



(REVIEW ARTICLE)



## ***MUSA PARADISIACA* FLOWER: A REVIEW OF ITS PHARMACOLOGICAL POTENTIAL**

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### **ABSTRACT**

**Objective:** To review phytochemical composition and pharmacological potentials of *Musa paradisiaca* inflorescence and summarize experimental evidence supporting the therapeutic use of plant part.

**Methods:** Scientific literature reporting phytochemical constituents and pharmacological activities of *Musa paradisiaca* flower was gathered and evaluated. Individual studies investigating biological activities and mechanisms of action were included in the review.

**Results:** *Musa paradisiaca* flower contains phenolics, flavonoids, tannins, alkaloids, saponin glycosides, terpenoids, steroids, fatty acid, quercetin, catechin, chlorogenic acid and beta-sitosterol.

The reviewed studies reported that *Musa paradisiaca* flower extract possesses antioxidant, antidiabetic, anticancer, antimicrobial, anti-inflammatory, immunomodulatory, osteoprotective, antiulcer, galactagogue and hypolipidemic activities. The mechanism by which the extract exerts its effect are free radical scavenging, alpha-amylase and alpha-glucosidase inhibition, modulation of cell-cycle regulatory proteins and apoptosis-related pathways, improvement of glucose and lipid metabolism and suppression of the TLR4/NF- $\kappa$ B signaling cascade. Most of the included studies were conducted using in vitro and in vivo models.

**Conclusion:** *Musa paradisiaca* flower is a rich source of biologically active phytoconstituents. The review confirmed the need for further preclinical and clinical studies to explore the pharmacological potential and safety of this plant part.

**Keywords:** *Musa paradisiaca*; Banana Inflorescence; Phytoconstituents; Anti-oxidant

## 1 INTRODUCTION

Medicinal plants are frequently used in traditional medicine to treat various diseases in different areas of the world. This indigenous knowledge is passed down from generation to generation from different parts of the world and has significantly contributed to the development of various traditional systems of medicine thereby helped as to explore different medicinal plants to find out the scientific bases of their traditional uses.[1]

*Musa paradisiaca* is a widely grown herbaceous plant, particularly common across South Asia, and it is valued both as a food crop and for various medicinal applications. Botanically, it arises as a natural hybrid between *Musa acuminata* and *Musa balbisiana*. [1] This plant belongs to the family *Musaceae* and order *Zingiberales*. [5] Different parts of the banana plant its fruit, flower, stem sap, and roots are associated with distinct therapeutic properties to treat various non-communicable and communicable diseases and other pharmacological properties like antioxidant, immunomodulatory effects. [6] Although inflorescences are economically regarded as waste, the use of these parts in traditional medicine is common practice in many cultures. [2]

*Musa paradisiaca* is a herbaceous plant (up to 9 m long) with a robust tree like pseudostem, a crown of large elongated oval deep-green leaves (up to 365 cm in length and 61 cm in width), with a prominent midrib, each plant produces a single inflorescence like drooping spike, and large bracts opening in succession, ovate, 15-20 cm long, concave, dark red in color and somewhat fleshy. Fruits are oblong, fleshy, 5-7cm long in wild form and longer in the cultivated varieties. [1]



**Figure 1: Musa Paradisiaca Inflorescence [28]**

The flower parts contain alkaloids, saponins, glycosides, tannins, flavanoids and terpenoids or steroids. The preliminary phytochemical analysis with petroleum ether extract has revealed the presence of glycosides, alkaloids and steroids. This can be seen by the presence of saponins, flavanoids and tannins in the flower extract. [7] They include Omega 3 / Omega 6 fatty acids, quercetin, catechin, chlorogenic acid and b-sitosterol. [8] Proximate composition of banana flower is highly impressive as they contain a wide variety of minerals including phosphorous, calcium, potassium and magnesium. [6,15]



**Figure 2: Musa paradisiaca Fruit and Flower [12]**

The inflorescence of *Musa paradisiaca* is characterized by bracts with a uniseriate epidermis, tetracytic stomata on both surfaces, fiber caps adjacent to the phloem, and distinctive papillose cells. The tepals possess a multilayered epidermis with vascular bundles located near the abaxial surface. Male flowers contain tetrasporangiate anthers with a single vascular bundle, while female flowers exhibit a trilocular ovary with a uniseriate epidermis. [8]

### 1.1 Anticancer Activity

Studies have demonstrated the promising anticancer potential of *Musa paradisiaca* flower extracts in both in vitro and in vivo models. In a DMBA-induced mammary carcinogenesis model in female Wistar rats, *Musa paradisiaca* flower extract significantly reduced tumor development and enhanced antioxidant defence, indicating its protective effect against breast cancer [10]. Likewise, Timsina and Nadumane reported that banana flower extract inhibited cancer cell proliferation and induced apoptosis in vitro [11]. In addition, *Musa paradisiaca* inflorescence was found to promote apoptosis in human colon cancer cells by modulating transcriptional pathways involved in cell-cycle regulation and programmed cell death. These findings collectively suggest that *Musa paradisiaca* flower possesses significant anticancer activity through antioxidant, antiproliferative, and apoptosis-inducing mechanisms.[3]

Recent studies have highlighted the immunomodulatory potential of *Musa paradisiaca* inflorescence in inflammatory disorders through the regulation of the NF- $\kappa$ B signaling pathway. In a Combined Allergic Rhinitis and Asthma Syndrome (CARAS) model, *Musa paradisiaca* inflorescence significantly attenuated airway inflammation by inhibiting NF- $\kappa$ B activation and modulating immune responses, thereby reducing allergic manifestations [13]. Similarly, in an LPS-induced acute lung injury model, *Musa paradisiaca* inflorescence suppressed neutrophil activation by downregulating the TLR4/NF- $\kappa$ B signaling pathway, leading to reduced inflammatory cytokine production and improved lung tissue protection [14]. These findings suggest that *Musa paradisiaca* inflorescence possesses potent anti-inflammatory and immunomodulatory properties, primarily through the inhibition of the TLR4/NF- $\kappa$ B signaling cascade.

### 1.2 Antidiabetic Activity

*Musa paradisiaca* inflorescence and unripe fruit, has demonstrated considerable promise as a natural antidiabetic agent through multiple complementary mechanisms. Unripe bananas are rich in resistant starch and soluble dietary fiber, which slow carbohydrate digestion, blunt post-meal blood sugar surges, and enhance the body's sensitivity to insulin. Complementing this, phenolic compounds and flavonoids concentrated in the peel and flower tissue act as natural inhibitors of the digestive enzymes  $\alpha$ -amylase and  $\alpha$ -glucosidase, thereby slowing the breakdown and uptake of dietary sugars. Chemical profiling of the flower and bract extracts using HPLC-DAD-MS has confirmed the presence of a diverse array of such bioactive constituents, including glycosylated and acetylated derivatives of p-coumaric and caffeic acid, a glycosylated flavanol, and various anthocyanins.[2] Beyond their enzyme-inhibiting and glucose-modulating effects, these extracts also appear to strengthen the antioxidant capacity of pancreatic tissue, offering protection to insulin-producing beta cells against oxidative stress. Mechanistic evidence from Sundaram and Subramanian's work on streptozotocin-induced diabetic rats given ethanolic tepal extract for 30 days further clarifies how this protection extends to the liver: the treatment normalized elevated fasting blood glucose, plasma insulin, and glycosylated haemoglobin levels, while also rebalancing the activity of key hepatic enzymes governing carbohydrate metabolism among them glucokinase, pyruvate kinase, glucose-6-phosphatase, fructose-1,6-bisphosphatase, glucose-6-phosphate dehydrogenase, glycogen synthase, and glycogen phosphorylase and significantly restored depleted hepatic glycogen stores, indicating that the extract helps re-establish normal blood sugar control by correcting the enzymatic machinery of glucose metabolism in the liver. In line with this, further controlled studies in streptozotocin-induced diabetic rats found that aqueous extracts of the bracts, along with the methanolic fraction of the flowers, produced measurable improvements in glucose tolerance after two weeks of treatment compared with untreated diabetic controls.[16] Taken together, these findings spanning improved lipid profiles, reduced fasting glucose, corrected hepatic enzyme activity and glycogen storage, and better insulin function lend strong scientific support to the long-standing traditional use of banana flowers, tepals, and bracts as a dietary and therapeutic aid in managing diabetes, reinforcing their potential value as a complementary treatment option grounded in a well-defined biochemical basis.[19]

### 1.3 Antimicrobial Activity

**Antimicrobial activity** Several studies have demonstrated that *Musa paradisiaca* possesses broad-spectrum antimicrobial activity against a variety of Gram-positive and Gram-negative bacteria, including *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Klebsiella pneumoniae*, and *Salmonella typhi*, as well as fungal pathogens such as *Candida albicans*, *Candida tropicalis*, *Cryptococcus albidus*, and *Aspergillus niger*[30]. Organic solvent extracts, particularly ethanolic, methanolic, hydroethanolic and ethyl acetate extracts, exhibited greater antimicrobial efficacy than aqueous extracts, with flower and peel extracts showing the highest activity.[17]

Furthermore, in vitro studies have confirmed that *Musa paradisiaca* floret extracts possess potent bactericidal activity against both Gram-positive and Gram-negative bacteria, exhibiting low minimum inhibitory concentration (MIC) values and pronounced activity against *Escherichia coli* and *Pseudomonas aeruginosa*. These findings suggest that *Musa paradisiaca* is a promising natural source of antimicrobial compounds with potential applications in pharmaceutical formulations and food preservation.

### 1.4 Antioxidant Activity

Several studies have demonstrated that *Musa paradisiaca* flowers are a rich source of bioactive phytochemicals with potent antioxidant properties. Phytochemical analyses have identified the presence of phenolics, flavonoids, tannins, alkaloids, saponins, and other secondary metabolites that contribute significantly to the antioxidant capacity of banana flowers [7]. Furthermore, ultrasound-assisted extraction has been shown to enhance the recovery of antioxidant and neuroprotective compounds from banana flowers by optimizing solvent combinations, highlighting an efficient approach for obtaining bioactive extracts with improved therapeutic potential [20]. In addition, preliminary phytochemical screening of the *Musa paradisiaca* AAB Nendran variety confirmed the abundance of phytoconstituents and demonstrated significant in vitro free radical scavenging activity, supporting the role of banana flowers as a natural source of antioxidants [21]. Collectively, these findings establish *Musa paradisiaca* flowers as a valuable reservoir of phytochemicals with strong antioxidant potential, making them promising candidates for the development of functional foods and therapeutic agents.

### 1.5 Osteoprotective Activity

In addition to its antioxidant and anticancer properties, *Musa paradisiaca* flower has demonstrated promising osteoprotective effects. Studies have shown that both the crude extract and its fractions promote osteogenesis and effectively prevent ovariectomy-induced osteopenia, a widely used experimental model of postmenopausal osteoporosis. These beneficial effects are attributed to the enhancement of bone formation, preservation of bone mineral density, and the presence of bioactive phytochemicals that regulate bone metabolism [22]. These findings suggest that *Musa paradisiaca* flower may serve as a potential natural therapeutic agent for the prevention and management of osteoporosis.

### 1.6 Antiulcer Activity

*Musa paradisiaca* has long been valued in traditional medicine for protecting the stomach lining, and this has since been backed up by laboratory research. An experimental study on albino mice examined methanol extracts made from banana tepal (the flower bud) and peel, given at a dose of 100 mg/kg alongside cimetidine before inducing ulcers with indomethacin. Both plant parts contained beneficial compounds such as phenols and flavonoids, and were found to guard against ulcer formation, with the tepal extract preventing roughly 69% of ulcer development and the peel extract around 43%. The tepal treatment also produced a notable increase in gastric juice pH, pointing to a marked drop in acidity, although changes in gastric fluid volume and mucus thickness across both extracts did not reach statistical significance. Taken together, these findings reinforce that, different parts of the banana plant not just the ripe fruit-offer real, measurable protection against ulcers, largely by reinforcing the stomach's mucosal barrier and reducing acid-driven damage, making *Musa paradisiaca* a promising and low-cost candidate for further development as a natural antiulcer agent.[23]

### 1.7 Galactagogue Activity

*Musa paradisiaca* has demonstrated promising galactagogue activity in both experimental and clinical studies. It has been reported that the aqueous flower extract produced the highest increase in milk production in lactating rats, with an approximately 25% increase compared with the control group, while the petroleum ether extract produced an 18% increase [24]. In another clinical study, it was found that consumption of a banana blossom beverage increased breast milk flow and milk volume among mothers after cesarean section, particularly on the second and third postpartum days [25]. There were also reports that banana inflorescence contained several bioactive compounds and exhibited antioxidant activity, supporting its potential nutritional and functional value as a beverage for breastfeeding mothers [26]. Overall, these findings suggest that *M. paradisiaca* blossom may have potential as a natural galactagogue

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## 2 HYPOLIPIDEMIC EFFECT

A study has investigated the effects of *Musa paradisiaca* on lipid abnormalities in alloxan-induced diabetic rats. Treatment with *M. paradisiaca* was reported to improve the altered lipid profile, particularly by reducing elevated total cholesterol and other lipid parameters associated with diabetes. The hypolipidemic effect was accompanied by improvement in pancreatic morphology and function, suggesting that the plant may help restore metabolic balance in diabetic conditions. These findings indicate the potential of *M. paradisiaca*, including its flower, as a natural source of bioactive compounds with beneficial effects on cholesterol metabolism.[27]

### 3 ANTI-INFLAMMATORY ACTIVITY OF *MUSA PARADISIACA* FLOWER

The anti-inflammatory potential of *Musa paradisiaca* L. flower has been supported by in-vitro, review-based, and in-vivo evidence. It was reported that banana flower extracts exhibited anti-inflammatory potential in in-vitro assays, indicating the ability of flower constituents to attenuate processes associated with inflammation [28]. In a review of the pharmacological properties of *M. paradisiaca*, it was further highlighted its anti-inflammatory and antioxidant activities and suggested that phytochemicals with antioxidant properties may contribute to the suppression of inflammation [29]. More recently, studies provided mechanistic evidence using an LPS-induced acute lung injury model, where *M. paradisiaca* inflorescence extract reduced neutrophil migration, CD18 expression, MPO activity, free DNA release, and the production of pro-inflammatory cytokines such as TNF- $\alpha$  and IL-1 $\beta$ . These effects were associated with inhibition of TLR4-mediated NF- $\kappa$ B activation and improvement in inflammatory lung injury, with increased survival observed in extract-treated animals [14]. Collectively, these findings indicate that *M. paradisiaca* flower/inflorescence may exert anti-inflammatory effects through antioxidant activity, inhibition of neutrophil activation and migration, suppression of pro-inflammatory cytokines, and modulation of the TLR4/NF- $\kappa$ B signaling pathway. However, further studies are required to identify the active constituents and establish their clinical relevance.

### 4 CONCLUSION

*Musa paradisiaca* inflorescence is an underutilized plant part with considerable pharmacological potential. The available evidence indicates the presence of diverse bioactive phytoconstituents, including phenolics, flavonoids, tannins, alkaloids, terpenoids, and other secondary metabolites, which may contribute to its antioxidant, antidiabetic, anticancer, antimicrobial, anti-inflammatory, immunomodulatory, osteoprotective, antiulcer, galactagogue, and hypolipidemic activities. Several experimental studies have also suggested mechanisms involving oxidative stress reduction, regulation of glucose and lipid metabolism, apoptosis, and modulation of inflammatory pathways such as TLR4/NF- $\kappa$ B. However, the current evidence is predominantly derived from in vitro and animal studies, with considerable variation in plant varieties, extraction procedures, doses, and experimental models. Future research should focus on standardized extraction methods, isolation and characterization of active constituents, molecular mechanism studies, pharmacokinetic and toxicity evaluation, and well-designed clinical investigations. Such studies may help establish the scientific basis for the traditional use of banana flower and determine its potential for development as a safe and standardized pharmaceutical or functional-food ingredient.

### STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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#### Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

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