



Medicinal Plants and Their Alkaloids: Therapeutic Potential and Significance for Human Health

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ABSTRACT

Medicinal plants are an important resource of bioactive compounds contributing greatly to traditional medicine and pharmacology. Plant secondary metabolites include many structurally diverse molecules, among which alkaloids are notable owing to their wide range of pharmacological activities. Alkaloids are nitrogen-containing compounds synthesized by various medicinal plants and possess antimicrobial, anti-inflammatory, analgesic, antimalarial, antidiabetic, cardiovascular, neuroprotective and anticancer properties. Clinically useful medications have been derived from plant alkaloids, such as morphine from *Papaver somniferum*, quinine from *Cinchona* species, atropine from *Atropa belladonna*, and vincristine and vinblastine from *Catharanthus roseus*. However, alkaloids can show significant toxicity according to their chemical structures and mode of administration. Knowledge regarding their pharmacodynamics, mechanism of action, pharmacokinetics and toxicology is crucial for safe use. The present article addresses key medicinal plants producing pharmacologically relevant alkaloids and discusses their potential importance to human health, pharmacology and pharmaceutical sciences.

Keywords: Medicinal Plants, Alkaloids, Anti-cancer Properties, Anti-diabetic, Pharmacological

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1. INTRODUCTION

Medicinal plants have played an indispensable role as sources of pharmacologically active substances for centuries, and they continue to be important in current pharmaceutical research. Plant alkaloids belong to the complex class of specialized plant metabolites synthesized in medicinal plants alongside other important classes like phenolics, terpenoids, glycosides and steroids. Alkaloids are characterized by nitrogenous structures and numerous biological activities. Plant genera producing alkaloids belong to various important botanical families, which include Papaveraceae, Solanaceae, Apocynaceae,

Menispermaceae, Ranunculaceae and Fabaceae. Plant alkaloids have made considerable contributions to medicine owing to successful development of several important drugs from medicinal plants. Structural diversity permits plant alkaloids to act on multiple molecular targets including enzymes, receptors, ion channels, DNA and microtubules. They have provided important leads for analgesics, antimalarial drugs, anticancer agents, cardiovascular medications and neurological therapeutics.

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2. IMPORTANT MEDICINAL PLANTS AND THEIR MAJOR ALKALOIDS

Alkaloids are one of the most important constituents among various chemical constituents. Alkaloids are found in various plant sources around the world. This class of constituents has been used for various medicinal purposes including the treatment of various diseases.

3. ALKALOIDS AND THEIR ANTICANCER ACTIVITY

Plant-derived alkaloids have played a key role in cancer chemotherapy. The vinca alkaloids

Table 1. Alkaloids in major medicinal plants

Medicinal plant	Major alkaloid(s)	Major activity/relevance	Human-health significance
<i>Papaver somniferum</i>	Morphine, codeine	Analgesic; antitussive	Pain management; controlled medical use
<i>Catharanthus roseus</i>	Vincristine, vinblastine	Anticancer	Chemotherapy
<i>Cinchona spp.</i>	Quinine, quinidine	Antimalarial; antiarrhythmic	Malaria treatment and cardiovascular applications
<i>Atropa belladonna</i>	Atropine, scopolamine	Anticholinergic	Clinical anticholinergic applications
<i>Rauvolfia serpentina</i>	Reserpine, ajmaline	Antihypertensive; cardiovascular	Historical and pharmacological significance
<i>Berberis spp.</i>	Berberine	Antimicrobial; anti-inflammatory research	Investigated for metabolic and inflammatory disorders
<i>Mucuna pruriens</i>	L-DOPA	Dopaminergic activity	Relevance to Parkinson's disease
<i>Colchicum autumnale</i>	Colchicine	Anti-inflammatory	Gout treatment
<i>Camellia sinensis</i>	Caffeine	CNS stimulant	Alertness and stimulant effects
<i>Peganum harmala</i>	Harmine, harmaline	Neuropharmacological research	Experimental therapeutic potential
<i>Strychnos nux-vomica</i>	Strychnine	Potent neuroactive alkaloid	Highly toxic; safety concern
<i>Nicotiana tabacum</i>	Nicotine	Nicotinic receptor activity	Dependence and toxicity concerns

vincristine and vinblastine, isolated from *Catharanthus roseus*, inhibit tubulin dynamics and mitosis and serve as anticancer drugs. Other plant-derived compounds such as vinorelbine and vinflunine have been utilized for anticancer purposes. Multiple anticancer properties of alkaloids include inhibition of cell proliferation, induction of apoptosis, inhibition of microtubule dynamics and modulation of signaling pathways.

4. NEUROLOGICAL HEALTH

Many plant alkaloids act upon various targets within the CNS and PNS. Morphine binds to opioid receptors and functions as an effective painkiller. Scopolamine and atropine affect muscarinic cholinergic receptors, whereas L-DOPA, which occurs in *Mucuna pruriens* seeds, is converted to dopamine for dopamine-related therapy. Some investigations have assessed the potential benefits of plant-derived alkaloids for neurodegenerative diseases, such as Alzheimer's disease and Parkinson's disease. Proposed mechanisms include modulation of

acetylcholinesterase, inflammation and oxidative-stress responses. Positive outcomes observed in vitro and in animals cannot always be assumed directly to represent clinical utility.

5. ANTIMICROBIAL AND ANTIPARASITIC POTENTIAL

Several alkaloids have exhibited antimicrobial activity against bacteria, fungi and parasites. Berberine, a benzylisoquinoline alkaloid extracted from various *Berberis* plants, has gained significant scientific interest because of its antimicrobial, anti-inflammatory and metabolic effects. Quinine, which is

isolated from Cinchona plants, is considered one of the most historically important antimalarial alkaloids derived from medicinal plants. Antimicrobial effects of alkaloids may arise from membrane disruption, inhibition of nucleic acid synthesis, enzyme inhibition and modulation of cellular signaling pathways.

6. ANTI-INFLAMMATORY AND ANTIOXIDANT EFFECTS

Inflammation and oxidative stress are associated with many chronic conditions. Several plant-derived alkaloids exhibit anti-inflammatory activity in experimental settings. Mechanisms underlying this property include effects on NF- κ B and COX-2 signaling pathways, as well as anti-oxidant and anti-inflammatory activities. However, antioxidant or anti-inflammatory activity in vitro should not be assumed to correlate with clinical efficacy. Bioavailability, metabolism, dosage and pharmacokinetics need to be evaluated before making therapeutic recommendations based on these preliminary results.

7. CARDIOVASCULAR HEALTH

The historical contribution of certain plant alkaloids to cardiovascular pharmacology includes antihypertensive drugs, e.g., reserpine isolated from *Rauvolfia serpentina*, and antiarrhythmic medications such as quinidine. The example illustrates how medicinal plants provide structurally diverse alkaloids that may influence crucial physiological functions.

8. IMPORTANCE IN MODERN DRUG DISCOVERY

Phyto-alkaloids continue to serve as good leads for new drugs due to the complexity of their structures and their interactions with biological targets. They can be modified via medicinal chemistry, semi-synthesis, and biotechnology. Plant tissue culture and metabolic engineering may help in improving the biosynthesis of these phyto-alkaloids.

9. SAFETY AND TOXICITY CONSIDERATIONS

The usefulness of alkaloids in treatment cannot be dissociated from their toxicological effects. Alkaloids may have the potential to generate neurotoxicity, hepatotoxicity, nephrotoxicity, cardiotoxicity, or cytotoxicity based on the type of alkaloids and the degree of exposure. The pyrrolizidine alkaloids deserve special mention in terms of safety considerations related to both food and herbal medicines since certain types of this family of alkaloids can generate hepatotoxicity and are capable of inducing cancer.

10. FUTURE PERSPECTIVES

The following areas that need to be explored in future research are the synthesis of alkaloid-based medicines by combining phytochemistry, pharmacology, metabolomics, molecular biology, biotechnology, and nanotechnology. New techniques involving plant tissue culture and metabolic engineering could assist in enhancing the production of economically valuable alkaloids. Meanwhile, pharmacokinetic and toxicological research needs to be conducted to evaluate the safety and therapeutic potential of alkaloids.

The most important future research direction would be the translation of promising in vitro and in vivo research to clinical trials in humans. Alkaloids have also found applications in pharmaceutical quality control as chemical markers of botanical products.

11. CONCLUSION

Plants used for medicinal purposes offer an important reservoir of pharmacologically active alkaloids with great relevance to human well-being. Such alkaloids as morphine, quinine, atropine, reserpine, berberine and vinca alkaloids showcase the wide spectrum of pharmacological properties of compounds obtained from plants. These properties range from analgesic, antimalarial, anti-cancer, antibacterial, anti-inflammatory, cardio- and neuro-protective properties. However, biological activity is no proof of safety, and many alkaloids pose serious toxicological dangers. Future advancement in the field of medicinal plant alkaloids should incorporate traditional wisdom with scientific analysis.

REFERENCES

- Croteau, R., Kutchan, T. M., & Lewis, N. G. (2000). Natural products (secondary metabolites). *Biochemistry and Molecular Biology of Plants*, 24, 1250-1319.
- EFSA Panel on Contaminants in the Food Chain (CONTAM), Knutsen, H. K., Alexander, J., Barregård, L., Bignami, M., Brüschweiler, Ceccatelli, S., Cottrill, B., Dinovi, M., Edler, L. and Grasl-Kraupp, B. (2017). Risks for human health related to the presence of pyrrolizidine alkaloids in honey, tea, herbal infusions and food supplements. *EFSA Journal*, 15(7), e04908.
- Pradhan, J., Pramanik, K., Jaiswal, A., Kumari, G., Prasad, K., Jena, C., & Srivastava, A. K. (2024). Biosynthesis of secondary metabolites in aromatic and medicinal plants in response to abiotic stresses: a review. *Journal of Experimental Biology and Agricultural Sciences*, 12(3), 318-334.