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A REVIEW ARTICLE ON ISOLATION, CHARACTERIZATION, PHYTOCHEMICAL PROFILE AND INVITRO ANTIOXIDANT ACTIVITY OF *ACACIA NILOTICA* SEEDS

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ABSTRACT

Babul, also known as *Acacia Nilotica* (L.) Delile, is a versatile medicinal plant that is a member of the Fabaceae family. It is widely found in tropical and subtropical areas and has long been utilized in a number of indigenous medical systems to treat a variety of illnesses. Because of its abundance of naturally occurring bioactive chemicals, the plant has significant pharmacological and economic value. Due to its wide range of biological activity and the existence of structurally diverse secondary metabolites, *Acacia Nilotica* has drawn more attention from scientists in recent years. Cellular damage and the development of several chronic illnesses are significantly influenced by oxidative stress, which arises from an imbalance between the body's antioxidant defense system and the production of reactive oxygen species. Because of their ability to scavenge free radicals and provide protection, phytochemicals produced from plants are seen as viable natural options for preventing oxidative damage. According to reports, *Acacia Nilotica* has a number of significant phytoconstituents that contribute to its antioxidant, antibacterial, anti-inflammatory, antidiabetic, and therapeutic potential, such as phenolic compounds, flavonoids, tannins, alkaloids, terpenoids, saponins, and other bioactive molecules. This review focuses on *Acacia Nilotica*'s botanical description, taxonomical features, geographic distribution, traditional uses, phytochemical composition, and medicinal importance. According to the scientific data at hand, *Acacia Nilotica* is a valuable natural source of bioactive chemicals with potential

uses in pharmaceutical and nutraceutical research, especially for the creation of therapeutic agents based on antioxidants.

KEYWORDS: *Acacia Nilotica*; Phytochemicals; Antioxidant activity; Flavonoids; Tannins; Pharmacological properties; Medicinal plant; Natural products.

INTRODUCTION

In both traditional healthcare systems and contemporary drug research, medicinal plants have been acknowledged as important sources of therapeutic compounds. The existence of various secondary metabolites, such as phenolic compounds, flavonoids, tannins, alkaloids, terpenoids, saponins, and other bioactive molecules, is primarily linked to the biological and pharmacological potential of plants. By interacting with cellular pathways and shielding biological systems from oxidative damage, these naturally occurring components support a variety of biological processes. Because of their capacity to neutralize reactive species and their prospective uses in the creation of pharmaceutical goods, herbal formulations, and nutraceutical agents, plant-derived antioxidants have drawn a lot of scientific attention in recent years.

An imbalance in biological systems is caused by oxidative stress, which happens when the generation of reactive oxygen species (ROS) surpasses the capability of endogenous antioxidant defense mechanisms. Important biological components, such as proteins, membrane lipids, and nucleic acids, may undergo structural and functional changes as a result of an excessive buildup of free radicals. Numerous clinical problems, including as cardiovascular disorders, diabetes mellitus, inflammatory diseases, neurodegenerative disorders, and aging-related consequences, have been linked to the onset and development of this oxidative imbalance. As a result, investigating naturally occurring antioxidant molecules from medicinal plants has emerged as a crucial field of study for creating therapeutic and preventative measures against illnesses caused by oxidative stress.

Acacia Nilotica (L.) Delile, sometimes referred to as Egyptian acacia or babul, is a significant medicinal plant in the Fabaceae family. Because of its many therapeutic uses, it is frequently found in tropical and subtropical areas and has long been used in many indigenous medical systems. The plant is well recognized for its industrial uses, gum production, and ecological significance, but more research has shown that it has substantial therapeutic potential. The

pharmacological properties and phytochemical makeup of several *Acacia Nilotica* components, including as bark, leaves, pods, flowers, seeds, and gum, have been studied.

Numerous bioactive components, including polyphenolic compounds, flavonoids, condensed tannins, phenolic acids, alkaloids, terpenoids, and polysaccharides, are responsible for *Acacia Nilotica*'s medicinal value. Its purported antioxidant, antibacterial, anti-inflammatory, antidiabetic, hepatoprotective, and wound-healing properties are attributed to these phytoconstituents. Among these biological characteristics, antioxidant activity has drawn a lot of attention because of the plant's phenolic and flavonoid components' capacity to scavenge free radicals, prevent oxidative processes, and shield cells.

The botanical traits, taxonomical categorization, geographic distribution, traditional usage, phytochemical contents, extraction and characterisation techniques, antioxidant capacity, and medicinal importance of *Acacia Nilotica* are all well covered in this paper. This medicinal plant appears to be a promising natural source of bioactive chemicals with prospective uses in the creation of pharmaceutical, nutraceutical, and herbal drugs, according to the scientific data that is now accessible.

Taxonomical Classification of Tectona grandis

Kingdom	**Plantae**
Subkingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Sub class	Rosidae
Order	Fabales
Family	Fabaceae
Sub family	Mimosoideae
Tribe	Acacieae
Genus	*Acacia*
Species	*Nilotica*
Sub species	*Indica*

Plant Profile of *Acacia Nilotica*

Botanical description

The babul or gum arabic tree, *Acacia Nilotica* (L.) Delile, is a member of the Fabaceae family. Numerous tropical and subtropical areas of Africa, Asia, and the Indian subcontinent are home to this versatile nitrogen-fixing tree. The Greek term "akis," which describes its

prickly quality, is the source of the species name Acacia, while nilotica denotes its connection to the Nile area.

The plant is a small to medium-sized evergreen tree with a maximum height of 15 to 25 meters. It has bipinnate leaves, paired thorns, dark fissured bark, and a spreading crown. The fruits are lengthy pods with many seeds, and the fragrant yellow flowers are grouped in globose clusters. *Acacia Nilotica* can withstand high temperatures, salty soils, and arid climates. The plant's many parts—bark, leaves, pods, seeds, and gum—have long been utilized because of its therapeutic and commercial value.

Morphological Characteristics

Stem

Acacia Nilotica has an upright, woody, branching stem that forms a wide, spreading crown. While adult stems have a rough, thick, dark brown to blackish bark with longitudinal cracks, young branches are often smooth and greenish in appearance. Younger branches of the plant have paired axillary spines that are straight, pointed, and protective. The mature bark's high tannin content contributes to its distinctive astringent qualities, and the sturdy, cylindrical trunk supports many lateral branches.

Leaves

Acacia Nilotica has complex, bipinnately arranged leaves with a distinctive feathery look. A core rachis with many pairs of tiny leaflets arranged in opposing pairs makes up each leaf. The leaflets have a smooth surface, full edges, and a tiny, oblong to linear form. Short petioles with spinescent stipules support the leaves, which are typically green in color. An adaptive characteristic that helps the plant survive arid climatic circumstances is the bipinnate leaf shape.

Flowers

Acacia Nilotica has tiny, fragrant, yellow blooms that are grouped in small, globose clusters. Usually seen in clusters, these spherical flower heads emerge from the leaf axils and are carried on thin stalks. Each flower has many conspicuous stamens, a yellowish corolla, and a tiny calyx, all of which contribute to its distinctive look. Typically, flowering takes place during the rainy season, and the eye-catching clusters of flowers enhance the plant's aesthetic appeal and aid in pollination.

Fruits

After flowering, *Acacia Nilotica* produces dry, long, pod-like fruits. The pods exhibit constrictions between the individual seeds, giving them a beaded look, and are typically cylindrical to slightly curved in form. They have many spherical, firm seeds inside the pod wall. The mature pods are a crucial diagnostic characteristic for the plant's identification because of their greyish-brown color.

Geographical Distribution

Acacia Nilotica (L.) Delile is found in many tropical and subtropical sections of the world, especially in portions of the Middle East, Africa, and the Indian subcontinent. Although the plant is thought to be native to parts of Africa, Arabia, and South Asia, its adaptability and ecological significance have led to its introduction and naturalization in a number of other nations. It is frequently found in arid and semi-arid areas of India, particularly in plains, riverbanks, and agricultural borders. The species' vast spread is a result of its ability to withstand a variety of environmental factors, such as high temperatures, drought, and salty soils. It is a significant multifunctional tree with economic, ecological, and medical uses due to its capacity to flourish in a variety of climates.

Phytochemical Profile of *Acacia Nilotica*

The varied biological activities of *Acacia Nilotica* are attributed to a range of secondary metabolites. Phenolics, flavonoids, tannins, alkaloids, terpenoids, saponins, and other bioactive components have been found in various plant sections according to phytochemical analyses.

S. No.	Plant part	Phytochemical constituents
1	Seeds	Proteins, fatty acids, phenolic compounds, flavonoids, alkaloids
2	Leaves	Flavonoids, phenolic compounds, alkaloids, tannins, saponins
3	Flowers	Flavonoids, phenolic compounds, essential oil constituents
4	Stem bark	Tannins, flavonoids, phenolic compounds, gallic acid, catechin, terpenoids
5	Gum	Polysaccharides, tannins, mineral components
6	Roots	Tannins, flavonoids, terpenoids, phenolic constituents
7	Stem/Heartwood	Tannins, phenolic compounds, flavonoids, lignin-derived constituents

Extraction and Isolation of *Acacia Nilotica* Seeds

The phytochemical content of *Acacia Nilotica* seeds has been thoroughly studied using both traditional and sophisticated extraction methods. In order to get extracts enriched with various classes of bioactive chemicals, dried and powdered seeds are frequently treated to

sequential solvent extraction using solvents of increasing polarity, such as n-hexane, chloroform, ethyl acetate, methanol, ethanol, and water. Because it effectively recovers both polar and non-polar phytoconstituents, Soxhlet extraction is one of the most often used techniques. To separate the components that are soluble in water, aqueous extracts are often made by decoction or maceration.

The crude extracts are dried for further examination after the extraction solvent is extracted under low pressure using a rotary evaporator or vacuum distillation. Chromatographic methods including column chromatography (CC), thin-layer chromatography (TLC), high-performance thin-layer chromatography (HPTLC), and high-performance liquid chromatography (HPLC) are frequently used to isolate and purify specific phytochemicals. Modern spectroscopic methods, including as Fourier-transform infrared spectroscopy (FTIR), gas chromatography–mass spectrometry (GC–MS), liquid chromatography–mass spectrometry (LC–MS), and nuclear magnetic resonance (^{1}H and ^{13}C NMR) spectroscopy, are used to further characterize the purified compounds and enable structural elucidation of the separated bioactive ingredients.

Pharmacological Activities of *Acacia Nilotica*

Acacia Nilotica extensive phytochemical makeup, which includes flavonoids, phenolic compounds, tannins, alkaloids, terpenoids, and saponins, is largely responsible for its varied pharmacological characteristics. The plant's historic usage in treating a variety of illnesses is supported by these bioactive components' many biological actions.

Antioxidant activity

Acacia Nilotica's high phenolic and flavonoid content contributes to its exceptional antioxidant activity. These phytochemicals successfully prevent lipid peroxidation, scavenge reactive oxygen species (ROS), and shield cellular components from oxidative damage. In vitro tests including DPPH, ABTS, FRAP, and nitric oxide radical scavenging techniques have been used to show the antioxidant capability of various plant components.

Antimicrobial activity

Extracts from *Acacia Nilotica*'s bark, leaves, pods, and seeds have demonstrated broad-spectrum antibacterial action against a variety of pathogenic fungi and both Gram-positive and Gram-negative bacteria. Tannins, flavonoids, and phenolic components that obstruct microbial development and cell membrane integrity are primarily responsible for this effect.

Anti-inflammatory activity

By lowering the synthesis of inflammatory mediators and inhibiting oxidative stress, the plant has shown notable anti-inflammatory properties. *Acacia Nilotica* contains polyphenols and flavonoids that help to reduce tissue inflammation by inhibiting inflammatory pathways.

Antidiabetic activity

Acacia Nilotica has been shown in several studies to have antidiabetic potential by enhancing antioxidant defense and reducing blood glucose levels. The phytoconstituents may lower oxidative stress, increase insulin sensitivity, and block the enzymes that hydrolyze carbohydrates and are involved in the metabolism of glucose.

Hepatoprotective activity

Extracts of *Acacia Nilotica* have been shown in experiments to shield liver tissues against chemical damage. Its antioxidant components, which reduce lipid peroxidation and restore normal liver enzyme levels, are linked to the hepatoprotective action.

Future Perspectives

Even though *Acacia Nilotica* has shown a great deal of pharmacological potential, more research is needed to properly determine its therapeutic uses. Future studies should concentrate on standardizing extracts, identifying and characterizing new bioactive components, and clarifying their molecular mechanisms of action. To validate its safety and effectiveness, thorough toxicology investigations, pharmacokinetic analyses, and carefully planned clinical trials are also required. *Acacia Nilotica*'s potential as a useful source of natural medicinal compounds may be further enhanced by the development of sophisticated herbal formulations and innovative drug delivery technologies.

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