REVIEW ARTICLE

A Review on Phytochemical Properties and Therapeutic Applications of *Musa acuminata*

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Abstract: *Musa acuminata*, a perennial tree-like plant of the Musaceae family, grows extensively across tropical and subtropical regions worldwide. Bananas serve as a vital crop in numerous countries due to their nutritional density and medicinal properties both as a fruit and vegetable source. *M. acuminata* contains diverse bioactive compounds including myricetin, apigenin glycosides, dopamine, N-acetyl serotonin, rutin, polyphenols, flavonoids, and various glycosides. Traditional medicine systems have employed different parts of *M. acuminata* to treat conditions such as fever, cough, bronchitis, dysentery, allergies, and sexually transmitted diseases. Modern pharmacological studies validate several therapeutic properties of *M. acuminata*, including antioxidant, antidiabetic, immunomodulatory, hypolipidemic, anticancer, and antimicrobial activities. The plant demonstrates significant cholesterol-reducing effects through compounds present in its peel, particularly flavonoids, tannins, and saponins. The antioxidant capacity of *M. acuminata* relates to its cell wall phenolic content, while its hepatoprotective and anti-ulcer properties rival conventional medications in animal models. The plant exhibits notable enzyme inhibition activities, particularly against alpha-glucosidase and acetylcholinesterase. *M. acuminata* also shows promising results against Leishmania species through its phytoalexin compounds.

Keywords: *Musa acuminata*; Phytochemicals; Therapeutic properties; Traditional medicine; Leishmaniasis.

1. Introduction

Botanical sources have maintained a fundamental role in medicine and healthcare throughout human history. Plant-derived remedies, ranging from powders to infusions and extracts, have served as primary therapeutic agents for centuries. The historical significance of botanical medicine continues in present times, with numerous communities worldwide relying on plant-based treatments [1]. The World Health Organization reports that a substantial portion of developing nations' populations depends on traditional medicine for primary healthcare needs. Consequently, the demand for medicinal plants has risen steadily across both developed and developing countries [2]. Among these valuable botanical resources, *Musa acuminata* stands out for its versatility and widespread application in traditional medicine systems across America, Asia, Oceania, India, and Africa [3]. *M. acuminata* represents more than a food source; its various parts, including roots, stem, pseudostem, fruits, and leaves, demonstrate significant medicinal value. Traditional healers have utilized these plant components to address diverse health conditions, establishing a rich ethnomedicinal heritage that modern research increasingly validates [4]

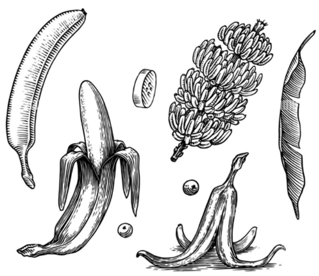

Figure 1. Fruits and leaves of *Musa acuminata* (Image credit: Alamy)

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]. Recent scientific investigations have identified numerous bioactive compounds in *M. acuminata*, including myricetin and apigenin glycosides, dopamine, N-acetyl serotonin, rutin, polyphenols, and various flavonoids. These compounds contribute to the plant's therapeutic properties, supporting its traditional applications while opening new avenues for modern pharmaceutical development [5]. The nutritional profile of *M. acuminata* extends beyond basic sustenance. Its fruits provide essential vitamins, minerals, and bioactive compounds that contribute to various health benefits. The plant's different parts exhibit distinct phytochemical compositions, leading to varied therapeutic applications [6, 7].

2. Botanical description

2.1. Taxonomic classification

M. acuminata belongs to the kingdom Plantae, family Musaceae, and genus Musa. The species name 'acuminata' refers to the pointed apex of its fruits. As a member of the order Zingiberales, it shares characteristics with other economically significant plant families like Strelitziaceae and Heliconiaceae [8].

2.2. Morphological Features

The plant produces varying numbers of stems, ranging from 1-2 to over 100 in mature specimens. The leaf structure consists of blades measuring 2.0-2.5 m in length and 0.4-0.6 m in width, typically displaying rectangular shapes with rounded bases and truncated apices. Leaf sheaths and petioles exhibit a distinctive pruinose or glaucous appearance [9]. The inflorescence demonstrates either subhorizontal or vertical deflection patterns. Fruits develop with notable characteristics, including a prominent acumen measuring 0.6-1.5 cm at the apex and a pedicel approximately 1 cm in length. The mature pericarp maintains a thickness of about 2 mm and displays bright yellow coloration, while the pulp varies from white to creamy yellow [10]. Seeds measure 6-7 mm in length and 3 mm in height, exhibiting irregular angular shapes. Their surface appears either smooth or minutely tuberculate, with a dull black coloration [11].

2.3. Geographical Distribution

M. acuminata naturally occurs across various regions, including the southern and middle Andamans, Western Ghats of Karnataka, Khasi hill ranges of Meghalaya, and Kaziranga forest range of Assam [12].

Current cultivation extends globally, with major production centers in Brazil, China, India, Ecuador, Columbia, and Venezuela. The plant's adaptability to various tropical and subtropical climates has facilitated its widespread cultivation [13].

Several recognized subspecies exist, including *M. acuminata* subsp. burmannica, subsp. acuminata, subsp. halabanensis, subsp. errans, subsp. microcarpa, and subsp. malaccensis. Each subspecies demonstrates unique geographical preferences and morphological variations [14].

2.4. Phytochemical composition

M. acuminata contains diverse chemical compounds including alkaloids, fatty acids, anthocyanins, terpenoids, steroids, tannins, phenols, and saponins. These compounds distribute differently across plant parts, including fruit, peel, flower, leaf, pseudostem, and rhizome [15]. The main bioactive substances identified include apigenin-7-glucoside, myricetin-3-O-galactoside, myricetin-3-O-rutinoside, naringenin-7-O-glucoside, and kaempferol-3-O-rutinoside. Additionally, the plant contains significant amounts of dopamine and N-acetyl serotonin [16].

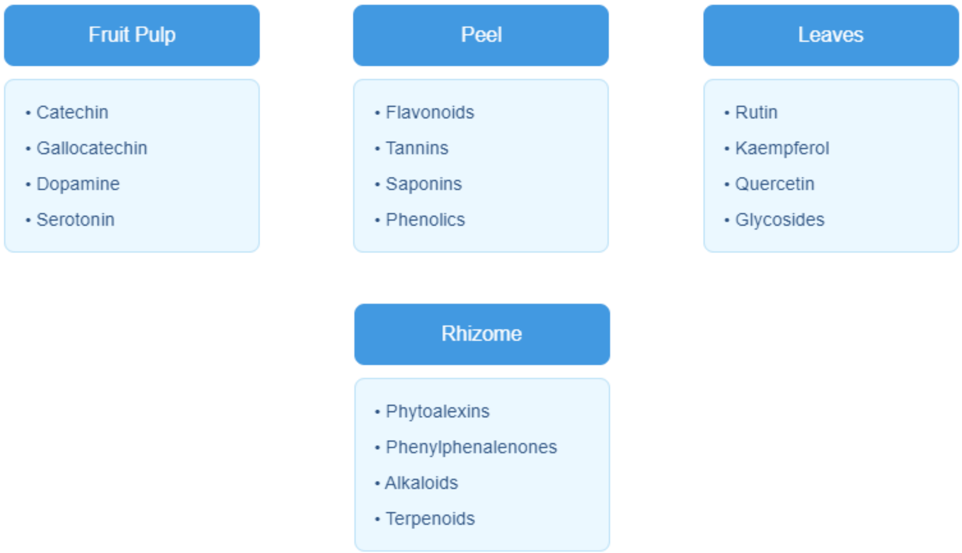

Figure 3. Phytochemical distribution in *Musa acuminata*

Table 1. Major Phytochemical Constituents of Different Parts of *M. acuminata*

Plant Part	Major Constituents	Biological Activity
Fruit Pulp	Catechin, Gallocatechin, Dopamine, Serotonin	Antioxidant, Neuroprotective
Peel	Flavonoids, Tannins, Saponins	Hypocholesterolemic, Antimicrobial
Leaves	Rutin, Kaempferol glycosides, Quercetin derivatives	Anti-inflammatory, Antidiabetic
Pseudostem	Phenolics, Alkaloids, Terpenoids	Wound healing, Antimicrobial
Rhizome	Phytoalexins, Phenylphenalenones	Anti-leishmanial, Antifungal

3. Pharmacological Activities

3.1. Antioxidant Properties

M. acuminata fruit pulp demonstrates significant antioxidant activity through its phenolic content and cell wall components. The soluble extract contains condensed tannins, (+)-catechin, gallocatechin, and (-)-epicatechin. The cell wall fractions, particularly after hydrolysis, exhibit substantial antioxidant capacity, attributed to hydroxycinnamic acid derivatives and anthocyanidin-delphinidin [17].

3.2. Cholesterol-Lowering Effects

The plant's peel extracts show remarkable hypocholesterolemic activity, primarily due to bioactive compounds including saponins, tannins, and flavonoids. Studies on obese mice demonstrate significant reduction in total blood cholesterol levels following treatment with kepok banana peel extract. The effectiveness varies with dosage, showing optimal results at specific concentrations [18].

3.3. Hepatoprotective and Anti-ulcer Activities

Methanolic extracts of unripe *M. acuminata* exhibit hepatoprotective and anti-ulcerogenic properties comparable to standard medications like omeprazole and silymarin. These effects stem from the synergistic action of saponins, flavonoids, triterpenes, and tannins present in both peel and pulp extracts [19].

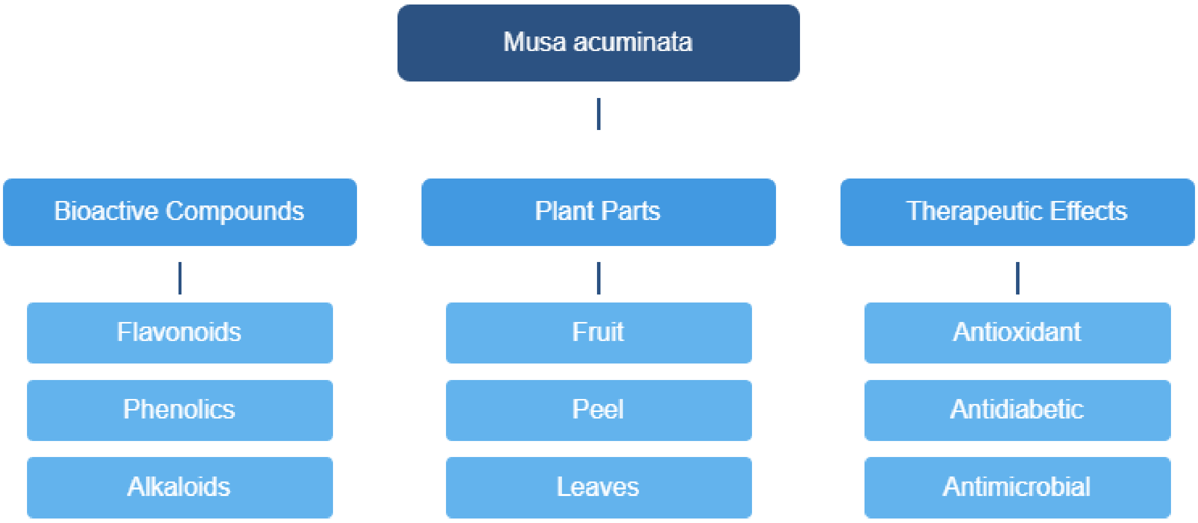

Figure 3. Bioactive compounds and therapeutic effects of *Musa acuminata*

3.4. Enzyme Inhibition

Leaf fractions of *M. acuminata* show superior pharmacological activity compared to fruit portions. The ethyl acetate fraction demonstrates potent DPPH-scavenging activity with significant total phenolic content. Notable inhibitory effects are observed against alpha-glucosidase and acetylcholinesterase, while showing moderate amylase inhibition [20].

3.5. Antimicrobial Properties

M. acuminata leaf extracts exhibit broad-spectrum antimicrobial activity. Methanol extracts show effectiveness against both gram-positive and gram-negative bacteria, including Staphylococcus aureus and Escherichia coli. The plant also demonstrates antifungal properties against Aspergillus terreus and Penicillium solitum [21].

3.6. Antidiabetic Effects

Ethanolic extracts from *M. acuminata* fruit inner peels display dose-dependent anti-hyperglycemic effects in normoglycemic rats. Studies indicate significant blood glucose reduction in glucose-loaded conditions, particularly at doses of 200-400 mg/kg body weight [22].

3.7. Anti-leishmanial Activity

Phytoalexins from *M. acuminata*, particularly anigorufone and phenylphenalenone phytoalexin REF20, show promising leishmanicidal properties. These compounds target mitochondrial functions in Leishmania donovani and L. infantum, affecting crucial enzymes like fumarate reductase and succinate dehydrogenase [23]

Table 2. Therapeutic Applications

Health Condition	Active Components	Mechanism of Action
Diabetes	Flavonoids, Pectin	α-glucosidase inhibition
Hypertension	Potassium, ACE inhibitors	Blood pressure regulation
Ulcers	Leucocyanidin	Mucosal protection
Leishmaniasis	Anigorufone	Mitochondrial targeting
Inflammation	Rutin, Quercetin	COX-2 inhibition

Table 3. Nutritional Composition of *M. acuminata* Fruit (per 100g)

Nutrient	Amount	% Daily Value*
Energy	89 kcal	4.5%
Carbohydrates	22.84 g	7.6%
Dietary Fiber	2.6 g	10.4%
Potassium	358 mg	10.2%
Vitamin B6	0.367 mg	21.6%
Vitamin C	8.7 mg	9.7%
Magnesium	27 mg	6.8%
Total Phenolics	110 mg GAE	-

*Based on a 2000 calorie diet
GAE: Gallic Acid Equivalents

4. Agricultural significance

4.1. Propagation Methods

M. acuminata propagates through both sexual and asexual means in wild conditions. Commercial cultivation primarily relies on vegetative propagation through suckers or tissue culture techniques for edible cultivars. Seed-based propagation remains crucial for research and development of new cultivars [24].

4.2. Ecological Role

The species functions as a pioneer plant, rapidly colonizing disturbed areas, particularly post-forest fires. Its role as a keystone species proves vital in ecosystem rehabilitation, facilitating the establishment of diverse flora and providing sustenance for wildlife populations [25]. The domestication of *M. acuminata* dates back approximately 7,000 years, originating in Wallacea and New Guinea. Initial cultivation may have served multiple purposes beyond fruit production, including fiber extraction and construction material harvesting. The development of current cultivars involved selection for parthenocarpy and seed sterility, leading to the creation of diploid and triploid clones [26].

4.3. Commercial Importance

Global banana production relies heavily on *M. acuminata* cultivars, particularly those belonging to the AAA group. Major producing nations have developed sophisticated cultivation and distribution systems, making bananas one of the world's most traded fruits [27]. *M. acuminata* serves ornamental purposes due to its striking morphology and foliage. The 'Dwarf Cavendish' cultivar has received recognition from horticultural societies for its ornamental qualities, though it requires specific care in temperate climates [28]. Genome studies reveal three complete genome duplications in *M. acuminata*'s evolutionary timeline. These duplications predate the species' speciation, contributing to its genetic diversity and adaptability [29]. Contemporary research utilizes genomic information for crop improvement, disease resistance development, and understanding evolutionary relationships within the Musaceae family [30-32].

5. Conclusion

M. acuminata represents a significant botanical resource with extensive applications in medicine, agriculture, and culture. The plant's diverse phytochemical profile underpins its therapeutic properties, validating traditional medicinal applications while offering potential for modern pharmaceutical development. Pharmacological studies demonstrate promising activities including antioxidant, antidiabetic, antimicrobial, and anti-leishmanial properties. The species' importance extends beyond medicinal applications to its crucial role in global food security and ecosystem functions. While current research provides substantial evidence for various therapeutic applications, further investigation of specific bioactive compounds and their mechanisms of action could lead to development of novel pharmaceuticals. Integration of traditional knowledge with modern scientific approaches may unlock additional benefits from this versatile plant species.

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