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**Review Article**

# Macaranga Species: Phytochemicals, Health Benefits, and Cosmetic Potential

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## ABSTRACT

The Macaranga genus (family Euphorbiaceae) consists of over 300 species, predominantly found in tropical regions, and is known for its diverse range of bioactive compounds. These plants are rich in secondary metabolites, such as flavonoids, stilbenes, tannins, terpenes, and coumarins, which contribute to their pharmacological properties. Various Macaranga species have demonstrated potent antioxidant, anti-inflammatory, antimicrobial, hepatoprotective, antihyperglycemic, antihyperlipidemic, and anticancer activities. Additionally, extracts from Macaranga species have shown potential for cosmetic applications due to their bioactive compounds with antioxidant and anti-inflammatory properties. However, safety concerns, including potential toxicity and phototoxic effects, necessitate further clinical research. Nanotechnology is being explored to enhance the stability of these bioactive compounds in cosmetic formulations. Despite promising pharmacological and cosmetic potential, further systematic research is required to validate their efficacy and ensure safety for medicinal and industrial applications.

## INTRODUCTION

The genus Macaranga (family Euphorbiaceae) consists of shrubs or trees that can grow up to 15 meters tall. These plants are known for their mutualistic relationships with ants, which protect the trees by preying on or deterring herbivorous insects. In traditional medicine, fresh or dried leaves from certain Macaranga species are used to treat swellings, cuts, sores, boils, and bruises.[1] Phytochemical studies have revealed that Macaranga is a rich source of isoprenylated, geranylated, and farnesylated flavonoids, as well as stilbenes. Additionally, various secondary metabolites, including terpenes, tannins, coumarins, and other bioactive compounds, have been identified in different Macaranga species. Flavonoids and stilbenes are considered the primary constituents, likely responsible for many

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of the plant's medicinal properties.[2] Due to its traditional uses and pharmacological potential, research on Macaranga has been expanding. Natural compounds extracted from this genus have demonstrated a range of biological activities, including antitumor, antioxidant, antimicrobial, anti-inflammatory, anti hepatoprotective, anti hyperlipidemic and anti hyperglycemic effects. Given the diverse pharmacological properties and complex chemical composition of Macaranga, further systematic and critical research is needed to explore its full potential.[3] This study evaluates the scientific evidence supporting the therapeutic claims of Macaranga in traditional medicine and provides an overview of its bioactive chemical constituents. Additionally, it highlights the scientific foundation for future research on this genus, particularly in the development of Macaranga-based herbal medicines.[4]

**Botanical classification:**

The taxonomic hierarchy of the genus Macaranga is as follows:

•Kingdom: Plantae
•Division: Magnoliophyta (Angiosperms)
•Class: Magnoliopsida (Dicotyledons)
•Order: Malpighiales
•Family: Euphorbiaceae
•Subfamily: Acalyphoideae
•Tribe: Acalypheae
•Subtribe: Macaranginae
•Genus: Macaranga

**Geographical Distribution of Macaranga Species**

Macaranga is the largest genus in the Euphorbiaceae family, comprising approximately 300 species primarily found in the tropical regions of Africa, Southeast Asia, Australia, and the South Pacific.[5] The genus exhibits the greatest diversity in Southeast Asia and New Guinea, where around 200 species are recorded. It is also present in Africa and Madagascar (37 species), continental Asia (30 species), the Pacific Islands (24 species), and Australia (7 species) (Siregar & Sambas, 2000).[6] In East Africa, particularly in Tanzania, Kenya, and Uganda, seven species are found growing mainly along forest margins, whereas South Africa hosts only a single species.[7]

**Phytochemistry of Macaranga**

Limited phytochemical research has been conducted on the Macaranga genus. A review of the literature reveals that only 26 species have undergone phytochemical investigation, despite the genus comprising approximately 300 species.

The chemical composition of the following species has been studied: Macaranga alnifolia, Macaranga barteri, Macaranga bicolor, Macaranga conifer, Macaranga denticulata, Macaranga gigantea, Macaranga gigantifolia, Macaranga hemsleyana, Macaranga indica, Macaranga kurzii, Macaranga lowii, Macaranga mappa, Macaranga monandra, Macaranga peltata, Macaranga pleiostemona, Macaranga pruinosa, Macaranga recurvata, Macaranga rhizinoides, Macaranga sampsonii, Macaranga schweinfurthii, Macaranga sinensis, Macaranga tanarius, Macaranga trichocarpa, Macaranga triloba, and Macaranga vedeliana.[8]

The identified chemical constituents provide valuable insights into the biological and chemical properties of these species, including their pharmacological activities, mechanisms of action, and principles of quality control. These findings also pave the way for further exploration of the genus for medicinal and industrial applications.[9]

To date, 190 secondary metabolites have been isolated and identified from Macaranga species. These include flavonoids (1–84), stilbenes (85–100), tannins (101–144), terpenes (145–156), coumarins (157–158), steroids (159–161), and other compounds (162–190). Notably, approximately 90% of these compounds have been extracted from leaves, while only 10% have been obtained from other plant parts. This highlights the need for further research on other parts of the plant, such as the stems, root bark, fruits, seeds, and flowers.[10] Additionally, observations of Macaranga species in their natural environment have shown that they produce threadlike wax crystals on their stems. Chemical analysis has revealed that terpenoids form the majority of this wax bloom, which plays a crucial role in maintaining the symbiotic relationship between the plant and insects. Table 1 presents the names of these constituents along with the plant parts from which they are obtained.[1]

**Table 1**

| Sl. no: | Type of phytoconstituent | Name | Plant species | Part | Country of origin |
|---|---|---|---|---|---|
| 1. | Flavonoids | Macarangaflavanone A | M. pleiostemona[3] | Leaves | Papua New Guinea |
| | | Macarangaflavanone B | M. pleiostemona | Leaves | Papua New Guinea |
| | | Bonannione A | M. pleiostemona | Leaves | Papua New Guinea |
| | | Macarangin | M. vedeliana | Leaves | New Caledonia |
| | | Alnifoliol | M. alnifolia | Fruit | Madagascar |
| | | Bonnaniol | M. alnifolia | Fruit | Madagascar |
| | | diplacol | M. alnifolia | Fruit | Madagascar |
| | | Glabranin | M.kurzii | Leaves | Vietnam |
| | | Izalpnin A | M.kurzii | Leaves | Vietnam |
| | | Macaranone A | M. sampsonii[11] | Leaves | China |
| | | Macaranone B | M. sampsonii | Leaves | China |
| | | Macaranone C | M. sampsonii | Leaves | China |
| | | Macaranone D | M. sampsonii | Leaves | China |

**Table 1 Contd.**

| Sl. no: | Type of phytoconstituent | Name | Plant species | Part | Country of origin |
|---|---|---|---|---|---|
| | | Vedelianin | M. Vedeliana[12] | Leaves | New Caledonia |
| | | Mappain | M. mappa | Leaves | Hawaii |

| | | | | | |
|---|---|---|---|---|---|
| 2. | StilbeneS | Schweinfurthin A | M.schweinfurthii[13] | Leaves | Cameroon |
| | | Schweinfurthin B | M. schweinfurthii | Leaves | Cameroon |
| | | Schweinfurthin C | M.schweinfurthii[14] | Leaves | Cameroon |
| | | Schweinfurthin E | M. alnifolia | Leaves | Madagascar |
| | | Schweinfurthin F | M. alnifolia | Leaves | Madagascar |
| | | Schweinfurthin G | M. alnifolia | Leaves | Madagascar |
| | | Schweinfurthin H | M. alnifolia | Leaves | Madagascar |
| | | Schweinfurthin I | M. schweinfurthii | Leaves | Cameroon |
| | | Schweinfurthin J | M. schweinfurthii | Leaves | Cameroon |

**Table 1 Contd.**

| Sl. no: | Type of phytoconstituent | Name | Plant species | Part | Country of origin |
|---|---|---|---|---|---|
| 3. | Steroids | β-Sitosterol | M. hemsleyana[15]<br>M. peltate | Stem bark<br>Stem bark | China<br>India |
| | | Stigmast-4-en-3-one | M. hemsleyana | Stem bark | China |
| | | Stigmast-4-en-3,6-dione | M. hemsleyana | Stem bark | China |

**Table 1 Contd.**

| Sl. no: | Type of phytoconstituent | Name | Plant species | Part | Country of origin |
|---|---|---|---|---|---|
| 4. | Coumarins | Scopoletin | M. denticulata[16]<br>M. triloba<br>M. barteri<br>M. triloba | Leaves<br>Leaves<br>Stem bark<br>Inflorescenes | Thailand<br>Indonesia<br>Cameroon<br>Malaysia |
| | | 5,7-dihydroxycoumarin | M. gigantifolia<br>M. triloba[17] | Leaves<br>Inflorescenes | Indonesia<br>Malaysia |

**Table 1 Contd.**

| Sl. no: | Type of phytoconstituent | Name | Plant species | Part | Country of origin |
|---|---|---|---|---|---|
| 5. | Tannins | Mallotinic acid | M. tanarius [18] | Leaves | Indonesia |
| | | Corilagin | M. tanarius | Leaves | Indonesia |
| | | Macatannin A | M. tanarius | Leaves | Indonesia |
| | | Macatannin B | M. tanarius | Leaves | Indonesia |
| | | Chebulagic acid | M. tanarius | Leaves | Indonesia |

## Pharmacological properties

### Antioxidant Activity

The antioxidant potential of Macaranga peltata has been evaluated using reducing power and DPPH free radical scavenging assays. A comparison of IC50 values between the standard and test samples indicates that Macaranga peltata possesses significant antioxidant activity. The methanolic extract effectively scavenges DPPH radicals and superoxide anions, exhibiting superior efficacy compared to standard antioxidants such as ascorbate and quercetin.[19] This potent activity is attributed to its high total phenolic content, which plays a crucial role in antioxidant mechanisms. Additionally, recent studies have explored the bioactivities of methanolic fresh leaf extracts from other Macaranga species, including M. gigantea, M. pruinosa, M. tanarius, and M. triloba, focusing on their antioxidant, tyrosinase inhibition, and antibacterial properties. [20,21]

### Anti-inflammatory Activity

The in vitro anti-inflammatory potential of Macaranga peltata has been assessed using the bovine serum albumin denaturation inhibition method.[22] Its anti-inflammatory effects are believed to be linked to the presence of bioactive compounds such as flavonoids, tannins, and phenols.[23] Additionally, the stem bark extract of Macaranga barteri has demonstrated significant anti-inflammatory activity in a rat model using the carrageenan-induced foot edema method.[24]

**Antimicrobial Activity**

The antibacterial properties of Macaranga peltata were tested using the disc diffusion method against Escherichia coli, Proteus vulgaris, and Klebsiella pneumoniae.[25] The acetone and petroleum ether extracts of the plant's fruit showed antimicrobial activity, with the acetone extract exhibiting a higher level of inhibition than the petroleum ether extract across all tested bacterial strains.[26,27]

**Analgesic Activity**

The analgesic potential of Macaranga peltata leaves was assessed using the in vivo Eddy's hot plate method. Results suggest that a higher dose of the ethanolic leaf extract provides greater analgesic effects compared to a lower dose, although neither dosage matched the efficacy of standard Tramadol. Phytochemical analysis confirmed the presence of alkaloids, flavonoids, carbohydrates, and sterols, which contribute to the plant's analgesic activity.[28]

**Anti-cancer Activity**

In vitro studies on human oral cancer cell lines have been conducted using the ethanolic extract of Macaranga peltata leaves.[29] MTT and Comet assays were performed to evaluate cytotoxic effects.[30] The MTT assay determined viable cell numbers and LC50 values, while the Comet assay results, analyzed using Tritek Comet software, were statistically correlated.[31] The findings indicate that the leaf extract of Macaranga peltata exhibits cytotoxic properties against cancer cells.[32]

**Hepatoprotective Activity**

The hepatoprotective potential of Macaranga peltata has been studied across various experimental models. The plant's methanolic and ethanolic extracts exhibit notable liver-protective effects, likely due to the presence of bioactive compounds such as flavonoids, tannins, and phenolics. These constituents play a key role in reducing oxidative stress, stabilizing liver enzyme levels, and preventing hepatic damage.[33]

In vivo studies using hepatotoxicity-induced animal models have demonstrated that Macaranga peltata extract significantly lowers elevated liver enzyme levels, including ALT, AST, and ALP, indicating its protective role in liver function. Additionally, the extract enhances antioxidant enzyme activity, reduces lipid peroxidation, and improves overall liver health. Its hepatoprotective effects are comparable to those of standard liver-protective agents.[34]

The hepatoprotective properties of Macaranga peltata are primarily attributed to its strong antioxidant activity, free radical scavenging potential, and anti-inflammatory effects, which help counteract liver damage caused by toxins, drugs, or oxidative stress. Further research is required to fully understand its therapeutic potential in liver disorders.[35]

**Anti-hyperglycemic Activity**

Several species within of Macaranga genus have potential anti-hyperglycemic (blood sugar-lowering) properties through various mechanisms:

**1. Macaranga tanarius:**

Compounds extracted from Macaranga tanarius leaves have been identified as novel α-glucosidase inhibitors. By inhibiting this enzyme, these compounds can slow carbohydrate digestion, thereby reducing postprandial (after-meal) blood glucose levels.[36] Additionally, prenylflavonoid compounds from Macaranga tanarius have demonstrated anti-inflammatory, antioxidant, and antibacterial properties. In a study using a diabetic

mouse model, these compounds reduced the expression of fibronectin, α-smooth muscle actin, and collagen IV in renal cells, indicating a protective role against diabetic nephropathy—a common diabetes-related kidney complication.[37]

**2. Macaranga barteri:**

The methanol extract of Macaranga barteri leaves exhibited strong α-amylase inhibitory activity and free radical scavenging properties. These effects are beneficial for diabetes management, as they help slow the conversion of starch into glucose and reduce oxidative stress linked to hyperglycemia.[38]

**3. Macaranga hurifolia:**

The hypoglycemic effects of the methanol extract of Macaranga hurifolia were assessed using an alloxan-induced diabetic rat model. The study revealed its potential to lower blood glucose levels, reinforcing its traditional use in diabetes management.[39]

**Antihyperlipidemic activity**

Studies on Macaranga tanarius leaf extracts have yielded mixed results. One study found that the hexane-ethanol fraction of the methanol extract exhibited significant antihyperlipidemic and hepatoprotective effects in rats, suggesting potential benefits for managing hyperlipidemia and protecting liver function.[40] However, another study reported that the same extract did not show significant antidiabetic or antihyperlipidemic effects in rats fed a high glucose-fructose diet. These discrepancies highlight the need for further research to clarify the therapeutic potential of M. tanarius extracts.[41]

**Safety and Potential of Macaranga Extract in Cosmetic Applications**

Macaranga extract contains antioxidant, anti-inflammatory, and antimicrobial compounds with potential in cosmetic formulations. However, some natural ingredients may pose risks, including carcinogenic, mutagenic, or reprotoxic effects, requiring careful evaluation. Despite promising benefits, clinical validation is needed due to limited supporting data. Plant based cosmetics can sometimes cause allergic reactions, dermatitis, or photosensitivity. Antioxidants may also lead to toxicity, irritation, or instability. Safe concentrations are crucial, with certain compounds, like furocoumarins, recommended for nighttime use due to phototoxic effects. Nanotechnology enhances the stability of natural antioxidants in cosmetics, using nanoemulsions, nanoparticles, and liposomes to reduce toxicity and side effects. However, concerns over safety have led to further research. The EU has introduced regulations for safer nanocosmetics. While natural antioxidants are safer than synthetic ones, they remain more expensive to produce.

## CONCLUSION

The Macaranga genus is a rich source of bioactive compounds with significant pharmacological and cosmetic potential. Various species exhibit antioxidant, anti-inflammatory, antimicrobial, hepatoprotective, antihyperglycemic, antihyperlipidemic, and anticancer activities, largely attributed to their flavonoids, stilbenes, tannins, terpenes, and coumarins. Despite these promising properties, concerns regarding safety, toxicity, and phototoxic effects necessitate further clinical research. The incorporation of nanotechnology offers a potential solution to enhance the stability of these compounds in cosmetic formulations. However, systematic studies are required to validate their efficacy, optimize safe concentrations, and explore their full potential in medicinal and industrial applications.

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