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A COMPREHENSIVE PHYTOCHEMICAL AND PHARMACOLOGICAL REVIEW OF *MORUS ALBA*

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ABSTRACT

Medicinal plants are important in the management and prevention of various health ailments across centuries. Historical literature such as the Atharva Veda and Sushruta Samhita provides extensive documentation on the preventive and curative use of plants. Herbal medicines have gained increased acceptance in recent decades due to their accessibility, effectiveness, and typically favorable safety profiles. Morus alba commonly referred to as white mulberry, is known for its rapid growth. Native to China, it is now cultivated extensively across Asia, Europe, North America, and other parts of the world. As a member of the Moraceae family, it thrives in diverse climatic conditions, making it an important medicinal plant globally. Recent pharmacological validated many traditional claims Morus alba, highlighting its potential role in managing chronic disorders like diabetes, hypertension, atherosclerosis, and neurodegenerative diseases. Its therapeutic efficacy, combined with low toxicity, makes it a strong candidate for the development of plant-derived formulations and health products. This review provides detailed information on the phytochemistry and pharmacology of Morus alba.

Keywords: Morus alba; Phytochemistry; Pharmacology; Quercetin; Antimicrobial.

INTRODUCTION

Morus alba

Medicinal plants are important in the management and prevention of various health ailments across centuries[1]. As reported by the World Health Organization, nearly 80% of the global population still relies on traditional medicine, which is predominantly plant-based. Continuous scientific exploration of medicinal flora has revealed the immense therapeutic potential of their bioactive compounds, offering innovative avenues for addressing diverse medical challenges[2]. These plants naturally produce a wide array of pharmacologically active constituents, positioning them as a rich resource for new drug discovery.

Historical literature such as the *Atharva Veda* and *Sushruta Samhita* provides extensive documentation on the preventive and curative use of plants. In contemporary times, more than half of the drugs in clinical use originate from natural sources[3], reaffirming their significance in drug development. Additionally, natural compounds continue to inspire and guide the discovery of new therapeutic agents[4]. Herbal medicines have gained increased acceptance in recent decades due to their accessibility, effectiveness, and typically favorable safety profiles.

Morus alba commonly referred to as white mulberry, is known for its rapid growth. Native to China, it is now cultivated extensively across Asia, Europe, North America, and other parts of the world[5]. Traditionally, its leaves have been essential in the sericulture industry as the primary food (*Bombyx mori*). Ayurveda, and Unani for its broad therapeutic effects[6]. As a member of the Moraceae family, it thrives in diverse climatic conditions, making it an important medicinal plant globally.

Recent pharmacological validated many traditional claims *Morus alba*, highlighting its potential role in managing chronic disorders like diabetes, hypertension, atherosclerosis, and neurodegenerative diseases. Its therapeutic efficacy, combined with low toxicity, makes it a strong candidate for the development of plant-derived formulations and health products. Current research efforts are directed toward understanding its molecular mechanisms of action, enhancing its bioavailability, and integrating it into evidence-based modern medicine.

***Morus alba* Synonyms[7]**

Morus alba, commonly referred to as white mulberry, has been recognized under various scientific and regional names across different classification systems and geographic regions. Over time, botanical nomenclature has evolved, and several alternative scientific names have been associated with this species. These synonyms reflect the diversity in taxonomy and the historical evolution of plant classification.

Scientific Synonyms

Some of the widely cited botanical synonyms or varietal forms of *Morus alba* include:

Morus alba var.

Morus stylosa

Morus indica (sometimes inaccurately used for *M. alba*, though taxonomically distinct)

Morus japonica (appears in older botanical literature)

Morus alba L. (The "L." signifies that Carl Linnaeus was the first to formally describe the species)

Common Names in Various Languages

In addition to its scientific synonyms, *Morus alba* is also known by different vernacular names depending on the region and language:

White Mulberry – English

Shahtoot Safed – Hindi/Urdu

Sang Bai – Chinese (桑白)

Gelso Bianco – Italian

Mûrier Blanc – French

Distribution of *Morus alba*

Morus alba, known as white mulberry, origin from China, where it has been cultivated for thousands of years—most notably for its crucial role in feeding silkworms within the sericulture industry[8]. Its historical importance led to its introduction into neighboring Asian countries such as Japan, Korea, and India, and later to Europe, Africa, and the Americas through trade routes and colonial influence[9]

Today, *Morus alba* is extensively naturalized across various climatic zones—tropical, subtropical, and temperate—owing to its exceptional adaptability to different environmental and soil conditions[10]. In South and Southeast Asia, especially in nations like India, Pakistan, Bangladesh, and Thailand, the tree is cultivated both for commercial leaf production and for its traditional medicinal uses. In Europe, its introduction was initially driven by the demand for silk production. It is now established in countries such as Italy, France, and the Balkan states.

It often grows spontaneously along roadsides, in abandoned fields, and within urban landscapes[11]. Its vigorous growth habit, combined with resistance to drought and a wide range of climate tolerance, has allowed it to become naturalized in many regions—though in some non-native ecosystems, it is now considered invasive.

Cultivation of *Morus alba*

The cultivation of *Morus alba* is straightforward, making it highly suitable for a wide range of agricultural systems. Its resilience and adaptability allow it to thrive under diverse agro-climatic conditions, particularly in temperate and subtropical zones[12]. Including sandy, loamy, and clay—although it grows best in well-drained, fertile soils with a slightly acidic to neutral pH (6.0–7.5)[13].

One of the key advantages of *Morus alba* is its tolerance to drought and moderate frost, which broadens its cultivation potential. Planting is typically done in the early monsoon season or spring, with spacing adjusted according to its purpose—closer spacing for leaf production and wider spacing when grown for fruit or timber.

For sericulture, regular and strategic pruning is necessary to encourage dense, leafy growth that

ensures high leaf yield. While *Morus alba* can survive short periods of drought once established, young plants benefit significantly from supplemental irrigation during dry spells. Application of nitrogen-rich fertilizers or organic compost improves both growth and leaf quality.

Maintenance practices such as weed control, pest and disease management, and routine pruning are important for sustained productivity. Depending on its end use, the plant can be harvested multiple times a year. Leaves are collected regularly for silkworm feeding, while the fruit is typically harvested from late spring through early summer once fully matured[14].

Morus alba is a hardy, low-maintenance crop that not only contributes to economic development—especially in the sericulture and herbal medicine industries—but also holds promise for ecological sustainability due to its soil-binding and air-purifying properties.

Morus alba Plant Description

Morus alba, more commonly known as white mulberry, is a vigorous and moderately tall deciduous tree, generally growing to a height of 10 to 20 meters under favorable conditions[15]. It features a short main trunk that branches out into a broad, rounded crown. As the tree ages, its bark becomes grayish-brown and develops deep fissures, contributing to its characteristic rugged appearance.

The leaves display remarkable variation—especially between younger and older growth—with exhibiting lobes, while mature leaves are usually unlobed. The upper leaf surface is a glossy, rich green, while the underside is lighter in color, and both surfaces are lined with serrated edges and pronounced venation[16].

The plant greenish flowers that are unisexual. Pollination is facilitated either by wind or insect activity. Its fruit, which resembles a blackberry in appearance, is a multiple fruit formed from a cluster of small drupelets. When ripe, the fruits vary in color—ranging from white to pinkish to dark purple—and edible, offering a sweet, slightly tangy flavor[17].

White mulberry is known for its adaptability, growing well in various soil condition and thriving in both temperate and subtropical climates. It exhibits excellent resistance to drought, environmental stress, and urban pollution, making it a highly resilient species. The tree is usually propagated through seeds, stem cuttings, or grafting, depending on the intended purpose

Plant Part Description of *Morus alba*

Leaves

Leaves are arranged alternately on the branches and are simple in structure with a broadly ovate shape. contributing to their textured appearance. Depending on the age of the plant and surrounding environmental conditions, the leaves may be either lobed or unlobed. Typically, their size ranges from 5 to 20 cm in length[18].

In terms of coloration and texture, young leaves are soft, delicate, and light green, while mature leaves develop a tougher texture and turn a deeper green. These leaves hold substantial economic and therapeutic significance. Agriculturally, they

are the essential dietary component for silkworms, making them crucial in sericulture. From a medicinal perspective, they are valued for their phytochemical content and are traditionally used to help manage conditions such as diabetes and inflammation, due to their reported antihyperglycemic and anti-inflammatory activities[19].

Fruits

The fruits of *Morus alba* are distinctive, berry-like formations known as syncarps, which develop from the fusion of multiple small drupes. These cylindrical fruits typically measure between 1 to 2.5 cm in length and display a wide range of colors depending on their ripeness—starting from white or pale pink and progressing to deep purple or black.

Ripe mulberry fruits are pleasantly sweet with a mildly tart undertone, making them not only but also a versatile ingredient in culinary applications. Rich in vitamin C, anthocyanins, and other antioxidants, these fruits contribute to traditionally used for their immunomodulatory and anti-inflammatory benefits. In various cultures, the fruits are processed into jams, wines, syrups, and desserts, reflecting both their nutritional and commercial value.

Flowers

Morus alba generally displays a dioecious reproductive system. The flowers are small, greenish in color, and unisexual. Male flowers form in elongated, catkin-like clusters, while the female flowers are borne in shorter, compact spikes. Flowering usually takes place in the spring season, marking the start of its reproductive cycle.

Bark

Initially smooth and grayish-brown in young trees, but as the tree matures, the surface becomes rough and deeply fissured. The inner bark is fibrous and has traditionally been textiles. In herbal medicine, the bark is valued for its therapeutic properties and is commonly used in decoctions for its reputed anti-asthmatic, diuretic, and blood pressure-lowering effects.

Roots

The roots of *Morus alba* are typically deep, woody, and well-branched, providing strong anchorage. A particularly important part is the root bark, known as “Sang Bai Pi” in traditional Chinese medicine. It is highly valued for its medicinal properties, especially as an expectorant, diuretic, anti-inflammatory, and for lowering blood pressure. Root bark is rich in bioactive constituents such as alkaloids, flavonoids, and coumarins, contributing to its therapeutic relevance**.**

Powder

Powder of *Morus alba* is soft, green, and pliable, gradually becoming woody and brown as they mature. The branches are abundant and widely spread, creating a dense, rounded canopy. These branches not only contribute to the tree’s ornamental and ecological value but are also pruned regularly in cultivation, especially for leaf production. In addition, the stems and slender branches have found use in traditional crafts such as basket weaving and small wooden articles.

Morus alba Phytoconstituents

These naturally occurring compounds are distributed across various parts of the plant—including the leaves, fruits, roots, and bark—and are central to its wide-ranging therapeutic properties.

The plant is especially rich in flavonoids, alkaloids, phenolic acids, stilbenes, coumarins, terpenoids, and polysaccharides. Flavonoids such as quercetin, kaempferol, morin, and rutin are notably abundant in the leaves and fruits, offering potent antioxidant, anti- inflammatory, and anti-diabetic benefits[20].

The plant also contains a variety of phenolic acids, including chlorogenic acid, gallic acid,

and caffeic acid. Stilbenes like resveratrol add cardioprotective and neuroprotective effects.

In the root bark, specialized compounds such as mulberroside A and kuwanon G, both benzofuran derivatives, demonstrate significant antimicrobial, anti-inflammatory, and anticancer properties. Additionally, polysaccharides extracted from the fruits and leaves have shown hepatoprotective and immunomodulatory effects, enhancing the plant's utility in liver support[21].

Terpenoids and coumarins, also present in various parts of the plant, contribute to its anti-inflammatory and mild analgesic effects, further broadening its therapeutic reach.

Altogether, the rich and diverse phytochemistry of *Morus alba* not only supports its extensive traditional use in herbal medicine but also continues to attract scientific interest for development into modern nutraceutical and pharmaceutical applications.

Table 2 Major Phytoconstituents of Morus alba and Their Biological Roles

Phytochemical Class	Representative Compounds	Plant Part	Therapeutic Applications
Flavonoids	Quercetin, Kaempferol, Rutin, Morin	Leaves, Fruits	Regulate blood sugar.
Alkaloids	1-Deoxynojirimycin (DNJ), Moranoline	Leaves, Root Bark	Help control diabetes by inhibiting carbohydrate-digesting enzymes.
Phenolic Acids	Caffeic acid, Chlorogenic acid, Gallic acid	Leaves, Fruits	Exhibit strong antioxidant effects and offer antimicrobial benefits.
Stilbenes	Resveratrol,	Root Bark,	Support brain health and

	Oxyresveratrol	Stem Bark	reduce inflammation.
Triterpenoids	Ursolic acid, Oleanolic acid	Root Bark, Leaves	Known for protecting liver health and combating inflammation.
Anthocyanins	Cyanidin-3-glucoside, Pelargonidin	Fruits	Act as antioxidants and support heart and vascular health.
Polysaccharides	Arabinose, Galactose, Glucose Polymers	Leaves, Fruits	Modulate the immune system and aid in controlling blood glucose levels.
Sterols	β-Sitosterol, Stigmasterol	Leaves, Root Bark	Help reduce cholesterol and have anti-inflammatory activity.
Volatile Compounds	Linalool, α-Terpineol, Eucalyptol	Leaves, Fruits	Possess antimicrobial properties and contribute to aroma and flavor.

Pharmacological Activities of *Morus alba*

Morus alba has a broad spectrum of pharmacological activities, attributed to its phytochemical constituents such as flavonoids, alkaloids, phenolic acids, and stilbenoids. These bioactive compounds play a central role in its medicinal efficacy across several health domains[22-26]

Antimicrobial Properties

Morus alba has shown remarkable antimicrobial potential, making it a compelling candidate for natural treatment against bacterial and fungal infections.

The proposed mechanisms behind these antimicrobial actions include disruption of microbial cell membranes, interference with enzyme systems essential for pathogen survival, and inhibition of biofilm formation. Furthermore, the alkaloid 1- deoxynojirimycin (DNJ) contributes by impairing microbial carbohydrate metabolism.

Anti-Inflammatory, Analgesic, and Antipyretic Effects

its strong anti-inflammatory, pain-relieving (analgesic), and fever-reducing (antipyretic) effects—attributes well documented in both folk medicine and modern research. The anti-inflammatory effects are mainly driven by bioactives such as quercetin, such inhibition helps reduce swelling, redness, and pain associated with inflammation.

The analgesic action of *Morus alba* has been verified through animal model studies, where plant extracts lowered pain responses, likely by affecting pain-signaling pathways and reducing prostaglandin levels. Its antipyretic effect is thought to result from the downregulation of fever-inducing cytokines in the hypothalamus, thereby stabilizing body temperature during febrile conditions. Together, these properties support the traditional application of *Morus alba* in managing inflammatory disorders, muscle aches, joint pain, and fever.

Immunomodulatory Effects

Morus alba is well-regarded for its ability to positively influence the immune system, a property largely credited to its diverse array of phytochemicals, including flavonoids, polysaccharides, phenolics, and alkaloids[27]. These compounds work together to regulate and enhance both innate and adaptive immune mechanisms, positioning *Morus alba* as a valuable natural immunomodulator.

it contributes by exhibiting antioxidant and anti-inflammatory properties, helping to regulate immune function and minimize oxidative stress, which can otherwise impair immune activity. In addition, these flavonoids support immune balance by modulating the inflammatory pathways involved in chronic diseases.

Morus alba also enhances humoral immunity by promoting antibody production. Notably, the alkaloid 1-deoxynojirimycin (DNJ) plays a dual role by improving glucose metabolism and dampening chronic inflammation, which indirectly supports a healthier immune response.

In summary, *Morus alba* fortifies immune health through a combination of immunostimulatory, anti-inflammatory, and antioxidant effects, making it a promising botanical agent for strengthening the body's natural defenses and preventing immune-related disorders[27].

Antioxidant Properties

Experimental studies conducted both in vitro and in vivo have shown that extracts derived from the leaves, fruits, and root bark of *Morus alba* significantly reduce oxidative biomarkers. These extracts not only suppress lipid peroxidation and DNA fragmentation but also enhance SOD and GPx, all of which are essential for maintaining redox balance in cells.

Among the various parts of the plant, the leaves have demonstrated particularly high antioxidant potential due to their rich phenolic and flavonoid content[28,29]. Given these properties, Natural antioxidants for use in therapeutic applications and in the development of functional foods aimed at improving general well-being and slowing the aging process.

Antidiabetic Effects

Morus alba has gained significant scientific and clinical interest for its promising antidiabetic potential, largely attributed to the wide spectrum of bioactive compounds present in its leaves, fruits, and root bark[30]. Among these, 1-deoxynojirimycin (DNJ) stands out as a key compound, especially abundant in the leaves. DNJ functions as a natural α- glucosidase inhibitor, effectively slowing down the digestion and absorption of carbohydrates in the intestines, which helps control post-meal blood sugar spikes.

Promote glucose uptake by peripheral tissues, and shield pancreatic β-cells from oxidative damage—a crucial aspect of preventing the progression of type 2 diabetes. Their antioxidant and anti-inflammatory actions further support the reduction of insulin resistance.

Given its natural origin and multifaceted mechanism of action, *Morus alba* is being increasingly recognized as a valuable adjunctive or alternative therapy in the management of diabetes mellitus[31].

Anticancer Activity

Morus alba has emerged as a potential natural source for anticancer therapy due to its rich reservoir of bioactive phytochemicals, including flavonoids, alkaloids, stilbenes, and phenolic compounds[30,32]. These constituents exhibit diverse mechanisms of action against cancer cells, making *Morus alba* a promising candidate for multi-targeted intervention in cancer management.

One of the primary ways in which *Morus alba* exerts its anticancer effect is through the induction of apoptosis, or programmed cell death. Phytochemicals such as oxyresveratrol and quercetin, which are naturally present in the plant, have demonstrated the ability to activate caspase enzymes and disrupt mitochondrial membrane potential, leading to the controlled death of cancer cells in various models, including breast, liver, and lung cancers[33].

In addition, the alkaloid 1-deoxynojirimycin (DNJ), commonly found in the leaves, exhibits anti-proliferative properties by interfering with tumor cell metabolism, particularly by disrupting glycolysis—a key energy source for rapidly dividing cancer cells.

Extracts from the root bark and leaves have also shown the *Morus alba* compounds can downregulate oncogenes and inflammatory markers such as NF-κB and COX-2, which are closely linked to tumor progression and metastasis.

Taken together, the anticancer effects of *Morus alba* result from a synergistic and multi- pronged approach, involving direct cytotoxic effects on cancer cells, inhibition of tumor- supporting mechanisms. While these findings are promising, further clinical research is essential to confirm its efficacy and safety in human cancer therapy.

Cardiovascular Activity

Morus alba has garnered attention for its beneficial impact on cardiovascular health, largely attributed to its abundance of naturally occurring bioactive constituents such as flavonoids, anthocyanins, triterpenoids, and polysaccharides[34]. These compounds work through multiple pathways to support heart function and vascular integrity, making the plant a promising candidate in the realm of natural cardioprotective agents.

Furthermore, *Morus alba* contains other valuable compounds such as resveratrol and oleanolic acid, found predominantly in the leaves and root bark. These molecules exhibit and vasodilatory effects, promoting smoother blood flow and preventing the accumulation of fatty deposits in the arteries. This helps in maintaining arterial health and reducing the risk of plaque formation.

In addition to these effects, research has shown that *Morus alba* can positively influence lipid metabolism. Such modulation of lipid profiles is vital in preventing cardiovascular conditions linked to hyperlipidemia.

The polysaccharides present in *Morus alba* also play a supportive role by offering immunomodulatory benefits, which contribute to vascular health by minimizing inflammation and enhancing the body's defense mechanisms.

Together, these cardioprotective actions suggest that *Morus alba* could be a valuable natural supplement for the prevention and management of cardiovascular diseases, particularly those related to hypertension, high cholesterol, and arterial plaque formation.

Dermatological Applications

These compounds are known to neutralize free radicals, which in turn helps preserve collagen and elastin—the structural proteins essential for maintaining skin firmness, elasticity, and resilience.

Beyond *Morus alba* has been noted for its anti-inflammatory effects, which may

inflammation associated with common skin disorders such as eczema, acne, and psoriasis. By modulating inflammatory pathways, it helps soothe irritated skin and supports faster healing.

Conclusion

The plant also exhibits broad-spectrum antimicrobial activity, making it effective against bacterial and fungal pathogens that commonly affect the skin. These properties are especially beneficial for treating minor wounds, infections, and acne-prone skin, where preventing microbial colonization is key to recovery. In addition, the polysaccharides found in *Morus alba* contribute to skin hydration and nourishment. This makes the plant a valuable ingredient in cosmetic and skincare formulations, particularly those designed for anti-aging, moisturization, and skin tone improvement. Altogether, the multifunctional benefits of *Morus alba* make it a promising natural option for promoting healthy, youthful, and resilient skin, with broad applications in both traditional and modern practices.

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