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The Anti-Obesity Effects of Morus alba: A Literature Review

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Abstract
Purpose:
This literature review explores the anti-obesity potential of Morus alba (white mulberry) and its role in the prevention and management of obesity. It highlights the mechanisms by which Morus alba may influence metabolic pathways related to fat accumulation, lipid metabolism, inflammation, and gut microbiota modulation.
Methodology:
A narrative review of 20 selected peer-reviewed studies was conducted, focusing on experimental and preclinical evidence of Morus alba's metabolic effects. Key areas of interest included lipid regulation, adipogenesis, antioxidant activity, and interactions with the gut microbiota.
Findings:
The studies reviewed suggest that Morus alba exhibits significant anti-obesogenic effects through various mechanisms, including inhibition of lipid accumulation, regulation of adipogenic gene expression, enhancement of fatty acid β-oxidation, activation of AMPK signaling, and improvement in glucose metabolism. Some studies also report its potential to restore gut microbial balance in obesity models.
Conclusions:
Morus alba represents a promising candidate for complementary obesity management strategies due to its multifactorial action on adiposity, metabolism, and inflammation. However, more clinical trials are needed to determine effective dosages and long-term safety in humans.

Keywords: Morus alba, white mulberry, obesity, adipogenesis, lipid metabolism, gut microbiota, antioxidant

1. Introduction

Obesity is one of the most serious and prevalent non-communicable diseases of the 21st century, posing a major threat to global health systems. It is characterized by excessive fat accumulation that impairs health and is associated with a wide range of comorbidities, including type 2 diabetes mellitus, cardiovascular diseases, hypertension, dyslipidemia, non-alcoholic fatty liver disease (NAFLD), and certain types of cancer (Kim et al., 2021). According to the World Health Organization, the global prevalence of obesity has nearly tripled since 1975, and over 1.9 billion adults are currently classified as overweight. Its etiology is multifactorial, involving genetic predisposition, sedentary lifestyle, high-calorie diets, and gut microbiota dysbiosis (Jaiswal et al., 2024).

Despite the availability of pharmacological and surgical interventions, the long-term management of obesity remains challenging due to cost, side effects, limited accessibility, and the high rate of relapse following treatment cessation. Moreover, several anti-obesity drugs have been withdrawn from the market due to safety concerns, including adverse cardiovascular and psychiatric effects. Therefore, there is a growing demand for natural, food-based strategies that can support weight management while improving metabolic health.

In this context, plant-derived bioactive compounds have emerged as promising alternatives or adjuncts to conventional therapies. Morus alba L., commonly known as white mulberry, is a deciduous tree belonging to the Moraceae family. Native to Asia and widely cultivated in Europe and North America, it has a long history of use in traditional Chinese, Indian, and Korean medicine, particularly for its antidiabetic, anti-inflammatory, and hepatoprotective properties. More recently, Morus alba has been studied for its potential anti-obesity effects through various physiological and molecular mechanisms. The leaves of Morus alba are rich in bioactive compounds such as flavonoids (quercetin, rutin, apigenin), phenolic acids (chlorogenic, protocatechuic, ferulic acid), alkaloids (notably 1-deoxynojirimycin), and other phytochemicals with antioxidant and anti-inflammatory activity (Zhao et al., 2021).

These compounds have been shown to influence key metabolic pathways related to adipogenesis, lipid metabolism, insulin sensitivity, and glucose uptake. In particular, 1-deoxynojirimycin acts as an α-glucosidase inhibitor, reducing carbohydrate absorption and postprandial glycemic response, which may contribute to its anti-obesogenic effects (Kim et al., 2021).

Emerging evidence also highlights the role of Morus alba in modulating gut microbiota, an increasingly recognized factor in the pathophysiology of obesity. High-fat diet-induced obesity is frequently associated with gut dysbiosis, characterized by an increased Firmicutes/Bacteroidota ratio, elevated plasma lipopolysaccharide (LPS) levels, and intestinal inflammation. Studies have demonstrated that Morus alba extract can help restore microbial balance and reduce metabolic endotoxemia, thus attenuating obesity-related inflammation and insulin resistance (Rodríguez-Sojo et al., 2023).

Animal studies using high-fat diet (HFD)-induced obese models have consistently shown that supplementation with Morus alba extracts leads to reductions in body weight gain, adipose tissue mass, serum lipid levels, and hepatic fat accumulation. Furthermore, mechanistic studies have revealed that Morus alba activates AMP-activated protein kinase (AMPK), a central regulator of energy homeostasis that promotes fatty acid oxidation and inhibits lipogenesis (Kim et al., 2021).

Given the increasing burden of obesity and its complications, the search for effective, safe, and sustainable interventions remains a priority. The multifactorial action of Morus alba on key aspects of obesity pathophysiology—including metabolic regulation, gut microbiota modulation, and anti-inflammatory activity—makes it a compelling candidate for further research and clinical application.

This review aims to synthesize the current scientific knowledge on the anti-obesity potential of Morus alba, with a particular focus on its molecular mechanisms of action and effects observed in experimental models. The following sections will examine the available evidence from in vitro studies, animal models, and clinical trials to assess the therapeutic relevance of Morus alba in the context of obesity prevention and management.

2. Methodology

This review is based on the analysis of scientific articles selected for their relevance to the anti-obesity properties of Morus alba. The literature search was conducted using PubMed databases, with keywords including Morus alba and obesity.

Only articles published in English and accessible in full-text form were included. The selection encompassed in vitro studies, animal experiments, and human clinical trials that examined the biological activity of Morus alba or its extracts in the context of obesity or metabolic dysfunction. Exclusion criteria involved articles unrelated to obesity or lacking specific reference to Morus alba's bioactivity.

The studies were evaluated qualitatively, with attention to their reported mechanisms of action, biological targets, and experimental models. The main findings were categorized and summarized thematically to provide a comprehensive overview of Morus alba's potential role in obesity prevention.

3. Bioactive Compounds and Mechanisms of Action

Leaves of Morus alba have long been valued in Asian traditional medicine and are now widely recognized as a functional food due to their rich profile of biologically active compounds. Among these, quercetin, rutin, and 1-deoxynojirimycin (DNJ) stand out for their therapeutic potential. The plant has been historically used to support the treatment of metabolic disorders such as elevated blood lipids, diabetes, hypertension, and liver dysfunction. Additionally, extracts from Morus alba have demonstrated the ability to stimulate antioxidant defense systems in diabetic animal models, which may help counteract oxidative stress associated with obesity and related conditions (Ann et al., 2015).

Different parts of the plant, including leaves, fruits, branches, and roots, have long been used in folk medicine for their calming, digestive, and toning effects. The fruit has been applied as a remedy for pain, infections, high blood pressure, and digestive disorders. Phytochemical analysis revealed the presence of numerous compounds such as flavonoids, phenolic acids, alkaloids, vitamins, and minerals. These substances are believed to contribute to the plant's antioxidant, anti-inflammatory, antimicrobial, antidiabetic, lipid-lowering, and anti-obesity effects (Batiha et al., 2023).

Flavonoids such as quercetin and rutin have been shown to influence fat metabolism by limiting the formation of new fat cells and promoting the breakdown of existing fat stores. Chlorogenic acid and protocatechuic acid, present in various extracts, have been found to support better glucose use by cells and reduce fat accumulation through the activation of enzymes responsible for maintaining energy balance (Peng et al., 2018). Together, these effects may help improve insulin sensitivity and body composition. Moreover, extracts with high levels of protocatechuic acid, such as those obtained from specific genotypes of Morus alba, appear to stimulate heat production and optimize fat tissue function. These benefits are linked to improved activity of proteins involved in transporting glucose into cells and to enhanced signaling that promotes a healthier metabolic profile, including the upregulation of hormones like adiponectin and receptors that help regulate fat storage and sugar metabolism (Leyva-Jiménez et al., 2020). In addition, extracts from the bark of Morus alba have been shown to lower harmful blood lipids, such as total cholesterol and low-density lipoproteins, while improving the balance between different cholesterol fractions. They also protect the liver from fat accumulation and support

the balance between hormones involved in inflammation and fat metabolism, contributing to overall metabolic health (Noh & Yoon, 2022).

A critical compound in Morus alba leaves, 1-deoxynojirimycin (DNJ), plays a key role in reducing energy absorption by inhibiting enzymes that break down carbohydrates in the small intestine. This enzymatic inhibition slows the release of glucose into the bloodstream after meals, helping reduce total caloric intake without requiring restrictive diets. Such extracts have demonstrated significant effects in decreasing the absorption of sugars, supporting weight reduction strategies through a lowered energy yield from carbohydrates. Morus alba extracts also influence inflammatory processes involved in metabolic disorders. Their polyphenolic content can suppress the activity of pro-inflammatory molecules, including cytokines like TNF-α and interleukin-1β, by modulating key cellular signaling pathways. These actions may help protect against insulin resistance and systemic inflammation commonly observed in obesity (Ntalouka & Tsirivakou, 2024).

Oxidative stress, another major contributor to obesity-related complications, is likewise mitigated by Morus alba polyphenols. These compounds help neutralize reactive oxygen species, reduce lipid peroxidation, and protect mitochondria from damage (Rodríguez-Sojo et al., 2023). This antioxidant action may support the health of metabolically active organs such as the liver and pancreas. Moreover, Morus alba exhibits prebiotic-like effects by positively influencing the gut microbiota. Rodríguez-Sojo et al. reported that dietary supplementation with Morus alba extract reduced the Firmicutes-to-Bacteroidota ratio and plasma lipopolysaccharide (LPS) concentrations in obese mice, suggesting enhanced gut barrier integrity and reduced metabolic endotoxemia.

Similarly, recent research demonstrated that extracts derived from Morus alba leaves and twigs could remodel the gut microbiota and short-chain fatty acid (SCFA) metabolism in high-fat diet-induced obesity. These effects included an increase in beneficial genera such as Bifidobacterium and Enterococcus faecalis, suppression of obesity-associated microbial profiles, and alterations in SCFA levels — notably elevated propionic acid and reduced butyric acid concentrations in the cecum (Qian et al., 2025). These findings highlight the potential of Morus alba not only as a nutraceutical but also as a sustainable use of agricultural by-products for obesity management.

Together, these diverse mechanisms support the anti-obesity potential of Morus alba, acting through coordinated effects on energy metabolism, glucose handling, inflammation, oxidative stress, and intestinal homeostasis.

4. Preclinical Evidence

Numerous experimental studies have demonstrated the anti-obesity effects of Morus alba in both in vitro and animal models. These studies provide important insight into the potential mechanisms through which mulberry extracts may regulate metabolism, reduce fat accumulation, and improve overall metabolic health.

In a study by Noh, bark extract of Morus alba was administered to obese rats fed a high-fat diet. The extract significantly reduced total cholesterol and the harmful fraction of low-density lipoproteins, while also lowering the ratio of total to high-density cholesterol. Liver enzyme activity improved, and fat accumulation in the liver was reduced. These findings suggest that Morus alba may help protect against lipid disorders and fatty liver disease by restoring the balance between inflammation-related hormones such as leptin and adiponectin (Noh et al., 2022).

In another animal study, Rodríguez-Sojo reported that Morus alba leaf extract improved glucose tolerance and reduced body fat levels. Moreover, it helped restore the integrity of the intestinal barrier and decreased markers of inflammation derived from the gut. These benefits were linked

to changes in the gut microbiota, particularly a reduction in bacteria associated with metabolic disorders (Rodríguez-Sojo et al., 2023).

Qian compared leaf and twig extracts of Morus alba in obese mice. Both types of extract led to favorable changes in gut microbiota composition, with increased numbers of beneficial bacteria and a shift in short-chain fatty acid profiles. These modifications were accompanied by reduced weight gain and improved glucose and lipid metabolism (Qian et al., 2025).

In cellular studies, Lim tested the effects of compounds isolated from Morus alba fruit on cultured fat cells. The results showed that two of these compounds, rutin and Q3G, improved glucose uptake by the cells and had a beneficial effect on fat metabolism. Importantly, they supported this process without increasing fat accumulation, which suggests they may be helpful in managing blood sugar levels without causing weight gain. These findings indicate potential for using Morus alba fruit components in future therapies aimed at type 2 diabetes and obesity (Lim et al., 2021).

Kim investigated the combined effects of mulberry leaf and mulberry root extracts on fat metabolism. In laboratory tests on fat cells, the mixture promoted the development of cells that burn fat and produce heat, a process known to help reduce weight. In a mouse model of obesity caused by a high-fat diet, the combination of both extracts significantly reduced weight gain, fat storage, blood cholesterol levels, and the size of fat cells. The treatment also improved the activity of genes involved in fat breakdown and energy use. These findings suggest that using both parts of the plant together may support the transformation of unhealthy white fat into more active brown fat, helping prevent obesity and related metabolic problems (Kim et al., 2023).

Sun focused on the effects of mulberry twig alkaloids in mice with diet-induced obesity. After several weeks of treatment, the extract significantly reduced body weight and lowered blood levels of fat-related markers such as cholesterol and triglycerides. In addition, it decreased the concentration of several inflammatory substances linked to obesity. The treatment also improved fat tissue metabolism and reduced the presence of immune cells responsible for inflammation. These results suggest that mulberry twig alkaloids may help regulate fat breakdown and reduce inflammation in fat tissue (Sun et al., 2022).

In an animal study, a special mulberry leaf extract fermented with the medicinal fungus Cordyceps militaris was tested for its effects on fatty liver disease caused by a high-fat diet. Mice given this extract for 12 weeks showed fewer fat droplets in the liver and lower activity of genes linked to fat buildup. The treatment also reduced signs of inflammation in the liver, including a lower presence of inflammatory cells and proteins that trigger inflammation. Additionally, the extract helped normalize processes related to cell cleaning and recycling, known as autophagy, which are often disrupted in liver disorders. These results suggest that fermented mulberry leaf extract may protect the liver by reducing fat accumulation, calming inflammation, and restoring cellular balance (Lee et al., 2020).

Ma explored the effects of mulberry leaf extract in rats with type 2 diabetes caused by a high-fat diet and a chemical agent. The treatment lowered fasting blood sugar levels and improved typical symptoms of diabetes, such as excessive hunger and urination. It also changed the levels of many substances in the blood involved in sugar, fat, and amino acid metabolism. The extract showed antioxidant and anti-inflammatory properties and helped reduce insulin resistance and weight gain. These results suggest that mulberry leaves may act on several processes in the body at once, making them a promising option in the search for new treatments for diabetes and related metabolic disorders (Ma et al., 2022).

Kim studied the effects of a combined extract from mulberry leaves and fruits on memory and brain function in mice with diet-induced obesity. Mice fed a high-fat diet for several weeks gained weight and showed signs of reduced brain activity and memory problems. However, mice that received the mulberry extract mixture alongside the high-fat diet lost weight and showed improved neural function. Markers of brain activity and connections between brain

cells were restored, and performance in memory tests improved. These results suggest that the anti-obesity effect of mulberry extract may also help protect the brain from obesity-related cognitive decline (Kim et al., 2015).

Lee evaluated the effects of a special mulberry leaf extract prepared using high hydrostatic pressure, a modern method to enhance the release of active plant compounds. In rats fed a high-cholesterol diet, this extract significantly lowered blood levels of cholesterol, triglycerides, and the harmful LDL fraction. It also reduced the amount of fat stored in the liver. Interestingly, the extract increased the amount of cholesterol and bile acids excreted in the feces, without affecting body weight or liver enzyme levels. The treatment improved the expression of liver genes involved in the breakdown and removal of cholesterol, while also reducing the activity of molecules that normally suppress this process. These findings suggest that this type of mulberry leaf extract may lower cholesterol by supporting its breakdown in the liver and promoting its removal from the body (Lee et al., 2021).

In Suthamwong's studies, the effects of mulberry leaf consumption on insulin-producing cells in the pancreas, using a mouse model of type 2 diabetes are shown. The animals that received mulberry leaf powder in their diet maintained better blood sugar control and showed improved insulin secretion. The treatment helped preserve the number of pancreatic cells responsible for producing insulin, partly by reducing cellular stress that normally leads to their damage. It also increased the regeneration of these cells. These findings suggest that mulberry leaves may help support insulin function and protect the pancreas in the context of type 2 diabetes (Suthamwong et al., 2020).

4.1 Human Evidence

Although most studies on Morus alba focus on animal or cellular models, a clinical study by Parklak evaluated its effects in humans with impaired glucose metabolism. In this study, 24 participants were given mulberry leaf extract three times a day before meals for 12 weeks. The results showed a reduction in postprandial blood glucose levels and insulin secretion, without significant side effects. These findings suggest that mulberry leaf extract may help improve glucose regulation in humans. However, further large-scale studies are needed to confirm its safety and effectiveness in broader populations (Parklak et al., 2024).

5. Discussion

The growing prevalence of obesity and its metabolic complications has led to an urgent search for effective, safe, and sustainable therapeutic strategies. Among natural products, Morus alba (white mulberry) has emerged as a promising candidate due to its rich content of bioactive compounds and multifaceted mechanisms of action. This review highlights evidence from preclinical and limited clinical studies supporting the anti-obesity potential of Morus alba extracts.

Numerous in vitro and animal studies demonstrated the capacity of Morus alba to reduce weight gain, adipose tissue mass, and serum lipid levels in models of high-fat diet-induced obesity. The beneficial effects are largely attributed to the modulation of lipid and glucose metabolism, suppression of inflammation, enhancement of antioxidant defense, and positive influence on gut microbiota (Rodríguez-Sojo et al., 2023; Lim et al., 2021; Kim et al., 2023).

Bioactive compounds such as quercetin, rutin, protocatechuic acid, and 1-deoxynojirimycin (DNJ) play central roles in these effects. Their mechanisms include inhibition of adipocyte differentiation, stimulation of glucose uptake, and activation of energy-regulating pathways such as AMPK (Peng et al., 2018; Leyva-Jiménez et al., 2020; Sun et al., 2022). These actions contribute to better insulin sensitivity and reduced fat accumulation without promoting lipogenesis (Lim et al., 2021).

In addition, Morus alba has shown hepatoprotective properties by reducing hepatic fat accumulation, improving liver enzyme profiles, and normalizing pathways related to autophagy and inflammation (Lee et al., 2020; Lee et al., 2021). The fermented extract (EMfC) and high hydrostatic pressure extract of Morus alba leaves were particularly effective in addressing hepatic steatosis and dyslipidemia, respectively.

An important aspect of Morus alba's anti-obesity action is its influence on the gut microbiota. Studies observed an increase in beneficial bacterial populations such as Bifidobacterium and Enterococcus faecalis, as well as favorable changes in short-chain fatty acid profiles, including increased propionic acid levels (Qian et al., 2025). These microbial shifts were associated with reduced systemic inflammation and improved metabolic outcomes.

Moreover, cognitive benefits were noted in obese mice treated with mulberry leaf and fruit extracts, indicating that the anti-obesity effects of Morus alba may also extend to neuroprotection and improved synaptic activity (Kim et al., 2015).

Although the evidence from animal and cellular models is robust, clinical research remains limited. The only included human study by Parklak et al. (2024) showed promising results, with improved postprandial glucose control after 12 weeks of Morus alba extract supplementation. However, the small sample size and short duration underline the need for larger, well-designed clinical trials.

Morus alba exerts anti-obesity effects through a broad spectrum of mechanisms, including metabolic regulation, anti-inflammatory and antioxidant activity, gut microbiota modulation, and even cognitive improvement. These multifactorial actions make it a strong candidate for further exploration as a supportive agent in obesity management. Nevertheless, the current lack of comprehensive human data highlights the necessity for future clinical studies to validate these findings and to establish safe, effective dosing regimens.

6. Conclusions

The present review synthesizes current knowledge on the anti-obesity potential of Morus alba and highlights its multifaceted role in metabolic regulation. The data derived from in vitro and animal studies provide robust evidence that extracts from various parts of the plant—particularly leaves, fruits, roots, and twigs—exert significant effects on processes involved in obesity pathogenesis. These include inhibition of adipocyte differentiation, stimulation of fatty acid oxidation, regulation of cholesterol and triglyceride levels, and improvement of glucose homeostasis.

Additionally, Morus alba appears to exert strong anti-inflammatory and antioxidant actions, which may further contribute to metabolic improvements, especially in tissues such as adipose tissue, liver, and pancreas. These effects are mediated through the modulation of signaling pathways involved in energy metabolism, cellular stress, and immune responses. The plant’s ability to reduce pro-inflammatory cytokines and support insulin-producing pancreatic cells underscores its therapeutic potential not only in obesity but also in obesity-related complications such as type 2 diabetes.

Another noteworthy mechanism involves the modulation of gut microbiota composition and activity. Several studies indicate that Morus alba may restore microbial balance disrupted by high-fat diets, increase the abundance of beneficial bacterial genera, and influence the production of short-chain fatty acids—factors that are increasingly recognized as key modulators of metabolic health.

Although the preclinical evidence is substantial, only limited data exist on the efficacy and safety of Morus alba in human subjects. One clinical study demonstrated promising results in improving postprandial glucose levels without adverse effects, but larger, well-controlled human trials are urgently needed. Important questions remain regarding optimal dosing, long-

term outcomes, interactions with other treatments, and standardization of plant-derived preparations.

In conclusion, Morus alba represents a promising natural intervention for obesity management due to its broad spectrum of biological activity. While current findings support its use as a functional food or nutraceutical, the translation of these benefits into clinical practice requires further research. If confirmed in future trials, Morus alba could offer a safe, accessible, and multifactorial approach to improving metabolic health in the face of the growing global obesity epidemic.

Disclosure:

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