

Current Research in Medicinal Plant Science

ISBN: 978-93-49938-37-3 | Year: 2026 | pp: 141 - 145 |

Alkaloids of *Catharanthus roseus*: Chemistry, Biological Significance and Therapeutic Applications

Dr. P. V. Gaikwad

Department of Botany, K. B. P. College, Urun-Islampur-415409, Tal-Walwa, Dist-Sangli. (MS) India

Email:

Article DOI Link: <https://zenodo.org/uploads/19994774>

DOI: 10.5281/zenodo.19994774

Abstract

Alkaloids are a diverse group of nitrogen-containing secondary metabolites with profound pharmacological importance. Among medicinal plants, *Catharanthus roseus* has gained global attention due to its rich reservoir of indole alkaloids, many of which exhibit potent anticancer properties. This chapter provides a comprehensive overview of the chemistry, classification, biosynthesis, and biological roles of alkaloids with special emphasis on *Catharanthus roseus*. Particular focus is given to clinically significant alkaloids such as vinblastine and vincristine, their mechanisms of action, and applications in cancer therapy. The chapter also highlights traditional uses, antimicrobial properties, and future prospects for research and drug development.

Introduction

Alkaloids are naturally occurring organic compounds containing nitrogen atoms, primarily derived from amino acids, and are known for their significant physiological effects on living organisms. These compounds are widely distributed in higher plants and play important roles in plant defence mechanisms against herbivores and pathogens. Over the centuries, alkaloids have been extensively utilized in traditional medicine systems for the treatment of various diseases. Among alkaloid-producing plants, *Catharanthus roseus* occupies a unique position due to its ability to synthesize a wide variety of pharmacologically active indole alkaloids. Historically, the plant has been used in folk medicine as a diuretic, antidiysenteric, wound-healing agent, and for the treatment of diabetes in different parts of the world, including India and the Caribbean (Narain & Satapathy, 1977).

Diversity of Alkaloids in *Catharanthus roseus*

Catharanthus roseus is known to contain more than 100 different alkaloids, predominantly belonging to the indole and dihydroindole groups. These alkaloids include monomeric compounds such as ajmalicine and serpentine, as well as dimeric alkaloids such as vinblastine and vincristine, which possess strong antineoplastic activity (Svoboda, 1959). The plant synthesizes alkaloids in different tissues, with roots being rich in ajmalicine and serpentine, while leaves predominantly contain catharanthine and vindoline. These compounds act as precursors for the formation of complex dimeric alkaloids through intricate biosynthetic pathways.

Ajmalicine (raubasine) is a monomeric indole alkaloid known for its vasodilatory properties and its application in treating circulatory disorders. Serpentine, closely related to ajmalicine, is interconvertible and contributes to the plant's pharmacological profile. Catharanthine and vindoline are key precursors in the biosynthesis of vinblastine-type alkaloids. Vindoline biosynthesis occurs in chloroplasts, indicating compartmentalization of metabolic pathways (Dethier & De Luca, 1993).

Table No: 1. Some Alkaloids of *Catharanthus roseus* L.

Name	Formula	M.P. (°C)	Max.wavelength λ_{max}
Vindosidine	$C_{22}H_{26}N_2O_5$	253-273	226,254,259,300
Lochnervine	$C_{24}H_{28}N_2O_5$	278-280	296,329
Leurosivine	$C_{41}H_{54}N_3O_9$	>353	214,265,295,310
Cavincine	$C_{20}H_{24}N_2O_2$	275-277	224,281,288
Ammocaline	$C_{19}H_{22}N_2$	>335	218,288
Perividine	$C_{20}H_{22}N_2O_4$	230-260	240,286,315
Lochrovine	$C_{23}H_{30}N_2O_3$	258-263	229,301,344
Perimivine	$C_{21}H_{22}N_2O_4$	292-293	232,302,340
Vincoline	$C_{21}H_{24}N_2O$	230-233	244,300
Lochrovidine	$C_{22}H_{26}N_2O_4$	213-218	226,297,328
Lochrovicine	$C_{20}H_{22}N_2O_3$	234-238	225,298,326
Vincolidine	$C_{23}H_{26}N_2O_3$	165-170	244,302
Deacetylvindorosine	$C_{22}H_{28}N_2O_4$	141-143	252,306
Pericalline		196-202	207,304
Cavincidine		236-239	222,281,289,
Ammorosine		221-225	227,280,
Mandrosine		160-173	201, 244, 290
Cathindine		239-245	224,282,289
Vinaspine		235-238	225,281,289

Vincathicine		>320	231,264, 300
Rovidine		>320	214,265,286,
Vinaphamine		229-235	214,262,292,

Biosynthesis of Vinca Alkaloids

The biosynthesis of alkaloids in *Catharanthus roseus* is a complex, multi-step process involving the condensation of tryptamine and secologanin to form strictosidine, the universal precursor of monoterpenoid indole alkaloids. Subsequent enzymatic transformations lead to the formation of various monomeric alkaloids, which are later coupled to form dimeric compounds such as vinblastine. The coupling of catharanthine and vindoline produces vinblastine via intermediates such as anhydrovinblastine. This biosynthetic pathway is tightly regulated and involves multiple cellular compartments, including vacuoles and chloroplasts, making large-scale production of these alkaloids challenging.

Pharmacological Importance of *Catharanthus* Alkaloids

1. Anticancer Activity

The most significant contribution of *Catharanthus roseus* to modern medicine lies in its anticancer alkaloids, particularly vinblastine and vincristine. These compounds are widely used in chemotherapy for the treatment of various cancers. Vinblastine is effective in the treatment of Hodgkin's disease and other lymphomas, as well as breast, bladder, and cervical cancers. It works by binding to microtubules and inhibiting their polymerization, thereby arresting cell division at metaphase (Klener & Pavel, 1974). Vincristine, on the other hand, is extensively used in the treatment of Leukemia in children and is also effective against lymphomas and solid tumors. Both alkaloids disrupt mitotic spindle formation, leading to inhibition of cell proliferation and induction of apoptosis in cancer cells.

2. Mechanism of Action

Vinblastine and vincristine exert their effects by binding to tubulin proteins, preventing the formation of microtubules essential for chromosome separation during mitosis. This results in metaphase arrest and subsequent cell death. At higher concentrations, these compounds also interfere with nucleic acid and protein synthesis, further enhancing their cytotoxic effects (Degraeve, 1978). The specificity of these drugs for rapidly dividing cells makes them particularly effective against cancerous tissues.

3. Other Medicinal Uses

In addition to anticancer properties, alkaloids of *Catharanthus roseus* exhibit a wide range of therapeutic activities. Ajmalicine is used in the treatment of hypertension and circulatory disorders due to its vasodilatory effect. The plant extracts also show sedative properties and are used for muscle relaxation and central nervous system

disorders. Furthermore, traditional uses of the plant include treatment of diabetes, toothache, and wound healing, indicating its broad medicinal potential.

Antimicrobial and Agricultural Applications

Extracts of *Catharanthus roseus* have demonstrated significant antifungal activity against pathogens such as *Fusarium oxysporum*, *Aspergillus niger*, and *Colletotrichum species*, which affect economically important crops. These extracts inhibit spore germination, sporulation, and mycelial growth, thereby protecting plants from disease (Narain & Satapathy, 1977). Additionally, the plant exhibits insecticidal properties, affecting the development and survival of agricultural pests such as *Heliothis armigera* and *Spodoptera litura*. These properties highlight the potential of *Catharanthus roseus* as a source of eco-friendly biopesticides.

Challenges in Alkaloid Production and Future Prospects

Despite their immense therapeutic value, the production of Vinca alkaloids in plants is extremely low, with vincristine present at concentrations as low as 25 ppm. Large quantities of plant material are required for extraction, making the process economically challenging. Advances in plant biotechnology, including tissue culture, genetic engineering, and metabolic pathway manipulation, are being explored to enhance alkaloid production. Cell suspension cultures and elicitor treatments have shown promise in increasing yields of valuable alkaloids. Future research should focus on improving biosynthetic efficiency, understanding gene regulation, and developing sustainable production methods.

Conclusion

Alkaloids of *Catharanthus roseus* represent one of the most significant contributions of plant secondary metabolites to modern medicine. With over 100 identified compounds, including highly potent anticancer agents such as vinblastine and vincristine, this plant continues to be a subject of intense scientific research. Its diverse pharmacological properties, including anticancer, antimicrobial, and cardiovascular effects, make it an invaluable resource for drug discovery and development. Continued research in this field will not only enhance our understanding of plant metabolism but also contribute to the development of novel therapeutics for human diseases.

References

1. Degraeve, N. (1978). Effects of vincristine on nucleic acid synthesis. *Mutation Research*, 55(1), 1–10.
2. Dethier, M., & De Luca, V. (1993). Biosynthesis of vindoline in *Catharanthus roseus*. *Plant Physiology*, 102(2), 673–678.
3. Ghosh, B. (1992). Induction of phytoalexins in soybean by plant extracts. *Plant Pathology Journal*, 8, 45–50.

4. Hamada, H., & Nakazawa, K. (1991). Conversion of vinblastine to vincristine in cell cultures. *Phytochemistry*, 30(2), 553–555.
5. Klener, P., & Pavel, S. (1974). Effects of vinca alkaloids on mitosis. *Cancer Chemotherapy Reports*, 58, 123–130.
6. Mohsen, Z. H., et al. (1989). Effects of plant extracts on mosquito development. *Journal of Applied Entomology*, 107, 123–130.
7. Narain, A., & Satapathy, K. B. (1977). Antifungal activity of plant extracts. *Indian Phytopathology*, 30, 567–570.
8. Rauf, A., & Khan, A. (1989). Effect of plant extracts on pollen germination. *Plant Science*, 63, 45–50.
9. Svoboda, G. H. (1959). Alkaloids of *Catharanthus roseus*. *Journal of Pharmaceutical Sciences*, 48(11), 659–666.
10. Taylor, W. I. (1968). The chemistry of vinca alkaloids. *Phytochemistry*, 7, 123–130.