Jurnal Biologi Tropis

Original Research Paper

Phytochemical Constituents, Nutritional Composition, and Pharmacological Potentials of Mangifera foetida: A Comprehensive Review

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Article History
Received : June 19th, 2025
Revised : June 27th, 2025
Accepted : July 02th, 2025

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Abstract: *Mangifera foetida*, commonly referred to as bacang, is a tropical fruit tree of the Anacardiaceae family widely used in traditional medicine throughout Southeast Asia for a variety of therapeutic purposes. Recent scientific studies have validated many of these ethnomedicinal uses by uncovering a diverse phytochemical composition alongside notable pharmacological activities. This review synthesizes current knowledge on the nutritional content, bioactive compounds, and pharmacological effects of *M. foetida*, with particular focus on its antioxidant, antimicrobial, cytotoxic, antidiabetic, and anti-inflammatory properties. Key secondary metabolites, including mangiferin, phenolic compounds, flavonoids, and essential oils, are believed to underpin its therapeutic efficacy. Moreover, the fruit and other plant parts provide considerable nutritional benefits, supplying essential vitamins, minerals, and dietary fiber. Despite these promising findings, further investigations are needed to clarify underlying mechanisms, improve extraction techniques, and evaluate clinical effectiveness. This review seeks to establish a comprehensive reference to support future research and facilitate the development of *M. foetida*-derived nutraceuticals and pharmaceuticals.

Keywords: *Mangifera foetida*, phytochemicals, pharmacological activity, traditional medicine, Southeast Asia.

Introduction

Natural products have served as a crucial foundation for therapeutic development for centuries, particularly through the use of medicinal plants which have long been central to traditional healing practices across cultures (Chaachouay & Zidane, 2024). Even today, the World Health Organization estimates that over 80% of the population in developing countries relies on herbal medicines for primary healthcare needs (Aware et al., 2022). Plant-derived compounds, with their vast chemical diversity and potent biological and pharmacological activities, have significantly contributed to the treatment of a wide range of diseases, including cancer, diabetes, and infectious conditions, making them invaluable in both communicable and non-communicable disease management (Atanasov et al., 2021; Dzobo, 2022). As such, natural products remain a vital and promising resource for the discovery of novel therapeutic agents. In recent decades, there has been a growing body of research focusing on tropical plants, particularly those that are underutilized in modern pharmacology but are widely employed in traditional medicine.

Mangifera foetida L., commonly known as bacang or wild mango, is a tropical plant from the Anacardiaceae family and is native to Southeast Asia. Unlike the extensively studied *Mangifera indica, M. foetida* remains relatively underexplored despite its traditional medicinal use. Pharmacological studies have highlighted various parts of the plant—leaves, fruits, and twigs—for their therapeutic potential. Leaf extracts have shown antibacterial and anti-tumor-promoting activities, while the fruits demonstrate significant antioxidant capacity. Acetone extracts from the twigs also exhibit notable antioxidant activity (Panthong et al., 2015; Koernia Wahidah & Kanedi, 2017). Furthermore, methanol and ethanol extracts of related *Mangifera* species have demonstrated inhibitory effects on pancreatic lipase, suggesting anti-obesity potential (Aji et al., 2021).

Phytochemical screenings have revealed the presence of diverse bioactive compounds, including mangiferin, coumarins, alkaloids, quercetin, phenols, flavonoids, tannins, carotenoids, terpenes, and terpenoids (Aji et al., 2021; Panthong et al., 2015; Zivković et al., 2024; Koernia Wahidah & Kanedi, 2017). The diverse phytochemicals found in *Mangifera foetida* have been associated with a range of biological activities, suggesting potential roles in mitigating oxidative stress, combating infections, regulating metabolic conditions such as diabetes and obesity, modulating immune responses, and inhibiting cancer progression (Aji et al., 2021; Fajri et al., 2017; Fitmawati et al., 2021; Koernia Wahidah & Kanedi, 2017).

Preclinical studies have demonstrated that ethanolic extracts of *Mangifera foetida* leaves exhibit significant antibacterial activity against both Gram-positive and Gram-negative bacteria, notably *Streptococcus mutans* and *Propionibacterium acnes*, indicating potential utility in oral and skin-related therapeutic applications (Aditya et al., 2024; Koernia Wahidah & Kanedi, 2017). Furthermore, the extract has demonstrated inhibitory activity against pancreatic lipase, an enzyme essential for lipid digestion, indicating potential relevance in obesity management (Aji et al., 2021). Its antioxidant capacity, evidenced through both chemical assays and *in vivo* models, also suggests a role in reducing oxidative stress, a key factor implicated in chronic inflammation and tumor development (Fajri et al., 2017).

Given the growing volume of primary research and the lack of a comprehensive synthesis, this review systematically gathers and critically assesses the existing literature on the pharmacological properties of *Mangifera foetida*. Special attention is directed toward its phytochemical profile and reported biological activities, including antibacterial, antidiabetic, anticancer, and cytotoxic effects. By consolidating these findings, the review aims to provide a solid basis for future investigations and clarify the therapeutic relevance of this underexplored species.

Material and Methods

A systematic literature search was conducted to identify and synthesize primary research articles and peer-reviewed publications focusing on the pharmacological properties and bioactive constituents of *Mangifera foetida*. The literature search was conducted across multiple reputable scientific databases, including Google Scholar, Scopus, PubMed, and ScienceDirect. Publications selected were focus on recent findings to reflect the current state of scientific knowledge.

Search terms were used in both English and Indonesian to ensure broader coverage, including the keywords: *Mangifera foetida*, bacang, wild mango, biological activity, antibacterial, anticancer, antioxidant, antidiabetic, anti-inflammatory, cytotoxicity, bioactive compounds, mangiferin, and traditional medicine. Additional data were obtained from relevant international and national journals to support contextual understanding of traditional uses.

Articles were screened for relevance and scientific rigor. Inclusion criteria were based on the availability of experimental or review data regarding the biological activities, bioactive constituents, and traditional medicinal uses of *M. foetida*. Studies unrelated to pharmacological aspects or lacking methodological transparency were excluded from analysis.

The information extracted was organized into four main thematic categories: 1) Botanical Description, Distribution, and Ethnobotanical Uses; 2) Nutritional Composition; 3) Phytochemical Profile and Active Compounds; and 4) Pharmacological and Biological Activities. A narrative synthesis approach was applied to describe and interpret findings across diverse studies. To enhance clarity and comparison, summary tables were included to present key data on traditional uses and local names, identified phytochemicals profile and active compounds, and reported pharmacological and biological activities. This method allowed integration of

DOI: http://doi.org/10.29303/jbt.v25i3.9167

diverse study designs and findings to present a coherent overview of the current knowledge surrounding the potential therapeutic value of *M. foetida*.

Results and Discussion

Botanical Description, Distribution, and Ethnobotanical Uses of *Mangifera foetida L.*

Mangifera foetida L., commonly referred to as wild mango or bacang in Indonesia, is an underutilized tropical fruit-bearing species belonging to the family Anacardiaceae. The fruit is oval-shaped with smooth yellow-green skin when ripe. Native to South and Southeast Asia, *M. foetida* is widely distributed across Indonesia, Malaysia, Thailand, and India. Natural populations are particularly abundant in the dipterocarp forests of Peninsular Malaysia, Peninsular Thailand, Sumatra, Borneo, and Java. In regions such as the Moluccas and Sulawesi, it often grows wild in forested areas. Although the species has been introduced to and adapted in countries like Cambodia, Myanmar, Vietnam, and the Philippines, its cultivation beyond its native range remains limited. In Vietnam, Cambodia, and the Philippines, *M. foetida* is rarely cultivated and remains relatively unfamiliar to the general population. In contrast, it is extensively cultivated and holds cultural and economic significance in parts of its native range, including southern Myanmar (Tenasserim), where its popularity continues to grow (Orwa et al., 2009; Lim, 2012).

The complete taxonomic classification of *M. foetida* is as follows:

Kingdom	: Plantae
Phylum	: Tracheophyta
Class	: Magnoliopsida
Order	: Sapindales
Family	: Anacardiaceae
Genus	: *Mangifera*
Species	: *Mangifera foetida L.*

(National Center for Biotechnology Information, 2025)

As summarized in Table 1, *Mangifera foetida* is known by a wide range of vernacular names and utilized parts across Southeast Asia, reflecting its extensive cultural and ethnobotanical significance. In Indonesia alone, more than 40 ethnolinguistic designations have been documented, including mancang (Aceh), ambacang (Minangkabau), pate (Ambon), batjang (Batak), pakel (Java), taipa bacang (Makassar), and limus (Sundanese). In Borneo, local names such as hambawang, tempajang, and asam pamas are commonly used, while among Dayak communities, the fruit is referred to as thulik kaki or ambawa. In the Philippines and Malaysia, terms such as horse mango, bacang, macang, and membachang are frequently encountered. In Thailand, maa-chang and malamut are the prevalent local names (Lim, 2012).

Mangifera foetida L. has significant potential for use in traditional and herbal medicine. Despite its ethnobotanical and ecological importance, *M. foetida* is rarely cultivated and holds limited commercial value due to its sour fruit taste, coarse fiber content, and high levels of latex compared to other mango species. The wood is often used by local communities for light and temporary construction. However, the species is increasingly threatened by rapid deforestation in Indonesia, which continues to reduce its natural habitat. Ecologically, *M. foetida* plays an essential role as a food source for primates and other wildlife species (Fitmawati et al., 2021; Lim, 2012).

The ripe fruit emits a strong turpentine-like odor and contains an irritant latex primarily concentrated in the skin, which can cause inflammation of the lips and mouth if not peeled properly. Nevertheless, the fruit is commonly consumed in traditional culinary forms, particularly when unripe. In Indonesia, it is used in vegetable salads (rujak) and sour pickles (asinan), while in East Kalimantan (Borneo), it frequently replaces tamarind as an acidic component in sambal. In Malaysia, the fruit is used in chutneys, pickles, acar, rojak, and various curry dishes (Orwa et al., 2009; Lim, 2012).

Ethnomedicinally, *M. foetida* has been widely utilized across Southeast Asia. In Indonesia, young leaves are traditionally consumed with rice as a postpartum remedy (Panthong et al., 2015), believed to aid in uterine cleansing and recovery. An infusion of the leaves is traditionally used to treat gout, pain, and inflammation (Nuraeni et al., 2022), reflecting its potential anti-inflammatory and analgesic properties. In folk medicine, the seeds are traditionally used against trichophytosis, scabies, eczema, and itchiness (Lim, 2012). Additionally, the seeds of *M. foetida* are used in Indonesia to treat itchiness (Wiart, 2006), suggesting antipruritic potential in traditional use. Bark sap is used in lotions for treating ulcers, and among the Orang Asli of Peninsular Malaysia, the sap has been traditionally applied to deepen tattoo scars. When in bloom, the tree also serves as an attractive ornamental species due to its upright inflorescences (Orwa et al., 2009;Lim, 2012).

Table 1. Traditional Uses and Local Names of *Mangifera foetida* in Various Countries

No	Area	Local Name(s)	Plant Part	Traditional Use	Reference(s)
1	Indonesia	Mancang (Aceh, Sumatra), Pate (Ambon, Maluku), Pau Kasi (Alor, Timor), Ambawa (Bari, Sulawesi), Batjang (Batak), Pakel, Limus (Lampung, Sumatra), Taipa Bacang (Makassar, Sulawesi), Ambacang (Minangkabau), and many others across various regions.	Leaves	Consumed with rice as a postpartum remedy for uterine cleansing and recovery	(Panthong et al., 2015)
				Infusion used to treat gout, pain, and inflammation	(Nuraeni et al., 2022)
			Seeds	Used to treat itchiness	(Wiart, 2006)
			Fruit	Used in vegetable salads (rujak) and sour pickles (asinan), replaces tamarind in sambal	(Orwa et al., 2009)
2	Malaysia	Bacang, Machang, Utan, Kurau, Machai, Mempening, Embachang, Kemba chang, Membachang, Batel, Empelam, Sepam, Sepopn (Sakai), Pudu, Pelam (Kayan, Sarawak), Bacang (Sarawak), Asam (Sabah).	Sap	Applied to deepen tattoo scars	(Orwa et al., 2009)
			Bark Sap	Used in lotions to treat ulcers	(Lim, 2012)
			Fruit	Used to make chutneys as well as pickles	(Orwa et al., 2009)
3	Thailand	Maa-Chang, Malamut, Ma Mud, Som Mud	Fruit	Used as vegetable for Thai curry	(Lim, 2012; Chayamarit, 2010)
4	Philippines	Horse Bacang	–	No specific traditional use recorded	(Lim, 2012)
5	Vietnam	Xoai Hoi	–	No specific traditional use recorded	(Lim, 2012)
6	Southeast Asia	-	Seeds	Used against trichophytosis, scabies, and eczema	(Lim, 2012)
			Fruit	Used in curry, pickles (culinary)	(Lim, 2012)

Nutritional Composition of *Mangifera foetida*

Nutritional analyses of *Mangifera foetida* highlight its potential as a source of functional food ingredients. The edible portion represents approximately 56% of the total fruit weight. Based on 100 g of edible portion, the fruit contains water (72.5–78.5 g), protein (0.8–1.4 g), fat (0.2 g), carbohydrates (17.9–25.4 g), calcium (16–21 mg), phosphorus (15–19 mg), potassium (361 mg), and dietary fiber (1.8 g). It is also rich in vitamin C (47.4–56 mg) and provides moderate amounts of provitamin A carotenoids (255 µg), as well as B vitamins including thiamine (0.09 mg), riboflavin (0.04 mg), and niacin (0.6 mg) (Orwa et al., 2009; Tyug et al., 2010; Lim, 2012). Overall, the nutritional profile of *M. foetida* supports its potential inclusion in functional food formulations and nutraceutical development, particularly in view of its vitamin, mineral, and fiber content.

Phytochemical Profile and Active Compounds of *Mangifera foetida*

Mangifera foetida, commonly known as

bacang or wild mango, has garnered considerable scientific attention due to its rich phytochemical composition and broad pharmacological potential. A wide array of bioactive compounds has been identified throughout various parts of *Mangifera foetida*, including leaves, bark, pericarp, twigs, and fruit, as summarized in Table 2. LC-MS profiling of leaf extracts across three varietal types ('Limus', 'Batu', and 'Manis') revealed 667 metabolites, with flavonoids and amino acids as the predominant classes (Fitmawati et al., 2019; Kholifah et al., 2021). Complementary phytochemical screening of ethanolic and methanolic leaf extracts confirmed the presence of phenols, flavonoids, tannins, saponins, steroids/triterpenoids, and alkaloids, underscoring the species' biochemical diversity(Aditya et al., 2024; Aji et al., 2021). HPLC analysis further demonstrated that the 'Manis' variety contains the highest concentration of gallic acid, a well-characterized phenolic antioxidant (Fitmawati et al., 2020).

Table 2. Phytochemical Profile and Active Compounds of *Mangifera foetida*

Plant Part	Extraction Solvent	Analytical Method	Key Findings	Reference
Leaves	Methanol, Acetonitrile, and Dichlorometan	LC-MS	Identified 667 metabolites. Major compound groups include phenylpropanoids, flavonoids, alkaloids, amino acids, aromatic compounds, carboxylic acids, essential oils, sesquiterpenoids, medium-chain fatty acids, and nucleic acids.	Fitmawati et al., 2019;
	Methanol	LC-MS	Identified around 25 compounds. Major compound groups include alkaloids, flavonoids, amino acid, phenylpropanoids, fatty acyl, organic aromatic, and isoxepac.	Fitmawati et al., 2021
	Ethanol	Total Phenol Content (TPC) and Flavonoid content (FC)	Contains phenols and flavonoids	Aji et al., 2021; Fitmawati et al., 2020
		HPLC	Highest mangiferin content compared to *M. indica* and *M. odorata*	Retnaningtyas et al., 2020
		Phytochemical screening	Contains phenols, flavonoids, tannins, saponins, steroids/triterpenoids, and alkaloids	Aditya et al., 2024
		HPLC	Contains gallic acid and quercetin	Fitmawati et al., 2020
		TLC	Detection of mangiferin as a major compound; presence of alkaloids, flavonoids, saponins, and triterpenoids	Fajri et al., 2017
		Total Phenol Content (TPC) and Flavonoid content (FC)	Contains phenols (1.092 ± 0.978 mg QE/g) and flavonoids (17.295 ± 1.014 mg QE/g)	Sianipar et al., 2022
Bark	Ethanol	Total Phenol Content (TPC) and Flavonoid content (FC)	Bark contains the highest phenolic content compared to other parts. Contains phenols (24.642 ± 11.087 mg QE/g) and flavonoids (19.557 ± 1.065 mg QE/g)	Sianipar et al., 2022
Pericarp	Ethanol	Total Phenol Content (TPC) and Flavonoid content (FC)	Contains phenols (3.964 ± 0.673 mg QE/g) and flavonoids (12.057 ± 0.052 mg QE/g)	Sianipar et al., 2022

Twigs	Acetone	Compound isolation	Isolated mangiferenes A and B, and mangiferzene glucoside	Panthong et al., 2015
Fruit	Aqueous acetone	Antioxidant activity evaluation	High antioxidant activity correlated with phenolic, flavonoid, carotenoid, and ascorbic acid contents	Tyug et al., 2010
	Pentane	GC-MS	Identified 84 volatile compounds, dominated by esters (55.7%) and oxygenated monoterpenes (20.3%); ethyl butanoate most abundant	Wong & Ong, 1993

Secondary metabolite analyses reveal a broad spectrum of compounds, including flavonoids such as luteolin, liquiritigenin, nobiletin, quercitrin, morin, daidzein, sophoricoside, naringenin, sophoraflavone A, diosmetin, and davidigenin. Alkaloids detected include piperidine, isoquinoline, quinoline, indole, and sparteine sulfate. The amino acid profile is equally diverse, comprising histidine, threonine, methionine, valine, phenylalanine, lysine, and arginylglutamate, contributing to both the nutritional and pharmacological value of the plant. Additional chemical classes such as phenylpropanoids, aromatic compounds, carboxylic acids, essential oils, sesquiterpenoids, and nucleic acids further illustrate the phytochemical richness of *M. foetida* (Fitmawati et al., 2019).

Among these constituents, mangiferin, a C-glucosyl xanthone recognized for its strong antioxidant and pharmacological activities, has been identified as a key bioactive marker. Thin-layer chromatography detected mangiferin in leaf extracts (Fajri et al., 2017), and comparative studies report that *M. foetida* contains higher mangiferin levels than *M. indica* and *M. odorata*, highlighting its phytopharmaceutical potential (Retnaningtyas et al, 2024).

Beyond leaves, other plant parts significantly contribute to the phytochemical profile. Sianipar et al. (2022) found that the bark contained the highest total phenolic content (24.642 ± 11.087 mg GAE/g) compared to pericarp and leaves. Panthong et al. (2015) isolated three novel compounds from the acetone extract of *M. foetida* twigs, two triterpenes (mangiferenes A and B) and one coumaroyl glucoside (mangiferzene glucoside), alongside 19 previously known constituents, thereby expanding the species chemotaxonomic profile. Additionally, the bark is notably rich in phenolic and flavonoid compounds and exhibits strong antioxidant activity (Fitmawati et al., 2020).

The antioxidant capacity of *M. foetida* has been extensively studied. Tyug et al. (2010) demonstrated that fresh fruit exhibits high antioxidant activity closely correlated with its content of phenolics, flavonoids, carotenoids, and ascorbic acid. However, processing the fruit into powder or fiber significantly reduced this activity, indicating that bioactivity is best preserved in the fresh state. GC-MS analysis of the fruit's volatile profile identified 84 compounds, predominantly esters (55.7%) and oxygenated monoterpenes (20.3%), with ethyl butanoate (33.4%) as the main constituent, potentially contributing to both its distinctive aroma and biological effects (Wong & Ong, 1993).

In summary, the phytochemical wealth of *Mangifera foetida* spans multiple compound classes and plant organs, positioning it as a valuable source of natural antioxidants, antimicrobial agents, and therapeutic metabolites. The consistent findings across studies highlight the need for further pharmacological validation and compound isolation, especially of key metabolites such as mangiferin and gallic acid, to fully exploit its medicinal potential.

Pharmacological and Biological Activities of *Mangifera foetida*

Mangifera foetida has been widely reported to possess a diverse range of biological activities, including cytotoxic, antimicrobial, antiviral, antidiabetic, antioxidant, anti-obesity, and immunomodulatory effects, as listed in table 3. Cytotoxicity studies have demonstrated that *M. foetida* leaf extracts are capable of inhibiting MCF-7 breast cancer cell proliferation in a dose-dependent manner, particularly with *n*-hexane and ethyl acetate extracts, which showed consistent inhibitory trends. In contrast, methanol extracts displayed irregular dose responses and generally weaker cytotoxic effects. The strongest cytotoxicity was observed in the *n*-hexane fraction, likely due to the presence of nonpolar compounds such as fatty acid esters, which have been linked to enhanced apoptotic activity in cancer cell lines (Fitmawati, Anisa, Roza, & Juliantari, 2024). Furthermore, leaf extracts from *Mangifera foetida* have demonstrated immunomodulatory effects, suggesting additional benefits for immune system support (S. N. Kholifah & Fitmawati, 2020).

Table 3. Pharmacological and Biological Activities of *Mangifera foetida*

Bioactive Extract / Compound	Plant Part	Pharmacological Effect	Target / Disease / Pathogen	Type of Study	Model / Application	Reference
n-hexane and ethyl-acetate extract	Leaf	Cytotoxic	Breast cancer (MCF-7)	In vitro	Cell proliferation assay	Fitmawati et al., 2024
Methanolic extract	Leaf	Immunomodulatory	Immune system support	In vivo	Mouse model	Kholifah & Fitmawati, 2020
Ethanolic extract in gel form	Leaf	Antibacterial	*Propionibacterium acnes*	In vitro	Agar stab technique	Aditya et al., 2024
Ethanolic extract	Leaf	Antibacterial	*Streptococcus mutans*	In vitro	MIC, MBC	Wahidah & Kanedi, 2017
Methanolic extract in gel form	Leaf	Antibacterial	*Escherichia coli*	In vitro	MIC	Purwati et al., 2022
Methanolic extract	Leaf	Antibacterial	*Staphylococcus aureus*	In vitro	Agar well diffusion method	Grosvenor et al., 1995
Methanolic extract	Stem bark	Antiviral	Dengue virus	In vitro	Cell culture antiviral assay	Fitmawati et al., 2021
Methanolic extract	Leaf	Anti-obesity	Lipid metabolism	In vitro	Pancreatic Lipase Inhibition Assay	Aji et al., 2021
Combination extract (*M. foetida* + *P. amaryllifolius*)	Leaf	Antidiabetic	Hyperglycemia	In vivo	Mice model	Retnaningtyas et al., 2024
Mangiferin-containing extract	Leaf	Antioxidant, iron chelation	Iron overload, oxidative stress	In vivo	Rat model	Estuningtyas et al., 2019; Fajri et al., 2017
Gallic acid-rich extract (Ethanolic extract)	Leaf and bark	Antioxidant, anti-inflammatory	Inflammation-related diseases	Review / literature	Chemical analysis	Fitmawati et al., 2020; Bai et al., 2021
Quercetin-containing extract (Ethanolic extract)	Leaf and bark	Antioxidant, antimicrobial	Disease prevention, food preservation	Review / literature	Bioactive profiling	Fitmawati et al., 2020; Yang et al., 2020
Mangiferin	Leaf	Multi-target therapeutic	Neurodegeneration, diabetes, obesity	Literature review	Various models	Kaurav et al., 2023; Zivković et al., 2024b

Antibacterial activity of *M. foetida* has been demonstrated across several studies. Ethanol extracts of the leaves at a concentration of 20% showed notable inhibition against *Propionibacterium acnes*, with this concentration selected for gel formulation due to its superior activity (Aditya et al., 2024). Although incorporation into gel form resulted in a slight reduction of the inhibition zone, the preparation maintained moderate antibacterial activity. Ethanolic extracts also inhibited *Streptococcus mutans*, a key pathogen in dental caries, with inhibition zones comparable to erythromycin at the highest tested concentration. The extract exhibited a MIC of 14%, and its bactericidal potential was confirmed through MBC analysis (Koernia Wahidah & Kanedi, 2017).

A separate study formulated methanolic leaf extract into hand sanitizer gels and tested its effect against *Escherichia coli*. Results showed increased inhibition zones with higher extract concentrations (1, 5, and 10 ppm), while gel characteristics such as pH, dispersive power, and homogeneity met pharmaceutical standards (Purwati, Zusfahair, Ningsih, Cahyani, & Lutpiani, 2022). Earlier work suggested that while *M. foetida* extracts were effective against *Staphylococcus aureus*, they showed no inhibitory effects against *E. coli*, *Saccharomyces cerevisiae*, or *Fusarium oxysporum*, highlighting their selective antimicrobial spectrum (Grosvenor, Supriono, & Gray, 1995).

Antiviral activity has also been observed in the stem bark of *M. foetida*, particularly in the Limus, Manis, and Batu cultivars, which showed potential activity against dengue virus (Fitmawati et al., 2021). In metabolic studies, the plant's role in glucose and lipid regulation has drawn interest. Leaf extracts demonstrated inhibitory activity on pancreatic lipase, indicating potential as an anti-obesity agent (Aji et al., 2021). Moreover, a combination of *M. foetida* and *Pandanus amaryllifolius* extracts at a 1:1 ratio significantly reduced blood glucose levels in animal models, suggesting antidiabetic synergy (Retnaningtyas et al., 2024).

The antioxidant and iron-chelating activities of *Mangifera foetida* are primarily attributed to mangiferin and related polyphenolic compounds. In animal models of iron overload, ethanolic leaf extracts rich in mangiferin (EMF) effectively mitigated oxidative stress and reduced iron deposition. An optimal dose of 50 mg/kg body weight was established, with higher doses offering no additional therapeutic benefit, likely reflecting the compound's non-linear pharmacokinetics (Estuningtyas et al., 2019; Fajri et al., 2017). These results highlight the potential application of *M. foetida* as a dietary supplement for managing iron-overload disorders such as thalassemia.Gallic acid, a potent antioxidant and anti-inflammatory agent, has been detected in high concentrations in the leaves of the 'Manis' variety of *M. foetida*, marking this cultivar as a particularly promising candidate for further pharmacological exploration (Fitmawati Fitmawati et al., 2020). Gallic acid has demonstrated broad-spectrum biological activities, including anti-inflammatory, antitumor, antibacterial, antidiabetic, anti-obesity, antimicrobial, and cardioprotective effects, making it a versatile compound for managing inflammation-related pathologies (Bai et al., 2021).

In addition to gallic acid, quercetin, a well-characterized bioactive flavonoid, has also been identified in the leaves of *M. foetida* (Fitmawati Fitmawati et al., 2020). Quercetin exhibits strong antioxidant, anti-inflammatory, antitumor, and antimicrobial properties, positioning it as a potential agent for disease prevention, livestock health improvement, and natural food preservation strategies (Yang, Wang, Long, & Li, 2020). Mangiferin, detected as a major bioactive compound in *Mangifera foetida*, exhibits diverse therapeutic potentials; its anti-inflammatory and antioxidant properties contribute to the management of chronic conditions such as neurodegenerative disorders, cardiovascular diseases, diabetes, obesity, hepatotoxicity, asthma, nephropathy, and Parkinson's disease (Kaurav et al., 2023) (Zivković et al., 2024).

Debbarma et al. (2023) successfully developed mangiferin-loaded poly(lactic-co-glycolic acid) (PLGA) nanoparticles characterized by spherical morphology and smooth surface texture, features conducive to efficient cellular uptake. The nanoformulation demonstrated a sustained release profile and exhibited markedly enhanced cytotoxicity against A549 lung carcinoma cells compared to free mangiferin. In a related study, although involving a different phytochemical, Dewi et al. (2022) reported that nanodiamonds conjugated with annonacin effectively suppressed breast cancer cell proliferation through modulation of the PI3K/Akt signaling pathway. While the latter investigation focused on a different compound, it reinforces the broader potential of nanocarrier-based delivery systems in augmenting the therapeutic efficacy of plant-derived bioactives such as mangiferin. Collectively, these findings highlight the promise of nanoparticle-mediated delivery in enhancing the pharmacological performance of natural compounds, particularly in oncology.

Taken together, the diverse bioactive constituents of *Mangifera foetida*, particularly in the leaves and bark, confer a broad spectrum of pharmacological activities including anticancer, antimicrobial, antiviral, antioxidant, antidiabetic, anti-obesity, and immunomodulatory effects supporting its strong potential as a multifunctional therapeutic and nutraceutical candidate. Key compounds such as gallic acid and mangiferin contribute significantly to these bioactivities, making *M. foetida* a valuable source for future drug development.

Conclusion

This review underscores the promising pharmacological potential of *Mangifera foetida*, a plant rich in ethnomedicinal significance and diverse secondary metabolites, including phenolics and flavonoids. These constituents have been associated with notable antioxidant, antimicrobial, antidiabetic, cytotoxic, and anticancer activities. While existing *in vitro* and *in vivo* studies offer encouraging insights, further exploration remains essential to deepen the understanding of its pharmacological mechanisms and therapeutic relevance. Future directions may include the standardization of extract preparations, isolation and characterization of bioactive compounds, and application of *in silico* modeling to predict molecular interactions. Moreover, conjugation with nanoparticle-based delivery systems represents a promising strategy to enhance the bioefficacy and targeted application of compounds such as mangiferin in drug development.

Acknowledgment

The authors acknowledge Universitas Terbuka for providing the necessary facilities and institutional support during the preparation of this review.

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