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Natural Ingredients Assisting Metabolism in the Liver and Alcohol Metabolism

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Alcohol-related harm remains a major global health concern, contributing to a significant number of preventable deaths each year. Chronic and excessive alcohol consumption exerts both acute and long-term toxic effects on the liver, progressively impairing hepatic structure and function. Sustained overconsumption markedly increases the risk of developing alcoholic liver disease (ALD) (Moon et al., 2023). Alcoholic liver disease (ALD) frequently progresses without noticeable symptoms, leaving individuals unaware that the condition has advanced beyond a readily reversible stage. In both acute and chronic contexts, ALD typically begins with hepatic steatosis (fatty liver) and may progress to alcoholic hepatitis, fibrosis, and ultimately cirrhosis. Because the early stages are largely asymptomatic, diagnosis is often delayed, making early detection both critical and challenging, as initial signs of liver injury may go unnoticed. At present, complete abstinence from alcohol remains the primary and most effective strategy for managing alcoholic liver disease (ALD), as therapeutic medical options are limited. Natural products which are bioactive compounds derived from plants with well-characterized chemical structures have gained increasing attention for their potential role in disease management. Further investigation into these compounds may not only enhance understanding of their mechanisms of action, but also support the development of natural compound–based therapeutic strategies for ALD. Several naturally occurring substances, including hesperidin, berberine, and silymarin, have demonstrated hepatoprotective properties in ALD models, with favorable safety profiles and minimal reported adverse effects (Vrentzos et al., 2025).

Hesperidin

Hesperidin is a flavonoid belonging to the broader class of phenolic compounds and is widely distributed across numerous plant species worldwide. Flavonoids, including hesperidin, are being extensively studied in both their aglycone and glycoside forms and have been attributed a range of biological activities, including antioxidant, anti-inflammatory, and anticancer effects. Adipose tissue plays a central role in regulating energy homeostasis and nutrient balance within the body. White adipose tissue (WAT) serves as the primary site for energy storage in the form of triglycerides, whereas brown adipose tissue (BAT) is characterized by smaller lipid droplets and a high density of mitochondria, enabling enhanced thermogenic activity (Lee et al., 2019). Under certain metabolic conditions, such as exposure to a high-fat diet, mitochondrial biogenesis within WAT can be stimulated—a process referred to as "browning." This adaptive transformation promotes the formation of brown-like (beige) adipocytes, which enhances energy expenditure and may help limit obesity and excessive lipid accumulation.

Citrus flavonoids have been widely reported to promote the browning of white adipose tissue, reduce circulating lipid levels, improve insulin sensitivity, and lower the risk of obesity and hyperglycemia (Zhang et al., 2019). Experimental evidence further demonstrates that prolonged consumption of a high-fat, high-cholesterol diet in animal models significantly influences atherosclerotic development, peroxisome proliferator–activated receptors (PPARs), lipoprotein receptor activity, apolipoprotein-related gene expression, and the production of inflammatory mediators such as monocyte chemoattractant protein-3 (Torikai et al., 2023). During adipocyte maturation, fatty acid–binding proteins and peroxisome proliferator–activated receptor gamma (PPAR-γ) play central roles in regulating lipid accumulation and adipogenesis. Citrus-derived yellow–orange pigments have been shown to inhibit intracellular fat and triglyceride accumulation through the downregulation of PPAR-γ expression (Aslan et al., 2023). In addition, citrus flavonoids have demonstrated the ability to suppress microRNA-122 and microRNA-33 both of which are induced by oleic acid and modulate their downstream target mRNAs, including carnitine palmitoyltransferase-1α and tumor necrosis factor-α (TNF-α). These regulatory effects may contribute to the prevention of obesity and its associated metabolic disorders.

Hesperidin is a plant-derived bioflavonoid predominantly found in citrus fruits, including grapefruit, oranges, limes, and lemons. Alcoholic liver disease (ALD) disrupts normal hepatic function and progresses through pathological stages such as alcoholic steatosis, steatohepatitis, and ultimately cirrhosis. The citrus flavanone hesperidin has been shown in multiple animal studies to exhibit potent antioxidant and anti-inflammatory properties, as well as protective effects against multi-organ damage (Pyrzynska, 2022). Emerging evidence suggests that hesperidin may beneficially influence hypercholesterolemia and fatty liver disease by inhibiting cholesterol synthesis and absorption, while also modulating mRNA expression of retinol-binding protein (RBP). In vitro studies further demonstrate its capacity to attenuate hepatic steatosis and fibrosis, highlighting hesperidin as a promising compound for further investigation in the prevention and supportive management of liver diseases.

Berberine

Berberine is a naturally occurring alkaloid widely used in traditional Chinese medicine and is found in several medicinal plants, including Oregon grape and barberry. Derived primarily from *Coptis chinensis*, berberine has been utilized for centuries and is recognized for its hepatoprotective properties (Phogat et al., 2024). Existing research has largely focused on its effects in liver cancer, nonalcoholic fatty liver disease, and toxin-induced hepatic fibrosis, particularly in models involving hepatotoxic agents such as carbon tetrachloride (CCl_4). In addition, animal studies have reported therapeutic benefits of berberine in mitigating alcohol-induced liver injury (Jia et al., 2024). Despite these findings, the mechanisms by which berberine influences liver injury resulting from chronic alcohol consumption remain incompletely understood. The acute-on-chronic alcohol feeding model, which closely mimics the drinking patterns observed in patients with alcoholic liver disease (ALD), has demonstrated that such consumption patterns significantly affect the severity and progression of alcohol-induced hepatic damage.

Berberine enhances hepatic lipid metabolism through multiple complementary mechanisms. One key pathway involves the upregulation of microsomal triglyceride transfer protein (MTP), which facilitates the export of triglycerides (TG) from hepatocytes into the circulation, thereby reducing intracellular TG accumulation and alleviating hepatic steatosis (Cai et al., 2023). In addition, berberine stimulates the expression and activity of ATP-binding cassette (ABC) transporters, which play a critical role in the efflux of cholesterol and phospholipids from liver cells (Cai et al., 2023). Collectively, these actions contribute to improved lipid handling and reduced lipid burden within hepatic tissue.

Inflammation is another major cause of the gradual loss of liver function. Inflammatory cytokines damage liver cells in various ways, including interrupting mitochondrial function and triggering cell death (Ma et al., 2025). The cells in the liver that have been damaged continue to inflame the area and further compromise the liver's ability to function, which causes a vicious cycle that moves towards chronic hepatitis and finally liver dysfunction. Berberine's anti-inflammatory effect is achieved by its action in two directions, since it blocks pathways that promote inflammation, and at the same time, activates AMPK and Nrf2 processes, which are known for their anti-inflammatory effects (García-Muñoz et al., 2024). Berberine's dual action on insulin sensitivity and liver function causes a decline in insulin resistance as well as an improvement in liver function, through lessening inflammation, thus becoming a powerful agent in

treating metabolic conditions.

Silymarin

Silymarin is a potent antioxidant and anti-inflammatory complex extracted from *Silybum marianum* (milk thistle), a medicinal plant long used in traditional medicine for the management of liver and biliary disorders. Historically, milk thistle has been utilized to support liver health in conditions such as chronic hepatitis and alcohol-related liver disease (Jaffar et al., 2024). Silymarin has demonstrated protective effects in human liver cells, particularly in models of nonalcoholic steatohepatitis and hepatic fibrosis. Silybin, the primary bioactive component of silymarin, plays a central role in modulating oxidative stress, hepatic lipid accumulation, and insulin regulation. Additionally, it has been shown to enhance overall liver function, mitigate hepatotoxicity associated with high-dose acetaminophen exposure, and significantly reduce oxidative stress within hepatic tissue.

Prior to the advent of modern pharmacotherapy, silymarin was widely recognized in both European and Asian traditional medicine as a bioactive therapeutic agent for a range of hepatic disorders. Its hepatoprotective effects are mediated through interactions with multiple cellular receptors and signaling pathways, including mitogen-activated protein kinases (MAPKs), the mammalian target of rapamycin (mTOR), β-catenin, and protein kinase B (AKT), as well as pathways involved in apoptosis and inflammatory cytokine gene expression (Kim et al., 2019). Silymarin has been shown to stimulate superoxide dismutase (SOD) expression in lymphocytes and erythrocytes, leading to increased levels of glutathione and glutathione peroxidase. This enhancement of endogenous antioxidant defenses contributes to reduced oxidative stress, particularly in patients with chronic liver disease. In addition, silymarin exerts membrane-stabilizing effects by influencing RNA polymerase I activity and ribosomal RNA (rRNA) transcription, thereby limiting toxin uptake into hepatocytes and slowing disease progression.

The hepatoprotective actions of silymarin are primarily attributed to its ability to scavenge free radicals and promote intracellular glutathione synthesis, resulting in the inhibition of lipid peroxidation and improved cellular resistance to xenobiotic insult. Silymarin also exhibits steroid-like regulatory effects through modulation of nuclear gene expression and reduces fibrogenesis by inhibiting the activation and transdifferentiation of hepatic stellate cells into collagen-producing myofibroblasts (Sharma et al., 2025). Furthermore, silymarin and its active constituent silybin enhance ribosomal protein synthesis through the activation of RNA polymerase, supporting hepatic regeneration and cellular repair.

Conclusion

Herbal medicines have long served as foundational therapeutic agents in the prevention and management of disease, with their use dating back to ancient medical systems across multiple cultures. Among their many applications, plant-derived compounds have played a significant role in supporting liver health, owing to their antioxidant, anti-inflammatory, and metabolic regulatory properties. In recent years, advances in extraction techniques and molecular characterization have enhanced the credibility and scientific validation of these natural agents, leading to increased interest in plant-based nutraceuticals as supportive strategies for liver function. As conventional treatment options for liver disease remain limited, particularly in conditions such as alcoholic liver disease, naturally derived bioactive compounds offer promising complementary approaches. The growing body of experimental and preclinical evidence supporting their hepatoprotective mechanisms underscores the potential of these agents to modulate oxidative stress, lipid metabolism, inflammation, and fibrotic pathways. Continued research into standardized formulations, bioavailability, and mechanistic pathways will be essential to fully integrate herbal and nutraceutical interventions into evidence-based strategies for liver health and disease prevention.

References

1. Aslan MN, Sukan-Karaçağıl B and Acar-Tek N. “Roles of citrus fruits on energy expenditure, body weight management, and metabolic biomarkers: A comprehensive review”. Nutrition Reviews 82.9 (2024): 1292-1307.
2. Cai Y., et al. “Efficacy and underlying mechanisms of berberine against lipid metabolic diseases: A review”. Frontiers in Pharma-

cology 14 (2023).

3. García-Muñoz AM., et al. "A descriptive review of the antioxidant effects and mechanisms of action of berberine and Silymarin". Molecules 29.19 (2024): 4576.
4. Jaffar HM., et al. "Silymarin: Unveiling its pharmacological spectrum and therapeutic potential in liver diseases-A comprehensive narrative review". Food Science & Nutrition 12.5 (2024): 3097-3111.
5. Jia R., et al. "Effects of berberine on lipid metabolism, antioxidant status, and immune response in the liver of tilapia (Oreochromis niloticus) under a high-fat diet feeding". Antioxidants 13.5 (2024): 548.
6. Kim S., et al. "Silymarin induces inhibition of growth and apoptosis through modulation of the MAPK signaling pathway in AGS human gastric cancer cells". Oncology Reports 42.5 (2019): 1904-1914.
7. Lee JH., et al. "The role of adipose tissue mitochondria: Regulation of mitochondrial function for the treatment of metabolic diseases". International Journal of Molecular Sciences 20.19 (2019): 4924.
8. Ma X., et al. "Molecular mechanisms in liver repair and regeneration: From physiology to therapeutics". Signal Transduction and Targeted Therapy 10.1 (2025).
9. Moon SY., et al. "Alcohol consumption and the risk of liver disease: A nationwide, population-based study". Frontiers in Medicine 10 (2023).
10. Phogat A, Singh J and Malik V. "Pharmacological effects of berberine-A Chinese medicine, against xenobiotic toxicity". Pharmacological Research - Modern Chinese Medicine 13 (2024): 100507.
11. Pyrzynska K. "Hesperidin: A review on extraction methods, stability, and biological activities". Nutrients 14.12 (2022): 2387.
12. Sharma P., et al. "Hepatoprotective effect of Silymarin herb in the prevention of liver dysfunction using pig as animal model". Nutrients 17.20 (2025): 3278.
13. Torikai H., et al. "Atherogenesis in Apoe−/− and Ldlr−/− mice with a genetically resistant background". Cells 12.9 (2023): 1255.
14. Vrentzos E., et al. "Nutraceutical strategies for metabolic dysfunction-associated Steatotic liver disease (MASLD): A path to liver health". Nutrients 17.10 (2025): 1657.
15. Zhang X., et al. "Flavonoids as inducers of white adipose tissue Browning and thermogenesis: Signalling pathways and molecular triggers". Nutrition & Metabolism 16.1 (2019).