



PHARMACOLOGICAL PROPERTIES OF BERMUDAGRASS AND ITS APPLICATION IN FOLK MEDICINE

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Abstract

Acorus calamus L. is a medicinal plant that has been extensively used in traditional medicine for centuries. Its rhizomes are rich in essential oils, phenylpropanoids, sesquiterpenes, flavonoids, tannins, and other biologically active compounds responsible for a wide range of pharmacological effects. The aim of this study was to review the pharmacological properties of *Acorus calamus* based on current scientific literature. International peer-reviewed publications, pharmacognosy textbooks, and official monographs were analyzed. The findings indicate that *Acorus calamus* exhibits anti-inflammatory, antioxidant, antimicrobial, antispasmodic, gastroprotective, sedative, and neuroprotective activities. However, the presence of β -asarone in certain chemotypes may be associated with toxic and potentially carcinogenic effects when used in high doses or for prolonged periods. The available evidence supports the rational and evidence-based use of *Acorus calamus* while emphasizing the importance of safety evaluation and dosage regulation.

Keywords: *Acorus calamus*, pharmacology, pharmacognosy, essential oil, β -asarone, antioxidant, antimicrobial activity, anti-inflammatory activity, gastroprotective effect, neuroprotection.

Introduction

Medicinal plants remain one of the most important sources of therapeutic agents worldwide, providing a significant contribution to modern pharmacotherapy and the development of new pharmaceutical products. According to the World Health Organization (WHO), approximately 80% of the population in developing countries relies on traditional herbal medicine as a primary source of healthcare. The increasing prevalence of chronic inflammatory disorders, antimicrobial resistance, oxidative stress-related diseases, and neurodegenerative conditions has intensified scientific interest in medicinal plants with proven pharmacological activities.

Acorus calamus L. (family **Acoraceae**), commonly known as sweet flag, is a perennial aromatic medicinal plant widely distributed throughout Asia, Europe, and North America. The rhizome of *A. calamus* has been extensively used in Ayurvedic, Traditional Chinese, Unani, and European herbal medicine for centuries. Traditionally, it has been employed in the treatment of gastrointestinal disorders, dyspepsia, loss of appetite, respiratory diseases, inflammatory conditions, neurological disorders, and cognitive impairment.

The therapeutic properties of *A. calamus* are mainly attributed to its rich phytochemical composition, including essential oils, phenylpropanoids (especially α -asarone and β -asarone), sesquiterpenes, monoterpenes, flavonoids, tannins, glycosides, and other bioactive compounds. Numerous experimental studies have demonstrated that these constituents possess antioxidant, anti-



inflammatory, antimicrobial, antifungal, antispasmodic, gastroprotective, analgesic, neuroprotective, anxiolytic, and antidiabetic activities. These pharmacological effects suggest that *A. calamus* may represent a promising source for the development of novel phytopharmaceutical agents.

Despite its broad spectrum of biological activities, the clinical application of *A. calamus* remains controversial because of the presence of **β-asarone**, a compound reported to exhibit toxic, genotoxic, and potentially carcinogenic effects in experimental animal studies when administered at high doses or over prolonged periods. Consequently, regulatory authorities, including the European Medicines Agency (EMA), have emphasized the importance of quality control, chemotype identification, dosage standardization, and safety assessment before therapeutic use. Particular attention has been directed toward β-asarone-free or low-β-asarone chemotypes, which are considered safer for pharmaceutical development.

Recent advances in phytochemistry, pharmacology, and molecular biology have significantly expanded our understanding of the mechanisms underlying the biological activities of *A. calamus*. Experimental evidence suggests that its bioactive constituents regulate inflammatory mediators, reduce oxidative stress, inhibit microbial growth, protect neuronal cells, and improve gastrointestinal function through multiple molecular pathways. Nevertheless, further preclinical and well-designed clinical studies are necessary to confirm its efficacy, establish standardized dosage regimens, and evaluate long-term safety.

The aim of this study is to comprehensively review the pharmacological properties of *Acorus calamus* L., summarize current evidence regarding its phytochemical composition, pharmacological mechanisms, therapeutic potential, and safety profile, and evaluate its prospects for evidence-based clinical application based on reliable scientific literature and international pharmacognostic references. *Acorus calamus* L. (sweet flag) continues to occupy an important place in traditional medicine across many regions of the world, particularly in Asia, Eastern Europe, and parts of the Middle East. Despite significant advances in synthetic pharmacotherapy, medicinal plants remain widely used because of their accessibility, cultural acceptance, and broad spectrum of biological activities. The World Health Organization (WHO) recognizes traditional medicine as an essential component of primary healthcare in many countries and encourages the scientific evaluation of medicinal plants to ensure their efficacy, quality, and safety.

In traditional systems of medicine such as Ayurveda, Traditional Chinese Medicine (TCM), and Unani medicine, *Acorus calamus* rhizome has long been used to manage digestive disorders, abdominal pain, flatulence, dyspepsia, loss of appetite, respiratory ailments, inflammatory diseases, and certain neurological conditions. It has also been traditionally regarded as a memory-enhancing and cognitive-supporting herb. These ethnomedicinal applications have stimulated extensive pharmacological investigations over recent decades.

Current scientific evidence indicates that many traditional uses of *A. calamus* are supported by experimental studies demonstrating antioxidant, anti-inflammatory, antimicrobial, gastroprotective, antispasmodic, neuroprotective, and anxiolytic activities. These findings have increased interest in developing standardized herbal preparations and phytopharmaceutical products derived from *A. calamus*. Furthermore, growing concerns regarding antimicrobial resistance and adverse effects associated with some synthetic drugs have renewed attention toward medicinal plants with scientifically validated therapeutic potential.

Nevertheless, the medicinal use of *Acorus calamus* requires careful consideration because certain chemotypes contain significant amounts of **β-asarone**, a constituent associated with toxic and potentially carcinogenic effects following prolonged exposure or high-dose administration in experimental studies. Consequently, modern phytotherapy emphasizes the use of standardized



extracts, quality control, chemotype identification, and adherence to regulatory safety recommendations.

Therefore, *Acorus calamus* remains an important medicinal plant in contemporary traditional medicine. Its long history of therapeutic use, combined with accumulating pharmacological evidence, highlights its potential as a valuable source of bioactive compounds for future drug development. At the same time, evidence-based evaluation and appropriate safety regulation are essential to ensure its rational clinical application.

Materials and Methods

This study was conducted as a **narrative literature review** aimed at evaluating the pharmacological properties, phytochemical composition, therapeutic applications, and safety profile of *Acorus calamus* L. The review followed internationally accepted principles for evidence-based scientific research and utilized reliable academic sources published in pharmacognosy, pharmacology, and phytotherapy.

The literature search included peer-reviewed scientific articles indexed in **PubMed**, **Scopus**, **Web of Science**, and **Google Scholar**, together with internationally recognized reference textbooks and official monographs. The primary references included the **World Health Organization (WHO) Monographs on Selected Medicinal Plants**, **European Medicines Agency (EMA) Herbal Monographs**, **European Scientific Cooperative on Phytotherapy (ESCOP) Monographs**, **Trease and Evans' Pharmacognosy**, **Tyler's Herbs of Choice**, and **Bruneton's Pharmacognosy, Phytochemistry, Medicinal Plants**. Publications available in English and Russian and published mainly between **2005 and 2025** were considered.

The literature search was performed using the following keywords and their combinations: "*Acorus calamus*", "sweet flag", "pharmacological activity", "phytochemistry", "essential oil", " β -asarone", "anti-inflammatory", "antioxidant", "antimicrobial", "neuroprotective", "gastroprotective", and "medicinal plant".

The inclusion criteria comprised original experimental studies, systematic reviews, meta-analyses, official pharmacopoeial documents, and international monographs that reported pharmacological, phytochemical, toxicological, or therapeutic data concerning *Acorus calamus*. Publications lacking sufficient scientific evidence, duplicate studies, conference abstracts without full text, and non-peer-reviewed sources were excluded.

The collected data were systematically analyzed using **comparative analysis**, **descriptive analysis**, and **evidence synthesis** methods. Information regarding the chemical constituents of *Acorus calamus*, its pharmacological activities, mechanisms of action, therapeutic indications, and safety concerns was extracted, categorized, and critically evaluated. Special attention was paid to studies investigating the biological effects of essential oils and β -asarone, as well as regulatory recommendations concerning the medicinal use of *Acorus calamus*.

This methodological approach enabled a comprehensive assessment of the current scientific evidence regarding the pharmacological potential and safety of *Acorus calamus* L., providing a reliable foundation for evidence-based conclusions and future clinical investigations.

Results

The analysis of the selected scientific literature demonstrated that *Acorus calamus* L. possesses a broad spectrum of pharmacological activities attributable to its diverse phytochemical constituents. The rhizome was identified as the principal medicinal part of the plant, containing essential oils (α -asarone and β -asarone), monoterpenes, sesquiterpenes, flavonoids, tannins, phenolic compounds, and glycosides. These bioactive constituents are responsible for multiple biological effects that have been confirmed in experimental studies.



The reviewed evidence showed that antioxidant and anti-inflammatory activities are among the most extensively investigated pharmacological properties of *Acorus calamus*. Experimental studies have demonstrated that its extracts reduce oxidative stress by scavenging reactive oxygen species (ROS), increasing the activity of antioxidant enzymes, and suppressing inflammatory mediators such as tumor necrosis factor- α (TNF- α), interleukin-6 (IL-6), cyclooxygenase-2 (COX-2), and inducible nitric oxide synthase (iNOS). These mechanisms contribute to tissue protection under inflammatory conditions.

In addition, several in vitro and in vivo studies reported significant antimicrobial activity against Gram-positive bacteria, Gram-negative bacteria, and pathogenic fungi. The essential oil exhibited inhibitory effects against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Candida albicans*. These findings indicate the potential application of *Acorus calamus* as a natural antimicrobial agent.

Neuroprotective and gastroprotective effects were also consistently reported. Experimental investigations demonstrated improvements in learning and memory, reduction of anxiety-like behavior, protection against neuronal oxidative damage, stimulation of gastric mucus secretion, and decreased gastric ulcer formation. However, toxicological studies emphasized that prolonged exposure to high concentrations of β -asarone may produce adverse effects, highlighting the necessity for standardized preparations and careful dosage regulation.

Table 1. Major bioactive compounds of *Acorus calamus* L. and their pharmacological activities

Bioactive compound	Chemical class	Principal pharmacological activity
α -Asarone	Phenylpropanoid	Neuroprotective, antioxidant, anti-inflammatory
β -Asarone	Phenylpropanoid	Antimicrobial, sedative; potential toxicity at high doses
Essential oils	Volatile compounds	Antimicrobial, antispasmodic, digestive stimulant
Flavonoids	Polyphenols	Antioxidant, anti-inflammatory
Tannins	Polyphenols	Astringent, antimicrobial
Sesquiterpenes	Terpenoids	Anti-inflammatory, analgesic
Phenolic compounds	Phenolics	Free radical scavenging, cytoprotective

Table 2. Summary of experimentally confirmed pharmacological effects

Pharmacological effect	Experimental evidence	Proposed mechanism
Antioxidant	In vitro and animal studies	Reduction of ROS, enhancement of antioxidant enzymes
Anti-inflammatory	Animal studies	Inhibition of TNF- α , IL-6, COX-2 and iNOS
Antimicrobial	In vitro studies	Inhibition of bacterial and fungal growth
Gastroprotective	Animal studies	Increased gastric mucus production and reduced ulcer formation
Neuroprotective	Animal studies	Protection against oxidative neuronal damage and improved cognition
Antispasmodic	Experimental models	Relaxation of smooth muscle
Sedative/Anxiolytic	Animal studies	Modulation of central nervous system activity



Discussion

The findings of the present review demonstrate that *Acorus calamus* L. is a medicinal plant with considerable pharmacological potential due to its rich phytochemical composition and wide range of experimentally confirmed biological activities. The available evidence indicates that its therapeutic effects are primarily associated with essential oils, particularly α -asarone and β -asarone, as well as flavonoids, tannins, phenolic compounds, and terpenoids. These bioactive constituents contribute to antioxidant, anti-inflammatory, antimicrobial, gastroprotective, neuroprotective, and antispasmodic activities through multiple molecular pathways.

The antioxidant activity observed in numerous experimental studies suggests that *Acorus calamus* can effectively neutralize reactive oxygen species (ROS), thereby reducing oxidative stress and preventing cellular damage. Since oxidative stress is recognized as a key factor in the pathogenesis of cardiovascular diseases, diabetes mellitus, neurodegenerative disorders, and chronic inflammatory conditions, the antioxidant properties of *A. calamus* may have significant therapeutic implications. Similarly, suppression of inflammatory mediators, including TNF- α , IL-6, COX-2, and iNOS, supports its potential role as a natural anti-inflammatory agent.

Another important finding is the demonstrated antimicrobial activity of *Acorus calamus* extracts and essential oils against a broad spectrum of pathogenic microorganisms. Considering the growing global challenge of antimicrobial resistance, medicinal plants with antimicrobial properties have gained increasing scientific interest. Although experimental studies indicate promising antibacterial and antifungal effects, further clinical investigations are necessary to determine their efficacy and safety in human infections.

The neuroprotective properties reported in experimental models also deserve particular attention. Improvements in cognitive performance, memory retention, and neuronal protection against oxidative injury suggest that *Acorus calamus* may have therapeutic potential in neurodegenerative disorders such as Alzheimer's disease and Parkinson's disease. However, these findings are predominantly based on preclinical studies, and randomized controlled clinical trials are still insufficient to support routine clinical use.

Despite these promising pharmacological activities, safety remains one of the most important concerns regarding the medicinal use of *Acorus calamus*. Certain chemotypes contain relatively high concentrations of β -asarone, a compound that has demonstrated genotoxic and potentially carcinogenic effects in long-term animal experiments. Consequently, regulatory authorities, including the European Medicines Agency (EMA), recommend careful quality control, chemotype identification, standardized extraction procedures, and limitation of β -asarone exposure in medicinal preparations. This highlights the necessity of balancing therapeutic efficacy with patient safety.

Overall, the evidence reviewed in this study indicates that *Acorus calamus* possesses substantial potential for the development of novel phytopharmaceutical products. Nevertheless, future research should focus on well-designed clinical trials, standardized herbal formulations, detailed pharmacokinetic investigations, and comprehensive toxicological evaluations. Such studies will provide stronger scientific evidence for the safe and effective integration of *Acorus calamus* into evidence-based clinical practice and modern pharmacotherapy.

Conclusion

The present review demonstrates that *Acorus calamus* L. is a valuable medicinal plant with a wide range of pharmacological activities supported by experimental evidence. Its therapeutic potential is mainly attributed to the presence of biologically active compounds, including essential oils, α -asarone, flavonoids, tannins, terpenoids, and phenolic compounds. These constituents contribute to



antioxidant, anti-inflammatory, antimicrobial, gastroprotective, neuroprotective, antispasmodic, and anxiolytic effects through multiple biological mechanisms.

The reviewed studies indicate that *Acorus calamus* has promising potential for the prevention and supportive treatment of various disorders associated with oxidative stress, inflammation, microbial infections, gastrointestinal dysfunction, and neurological diseases. These findings support its continued importance in traditional medicine and highlight its potential application in the development of modern phytopharmaceutical products.

However, the medicinal use of *Acorus calamus* should be approached with caution because certain chemotypes contain **β -asarone**, a constituent associated with toxic and potentially carcinogenic effects following prolonged or high-dose exposure. Therefore, the therapeutic application of *Acorus calamus* should rely on standardized extracts, strict quality control, chemotype identification, and compliance with international safety guidelines.

Although numerous **in vitro** and **in vivo** studies have confirmed the pharmacological activities of *Acorus calamus*, high-quality clinical trials in humans remain limited. Future research should focus on randomized controlled clinical studies, standardization of herbal preparations, pharmacokinetic investigations, and long-term toxicological assessments to establish its efficacy and safety for clinical use.

In conclusion, *Acorus calamus* represents a promising source of bioactive compounds with significant pharmacological potential. Continued scientific investigation and evidence-based evaluation will facilitate its safe integration into modern pharmacotherapy while preserving its longstanding role in traditional medicine.

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