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PHYTOCHEMICAL PROFILE AND PHARMACOLOGICAL APPLICATIONS OF *SILYBUM MARIANUM* (L.)

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Abstract: *Silybum marianum* L. of the Asteraceae family is a widely used medicinal plant valued for rich bioactive content and broad pharmacology. Native to the Mediterranean yet now global, it tolerates poor soils and harsh climates. Its key constituent, silymarin, is a flavonolignan complex, chiefly silibinin, isosilibinin, silychristin and silydianin, with strong antioxidant, anti-inflammatory and hepatoprotective effects. The plant also provides phenolic acids, flavonoids, unsaturated fatty acids, proteins and fibres. Silymarin stabilises hepatocyte membranes, limits toxin entry and promotes regeneration, with antidiabetic actions via improved insulin sensitivity and antitumour effects through apoptosis. Modern extraction and nanoformulations enhance its bioavailability and efficacy, supporting clinical use. Agronomically, *S. marianum* needs few inputs and suits ecological systems, making it a sustainable model for research and phytotherapy.

Keywords: *Silybum marianum*, silymarin, flavonolignans, hepatoprotection, bioactive compounds, phytotherapy.

• Introduction

Silybum marianum L., commonly known as milk thistle, belongs to the Asteraceae family and is valued for its hepatoprotective effects attributed to the flavonolignan complex silymarin. It has a long tradition in European medicine for treating liver, biliary, and digestive disorders and, due to its high biopharmaceutical potential, is now one of the most extensively studied medicinal plants worldwide. Botanically, it has tall stems, green leaves with white spots and spiny edges, purple flowers, and fruits rich in oils and bioactive compounds. Agronomically, it offers high efficiency through low nutrient requirements and resistance to drought, pests, and diseases, making it a sustainable, non-irrigated crop cultivated in many European countries. Its composition includes flavonolignans such as silibinin, silydianin, and silychristin, flavonoids (taxifolin, apigenin, luteolin), unsaturated fatty acids, proteins, and phenolic compounds with antioxidant activity. Extracts protect the liver against toxins and oxidative stress, while studies also report anti-inflammatory, antifibrotic, antidiabetic, and antitumour activities, supporting its use in dietary supplements and cosmetics. Recent phytochemical research confirms a complex profile of phenolic acids and flavonolignans that enhance its therapeutic and antioxidant value, positioning milk thistle as a strategic resource at the intersection of botany, pharmacology, and sustainable agriculture, with applications in food, therapeutic, and cosmetic innovations.

• Taxonomy, origin, and geographical distribution of the species *Silybum marianum*

The genus includes two closely related species, *S. marianum*, with green leaves marked with white patches, and *S. eburneum*, with uniformly green leaves, both capable of natural hybridisation. It is an annual or biennial plant, native to the Mediterranean region, and has spread to Europe, Asia, North Africa, Australia, and the Americas, often remaining in the vegetative stage during its first year. Its adaptability to drought and poor soils has enabled naturalisation in many regions, where it is sometimes regarded as invasive. Cytogenetically, it is a diploid species ($2n = 34$), predominantly self-pollinating, with an average natural cross-pollination rate of about 2%. This genetic stability supports phenotypic uniformity, though studies show notable genomic diversity among ecotypes from Greece, Korea, and Tunisia. Morphologically, it has branched stems reaching 90–200 cm, occasionally up to 300 cm, with large, spiny-margined leaves and purple flowers. The seeds contain approximately 20% protein, 39% fat, and 31% fibre, along with oils and flavonolignans. The main bioactive fraction is silymarin, a mixture of silybin, isosilybin, silydianin, silychristin, and isosilychristin, extensively studied for its hepatoprotective and antioxidant properties. The Mediterranean basin is the plant's primary centre of diversity, with historical evidence of its therapeutic and nutritional uses dating back to antiquity. The species has spread globally and naturalised in North and South America, Australia, and New Zealand, thriving on marginal and degraded lands. Today, *S. marianum* is widely cultivated in Spain, Italy, Greece, Hungary, Poland, the Czech Republic, and Moldova, representing a strategic crop for the pharmaceutical and phytotherapeutic industries. Its global distribution confirms its cosmopolitan nature and dual role as both a valuable economic resource and, in some contexts, an invasive species highlighting its ecological, agronomic, and commercial significance worldwide.



Fig.1 *Silybum marianum*

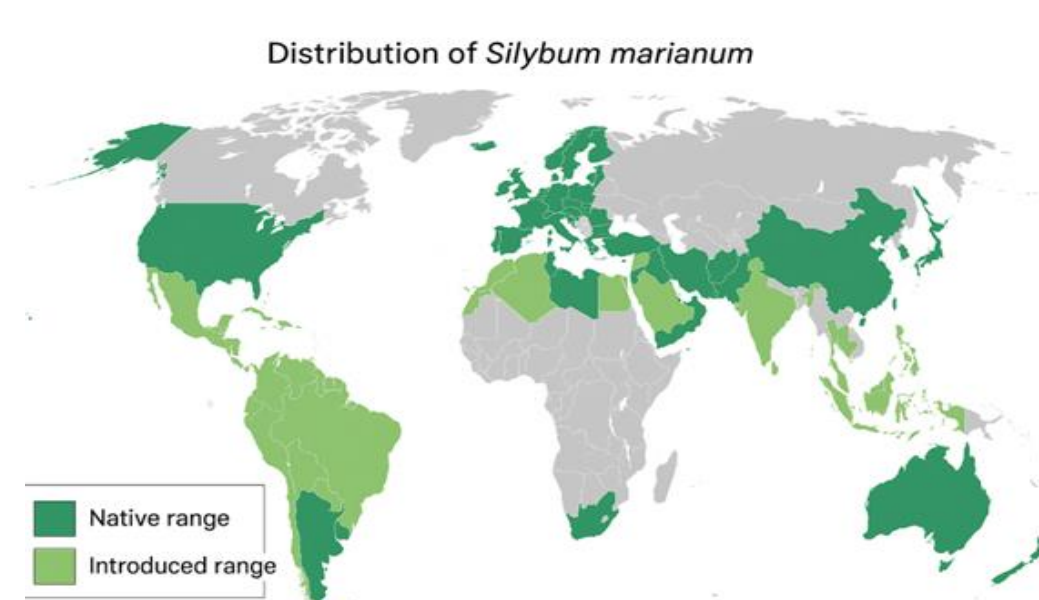


Fig.2 Global distribution of
Silybum marianum (L.): native and
introduced range

• Phytochemical profile, pharmacological significance, and therapeutic applications of *Silybum marianum*

Milk thistle is one of the most valuable medicinal plants due to its high content of phenolic compounds and flavonolignans, responsible for its wide range of pharmacological effects. The main component, silymarin, is a natural complex composed mainly of silibinin, silychristin, silydianin, isosilibinin, and isosilychristin. In addition to flavonolignans, seed extracts contain flavonoids such as taxifolin, quercetin, and apigenin, as well as essential fatty acids (e.g. linoleic acid), esters, sugars, and phenolic compounds involved in protection against oxidative stress and inflammation. The seeds are also nutritionally rich, containing 20–25% proteins, over 30% fibre, and about 40% fats. Pharmacologically, *S. marianum* exhibits anti-inflammatory, antimicrobial, antidiabetic, and antitumour properties, offering a wide therapeutic spectrum. Recent studies on silymarin-enriched extracts have demonstrated thermogenic activation and enhanced mitochondrial function by modulating the expression of genes UCP1, SIRT1, CKMT, TFAM, and PPAR γ , which are involved in mitochondrial biogenesis, fatty acid oxidation, and lipid reduction. Silymarin's hepatoprotective effect is based on stabilising hepatocyte membranes, preventing toxin penetration, stimulating protein synthesis, and accelerating regeneration of cells damaged by substances such as paracetamol or heavy metals. It also increases intracellular glutathione levels, thereby reducing oxidative stress and chronic inflammation. Beyond hepatic activity, silymarin has antidiabetic effects, improving insulin sensitivity and glucose metabolism, leading to reduced HbA1c and better lipid profiles in type 2 diabetes patients, through inhibition of lipid peroxidation and activation of antioxidant enzymes. In oncology, it demonstrates antitumour properties by inducing apoptosis, cell cycle arrest, and inhibiting tumour proliferation in hepatic, breast, and colorectal cancers, while regulating gene expression related to oxidative stress and inflammation, making it a valuable adjuvant in cancer therapy. At the cardiovascular level, *S. marianum* extracts show cardioprotective and hypocholesterolaemic effects, attributed to their high content of unsaturated fatty acids and antioxidant flavonoids. Therapeutic applications also extend to veterinary medicine, where supplementation supports liver function in dogs and promotes metabolic and hepatic health in horses, improving performance and vitality. In dermocosmetics, *S. marianum* extracts protect the skin from oxidative stress, photoageing, and inflammatory conditions. Overall, *Silybum marianum* is a natural source of antioxidants, flavonolignans, and essential fatty acids with a broad pharmacological versatility and excellent safety profile. These features consolidate its status as one of the most important phytotherapeutic agents of the 21st century, with expanding applications in phytotherapy, nutrition, and modern biomedical research.

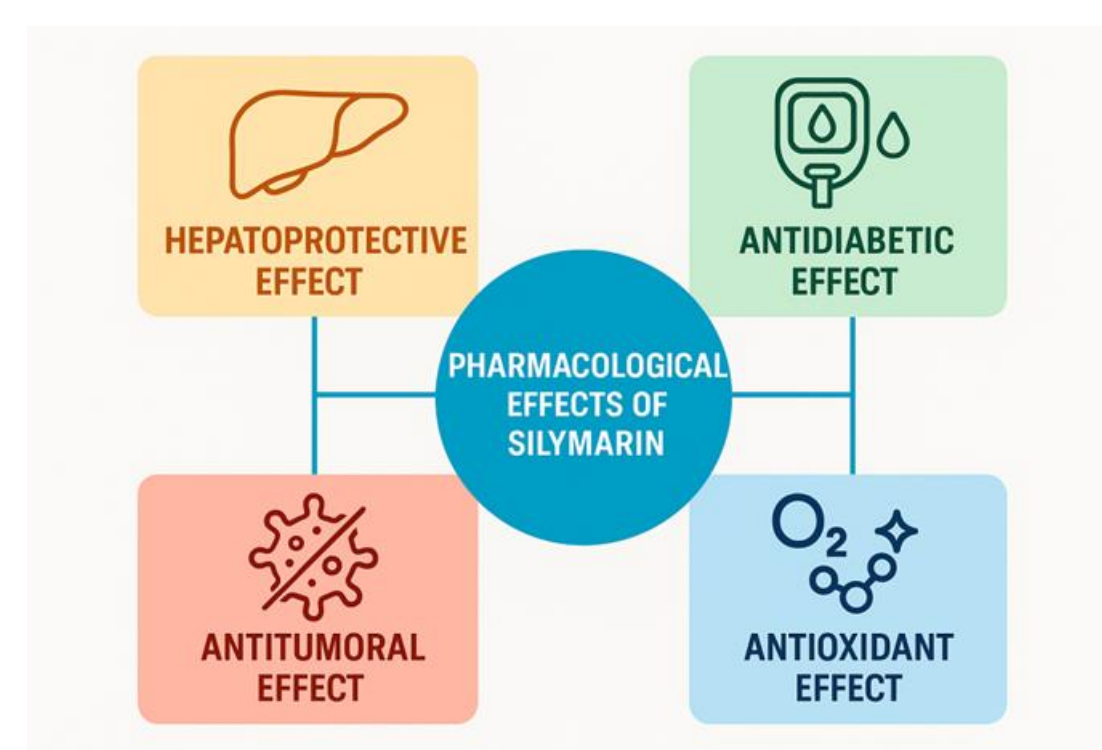


Fig. 3 The main pharmacological effects of
silymarin

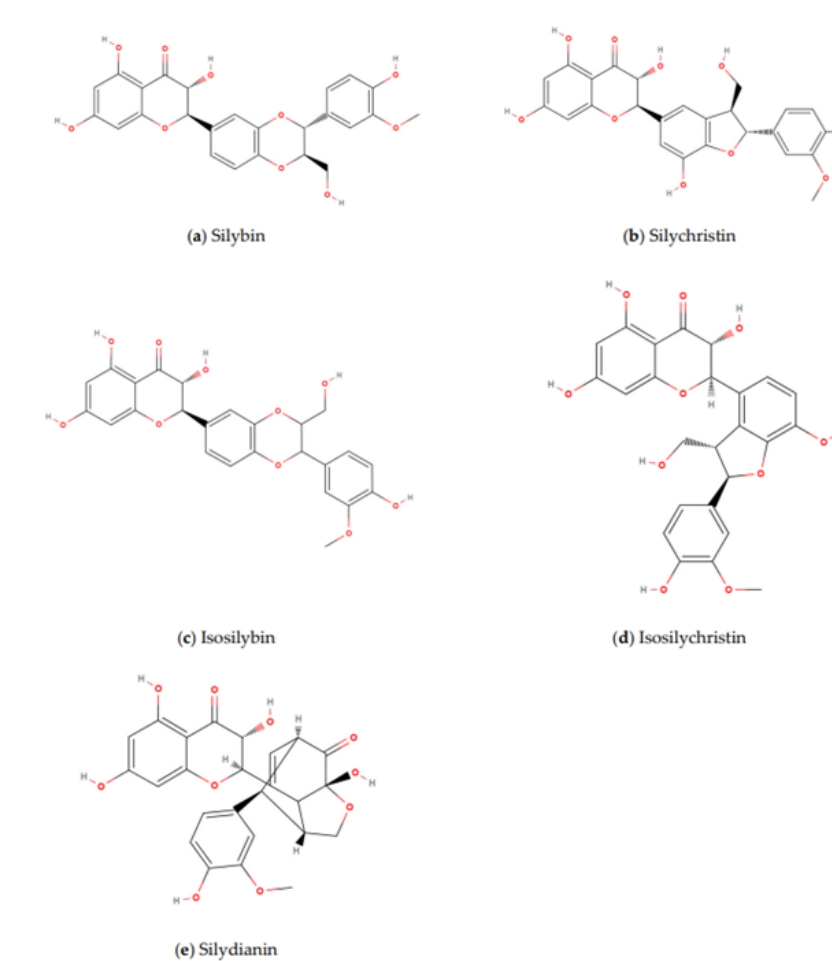


Fig. 4 Chemical structures of the
main flavonolignans

• Conclusions

Silybum marianum is a long-known medicinal plant rich in bioactive compounds. Its main constituent, silymarin, shows hepatoprotective, antioxidant, anti-inflammatory, antidiabetic and antitumour effects, supporting use in phytotherapy and pharma. The crop is highly adaptable to poor, dry soils, and modern green extractions plus nanoformulations improve purity and bioavailability. Further standardisation and clinical trials are needed to confirm benefits in complex metabolic diseases.