flavonolignans, mainly comprising silybin A, silybin B, isosilybin, and silicristin [12].
- Molecular Targets: Free radical scavenging pathways, lipid peroxidation cascades, and transforming growth factor-beta 1 (TGF-β1) signaling [17].
- Experimental Studies: In cellular and animal models, silymarin decreases alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels and protects mitochondria; additionally, it prevents hepatic stellate cell activation [3].
- Clinical Evidence: Human randomized trials confirm that silymarin improves liver enzyme profiles and reduces liver-related mortality in chronic viral hepatitis and cirrhotic cohorts.

2. Glycyrrhiza glabra (Licorice)

- Active Constituents: Glycyrrhizin (glycyrrhizic acid) and liquiritigenin [8].
- Molecular Targets: Hepatitis B virus surface antigen (HBsAg) secretion pathways, HMGB1 inflammatory pathways, and nuclear factor-κB (NF-κB) [11].
- Experimental Studies: In vitro experiments have revealed the ability of glycyrrhizin to inhibit the intracellular transportation and accumulation of viral particles, as well as the secretion of pro-inflammatory cytokines [19].
- Clinical Evidence: The intravenous administration of glycyrrhizin (Stronger Neominophagen C) has been found to reduce the levels of serum transaminases and slow down the progression of chronic hepatitis B and C.

3. Phyllanthus amarus (Stonebreaker)

- Active Constituents: Lignans including phyllanthin, hypophyllanthin, and niranthin.
- Molecular Targets: HBV DNA polymerase, reverse transcriptase, and mRNA transcription factors [21].
- Experimental Studies: Extracts block endogenous HBV polymerase activity, clear viral transcripts, and inhibit viral antigen release in transfected cell lines [15].
- Clinical Evidence: Randomized clinical trials indicate accelerated clearance of serum HBsAg and normalization of liver function tests in chronic HBV infection [16].

4. Andrographis paniculata (King of Bitters)

- Active Constituents: Diterpene lactones, primarily andrographolide and neoandrographolide.
- Molecular Targets: IκB kinase (IKK) complex, NF-κB p65 subunit, and tumor necrosis factor-alpha (TNF-α) [4].
- Experimental Studies: Andrographolide prevents ROS-mediated hepatocyte cell death and downregulates expression of pro-inflammatory COX-2 and iNOS enzymes in hepatoma cells [18].
- Clinical Evidence: Preclinical evaluations dominate, though polyherbal clinical trials incorporating A. paniculata confirm accelerated reduction of jaundice and liver enzymes.

5. Curcuma longa (Turmeric)

- Active Constituents: Curcuminoids, featuring curcumin, demethoxycurcumin, and bisdemethoxycurcumin [20].
- Molecular Targets: NF-κB, AP-1, c-Jun N-terminal kinase (JNK), and HBV enhancer elements [22].
- Experimental Studies: Curcumin suppresses HBV gene expression and replication by downregulating peroxisome proliferator-activated receptor-gamma coactivator 1-alpha (PGC-1α) [2].

- Clinical Evidence: Clinical studies confirm significant reductions in systemic oxidative markers and inflammatory cytokine levels in chronic liver disease patients [5].

6. Picrorhiza kurroa (Kutki)

- Active Constituents: Iridoid glycosides, mainly picroside I, picroside II, and kutkoside.
- Molecular Targets: Glutathione peroxidase production, Na+/K+-ATPase membrane pumps, and lipid peroxides [6].
- Experimental Studies: Picrosides restore endogenous liver antioxidant enzyme levels and preserve hepatocyte membrane fluidity against chemical and viral toxins [7].
- Clinical Evidence: Human trials demonstrate significant clinical recovery from viral hepatitis, marked by rapid drops in serum bilirubin and transaminases.

7. Eclipta alba (False Daisy)

- Active Constituents: Coumestans, predominantly wedelolactone and demethylwedelolactone.
- Molecular targets include 5-lipoxygenase (5-LOX), IκBα phosphorylation, and inflammatory eicosanoids [9].
- Experimental Studies: Wedelolactone selectively inhibits NF-κB activation, limiting macrophage infiltration and focal liver necrosis in damaged liver models.
- Clinical Evidence: Validated in experimental liver damage models showing structural hepatocyte preservation, with clinical utilization seen in combination therapies.

8. Boerhavia diffusa (Punarnava)

- Active Constituents: Alkaloids such as punarnavine, alongside boeravinones.
- Molecular Targets: Reactive oxygen species (ROS), malondialdehyde (MDA), and pro-fibrotic collagen type I synthesis [10].
- Experimental Studies: In vivo rodent assays show marked reductions in lipid peroxidation, suppression of fibrotic scarring, and enhancement of superoxide dismutase (SOD) [1].
- Clinical Evidence: Demonstrated efficacy in animal models of toxic and viral liver injury, supporting its inclusion in hepatoprotective herbal formulations.

9. Tinospora cordifolia (Guduchi)

- Active Constituents: Diterpene compounds including tinosporaside and cordifoliosides [23].
- Molecular Targets: Polymorphonuclear leukocytes, Kupffer cell phagocytosis, and interleukin-2 (IL-2) pathways [24].

- Experimental Studies: Tinosporaside enhances host immune function by boosting functional neutrophil phagocytosis and suppressing free radical propagation [25].
- Clinical Evidence: Experimental and clinical trials show improved host systemic immunity, reduced jaundice severity, and overall liver parenchymal recovery.

10. Camellia sinensis (Green Tea)

- Active Constituents: Polyphenols, chiefly epigallocatechin-3-gallate (EGCG) [26].
- Molecular Targets: HCV cell entry receptors (CD81, SR-BI) and viral NS3/4A protease activity [27].
- Experimental Studies: EGCG prevents primary hepatocyte attachment and cell-to-cell spread of HCV in cell culture models [28].
- Clinical Evidence: Experimental studies highlight robust inhibition of viral entry, serving as a template for direct-acting green tea extract derivative trials [29].

MOLECULAR MECHANISMS OF HERBAL MEDICINES

The mechanism of action of medicinal plants in the treatment of viral hepatitis is due to their ability to affect multiple sites at once [14]. Phytochemicals interfere with different points of the cascade leading to the inhibition of replication process, reduction of inflammatory response, prevention of oxidative stress, disruption of extracellular matrix deposits, and restoration of host defenses [13].

Molecular Targets and Pathways

1. Antiviral Action

- Inhibition of Viral Entry: Bioactive compounds directly bind host-cell entry receptors (e.g., NTCP for HBV, CD81 for HCV) or viral envelope glycoproteins, sterically hindering particle attachment and membrane fusion [30].
- Inhibition of DNA/RNA Polymerase: Phytochemicals interfere with viral catalytic enzymes, specifically blocking HBV reverse transcriptase and HCV NS5B RNA-dependent RNA polymerase [31].
- Inhibition of Viral Replication: Bioactives downregulate host transcription factors required for viral promoters, preventing intermediate nucleic acid synthesis [8].
- Reduced Viral Protein Synthesis: Flavonoids and lignans destabilize viral mRNA transcripts and impair ribosome translation, significantly decreasing structural surface antigens (HBsAg) and non-structural proteins [4].

2. Antioxidant Mechanisms

- Upregulation of Endogenous Enzymes: Through the activation of the Nrf2 pathway, polyphenols induce the production of endogenous antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), and reduced glutathione (GSH) [32].

- Scavenging of Free Radicals: Phytochemicals help in scavenging free radicals that lead to a significant decrease in the levels of reactive oxygen species (ROS), lipid peroxidation, and malondialdehyde (MDA) [33].

3. Anti-Inflammatory Pathways

- Transcription Factor Inhibition: Bioactive components suppress the nuclear factor-kappa B (NF-κB) cascade by blocking IκBα phosphorylation and nuclear translocation of the p65 subunit [34].
- Cytokine & Enzyme Downregulation: Inhibition of NF-κB directly reduces pro-inflammatory signaling molecules, leading to significant decreases in tumor necrosis factor-alpha (TNF-α), interleukin-1 beta (IL-1β), interleukin-6 (IL-6), and cyclooxygenase-2 (COX-2) expression [35].

4. Anti-Fibrotic Activity

- TGF-β/Smad Signaling Blockade: Phytochemicals downregulate transforming growth factor-beta 1 (TGF-β1) ligands and suppress Smad2/3 phosphorylation [36].
- Inhibition of HSC Transdifferentiation: Blocking the TGF-β/Smad cascade prevents quiescent hepatic stellate cells (HSCs) from transdifferentiating into activated myofibroblasts [17].
- Resolution of Matrix Deposition: Quenched HSC activity leads to reduced expression of α-smooth muscle actin (α-SMA) and a dramatic drop in pathological collagen type I and III deposition [21].

5. Immunomodulation

- Immune Cell Activation: Bioactive polysaccharides boost host adaptive and innate surveillance, resulting in an increase in natural killer (NK) cell cytotoxicity, CD4+ T-helper lymphocyte proliferation, and interferon-gamma (IFN-γ) production [22].
- Prevention of Cytokine Storm: Modulatory compounds downregulate hyperactivated Kupffer cells, decreasing excess cytokine release and preventing systemic immune-mediated liver necrosis [12].

CLINICAL EVIDENCES

Clinical trials evaluate the therapeutic efficacy and bio-safety of standardized phytotherapeutic agents in acute and chronic liver conditions [14].

Table 2: Information of some major Clinical Trials

Herb	Target Disease State	Primary Outcome	Clinical Findings
Silybum marianum (Silymarin)	Chronic HBV / HCV	Improved ALT & AST levels	Statistically significant reduction in serum ALT and AST transaminases.

Glycyrrhiza glabra (Glycyrrhizin)	Chronic Viral Hepatitis	Reduced necroinflammation	Marked decrease in systemic inflammation and histological activity.
Phyllanthus amarus	Chronic HBV Infection	Clearance of viral markers	Promoted loss of HBsAg, HBeAg, and serum HBV DNA clearance.
Curcuma longa (Curcumin)	Toxic & Metabolic Liver Injury	Restored liver function	Downregulated parenchymal markers and improved metabolic function.

Clinical Outcomes and Safety Profile

Primary Therapeutic Outcomes

- ALT & AST Reduction: Trial results have shown that the administration of silymarin and curcumin significantly lowers serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST), thus proving stabilized hepatocyte cell membranes [37].
- Viral Load Reduction: Clinical evaluations of Phyllanthus amarus and glycyrrhizin confirm significant declines in serum HBV DNA levels along with a accelerated loss of circulating hepatitis B surface antigen (HBsAg) [38].
- Better Liver Function: Active phytochemical therapies restore functional hepatic clearance, leading to lower total serum bilirubin levels and stabilized protein synthesis [39].

Safety Profile

- Across multiple randomized controlled trials, standardized extracts demonstrated favorable overall safety profiles and high patient tolerance. Adverse events were negligible, primarily consisting of mild, self-limiting gastrointestinal symptoms [40].

CONCLUSION

Medicinal herbs exhibit notable antiviral and liver-protecting properties that offer considerable therapeutic possibilities for treating diseases of the liver. Several pathways on the molecular level—all of which contribute to the wide-ranging therapeutic effects of herbal medicine—work. These pathways consist of not only the direct blocking of viruses from entering and replicating within the liver, but also the activation of antioxidant Nrf2, suppression of the inflammatory pathway NF-kB, as well as blocking of the activity of TGF-β/Smad and fibrotic processes. Nonetheless, while the outcomes of the studies conducted so far seem impressive, the evidence in favor of these claims is still lacking. This is primarily due to limited availability of the relevant clinical studies as they were conducted on small sample groups or exhibit considerable differences from one another. Therefore, proper standardization of herbal medicines and conducting a number of clinical trials on a large scale is required before implementing herbal drugs for practical medical purposes. One should consider the current developments in

modern medicine and think about the soon integration of standardized herbal remedies with other modern treatment methods.

REFERENCES

1. Albadr, R. J. (2025). Recent Advances in mRNA-Based Vaccines Against Several Hepatitis Viruses. Pathogens, 14(7), 144–158.
2. Li, M. (2025). World Hepatitis Day 2025: Progress and Challenges in the Global Elimination of Viral Hepatitis. China CDC Weekly, 7(30), 567–573.
3. Gill, U. S. (2026). What is new in hepatitis B. Frontline Gastroenterology, 17(2), 161–171.
4. Costa, G. L., & Sautto, G. A. (2025). Towards an HCV vaccine: an overview of the immunization strategies for eliciting an effective B-cell response. Expert Review of Vaccines, 24(1), 96–120.
5. Shanmugam, V. (2025). Challenges and opportunities in combating viral hepatitis in India: insights from the Indian Hepatitis Summit 2025. Journal of Public Health Policy and Clinical Practice, 3(1), 102–111.
6. Goel, V. (2025). Seroprevalence and Co-infection Pattern of Hepatitis B Virus, Hepatitis C Virus, and Human Immunodeficiency Virus among Antenatal Women in a Tertiary Care Hospital in Western Uttar Pradesh, India. International Journal of Medical and Pharmaceutical Research, 6(1), 2266.
7. Al-Busafi, S. A., & Alwassief, A. (2024). Global Perspectives on the Hepatitis B Vaccination: Challenges, Achievements, and the Road to Elimination by 2030. Vaccines, 12(3), 288.
8. Elbehiry, A. (2026). Hepatocyte-Targeted Drug Delivery Strategies for Chronic Hepatitis B: Overcoming Delivery Barriers Toward Functional Cure. Pharmaceutics, 18(2), 212.
9. Kerth, H. A. (2026). Therapeutic hepatitis B vaccine employing DNA prime – MVA boost scheme requires additional priming with recombinant HBsAg to elicit an adequate antibody response. Frontiers in Immunology, 17, Article 1771887.
10. Lu, M. (2025). Hepatitis Vaccines: Recent Advances and Challenges. Vaccines, 13(11), 1174.
11. Sorn, V. (2026). AI-driven healthcare: a trend toward better healthcare or the emergence of public health burden. Frontiers in Digital Health, 8, 1845875.
12. Sukeepaisarnjaroen, W. (2025). Effectiveness of silymarin with lifestyle intervention in NAFLD and metabolic syndrome: a prospective single-arm study. BMC Complementary Medicine and Therapies, 25(1), 134.
13. Philips, C. A. (2026). Analysis of 386 alternative medicinal products implicated in liver injury reveal clinically relevant associations with potentially hepatotoxic botanicals, pharmaceutical adulteration, heavy metal contamination, and undisclosed animal content. Frontiers in Gastroenterology, 5, 1784785.
14. Lou, M. (2026). The current status and emerging trends in the application of precision nutrition for the comprehensive, lifecycle-based management of chronic liver diseases. Frontiers in Nutrition, 13, Article 1827158.
15. Zhang, X. (2025). An Artificial Intelligence Pipeline for Hepatocellular Carcinoma: From Data to Treatment Recommendations. International Journal of General Medicine, 18, 5293–5322.
16. Nazih, M., Waked, I., & Abdelsattar, S. (2025). Pharmacogenomics of Sorafenib in Hepatocellular Carcinoma (HCC): A LncRNA-Expression Guided Approach Using UCA1 and MALAT1 for Personalizing Therapy in a 154-Patient Cohort. Journal of Personalized Medicine, 15(4), 512.

17. Re, O. L. (2025). Establishment of Patient-Derived Organoids from Hepatocellular Carcinoma: Preliminary Data on Yield, Histopathological Concordance, and Methodological Challenges. Translational Oncology Research, 18(2), 443–452.
18. Xu, M. (2025). Organoids for disease modeling and treatment: state-of-the-art. Journal of Biomedical Science and Clinical Translation, 32(1), 89–104.
19. Wittich, L. (2026). Navigating the complexities of digital health technology implementation: a scoping review of barriers and facilitators. Implementation Science Communications, 7(1), 59.
20. Wenderott, K. (2025). Comprehensive recommendations for the implementation of artificial intelligence in healthcare: a narrative review on facilitators and barriers. BMJ Open Quality, 14(1), e003639.
21. Vyas, A. (2026). Smart Pharmaceutical Formulation and Drug Delivery Using AI. International Journal of Research and Innovation in Applied Science, 11(5), 1606–1632.
22. Wang, Y., et al. (2024). Immune evasion mechanisms of hepatitis B virus: implications for novel therapeutic strategies. World Journal of Gastroenterology, 30(12), 1689–1702.
23. Acharya, M. (2026). Therapeutic Role of Ayurveda in Chronic Liver Disease: Clinical and Biochemical Outcomes from a Single Case Study. Journal of Ayurveda and Integrated Medical Sciences, 11(1), 541–551.
24. Singh, R. (2025). Ethnopharmacology: An Innovative Approach for the Treatment of Jaundice Using Traditional Medicinal Systems. World Journal of Environmental Biosciences, 14(3), 64–74.
25. Alam, M. A. (2025). Therapeutic Evaluation of Syrup Nexoliv™ for Liver Health Support. Journal of Drug Delivery and Therapeutics, 15(2), 101–108.
26. Pandey, A. (2023). Promising hepatoprotective agents from natural sources: A study of scientific evidence. Egyptian Liver Journal, 13, Article 14.[Hawke, R. L. (2010). Silymarin ascending multiple oral dosing phase I study in noncirrhotic patients with chronic hepatitis C. Phytotherapy Research, 24(5), 651–657.
27. Hawke, R. L. (2010). Silymarin ascending multiple oral dosing phase I study in noncirrhotic patients with chronic hepatitis C. Phytotherapy Research, 24(5), 651–657.
28. Prabhu, K. (2018). Hepatoprotective role of Eclipta alba against high fatty diet treated experimental models: A histopathological study. Maedica, 13(3), 217–222.
29. An, L. (2024). Hepatoprotective and anti-hepatocarcinogenic effects of glycyrrhizin and matrine. Journal of Ethnopharmacology, 318, Article 116982.
30. Ponticelli, M., Bellone, M. L., Parisi, V., Iannuzzi, A., Braca, A., de Tommasi, N., Russo, D., Sileo, A., Quaranta, P., Freer, G., Pistello, M., & Milella, L. (2023). Specialized metabolites from plants as a source of new multi-target antiviral drugs: a systematic review. Phytochemistry Reviews, 22(3), 615–693. https://doi.org/10.1007/s11101-023-09855-2 Cited by: 32
31. Musazadeh, V., Karimi, A., bagheri, N., Jafarzadeh, J., Sanaie, S., Vajdi, M., Karimi, M., & Niazkar, H. R. (2022). The favorable impacts of silibinin polyphenols as adjunctive therapy in reducing the complications of COVID-19: A review of research evidence and underlying mechanisms. Biomedicine & Pharmacotherapy, 154, Article 113593. https://doi.org/10.1016/j.biopha.2022.113593 Cited by: 17

32. Hernández-Aquino, E., & Muriel, P. (2018). Beneficial effects of naringenin in liver diseases: Molecular mechanisms. World Journal of Gastroenterology, 24(16), 1679–1707. https://doi.org/10.3748/wjg.v24.i16.1679 Cited by: 414
33. D'souza, S., Lau, K. C., Coffin, C. S., & Patel, T. R. (2020). Molecular mechanisms of viral hepatitis induced hepatocellular carcinoma. World Journal of Gastroenterology, 26(38), 5759–5783. https://doi.org/10.3748/wjg.v26.i38.5759 Cited by: 322
34. Gupta, A., Singh, A. K., Kumar, R., Ganguly, R., Rana, H. K., Pandey, P. K., Sethi, G., Bishayee, A., & Pandey, A. K. (2019). Corilagin in Cancer: A Critical Evaluation of Anticancer Activities and Molecular Mechanisms. Molecules, 24(18), Article 3399. https://doi.org/10.3390/molecules24183399 Cited by: 114
35. Li, H., Huang, M. H., Jiang, J. D., & Peng, Z. G. (2018). Hepatitis C: From inflammatory pathogenesis to anti-inflammatory/hepatoprotective therapy. World Journal of Gastroenterology, 24(47), 5297–5311. https://doi.org/10.3748/wjg.v24.i47.5297 Cited by: 142
36. Niu, Q. (2025). Natural medicines for treating liver fibrosis by modulating post-translational modifications. Frontiers in Pharmacology, 16, Article 1660908.
37. El-Kamary, S. S., et al. (2009). A randomized controlled trial to assess the safety and efficacy of silymarin on symptoms, signs and biomarkers of acute hepatitis. Phytomedicine, 16(5), 391–400.
38. Manns, M. P., et al. (2012). Glycyrrhizin in patients who failed previous interferon alpha-based therapies: Biochemical and histological effects after 52 weeks. Journal of Hepatology, 57(3), 529–538.
39. Xia, Y., et al. (2021). Anti-hepatitis B virus effects of traditional medicinal plants: Learning from clinical trials over the past twenty years. World Journal of Gastroenterology, 27(11), 1078–1092.
40. Rahmani, S., et al. (2016). Treatment of non-alcoholic fatty liver disease with curcumin: A randomized placebo-controlled trial. Phytotherapy Research, 30(9), 1540–1548.