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Nutritional and Herbal Interventions for Liver Health: A Comprehensive Review

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Abstract-

The bodies primary organ for metabolic and detoxifying processes is the liver. As a result, its illnesses can be linked to exogenous insults like medications, xenobiotics, or alcohol as well as metabolic problems like insulin resistance, obesity, diabetes, or dyslipidemia . In fact, the main strategies for preventing and treating liver illnesses are lifestyle modifications. Based on its anti-inflammatory, anti-apoptotic, and antioxidant properties, herbal remedies have also been employed for therapeutic and preventive purposes since ancient times. In vitro and in vivo research, as well as clinical trials, were included in the examination of the literature for possible therapeutic effects of plants and their components. The indications and posology of particular plants need to be defined by multi-center, randomized clinical trials, even though the data now available suggests some beneficial activities of herbal remedies on the liver.

key word –

Fibrosis, herbal remedies, alcoholic and non-alcoholic liver diseases, plants, and silymarin

Introduction –

The human liver is an essential organ that supports metabolism, immunity, digestion, detoxification, and vitamin storage, among other processes. It makes up about 2% of the body weight of an adult. The liver is special because it receives blood from both the hepatic artery (about 25%) and the portal vein (about 75%).[1]

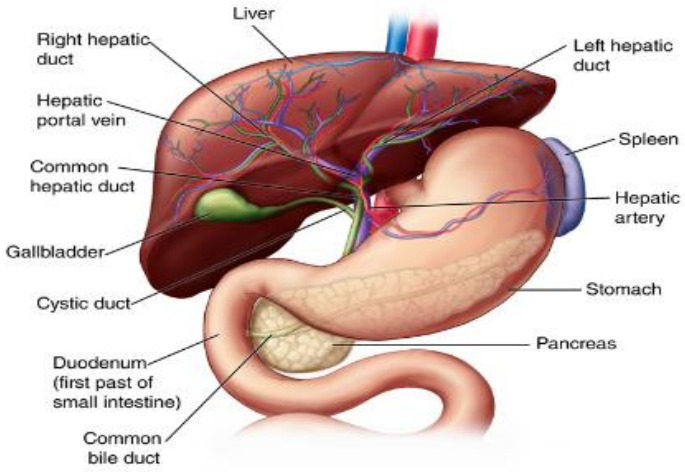


Figure 1: Anatomy of the Hepatobiliary System and Associated Digestive Organs.

The liver is completely covered by visceral peritoneum, with the exception of the bare area, which is where the liver is in contact with the diaphragm.[2]

Key facts

Function	Xenobiotic biotransformation, protein synthesis, nutrient storage, bile production, bilirubin metabolism
Anatomy	Liver Lobes: Right, left, caudate, and quadrate Surfaces: Diaphragmatic and visceral Ligaments: Coronary, left triangular, falciform, round ligament, and venous Fissures and Recesses: Porta hepatis (central fissure), subphrenic recess, and hepatorenal recess
Lymphatic drainage	Superficial system (lymphatic vessels of subserosal areolar tissue) Deep system (lymphatic vessels within the substance of the liver)
Vascularization	Functional: portalvein Nutritive: hepaticartery Drainage: hepatic vein > inferior vena cava > right atrium
Innervation	Hepatic plexus, cervical plexus

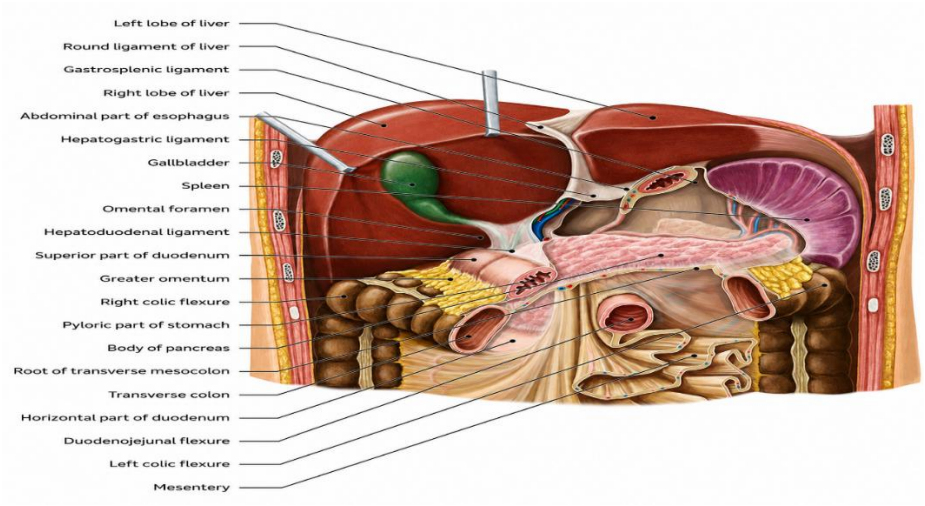


Figure 2: Anatomy of the abdominal viscera, peritoneal ligaments, and mesentery.

Lobes of the liver

The four anatomical lobes are further subdivided into even smaller sections based on the liver's blood supply. The left lobe is a smaller, flattened lobe, while the right lobe is the biggest of the four. The fossae for the gallbladder and inferior vena cava divide these two lobes. The quadrate lobe is situated between the gallbladder and the ligamentum teres hepatis fissure, whereas the caudate lobe is situated between the ligamentum venosum fissure and the inferior vena cava.[2]

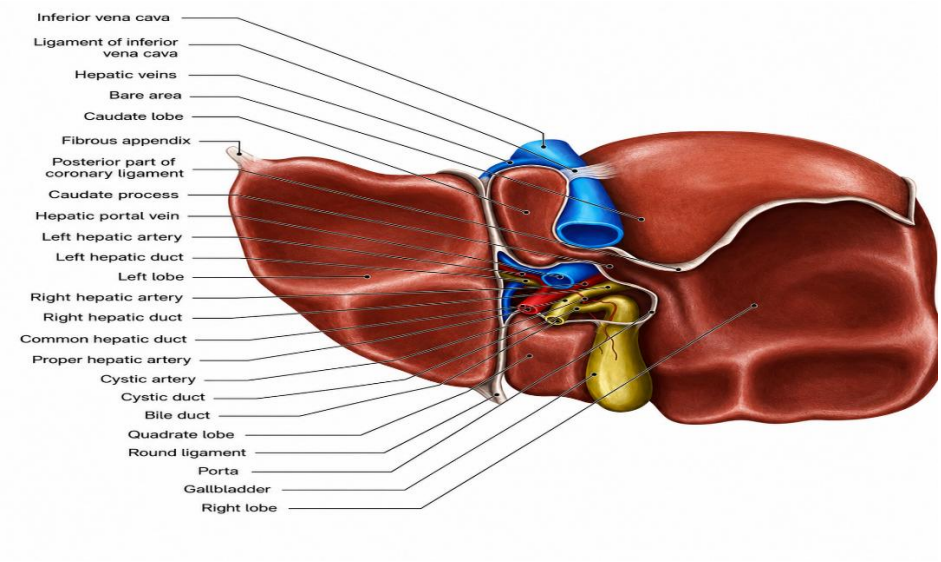


Figure 3: Visceral surface of the liver showing anatomical structures, blood vessels, and biliary ducts.

Surfaces- The diaphragmatic surface and the visceral surface are the liver's two primary surfaces. With the exception of the porta hepatis and the gallbladder bed, the latter is covered by visceral peritoneum. This surface has a direct connection to a number of anatomical structures, such as the:[2]

Deodenum | Gallbladder | Hepatic flexure of the colon | Transversal colon | Right kidney

The suprarenal gland with the exception of the naked area, the visceral peritoneum covers the diaphragmatic surface, which rests against the diaphragm's inferior surface.

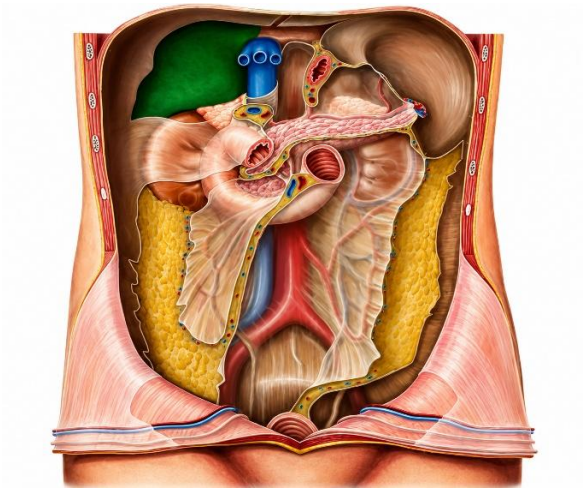


Figure 4: Abdominal cavity showing the peritoneum, mesentery, and associated digestive organs.

Segments of the liver - Eight hepatic segments are created by splitting each sector into two. The segments around the porta hepatis would be numbered anticlockwise if the patient was supine and the liver was reflected along its inferior border towards the diaphragm. [3]

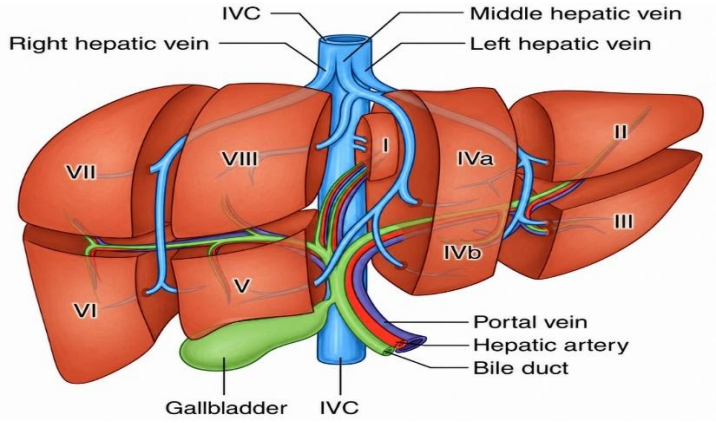
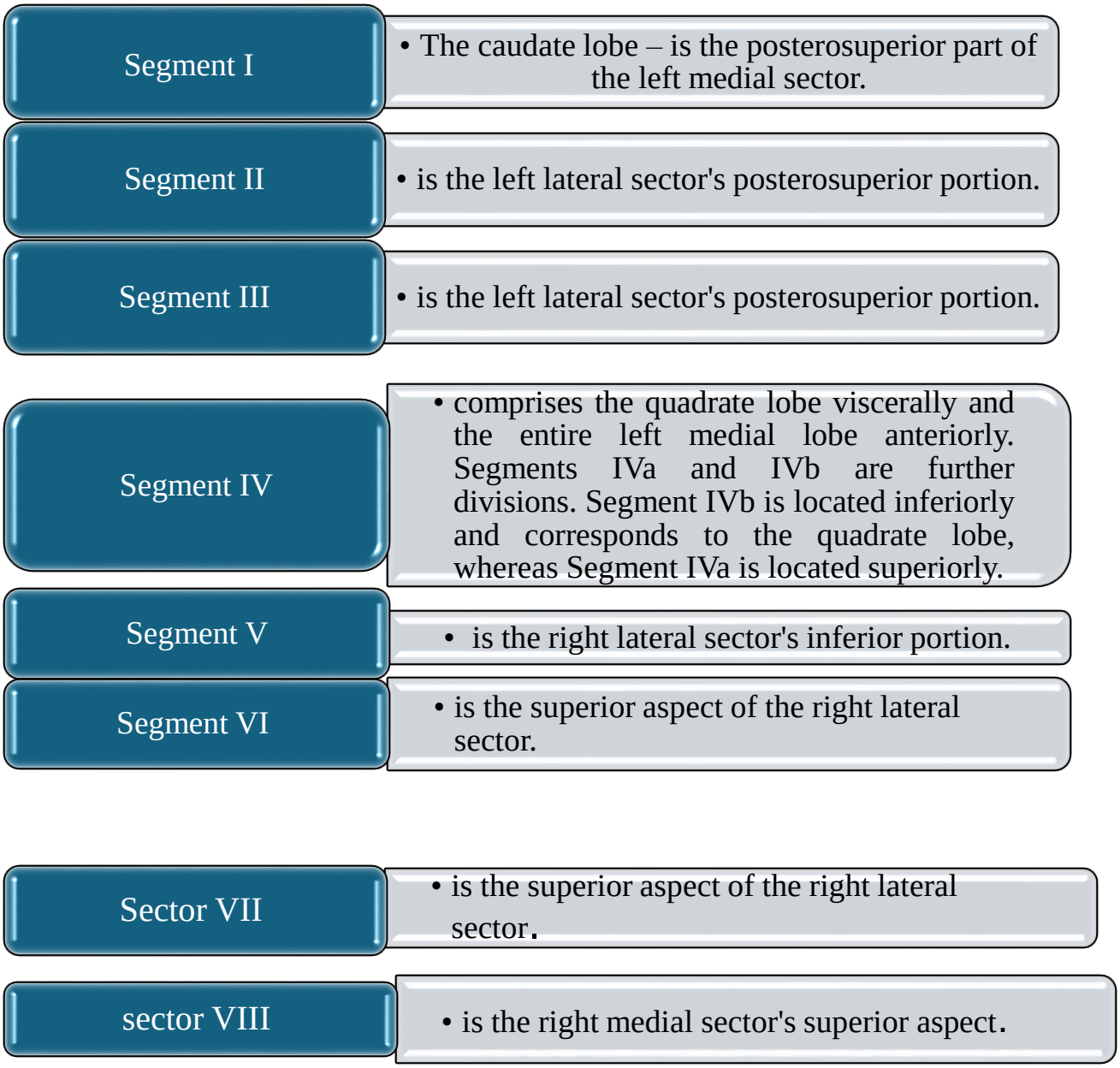


Figure 5: eight functional segments of the liver and associated vascular structures



Blood flow -About 70% of the blood that travels through the liver is delivered via the hepatic portal vein. The hepatic artery carries the remaining approximately 30%. The splenic vein, inferior mesenteric vein, and superior mesenteric vein unite to produce the hepatic portal vein. Additionally, it gets tributaries from the left and right gastric veins. The splenic vein drains the left gastroepiploic vein to the portal vein, whereas the superior mesenteric vein drains the right gastroepiploic vein and the inferior and superior pancreaticoduodenal veins [2]

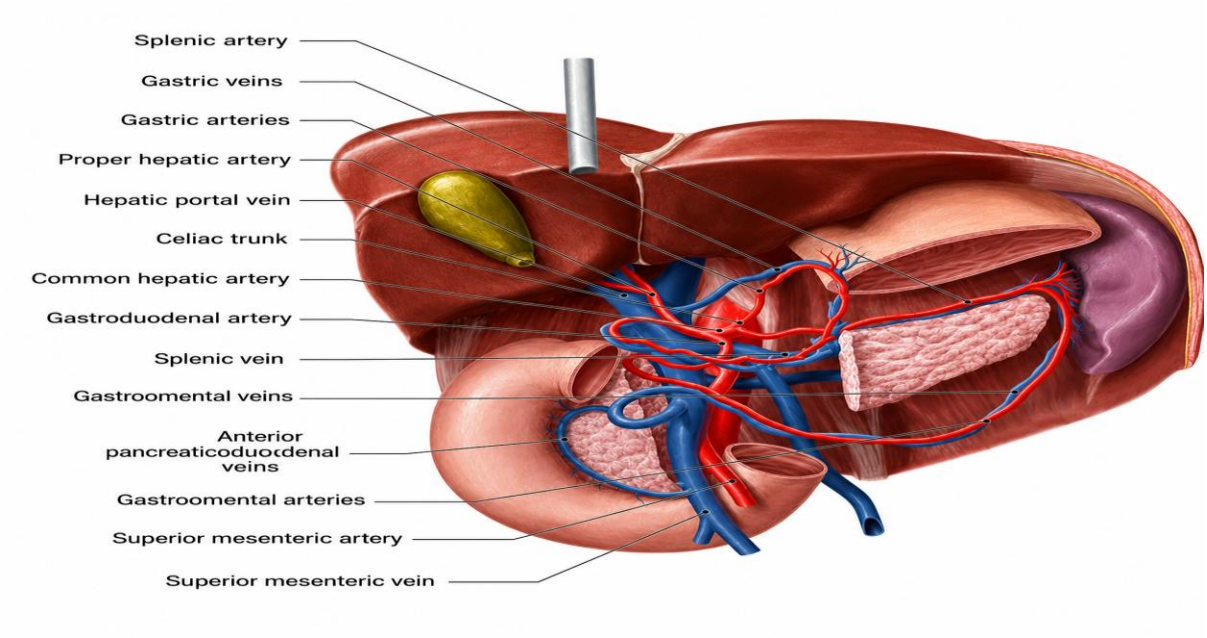


Figure 6: Arterial and venous supply of the hepatobiliary system and associated digestive organs.

Through the splenic, gastric, and inferior mesenteric veins, the left lateral segment receives blood from the stomach and lower esophagus, the distal body and tail of the pancreas, the larger curvature of the stomach, and the hindgut. Conversely, the liver's functional right lobe uses the superior mesenteric vein to process blood from the pancreatic head, the stomach's pylorus and antrum, and the midgut. The whole gastrointestinal system supplies blood to the left medial segment. The liver's autonomous zone is the caudate lobe (segment I). Both branches of the aforementioned veins provide it with hepatic arterial and portal venous blood. Furthermore, both branches of the hepatic ducts drain its bile, and the inferior vena cava receives its venous return. The left branches of the relevant vessels provide venous and biliary outflow, and Segments II, III, and IV access the blood supply.[3]

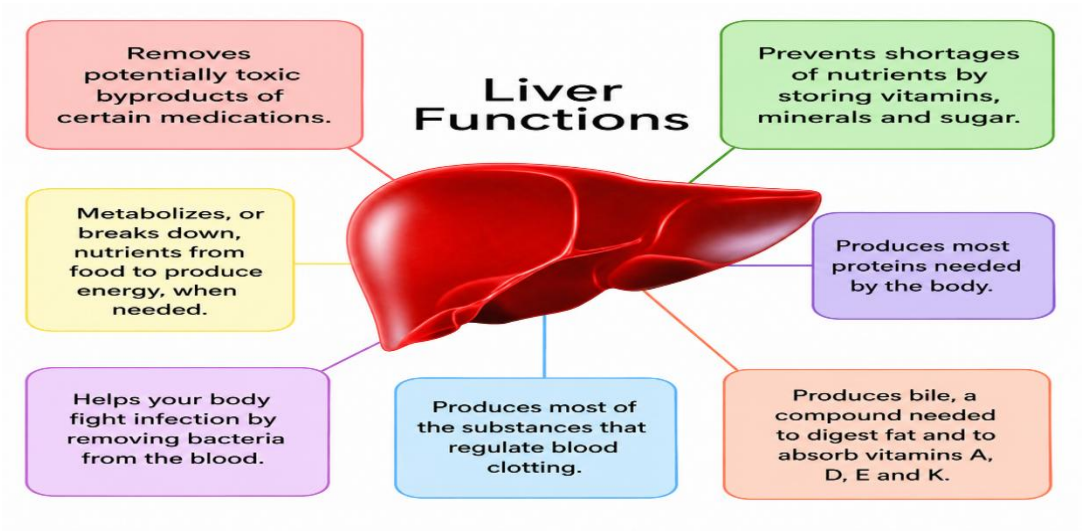
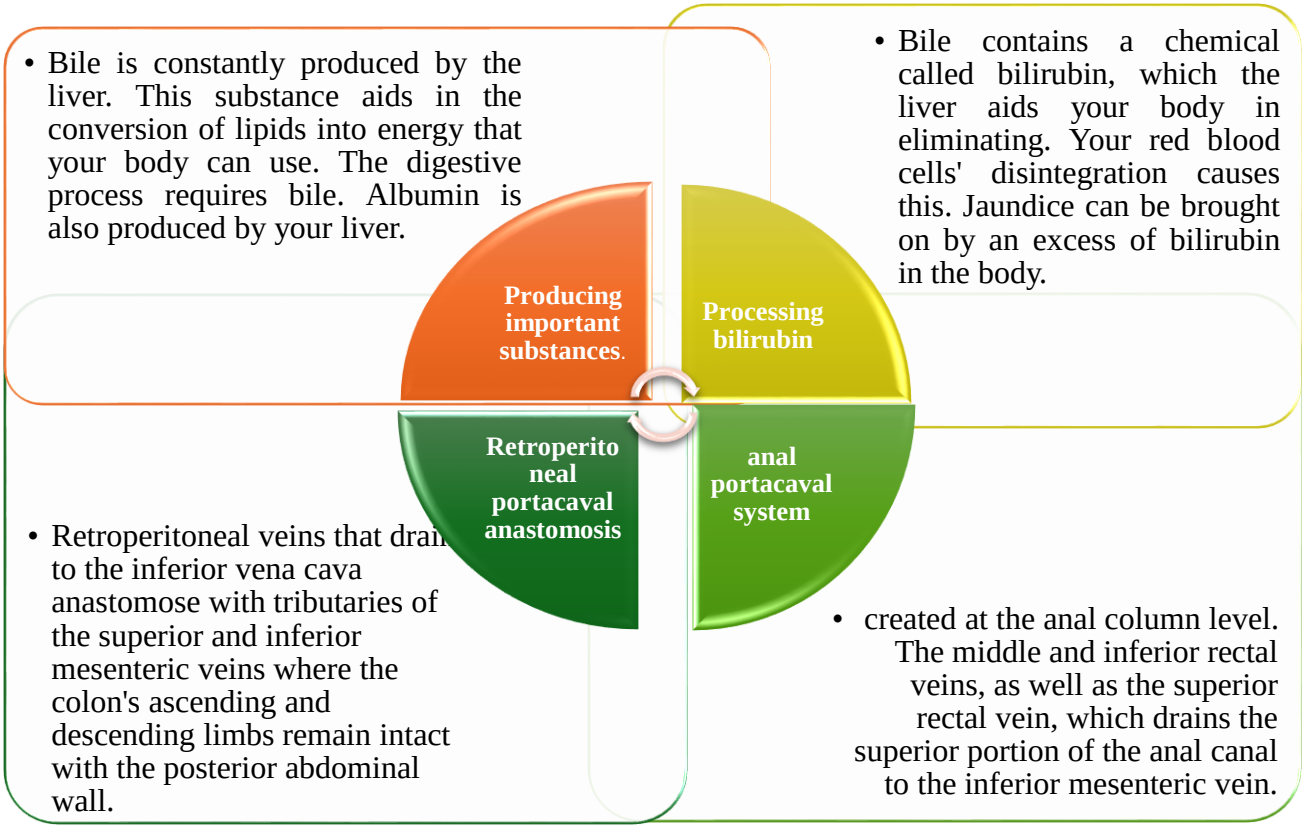
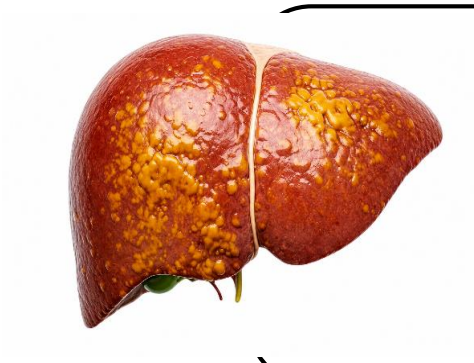


Figure 7: Major physiological and metabolic functions of the liver.



Liver Disease - Any ailment that harms the liver and impairs its capacity to carry out regular functions is referred to as liver disease. any ailment that harms the liver and impairs its capacity to carry out regular functions is referred to as liver disease. hepatocyte damage, inflammatory cell infiltration, and HSC activation are the hallmarks of a broad range of liver illnesses that collectively impair liver function and alter its architecture. hepatotropic virus infections are frequently the cause of acute liver disorders, although drug-induced liver damage (DILI) is also on the rise globally. Conversely, hepatitis B virus (HBV), hepatitis C virus (HCV), alcohol use, and an increasing prevalence of metabolic dysfunction-associated steatotic liver disease (MASLD) worldwide are the main causes of chronic liver diseases. Morbidity and mortalitare greatly increased when such chronic disorders progress to end-stage liver diseases, such as cirrhosis and liver cancer [4]





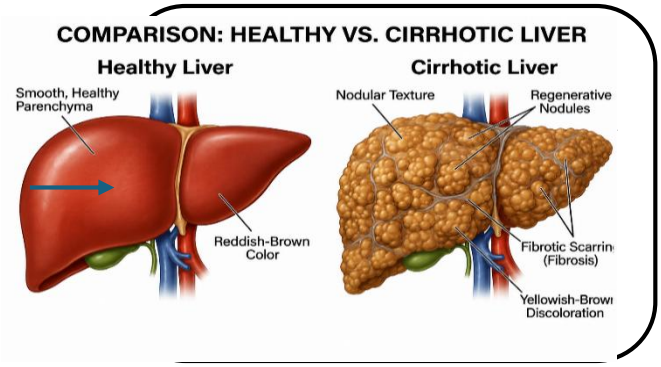
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Hepatitis –

Inflammation of the liver caused by viruses (Hepatitis A, B, C, D, E), autoimmune disorders, or certain drugs.



Liver cancer –

Most commonly hepatocellular carcinoma (HCC), often developing in patients with chronic liver disease or cirrhosis.

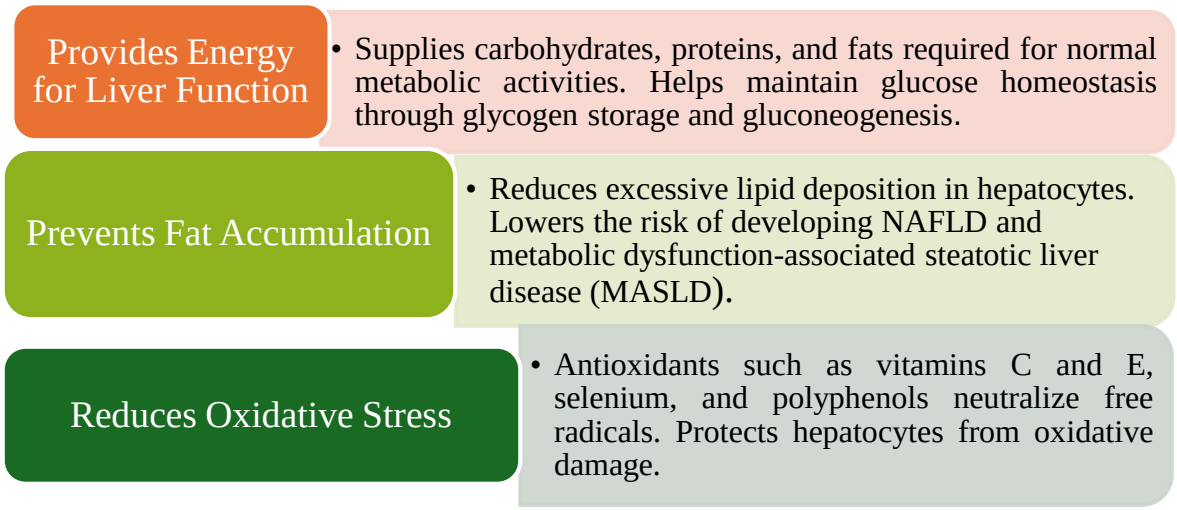
Liver Disease And Their Symptoms

Role of Nutrition in Liver Health - Through supporting metabolic processes, lowering oxidative stress, encouraging liver regeneration, and halting the development of liver diseases like non-alcoholic fatty liver disease (NAFLD), hepatitis, fibrosis, cirrhosis, and hepatocellular carcinoma, nutrition plays a critical role in preserving liver health. For individuals with liver problems, a well-balanced diet full of vital nutrients enhances clinical outcomes and helps maintain normal liver function.[5][6]

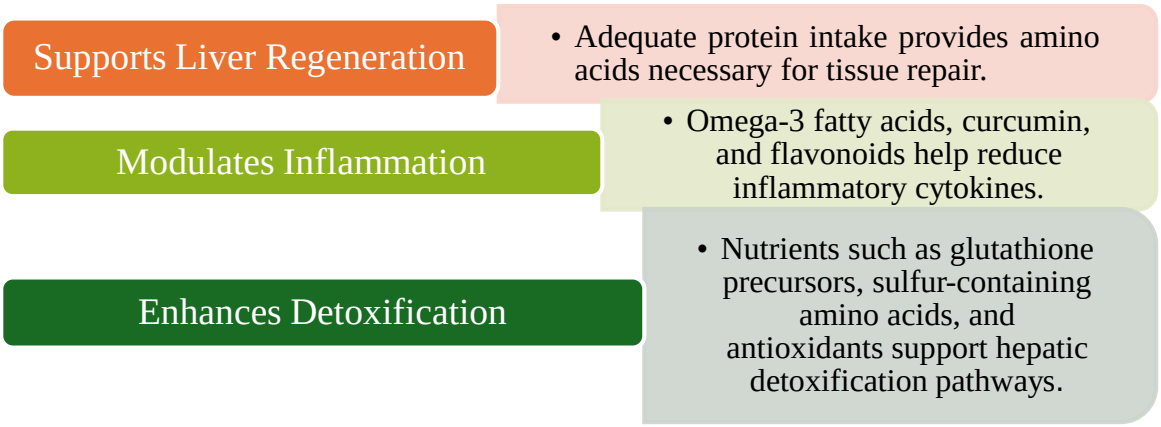
Important Nutrients for Liver Health [9] –

Nutrient	Function	Food Sources
Protein	Liver repair and regeneration	Eggs, fish, legumes, milk
Complex carbohydrates	Energy supply	Whole grains, oats, brown rice
Healthy fats (Omega-3)	Anti-inflammatory	Fish, flaxseed, walnuts
Vitamin C	Antioxidant	Citrus fruits, guava
Vitamin E	Prevents oxidative damage	Almonds, sunflower seeds
Vitamin D	Immune regulation	Fish, fortified milk
B-complex vitamins	Energy metabolism	Whole grains, legumes
Zinc	Tissue repair	Nuts, seeds, seafood
Selenium	Antioxidant defence	Brazil nuts, fish
Dietary Fiber	Improves gut health	Fruits, vegetables, oats

Key Roles of Nutrition –



Key Roles of Nutrition [7]



Key Roles of Nutrition [7]

Herbal Interventions: An Overview – The medicinal potential of herbal remedies used to cure and prevent liver issues is derived from a variety of phytochemical components. These bioactive substances have hepatoprotective qualities through their interactions with several molecular and cellular targets involved in oxidative stress, inflammation, lipid metabolism, and liver regeneration.[8]Polyphenols, flavonoids, terpenoids, alkaloids, saponins, and tannins are the primary classes of phytochemicals that have demonstrated noteworthy liver-protective properties.the medicinal potential of herbal remedies used to cure and prevent liver issues is derived from a variety of phytochemical components.[10]These bioactive substances have hepatoprotective qualities through their interactions with several molecular and cellular targets involved in oxidative stress, inflammation, lipid metabolism, and liver regeneration. Polyphenols, flavonoids, terpenoids, alkaloids, saponins, and tannins are the primary classes of phytochemicals that have demonstrated noteworthy liver-protective properties.[10]

Key Medicinal Plants used for Liver Protection-

The hepatoprotective efficacy of herbal medicines is mainly due to the presence of bioactive phytochemicals that have anti-inflammatory, antioxidant, membrane- effects on hepatocyte regeneration and stabilization [11]. the most research has been done on Silybummarianum, Phyllanthus niruri, Andrographispaniculata, Boerhaviadiffusa, and Picrorhizakurroa, among the several medicinal plants that have historically been used to treat liver issues. The application of these botanicals in various ethnomedical systems is supported by preclinical and clinical data.[12]

Silybum marianum (milk thistle)-Milk thistle is one of the most researched hepatoprotective herbs. Its active element, silymarin, contains flavonolignans such silybin, silydianin, and silychristin. Silymarin possesses hepatoprotective properties and encourages hepatocyte regeneration by scavenging free radicals, blocking lipid peroxidation, altering inflammatory cytokines, and activating ribosomal RNA polymerase I. [12]

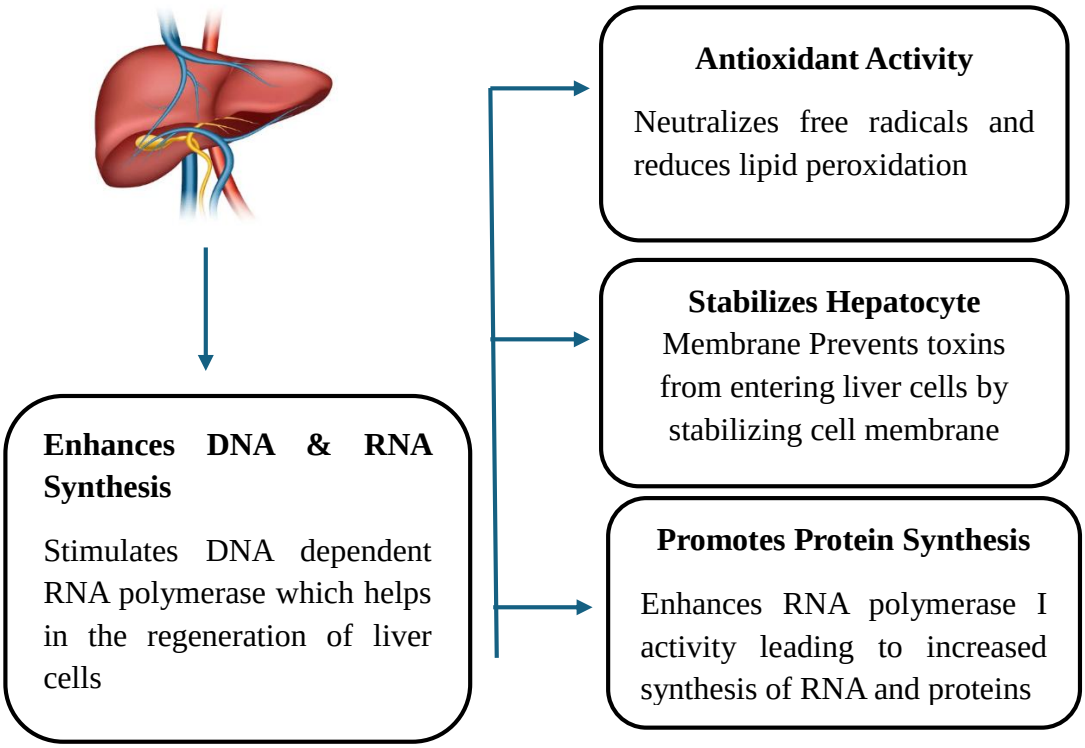


Figure 8: Milk Thistle's Benefits for Liver Disease

People with liver damage from diseases including alcoholic liver disease, non-alcoholic fatty liver disease, hepatitis, and even liver cancer frequently utilize it as a supplemental treatment.[13] A 2021 study found that taking a milk thistle supplement improved liver function in patients with non-alcoholic fatty liver disease, indicating that it may help lessen liver damage and inflammation.[15]

Mechanism

It is feasible to use silymarin for hepatoprotection. Since Silymarin has a steroid structure, it expands the recovery of the liver cell and improves the combination of DNA and RNA. The half-life of silymarin is short, and it forms quickly in the liver.[14] Silybum marianum L. (Milk Thistle), has a place with the group of Carduus marianum. Silymarin is an antiquated restorative Plant and individuals are utilized from hundreds of years for the liver's treatment illness like hepatitis C infection, non-alcoholic greasy liver sickness and it is likewise viable against snake bite. Silymarin is located in Kashmir with prickly enormous leaves and a rosy purple Blossom and the therapeutic piece either the seeds or the plant or fruits. The first utilization of Silymarin was known for hepatoprotective action. Silymarin is the dynamic constituents of the spice and milk thorn decoction is coming in market as Silymarin and silybinin containers and tablets [14]



Camellia sinensis (Green Tea)

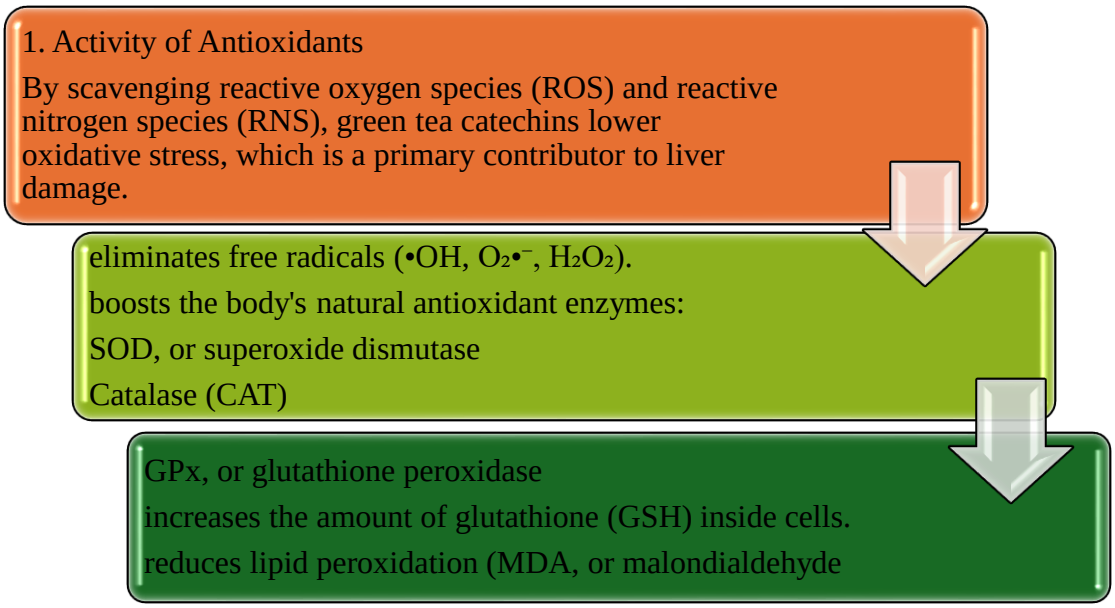
The leaves of the Camellia sinensis plant, an indigenous herb from Southern China, are used to make Camellia sinensis (green tea), which is mostly made in China. The leaves have thermogenic, appetizing, digestive, carminative, and diuretic properties.[16] They also help with inflammation, hemorrhoids, cardiodynia, and abdominal diseases. Green tea has been demonstrated to be useful in preventing the Hepatitis C virus (HCV) from entering the liver cells, in addition to being utilized to cure severe liver damage and oxidative stress injury. Among the active compounds in green tea—such as epicatechin, gallocatechin, epigallocatechin, epicatechingallate, and catechin—EGCG is considered the most therapeutically significant. It works by lowering liver enzyme levels and preventing related damage, oxidative stress, and reducing fat accumulation in non-alcoholic fatty liver disease (NAFLD), drinking green tea (Camellia sinensis) may enhance liver health. Concentrated green tea extracts in high doses, however, can occasionally harm the liver [17]

Chamomile contains various pharmacologically active and health-promoting substances. More than 500 chemical components, including more than 400 organic and more than 40 inorganic chemicals, have reportedly been identified from tea since the early 19th century.[18]as a non-fermented tea, green tea fully preserves its natural chemical constituents. This section outlines the phytochemistry studies on green tea and categorizes its primary constituents.



Mechanism of Action-

Green tea, or Camellia sinensis, is high in polyphenols, especially catechins, of which epigallocatechin-3-gallate (EGCG) is the most physiologically active. Through a variety of molecular processes, these phytochemicals have hepatoprotective properties. [19]



Mechanism of Action Camellia sinensis [19]

Phyllanthus niruri

Commonly known as Stonebreaker, Seed-under-leaf, or bhui amla is a small annual medicinal herb widely distributed in tropical and subtropical regions, including India, Sri Lanka, China, Africa, and South America. It has been extensively used in Ayurveda, Siddha, and traditional medicine for the treatment of liver disorders, jaundice, kidney stones, urinary tract infections, and diabetes. Due to its potent hepatoprotective and antioxidant properties, P. niruri has gained considerable attention in modern pharmacological research[20]

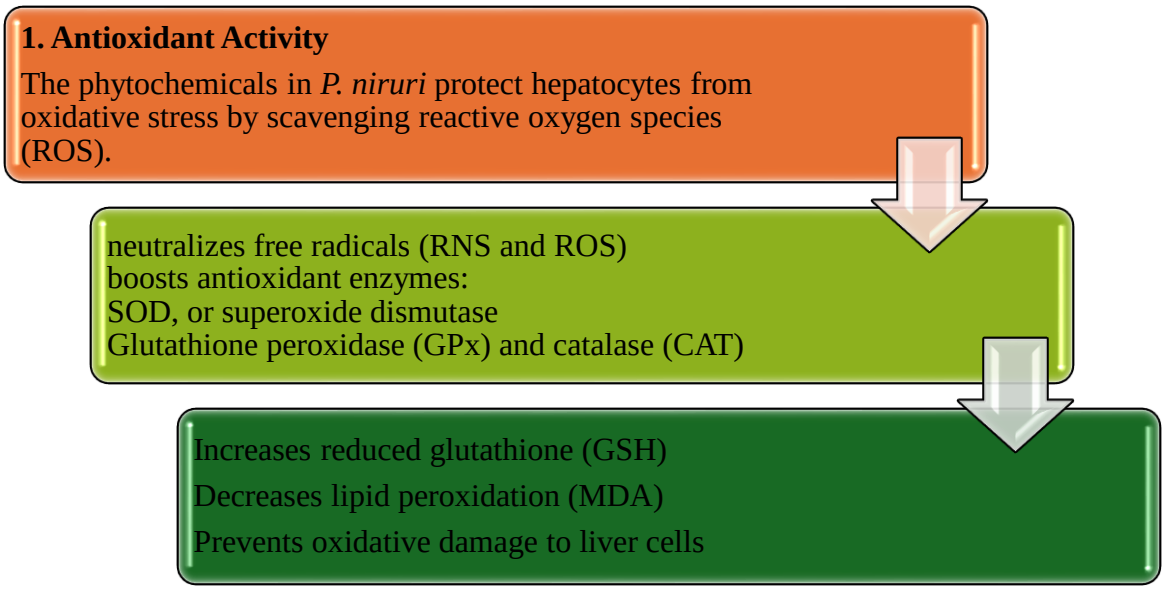
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Figure 9: Phyllanthus niruri

Phyllanthus niruri exerts potent hepatoprotective effects through multiple complementary mechanisms, including antioxidant, anti-inflammatory, antiviral, membrane-stabilizing, anti-fibrotic, anti-apoptotic, and detoxification-enhancing actions.[21] The synergistic effects of its phytochemicals, particularly phyllanthin and hypophyllanthin,

make it a promising herbal agent for the prevention and management of liver disorders such as hepatitis, non-alcoholic fa liver disease, drug-induced hepatotoxicity, and liver fibrosis .[22]



Mechanism of Action Phyllanthus niruri[23]

Guduchi (Tinospora cordifolia)

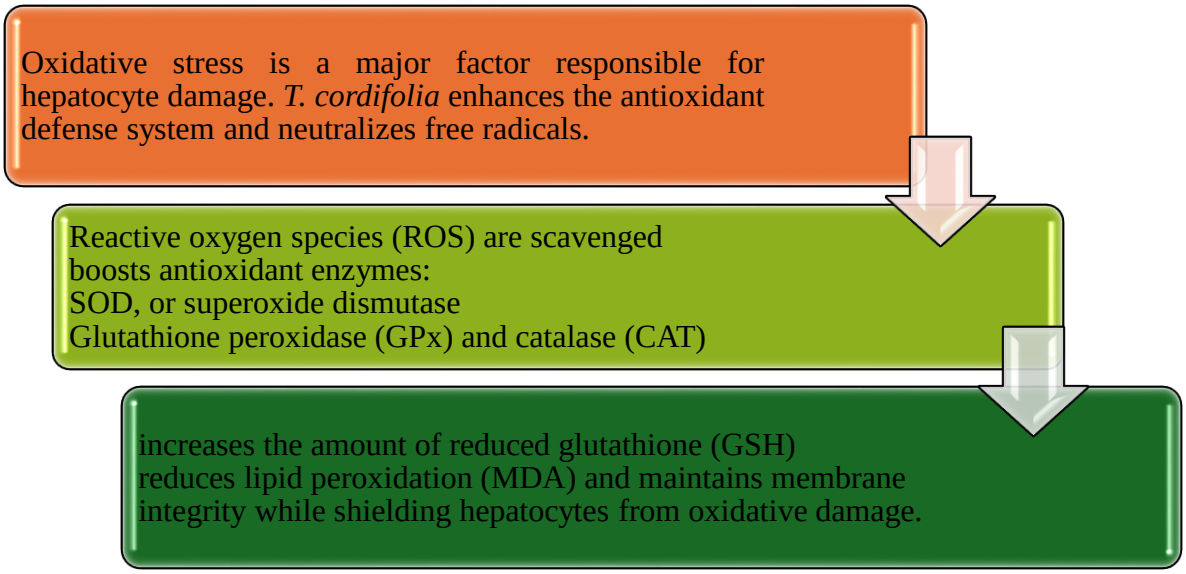
contains polysaccharides, diterpenoid lactones, and alkaloids (berberine, magnoflorine) that have immunomodulatory, detoxifying, and hepatoprotective qualities. It enhances hepatic antioxidant defences and reduces liver damage caused by paracetamol and CCl4 in animal models.[27]



Figure 10: Guduchi (Tinospora cordifolia)

Mechanism of Action

Tinospora cordifolia exhibits potent antioxidant activity due to the presence of tinosporaside, cordifolioside A, berberine, magnoflorine, flavonoids, phenolic compounds, diterpenoid lactones, and polysaccharides. These phytochemicals protect the liver by reducing oxidative stress, which is a major cause of hepatocellular injury.[27]



Mechanism of Action of Tinospora cordifolia [28]

Discussion –

The use of herbal drugs for liver protection has gained substantial scientific interest in recent decades due to the rising prevalence of hepatic disorders and the limitations associated with synthetic hepatoprotective agents. Liver diseases, both acute and chronic, are often the consequence of oxidative stress, inflammation, viral infections, or drug induced toxicity. In order to maintain liver function and stop the development of hepatic diseases, proper nutrition is essential. In addition to encouraging liver regeneration, a balanced diet full of fruits, vegetables, whole grains, lean proteins, healthy fats, vitamins, minerals, and dietary antioxidants helps lower oxidative stress, inflammation, and lipid accumulation. Optimal liver health is further enhanced by lifestyle changes such keeping a healthy body weight, exercising frequently, consuming less alcohol, and avoiding exposure to hepatotoxic drugs.

Herbal medicines, particularly those derived from Silybum marianum, Phyllanthus niruri, amellia sinensis (Green Tea), Guduchi (Tinospora cordifolia) offer a multifaceted therapeutic approach that includes antioxidant, anti-inflammatory, antiviral, and regenerative activities. These effects are attributed to diverse phytochemicals such as flavonoids, alkaloids, lignans, and terpenoids, which modulate cellular signaling pathways, stabilize hepatocyte membranes, and enhance detoxification enzymes. Even though there is a lot of evidence that these nutritional and herbal therapies have hepatoprotective potential, more well planned clinical trials are needed to determine their long-term safety, ideal dosage, effectiveness, and any interactions with prescription drugs. To guarantee consistent therapeutic results, quality control and standardization of herbal formulations are also crucial.

In summary, a potential approach to preserving liver function, avoiding liver disorders, and enhancing clinical outcomes is to combine a nutritious diet with scientifically proven herbal remedies. The importance of nutritional

and herbal interventions in all-encompassing liver care will be further reinforced by future studies that concentrate on molecular mechanisms, phytochemical standardization, individualized nutrition, and evidence-based herbal therapy[29][30]

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